AROMATICS IN AVIATION FUEL

by Paul Millner

Modern, high-performance aviation fuels came out of research undertaken by Standard Oil of New Jersey and others in the 1930s and 1940s. They discovered that combining the hydrogen-poor olefinic light gases that were a side product of catalytic cracking with isobutane in an alkylation reaction resulted in very high-octane (close to 100) gasoline blendstocks.

By simply adding up to four grams/gallon of tetraethyl lead (TEL) to enhance octane, the 100/130 green avgas specification could be met. To achieve the even higher performance 115/145 purple avgas, though, even the allowable eight grams/gallon of lead weren't enough. To enhance the blend, aromatics were added.

Aromatics are simply compounds that contain a six-carbon benzene ring. The simplest aromatic is benzene itself, six carbon atoms plus 12 hydrogen atoms or C6H12 and referred to as a C6 aromatic. Although benzene has decent blending octane, it's the most biohazardous of the aromatics and the most aggressive toward fuel system materials.

In the past few decades, benzene in motor gasoline has been significantly limited to reduce both inhalation and skin-contact hazards, as well as limiting tailpipe emissions.

The next heavier aromatic, toluene or C7, is much more benign. In addition to good octane-blending value, it fits nicely within the distillation and specific gravity specification range for avgas. With the advent of 100LL in the 1980s, limited to two grams/gallon of lead, some blenders added toluene to achieve octane performance, especially at refineries whose alkylate quality wasn't spectacular.

The next heavier aromatic, xylene or C8, comes in three differently shaped isomers and so does the next heavier one, mesitylene or C9. The symmetrical one, 1,3,5 trimethylbenzene, is the most benign C9 and of good octane performance. Historically, little C8 or C9 was included in avgas blends. However, work by Swift Fuels, GAMI and others has demonstrated that tweaking the avgas specification to allow the slightly heavier distillation and specific gravity required to include C8 and C9 aromatics has no discernible adverse effect on engines or performance.

All refineries make at least trace amounts of all the aromatics in normal processing, varying with the content of aromatics and aromatics precursors in the crudes they process. However, only refineries with naphtha reformers—common technology—and aromatics extraction units can make substantial amounts of mostly pure C6, C7 and C8. That capability is common in the Gulf Coast chemical industry.

C9 is more of a specialty chemical, although it can be made from the feedstocks produced by refineries. Due to variations in processing technology and refinery configurations, the composition of these aromatic streams vary from refinery to refinery and from time to time, making predicting their price and availability at all refineries uncertain.

For instance, mixed xylenes are commonly available in a 2:1:1 ratio for meta, ortho and para xylenes, but that can vary significantly depending on processing details. For aviation blending, maximum metaxylene, paraxylene to a freeze point limit and minimum orthoxylene makes the most beneficial impact on the octane blend.

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