Icing And Turbulence

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Understanding and being able to recognize these hazards are essential to pilots who must cope with them

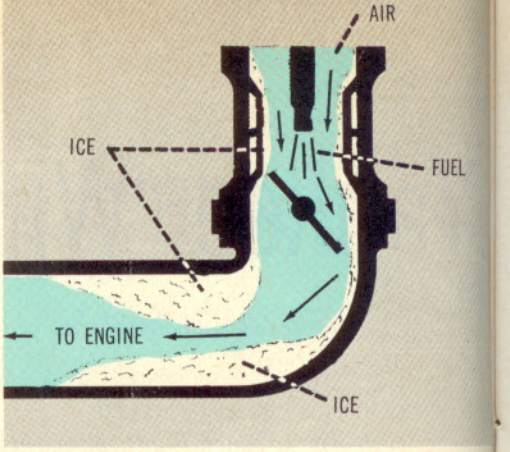


FIGURE 2. Carburetor icing is a frequent cause of engine failure

EDITOR'S NOTE: This article, the third in a series based on the Weather Bureau's proposed "Guide For Aviation Weather Seminars," discusses some preventive and corrective measures the pilot can take to combat icing and turbulence.

Icing and turbulence are elements of the weather that cannot be eliminated. They are, moreover, elements that every pilot is likely to come in contact with at one time or another in his flying. What he knows about them, and to what extent he is qualified to handle them, may often be the deciding factor as to whether he becomes a fatality statistic in the files of the CAB.

Both icing and turbulence are extremely important problems connected with flight. Icing is insidious because it can sneak up without warning on the unknowing pilot, and because it can become overwhelming in so short a time.

Turbulence is dangerous because it puts strain on so many parts of the aircraft in places where it doesn't show; the effects are cumulative and can lead to structural failure.

"An informed pilot," states one observer in the U.S. Weather Bureau in Washington, D.C., "can usually cope with icing and turbulence and by the intelligent use of proper procedures, can prevent many of the serious accidents caused by these two problems connected with flight."

It is with this goal in mind, to inform pilots, that the Weather Bureau is preparing its "Guide For Aviation Weather Seminars." Above all, the pilot should know how to recognize weather hazards and thereby use his weather knowledge to the best advantage in order to promote safe and efficient flight.

There are two fundamental requirements for in-flight ice formation on an aircraft. The aircraft must first be flying through visible water in the form of cloud droplets or rain, and the temperature must be freezing or below.

The VFR pilot is most likely to encounter wing icing from precipitation. This is one of the most dangerous types of icing because it can accumulate fast, and without deicing equipment the pilot is in almost certain danger.

There are two main descriptions of ice—rime and clear. Rime ice is white or milky in color and accumulates on the leading edges of wings and antennas of an aircraft. Its surface is usually rough and has a splintery structure. It is less compact than clear ice and does not adhere tenaciously to exposed objects. Clear ice, on the other hand, adheres firmly to the surfaces upon which it forms and is difficult to remove. It is transparent and has a glassy surface appearance. It also forms on the leading edges of wings and antennas.

The effects of ice on the external surfaces of an airplane are extremely important to the pilot. They are: increased load, increased drag, decreased lift; airfoil dimensions and characteristics are changed; stalling speed is increased; power is decreased (See Figure 1). Ice can also plug the pitot tube and may cause loss of the airspeed indicator, rate of climb gauge and altimeter.

Frost on an aircraft should be another danger signal to the pilot. It forms on cold exposed airfoil surfaces when planes remain outside overnight. Its irregular surfaces change the lift characteristics of wings and increases drag. It should always be removed from the plane before attempting takeoff, because even in short taxi and takeoff runs, the amount of deposit can grow to dangerous proportions. In addition to airfoil icing conditions, the pilot should watch out for "splash ice" which occurs from taxiing through puddles of water when the temperature is below freezing. It can cause malfunction of gear retraction or extension, failure of the gear warning system, and flap extension or retraction. It can also alter airfoil characteristics.

Other on-ground icing conditions occur when an aircraft is brought out of a warm hangar into a snow storm, or into below-freezing temperatures.

The most frequent and serious result of icing conditions is known as carburetor icing and engine failure may result. The temperature of air passing from the intake manifold through the carburetor mixing chamber may drop as much as 60° F within a fraction of

FIGURE 1. Effects of icing are cumulative

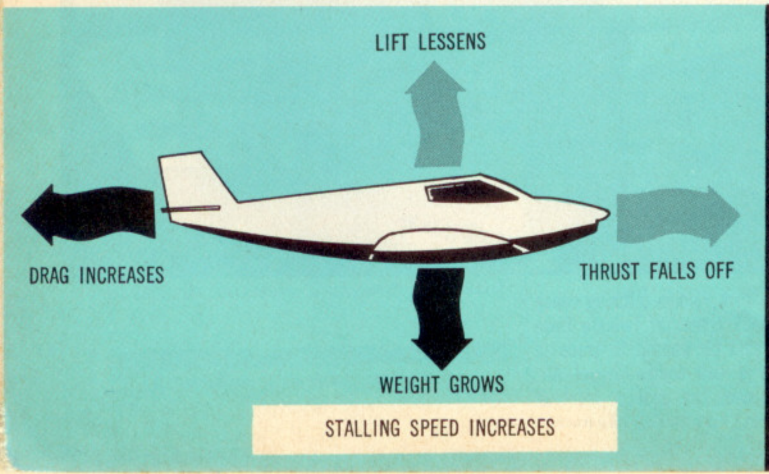
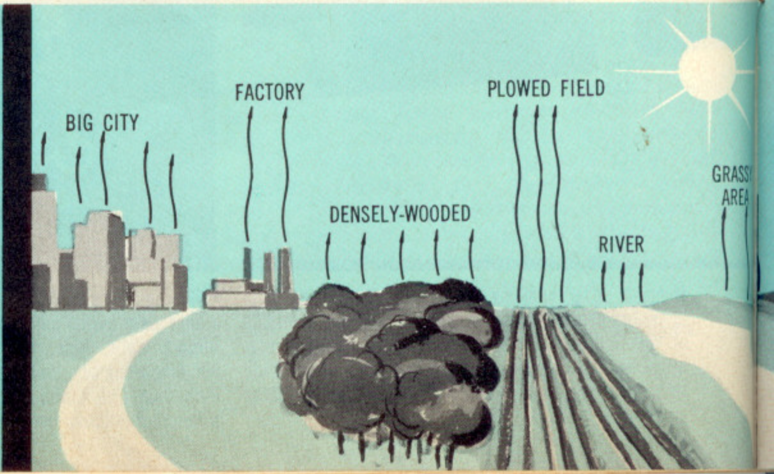


FIGURE 3. Turbulence can result from the disturbed air flow that arises when air moves over irregular or hilly terrain



a second. Water vapor is condensed by this cooling and, if the temperature in the carburetor reaches 32° F or below, the moisture is then deposited as frost or ice inside the carburetor, thus causing loss of power, loss of r.p.m. and possible complete fuel starvation and engine stoppage. (See Figure 2)

Carburetor ice can be removed by application of carburetor heat, but the use of heat cuts down on power, so heat must be used carefully. It is important to recognize carburetor ice early in the stage of formation before loss of engine power becomes serious. Actually, carburetor heat may best be used as a preventive measure against carburetor ice formation.

A pilot should always know his engine's characteristics with respect to carburetor icing, and study the manufacturer's recommendations for use of carburetor heat. Always make it a rule never to attempt to take off without removing all frost, ice or snow from an aircraft. If necessary to taxi through water or slush before takeoff, run the gear and flaps through extension and retraction cycles soon after takeoff to make sure they do not freeze in place.

Before each flight, it is always a good idea to bleed the fuel lines as tank-ice may occur anytime the aircraft is subjected to below-freezing temperatures. Also check the fuel tank vents for type to determine whether they will easily plug up with ice. When they plug, a vacuum is created in the tank and fuel starvation results.

If icing overtakes you suddenly—a lower altitude is the best move, providing it's warmer there. A 180° turn is recommended because flying ahead is a poor risk. Climbing up higher in order to reach warmer temperatures is not for VFR pilots, or for aircraft without deicers. Most important of all factors concerning icing conditions to remember is that trying to fly a plane overloaded with ice is like trying to stretch a glide —you never make it.

Just as likely not to make it is the pilot who loses control of his plane or causes physical damage to it because of turbulence. The lack of knowledge of this factor is the cause of more accidents than we like to think about.

It is helpful to the pilot to understand the principal causes of turbulence in order that he recognize the weather conditions that are most favorable for turbulence and plan his flight to avoid them.

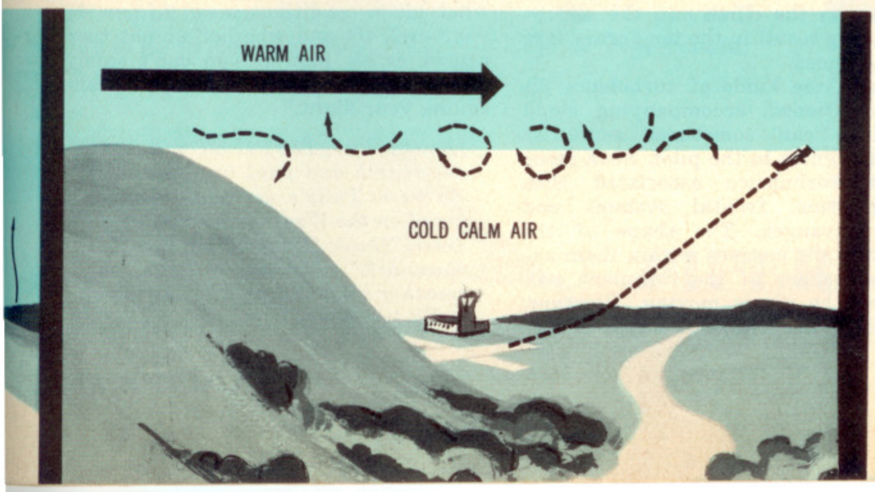
Turbulence affecting an aircraft covers a wide range. It can exist in the form of just a few annoying bumps or it can be severe enough to cause serious structural damage to the aircraft. The intensity of the disturbance varies not only with the irregular atmospheric conditions but also with such airplane characteristics as flight speed, weight, and stability.

Generally speaking, however, turbulence can be placed in three main categories: (1) the disturbed air flow that results when vertical air currents exist such as caused by convection, (i.e., the upward or downward movement, mechanically or thermally produced, of a limited portion of the atmosphere); (2) the disturbed air flow that arises when air moves over irregular or hilly terrain (See Figure 3); (3) the disturbed air flow that is associated with wind shear (See Figure 4). Sometimes two or even all three of these factors can be acting at the same time.

Frequently encountered is the form of turbulence associated with vertically moving air. It is found in and below convective-type clouds, such as cumulus or cumulonimbus. Convection currents are usually caused by heating of the air near the earth's surface and they occur mostly on warm summer afternoons when the wind is light. The strength of a convective current partially depends on the extent to which the ground is heated. If heated enough or disturbed in some way, bubbles of warm air rise as convective currents until they reach a level where the temperature of the rising air is the same as the surrounding air. This is usually a height of several thousand feet or more. Rising columns of air can be present without one seeing a convective-type cloud because the rising air may not contain sufficient moisture to cause a cloud. Also, there are compensating downward-moving currents that are found near areas of rising air and these add to the turbulence effects.

Convective-type turbulence also occurs when a cold air mass travels over a warm surface or if the air loft is being replaced by colder air to the

FIGURE 4. Disturbed air flow that is associated with wind shear produces turbulence



extent that the atmosphere becomes unstable. For example, in the fall or very early winter, ground surfaces are still relatively warm. Thus when an outbreak of cool weather occurs, it passes over the warm surface below, is heated and thereby becomes unstable. Considerable bumpiness results to heights of several thousand feet or more within the area over which the cold air passes.

As the pilot flies through a series of convective currents, the frequency of the bumpiness increases with the speed of the aircraft since it hits more of the currents in a given amount of time.

The turbulence that results from air as it flows over irregular terrain or other obstructions is referred to as mechanical turbulence. It is usually confined to lower altitudes (500-1,000 feet) and is dependent on the strength of the surface wind. This type of turbulence is most dangerous to landings and takeoffs. When the wind is faster and ground obstructions are larger, the turbulence increases and extends to higher levels. If winds blowing across a mountain range, for instance, are strong enough, the resulting turbulence on the lee side can reach dangerous proportions. As a result, updrafts and downdrafts may extend to heights considerably above the level of the mountain crests. Turbulence in such an area may be severe enough to cause structural damage and the downdrafts in some instances may exceed the aircraft's rate of climb and therefore hurl it to the ground.

The wind-shear type of turbulence can best be described as a situation in which there is a change in wind speed or in the wind direction in a short distance. This results in a "tearing" or "shearing" effect. This condition can exist in a horizontal or vertical plane or sometimes in both. It may exist at any altitude, in or out of clouds.

To further exemplify this, let us take an airport that is located in a valley. Cooling takes place near the surface, such as occurs on a clear, calm night. A small pocket of cool air results, probably only a few hundred feet thick. This pocket is overlaid with warmer air that is moving.

Because of the different speeds at which these two air currents are moving, a narrow zone of wind shear forms along their boundary. Therefore a pilot taking off will encounter turbulence as he passes through the "shear zone" into the warmer air. Should the direction of the wind above the cold layer be the same as the climb out, the abrupt change may result in the temporary loss of flying speed.

In the three kinds of turbulence already mentioned, accompanying cloud formations can sometimes serve as warning signals to the pilot. Such cases take in turbulence associated with thunderstorms, frontal systems and mountain ranges. The shape of the clouds and the motions within them are good indications of the turbulent way in which the air is moving. However, pilots today are aware of a type of turbulence that was almost unknown 10 years ago—"clear air turbulence." It may be caused by the passage of an aircraft through the air, or the wind shear in the vicinity of a jet stream. This form of turbulence occurs without any visual warning at all and can happen at any altitude. For instance, turbulence when experienced in the wake of another aircraft near the ground during a landing or takeoff occasionally results in complete loss of control of the aircraft without adequate altitude for recovery. This is why it is a sound safety measure to always allow plenty of time between successive landings or takeoffs. Additional preventive or corrective measures to combat turbulence are:

1. Low-level mechanical turbulence can often be avoided by selecting a slightly higher altitude. If cumulus clouds are present at low levels, an altitude just above them will be smooth.
2. If turbulence cannot be avoided by altitude change, reduced airspeed is advised to decrease strain on the aircraft. Lowering the landing gear is often helpful to reduce speed. On landing, sufficient power and speed should be used to give positive control. A high approach is better than a low approach.
3. Proper spacing in takeoff and landing behind larger aircraft will allow prop-wash or jet-wash to dissipate. On a calm day, a wait of several minutes is advisable. Never position a small aircraft for holding on the ground in the blast from engine run-up of a large aircraft.
4. When convective or dynamic turbulence is present, a change of altitude usually does not help—only slower air speed. In thunderstorms, the greater turbulence is at higher altitudes.
5. In mountainous terrain, have extra altitude when approaching a ridge upwind; downdrafts are worse on the lee side. Remember that sustained downdrafts from mountain waves can exceed the rate of climb of many small aircraft.

The above rules of thumb were taken from the U.S. Weather Bureau's "Guide For Aviation Weather Seminars." All who worked on this guide with the hope of promoting safer flying habits echo the same words:

"It is not enough to call 'weather' before taking off. You have to *know* what given conditions mean to *you*, to your *aircraft* and whether or not they can be safely met. If you can't safely meet them, it is better to consider cancelling your flight."

(Next month, The PILOT will carry the fourth and final installment of Barbara Tully's series of articles based on the Weather Bureau's proposed "Guide For Aviation Weather Seminars." It will discuss the weather map and weather services. —Ed.)