



Properties of Aviation Grade E85 (AGE85) and  
Compatibility with 100LL Aviation Gasoline  
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### AGE85 Composition

AGE85 comprises about 87 volume percent (vol%) nondenatured ethanol, 12 vol% pentane isomerate (tipate) from a midwest oil refinery, and 1% biodiesel, and has a Reid vapor pressure of 8.0 psi. Ethanol used for AGE85 must meet specifications described in American Society for Testing and Materials (ASTM) Designation D4806–95b, “Standard Specification for Denatured Fuel Ethanol for Blending with Gasolines for Use as Automotive Spark-Ignition Engine Fuel,” tipate must meet refinery quality control specifications, and biodiesel must meet specifications described in the ASTM provisional designation for biodiesel. Tipate is a relatively light, high-octane, highly isoparaffinic mixture normally used as a gasoline blendstock, with the composition shown in Table 1. Typical tipate research and motor octane numbers are 88.7 and 85.9, respectively.

Table 1 – Tipate Composition

Component	Approximate Volume%
Isobutane	1
normal Butane	1
Isopentane	53
normal Pentane	4
Dimethylbutanes	11
Isohexane	23
normal Hexane	1
Cyclohexane	5
Total	99

### Tipate Suitability as AGE85 Component

Because tipate has essentially no olefins, aromatics (including benzene), or sulfur, it is ideally suited for use as an aviation gasoline blendstock. According to “The Chemistry and Technology of Petroleum,” J.G. Speight, Marcel Dekker, Inc., 1980, aviation gasolines are

composed of paraffins and isoparaffins (50 to 60%), lesser amounts of naphthenes or “cyclics” (20 to 30%), small amounts of aromatics (about 10%) and usually no olefins. Under conditions of use in aircraft, olefins have a tendency to form gum and cause preignition, and have relatively poor antiknock characteristics under lean-mixture (cruising) conditions. For these reasons, olefins are detrimental to aviation gasolines. Aromatics have excellent antiknock characteristics under rich-mixture (takeoff) conditions, but are much like olefins under lean-mixture conditions. Under ASTM Designation D910–97, “Standard Specification for Aviation Gasolines,” sulfur content for all aviation gasolines is limited to a maximum of 0.05 mass% because products of sulfur combustion can cause corrosive wear of engine components.

#### AGE85 Stability and Compatibility with 100LL

A crucial component of the ASTM aviation gasoline specification is the requirement that aviation fuel be stable in resistance to oxidation, because oxidation reactions can yield nonliquid products that clog fuel systems. Of the primary chemical groups that comprise aviation gasoline (paraffins [including isoparaffins and cycloparaffins], aromatics, and small amounts of olefins), olefins are the most reactive and are capable of reacting with many materials. Olefins can react with air to form varnish or rubber-like compounds, or react with other olefins to form gum- or wax-like polymers of higher molecular weight. According to “The Handbook of Aviation Fuel Properties,” Coordinating Research Council Report Number 530, Society of Automotive Engineers, 1983, for turbine fuels, “the specification content of olefins in the final fuel is limited to five percent by volume in order to reduce the formation of gums and polymers which limit the useful life of fuels in storage.” As shown in Table 1, tipate contains essentially all paraffins and no olefins.

The primary component of avgas is “aviation alkylate,” a high-octane, highly isoparaffinic mixture very chemically similar to, but slightly less volatile than tipate. The complete miscibility of tipate with ethanol indicates that AGE85 and avgas should also be completely miscible at any blending combination. Because ethanol water content is limited by ASTM D4806 to a maximum of 1.25 mass%, phase separation of ethanol and tipate should not be a problem. For the same reason, blending AGE85 with various levels of avgas should not present phase separation problems, but this hypothesis could be evaluated with a series of experiments in which AGE85 is blended with increasing levels of avgas and stored for several days over a range of temperatures.

Oxidative stability of aviation gasoline is addressed by ASTM D873, which specifies a potential gum formation maximum of 6 grams (g) per 100 milliliters (mL) over a 5-hour “accelerated aging” period. In recent EERC tests conducted with commercial automotive gasolines, fuels with olefins contents of 3, 6, and 19 vol% were found to have potential gum formation values of 2, 4, and 8 mg/100 mL, respectively, which illustrates the direct relationship of olefins content to gum formation. These results indicate that to meet the ASTM specification, aviation gasolines need to have low olefins levels. Because AGE85 contains no olefins, blending of AGE85 with ASTM-compliant avgas at any level would necessarily reduce the olefins content of the blended fuel, which would likely translate to a reduced gum-forming potential. This

hypothesis could be evaluated via a series of gum-forming tests using AGE85 blended with increasing levels of avgas.