Engine Combustion Network



# Fuels

The composition and properties of the fuels used in the experiments are given in Table 6.1. They consist of three oxygenated fuels (T70, GE80, and BM88) and five hydrocarbon fuels (NHPT, CET, HMN, CN80 and D2). T70 was originally used as a low-sooting fuel with a similar ignition delay as a cetane number 42.5 diesel reference fuel in order to facilitate optical diagnostics in the Sandia/Cummins optical engine (Dec, SAE 970873). Similarly, the oxygenated fuels GE80 and BM88 had the same ignition delay as CN80 (cetane number 80) (Mueller, SAE 2003-01-1791). Ignition delays were matched only after adding a significant portion of an ignition enhancer, EHN, to BM88.

The fuel temperature ($T_f$) and density ($\rho_f$) at the fuel injector orifice are included in Table 6.1. Note that experiments were conducted at two fuel temperatures for D2 and CN80. This is because a fuel injector cooler was added after the initial D2 tests were completed. Table 6.1 shows that fuel density tends to decrease as temperature increases and that the fuel density of CN80 at 373;K is actually closer to the fuel density of D2 at 436 K. The fuel density can be important because fuel jets with the similar fuel density and pressure drop across the orifice will have similar jet momentum, which ultimately affects the mixing of the fuel jet. However, the fuel temperature difference had little effect on the soot level and location, or on the lift-off length and ignition delay (Pickett SAE 2003-01-3080).

**Table 6.1**

| Fuel | Composition (by volume) | $\rho_f$ [g] [kg/m$^3$] | $T_f$ [K] | $O_2$ [h] [wt%] | $\Omega_f$ [i] [%] | Cetane Number | Atomic H/(C-O) Ratio | LHV[j] [MJ/kg] | $(A/F)_{st}$ [k] |
|---|---|---|---|---|---|---|---|---|---|
| **T70** | 70% TEOP[a]<br>30% HMN[b] | 808 | 373 | 21.5 | 7.8 | - | 2.84 | 32.6 | 11.1 |
| **GE80** | 80% TPGME[c]<br>20% HMN[b] | 858 | 373 | 25.8 | 10.0 | - | 3.15 | 30.5 | 10.2 |
| **BM88** | 88% DBM[d]<br>7% nC16[e]<br>5% EHN[f] | 907 | 373 | 26.5 | 10.9 | - | 2.49 | 28.7 | 9.5 |
| **NHPT** | 100% n-heptane | 613 | 373 | 0 | 0 | 56 | 2.29 | 44.6 | 15.4 |
| **CET** | 100% nC16[e] or cetane | 673 | 436 | 0 | 0 | 100 | 2.13 | 43.9 | 15.2 |
| **HMN** | 100% HMN[b] | 689 | 436 | 0 | 0 | 15 | 2.13 | 43.9 | 15.2 |
| **CN80** | 76.5% nC16[e]<br>23.5% HMN[b] | 724<br>682 | 373<br>436 | 0 | 0 | 80 | 2.13 | 43.9 | 15.2 |
| **D2** | 33.8% aromatics<br>65% paraffins<br>1.2% olefins | 767<br>712 | 373<br>436 | 0 | 0 | 46 | 1.8 | 42.8 | 14.7 |

[a] 1,1,3,3 tetraethoxy-propane ($C_{11}H_{24}O_4$)
[b] 2,2,4,4,6,8,8 heptamethyl-nonane ($C_{16}H_{34}$)
[c] tri-propylene-glycol-methyl-ether ($C_{10}H_{22}O_4$)
[d] dibutyl-maleate ($C_{12}H_{20}O_4$)
[e] normal-hexadecane ($C_{16}H_{34}$)
[f] 2-ethylhexyl-nitrate ($C_8H_{17}NO_3$)
[g] Density at a fuel temperature, $T_f$, and atmospheric pressure. The uncertainty is ±2 kg/m$^3$.
[h] Oxygen weight percent.
[i] Oxygen ratio of the fuel. See SAE 2003-01-1791.
[j] Lower Heating Value
[k] Stoichiometric air-to-fuel ratio by mass of the given fuel mixing with simulated ambient at 21% $O_2$, 6.1% $CO_2$, 3.6% $H_2O$, 69.3% $N_2$.

*For further information, contact [Web Grand Pooh-Bar]*
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