Carburetor Heat: How To

Proper temperature at right time can help you avoid carburetor icing and plug fouling, major causes of engine failures in light aircraft

You're flying along, fat and happy, the engine just purring on this cool fall day. The air is smooth and the weather strictly Victor Fox. You glance over at your passenger and the thought passes through your mind that this is the kind of day that sells airplanes.

Just then your ear, so familiar with the exact accustomed pitch of Old Reliable up front, hears a little roughness. Probably you're over the highest mountain or making that shortcut across a swamp or lake. Quick reflex tells you "carburetor heat." So you grab for the carburetor heat control and pull it full on. By the time your heart has had a chance to skip only a couple of beats, Old Reliable is purring again.

What is carburetor ice? And how does it form when the outside air temperature is nowhere near freezing?

The answer lies in the fact that most light aircraft flying today are equipped with a float type carburetor not yet surpassed by any other system for over-all economy and dependability. However, the Achilles heel of the float carburetor is the fact that fuel is mixed with incoming air just at the point where the pressure of the mixture is reduced intentionally by the shape of the carburetor barrel. The reduction of pressure aids the efficient vaporization of the fuel. But when a volatile fluid is mixed with air and the combination is subjected to a sudden drop in pressure, the temperature drops sharply. This is the principle on which most mechanical refrigerators operate. Your carburetor is one of the prettiest little refrigerators you ever saw.

by KENNETH RICHTER
AOPA 113608

The temperature drop can be as much as 40° F. Usually it is around 25° to 30° F at cruise power. Just how much the drop depends upon several factors:

1. The density of the air.
2. The temperature of the fuel.

An Iced-Up Carburetor Leads To Development Of A New Temperature-Measuring Device

Kenneth Richter, author of "Carburetor Heat: How To Use It," is a man with an inquiring mind. Never satisfied with what he sees before him, the Essex, N. Y., photographer-inventor-astronomer is the type of person who has to see "the other side of the hill"—or if there is a problem involved, he has to solve it.

This quest for knowledge led Ken Richter to take up astronomy and photography while still in his teens at his home in Bridgewater, Mass. Eventually, this trait was responsible for his making an intensive study of carburetor heat and what should be done about it. His article tells how he developed a simple temperature probe, which is rapidly becoming standard equipment in many lightplanes. Success of the Richter Aero Equipment's Type B-5 carburetor temperature probe and gauge has been phenomenal. The efforts of a large segment of the population of Essex, N. Y., have been put to work in order to supply the demand.

Son of a chemist-inventor father and an ex-school teacher mother, Ken got his formal academic training in astronomy at Harvard, but photography always was in the background, helping to pay the bills. Photography finally won out over the planets and stars. In the end, as Ken puts it, "I was like a friend of mine who washed dishes to pay his way through Harvard Law School. When he finished he got a fine job well suited to his talents—and as far as I know he is still washing dishes. I became a photographer."

Next, came five years in Hollywood working on camera crews at major studios. While at Harvard, Ken had been most interested in determining the problems of astronomers in order to develop the technical means of solving them, and had built equipment for the Harvard observatory. In Hollywood, he was soon running a photographic specialty equipment business, building high-precision equipment to solve photographic problems.

Use It

3. And principally, the rate of expansion which in turn is controlled by the power setting and also by the configuration of the intake system.

With all these variables, no wonder the average pilot is instructed, "When in doubt, pull full carburetor heat." But full carburetor heat causes the same power loss that is experienced on hot days. Hot air is less dense than cold air and thus a normal fuel mixture set for ordinary temperatures will be wastefully rich when full carburetor heat is applied.

The same amount of fuel is being fed in at the same rate, but the engine is getting less oxygen to burn it, so power plant efficiency is reduced, and plugs foul with unburned carbon. The power loss can be as much as 15%, meaning that it takes up to 15% more time and fuel to cover a given distance. If you are on that long trip home nonstop, with enough gas to make your unlit home field, and just enough daylight left, an extra fuel stop to replace fuel wasted by the application of full carburetor heat may be the difference between getting home tonight ahead of that front or being stuck in some en route town with nothing to do until the weather blows past.

Actually, there are five points in the fuel system where ice can give trouble. They are:

1. The tanks or fuel line. If water is present it can freeze on cold days or at high altitudes where the standard temperature lapse rate of about 3.5° F per 1,000 feet reduces the outside air temperature below freezing even when the field where you took off is comparatively warm. The remedy for this is to use the gascolator and wing tank drains so that no water remains in the fuel system to freeze.

2. The intake air screen. This can become plugged with snow or slush, and thus cut off air to the engine. You have an alternate air source through the carburetor heater, so the plane will at least continue to fly.

3. Elbows or angles in the air scoop. These can accumulate a deposit of freezing slush that has filtered through the intake screen. But most intake systems are designed so that the carburetor heat duct enters after the last bend, so you are still flying thanks to your alternate air source via the carburetor heater.

4. The carburetor. Of this more below.

5. The intake manifold. An extensive set of experiments by a carburetor manufacturer has shown that in no case was there an important accumulation of manifold ice without a hazardously large ice accumulation already in the carburetor itself.

So the moral would seem to be: the crucial icing point in the whole fuel system is in the carburetor. If this is plugged with ice there is no alternate air source and you go down.

Studies with transparent carburetors have shown that ice forms at the point in the carburetor where the pressure drop begins. The air has been squeezed all the way down the air scoop and then at the point where the fuel is mixed in, the carburetor bore is enlarged. The expanding fuel-air mixture goes into the manifold and thence to the cylinders.

This expansion in the carburetor helps the volatilization of the fuel, which will not burn readily as a liquid. But unfortunately (see your physics textbook), this arrangement makes a very effective refrigerator. If the intake air is moist, the cooler air resulting from the refrigeration effect can no longer sustain the load of moisture and it condenses, usually harmlessly, on the coolest surface around, the carburetor wall and the throttle valve, which have been chilled by the refrigeration effect. If the temperature of the intake air is low enough, the temperature drop in the carburetor can result in the moisture freezing on the walls of the carburetor. The transparent carburetors revealed that ice occurs first as a rim around the edge of the throttle or butterfly valve and a deposit begins to develop on the carburetor wall at

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The Hollywood years have been followed by more than a decade of very successful specialization in foreign film work on educational, documentary and commercial motion pictures. Always interested in the equipment to make the hitherto impossible shot possible, he set up in an unused former barn a machine shop to make the equipment he needed. It was in this barn that he developed his carburetor probe and gauge after that fateful day when he got carburetor ice while flying over the mountains and discovered that the equipment his plane carried was inadequate.

Ken has been flying since 1946. He presently is flying a Cessna 180, and as he puts it, "lands on the front

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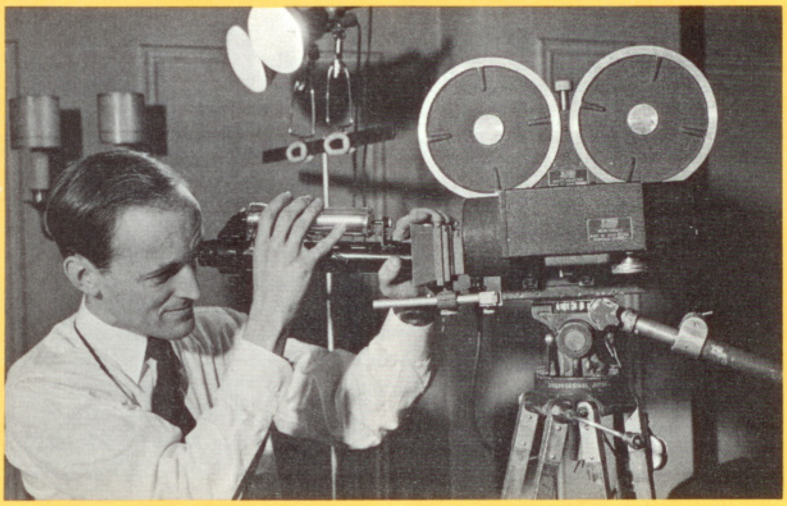
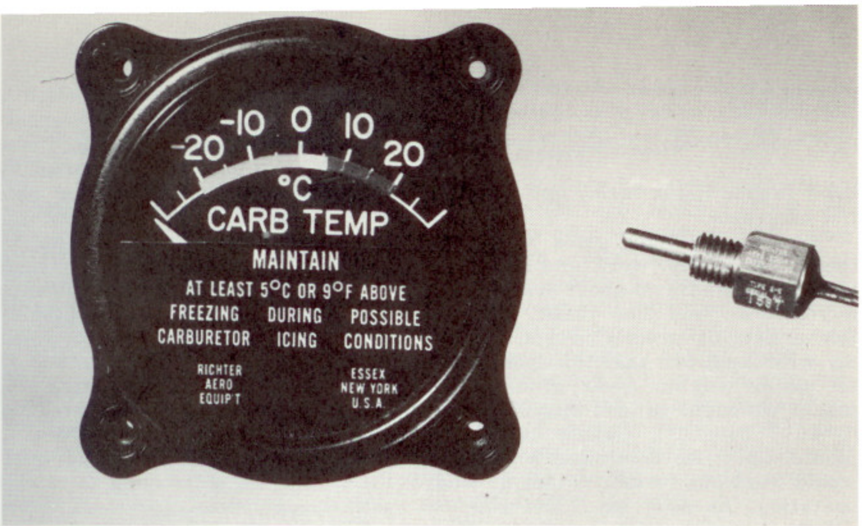


Ken Richter checks his camera with a reflex auto-collimator, a lens checking device he designed and is now building at the Essex, N. Y. plant where the B-5 temperature probe is manufactured



Here is the B-5 carburetor temperature probe and gauge Richter developed. The recently developed gauge has an expanded scale in the vicinity of the freezing point to permit more accurate reading

and told whether the carburetor heater was working, but only indirectly indicated the possibility of carburetor ice. Dependent as it is upon so many different factors, the temperature conducive to the formation of carburetor ice should, it seemed obvious, be measured at the point where the troublesome ice occurs.

The project of evolving a suitable temperature probe and placing it properly appeared easier than it turned out to be. It took three years and the price of a light twin to establish the facilities and conduct the tests, which eventually resulted in a Supplemental Type Certificate for the installation of the probe on licensed aircraft. New carburetors are being supplied already drilled and tapped to accept the probe. Older carburetors have an existing hole, which needs only slight modification, in exactly the right place.

The sensing unit is wound and assembled in a pressurized, dust-free room entered through an air lock. A filter system removes all airborne dirt over 1/75,000 of an inch in diameter. Special machinery and an assembly line operated under microscopes, together with sophisticated electrical and vibration test equipment, qualified the small plant recently for its Federal Aviation Agency Parts Manufacturers Authorization. The product, the Richter Aero Equipment B-5 Carburetor Temperature Probe, has been adopted as factory equipment by leading aircraft manufacturers.

A collateral benefit derived from the use of information provided by the Type B-5 probe has recently come to light as a result of complaints about plug fouling in higher compression engines. A major spark plug manufacturer has found that lead deposits on the plugs in engines using higher octane gasoline are usually the result of inadequate volatilization of the anti-knock compounds used to raise the octane rating of the fuel. Most such fuels contain tetraethyl lead, which if allowed to burn without an inhibitor, would form metallic lead oxide. Therefore another substance, ethylene dibromide, is added to the fuel along with the tetraethyl lead. The combustion product is lead bromide, a fine powder which is readily blown out the exhaust system. But gasoline has a lower vaporization temperature than ethylene dibromide, which in turn vaporizes more readily than tetraethyl lead. So if the mixture is too cold in the carburetor to vaporize all the fuel components properly, the tetraethyl lead may be concentrated in only a part of the engine, in the form of large, heavy droplets, and possibly separated from its inhibiting ethylene dibromide. During combustion, therefore, lead oxide may be formed. This lands on the lowest point in the cylinder, the lower plugs, which then foul out. To avoid this, it has been found that warming the fuel-air mixture in the carburetor will aid the volatilization of all the fuel elements together. Experiments have shown that an indicated temperature of about 5°C (9°F) above freezing measured at the throttle valve will assure proper volatilization, preparing the fuel for maximum efficiency. This results in increased plug life and engine reliability.

Max Conrad (AOPA 95611), that grand fellow of trans-Atlantic lightplane commuting, uses this mixture-warming gimmick in a very foxy way on his long hauls. He takes off the oil radiator, eliminating its weight and drag (and also his fast climbout capabilities). In his engine, the intake manifold, passing through the hot oil sump, runs warmer than usual: 210°F as against 175° normal. This improves his fuel preparation and distribution, he leans a little to compensate for the warmer mixture, and arrives in Paris, San Francisco, or Timbuktu with clean plugs and gas to spare. The average pilot can get the same effect with measured carburetor heat, and keep his oil radiator functional for that hot day climbout.

No pilot trained in recent years is likely to forget how his instructor harped on "carb heat before throttling back just before turning base leg." This may be of value in keeping the carburetor parts warm enough to assist fuel volatilization if power is required, but with the engine demanding a minimum volume of air, the resulting pressure drop or manifold pressure differential is very small. Thus the refrigerating effect in the carburetor is also very much reduced: a temperature drop of only two or three degrees below outside air temperature at idle.

The place where carburetor heat is often needed and not used is in climbout immediately after takeoff. For maximum power at takeoff densest (hence coldest) air is required. But this air may be moist and of a temperature such that carburetor ice will form. Ideal conditions for carburetor ice are around 58°F with humidity 60% or higher. Terrain permitting, proper technique would appear to be cold air for takeoff run, and application of plus 5°C (9°F above freezing) of carburetor heat as measured by the B-5 probe immediately after becoming airborne. The mixture can be leaned after the climb.

The limitation of any carburetor temperature measuring system is that the indication does not supply information concerning the presence of sufficient moisture to form ice. Dew point indications given by air weather stations are a fair indicator of moisture in the air. The closer the dew point to the reported temperature, the higher the humidity. On the other hand it is quite possible to fly ice-free with temperatures 30° to 50° below freezing. Ice formation in carburetors seems to give its principal trouble at or near the actual freezing point, where moisture, condensing on cold metal, begins to build up a deposit, usually starting adjacent to the throttle valve exactly where the Type B-5 probe is located. Laboratory experiments have shown that under conditions of 100% humidity, ice will accumulate in the carburetor at temperatures from freezing down to 18°F (−8°C), possibly lower, as measured at the throttle valve. At lower temperatures moisture will be precipitated out of the air in the form of harmless crystals by the refrigerating effect of the expansion of the gas-air mixture into the manifold. With this expansion—refrigeration effect manufacturing carburetor ice from moist air — the pilot must be alert to keep the carburetor heat level above freezing during conditions of high humidity. If allowed through oversight to drop a degree or two below freezing, the partial use of carburetor heat could bring about icing trouble.

Since more than half of the engine failures in light aircraft are attributed to carburetor icing and plug fouling, proper management of carburetor heat is essential. The Richter Aero Equipment True Carburetor Temperature B-5 Probe, the final element making possible this proper management, has already been installed on over 1,500 lightplanes, single-engine and twins, all over the world. Statistically, a single-engine plane equipped with this system is less likely to have a forced landing due to engine failure than a twin without it. END