

Memo



To: _____ **From:** Nigel McKenzie

Cc: _____ **Date:** 05/07/06

Subject: Engineering Bulletin – Explanation of Octane/Cetane

DIESEL FUELS – Cetane Number and Cetane Index

Cetane Number - The cetane number of a diesel fuel is a rating on a scale used to indicate how quickly a fuel will ignite in a diesel engine. It is a figure of merit for diesel fuel just as the octane number is a figure of merit for gasoline burned in spark ignition engines. *A diesel engine run on a fuel with a lower cetane number than it was designed for will be harder to start, noisier, operate roughly and have higher emissions.*

In a diesel engine, the fuel is ignited by hot air; the air is heated by compression. The fuel is injected into this hot air just before the piston reaches top center. (“Top center” is the moment when the piston has traveled into the cylinder as far as it can go, and compression is at a maximum.) Ideally, ignition should begin just as the piston reaches top center. If it does not, the entire charge of fuel may have time to become thoroughly mixed with air, and when it does ignite, the pressure rise will be much steeper than it would have been had ignition occurred earlier. So a desirable property of a diesel fuel is that it ignites quickly.

In the 1930's the Cooperative Fuel Research committee sought a way of expressing the tendency of a diesel fuel to ignite quickly, and their work was taken up by the ASTM. A substance that ignited very quickly, cetane (n-hexadecane) was arbitrarily given a rating of 100, and a substance that was slow to ignite, alpha-methylnaphthalene (later called 1-methylnaphthalene), was assigned a rating of zero. Values on this scale were named “cetane numbers.”

A specially-designed engine with adjustable compression is used to determine a fuel's cetane number. The fuel being tested is injected at 13° before top center. (This describes a particular moment in the engine's cycle. “13°” refers to the rotation of the crankshaft.) The engine's compression ratio is then adjusted until the fuel ignites at top center. Retaining this compression ratio, the engine is then run on various blends of cetane with 1-methylnaphthalene, until a blend is found for which ignition occurs at top center. The cetane number is the percentage by volume of cetane in the mixture that has the same performance as the fuel being tested.

In 1962, difficulties in handling alpha-methylnaphthalene and its expense led the ASTM to replace it with a secondary reference fuel: 2,2,4,4,6,8,8-heptamethylnonane (also called isocetane). Heptamethylnonane was assigned a cetane rating of 15, based on engine testing. Since 1962 engine tests of diesel fuel have ordinarily been conducted with blends of cetane and heptamethylnonane. In calculating the cetane number allowance is made for the 15-cetane rating of the heptamethylnonane, to keep the scale as it was. The new formula is as follows:

Cetane Number = Volume % of Cetane + 0.15(Volume % Isocetane)

Cetane Index - Often the cetane number is not determined experimentally by an engine test. Instead an estimate is made from the fuel's specific gravity and the temperature at which half of a sample will boil away. Such estimates are called cetane indexes, not cetane numbers. An improved method relies on the temperatures at which 10%, 50% and 90% of the sample boils away. *It is important to note, the various additives used to increase a fuel's cetane number have no effect on its cetane index.*

The two cetane index methods most commonly used to estimate cetane number, ASTM D 976 and ASTM D 4737, were developed in 1966 and 1987, respectively. These methods are based on correlations between physical properties of diesel fuels and their cetane numbers. However, diesel fuels have changed since these correlations were developed. In 1993 two new diesel fuels were introduced: EPA low sulfur diesel for on-road use in the U.S., and CARB low aromatics diesel for use in California. Since these types of diesel fuels were not in use when the cetane index methods were developed, it isn't surprising that the correlations between physical properties and cetane number does not work as well for the new fuels. ASTM is working to develop a new correlation that accurately predicts the cetane numbers of today's fuels.

Enough science for now

Mac