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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Research and Development
Washington, D.C. 20460

ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM VERIFICATION STATEMENT

TECHNOLOGY TYPE:	**AIR POLLUTION CONTROL TECHNOLOGY**
APPLICATION:	**EXTERNAL COMBUSTION BOILERS AND FURNACES**
TECHNOLOGY NAME:	**A-55® CLEAN FUELS**
COMPANY:	**A-55 LIMITED PARTNERSHIP**
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The U. S. Environmental Protection Agency (EPA) has created a program to facilitate the deployment of innovative technologies through performance verification and information dissemination. The goal of the Environmental Technology Verification (ETV) Program is to further environmental protection by substantially accelerating the acceptance and use of improved and more cost-effective technologies. The ETV Program is intended to assist and inform those involved in the design, distribution, permitting, and purchase of environmental technologies. This document summarizes the results of a demonstration of A-55® Clean Fuels for use in boilers.

PROGRAM OPERATION

The EPA, in partnership with recognized testing organizations, objectively and systematically evaluates the performance of innovative technologies. Together, with the full participation of the technology developer, they develop plans, conduct tests, collect and analyze data, and report findings. The evaluations are conducted according to a rigorous demonstration plan and established protocols for quality assurance. EPA's National Risk Management Research Laboratory which conducts demonstrations of air pollution control technologies, conducted the performance verification of A-55® Clean Fuels for boiler applications.

DEMONSTRATION DESCRIPTION

During the period of August through November 1997, the performance of two A-55® Clean Fuels was evaluated by comparing the pollutant emissions and thermal efficiency from the combustion of these fuels with the emissions and efficiency from the combustion of the same, but non-emulsified, fuel in a single boiler. The boiler chosen for the tests was a full scale, 2.5×10^6 Btu/hr firetube package boiler, similar in design to boilers used in light industrial, commercial, and institutional applications. The boiler was fully instrumented to measure emissions of carbon monoxide (CO), nitrogen oxide (NO), sulfur dioxide (SO_2), and total hydrocarbons (THC). In addition, extractive sampling of the combustion flue gases provided information on emissions of particulate matter (PM). Temperature and flow measurements were made to allow calculation of thermal efficiency. The operating conditions of the boiler were chosen to be typical of those used in actual practice, both for the emulsified and non-emulsified fuels. The fuels combusted were a standard #2 (diesel) fuel oil, an A-55® emulsified #2 oil formulated using the same #2 oil, and an A-55® emulsified fuel naphtha. The fuels were combusted at three loads, with four test runs per load. Details of the demonstration, including a data summary and discussion of results, may be found in the report entitled "Verification Testing of Emissions from the Combustion of A-55® Clean Fuels in a Firetube Boiler," EPA Report EPA-600/R-98-035.

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TECHNOLOGY DESCRIPTION

Extensive literature documents the effects of emulsified fuels on combustion emissions in a variety of system types. Such emulsions have been shown to be able to reduce emissions from combustion sources; however, the impacts of oil/water emulsions on particular pollutants vary. With distillate oils, PM and nitrogen oxides (NO_x) have been shown to be reduced when using an oil/water emulsion compared to using the same oil without emulsification, but CO emissions were not significantly changed. The use of an emulsified fuel results in improved secondary atomization of the fuels, often allowing operation at a reduced stoichiometric ratio, and also tends to reduce the peak combustion temperature. Both of these effects result in lower NO_x emissions, and the improved atomization can also result in lower CO and PM emissions.

The impact of these fuels on operating efficiency will vary according to the particular characteristics of the fuel and the system in which it is used. For combustion systems (such as gas turbines) that rely on expansion of the gases, the water contained in the emulsified fuel can provide additional expansive energy as it is heated along with the combustion products. In other systems, where heat transfer is the primary mode of energy transfer, too much water can cause the thermal efficiency to drop due to the energy required to heat the water, rather than that energy's being transferred to the process. However, the ability to operate at lower stoichiometric ratios when using emulsified fuels can reduce the energy required to heat the atmospheric nitrogen and excess oxygen. In short, the thermal efficiency of a unit using emulsified fuels may either increase or decrease compared to the efficiency of the unit using the non-emulsified base fuel, depending upon the combustor type and the characteristics of the fuel.

A-55® Clean Fuels are essentially emulsions of water suspended in fuel oil, with small amounts of an emulsifying agent designed to maintain the stability of the mixture. This effort was designed to verify the performance of A-55® Clean Fuels in package boilers.

VERIFICATION OF PERFORMANCE

The performance characteristics of the A-55® Clean Fuels include:

- NO emissions: Emission concentrations of the A-55® emulsified #2 oil and emulsified naphtha were consistently lower than NO emissions from the non-emulsified #2 oil. Emission concentrations for the A-55® emulsified #2 oil and emulsified naphtha ranged between 62 and 88 ppm (corrected to 3% O_2). Reductions in emission concentrations of 34% at high load and 15% at low load were measured for the emulsified #2 oil compared to the non-emulsified #2 oil. For the emulsified naphtha, emission concentrations were reduced by 51% at high load and 33% at low load compared to the non-emulsified #2 oil. NO emission factors were measured at 0.063 to 0.070 lb/10^6 Btu for the A-55® emulsified #2 oil and 0.048 to 0.055 lb/10^6 Btu for the A-55® emulsified naphtha.

- PM emissions: PM concentrations from the A-55® Clean Fuels were slightly higher in general for the emulsified #2 oil and the emulsified naphtha compared to the non-emulsified #2 oil. For the A-55® emulsified #2 oil and emulsified naphtha, the PM emission concentrations were less than 4.88 mg/dscm (corrected to 3% O_2) for all cases, and PM emission factors for these two fuels were $1.9x10^{-3}$ to $3.8x10^{-3}$ lb/10^6 Btu.

- PM size distribution: Optical measurements of particle size distributions in the stack emissions indicated that combustion of the A-55® Clean Fuels generates greater amounts of particulate matter smaller than 2.5 µm in aerodynamic diameter ($PM_{2.5}$) than the non-emulsified #2 oil. Although the tests were unable to measure the mass emissions of $PM_{2.5}$, changes in the particle size distributions of the emulsified fuels indicated greater particle mass in the sizes less than 0.1 µm and less particle mass in the sizes greater than 0.3 µm compared to the non-emulsified #2 oil. The tests showed that the emulsified #2 oil did not exhibit a distinct minimum in the size distribution near 0.06 µm as does the non-emulsified #2 oil. The size distribution for the emulsified #2 oil showed a minor decrease near 0.06 µm and a second minor decrease near 0.7

μm, but was roughly flat for particle sizes greater than 0.04 μm. The emulsified naphtha showed a maximum near 0.05 μm and a minimum near 0.2 μm.

- CO emissions: Measurements of the CO emission concentrations resulting from the combustion of the A-55® Clean Fuels did not meet the data quality requirements established for precision, as measured by the variation in measurements during each test run. While the continuous CO monitor was found to be in calibration for all test runs, the measured levels of CO were at or near the instrument's quantitative detection limit. Due to the uncertainties in the quantitative measurements, comparisons between quantitative values may not be statistically significant. Nevertheless, the measured values are reported in the accompanying test report for completeness. For all cases, average CO emissions were less than 10 ppm at 3% O_2. Testing indicated additional optimization could result in even lower CO emissions.

- Thermal efficiency: Boiler thermal efficiency dropped by an average of 2.5 percentage points when using the A-55® emulsified #2 oil and by an average of 3.4 percentage points when using the A-55® emulsified naphtha, compared to the non-emulsified #2 oil. These decreases were almost entirely due to the additional water in the fuel.

- Applicability: The A-55® emulsified #2 oil and emulsified naphtha operated well in the test boiler. During initial use of the A-55® emulsified #2 oil, solid residues in the fuel lines from previous operations were entrained into the fuel, probably due to the solvent properties of the emulsifying agent. Following a flushing of the fuel lines over a period of 2-3 hours, no additional difficulties in operation were noted. The A-55® emulsified #2 oil and the emulsified naphtha maintained stability for the duration of the test program. No changes in burner nozzles or fuel feed equipment were necessary for use of the fuel, although greater volumetric fuel flows were required to maintain Btu input. Systems that operate near capacity with respect to volumetric fuel flow may require changes in fuel feed equipment to maintain constant energy feed into the boiler.

The A-55® Clean Fuels demonstrated reductions in NO for all test cases. While duplication of the quantitative results is unlikely at other facilities using different equipment and different operating conditions, the trends in emissions are expected to be similar to these tests. Both emission levels and thermal efficiency are likely to be improved by optimizing the system in which the A-55® Clean Fuels are used. The A-55® Clean Fuels can provide reduced emissions of NO without significant increases in CO, but with a potential increase in operating costs associated with reduced thermal efficiency. No evaluation of total costs associated with the use of A-55® Clean Fuels was conducted under this series of tests.

E. Timothy Oppelt — Date
Director
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NOTICE: EPA verifications are based on an evaluation of technology performance under specific, predetermined criteria and the appropriate quality assurance procedures. EPA makes no expressed or implied warranties as to the performance of the technology and does not certify that a technology will always, under circumstances other than those tested, operate at the levels verified. The end user is solely responsible for complying with any and all applicable Federal, State, and Local requirements.

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