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THE EFFECT OF FPC® CATALYST UPON OXIDES OF NITROGEN (NO_x)

Abstract

This bulletin summarizes the results of tests conducted by independent laboratories to determine the effect of the FPC® Catalyst upon oxides of nitrogen (NO_x). The paper also discusses the possible mode of action by which the FPC® active ingredient is able to create greater fuel savings, and reduce carbon monoxide and unburned hydrocarbons formation without increasing NO_x.

These tests include the RP-503 procedure by Southwest Research Institute (SwRI), San Antonio, Texas, and several Environmental Protection Agency (EPA) standardized test procedures (the EPA-Federal Test Procedure and the EPA-Highway Fuel Economy Test). These studies, which were conducted on both compression-ignition and spark-ignition engines, show the use of FPC® Catalyst does not increase NO_x emissions. In fact, these data indicates the FPC® Catalyst has a positive effect upon NO_x.

Background

The formation of NO_x is complex and is dependent upon a series of reactions. Chemical kinetics shows that the formation of NO_x and other oxides of nitrogen increase with increasing flame temperature. However, NO_x will also be influenced by the flame speed. Lower flame speeds (longer burn duration) provide a longer time for NO_x to form. Therefore, NO_x may be reduced by lowering flame temperature or by shortening burn duration or both.

In a compression-ignition engine, NO_x is formed during the diffusion-controlled or mixing controlled phase of combustion, on the weak side (stoichiometric side) of the reaction zone. The rate of combustion or the speed of flame propagation during this phase is controlled by the rate at which the fuel can find and mix with oxygen. Reducing the duration of this phase of combustion, by increasing the speed of the flame, leads to NO_x reduction; that is if propagation can be done without significant increase in flame temperature.

Fuel Treatment with FPC® Products

FPC® is a burn rate modifier that speeds the rate of flame propagation (increases flame speed) thereby shortening the duration of the diffusion-controlled phase of combustion. Nitrogen and oxygen are both exposed to high temperatures for a shorter period of time, thus the length of time for the two to

react together is diminished.

There is no evidence that FPC® Catalyst increases combustion temperatures. Fuel properties analyses show FPC® does not affect fuel cetane, so the additive will not shorten the delay period. Therefore, the catalyst has little effect upon the rate of pressure and temperature rise, nor the **peak pressure and temperature achieved.** The catalyst does appear to affect flame speed after the pre-mixed phase when much of the oxygen supply has been depleted and combustion temperatures have fallen. At this point, pressure and temperatures are much lower than the peak. This is evidenced by the almost universal reduction in carbon monoxide and carbon particulate, which are predominantly formed after pre-mixed combustion.

Test Results

SwRI conducted a study of the effect of the FPC® active ingredient on whole emissions as part of the Association of American Railroads Recommended Practice-503 (RP-503) test procedure. The test of a full size, 12 cylinder, turbocharged, EMD locomotive engine, run at full throttle and load showed no change in NO_x after FPC® fuel treatment, while brake specific fuel consumption was reduced (see Appendix 1, Table 5, page 19 of the Southwest Research Institute report. Note the statement about reproducibility above the table).

Similarly, the EPA-FTP and HFET procedures, conducted in two, compression-ignition engine powered and four, spark-ignition engine powered passenger vehicles showed NO_x was reduced in nine of thirteen tests (70%). The average change in NO_x for the two vehicles was –6.4%. The average change for the four gasoline engines was –2.3%. Fuel consumption in the same vehicles (diesel and gasoline) was reduced 3.6%.

Finally, a study done by the State Energy Commission of Western Australia in several high horsepower diesel gensets (1000 to 2200kW) showed NO_x emissions generally lower with FPC® (FTC) treated fuel. Fuel consumption was also reduced by as much as 5% during the FPC® studies.

Conclusion

NO_x formation is both temperature and burn duration dependent. Higher temperatures and longer burn times increase NO_x emissions.

Laboratory tests indicate FPC® fuel treatment does not increase the emissions of NO_x. In fact, these data indicate the use of FPC® Catalyst may reduce NO_x emissions. In these same studies, the use of FPC® Catalyst reduced fuel consumption and generally reduced the emissions of the products of incomplete combustion (CO and smoke).

FPC® Catalyst does not affect fuel cetane number and appears to have no affect upon ignition delay nor increase flame temperature during the early phase of combustion (pre-mix) when most NO_x formation takes place. However, the observed effect of the catalyst upon the products of incomplete combustion (CO and smoke) that are predominantly formed during the later phases of combustion

(mixing-controlled and tail of combustion) indicate FPC® Catalyst shortens burn duration or combustion time after the pre-mix phase. This is the likely mechanism by which FPC® improves the engines efficient use of fuel without increasing NO_x.

It is also probable that average flame temperature is lowered with FPC® treated fuels, result of the apparent reduction in fuel mass (reduced fuel consumption) and therefore, the reduced heat energy to create the same engine load (kW or hp).

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