# Operating Principles of ECO Systems Fuel Enhancer

by
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## Objective:

Many tests have been conducted on the ECO Systems family of products. These tests have consistently shown improved fuel efficiency in a variety of engines and fuels types. The objective of this study is to establish how the device produces the observed improvements in combustion and how they relate to natural gas fuel engines and burning equipment.

## Device Description:

The ECO Systems device consists of a steel tube containing a series of copper disks with a center hold and holes formed between the disks and the inside of the steel tube. The device does not contain magnets, consume chemicals, or use external electrical power. The device is produced in several sizes. The same device design is used for liquid fuels and for natural gas. The design promotes turbulent flow and extensive metal to fluid (liquid or gas) surface contact. The device is installed inline to an existing pipeline by cutting out a section, threading the ends and using pipe unions to attach the device. The device is manufactured by Emissions Technology, Inc., (ETI) of Tulsa, OK. The product is labeled ECO-x where x is the product model (size).

## ECO Systems Sponsored Tests:

ETI has sponsored several tests to establish the fuel efficiency and emission reduction benefits plus any physical-chemical changes in the treated fuel. Teeter (1), determined that there was no significant effect on surface tension or chemical composition of diesel fuel, although vapor pressure was increased and pour point temperature was lower in the treated fuel compared to untreated fuel. Johnson (2) evaluated the vapor pressure changes due to the device in diesel fuel and gasoline and believed they were significant (not quantified) and related to improved combustion. A test conducted by SGS US Testing Co. (3) on a natural gas burner showed a 1.8% increase in combustion gas temperature at constant methane and air supply when using the ECO System fuel enhancer. A test conducted for the Texas Commission for Environmental Quality (4) showed an average reduction in HC and NOx emissions of 6-7% and 1% in fuel consumption from 4 high-mileage gasoline vehicles when using the ECO-System device.

## Suggested Mechanism:

Based on the device description, several possible mechanisms (magnetic force, chemical reactivity or compositional changes, flow restriction or line pressure modulation) cannot occur. However, extensive laboratory and field research has established (5) that low conductivity flowing fluids can generate electrostatic charges on pipes and hoses. An equal and opposing charge occurs within low conductivity fluids, a process called flow electrification and the resulting current is usually referred to as a streaming current. The electrostatic charge density (Coulombs/kg) of a fluid in a duct or tube increases with increased flow velocity and decreases with increased mass flow density. This is basically related to the frequency of molecular collisions of the fluid with the duct surfaces.

Independent Research Reports:

Gasoline, diesel fuel, and natural gas have low electrical conductivity. This phenomenon results in well known transportation and handling risk because the electrostatic charge can cause a sudden spark that can ignite the fuel. Parameters causing increased levels of electrostatic potential include (5):

- Decreasing fluid conductivity
- Increasing flow velocity
- Increasing turbulence due to bends, constrictions, etc
- Increasing temperature of the fluid
- Decreasing humidity of the fluid.

Many technical papers discuss the beneficial effects of electrostatic charge on fuel atomization and distribution in liquid fuels. Leuteritz (6) reported that induced electrostatic charge of diesel fuel affected the core of the fuel spray such that additional waves were produced causing earlier breakup of the spray leading to smaller droplet diameters and larger spray angles. DiSalvo (7) expanded on this by showing that electrostatic energy improved atomization of diesel fuel yielding a significant improvement in combustion uniformity and efficiency. Parsons (8) determined that a negative charge induced in liquid flowing fuel survives through the injector orifice because the fuel is electrically insulating. The resulting spray pattern is better atomized and dispersed due to the electrostatic forces. Allen (9) reported data on an induced electrostatic charge in the fuel which resulted in improved atomization of diesel fuel. The paper reports that the physical mechanism is to reduce the inherent surface tension of the droplet surface. Reducing surface tension will generally increase the observed vapor pressure of liquid fuels which has been a commonly reported effect of the ECO-System device.

The above reports support the conclusion that liquid fuels are electrostatically charged by turbulent flow caused by impact of fuel droplets with the metallic surface; and that, once charged, retain that charge long into the engine, where the effect can be seen in improved dispersion and more rapid cylinder pressure rise.

Application of ECO Systems Fuel Enhancer to Natural Gas Engines and Gas Burners:

The data reported above was based on electrostatic properties in liquid fuels. However, natural gas also is non-conductive and is predominately methane. Lu (10) reported a generalized model for determining the entraining electrostatic charge in flowing compressed natural gas, generally referred to as the streaming current. Natural gas flowing through the ECO-System device accumulates electrostatic charge due to gas/surface collisions which is enhanced by the turbulence inherent in the device design. Mattheson Tri-Gas (11) reported that electrostatic charges are generated by flowing methane and they may be sufficiently high to cause explosive discharge in the presence of gas leaks. Methane is a non-polar molecule with strong covalent bonds between carbon and hydrogen atoms. This makes the molecules resistant to magnetic forces but still susceptible to electrostatic charging.

The Gas Research Institute has studied the effects of electrostatic charging on piping failures and gas explosions. Ersoy (12) reported that friction of high velocity flowing natural gas in a pipe will generate an electrostatic charge. Any obstacles in the flow path increase turbulence and friction and in turn increase the generation of static charge on the pipe and in the flowing gas.

Field Tests of ECO System Fuel Enhancer:

Tests were conducted on a natural gas engine and boiler plant operating in the San Joaquin Valley. These tests consistently showed a 2% reduction in fuel used for the same work output.

| Grimmway Farms Pump PE185 (02-18-2009) | Baseline | ECO-GAS | % Change |
|---|---|---|---|
| Gas Input (cu.ft./hr) | 1469.39 | 1440.00 | -2.00 |
| Energy Input (Therms/hr) | 15.16 | 14.86 | -1.98 |
| Work (Acre-ft/hr) | 0.145 | 0.145 | 0.00 |
| Therms/Acre-ft | 104.85 | 102.75 | -2.00 |

| Langer Farms Miura 7.9MBTU Boiler (05-5-2009) | | | |
|---|---|---|---|
| Low Load Gas Input (cu.ft.) | 2434 | 2391 | -1.77 |
| High Load Gas Input (cu.ft.) | 6462 | 6308 | -2.38 |

Residential Gas Appliance Tests of ECO Systems Fuel Enhancer:

Tests were run on a residential stove/oven by measuring the time required to raise water in a sauce pan and to heat the oven a fixed number of degrees. An ECO-5 gas unit was installed on the gas line entering the stove. The heating time was reduced 2-3%.

| Boil Water Test (7-10-2009) | Baseline | ECO-GAS | % Change |
|---|---|---|---|
| Starting air temperature (F) | 70 | 70 | 0.00 |
| Starting water temperature (F) | 64 | 64 | 0.00 |
| Amount of water (oz) | 128 | 128 | 0.00 |
| Time to reach 200F (seconds) | 1,291 | 1,253 | -2.94 |

| Oven Pre-heating Test (7-10-2009) | Baseline | ECO-GAS | % Change |
|---|---|---|---|
| Starting oven wall temperature (F) | 67 | 67 | 0.00 |
| Time to reach 350F (seconds) | 471 | 459 | -2.55 |

Discussion:

The data collected from tests of the ECO Systems Fuel Enhancer has shown consistent 2% energy efficiencies in natural gas fueled engines, a boiler, and residential appliances. The principal of operation has been shown to be electrostatic charging of the fuel by the Fuel Enhancer, because other principals of operation (chemical reaction, magnetic charge, catalytic reforming of the fuel, external electrical charging or plasma) are not embodied in the Fuel Enhancer. Technical literature supports that fuel, once charged, retains the charge for the time required to travel from the Fuel Enhancer into the engine or gas burner due to the low electrical conductivity of natural gas. The electrostatically charged gas molecules promote more complete fuel/air mixing which results in more complete combustion and the observed energy saving. This electrostatic charge effect is small compared to the inherent energy of the fuel molecule and is insufficient to reach an explosive discharge potential.

Conclusions:

1) The ECO-System Fuel Enhancer design promotes electrostatically charging of flowing fluids, including natural gas.
2) Natural gas fuels are electrostatically charged by flowing through the Fuel Enhancer.
3) Electrostatically charged fuel retains its charge during the time required to transit the fuel delivery system into the engine or burner.
4) Electrostatically charged fuel mixes with air and burns more efficiently than uncharged fuel resulting in reduced fuel consumption for the same work performed.
5) Electrostatically charged fuel from the Fuel Enhancer has provided a reproducible 2% energy savings in a number of tests.

References:

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Credentials of Richard Carlson:

1. Master of Science degree in Environmental Engineering from UCLA.
2. Member - Society of Automotive Engineers for over 15 years.
3. 25 years performing and managing emission and performance tests at independent vehicle and engine testing laboratories in Southern California for government and corporate clients.
4. 12 years developing, testing, and certifying catalytic converters for major aftermarket catalytic converter manufacturer.
5. 5 years developing, testing, and certifying diesel emission control systems such as particulate filters, selective catalytic systems, and lean NOx traps.