

MEMORANDUM

FROM: Aron Butler
United States Environmental Protection Agency
Office of Air and Radiation
Office of Transportation and Air Quality
Assessment and Standards Division

TO: Tier 3 Fuel Economy Adjustment Docket EPA-HQ-OAR-2016-0604

DATE: May 2, 2018

RE: Distillation adjustment for ethanol blending in Tier 3 and LEVIII test fuels

EPA is proposing use of ASTM D3343 and D3338 for determination of carbon mass fraction (CMF) and net heat of combustion (NHC), respectively, when calculating fuel economy for Tier 3 E10 test fuel. Those ASTM methods are not applicable as published to ethanol blends, so additional calculations are proposed whereby the published method is applied to the hydrocarbon (non-ethanol) fraction of the test fuel, and that result is combined in a mass-weighted sum with the value for pure ethanol.

The published methods determine the CMF and NHC by correlation to other known properties, namely volume percent aromatics, API gravity, and average distillation temperature (computed as $(T_{10} + T_{50} + T_{90}) / 3$). In order to apply the published methods to the hydrocarbon fraction, its properties are computed from the measured properties of the E10 test fuel and the reference values for pure ethanol. This computation is straightforward for aromatics and gravity, however, the impact of ethanol on the distillation profile is nonlinear and varies depending on the composition of the hydrocarbon components. In previous descriptions of this method, such as in EPA Guidance Letter CD-95-09 and SAE technical paper 930138, the average distillation temperature of the hydrocarbon fraction was simply taken as that of the oxygenate blend, and any error this produced in NHC or CMF was deemed negligible.

During the course of discussion related fuel property determination for E10 test fuel, General Motors staff, working on behalf of the Alliance of Automobile Manufacturers and Global Automakers, proposed using data from a 2010 American Petroleum Institute (API) study to derive an ethanol adjustment for the average distillation temperature.¹ The API study collected 71 E0 (non-ethanol) gasoline samples in 2008-2009 covering the six ASTM volatility classes and blended them with denatured ethanol at 10, 12.5, 15, 20, and 30 volume percent. Several properties were measured for the base fuel and each subsequent blend, including D86 distillation profiles. In this data, it was possible to find E10 blends closely matching the 10%, 50%, and 90% distillation points of Tier 3 and LEVIII test fuels (API sample IDs 839224 and 836230, respectively). The distillation adjustment for removal of ethanol was then computed using the D86 results for the corresponding E0 fuels, as shown in Figure 1 and Figure 2 below. The resulting adjustment values are +14.8°F and +11.8°F for Tier 3 and LEVIII fuels, respectively. This analysis is described in more detail in a letter submitted jointly by the Alliance of

¹ American Petroleum Institute. "Determination of the Potential Property Ranges of Mid-Level Ethanol Blends, FINAL REPORT." April 23, 2010. Available at <http://www.api.org>.

Automobile Manufacturers and Global Automakers to Mike Olechwi, Director, Light-Duty Vehicle and Small Engine Center (EPA).²

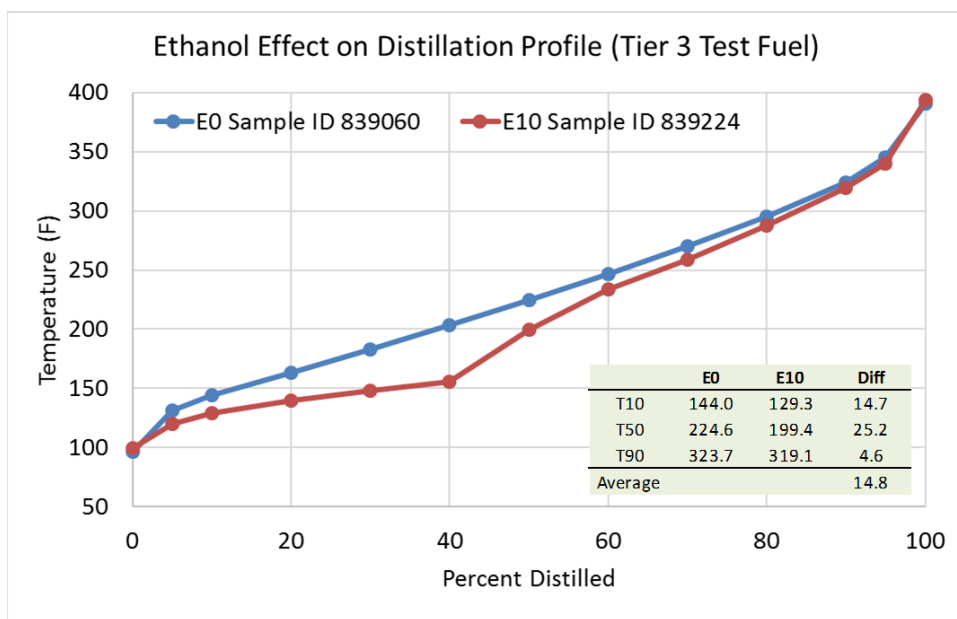


Figure 1. Derivation of average distillation adjustment for Tier 3 test fuel using data from the 2010 API blending study.¹

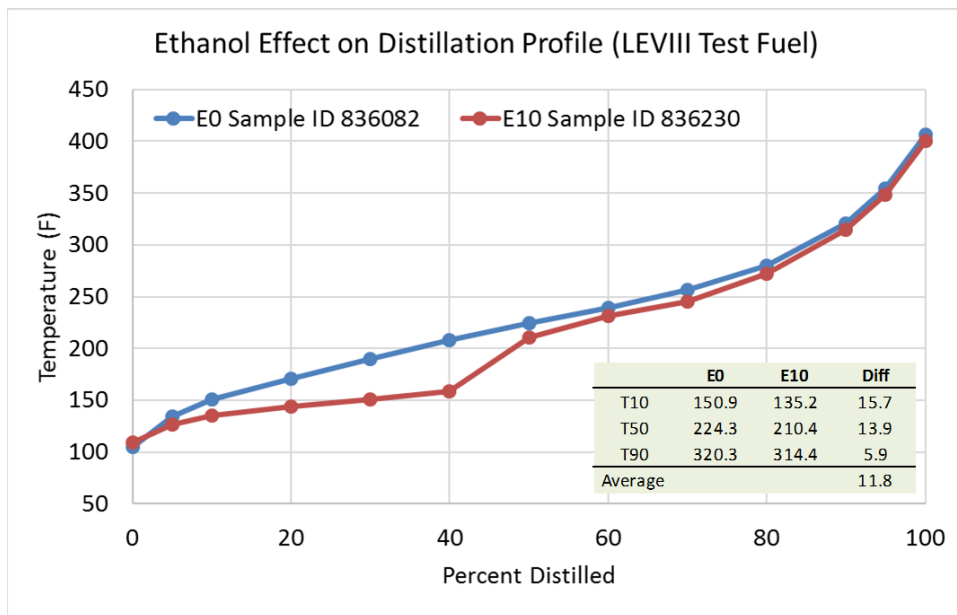


Figure 2. Derivation of average distillation adjustment for LEVIII test fuel using data from the 2010 API blending study.¹

² This letter is available in docket EPA-HQ-OAR-2016-0604.