Fitch Fuel Catalyst Combustion Performance Research Report

Prepared for INNOVATION East/CTNext

Jagadeswara Kona and Steven L. Suib

University of Connecticut, Department of Chemistry

July 18, 2013

This report was funded by the State of Connecticut through the CTNext Voucher Program.

EXECUTIVE SUMMARY

A research team from the School of Chemistry at the University of Connecticut has analyzed the Fitch Fuel Catalyst in live field installations and, in conjunction with prior research on the technology, confirmed:

- That a molecular reformulation of the fuel does take place when passing through the Fitch Fuel Catalyst;
- That this reformulation positively affects the combustion within the furnace, enabling a reduction in nozzle size of the furnace;
- That the average user in observed and historical instances[1] reveals 6.7% to 36.4% reductions, with an average of 18.8% across all installations; and,
- That residential installations tended to yield greater reductions, averaging 20.3%, versus commercial installations, which averaged 14.0%.

Based on these findings, it was recommended that a full-scale pilot across several hundred homes be pursued in order to better quantify average savings across a larger sample of installations.

Details of the research follow in the text of the report and in its appendices.

Overview

The Fitch Fuel Catalyst for heating oil furnace applications is a non-mechanical device which is installed in-line of the fuel line, between the heating oil filter/tank and the burner. The device constructively reformulates hydrocarbon fuels passing through the catalyst – through modification of molecular sequence and structure – at low temperatures and low pressure. Details of the Fitch Fuel Catalyst are contained in Appendix A.

The Suib Research Group at the University of Connecticut (UCONN) Department of Chemistry has previously reviewed certain aspects of the Fitch Fuel Catalyst product, including the general concept and chemical principles.[2] Our latest charge was to evaluate the performance of the Fitch Fuel Catalyst in combustion experiments, with a particular focus on the performance of the Fitch Fuel Catalyst in the home and commercial heating oil furnace application. In short, the goal of this research was to confirm whether the Fitch Fuel Catalyst product does indeed enhance the efficiency and combustion of heating oil, and to define a range of performance if it does.

---

[1] Historical measurement data gathered by the installing technicians from prior installs, as provided by the company

[2] (a) Hu, B.; Yuan, J.; Kona, J.; Suib, S. L., prior results; (b) Ghosh, R.; Koerting, C.; Suib, S. L.; Best, M. Berlin, A., The effect of a metal alloy fuel catalyst on bacterial Growth, *Langmuir*, 2005, *21*, 10655-10661.

Towards this end, the UCONN team – lead by Dr. Steven L. Suib, UCONN Board of Trustees Distinguished Professor and head of the Suib Research Group, with support from researcher Jagadeswara Kona – undertook a number of activities, including:

1) Review of procedures and policies regarding the installation and maintenance of the Fitch Fuel Catalyst;
2) Review of installation and historical performance metric data collected from a number of Fitch Fuel Catalyst implementations currently in use;
3) Observation of live installations of the Fitch Fuel Catalyst and measurements of efficiency and fuel consumption at several different site profiles; and,
4) Interviews with customers who have installed and currently use the Fitch Fuel Catalyst product in their operations.

The research was initiated and completed in the June-July 2013 time period, and was based in/near Storrs, CT.

Our team found that the installation of the Fitch Fuel Catalyst reformulates the heating oil before it enters the burner, enabling it to burn more effectively in the burner. This more efficient combustion causes an increase in stack temperature in the furnace. Since this excess stack temperature is not needed, in order to reduce the stack temperature back down to its most efficient level, a smaller nozzle may be installed to match or exceed the original baseline efficiency. This smaller nozzle allows less fuel to be combusted and results in definitive, measurable savings in oil consumption.

Our analysis concludes that this increase in efficiency and decrease in fuel consumption is the only important measure of the efficacy of the Fitch fuel Catalyst. Such a decrease in fuel combustion will clearly create economic savings. It is important to note that additional fuel savings are likely due to the effect of the Fitch Fuel Catalyst on the fuel itself, but we are unable to fully predict or document this impact due to variability in fuel oil and combustion environments. Further research would be required to quantify these additional savings.

Below we summarize all of these studies and conclude in a separate section. Supporting data and documentation are included as Appendices to this report, as well as background on the team members supporting this study.

Relation of Use of Fitch Fuel Catalyst to Chemistry Occurring in the Fuel

In previous separate experiments,[3] it has been shown by the Suib Research Group that the Fitch Fuel Catalyst causes changes in fuel composition at the molecular level.

The inside of a Fitch Fuel Catalyst consists of a patented mixture of metallic alloys that, when exposed to fuels, causes a temporary catalytic conversion that can last for several days, depending on a number of

---

[3] The Suib Research Group at the University of Connecticut School of Chemistry has been evaluating this technology since 1999, with the support, in some instances, of the U.S. Department of Energy (DoE) and the U.S. Department of Defense (DoD).

environmental variables. Specifically, the Fitch Fuel Catalyst can extract hydrogen atoms from different fuel components, thereby changing the composition of the fuel. Oxygen is present when the catalyst is exposed to the fuel and oxygenated compounds that can burn more efficiently are produced. This may explain the enhanced combustion observed in the installations discussed above; further research is required to pinpoint a definitive explanation of the exact chemical conversion taking place.[4]

To be clear, prior research has confirmed that a chemical change does take place when fuel comes in contact with the Fitch Fuel Catalyst, and this effect is deemed to be beneficial to the combustion process.

This research was performed in August 2012 at the University of Connecticut Chemistry facilities in Storrs, CT. The research was lead by Dr. Suib as well. Summary of this research is shown in Appendix B.

Review of Fitch Fuel Catalyst Installation and Measurement Procedures

Key to validating the Fitch Fuel Catalyst performance was to validate the installation and measurement process that establishes the baseline and installed unit performance metrics that ultimately drive the performance claims of the product.

The research team was provided with a step-by-step installation process, documented in Appendix C, which was reviewed and studied by the research team. This process involved a series of measurements of key operational variables of the typical heating oil furnace environment. All measurements for the observed Fitch Fuel Catalyst installation process were completed using a C-127 Certified Digital Combustion Analyzer, manufactured by UEI Test Instruments.[5] This unit measures differential flue temperature, oxygen levels, flue and ambient carbon monoxide (CO), and differential pressure; it also calculates carbon dioxide levels, efficiency, excess air, and CO air free. These measurements are appropriate and sufficient to gauge performance of combustion related to the Fitch Fuel Catalyst. Information about the UEI C-127 unit is found in Appendix D.

The installation and maintenance of an oil-burning furnace is governed by standardized policies and procedures as adopted to support ASHRAE Standard 103.[6] Most HVAC[7] system installers in the U.S. are trained in these procedures as their baseline for their work on heating oil furnaces.

In general, the following process is used for installation of the Fitch Fuel Catalyst in a heating oil furnace application:

---

[4] There are many variables in the combustion process that can affect combustion, and an extensive research effort would be required to identify and model these. Heating oil fuel in particular encounters many different exposures to bacteria, temperature, changing storage environments, etc. on the way to customers, and as a result, fuel can vary substantially as an input to this process. What is clear from this analysis is that while there are many variables in this equation, the overall system has been confirmed as effective, per this study.

[5] http://www.ueitest.com/products/combustion/c127

[6] ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers). For info on AFUE, see http://en.wikipedia.org/wiki/Annual_fuel_utilization_efficiency

[7] Heating, ventilation, and air conditioning

1. Take baseline measurement
2. Clean, tune, and optimize the burner
3. Take new baseline measurement quantifying results of clean and tune (with focus on lower stack temperature)
4. Install the catalyst and re-optimize the burner
5. Take new measurement to determine benefit in key operational variables – calculate resultant new nozzle size if supported
6. Install the reduced-size nozzle
7. Take final confirmational measurement

Thus, four measurements are made with the C-127 unit, while the heating unit is operational and burning fuel for heat to the system:

1. Before doing anything
2. After cleaning, tuning and optimizing the burner
3. After installing the Fitch Fuel Catalyst
4. After installing the reduced-sized nozzle

The goal of the completed installation process is to have maximized efficiency with as close to zero smoke as possible.

In reviewing the installation and measurement process, our analysis concludes that the process for measuring the key attributes and performance characteristics are in line with ASHRAE standards, and appropriate for this application. Further, the combustion analyzer equipment used as part of the Fitch Fuel Catalyst standard process is likewise appropriate. Finally, the key measurement variables tracked by the installer and used to calculate the reduced nozzle size is also confirmed as appropriate.

The research team concludes that any future installation process that follows the same procedure as reviewed and documented as part of this study should result in similar results to those referenced in this study.

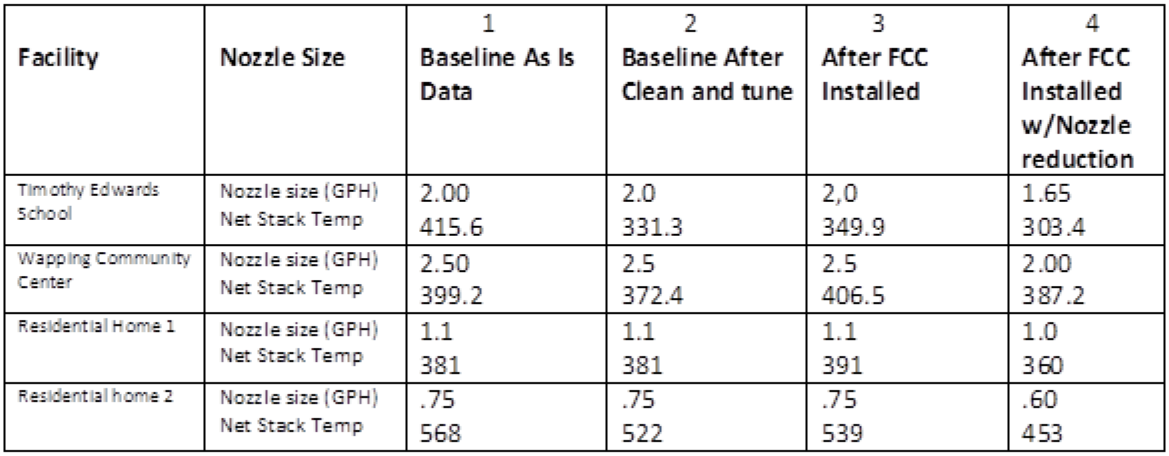
A detailed summary of the installation process is shown in Appendix C.

Observation of Installation of Fitch Fuel Catalyst and Efficiency and Fuel Consumption Studies

In order to evaluate the performance of the Fitch Fuel Catalyst in combustion experiments, members of the research team visited and observed live installation of the Fitch Fuel Catalyst in four different facilities. The end-to-end installation (and measurement) process was observed and compared to the documented installation process. These installations were in residential and commercial facilities. Residential facilities are defined as the GPH < 5.0. Commercial facilities are defined as GPH 10.0 and above.

In all four of these different facilities, the fuel consumption was measured and observed to decrease when the Fitch fuel Catalyst was used. The % decrease in these four Facilities was between 9.1% and 20%. We observed no smoke in all four of the installations, suggesting that soot was not formed when the catalyst was used. Key indicators are summarized in Table 1.

Table 1: Summary of key indicators for observed installations



Facility	Nozzle Size	1 Baseline As Is Data	2 Baseline After Clean and tune	3 After FCC Installed	4 After FCC Installed w/Nozzle reduction
Timothy Edwards School	Nozzle size (GPH) Net Stack Temp	2.00 415.6	2.0 331.3	2,0 349.9	1.65 303.4
Wapping Community Center	Nozzle size (GPH) Net Stack Temp	2.50 399.2	2.5 372.4	2.5 406.5	2.00 387.2
Residential Home 1	Nozzle size (GPH) Net Stack Temp	1.1 381	1.1 381	1.1 391	1.0 360
Residential home 2	Nozzle size (GPH) Net Stack Temp	.75 568	.75 522	.75 539	.60 453

The research team concluded from these observations that the installation and measurement process was sound, and that the resulting efficiency and fuel consumption gains were within the expected range, based on research of prior historical data.

Detailed measurements regarding the new installations are included in Appendix E.

Interviews with Customers Who Use the Fitch Fuel Catalyst

Observations from the on-site installs and background research by the team were confirmed with interviews of current Fitch Fuel Catalyst customers. Ten customers and installation engineers were called that presently have the Fitch Fuel Catalyst operational on one or more burners. Every person praised the device and all mentioned significant fuel savings after installing and using the Fitch Fuel Catalyst. One engineer said he did 200 installations and there have been no negative comments and excellent evaluations regarding fuel savings.

These interviews were complemented by "deep dives" into multi-year data provided by some customer maintenance staff for several current commercial customers of the Fitch Fuel Catalyst. Members of the research team spoke with engineers who maintain large numbers of boilers for property management companies, and reviewed their data over multiple years tracking the performance of the boilers when outfitted with Fitch Fuel Catalyst units.[8]

---

[8] Note that commercial Fitch Fuel Catalyst units can vary substantially in size and can grow to full-sized floor-standing units for extremely large implementations, including aboard cruise liners and freight ships.

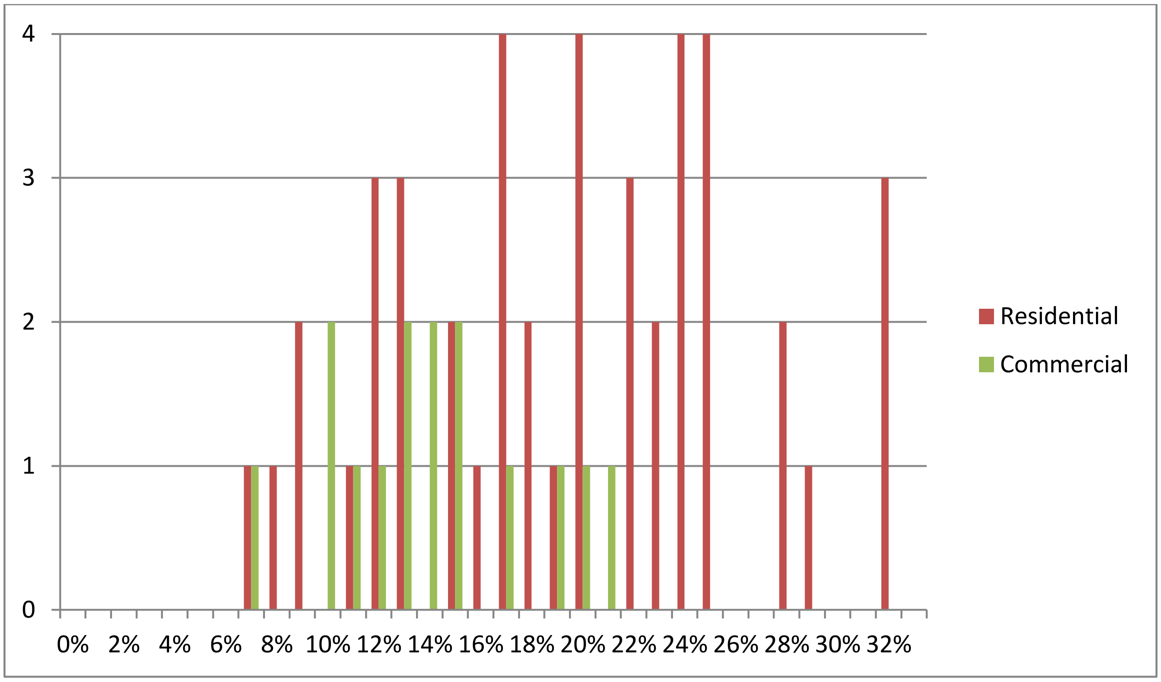
The research team noted that perhaps the biggest indirect indicator of fuel combustion savings from installation of the Fitch Fuel Catalyst is that all of the customers interviewed who are in a position to order successive units for other installations continue to purchase and use the Fitch Fuel Catalyst units.

Review of Historical Sample Data of the Fitch Fuel Catalyst

The installations observed by the research team all showed significant decrease in fuel consumption between 7.7% and 20%; note that we have only observed four installations.

To complement this on-site live research, the team evaluated a sample of historical installation data from Fitch's databases. Installation data sheets from a 62-record sample of different residential and commercial users of the Fitch Fuel Catalyst document decreases in fuel consumption ranging from 6.7% to 36.4%. A histogram of the distribution of the decrease in fuel consumption is given in Figure 1.[9]

Figure 1: Number of Instances in Sample Showing % Decrease in Fuel Consumption



The average decrease in fuel consumption for the 62 installations is 18.8%. These data clearly show a percentage decrease in fuel consumption when the Fitch Fuel Catalyst is used. When the data are broken out by residential versus commercial installations, there is a decided shift in the average, with commercial averaging 14.0% and residential 20.3% in gains.

Conclusions

The analyses by the University of Connecticut-based Suib Research Group suggest that the Fitch Fuel Catalyst, when installed in heating oil boilers, shows a measurable decrease in fuel consumption. Proper

---

[9] Data were rounded up from .5 and down from .4 to the next nearest whole value.

procedures need to be followed, such as cleaning the burner prior to installation of the catalyst; tuning the boiler to optimal efficiency is also necessary to achieve maximum impact. Further evaluation of the installation of the Fitch fuel Catalyst across a much broader base of data are warranted based on our observations to offer a complete view of the range of performance of the product.

Appendix A: The Fitch Fuel Catalyst Product Description

ADVANCED POWER SYSTEMS INTERNATIONAL, INC.

Toll Free-- 888-881-2774 or Ph. 860-496-7776 Fax. 860-496-7626

339 Main St Torrington, CT. 06790

www.fitchcatalyst.com

Fitch Fuel Catalyst

A Fuel Efficiency Technology for

Stationary Heating Oil Boilers and Furnaces

and

Stationary and Mobile

Diesel and Gasoline Engines

Product Profile

By Advanced Power Systems International, Inc.

Product Introduction

Advanced Power Systems International, Inc. (“APSI”) is a New England (Connecticut) based company has developed a novel catalyst technology that induces constructive changes in the sequence and structure of molecular bonds in hydrocarbon fuels. These changes allow a fuel to provide better combustion efficiency. The technology has been introduced into the market as permanent, maintenance free catalyst that reformulates fuel oil into a superior burning product at the point of use resulting in a net improvement to a building AFUE (annual fuel utilization efficiency). This pre-combustion, non-additive, fuel reforming fuel catalyst is commercially sold under the trade name “Fitch Fuel Catalyst” and is easily installed in existing buildings. (See installation photos).

The company has successfully introduced the product to the New York City Government and private sector owner and management community and achieved an impressive and consistent level of sales and acceptance among energy professionals.

The Fitch Fuel Catalyst is being retrofitted into the boiler rooms of energy conscious and forward thinking property owners. These installations are helping reduce the approximately 1 billion gallons of the fuel oil consumed annually to provide heat and hot water in New York City buildings. The financial rewards to property owners are substantial as the financial payback from an installation is no more than two and often less than one heating season.

As building owners contemplate the requirements of PLANYC2030 and the transition from #6, to #4 fuel oil and the option to utilize #2 fuel oil or natural gas with fuel oil as standby fuel, the Fitch Fuel Catalyst has a place in all these configurations, as it pays economic and environmental dividends immediately and insures future sustainable efficiency.

When employed broadly in the predominately oil heated New York New England area, the product has the potential to make a significant impact on regional fuel use and air quality.

The City of New York, property owners, and managers have investigated techniques of minimizing energy consumption, operating and maintenance costs, and the attendant carbon footprint from operating their heating and cooling facilities. The Fitch Fuel Catalyst is proving to be a viable and cost efficient solution, and many are adopting the Fitch Catalyst as first measure to insure their buildings are getting the most energy out of every gallon of fuel oil now and well into the future.

Fitch
FUEL CATALYST

Heating Oil Fuel Reformer

Find Out How You Can Save Money by:

- **Reducing Fuel Oil Consumption 5 – 15%**
- **Reducing Smoke & Soot**
- **Improving Combustion Efficiency**
- **Reducing Boiler Cleaning & Maintenance**
- **Preserving Quality of Back Up Fuel Oil**

**A Permanent Fuel Oil Reformer
For Commercial & Residential Heating
Systems That Use #2, #4 #6 Fuel Oil**

**Used by:
NYC Buildings, CO-OPS, Condos &
Building Owners throughout New York City**

References upon request

Typical Commercial Boiler Installation

BBB. ONLINE ACCREDITED BUSINESS

UL LISTED 37YC

OTCR Office of Technical Certification and Research

Before Fitch

After Fitch

MADE IN U.S.A.

Distributed by:

Fitch Fuel Catalyst

Location: 3 Sadore Lane, Yonkers NY. 10710 **Boiler:** Federal FST 250 **Oil type:** #6

	Combustion measurements	Base data Nov. 4th	1/22/10 Retest	% Change
	Efficiency %	80.5	88.5	**+9.88%**
Heating Season	Smoke	1	0	**-100.00%**
2008/2009 Heating season vs. 2009/2010 Heating season	Fuel use Gal/Degree Day	31.16	29.12	**-6.5%**
Estimated gallons saved for this period				**7,074**

Location: 1115 5th Ave, NY **Boiler: 2 x** Best 150 **Oil type:** #4

	Combustion & emissions measurements	**Baseline data 11/3/2010**	**Retest 2/16/11**	**% Change**
Boiler #1	Efficiency %	85.7%	87.8%	**2.5%**
	Smoke	1	0	**-100.0%**
Boiler #2	Efficiency %	86.2%	88.1%	**2.2%**
	Smoke	1	0	**-100.0%**
10/13/09 to 3/31/10 vs. 11/8/10 to 12/19/11	Avg. Gal/ Degree day	13.70	12.34	**-9.93%**
Estimated gallons saved for this period				**7,748**

Location: 1150 Park Ave, NY **Boiler type:** 2 x Nat OB793 **Oil type:** #6

	Combustion & emissions measurements	**Baseline data 3/5/10**	**Retest 2/23/11**	**% Change**
Boiler #1	Efficiency %	82.1%	83.7%	**1.9%**
	Smoke	1	0	**-100.0%**
Boiler #2	Efficiency %	85.0%	86.9%	**2.2%**
	Smoke	1	0	**-100.0%**
11/19/09 to 4/17/10 vs. 11/22/10 to 2/17/12	Avg. Gal/ Degree day	14.44	12.51	**-13.4%**
Estimated gallons saved for this period				**12,291**

Location: 760 Grand Concourse, Bronx, NY **Boiler Type:** FST200 **Oil type:** #6

	Combustion measurements	**Base data Nov. 4th**	**1/22/10 Retest**	**% Change**
	Efficiency %	82.1	85.5	**+4.10 %**
Heating Season	Smoke	2.5	0	**-100.00%**
2008/2009 Heating season vs. 2009/2010 Heating season	Fuel use Gal/Degree Day	10.11	7.95	**-21.4%**
Estimated gallons saved for this period				**4,898**

Manufactured by: Advanced Power Systems Inc – 339 Main Street – Torrington, CT 06790
Toll free: 888-881-2774 - Direct: 860-496-7776 - Info: info@fitchfuelcatalyst.com

Appendix B: Suib Research Group Analysis of Molecular Reformulation Caused by Fitch Fuel Catalyst

The following report was generated independently by researchers in the Suib group based on a variety of spectroscopic and microscopic experiments.

University of Connecticut Center for Clean Energy Engineering

---

INVESTIGATION OF EXISTING & DEVELOPMENT OF NEXT GENERATION FUEL REFORMING CATALYSTS FOR EFFICIENT ENERGY USAGE

SUMMARY OF WORK

AUGUST 2012

Hui Huang, **Steven L. Suib**,

[a] UCONN Dept of Chemistry 55 N. Eagleville Rd. Storrs, CT 06268

[b] APSI 339 Main Street, Torrington, CT 06790

C2E2 – DOE Conference

Executive Summary – Abstract – August 2012

FUEL REFORMING CATALYSTS FOR EFFICIENT ENERGY USAGE

ENHANCEMENT OF COMBUSTION THROUGH SELECTIVE CATALYSIS OF GASOLINE AND DIESEL FUELS

Upgrading of commercial gasoline and diesel fuel will further enhance US energy resources.

Catalysis through chemistry has been greatly involved in improved environmental protection and economic growth. Greater than 90% of today’s chemical processes have catalytic steps.

We have completed a series of experiments studying and measuring the ability of a novel catalyst to constructively modify commercial gasoline and diesel fuel. This catalyst has the ability to selectively remove hydrogen and or add oxygen to hydrocarbon components of fuel. The catalyst demonstrated the ability to produce reformed fuel species at room temperature which is novel and provides evidence these catalysts are broadly applicable in fuel applications.

The ability to selectively remove a few hydrogen atoms from specific sites is a key to the enhancement of fuel. Removing and redistributing hydrogen atoms from components of gasoline to produce olefins that can couple to form larger hydrocarbons has been measured. The ability of the same catalysts to introduce oxygen to hydrocarbons to form oxygenates has also been measured.

The combination of these two different reactions result in

- aromatic ring decomposition,
- coupling
- olefin formation, and
- oxygenation

simultaneously which is unique as regards chemical activity, constructive, and leads to enhanced combustion from the hydrocarbon fuel feedstock.

Data from our most recent experiments with small molecules that are model components of fuel have shown that chemical changes occur that involve the production of new types of bonds. These types of reactions have been demonstrated with some of the model fuel components of gasoline, heating fuel oil, and diesel fuel.

Data from combustion experiments demonstrated enhanced useful energy yield per unit of fuel.

Appendix C: Step-by-Step Installation Process

ADVANCED POWER SYSTEMS INTERNATIONAL, INC.

Toll Free-- 888-881-2774 or Ph. 860-496-7776 Fax. 860-496-7626

339 Main Street, Torrington CT. 06790

www.fitchfuelcatalyst.com

Fitch Fuel Catalyst Installation and Adjustment Instructions for Residential Burners

A licensed Mechanic or Boiler Technician must perform the installation of the Fitch Fuel Catalyst.

Before commencing installation ensure there are no open flames. Consult the burner manufactures guidelines for correct burner settings and procedures for relief of fuel system pressure prior to installation of the Fitch Fuel Catalyst product.

Before installing the Fitch Fuel Catalyst the Furnace / Boiler burner must be cleaned and in good electrical and mechanical condition. The Fitch Fuel Catalyst will not compensate for mechanical or electrical deficiencies. It is possible that higher fuel consumption and emission readings may be recorded immediately following installation, which is corrected through adjustment.

Installations – Take all necessary precautions relative to installing on an oil fired system. Locate a suitable location in the fuel line supply line at or near the burner.

NOTE: all units MUST be installed after the filter, vertically with the fuel flowing into the bottom and out the top of the unit. ***The direction arrow must be pointing UP.***

1. Clean the boiler or furnace first.
2. Establish Baseline. Measure the exhaust gas composition and ensure the system is functioning to the burner manufacturer's recommendation before installing or engaging fuel flow through the Fitch Fuel Catalyst.
3. Install the Fitch Fuel Catalyst at the selected location in compliance with building / piping codes. If a filter is not in place it is required one is installed before the Fitch Fuel Catalyst.
4. Once installed check for leaks and let the burner run at 100% for approx. 15 minutes and take new exhaust gas measurement per (1).

Typical Observations

i) Excess air may increase
ii) Stack temperature may increase
iii) CO and CO2 both change.
iv) Flame color change.

5. Make the necessary adjustments to bring the burner to manufacturer's recommendation.

Typical Adjustments

i) Reduce nozzle size or fuel pump pressure to reduce stack temp
ii) Reduction of air flow to reduce excess air.
iii) Adjust for optimal stack temp, minimal soot, minimal CO.

Appendix D: UEI C127 Combustion Analyzer

From http://www.ueitest.com/products/combustion/C127

EAGLE 3
COMBUSTION ANALYZER
C127

Featuring The New
WORKLIGHT

C127KIT - Combustion Analyzer Kit:

The C127KIT offers the same benefits of the Eagle 2 (C125KIT) with the additional ability to measure Nitric Oxide. This allows technicians to work in commercial and light industrial applications measuring Nitric Oxide at 1ppm resolution. The C127KIT offers a complete system analysis solution with clear-cut navigation.

Same features as the EAGLE 2 (C125) Plus:
- Measures: Nitric Oxide (NOx)

Also Available..

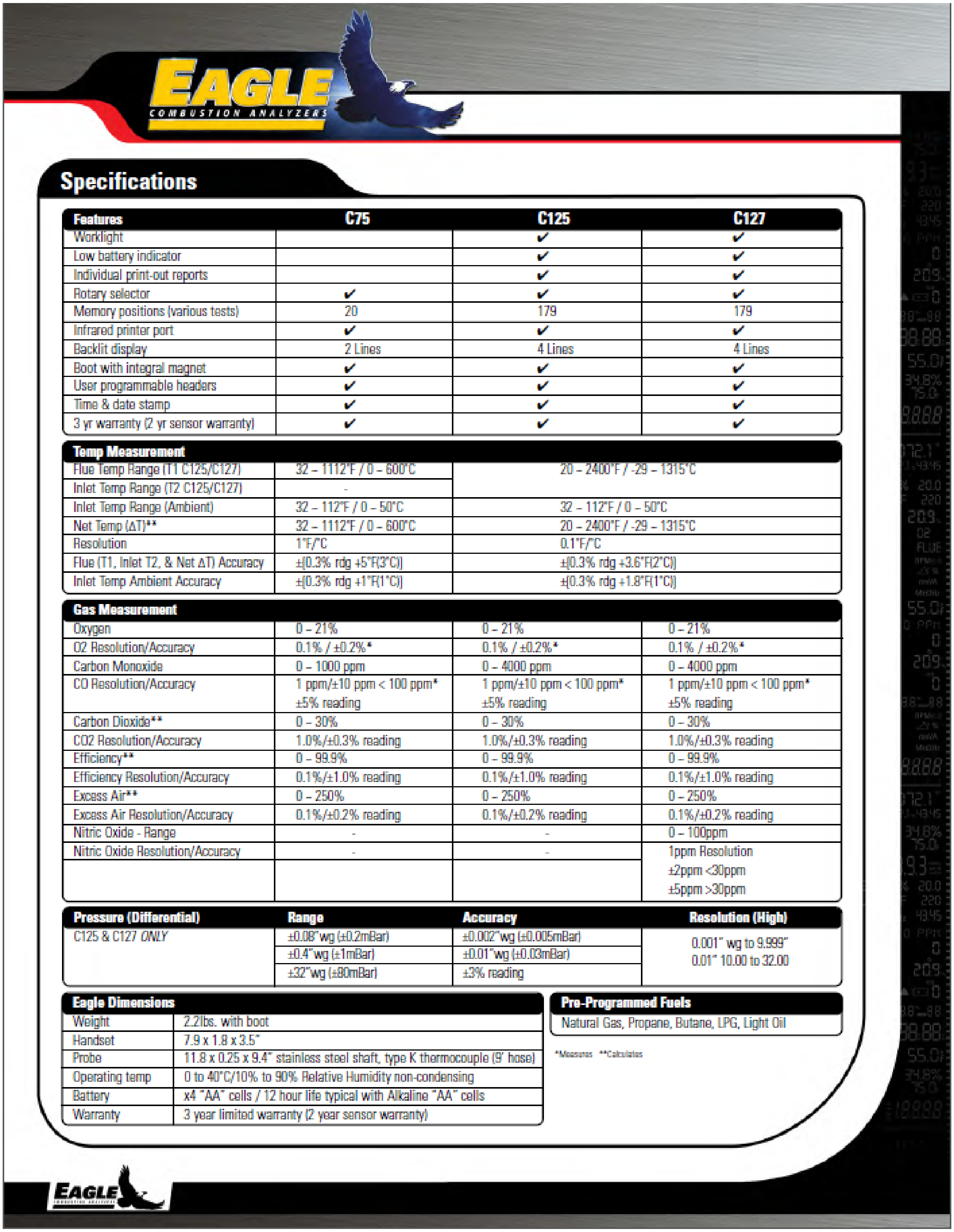
C127 Analyzer

Includes: C127 Analyzer, Flue Probe, Particle Filter, AC75 Soft Carrying Case,Quick Start Manual, and Owners Guide.

C127OILKIT

Includes: C127 Analyzer, KMIRP2 Printer, Flue Probe, Smoke Pump Test Kit, (2) K-Type Temp. Probes, AC Adapter, AC75 Soft Carrying Case, Particle filter, Thermal printer paper roll, Quick Start Manual, & Owners Guide.

Kit Includes:
- ***Eagle 3*** (C127) Combustion Analyzer
- KMIRP2 Infrared Thermal Printer
- Flue Probe
- (1) K-Type Temperature Probe
- AACA4 AC adapter
- AC75 soft carrying case w/protective foam interior
- Particle filter
- Thermal printer paper roll
- Quick start manual
- Owners guide



Specifications

Features	C75	C125	C127
Worklight		✔	✔
Low battery indicator		✔	✔
Individual print-out reports		✔	✔
Rotary selector	✔	✔	✔
Memory positions (various tests)	20	179	179
Infrared printer port	✔	✔	✔
Backlit display	2 Lines	4 Lines	4 Lines
Boot with integral magnet	✔	✔	✔
User programmable headers	✔	✔	✔
Time & date stamp	✔	✔	✔
3 yr warranty (2 yr sensor warranty)	✔	✔	✔

Temp Measurement		
Flue Temp Range (T1 C125/C127)	32 – 1112°F / 0 – 600°C	20 – 2400°F / -29 – 1315°C
Inlet Temp Range (T2 C125/C127)	-	
Inlet Temp Range (Ambient)	32 – 112°F / 0 – 50°C	32 – 112°F / 0 – 50°C
Net Temp (ΔT)**	32 – 1112°F / 0 – 600°C	20 – 2400°F / -29 – 1315°C
Resolution	1°F/°C	0.1°F/°C
Flue (T1, Inlet T2, & Net ΔT) Accuracy	±(0.3% rdg +5°F(3°C))	±(0.3% rdg +3.6°F(2°C))
Inlet Temp Ambient Accuracy	±(0.3% rdg +1°F(1°C))	±(0.3% rdg +1.8°F(1°C))

Gas Measurement			
Oxygen	0 – 21%	0 – 21%	0 – 21%
O2 Resolution/Accuracy	0.1% / ±0.2%*	0.1% / ±0.2%*	0.1% / ±0.2%*
Carbon Monoxide	0 – 1000 ppm	0 – 4000 ppm	0 – 4000 ppm
CO Resolution/Accuracy	1 ppm/±10 ppm < 100 ppm* ±5% reading	1 ppm/±10 ppm < 100 ppm* ±5% reading	1 ppm/±10 ppm < 100 ppm* ±5% reading
Carbon Dioxide**	0 – 30%	0 – 30%	0 – 30%
CO2 Resolution/Accuracy	1.0%/±0.3% reading	1.0%/±0.3% reading	1.0%/±0.3% reading
Efficiency**	0 – 99.9%	0 – 99.9%	0 – 99.9%
Efficiency Resolution/Accuracy	0.1%/±1.0% reading	0.1%/±1.0% reading	0.1%/±1.0% reading
Excess Air**	0 – 250%	0 – 250%	0 – 250%
Excess Air Resolution/Accuracy	0.1%/±0.2% reading	0.1%/±0.2% reading	0.1%/±0.2% reading
Nitric Oxide - Range	-	-	0 – 100ppm
Nitric Oxide Resolution/Accuracy	-	-	1ppm Resolution ±2ppm <30ppm ±5ppm >30ppm

Pressure (Differential)	Range	Accuracy	Resolution (High)
C125 & C127 *ONLY*	±0.08"wg (±0.2mBar)	±0.002"wg (±0.005mBar)	0.001" wg to 9.999" 0.01" 10.00 to 32.00
	±0.4"wg (±1mBar)	±0.01"wg (±0.03mBar)	
	±32"wg (±80mBar)	±3% reading	

Eagle Dimensions	
Weight	2.2lbs. with boot
Handset	7.9 x 1.8 x 3.5"
Probe	11.8 x 0.25 x 9.4" stainless steel shaft, type K thermocouple (9' hose)
Operating temp	0 to 40°C/10% to 90% Relative Humidity non-condensing
Battery	x4 "AA" cells / 12 hour life typical with Alkaline "AA" cells
Warranty	3 year limited warranty (2 year sensor warranty)

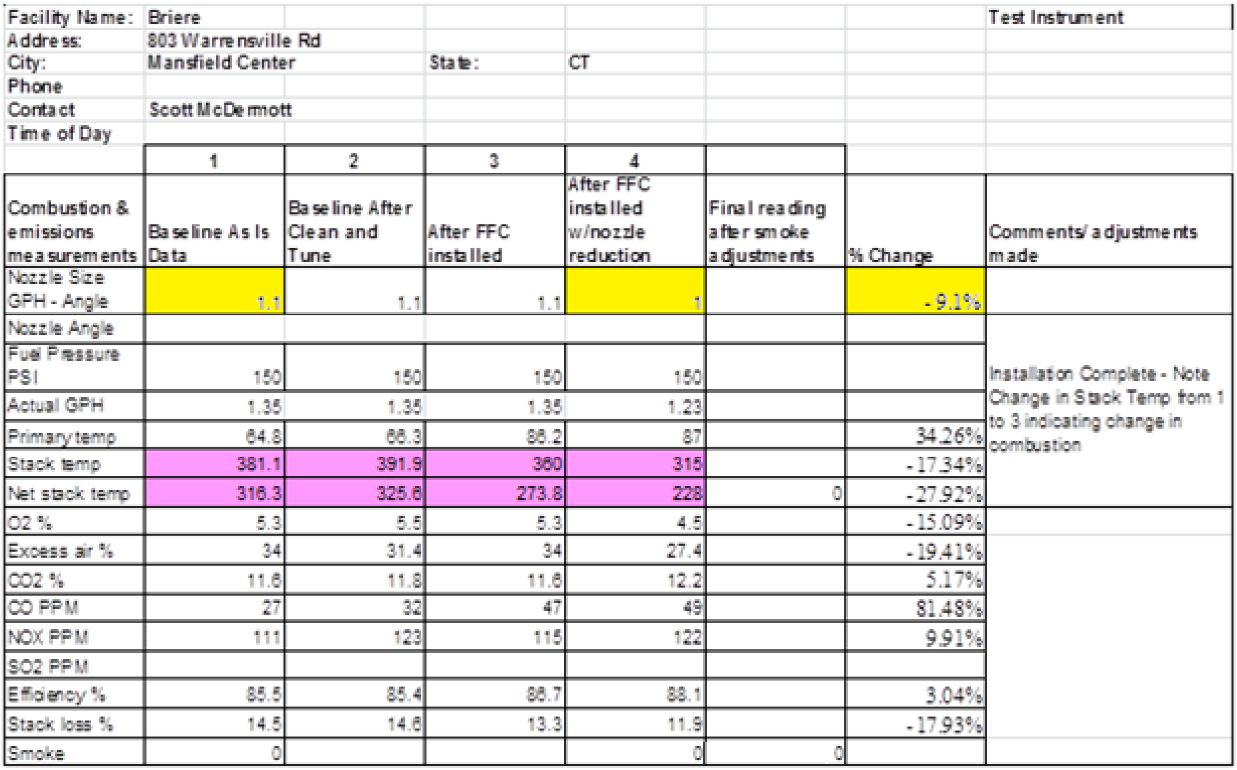
Pre-Programmed Fuels
Natural Gas, Propane, Butane, LPG, Light Oil

*Measures **Calculates

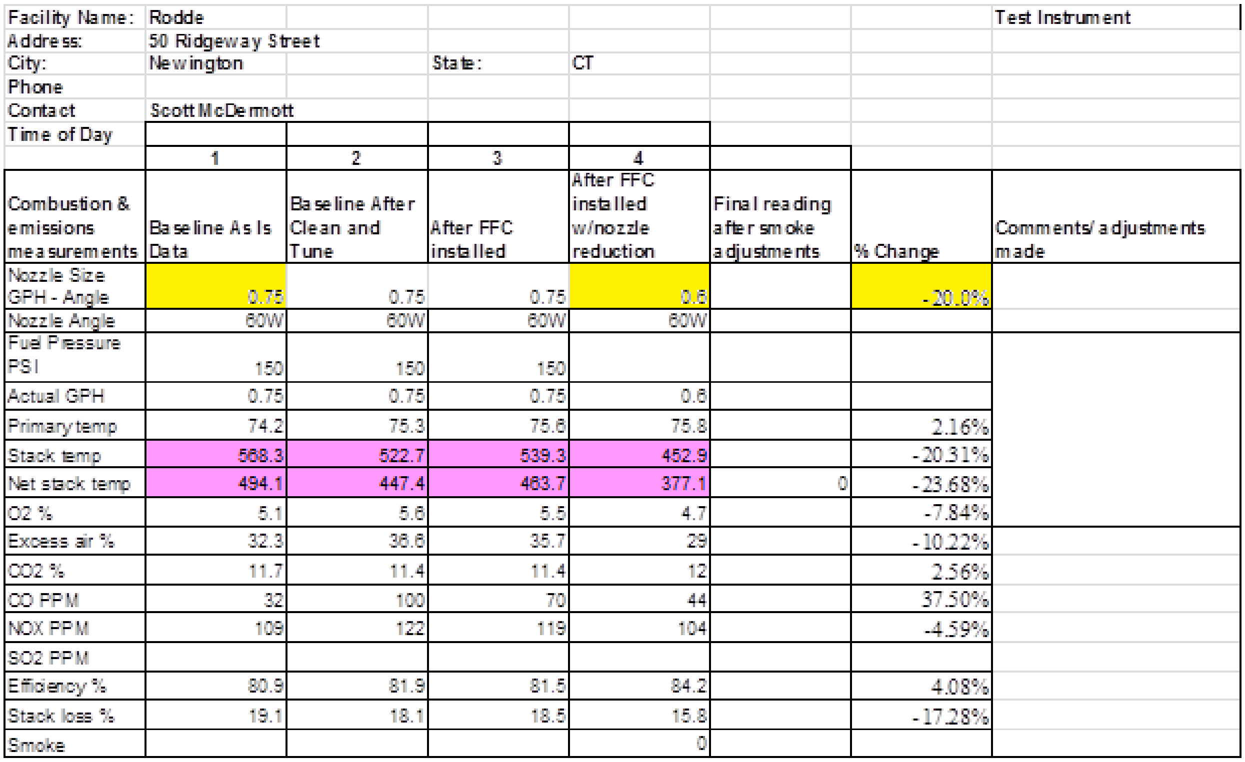
Appendix E: Observed Measurements in Four Installations

Facility Name:	**Wapping Community Center**						**Test Instrument**
Address:							
City:	**South Windsor**		**State:**	**CT**			
Phone							
Contact	**Aaron Wayner**	**New England Mechanical - EMCOR**					
Time of Day							
	1	**2**	**3**	**4**			
Combustion & emissions measurements	**Baseline As Is Data**	**Baseline After Clean and Tune**	**After FFC installed**	**After FFC installed w/nozzle reduction**	**Final reading after smoke adjustments**	**% Change**	**Comments/ adjustments made**
Nozzle Size GPH - Angle	2.50			2.0	2.0	-20.00%	
Nozzle Angle	SS 60			SS 60			
Fuel Pressure PSI	145			145	145		**Procedure Complete Analysis Complete - note change in Stack Temp between 2 & 3 indicating change in combustion**
Actual GPH	3.01			2.41	2.41	-19.93%	
Primary temp	86.9	86.7	85.5	82.8	82.8	-4.72%	
Stack temp	486.1	459.1	492	470	470	-3.31%	
Net stack temp	399.2	372.4	406.5	387.2	387.2	-3.01%	
O2 %	6.5	5.9	6.5	5.9	5.9	-9.23%	
Excess air %	42	36.6	42	39.3	39.3	-6.43%	
CO2 %	10.84	11.29	10.84	11.1	11.1	2.40%	
CO PPM	na	na	na	24			
NOX PPM				88			
SO2 PPM							
Efficiency %	83.7	84.7	83.5	83.3	83.3	-0.48%	
Stack loss %	16.3	15.3	16.5	16.7	16.7	2.45%	
Smoke	0				0		

Advanced Power Systems Int'l Inc.				**Facility Name:**	**Timothy Edwards School**						**Test Instrument**
339 Main Street				**Address:**							**Bacharach**
Torrington, CT 06790				**City:**	**South Windsor**		**State:**	**CT**			**Insight Plus**
860-496-7776				**Phone**							**SN SW1085**
				Contact	**John Mitchell - Mitchell Fuel**						
				Time of Day	**8:00:27**	**9:08:01**	**9:50:41**	**12:36:59**			
Boiler 1					1	**2**	**3**	**4**			
Test date	**Boiler Burner type & size**	**location**	**Fitch model**	**Combustion & emissions measurements**	**Baseline As Is Data**	**Baseline After Clean and Tune**	**After FFC installed**	**After FFC installed w/nozzle reduction**	**Final reading after smoke adjustments**	**% Change**	**Comments/ adjustments made**
June 18, 2013	**Burnham Riello**	**Timothy Edwards Middle School**	**HO10 UL**	Nozzle Size GPH - Angle	2.00			1.65	1.65	-17.50%	
				Nozzle Angle	60B			60B			
				Fuel Pressure PSI	145			145	145		**Procedure Complete Analysis Complete - note change in Stack Temp between 2 & 3 indicating change in combustion**
				Actual GPH	2.41			1.98	1.98	-17.84%	
				Primary temp	77.4	78.7	81.1	86.6	86.6	11.89%	
				Stack temp	493.0	410.0	431.0	390.0	390.0	-20.89%	
				Net stack temp	415.6	331.3	349.9	303.4	303.4	-27.00%	
				O2 %	8	7.5	8.1	7.3	7.3	-8.75%	
				Excess air %	56.9	53.4	58.6	50	50	-12.13%	
				CO2 %	9.7	10	9.6	10.1	10.1	4.12%	
				CO PPM	49	34	82	19	19	-61.22%	
				NOX PPM							
				SO2 PPM							
				Efficiency %	81.6	84.3	81.1	86.6	86.6	6.13%	
				Stack loss %	18.4	15.7	18.9	13.4	13.4	-27.17%	
				Smoke	0				0		



Facility Name:	Briere						Test Instrument
Address:	803 Warrensville Rd						
City:	Mansfield Center		State:	CT			
Phone							
Contact	Scott McDermott						
Time of Day							
	1	2	3	4			
Combustion & emissions measurements	Baseline As Is Data	Baseline After Clean and Tune	After FFC installed	After FFC installed w/nozzle reduction	Final reading after smoke adjustments	% Change	Comments/ adjustments made
Nozzle Size GPH - Angle	1.1	1.1	1.1	1		-9.1%	
Nozzle Angle							
Fuel Pressure PSI	150	150	150	150			Installation Complete - Note Change in Stack Temp from 1 to 3 indicating change in combustion
Actual GPH	1.35	1.35	1.35	1.23			
Primary temp	64.8	66.3	86.2	87		34.26%	
Stack temp	381.1	391.9	360	315		-17.34%	
Net stack temp	316.3	325.6	273.8	228	0	-27.92%	
O2 %	5.3	5.5	5.3	4.5		-15.09%	
Excess air %	34	31.4	34	27.4		-19.41%	
CO2 %	11.6	11.8	11.6	12.2		5.17%	
CO PPM	27	32	47	49		81.48%	
NOX PPM	111	123	115	122		9.91%	
SO2 PPM							
Efficiency %	85.5	85.4	86.7	88.1		3.04%	
Stack loss %	14.5	14.6	13.3	11.9		-17.93%	
Smoke	0			0	0		



Facility Name:	Rodde						Test Instrument
Address:	50 Ridgeway Street						
City:	Newington		State:	CT			
Phone							
Contact	Scott McDermott						
Time of Day							
	1	2	3	4			
Combustion & emissions measurements	Baseline As Is Data	Baseline After Clean and Tune	After FFC installed	After FFC installed w/nozzle reduction	Final reading after smoke adjustments	% Change	Comments/ adjustments made
Nozzle Size GPH - Angle	0.75	0.75	0.75	0.6		-20.0%	
Nozzle Angle	60W	60W	60W	60W			
Fuel Pressure PSI	150	150	150				
Actual GPH	0.75	0.75	0.75	0.6			
Primary temp	74.2	75.3	75.6	75.8		2.16%	
Stack temp	568.3	522.7	539.3	452.9		-20.31%	
Net stack temp	494.1	447.4	463.7	377.1	0	-23.68%	
O2 %	5.1	5.6	5.5	4.7		-7.84%	
Excess air %	32.3	36.6	35.7	29		-10.22%	
CO2 %	11.7	11.4	11.4	12		2.56%	
CO PPM	32	100	70	44		37.50%	
NOX PPM	109	122	119	104		-4.59%	
SO2 PPM							
Efficiency %	80.9	81.9	81.5	84.2		4.08%	
Stack loss %	19.1	18.1	18.5	15.8		-17.28%	
Smoke				0			

Appendix F: Customer Interview Summary

Telephone interviews were held with 10 different customers. All customers of the Fitch fuel catalyst mentioned significant savings in using the Fitch Fuel catalyst in relation to no previous use of any catalyst. One engineer that did 200 installations mentioned that all of these installations saved significant amounts of fuel and that there were no problems installing the catalyst.

Appendix G: Researcher Biographies

A. BIOGRAPHICAL SKETCH OF PRINCIPAL INVESTIGATOR

STEVEN L. SUIB

University of Connecticut, Dept. of Chemistry, 55 N. Eagleville Rd., Storrs, CT 06269-3060

Tel: (860) 486-2797, Fax: (860) 486-2981, Email: steven.suib@uconn.edu

Title: Board of Trustees Distinguished Professor, University of Connecticut

Professional Preparation:

B.S.	Chemistry	1975	State University of New York, Fredonia, NY
Ph.D.	Chemistry	1979	University of Illinois at Champaign-Urbana

Appointments:

2001-2011	Department Head, Department of Chemistry, University of Connecticut
2001	Board of Trustees Distinguished Professor, University of Connecticut
2000	Chancellor’s Research Fellow, University of Connecticut
1989-	Professor, Department of Chemistry, University of Connecticut
1986-1989	Associate Professor, Department of Chemistry, University of Connecticut
1980-1986	Assistant Professor, Department of Chemistry, University of Connecticut
1979-1980	Postdoctoral Associate, University of Illinois at Champaign-Urbana
1979	Visiting Lecturer, University of Illinois at Champaign-Urbana

Honors or Distinctions: CT Academy of Science and Engineering, 2012, ACS Fellow, 2011, Connecticut Medal of Science, 2011, CLAS Research Award, 2011, NASA Fellowship, 2009, Northeast Region Award of ACS, 2009, CT Academy of Arts and Sciences, 2008; Chemical Pioneer Award, 2005, AIC Fellow, 2005, Board of Trustees Distinguished Professor, 2001, Chancellor’s Research Fellow, 2000, SUNY Outstanding Achievement Award, 1998, NASA Fellowship, 1996, Olin Research Award, 1993, University of Connecticut Alumni Excellence in Research Award, 1993, ANL/Amoco Distinguished Speaker, 1993, CT Yankee Ingenuity Award, 1991, ACS Connecticut Valley Award, 1986, ACS Exxon Faculty Fellowship, Solid State Chemistry, 1983, University of Connecticut Faculty Fellowship, 1981-82, American Men and Women of Science, 1982, Excellence in Teaching, 1975-77, Mobil Oil Fellowship, 1975-76, President’s Scholar, SUNY Fredonia, 1975

Five Recent Publications Most Related to the Project (of over 500 total)

1. Espinal, L.; Wong-Ng, W.; Kaduk, J. A.; Allen, A. J.; Snyder, C. R.; Chiu, C.; Siderius, D. W.; Li, L., Cockayne, E., Espinal, A. E.; Suib, S. L., Time dependent CO_2 sorption hysteresis by octahedral molecular sieves with manganese oxide framework, *J. Am. Chem. Soc.*, 2012, 134, 7944-7951.

2. Iyer, A.; Del-Pilar, J.; King'ondu, C.; Kissel, E.; Garces, H.; Huang, H.; El-Sawy, A.; Dutta, P.; Suib, S., Water Oxidation Catalysis using Amorphous Manganese Oxides, Octahedral Molecular Sieves (OMS-2) and Octahedral Layered (OL-1) Manganese Oxide Structures, *J. Phys. Chem. C*, 2012, 116(10),6474-6483.
3. Njagi, E. C.; Genuino, H. C.; King'ondu, C. K.; Dharmarathna, S.; Suib, S. L., Catalytic Oxidation of Ethylene at Low Temperatures Using Porous Copper Manganese Oxides, *Appl. Catal. A*, 2012, 421-422, 154-160.
4. Zhang, X.; Galindo, H. M.; Garces, H. F.; Baker, P.; Wang, X.; Pasaogullari, U.; Suib, S. L.; Molter, T., Influence of Formic Acid Impurity on Proton Exchange Membrane Fuel Cell Performance, *J. Electrochem. Soc*., 2010, 157, B409-B414.
5. Espinal, A.; Suib, S. L. Nanostructured arrays of semiconducting octahedral molecular sieves by pulsed laser deposition, *Nature Materials*, 2009, 9, 54-59.

Five Recent Other Significant Publications.

1. Chen, C. H.; Crisostomo, V. M.; Li, W. N.; Xu, L.; Suib, S. L., A Designed Single-step Method for Synthesis and Structural Study of Organic-Inorganic Hybrid Materials: Well-ordered Layered Manganese Oxide Nanocomposites, *J. Am. Chem. Soc*., 2008, 130, 14390-14391.
2. Chen, C.; Abbas, S.; Morey, A.; Sithambaram, S.; Xu, L. X.; Garces, H. F.; Hines, W. A.; Suib, S. L. Controlled synthesis of Self-Assembled Metal oxide Hollow Spheres Via Tuning Redox Potentials: Versatile nanostructured Cobalt Oxides, *Adv. Mat*., 2008, 20, 1205-1209.
3. Luo, J.; Zhang, Q.; Garcia-Martinez, J.; Suib, S. L. Adsorptive and Acidic Properties, Reversible Lattice Oxygen Evolution, and Catalytic Mechanism of Cryptomelane-Type Manganese Oxides as Oxidation Catalysts, *J. Am. Chem. Soc*., 2008, 130, 3198-3207.
4. King'ondu, C.; Iyer, A.; Njagi, E.; Opembe, N.; Genuino, H.; Huang, H.; Ristau, R.; Suib, S., Light-Assisted Synthesis of Metal Oxide Heirarchical Structures and Their Catalytic Applications, *J. Am. Chem. Soc*., 2011, 133, 4186-4189.
5. Dharmarathna, S.; King’ondu, C. K.; Pedrick, W.; Pahalagedara, L.; Suib, S. L., Direct Sonochemical Synthesis of Manganese Octahedral Molecular Sieve (OMS-2) Nanomaterials Using Cosolvent Systems, Their Characterization, and Catalytic Applications, *Chem. Mat*., 2012, 24, 705-712.

Synergistic Activities

US Regional Editor - Microporous and Mesoporous Materials, Coauthor with John Tanaka of Experimental Methods in Inorganic Chemistry, Prentice Hall, 1999. This book is a result of development of innovative curriculum materials for undergraduates. Faculty Advisor of local American Ceramics Society; United Youth Among Nations. Outreach with Kids are Scientists Too Program (KAST). Service with American Chemical Society, PLU, MRS, Sigma Xi.

Additional collaborators over the past 48 months

Pratt & Whitney, 1994 – present, Olin Corp., 1992 – present, United Technologies, 1986-present, Uniroyal, 1996 – present, Anocoil, 1998 – present, DuPont, 1992 – present, Syntroleum, 1998 – present, Yardney, 1998 – present, APSI, 2000 – present, Toyota, 2002 –2006, Honda, 2003 – present, , M. Aindow, S. Auerbach, C. Conner, J. Dicarlo, F. S. Galasso, J. Hanson, M. Kmetz, C. V. Kumar, R. Malz, D. Mullins, J. Rusling.

Ph. D. Students and Postdoctoral Associates, past 5 years

Current graduate students: Sourav Biswas, Sheng-Yu Chen, Timothy Coons, Saminda Dharmarathna, Abdelhamid El Sawy, Samuel Frueh, Becca Gottlieb, Curt Guild, Homer Genuino, Aparna Iyer, Ting Jiang, Jagadeswara Kona, Dave Kriz, Chung-Hao Kuo, Nan Li, Zhu Luo, Nash Mazrui, Yongtao Meng, Lakshitha Pahalagedara, Madhavi Pahalagedara, Altug Poyraz, Justin Reutenauer, Gavin Richards, Saiful Seraji, Wenqiao Song, Yashan Zhang

Postdoctoral associates: Dambar Hamal
At Univ. of CT. since 1980: Total Ph. Ds.: 116, Total postdoctorals: 21

Graduate Mentor: Larry R. Faulkner (U. Texas); Postdoctoral Advisor: Galen D. Stucky (UC Santa Barbara)

B. CURRICULUM VITAE OF RESEARCH ASSISTANT

Jagadeswara R Kona

55 N Eagleville Rd Department of Chemistry University of Connecticut Storrs, CT-06269

Strengths:

Creative, enthusiastic, industrious, well organized, able to work independently as part of a team, able to get along with the people, ability to quickly grasp new technologies and adapt to changing environments.

Academic Profile:

Ph.D Inorganic Chemistry (2007 – Present)

M.Sc Chemistry (2003 – 2005)

- First Class with 60.3 %
- University of Hyderabad

Bachelor of Science (1999 – 2002)

- First Class with 78.9 %
- Sri Venkateswara University

Intermediate (1997 – 1999)

- First Class with 68.6 %
- Board of Intermediate Education

Secondary Education (1997)

- First Class with 66.5 %
- Board of Secondary Education

SKILLS:

Purification of Compounds by using Recrystallization, Sublimation, Simple Distillation and Fractional Distillation techniques

Separation of Compounds by using Thin Layer Chromatography, Ion Exchange Chromatography and Column Chromatography techniques

Knowledge and experience in catalyst characterization techniques such as BET Surface area measurements, Spectroscopic techniques like IR,UV-VIS, Mass, GC-MS, Nuclear Magnetic Resonance (NMR), X-ray diffraction (XRD), Scanning Electron Microscope (SEM-EDAX), X-ray Photo electron Spectroscopy (XPS) and Ultraviolet Photo Electron Spectroscopy (UPS)

Research Sponsors

About CTNEXT

CTNEXT is a statewide network dedicated to strengthening Connecticut's innovation community by opening up national, statewide, and local networks so entrepreneurs can access the knowledge, resources and opportunities they need to succeed. Working with leading entrepreneur support organizations, CTNEXT identifies and supports the growth of Connecticut's most promising early stage companies. CTNEXT highlights the importance of early stage companies as innovators and job creators and gives them access to the mentors and knowledge they need to succeed. For more information on CTNEXT, visit ctnext.com.

About INNOVATION East

INNOVATION East is a public-private partnership that brings the strengths and investment in the University of Connecticut ecosystem together with private-sector serial entrepreneurs who are organized under the *Horsebarn Hill Ventures* moniker. Together, these two groups have combined to offer a range of services supporting the growth of high-potential startups in the eastern part of Connecticut, geographically focused around the UConn campuses in Storrs and Avery Point in Groton.

INNOVATION East is headquartered at UConn / Storrs and is temporarily housed in the Gordon W. Tasker Building.