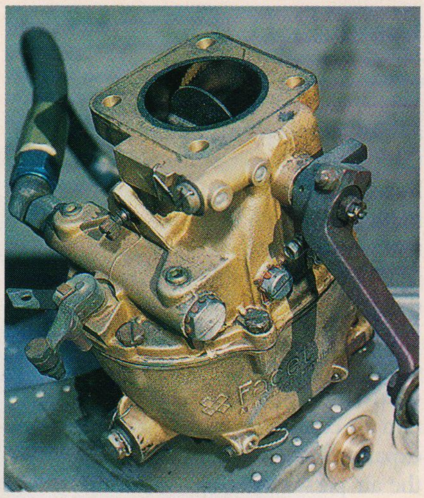
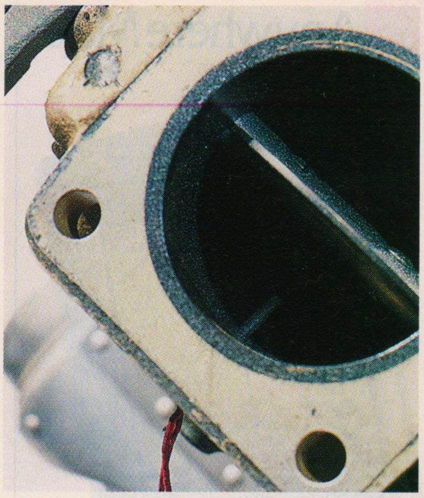
The carburetor provides a place for fuel and air to be mixed and vaporized before combustion. Air entering through the throttle valve flows into a venturi, where the effects of decreasing pressure and evaporating fuel cause a dramatic drop in temperature. Moisture from the air can be lowered to the freezing level and cause the formation of ice.





Carb Ice

Warmer weather and higher humidity make life miserable for your carburetor

By Bill Cox

Photography By C. F. Bales

It happens several times a year: A pilot launches from Ft. Lauderdale or Atlanta or Nashville on a warm spring day in seemingly good weather, climbs to a moderate altitude, sets up normal cruise and inexplicably loses engine power. If the pilot is lucky, power may return automatically as the airplane descends, even without corrective action. If not, he or she may ride the airplane into an emergency landing or, worse, without ever understanding the source of the trouble.

Carburetor ice can be a stealthy killer that sneaks up on a pilot, robs the engine of power so gradually that it's hardly noticeable and often melts and leaves no trace of its presence if the power loss results in an accident. Perhaps worst of all, statistics suggest many pilots misunderstand the nature of the beast, despite training that warns carb ice is nothing if not insidious.

An NTSB study in the late '80s revealed some 360 accidents induced by carburetor ice, resulting in 40 fatalities and 160 injuries. (In this case, "carburetor ice" was a generic term describing all induction-system accidents, whether logged in carbureted or fuel-injected airplanes.) Fully 74% of those carb-ice accidents occurred in clear air without visible moisture. Those statistics are all the more surprising in view of the fact that the large majority (read that as "all") of those accidents could have been prevented by the simple expedient of applying carburetor heat.

No matter how simple the fix, Cessna was so concerned with the carb-ice problem that the company made a major corporate decision in the early '90s to install only fuel-injected engines in its updated line of piston singles, the Skyhawk, Skylane and Stationair.

As most of us learned in primary flight training, the process of converting fuel from liquid to gas (called atomization) results in a dramatic temperature drop inside a carburetor, as much as 70 degrees F. This means even an outside air temperature (OAT) of 90 degrees F doesn't eliminate the threat of carb ice, though according to the NTSB, the normally accepted high-risk zone is said to be between 40 and 80 degrees F.

Technically, there are three types of carburetor ice: impact ice, fuel ice and throttle ice. Impact ice is the most obvious and doesn't require a nuclear brain surgeon to understand. It's simply ice induced by flying through visible moisture—clouds, rain, sleet or snow. By definition, this form of carburetor ice ranges in temperature from about 10 to 32 degrees and needs no help from atomization. When conditions are right, it coats the air scoop, heat valve, carburetor screen, throttle plate and metering elements, and can cause a gradual loss of power.

Unlike impact ice, fuel ice doesn't demand visible moisture of any kind. Instead, it feeds on humidity. Fuel ice is a result of fuel atomization (discussed on the previous page) and is susceptible to huge temperature drops. Moisture in the induction air can freeze as a result of the temperature drop associated with vaporization of fuel. The higher the humidity, the greater the likelihood of fuel ice.

The NTSB report suggests throttle ice occurs at or near "a partly closed throttle (butterfly) when water vapor in the induction air condenses and freezes due to the expansion cooling and lower pressure as the air passes the restriction imposed by the throttle." Because this drop rarely exceeds five degrees F, throttle ice isn't normally considered a problem when OAT is above 37 degrees F or so. Similarly, the construction of some engines makes the problem academic as normal engine heat may keep the butterfly warm.

Whichever form of ice you encounter, the Feds suggest the best course of action is to use the carb heat control as an anti-icer rather than a de-icer. This means, by definition, you'll need to develop the ability to recognize potential carb-ice conditions. It also means you'll be operating with something less than full power, but that may be a small price to pay for the security of knowing that carburetor ice is that much less likely.

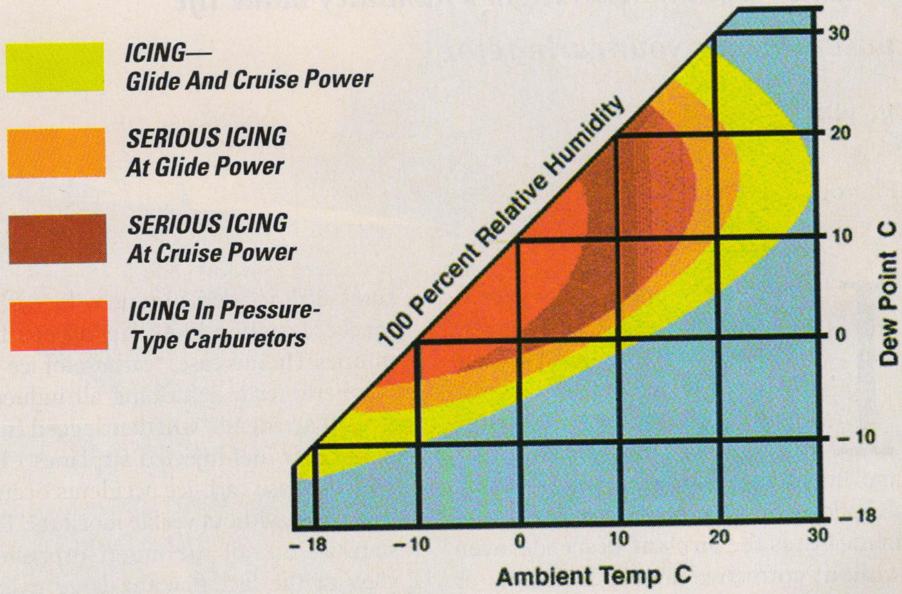
Carburetor heat systems in most general-aviation airplanes take their inlet air from a cuff adjacent to the exhaust manifold. When the pilot selects full carburetor heat, a simple valve opens an alternate intake source from the cuff, blocking off all air from the normal cowling induction system.

The NTSB warns that application of carb heat is better early than late. The report suggests a pilot can fall into the "vicious circle" syndrome if he or she flies on blindly without taking any corrective action: "An uncorrected carb ice condition can mean less power and thus reduced carburetor heat, which may result in the formation of more ice (and on and on). It is certainly prudent to guard against a buildup of carburetor ice before deicing capability is lost entirely."

It's perhaps ironic that very cold air is less likely to induce carburetor icing because of its generally lower humidity content. In flying aircraft delivery trips across the North Atlantic several times each year, I become considerably less concerned about icing of all types (airframe and induction system) in late fall, winter and early spring. Colder temperatures, often well below 20 degrees F, support less moisture, and ice becomes less likely as humidity decreases.

Another common misconception about carburetor icing is that it can't afflict an engine operating at full power. It's true carbureted engines are more susceptible to icing at partial throttle settings, especially the reduced power associated with approach and landing. It's also true an engine at full throttle is generating more heat and the carburetor butterfly valve is parallel to the windstream, presenting less surface for ice accretion, but even that configuration doesn't immunize an engine from the ills of carb ice.

NTSB tests on engines operated at varying power levels in optimum icing conditions verified that idle power is definitely the most at risk, but high power



also can be afflicted. Again, humidity is a key consideration, regardless of power setting. Using max cruise settings, the investigators encountered serious icing at carburetor air temperatures of 62 degrees F and humidity levels of 80% or more. Economy cruise settings resulted in icing to 63 degrees F with relative humidity of 60% or more. Finally, power-off glides resulted in icing at temperatures up to a blistering 93 degrees F with humidity as low as 30%.

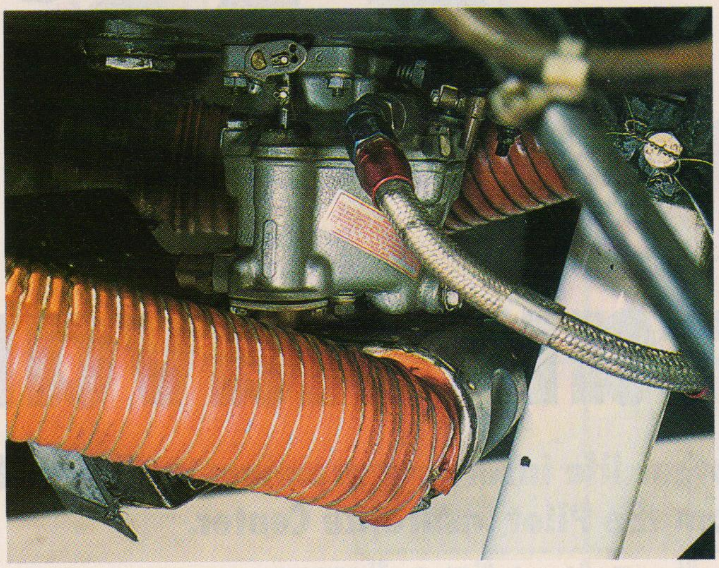
As the tests above suggest, full or high power are no guarantees against icing, especially when humidity is high. In fact, the NTSB survey indicated fully 27% of those 360 carb-ice accidents from the late '80s occurred on takeoff or climb when the throttle was presumably against the forward stop. Admittedly, that may have been a result of icing that occurred at idle in the runup area and was carried over into the takeoff roll, but it proves that full throttle is no panacea.

Even so, the NTSB continues to recommend that the carb heat control be set at full cold for takeoff, climb and go-arounds unless conditions are extreme. If the weather is so severe that you're forced to use carb heat on takeoff, perhaps you should reconsider flying in the first place. If you still insist on aviating, remember to recalculate takeoff distance on the assumption you're operating with 15% less power. One method of determining this figure is to choose a takeoff chart from the *POH* corresponding to 3,000 to 4,000 feet above your current level.

The standard rule, if you have any reason to suspect carb ice before takeoff, is to apply full carburetor heat immediately after completing the runup and leave it on as an anti-ice precaution until just before power-up for takeoff. Remember, though, that carburetor heat is unfiltered air, not routed through the air cleaner. That could be a consideration if you're departing Amarillo in the middle of a Texas dust storm.

According to Cessna, full power also can help as a de-ice measure if you do experience icing in flight. The Cessna Skyhawk 172M pilot's operating handbook recommends adding full power simultaneously while introducing carb heat, an action that will increase engine heat automatically without a loss of power (and might even solve the problem without the need of carb heat).

Traditional wisdom advises you should always use full carb heat or none at all. While that's a good rule of thumb and forefinger, it doesn't tell the whole story, and it may actually get you into more trouble. There are several circumstances when partial heat may do the job better than full-on or full-off. Yes, as every pilot learned in groundschool, partial heat may present problems at certain low OATs, as applying only partial heat may increase the temperature just enough to bring it to the freezing level and actually increase the likelihood of carb ice.



Adding carb heat switches the air flow to the carburetor from ambient air to warmed air ducted directly from the engine. The FAA and many engine manufacturers recommend applying heat any time conditions are conducive to icing. Familiarize yourself with the aircraft's POH and its suggestions regarding carb heat.

If you've already encountered icing, however, and half-heat restores engine power, you may want to stick with that setting to preserve as much power as possible. If temperature and humidity change notably, you may need to readjust your heat setting, but don't be too quick to simply pull the knob full out (or swing the lever full down) and leave it there.

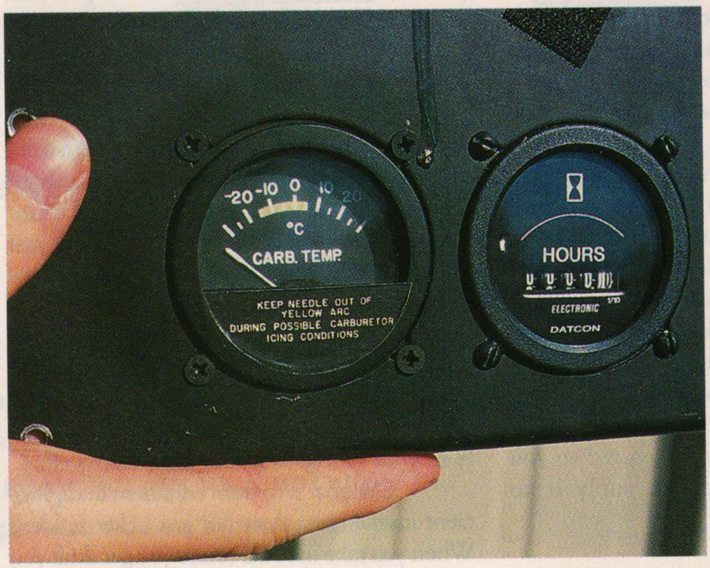
Likewise, don't assume the cure will be instantaneous when you apply carb heat. In fact, the initial application is virtually guaranteed to be frustrating, as it will nearly always result in a further power loss. If you've allowed carb ice to gain a secure foothold in the throat of your engine's carburetor, you may need to wait as long as 30 seconds before you'll see any improvement in power. If even that interval doesn't solve the problem, you may want to consider entering a V_Y climb to reduce cooling air and increase engine heat even more.

Remember that the FAA requires carburetor heat systems to provide a 90-degree-F heat rise. That means activating the little knob or lever on the panel will subtract something like 15% of your total available engine power. That may be acceptable if you have a large pad of airspace between you and the ground or if the load is fairly light. It may be unacceptable if you're flying heavy and trying to split the difference between ice protection and power loss. The same Cessna Skyhawk 172M manual quoted previously suggests, "If conditions require the continued use of carburetor heat in cruise flight, use the minimum amount of heat necessary to prevent ice from forming and lean the mixture slightly for smoothest engine operation."

I've always felt a carburetor air temperature gauge should be mandatory for all carbureted airplanes, especially those equipped with Continental engines. Lycomings are by no means immune from the ills of induction system icing, but the carburetor location on many Lycomings makes them less susceptible to icing, a conclusion supported by operators of the popular Cessna 150 (Continental O-200) and 152 (Lycoming O-235) trainers. Many carbureted airplanes that fly in Alaska and other areas where carb ice is a frequent problem feature a CAT gauge, and you can bet pilots in that part of the world live by its recommendations practically year-round.

On the other hand, don't place blind trust in an outside air temp gauge. The temperature range for carburetor ice is so broad that OAT accuracy barely matters, but be advised aircraft OATs are probably the second least-precise instrument in an airplane (right behind fuel gauges).

Introducing warm, thinner air to a constant fuel mixture will cause a super-rich combination, so you'll need to lean the mixture accordingly if you introduce carb heat. If you're flying without the benefit of an engine analyzer, however, don't be too aggressive with the red knob, as slightly rich is better than slightly lean. On the other hand, don't worry too much about running too lean, as Lycoming reports there has never been a case of detonation associated with the introduction of carb heat.



Commercial carb temperature gauges warn pilots when temperature ranges drop in the danger zone. More importantly, however, is that pilots operating aircraft with float carburetors be aware of atmospheric conditions that are conducive to the problem in the first place.

For a more in-depth discussion of the risks and rewards of carburetor heat, no matter what your experience level, check out Rod Machado's excellent *Private Pilot Handbook*, one of the best sources I know for readable instruction on all things aviation.

Carburetor ice isn't that tough to deal with. There's only one control to worry about and, much of the time, it's either on or off. When in doubt and when you can afford the power loss, turn it on and leave it on until the risk is gone. That's a concept any pilot should be able to grasp.

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