© Copyright Statement

FPC-1 FURNACE EVALUATION

for

FURNACE EFFICIENCY
SLUDGE CONTROL
ACID CORROSION
VARIOUS CONCENTRATION LEVELS

Prepared by:

Eugene S. Adams, PE
Consultant

Prepared for:

UHI Corporation
Provo, UT

December 29, 1981

ABSTRACT

The operational costs of light commercial and residential oil heating systems have increased over 50% in the past two years, as a result of distillate fuel oil price increases. By utilizing FPC-3 combustion fuel catalyst in fuel oil, a net average savings of between 5-12% can be realized - using ASTM D-2156 and ASTM D-2157 testing procedures.

The average net savings is made up of a combustion efficiency increase of 1-4%, and a maintenance efficiency increase of 4-8%. The evaluation conducted in this report was primarily designed to determine the effects of FPC-3 when added to #2 heating oil, in a ratio of 1600 parts oil to 1 part FPC-3. However, studies also include effects of FPC-3 on sulfuric acid formation due to sulfur content in oil; different FPC-3 concentration levels; cleanability of heat exchanger and burner systems when using FPC-3; and finally, operational characteristics found in the typical on/off home heating systems.

This report will show conclusively that FPC-3 is found to be effective in improving the overall efficiency and maintenance of oil-fired light commercial and residential heating systems.

INTRODUCTION

The typical oil-fired heating system, due to the dramatic increases in fuel costs, is under severe attack because of its inability from age to achieve and maintain maximum efficiency. It is generally recommended that the best way to obtain maximum efficiency from an oil-fired heating system is to replace the burner with a more efficient style, or to completely scrap the existing unit in favor of natural gas units, heat pumps or electric heat. FPC-3 Combustion Fuel Catalyst, when added to the fuel oil, can improve and subsequently maintain high furnace efficiency. The use of FPC-3 can achieve an increase in fuel efficiency of the existing burner system without substantial cost for major overhauls or modifications.

State-of-the-art estimates are that the average system is only 66% efficient. Burner replacements can achieve an increase of overall efficiency upto 80%. The results of this test document that with the addition of FPC-3 to No. 2 fuel oil, furnaces ranging in ages upto 25 years old can achieve an efficiency of 75-77%, and that this efficiency can be easily maintained.

The testing program was originally designed to evaluate FPC-3 and its effect on residential and light commercial oil-fired furnace efficiencies and maintanence. However, this program was expanded to encompass the following:

- To determine the acid dewpoint and rate of acid buildup in light furnaces
- To evaluate under ASTM D-2156 and D-2157 test procedures the effect of FPC-3 relating to smoke, and using the ASTM test procedures relating to real-life adjustments
- To verify the effects of FPC-3 concentration ratios of 1600:1 and 800:1 and 400:1
- To verify the ability of FPC-3 to clean furnace heat exchanger surfaces over a given period of time
- To evaluate the effects of start-stop operation on furnace efficiency and maintenance, using FPC-3
- To evaluate the effects of FPC-3 on sludge formations existing in older burner assemblies
- To determine the operational changes of a furnace previously using FPC-3, followed by ending the treatment

METHODOLOGY

In testing for the effectiveness of **FPC-3** Combustion Fuel Catalyst in furnace operation, all procedures covered in ASTM D-2156 and D-2157 were followed. ASTM D-2156 is the standard test method for "Smoke Density in Flue Gases from Burning Distillate Fuels", and deals with performing a smoke spot test. ASTM D-2157 is the standard test method for the "Effect of Air Supply on Smoke Density in Flue Gases from Burning Distillate Fuels"; and in conjunction with D-2156 covers the evaluation of the performance of distillate fuels from the standpoint of clean, efficient burning. Copies of both these test methods are attached to this report.

Additional testing procedures used in this test are not covered by any ASTM methods, and these procedures relate to acid dewpoint and the rate of acid buildup within the furnaces. Although ASTM has no prescribed methods for determining these factors, the procedures are accepted by industry and ASME; and are as specified by Land Combustion, Inc. using their Dewpoint Meter Model 200 (which is one of the instruments used in this test).

Utilizing the above procedures as a standard format, various tests were conducted. These tests include the following:

- Changing **FPC-3** concentration ratios from 1600:1; 800:1; 400:1
- Visual and photographic documentation of furnace heat exchanger surfaces, before and after using **FPC-3**
- Visual and photographic documentation of burner assemblies, including nozzles and strainers, before and after using **FPC-3** with emphasis on sludge and carbon deposits
- Operating furnaces through a start-stop sequence; typical of home useage
- At the end of testing with **FPC-3** untreated fuel was used again to determine any deterioration in efficiency

With the furnaces running at normal burner output, the following data was recorded:

oil flow	ambient temperature, WB/DB
O_2	furnace outlet temperatures
CO_2	smoke numbers
combustibles	rate of acid buildup
stack temperatures	burner damper settings

Test equipment used consisted of:

Land Model 200 Acid Dewpoint Meter
Bacharach Continuous O_2 Analyzer; Model CA-1
Bacharach O_2-CO_2 Analyzer; Model 10-5020
Neutronics Continous O_2 Analyzer
IMC Instruments Model 6100 Digital Thermometer
Bacharach Smoke Spot Tester; Model RCC-3

METHODOLOGY con't:

Tests were conducted on the following furnaces:

Unit No	Manufacturer	Model #	Burner Manuf.	Model	Oil Consumed
1	Carrier	58FH-106	Carrier	38M-105K 401	.75 gph
2	Crane	OY 90E	Crane	MP-1192	.75 gph
3	American Furnace	19-OC	Amer. Furnace	FM 175-C	1.50 gph
4	Unknown	Unknown	Hallmark Oil Burner Baltimore, MD	Unknown	.85 gph

Fuel Specifications

Gulf No. 2 heating oil -- Gulf No. 2 diesel oil

Gravity: ^{o}API		34.2
Viscosity, SUV: S 100^{o}F		36.4
Viscosity, KIN: CST 100^{o}F		3.12
Flash ^{o}F		156
Cloud ^{o}F		+14
Pour ^{o}F		0
Color, D 1500		less than 1.0
Sulfur: % (.20% max)		0.15 to 0.18
Neutralization No., D974	Total acid no.	0.06
Cetane Index (43 min.)		45-47

Carbon	87.69%
H_2	12.01%
N_2	180 ppm
O_2	650 ppm
Btu gross	139,921
Btu/lb	19,352

RESULTS

FPC-3 Combustion Fuel Catalyst has shown itself to be effective in improving the combustion and maintenance efficiency on residential and light commercial heating systems. The table below shows various stages of furnace efficiencies as calculated from basic test data, and Fig. 1-10.

UNIT NUMBER	#1	#2	#3	#3A	#4
Eff. w/FPC-3 (Date)	75.2(11-25)	77.55(12-1)	74.9(12-3)	74.9(12-3)	75.3(12-1)
Eff. w/o FPC-3 (Date)	63.7(10-6)	75.20(10-22)	71.1(10-6)	67.5(11-4)	74.1(10-26)
Net Change	7.9	2.35	3.81	7.33	1.2
% Increase	12.4	3.1	5.1	10.8	1.6

Conditions Evaluated; Per Unit

#1 - Typical of current, popular design and manufacturer; by Carrier Corp., Model 58FH-106, rated at 100,000 BtuH input. Unit was run to evaluate a typical overall efficiency gain, based on the unit as received with ususal adjustments, and then readjusted with FPC-3 and allowed to run. Unit improvement in performance is related to the combination of combustion and maintenance efficiency.

#2 - Very old burner, but a current furnace. The manufacturer was Crane Corp.-Model OY90E; rated 100,000 BtuH input. This unit was run to evaluate 25+ year old systems. This unit was completely clean at the beginning of the test; therefore the efficiency increase is due only to combustion improvement

#3 - and #3A Light commercial-duty furnace, with an age of approximately 10 years. This type unit is still currently available, and is manufactured by American Furnace - Model 19-OC. Extensive testing for FPC-3 ability to clean up a dirty system was performed on this unit. The data above shows the efficiency gain from "as received" to "as cleaned", under #3. However, the unit was made dirty by smoking, as shown under #3A. Pictures demonstrate quick physical cleaning of sooty surfaces

#4 - This unit is 25+ years old, but has the original burner, which is currently available. The furnace manufacturer is unknown, but the burner is a Hallmark Oil Burner from Baltimore, MD. This unit showed the least improvement in combustion efficiency.

Another indication of improved combustion efficiency is related to combustibles remaining in the flue gas. Any amount of combustibles shows the presence of unburned fuel. Units 1, 2 and 3 all showed .1% combustibles, or 200 ppm, when not using FPC-3. Immediately upon starting FPC-3, the combustibles went to "0" zero, indicating better burning. The only time combustibles occurred with FPC-3 was with the dampers open 100% on the burner. This results from so much air being injected into the burner that the flame is almost blown out, and therefore causes incomplete combustion of the fuel.

RESULTS con't...

Acid Rate of Buildup and Dewpoint

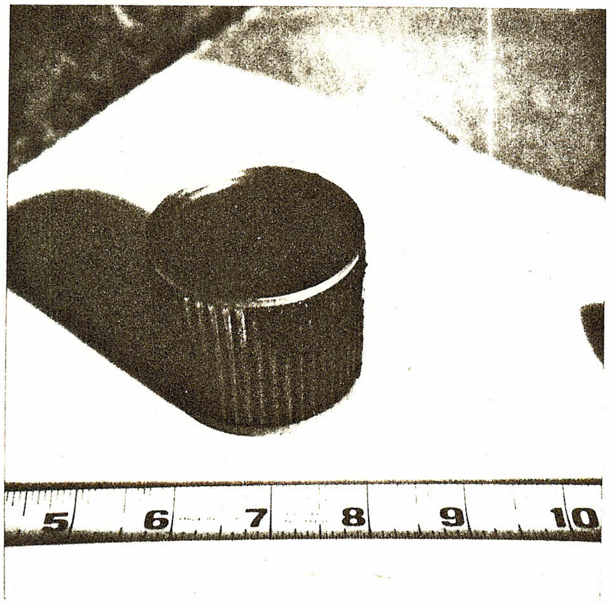
Utilizing the Land Dewpoint Meter, the acid dewpoint for the Gulf Oil Co. fuel used was 235^{o}F ±5^{o}F without FPC-3. Once FPC-3 was added, no dewpoint could be determined, which indicates no further acid corrosion problems on the heat exchanger surfaces, or the flue stack. This is proven by the rate of buildup (RBU) data shown below.

Flue Gas Temp	Unit #1 With FPC (micro amps/min)	Unit #1 Without (micro amps/min)	Unit #2 With FPC (micro amps/min)	Unit #2 Without (micro amps/min)	Unit #3 With FPC (micro amps/min)	Unit #3 Without (micro amps/min)
230^{o}F	-	0	0	0	0	0
220	-	1.6	-	-	0	1.9
210	-	4.4	-	-	-	1.8
200	0	4.5	0	.35	0	2.0
190	-	-	0	.50	0	-
180	-	4.1	0	.29	0	3.3
160	-	5.1	0	0	0	2.8

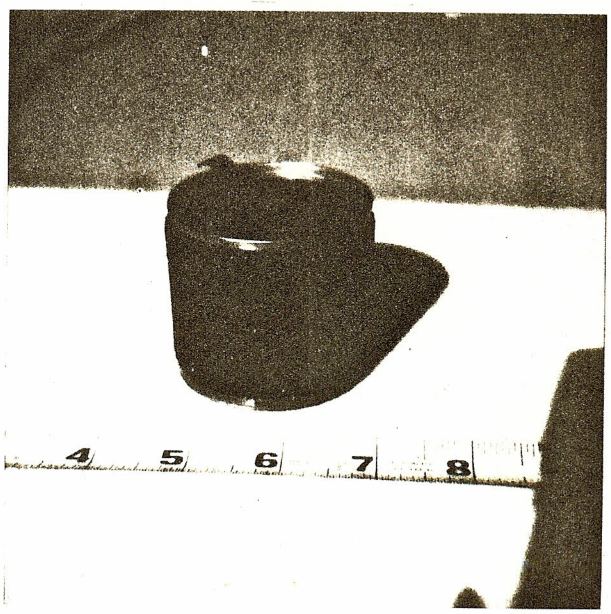
In all three furnaces used for the acid tests, the addition of FPC-3 reduced the acid potential to "0" zero; therefore eliminating any related acid problems. Acid corrosion is the major cause of heat exchanger failure in residential systems, and this feature of FPC-3 will extend the furnace life.

Sludge Formation

The use of FPC-3 will clean any existing sludge formations from the tank and burner system. The normal sludge consists of trash, such as sand and dirt suspended in fuel oil residue, which is a thick wax or parafin substance. Most fuel filters remove the sand and dirt, but the residue continues into the system and can eventually plug burner stainers and nozzles. The photos below show with and without FPC-3 and where the use of FPC-3 physically dissolved the residue, thereby cleaning the assembly.



WITH FPC-



WITHOUT FPC-

RESULTS con't...

Cold Start

Since normal furnace operation is not continuous, cold-start testing was evaluated on all units. A graph of Unit #3 (Fig. 8), which is typical, shows no change in smoke number due to cold start. The only changes are in efficiency, O_2 and flue stack temperature, which were to be expected. All cold-start testing was with FPC-3 only, and since smoke numbers did not change at any time, it was concluded that a test without FPC-3 would give the same results, except with higher smoke numbers.

Concentration Level Variances of FPC-3

In Fig. 9, a short test was run to evaluate various concentration levels of FPC-3. The standard level of 1600:1 was compared to 800:1, and 400:1. The net result was no change that would justify changing from 1600:1. A review of the Basic Test Data Page 7, and Fig. 9 appear to show a loss of efficiency. This was due to the higher than normal smoke number setting of 6.5 to 7.5, causing the furnace to get dirty, and therefore reducing the efficiency. In addition, the smoke test is only accurate to half a smoke, and no change could be noted.

Stopping FPC-3 Useage

Unit #3 was evaluated in the event that a customer using FPC-3 stopped treating his system. The effect was apparent within 1½ hours. The rate of acid buildup (RBU) had gone from "0" zero to .5 micro amps/min. at 200°F. In addition, the smoke number had changed so that if the unit had been adjusted to a No. 2 with FPC-3, it would need re-adjusting, as without FPC-3 the same burner setting would be a smoke No. 3 or 3.5, as indicated by the data below.

O_2% With FPC/Without	Smoke No. With FPC-3	Smoke No. Without FPC-3
12.4/12.3	0	0
11.1/11.4	0	0.5
9.3/9.2	1.0	2.0
8.6*/9.1	2.0*	2.5
7.9/8.2*	3.0	4.5*

* Indicates same percent O_2; but different smoke number

If the system were allowed to run for an extended period of time without FPC-3 the unit would become dirty and loose efficiency rapidly and possibly need cleaning twice a year.

CONCLUSIONS

1. An overall furnace efficiency of 5-12% is possible when using FPC-3.

2. At Smoke No. 2 operating conditions, as recommended by ASTM, the use of FPC-3 will completely clean the heat exchanger surface of carbon soot. Without FPC-3 carbon will form and reduce the efficiency so that cleanings of once-a-year minimum would be required (Refer to Photos #1, 2, 3, 4)

3. The use of FPC-3 removed all sludge from the burner strainers

4. Although the rate of acid buildup was already low, due to the low-sulfur fuel, the use of FPC-3 reduced this rate of acid buildup to "0"

5. When using FPC-3 three units operating at No. 2 smoke had combustibles of "0"; without FPC-3 these units' combustibles read .1%, or 200 ppm