UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

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MEMORANDUM

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

SUBJECT: Assessment of Emissions Data and State Permit Information Available for Burning Biofuels Fuels (e.g., Animal Fats and Reclaimed Greases and Oils)

FROM: Sims Roy, Combustion Group

TO: Sally L. Shaver, Director
Emission Standards Division

Summary

The National Renderers Association, Inc. (NRA) provided emission testing summaries, emission test reports and other information to EPA in 2001 and 2002 which reported emissions of criteria pollutants from the burning of biofuels (e.g., animal fats and reclaimed greases and oils), and in some cases for the purpose of comparison, from the burning of conventional fuels of natural gas, #2 fuel oil, and #6 fuel oil.

The NRA asked EPA to review and analyze this data and provide a summary of the results with an accompanying memorandum which would be helpful to local, State and Regional agencies in the permitting process for the burning of biofuels. This summary is based primarily on the analysis of the data provided by NRA.

Based on our analysis of the emissions data provided, we can make the following conclusion statements:

- Substitution of biofuels for #6 fuel oil results in less emissions of nitrogen dioxide (NO_2), sulfur dioxide (SO_2), particulate matter (PM), and carbon monoxide (CO) when emission test results of biofuels are compared to AP-42 emission factors for the burning of #6 fuel oil.

- In general, substitution of biofuels for #2 fuel oil results in less emissions of NO_2, SO_2, and emissions of PM and CO vary between slightly lower and higher when emission test results of biofuels are compared to AP-42 emission factors for the burning of #2 fuel oil. However, based on the University of Georgia (UGA) tests (Appendix 1, Attachment 7), chicken fat and choice white grease emit significantly higher PM and slightly higher NO_2 emissions compared to burning #2 fuel oil.

- Substitution of biofuels for natural gas results in slightly higher NO_2, SO_2 and PM emissions, and slightly lower and higher CO emissions when compared to emission test results and AP-42 emission factors.

Note: Burning these fuels with and without flue gas recirculation followed the same trends as above except that in all cases, the flue gas recirculation resulted in lower NO_2 emissions.

These emission comparisons are made based on the results of several summary test reports, eight stack testing reports which are identified in Appendix 1, Attachment 6, and a testing program report identified in Appendix 1, Attachment 7. The summary reports and the stack testing reports were reviewed and appear to be good tests. The emissions from the burning of yellow grease, tallow and cooking oil in boiler burners vary somewhat, and there may be differences in emissions of some pollutants between different types of biofuels. Thus, additional emission test data are needed to determine the similarity of these emissions.

Information provided by NRA indicates that the permitting agencies were accommodative to permitting switching from conventional fuels to biofuels especially when test reports of similar fuel switching were available (see Appendix 1, Attachment 5). In most cases, the information presented in this memorandum, plus the availability of the test reports that have already been conducted, should provide permitting agencies with sufficient information to make permitting decisions regarding switching from conventional fuels to biofuels without having to do expensive stack testing prior to issuing the permit.

Sources of Emissions and Other Data

Criteria pollutant emissions data from the burning of biofuels and conventional fuels and information from permitted units were sent to EPA at various times during 2001 and 2002 by the NRA. This information consists of the following submittals which are located in Appendix 1:

1. Article titled *"Turn up the Heat"*, Render Magazine, April 2001. (Appendix 1, Attachment 1)

2. Article titled *"Animal Fats and Recycled Cooking Oils - Alternative Burner Fuels"*, Directors Digest, Fats and Proteins Research Foundation, Inc., March 2001. (Appendix 1, Attachment 2)

3. Brochure titled *"Biofuels"* from Valley Proteins. (Appendix 1, Attachment 3)

4. Table transmitting summary results of boiler emission test results using biofuels from National Byproducts, Inc. (Appendix 1, Attachment 4)

5. Summary of CBI information regarding permit information on use of biofuels. (Appendix 1, Attachment 5)

6. List of test reports transmitted by NRA to EPA in 2001 and 2002. (Appendix 1, Attachment 6)

7. Report titled *"A Demonstration of Fat and Grease as an Industrial Boiler Fuel"*, Director's Digest, Fats and Proteins Research Foundation, Inc., November 2002. (Appendix 1, Attachment 7)

The summary reports and stack test reports that were submitted were reviewed and found to be valid tests. In addition to the information submitted by the NRA, information from the EPA document , AP-42, Fifth Edition, Vol. 1, Chaps. 1.3 and 1.4, was tabulated and used to make emission comparisons of burning biofuels to burning conventional fuels.

Analysis of Emissions and Other Data

Two general types of data were obtained from NRA – tabulated summaries of stack tests and actual stack test emission reports. The test results either included comparison testing of biofuels and the conventional fuels of natural gas, #2 fuel oil and #6 fuel oil, or included the testing of biofuels alone without comparison testing.

The NRA also supplied a complete report of a number of emission tests conducted by UGA on one UGA boiler (Appendix 1, Attachment 7). The testing was done on the same boiler using a number of biofuels. This report also provides practical information on the types of modifications that may be needed for pumping biofuels during cold weather and provides physical, chemical and heat content characteristics of various biofuels and blends of biofuels.

The most useful tests for the purpose of this analysis, which is to evaluate the impacts of using biofuels in place of conventional fuels, are those which directly compare criteria pollutant emissions from the burning of biofuels and #2 and #6 fuel oils in the same boiler and burner configuration. Other useful tests compared the burning of biofuels and natural gas in the same boiler, but using different burners. In some cases, direct comparisons could not be made and, in those cases, criteria pollutant emissions from biofuel stack tests were compared to emission factors in AP-42, Fifth Edition, Volume 1, Chapter 1.3 - Fuel Oil Combustion and Chapter 1.4 - Natural Gas Combustion, Final Section , Supplement E, September 1998, to make criteria pollutant emission comparisons.

Appendix 2, Table 1 summarizes the emission factors for criteria pollutants for small boilers and these emission factors will be used to compare the criteria pollutant emissions of biofuels to conventional fuels when no other information is available. Points to remember in Appendix 2, Table 1 are that the AP-42 emission factors for NO_2 varies with the type of burner when burning natural gas, and the #2 and #6 fuel oil SO_2 emissions vary with the sulfur content

of the fuel being burned. For those emission factors, assumptions have to be made to calculate the correct emission factor. For #6 fuel oil, a typical sulfur content of 1 percent sulfur by weight was selected, and for #2 fuel oil, a typical sulfur content of 0.1 percent sulfur by weight was selected. For NO_2 emissions, the emission factors vary by type of burner, uncontrolled vs. controlled (low NO_2 burner).

To facilitate comparison, the units of the emission factor had to be selected. Since pounds of criteria pollutant emissions per million BTU heat input (lb/MMBTU) was available, or could be calculated for the most test reports, it was selected. Therefore, the units in Appendix 2, Table 1 are pounds of criteria pollutant per MMBTU heat input.

Description of Data Tables

The data tables are included in Appendix 2.

Table 1 summarizes the criteria pollutant emission factors for small boilers. The values in the table are based on the information provided in the EPA document AP-42, Fifth Edition, Volume 1, Chapters 1.3 and 1.4 Final Section, Supplement E, September 1998. The emission factors for #6 fuel oil, #2 fuel oil and natural gas are used for comparison to biofuel emissions.

Tables 2, 7a, 7b, 8 and 9 contain emission testing results from the combustion of yellow grease. Table 3 contains emission testing results from the combustion of cooking oil. Tables 4 and 9 contain emission testing results from the combustion of finished and semi-finished lard. Tables 5, 7a, 8 and 9 contain emission testing results from the combustion of tallow. Tables 6, 8 and 9 contain emission testing results from the combustion of animal fats. Table 8 summarizes all of the emission test results which are available in terms of pounds of criteria pollutants per million BTU heat input. Table 9 summarizes all of the emission testing results which contain direct emission comparisons between biofuel combustion and conventional fuel combustion.

Comparing the Emissions of Different Biofuels

There could be some differences in emissions of NO_2 between the burning of yellow grease and the burning of tallow and cooking oil. We have much more data from the burning of yellow grease compared to other types of biofuels. Yellow grease has a 14 sample mean of 0.08 lb NO_2/MMBTU, while tallow has a 3 sample mean of 0.21 lb NO_2/MMBTU, and cooking oil has a 2 sample mean of 0.244 lb NO_2/MMBTU. The burning of animal fat has a 2 sample mean of 0.10 lb NO_2/MMBTU which is slightly higher but close to the NO_2 emissions from the burning of yellow grease. Also, as mentioned previously, the UGA emission tests (Appendix 1, Attachment 7) indicate that burning chicken fat or choice white grease results in significantly higher emissions of PM and slightly higher emission of NO_2 compared to the other biofuels.

The emissions of CO from the burning of tallow has a 3 sample mean of 0.11 lb CO/MMBTU which is higher than the 14 sample mean of CO emissions from the burning of yellow grease which is 0.018 lb CO/MMBTU.

The UGA emission tests from burning yellow grease and tallow in one boiler resulted in similar emissions compared to the other tests that were analyzed and discussed above.

In conclusion, there could be some emission differences between different types of biofuels for emissions of NO_2, CO, and PM. The maximum emissions from yellow grease are similar to the maximum emissions from the other biofuels. These differences, if real, could be determined by additional test results. The emissions of SO_2 appear to be similar for all of the biofuels tested.

Comparing Biofuels Emission to the Burning of Conventional Fuels

Direct Comparisons:

One of the most convincing methods of comparing emissions is when the emissions from the same boiler are measured burning conventional fuel and then measured burning a biofuel. There is limited information available regarding this type of comparison. The information is summarized below and in Appendix 2, Table 9. The comparison of yellow grease and tallow emissions to the burning of #2 fuel oil (diesel) in the section below titled "Diesel (presumably #2 Fuel Oil)", also includes the results of the UGA test results presented in Table 5, page 6-2 of Appendix 1, Attachment 7.

Natural Gas

- Yellow Grease vs. Natural Gas
  NO_2 and CO emissions for yellow grease were higher.

- Animal Fat vs. Natural Gas
  NO_2 emissions were higher for animal fat.

- Chicken Fat, Choice White Grease and Blends of Tallow, Yellow Grease and Chicken Fat vs. Natural Gas (UGA tests - Appendix 1, Attachment 7)
  In all cases, emissions of NO_2 from the burning of natural gas were lower than emissions from the burning of the above biofuels or blends of biofuels. In all cases, the emissions of SO_2 from the burning of natural gas were lower than emissions from the burning of the above biofuels and blends of biofuels and #2 fuel oil.

#6 Fuel

- Finished Lard vs. #6 Fuel
  NO_2 and SO_2 emissions for finished lard were lower and CO emissions for finished lard were slightly higher.

- Tallow vs. #6 Oil
  PM emissions for tallow were lower.

Diesel (presumably #2 Fuel Oil)

- Yellow Grease vs. Diesel
  NO_2 and SO_2 emissions for yellow grease were lower, and PM and CO emissions varied between slightly higher and lower.

- Tallow vs. Diesel
  NO_2 and CO emissions for tallow varied between slightly higher and lower, PM emissions were slightly higher, and SO_2 emissions were lower.

- Chicken Fat, Choice White Grease and Blends of Tallow, Yellow Grease and Chicken Fat vs. #2 Fuel Oil (UGA tests - Appendix 1, Attachment 7)
  PM emissions of choice white grease and chicken fat were significantly higher than PM emissions from the burning of #2 fuel oil. NO_2 emissions from burning chicken fat and choice white grease and blends of chicken fat and choice white grease with #2 fuel oil were slightly higher compared to burning of #2 fuel oil. NO_2 emissions from burning blends of yellow grease and tallow with #2 fuel oil were slightly lower when compared to burning #2 fuel oil alone.

Note: Burning these fuels with and without flue gas recirculation followed the same trends as above except that in all cases, the flue gas recirculation resulted in lower NO_2 emissions.

Comparisons of Stack Tests to AP-42 Emission Factors

In this type of comparison, the means from all tests were compared to the average emission factors found in AP-42. To facilitate comparisons, the stack tests were converted to units of pound of pollutant per million BTU heat input. (See Appendix 2, Table 8)

Yellow Grease vs. #2 Fuel Oil

The sulfur content of #2 fuel oil varies from 0.05 percent to about 1 percent sulfur by weight. The typical sulfur content of 0.1 percent sulfur by weight was selected to determine the

SO_2 emission factor. Compared to the mean of all the available data for yellow grease, emissions of NO_2 and SO_2 are lower for yellow grease, and emissions of PM and CO vary between slightly higher and lower.

Yellow Grease vs. #6 Fuel Oil

The sulfur content of #6 fuel oil selected to represent the typical sulfur content is 1 percent sulfur by weight. Compared to the mean of all the data available for yellow grease, emissions of NO_2, CO, PM, and SO_2 are much lower for yellow grease than for #6 fuel oil.

Yellow Grease vs. Natural Gas

The mean NO_2 emissions for 5 stack tests, where natural gas was fired, was 0.031 lbs NO_2/MMBTU. This value is identical to the AP-42 emission factor for natural gas NO_2 emissions using a controlled low NO_2 burner with recycle. Therefore, for the purpose of comparing the NO_2 emissions, an emission factor for natural gas combustion of 0.031 lb/MMBTU will be used. Compared to the mean of all data available for yellow grease, emissions of NO_2, PM and SO_2 are higher and CO is lower when burning yellow grease.

Adequacy of Available Data

There are 14 emission tests for yellow grease, two emission tests for lards, two emission tests for cooking oils, four emission tests for tallow, and two emission tests for fat. The UGA has conducted a series of emission tests (173) on a boiler (Appendix 1, Attachment 7) using a number of biofuels and blends of biofuel and #2 fuel oil. The available data is sufficient to support the following statements:

1. The burning of oils, greases, lards, tallows (i.e., biofuels) appear to emit less emissions compared to the burning of #6 fuel oil and heavy duty fuel;

2. In general, NO_2 and SO_2 emissions from burning biofuels appear to be lower compared to burning #2 fuel oil, and PM and CO emissions are slightly higher and lower (certain types of biofuels, i.e., chicken fat and choice white grease, emit significantly higher PM emissions and slightly higher NO_2 emissions compared to other biofuels); and,

3. Emissions from burning biofuels are higher in all cases compared to burning natural gas, except for CO being slightly lower.

Assessment of State Permit Information

The NRA sent a survey to their members to obtain information that EPA had requested in a letter dated June 26, 2001. The requested information were State permits that had allowed the

use of biofuel combustion to replace #6 and #2 fuel oils. The results of the NRA survey was sent to EPA in a cover letter dated August 16, 2001; but, the actual individual information from NRA members was declared confidential by the NRA.

The survey showed that the 27 NRA members responding to the survey are burning or have burned biofuels (animal fats, etc.) in 26 States. Some States required testing to show equivalence when little or no testing information was provided in the permit application. However, most States accept the results of similar credible test reports. States appear to be willing to allow the combustion of biofuels if the emissions from these fuels are equivalent or less than emissions from the fuels they are replacing. A summary of the State permits information submitted by the NRA is attached as Appendix 1, Attachment 5.

Conclusions

The available data appear to be adequate to conclude that biofuels emit less emissions when burned compared to burning #6 fuel oil, and that they emit more emissions when burned compared to burning natural gas. Emissions of NO_2 and SO_2 are lower, and emissions of CO and PM are slightly higher and lower when burning biofuels are compared to burning #2 fuel oil.

In most cases, the information presented in this memorandum, plus the availability of the test reports that have already been conducted, should provide permitting authorities with sufficient information to make permit decisions regarding the substitution of biofuels for conventional fossil fuels. Additionally, this information should alleviate the need for costly stack testing prior to issuing a permit.

cc: Penny Lassiter
Bob Wayland