FEROX®
CLEAN HYDROCARBON TECHNOLOGY

TECHNICAL BULLETIN
ORIGINAL 1 JULY 1993
REVISED 23 JANUARY 2013

The Effects of Ferox on SO_X

The treatment of carbon based fuels with Ferox has a significant effect on trace sulfur combustion chemistry. Numerous field tests run in diesel engines, gasoline engines and open flame applications (boilers) have consistently demonstrated a reduction of sulfur oxide (SO_X) emissions. Sulfur related acid corrosion problems are also significantly reduced.

Ferox does not react with sulfur in the fuel nor does Ferox have any effect on the sulfur content of the fuel. Commonly accepted fuel specifications are not effected by Ferox treatment at recommended treatment levels. A fuel containing one percent sulfur prior to Ferox treatment will still contain one percent sulfur after Ferox treatment. However, Ferox will affect where the sulfur ends up and its chemical state after combustion.

The combustion of sulfur in fuels invariably leads to the formation of sulfur dioxide (eq 1), and sometimes sulfur trioxide (eq 2). Sulfur trioxide formation (eq 2) is catalyzed by vanadium pentoxide (V^{5+}), which is the most stable oxidation product of vanadium when vanadium containing fuels are burned in air (eq 3). The catalytic effect is thought to relate to the reversible dissociation of V^{5+} (eq 4) at temperatures between 700-1125 ·C. The sulfur trioxide reacts with water vapor to form sulfuric acid (eq 5), which is primarily responsible for acid corrosion problems in combustion equipment.

$$S + O_2 \rightarrow SO_2 \qquad (1)$$

$$2SO_2 + O_2 \rightarrow 2SO_3 \qquad (2)$$

$$4V + 5O_2 \rightarrow 2V_2O_5 \qquad (3)$$

$$2V_2O_5 \_ 2V_2O_4 + O_2 \qquad (4)$$

$$SO_3 + H_2O \rightarrow H_2SO_4 \qquad (5)$$

A basic understanding of the effect that Ferox has on the combustion process (supplied in the following paragraph) is needed in order to understand how Ferox affects the production of gaseous SO_X emissions.

Ferox promotes the formation of CO_2 during the combustion phase thus limiting the amount of CO_2 produced during the exhaust phase. The increased production of CO_2 reduces the amount of excess O_2 available for other reactions. The difference in the amount of CO_2 produced during the two phases correlates to a temperature difference. This temperature difference results in cooler exhaust temperatures and quicker heat transfer times.

Minerals contained in fuel are generally oxidized to metal oxides during the combustion process. When vanadium is oxidized to V^{5+}, the production of sulfur trioxide increases due to the reversible dissociation of V^{5+}, and sulfuric acid is ultimately formed (eq 3 and eq 5). The use of Ferox inhibits the formation and reversible dissociation of V^{5+}, which occurs during the exhaust phase of the combustion process, by limiting the available O_2, high temperatures, and time periods needed for the reactions to occur. This greatly reduces the catalytic effect that V^{5+} has on the formation of Sulfur trioxide and thus the formation of sulfuric acid. By reducing the catalytic effect of V^{5+}, Ferox promotes the combination of SO_X compounds with other minerals in the fuel such as Na and Ni. This leads to the formation of stable mineral salts and low valence sulfur compounds, which show up in the clinker or fly ash. In this manner, Ferox shifts the gaseous sulfur emissions to the particulate portion of the combustion products. The ash from the combustion of Ferox treated fuels will therefore exhibit a slightly higher sulfur content than the ash from untreated fuel. Sulfur mass balance studies and functional group analysis will confirm increased sulfur in the ash from Ferox treated fuel.