Bioheat® Technical Steering Committee

NATIONAL BIODIESEL BOARD
NATIONAL OILHEAT RESEARCH ALLIANCE

Report

2015 Research Meeting Report

October 15, 2015

Bioheat Technical Steering Committee

The Bioheat Technical Steering Committee (BTSC) is a joint effort between the National Biodiesel Board and the National Oilheat Research Alliance for the purpose of identifying, prioritizing, and advising on the necessary pre-competitive industry research needed to support higher levels of biodiesel in the Bioheat market.

In 2008, ASTM (Standard D396) approved up to 5% biodiesel as a fungible component in #1 and #2 heating oil making blends up to 5% (B5) equivalent to #1 and #2 heating oil. This change was supported by research identified by the BTSC.

On December 15, 2014, ASTM approved performance specifications for bioblends of 6 to 20 percent biodiesel with traditional heating oil.

The BTSC is now focusing research necessary to develop a standard(s) for blends greater than 20%, as well as, any necessary research to implement the B6-B20 fuel standard.

To this end, the following industry experts met on October 2, at the LaGuardia Marriott, to begin the process of defining a research agenda to support increased blends of biodiesel in the Bioheat market.

Viewpoint	Representative		Affiliation
Biodiesel Industry	Steve	Howell	NBB
Biodiesel Refining	Dave	Slade	REG
Biodiesel Refining	Ben	Wootton	Keystone Biofuels
Fuel Industry Rep	John	Bruno	PriMedia
Fuel Industry Rep	Tom	Tubman	American Energy Coalition
Fuel Industry Rep	Rocco	Lacertosa	NY Oilheat Association
Fuel Industry Research	Rich	Sweetser	NORA
Fuel Industry Research	John	Huber	NORA
Fuel Marketer	Ray	Hart	Hart Home Comfort
Fuel Marketer	Ed	Noonan	Noonan Energy Corp
Fuel Marketer	Alison	Heaney	Skaggs-Walsh
Government	Judy	Jarnefeld	NYSERDA
Government	Tom	Butcher	Brookhaven National Laboratory
Manufacturer-Burner	Blaine	Serio	*Riello Burners* North America
Manufacturer-Burner	Jim	Jones	Carlin
Manufacturer-Burner	Chuck	Feldman	Carlin
Manufacturer-Burner	Vic	Turk	Beckett
Manufacturer-Burner	John	Bohan	Beckett
Manufacturer-Burner	Kevin	Beckett	Beckett
Manufacturer-Fuel Pump	Richard	Thiel	Danfoss
Manufacturer-Fuel Pump	Coralie	Bailly	Suntec
Manufacturer-Industry	Don	Farrell	OMA

This document captures the discussion items, as well as, research topics that serve as a starting place for additional discussion and prioritization. Three topic areas surfaced:

1. **High Priority Areas for Technical Effort, Potential B6-B20 Work**, focusing on existing systems and fuels, where research could help to clarify technical issues, support further standard development, and develop best practices guidance for fuel marketers.
2. **High Priority Areas for Technical Effort, Additional B21-B100 Work**, looking to develop future fuels above B20 blends, providing the necessary research to support new fuel standards, precompetitive product development and best practices.
3. **Non-Research Issues of Interest to the Industry,** identifying important issues that could assist the industry in moving forward with biodiesel in oilheat that are outside the research and technical focus areas of the BTSC.

High Priority Areas for Technical Effort, Potential B6-B20 Work

After the formal allowance of up to 5% biodiesel in all sulfur grades of both No. 1 and No. 2 heating oil in ASTM D396 in 2008, NORA and NBB utilized the advice and counsel of the BTSC to identify and prioritize needed research and technical information that were needed in order to secure passage of B6-B20 blends in the ASTM D396 standard. This 6 year effort resulted in a significant amount of technical work, mostly executed by Brookhaven National Laboratory that formed the basis for the passage of B6-B20 in ASTM D396.

Steve Howell of M4 Consulting and who chairs the ASTM Biodiesel Task Force provided a short power point overview of this previous technical activity as well as provided the white papers and power point presentations summarizing this technical data. The data, which was a direct result of the advice and guidance of the BTSC in place at the time (which included members from NORA, NBB, Brookhaven, R.W. Beckett, Suntec, Carlin and others), provided the substantiating technical information that was critical in passage of the B6-B20 grade in D396. The short power point presentation provided by Mr. Howell and the summary white papers and power points are attached to this report summary.

While a substantial amount of technical information is now available on B6-B20, the meeting attendees discussed several aspects of B6-B20 use that are candidates for additional research or technical effort. The four potential areas are summarized below.

1. **Piston seal impacts.** In the effort leading up to the B6-B20 ballot, the BTSC identified the compatibility of the shaft seal of existing pumps as a major area for additional technical data. Upon the advice of the BTSC, a major effort was undertaken by NORA and NBB—with substantial support and cooperation from Suntec and R.W. Beckett—to provide solid technical data on the impact of B6-B20 blends with pump shaft seals, which were viewed as the most potentially vulnerable elastomer within conventional pumps. The summary information is attached. Bench-scale testing indicated no difference with in-specification biodiesel or blends

vs. heating oil containing no biodiesel in bench scale testing. Actual pump shaft seal durability testing indicated less potential leaks with B12 and B20 than B0. Field surveys also indicated no additional issues with blends up to B20 compared to those reported with B0. However, Suntec had performed certain cyclical tests simulating approximately 50 years of use on their pressure regulating seal (piston seal) in Europe and expressed concern over their legacy material (note they have subsequently changed material). These tests have not been reproduced in the US nor has this appeared in the field among the significant base of biodiesel blends used by Bioheat[1] marketers.

Potential research: Develop a detailed test protocol including fuel test specifications, and create a third party independent study on piston seal durability similar to that completed with the shaft seal.

2. **Fuel quality survey for fuel quality.** Traditional, high sulfur heating oil is not without its own set of problems and issues. An entire oilheat service industry has been established with a major emphasis on addressing on-going issues associated with traditional oilheat. However, adding biodiesel into the mix changes the fuel mix, and complicates fuel quality questions because the first thought is the biodiesel is causing the problem. In NORA's and NBB's experience, most 'problems' that occur with biodiesel blends are related to "out-of-spec" fuels, raw vegetable oil type fuels, or normal issues observed with traditional oilheat. In the most recent forensic analysis where biodiesel has been implicated, the root cause of the issue has not been the use of in-spec biodiesel. Bioheat® blending consisting of in spec D396 and D6751 is critical to success.

   Potential research: Continuing fuel quality survey work is important to improve marketer performance and raise the bar for fuel quality across the board, provide a baseline of where the industry is really operating today, and guide manufacturers in burner development. The question to be developed here is what the most effective means of perform field fuel quality research. A discussion with respect to the efficacy of field test equipment for cloud point and percentage of biodiesel led to a subsequent discussion of means to conduct low cost fuel quality surveys.

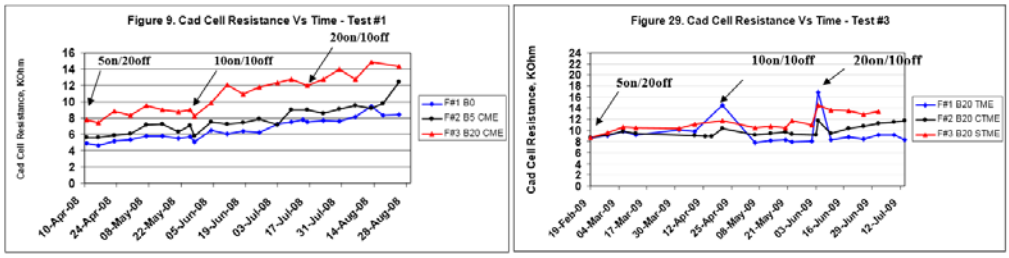
3. **Provide Industry Quality Baseline for UL Test Fuel Development.** There is no test fluid that has been established by UL for the official UL listing of burners and heating oil equipment for blends over B5. One of the questions associated with this is what the current B6-B20 Bioheat quality is in the field and what is reasonable to assume as a 'worst case' fuel that could serve as a UL test fluid for B6-B20. The fuel quality survey above should assist the industry in helping to develop an agreed-to B6-B20 test fluid for UL listings. However, other considerations may need to be taken into account, such as whether only in-spec fuel is assumed or out-of-spec fuel. If out-of-spec fuel – how far out of spec?

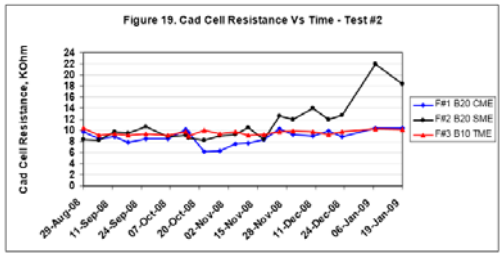
[1] Bioheat® is a registered trademark. Bioheat® is traditional home heating oil blended with Biodiesel.

Potential research: Determine the test fuel standard for UL testing of B6-B20 fuel in burners and burner components based on fuel quality surveys and discussions among fuel producers, marketers, technical experts and UL.

4. **Is there any work needed with lower blends on flame sensing?** This issue can be bifurcated into a) legacy systems and b) new systems. The latter question (new systems) is a matter of product development with several paths to success including further cad cell testing. The legacy question is explored below.
    a. No cad cell issues are being reported from the field. The significant installed base of systems operating at B20 and above has not reported flame sensing problems. Perhaps formalizing this dataset would be valuable.
    b. Need to re-publish new information and get it out to people more (i.e. flame sensing, etc.)

    Beckett cited a 2009 Canadian study[2] which found: the Riello burner could operate in the range between 5kΩ and 50kΩ. The three figures below (three difference furnaces) that the cad cell resistance remained well below the 50kΩ maximum limit throughout the test.





A 2006 study[3] indicated that "Blend ratios as low as 20% biodiesel could cause the flame sensing and control to shut the burner down".

[2]Bio Furnace Fuel Test Final Report, Research conducted by Imperial Oil, Products and Chemicals Division Research Department, Sarnia, Ontario, Canada, R491-2009, December, 2009

[3] Flame Sensing and Control Studies of Various Biodiesel Blends in Heating Oil, Phase II Summary Report, Prepared for the National Biodiesel Board, John E. Batey, Energy Research Center and C.R. Krishna, Brookhaven National Laboratory, March 2006.

Potential research: the industry could benefit from an updated literature search to compile the latest cad cell latest laboratory and field data with bioblends particularly in the up to B20 range for legacy equipment. This could be coupled with a more formal field research into this issue.

High Priority Areas for Technical Effort, Additional B21-B100 Work

The fundamental purpose of the BTSC is to assess and develop the body of research necessary to support higher blends of Bioheat®. The following research tropics were offered for further consideration:

1. Develop a UL Test Fuel for biodiesel (B6-B20 and > B20)
    a. 'Reasonable foreseeable issues'
    b. Need to define petroleum portion better
2. Manufacturers of burner components must OK their components for increased biodiesel content to the burner manufacturers. The fuel pump was cited as a case in point. The pump manufacturer must certify pump for fuel before the burner manufacturer can certify the burner. (Not a BTSC item but just a fact)
3. Are higher blends going to be mobilizing sludge more than ULSD? Could be one focus of formalized field study.
4.

    The group agreed in principle that for ASTM specifications over B20 the physical properties[4] (i.e. viscosity, cold flow properties, density, etc.) should be used to limit the various performance properties in the specs for higher blends vs. use of strictly the percent of biodiesel in the blend as much as is possible. In other words, if viscosity is the important factor don't limit the blend level to 80% biodiesel because the viscosity at that level may be too high—set the limit on viscosity and then any blend of biodiesel/oilheat can be used as long as the viscosity is within

[4] using as many properties as possible

spec.

TABLE 1 Detailed Requirements for Fuel Oils[A,B]

Property	ASTM Test Method[C]	No. 1 S500[C]	No. 1 S5000[C]	No. 2 S500[C]	No. 2 S5000[C]	B6–B20 S500[C]	B6–B20 S5000[C]	No. 4 (Light)[C]	No. 4	No. 5 (Light)	No. 5 (Heavy)	No. 6
Flash Point, °C, min	D93 – Proc. A	38	38	38	38	38	38	38	...	...	...	...
	D93 – Proc. B	...	...	...	...			...	55	55	55	60
Water and sediment, percent by volume, max	D2709	0.05	0.05	0.05	0.05	0.05	0.05	...	...	...	...	...
	D95 + D473	...	...	...	...			(0.50)[D]	(0.50)[D]	(1.00)[D]	(1.00)[D]	(2.00)[D]
Distillation Temperature, °C	D86											
10 % volume recovered, max		215	215	...	...	...	...					
90 % volume recovered, min		...	...	282	282	282	282					
90 % volume recovered, max		288	288	338	338	343	343					
Kinematic viscosity at 40 °C, mm^2/s	D445											
min		1.3	1.3	1.9	1.9	1.3	1.3	1.9	>5.5	...	...	...
max		2.4	2.4	4.1	4.1	4.1	4.1	5.5	24.0[E]			
Kinematic viscosity at 100 °C, mm^2/s	D445											
min		...	...	...	...			...	...	5.0	9.0	15.0
max		...	...	...	...			...	...	8.9[E]	14.9[E]	50.0[E]
Ramsbottom carbon residue on 10 % distillation residue percent by mass, max	D524	0.15	0.15	0.35	0.35	0.35	0.35	...	...	...	...	...
Ash, percent by mass, max	D482	...	...	...	...			0.05	0.10	0.15	0.15	...
Sulfur, percent by mass max[F]	D2622	0.05	0.5	0.05	0.5	0.05	0.5					
Copper strip corrosion rating, max, 3 h at a minimum control temperature of 50 °C	D130	No. 3	No. 3	No. 3	No. 3	No. 3	No. 3	...	...	...	...	...
Density at 15 °C, kg/m^3	D1298											
min		...	...	...	...			>876[G]	...	...	...	...
max		850	850	876	876	876	876	...	...	...	...	...
Pour Point °C, max[H]	D97	–18	–18	–6	–6	–6	–6	–6	–6	...	...	I
Oxidation Stability, hours, min	EN 15751	...	...	...	...	6	6					
Acid Number, mg KOH/g, max	D664	...	...	...	...	0.3	0.3					
Biodiesel Content, percent (V/V)[J]	D7371	...	...	...	...	6. – 20.	6. – 20.	...				

5. Need to get Listing agency listing requirements updated for anything biodiesel specific for higher blends. The question is one of responsible party. Is this a fuel industry function or a manufacturer's function? Will need to explore the scope of this matter and determine path forward.
    a. Oil Burners – UL 296
    b. Pumps for Oil-Burning Appliances– UL 343
    c. Strainers for Flammable Fluids and Anhydrous Ammonia – UL 331
    d. Valves for Flammable Fluids – UL 842
    e. Valves, Electrically-Operated – UL 429
    f. Oil-Fired Boiler Assemblies – UL 726
    g. Oil-Fired Central Furnaces – UL 727
    h. Oil-Fired Storage Tank Water Heaters – UL 732
    i. Steel Aboveground Tanks for Flammable and Combustible Liquids – UL 142
    j. Steel Underground Tanks for Flammable and Combustible Liquids – UL 58
    k. Glass-Fiber-Reinforced Plastic Underground Storage Tanks for Petroleum
    l. Products, Alcohols, and Alcohol-Gasoline Mixtures – UL 1316
    m. Level Controls – UL180
6. The consensus was that since emissions are not regulated this will not focus area for research at this time.
7. Impact of biodiesel on flame sensor effectiveness[5]—variability of different biodiesels---do literature search first and then potential pre-competitive research. This will be follow-on to the

[5] Luminosity may vary based on different components in biodiesel, especially as the blend goes higher

cad cell flame sensing work cited above. Note there is a body of research[6] that BNL has developed over the years focusing on flame detection and significant development in Europe with blue flame detection[7].

8. Slope of the parameters throughout the range for various physical properties of importance to burner or pump operation that may be different than for oilheat with no biodiesel. This may vary dramatically for a heated vs. non-heated system.
9. How does the oxygen content in the biodiesel impact burner settings and optimization as the biodiesel blend increases? This becomes a critical question, especially if a burner can expect to receive biodiesel blends ranging from B0 to B100 depending on what the customer purchases from any given supplier. This question may have technical and/or process implications.

Non-Research Issues Requiring Assessment

1. When did UL 'approve' B5 versus B6-B20 approval equivalence versus separate fuel standard

   January 7, 2009 "Underwriters Laboratories Inc. (UL) is announcing that products intended to use biodiesel blends up to B5 that are compliant with applicable ASTM International fuel standards will not require special investigation by UL. This is consistent with ASTM standards for heating oil and diesel fuel, which were recently updated to indicate that B5 blends may be considered the same as the conventional petroleum fuels under their scope." The UL and ASTM "considered the same as" approach, according to the manufacturers present at the BTSC meeting, means that there was no requirement for them to change, test or relabel their equipment.

   Ripple effect of the ASTM new fuel classification. The new ASTM grades B6-B20 S500 and B6-B20 S5000 (ASTM Table 1), presents manufacturers with another fuel that they must recognize. This is different from the considered the same as for up to B5 grades.

2. NFPA 31 has a reference to "appliance is listed and approved or is stipulated by the manufacturer…" This standard can easily be interpreted for new product installations, but does not deal with existing appliances where new fuels are created from listed liquid fuels.

[6] Development of a Two-Color FQI, Thomas Butcher and George Wei, Brookhaven National Laboratory 1973, Design Study for Advanced Flame Quality Indicator, Tino Posillico, Ph.D., Brookhaven National Laboratory, 1973
[7] Satronic AG infra-red flicker detector, the IRD 1010, Danfoss UV sensors are used to detect the flame in blue flame oil burners.

4.5 Acceptable Liquid Fuels.

4.5.1* The type and grade of liquid fuel used in a liquid fuel–burning appliance shall be that liquid fuel for which the appliance is listed and approved or is stipulated by the manufacturer. Liquid fuels shall meet one of the following specifications and shall not contain gasoline or any other flammable liquid:

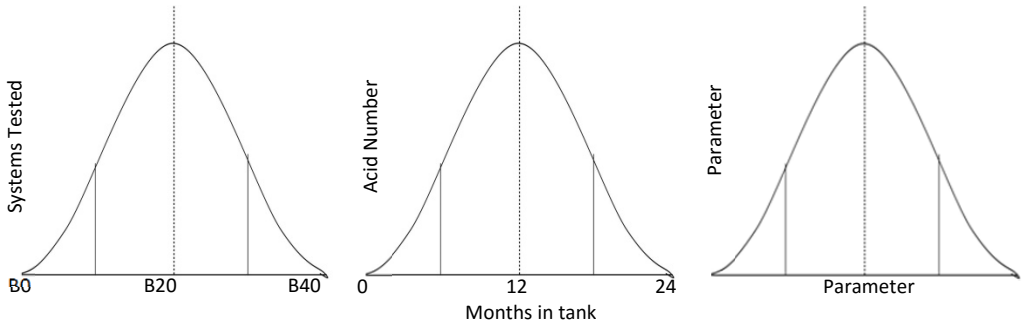
(1) ASTM D 396, *Standard Specification for Fuel Oils*
(2) ASTM D 3699, *Standard Specification for Kerosene*
(3) ASTM D 6448, *Industrial Burner Fuels from Used Lube Oils*
(4) ASTM D 6751, *Standard Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuel*
(5) ASTM D 6823, *Commercial Burner Fuels from Used Lube Oils*

4.5.2 Crankcase oil or used oil shall not be used as fuel unless all of the following conditions are met:

(1) The installation is in a commercial or industrial occupancy.
(2) The oil-burning appliance is designed to burn crankcase oil or used oil and is listed for such use.

← From NFPA 31 (2011)

3. Better understanding of stability and storage. The issue of shelf-life should be better defined for the marketplace. This includes better understanding of distribution of existing fuels and how long before it gets burned.
4. Given the issues of cold flow properties and biodiesel (including different feedstocks), is there an advantage of producing a summer/winter for biodiesel. Keep in mind that burner manufacturers must test to UL 296[8] which requires 35°F degree operating point test for listing which will impact all burners regardless if they are located in Florida or Maine.
5. If the concepts of winter/summer blends, as well as several new fuels in the range of B21 to B100 are created, then the logistics of managing a variety of different grades needs to be considered.
6. Provide List of open working issues with ASTM.
7. Regarding field research, there was consensus to continue to monitor the quality of fuel in residential tanks in the field. There was a discussion of the best methods and means of accomplishing this work. It was suggested that finding a means to better equip marketers with field test instruments to better quantify fuel conditions would significantly improve stat collection and analytics. There was discussion of field instruments for cloud point, percent biodiesel, acid number, etc. A fuel quality testing protocols and ongoing research program should be developed. It was suggested that Bell curves showing studied parameters provide best means of quickly showing performance



[8] Standard for Oil Burners

8. How do you make sure that people don't buy the cheapest fuel and have problems? It behooves the Bioheat® to educate blenders, fuel marketers, policy makers and the general public about fuel quality. This education effort is outside the scope of the BTSC.
    a. Out of spec fuel
    b. Cold flow, etc.
9. Monitoring and enforcement of the fuel standards and fuel quality was raised. It was stated that there are big incentive to use imposter biodiesel or raw vegetable oil. This is beyond the scope of the BTSC.
10. Field test analytical equipment details for percent biodiesel and cold flow were discussed and attached to this document are spec sheets of the equipment mentioned.
11. Need to get Listing agency requirements updated for anything biodiesel specific for higher blends.
12. Oil appliances, boilers and furnaces are rated on number #2 oil for performance. Does the industry need/want to work with DOE on efficiency levels and any biodiesel impacts? Will DOE require and changes for biodiesel in high blends?
13. Burner manufacturers are interested in more combustion testing with B6-B20. This was not defined and needs to be explored with respect to the need/goals of such testing.

Moving Forward

The Bioheat® Technical Steering Committee Roster was reviewed and it was the consensus of the meeting attendees the updated BTSC roster in the following table would serve NORA, the NBB and the oilheat industry well.

Viewpoint	Representative		Affiliation
Biodiesel Feedstock	Greg	Anderson	Nebraska Soybean
Biodiesel Industry	Paul	Nazzaro	AFS/NBB
Biodiesel Industry	Steve	Howell	MARC-IV/NBB
Biodiesel Refining	Holly	Koziorowski	Hero BX
Biodiesel Refining	Dave	Slade	REG
Fuel Industry Rep	Michael	Ferrante	MOHC
Fuel Industry Research	John	Huber	NORA
Fuel Industry Research	Bob	Boltz	NORA
Fuel Industry Research	Rich	Sweetser	NORA
Fuel Marketer	Jason	Mengel	Buckeye
Fuel Marketer	Al	Breda	OESP/Sippin
Fuel Marketer	Alison	Heaney	Skaggs-Walsh
Government	Tom	Butcher	Brookhaven National Laboratory
Government	Judy	Jarnefeld	NYSERDA
Manufacturer-Industry	Don	Farrell	OMA
Manufacturer-Appliance	Roger	Maran	Energy Kinetics
Manufacturer-Appliance	David	Scearce	Peerless Boilers
Manufacturer-Appliance	Everett	James	Thermo Pride

Manufacturer-Appliance Testing	Glenn	Green	Intertek
Manufacturer-Burner	Vic	Turk	Beckett
Manufacturer-Burner	Jim	Jones	Carlin
Manufacturer-Burner	Blain	Serio	Reillo
Manufacturer-Fuel Pump	Rich	Theile	Danfoss
Manufacturer-Fuel Pump	Ken	Skoda	Suntec Pumps
Manufacturer-Fuel Storage	Laurie	Grainawi	Steel Tank Institute

The technical recommendations from this meeting will be further discussed at the Biodiesel Technical Workshop on October 20 and 21. The collective findings will be disseminated to the BTSC and a research plan will be created. The research is expected to fall in to three categories: NORA focused research that will be conducted by staff using BNL, and fuel marketer resources, industry supported research that will be defined in a program opportunity notice (PON) to allow interested parties to perform NORA/NBB funded research and research by others. This latter category covers research that is product oriented and competitive in nature which should be funded by others.

Finally there were subjects discussed that are not precompetitive research that the BTSC focuses on and these topics have been referred to the NORA Board for consideration.

Attachments

- BTSC Previous Project Areas, Bioheat Technical Steering Committee Meeting, Steve Howell, NBB, October 2015
- Industry Survey on the Use of Biodiesel (Bioheat®)Blends, Dr. Thomas Butcher, Brookhaven National Laboratory and John Huber, National Oilheat Research Alliance, April 2014
- Combustion Performance of B-20 Biodiesel Blends in Residential Heating Appliances, C.R. Krishna and Christopher Brown, Brookhaven National Laboratory, April 2014
- Biodiesel/Heating Oil Blends – Interaction with Yellow Metals and Tank Sludge, Dr. Thomas Butcher, Brookhaven National Laboratory, April, 2014
- Elastomers and Pump Durability of Biodiesel in Heating Oil Equipment, Dr. Thomas Butcher, Brookhaven National Laboratory, April, 2014
- Combustion Performance of B-20 Biodiesel Blends in Residential Heating Appliances, C.R. Krishna and Christopher Brown, Brookhaven National Laboratory, April 2014
- Bioheat Use Survey, Dr. Thomas Butcher, Brookhaven National Laboratory, April, 2014
- Underwriters Laboratories Announces Position on Use of B5 Biodiesel Blends, January 7, 2009