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ADVISORY CIRCULAR

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

SUBJECT: INDUCTION ICING - PILOT PRECAUTIONS AND PROCEDURES

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1. PURPOSE. This circular has been developed to provide the pilot with information on the causes and results of induction icing in reciprocating aircraft engines, and the precautions he should take to reduce the likelihood of icing, and the means available to him in controlling icing when it is encountered.

2. REFERENCES. The following publications contain practical information on this subject of interest and value to the airplane pilot:

   a. INVESTIGATION OF ICING CHARACTERISTICS OF TYPICAL LIGHT AIRPLANE ENGINE INDUCTION SYSTEMS, NACA TN No. 1790, February 1949.

   b. ICING - PROTECTION REQUIREMENTS FOR RECIPROCATING ENGINE INDUCTION SYSTEMS, NACA Technical Report No. 982, June 1949.

   c. AIRCRAFT ICE PROTECTION, FAA Advisory Circular No. 20-73.

   d. Various AIRCRAFT OWNERS HANDBOOKS, provided by the manufacturers.

   e. CARBURETOR ICE IN GENERAL AVIATION, NTSB Special Report AAS-72-1.

3. PROBLEM. During the latest five-year period for which complete data are available, there was a total of 360 general aviation accidents involving induction icing as a probable cause factor. There were 40 fatalities and 160 persons injured, 40 of them seriously, in these accidents. Forty-seven aircraft were destroyed, and 313 others were substantially damaged. Because induction icing accidents can be attributed to the pilot in virtually all cases, improved pilot awareness, attention, and carefulness should reduce accidents of this type.

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4. KINDS OF INDUCTION ICE. It is important for a pilot to know the kinds of induction system icing and the manner in which each is formed. These kinds of ice may be characterized as IMPACT ICE, FUEL ICE, and THROTTLE ICE.

a. Impact Ice. Impact ice is formed by the striking of moisture-laden air at temperatures below freezing on elements of the induction system which are at temperatures of 32° F. or below. Under these conditions, ice may build up on such components as the air scoops, heat or alternate air valves, intake screens, and protrusions in the carburetor. Pilots should be particularly alert for such icing when flying in snow, sleet, rain, or clouds, especially when they see ice forming on the windshield or leading edge of the wings. The ambient temperature at which impact ice can be expected to build most rapidly is about 25° F., when the supercooled moisture in the air is still in a semiliquid state. This type of icing affects an engine with fuel injection, as well as carburetor engines.

b. Fuel Ice. Fuel ice forms at and downstream from the point where fuel is mixed with the incoming air, if the entrained moisture in the air reaches a freezing temperature as the result of the cooling of the mixture by the vaporization of the fuel. Moisture may then be precipitated from the incoming air and deposited on the walls of the induction passages as condensation. When the temperature is sufficiently reduced, this condensation accumulates as ice, especially on irregularities of the induction system, such as elbows and joints. If this buildup is allowed to continue, the ice may build up until it effectively throttles the engine. Visible moisture in the air is not necessary for fuel icing, sometimes making it difficult for the pilot to believe, unless he is fully aware of the fuel icing effect. Fuel icing is not a problem in systems which inject the fuel at a location beyond which the passages are kept warm by engine heat. Thus, the injection of fuel directly into each cylinder, or into air heated by a supercharger, will probably preclude such icing. Fuel icing may occur at temperatures from 32° to as high as 100° F., and with a relative humidity of 50 percent or above.

c. Throttle Ice. Throttle ice is formed at or near a partially closed throttle, typical of a cruising power setting. This occurs when water vapor in the air condenses and freezes because of the cooling caused by the expansion of the mixture as it passes downstream from the restriction caused by the throttle and the carburetor venturi. In conventional float-type carburetors, throttle icing usually occurs in combination with fuel icing, which compounds the rate of ice accretion within and immediately downstream from the carburetor.

5. INTAKE ICE FORMATION AND PREVENTION. Any one or a combination of the three kinds of induction icing described above can cause a serious loss of power by restricting the flow of the fuel/air mixture to the engine and by interference with the proper fuel/air ratio. It is usually preferable to use carburetor heat or alternate air as an ice prevention means, rather than as a deicer, because fast forming ice which is not immediately recognized by the pilot may significantly lower the amount of heat available from the carburetor heating system. Additionally, to prevent power loss from impact ice, it may be necessary to turn to carburetor heat or alternate air before the selector valve is frozen fast by the accumulation of ice around it. When icing conditions are present, it is wise to guard against a serious buildup before deicing capability is lost. The use of partial heat for ice prevention without some instrumentation to gauge its effect may be worse than none at all under the circumstances. Induction icing is unlikely under extremely cold conditions, because the relative humidity is usually low in cold air, and because such moisture as is present usually consists of ice crystals which pass through the system harmlessly. The use of partial heat when the temperature is below 32° F. may, for example, raise the mixture temperature up to the danger range, whereas full carburetor heat would bring it well above any danger of icing.

6. EXCESSIVE USE OF CARBURETOR HEAT. When no carburetor air or mixture temperature instrumentation is available, the general practice with smaller engines should be to use full heat whenever carburetor heat is applied. With higher output engines, however, especially those with superchargers, discrimination in the use of heat should be exercised because of the possible engine overheating and detonation hazard involved. A pilot of an airplane equipped with a carburetor air or mixture temperature gauge should make it a practice to regulate his carburetor heat by reference to this indicator. In any airplane, the excessive use of heat for full power operations, such as takeoffs or emergency go-arounds, may result in serious reduction in the power developed, as well as the hazard of engine damage. It should be noted that carburetor heat is rarely needed for brief high power operations.

7. INDICATIONS OF INDUCTION ICING. The possibility of induction icing should always be considered when the temperature is between 32° and 70° F. with a relative humidity greater than 50 percent, or when the temperature is below freezing with visible moisture in the air. The effect of induction icing is a gradual, progressive decline in the power delivered by the engine. With a fixed pitch propeller this is evidenced by a loss in engine RPM and a loss of altitude or airspeed unless the throttle is slowly advanced. With a constant speed propeller, there will normally be no change in RPM but the same decrease in airplane performance will occur. With a manifold pressure gauge, a decrease in manifold pressure will be noted before any significant decrease in engine RPM or airplane performance. With an exhaust gas temperature indicator, a decrease in exhaust gas temperature will occur

before any noticeable decrease in engine and airplane performance. If these indications are not noted by the pilot and no corrective action is taken, the decline in engine power will probably continue progressively until it becomes necessary to retrim to maintain altitude; and engine roughness will occur probably followed by backfiring. Beyond this stage, insufficient power may be available to maintain flight; and complete stoppage may occur, especially if the throttle is moved abruptly.

8. PREVENTION PROCEDURES. To prevent accidents due to intake icing, the pilot should regularly use heat under conditions known to be conducive to icing and be alert at all times for indications of icing in the induction system. The following precautions and procedures will tend to reduce the likelihood of intake icing problems:

a. Periodically check the carburetor heat systems and controls for proper condition and operation.

b. Start the engine with the carburetor heat control in the COLD position to avoid possible damage to the system and a fire hazard because of a backfire while starting.

c. As preflight item, check the carburetor heat effectiveness by noting the power drop (when heat is applied) on runup.

d. When the relative humidity is above 50 percent and the temperature is below 70° F., apply carburetor heat briefly immediately before takeoff to remove any ice which may have been accumulated during taxi and runup. Generally, the use of carburetor heat for taxiing is not recommended because of possible ingestion of foreign matter with the unfiltered air admitted with the control in the HOT or ALTERNATE AIR position.

e. Conduct takeoff without carburetor heat, unless extreme intake icing conditions are present.

f. Remain alert for indications of induction system icing during takeoff and climb-out, especially when the relative humidity is above 50 percent, or when visible moisture is present in the atmosphere.

g. With instrumentations such as carburetor or mixture temperature gauges, partial heat should be used to keep the intake temperature in a safe range. Without such instrumentations, full heat should be used intermittently as considered necessary.

h. If induction system ice is suspected of causing a power loss, apply full heat or alternate air. Do not disturb the throttle until improvement is noted. Expect a further power loss momentarily and then a rise in power as the ice is melted.

i. If the ice persists after a period with full heat, gradually advance the throttle to full power and climb at the maximum rate available to produce as much heat as possible. Leaning with the mixture control will generally increase the heat but should be used with caution as it may kill the engine under circumstances in which a restart is impossible.

j. Avoid clouds as much as possible.

k. As a last resort, a severely iced engine may sometimes be relieved by inducing backfiring with the mixture control. This is a critical procedure at best, should not be attempted with supercharged engines, and must be done with the carburetor heat control in the COLD position.

l. Heat should be applied for a short time to warm the induction system before beginning a prolonged descent with the engine throttled and left on during the descent. The pilot should be prepared to turn the heat off after power is regained to resume level flight or initiate a go-around from an abandoned approach.

m. The pilot should remember that intake icing is possible with temperatures as high as 100° F. and the humidity as low as 50 percent. It is most likely, however, with temperatures below 70° F. and the relative humidity above 80 percent. The likelihood of icing increases as the temperature decreases (down to 32° F.) and as the relative humidity increases.

NOTE: The effects and recommendations described in this circular are general in nature and appropriate to most certificated airplanes. The pilot should refer to all available operating instructions and placards pertaining to his airplane to determine whether any special considerations or procedures apply to its operation.

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