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ADVISORY CIRCULAR

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

SUBJECT: ANTI-ICING ADDITIVES TO REDUCE ICING PROBLEMS IN AVIATION GASOLINE

1. PURPOSE. This circular provides information pertaining to the use and approval of anti-icing additives and information about hazards to aircraft operation that may result from the presence of water and ice in aviation gasoline and aircraft fuel systems.

2. REFERENCES.

   a. Advisory Circular AC 20-24A, 4/14/67, Qualification of Fuels, Lubricants, and Additives.

   b. Advisory Circular AC 20-29B, 1/18/72, Use of Aircraft Fuel Anti-Icing Additives (for turbine-powered aircraft fuel systems).

   c. National Research Council of Canada, Mechanical Engineering Report LR-536, Aircraft Carburetor Icing Studies, July 1970.

3. BACKGROUND.

   a. Incidents and accidents which have been attributed to the formation of ice in the engine fuel system have occurred in the operation of military and civil aircraft using reciprocating engines.

   b. Because water in fuel may be exposed to subfreezing temperatures during flight regardless of ground surface temperature, the problem may be present during all seasons of the year.

   c. Engine malfunctions due to ice in the carburetor, fuel injector, or other parts of the system may be difficult to assess after an incident or accident, because the ice will disappear quickly when temperatures above freezing are reached.

Initiated by: AFS-140

4. DISCUSSION.

a. General. Ice formation in aircraft fuel systems results from the presence of water in the fuel system. This water may be undissolved or dissolved. One condition of undissolved water is entrained water which consists of minute water particles suspended in the fuel. This may occur as a result of mechanical agitation of free water or conversion of dissolved water through temperature reduction. Another condition of undissolved water is free water which may be introduced as a result of refueling or the settling of entrained water that collects at the bottom of a fuel tank. Free water is usually present in easily detectable quantities at the bottom of the tank, separated by a continuous interface from the fuel above. Dissolved water (i.e., water in solution with petroleum fuels) constitutes a relatively small part of the total potential water in a particular system, the quantity dissolved being dependent on fuel temperature and the existing pressure and the water solubility characteristics of the fuel.

b. Entrained Water. Entrained water will settle out in time under static conditions and may or may not be drained during normal servicing, depending on the rate at which it is converted to free water. In general, it is not likely that all entrained water can ever be separated from fuel under field conditions. The settling rate depends on a series of factors including temperature, quiescence and droplet size. The droplet size will vary depending upon the mechanics of formation. Usually, the particles are so small as to be invisible to the naked eye but, in extreme cases, can cause slight haziness in the fuel.

c. Free Water. Free water can be drained from a fuel tank through the sump drains which are provided for that purpose.

d. Water in Solution. Water in solution cannot be removed except by dehydration or by converting it through temperature reduction, to entrained, then to free water.

e. Results of Ice in the Fuel System.

(1) Free water, frozen on the bottom of reservoirs such as the fuel tanks and fuel filter, may render water drains useless. Ice can accumulate undetected in these locations in large quantities, and upon melting, release the water into the system, causing engine malfunction or stoppage.

(2) Entrained water will freeze in cold fuel and tend to stay in suspension longer since the specific gravity of ice is approximately the same as that of aviation gasoline.

(3) Water in suspension may freeze and form ice crystals of sufficient size that fuel screens, strainers, and filters may be blocked. Some of this water may be cooled when the fuel enters carburetor air passages and cause carburetor icing, when conditions are not otherwise conducive to this form of icing.

f. Preventing the Formation of Ice in the Fuel System. Heat is used in many turbine-powered airplanes to prevent ice accumulation on fine mesh filters near the engine and in the engine fuel metering components. Another means of preventing ice, widely used in turbine fuels, is by using anti-icing additives. If an anti-icing additive is used in turbine-powered aircraft design, its use becomes an FAA certification limitation, where no fuel heaters are provided. To date, very few approvals have been processed for the use of an anti-icing additive for gasoline in piston-engine-powered aircraft.

g. Anti-Icing Additives in Aviation Gasoline. While the advent of turbine engine transports has caused marked decrease in the number of large piston engine transports, the light aircraft population has increased, using both turbine and reciprocating engines. Interest in utilization of anti-icing additives as a means of preventing problems with water and ice in aviation gasoline has increased. Little work has been accomplished to date, however, to demonstrate that anti-icing additives in aviation gasoline would provide the same degree of protection that they have provided in turbine fuel systems. One salient difference is the lesser solubility of water in gasoline. Some laboratory testing has been conducted on a small scale using simulated aircraft installations. These preliminary tests indicate that the use of hexylene glycol, certain methanol derivatives, and ethyl glycol monomethyl ether (EGME) in small concentrations and in combination with other substances substantially reduced (but did not eliminate) carburetor ice and also inhibited fuel system icing. EGME is the same basic additive used in turbine engine fuel.

h. Problems in Using Anti-Icing Additives.

(1) The concentration of additives in the fuel is critical, the amount depending upon the particular additive used. Marked deterioration in additive effectiveness may result from too little or too much additive.

(2) Some simulated icing tests to evaluate the effectiveness of additives to prevent or minimize carburetor icing have been conducted under laboratory conditions. Results were inconclusive as the tests were not sufficiently comprehensive. Compatibility with engines, fuel tank sealing compounds, and many other interfacing relationships have not yet been evaluated.

(3) The evidence is clear that carburetor icing and aviation gasoline fuel system icing problems are prevented with proper use of aircraft carburetor air heat and by good housekeeping to eliminate water from gasoline and the aircraft fuel system. There is no evidence to indicate whether the use of anti-icing additives would prevent those incidents that resulted from either excessive water in fuel or misuse of carburetor heat.

5. CONCLUSIONS.

a. Additives may be approved for use in aviation gasoline fuel systems of aircraft and engines, and Advisory Circular AC 20-24A describes procedures that may be used for such an approval.

b. Fuel anti-icing additives have been found to have a beneficial effect when properly blended in the fuel of turbine-powered aircraft. Little is known about the degree of benefit that might be expected when used in the fuel systems of aircraft powered by reciprocating engines.

c. Whether or not fuel anti-icing additives for aviation gasoline are approved for use in reciprocating engine powered aircraft, proper maintenance procedures and use of carburetor heat should be continued to prevent icing problems.

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