COCKPIT CLASSROOM...

By Harold Holmes

HAZARDOUS WEATHER

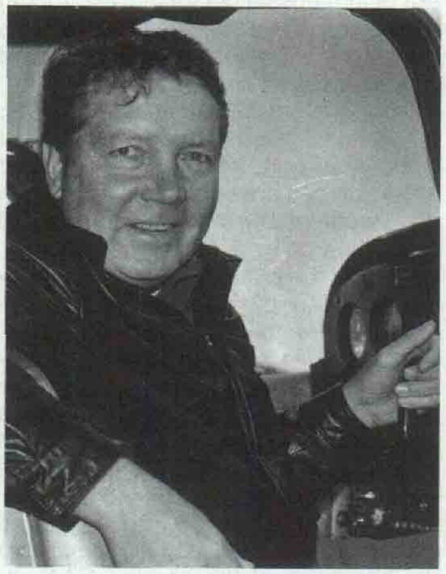
In January of this year, the FAA launched a "Back to Basics" program to improve general aviation safety. Thus far, the new program has been well received by the flying public. Take-offs and landings were reviewed the first quarter of 1986 before all aviation groups, including fixed base operators, aviation clubs, women's groups such as the 99's, and other groups interested in aviation safety. The "Back to Basics" audio visual program is an excellent sponsorship by EAA Chapters at their regular or special meetings. The talks and visual presentations are being given by FAA's Accident Prevention Specialists. "Back to Basics" started in January by reviewing take-offs and landings for the first three month period. Weather and weather related accidents were reviewed during the second quarter (April, May and June), followed by fueling problems and misfueling during July, August and September. In October through December, the topic of collision avoidance will be the major issue.

This article on hazardous weather is intended to coincide with the "Back to Basics" effort. Weather is an immensely broad subject area, therefore, I would like to limit it to atmospheric turbulence including the sub-topics of turbulence in general, mechanical turbulence, thermal turbulence, wind shear and gusts and turbulence penetration procedures.

Turbulence (General)

In general terms, turbulence is an atmospheric phenomenon associated with irregular movement of air. Turbulence is felt on the ground, as changes in strength and direction of the wind, e.g., movement of tree branches, blowing of smoke or dust, ripple patterns on water surfaces, etc.

The intensity and frequency of air movement, on the ground or in flight, is unpredictable. However, to a pilot and his or her passengers, turbulence is experienced in several ways, such as a series of up and down movements or different accelerations in pitch, roll or yaw or any combination of these movements. The entire range can vary from slightly perceptible movement to severe oscillations. In other words, the effect that turbulence has on an airplane in flight varies with the type of turbulence,



its severity or the magnitude of the up and down gusts. Fortunately for those of us who fly, there is only a slight chance that turbulence by itself causes structural failure even during severe turbulence.

Microburst

However, wind shear and gusts can endanger planes for other reasons. Once an aircraft enters wind shear (microburst), it encounters an increase in headwinds radiating away from the center of the downdraft. This increase in headwinds enhances the airflow over the wings, causing the nose of the airplane to pitch up and forcing the pilot to reduce power. Next, as the plane passes through the downdraft center, the headwind decreases abruptly and becomes a tail wind, and the airflow over the wings decreases with a loss of lift. At this point, the aircraft could stall and sink rapidly to the ground. Here the critical factor is the speed at which the gusts are encountered. Of course, the higher the airspeed, the greater the load on the aircraft, especially at speeds higher and (Va) maneuvering speed.

Gust Induced Stall

This past spring and summer we have had to maintain speeds below Va numerous times to prevent overstressing the aircraft structure. We have had more than our share of days when turbulence has been out of control, or in excess of 30 knots and gusting. A review of accident statistics shows that the problem is not structural failure; instead, it is loss of control caused by severe turbulence. For instance, if airspeed is too low on final, a gust-induced stall at a low altitude, may be difficult to avoid and recovery impossible even for the professional pilot. This type of stall can be caused by a vertical gust close to the ground. It can have a most serious effect on an airplane (FAA). Sudden changes in velocity or wind direction will always effect lift, IAS and thrust requirements.

From our "Cockpit Classroom" viewpoint, the main effect of the vertical gust will produce a change in the airplane's angle of attack. A positive (up) gust causes an increase in the wing's angle of attack. A negative (down) gust results in a decrease in the angle of attack (see Diagram 1).

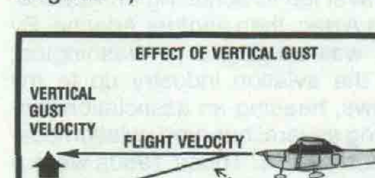


DIAGRAM 1

In accidents in the past two years, I have noted four landing accidents at nearby airports where high winds and gusty conditions were a major factor. Two were low time student pilots attempting to land in gusts exceeding 30 knots. I had landed a Cessna 172 at one of the airports 30 minutes prior to one of the accidents involving a student pilot. I found the gusts and wind shear on final almost beyond my limits. One of the student pilots attempted to land a Cessna 152 in the conditions described. According to eye-witness reports, the student pilot applied full flaps on final over the trees. Then, after reaching a three foot altitude above the runway, the student encountered a strong gust which lifted the airplane to approximately 30 feet. This was followed by a stall, causing the aircraft to crash in a nose down attitude. The aircraft was totalled and the student pilot received serious injuries.

Here is a situation where the student's instructor should have used better judgment by not allowing the fledgling student to fly in high wind gusts exceeding the student's capabilities. Again, from our point of view, another lesson can be learned here. Using full flaps in wind gusts can create problems. Flaps are a high-lift device, causing the airplane to become airborne in gusts after contacting the runway. Full flaps should not be used in high winds. Other times when full flaps should not be used are when one has allowed the airspeed to become too low; anytime there is the risk of a wind gradient; when descending below 200 feet. The cases we have just reviewed — flying in strong winds, crosswinds and/or strong gusts — negate the use of flaps. At low airspeeds, like during an approach, the effects of vertical gusts (see Diagram 1) **will** change the angle of attack. At approach speeds, the problem is one of stalling and sinking rather than overstress. Remember that at low speeds, the airplane is already at a higher than normal angle of attack and any further increases in the angle of attack could cause a stall.

A gust could cause the wing to exceed the critical angle of attack (see Diagram 1). Another factor to consider is a decrease in angle of attack. This will cause a loss of lift along with a decrease in airspeed followed by a **high sink** rate close to the ground (see Diagram 2). This situation could be dangerous, especially if there is a substantial decrease in airspeed during gusty conditions. A good rule of thumb when approaching a runway under gusty conditions is to add 5 to 15 knots to airspeed depending on the airplane. Use a power-assisted approach until the aircraft is near the ground (2 to 3 feet), then close the throttle.

Mechanical Turbulence

Mechanical turbulence is caused by resistance to free airflow resulting from objects such as buildings, hills, trees and mountains. Mechanical turbulence is an everyday hazard to light aircraft during taxiing, take-off and landing. When it occurs, the normal airflow (horizontal) is disturbed and the results are various patterns of eddies and other irregular wind patterns (see Diagram 3). In conditions of light winds, the eddies — rotating masses of air — are of relatively low intensity and remain relatively close to the windward side of the obstructions. If the winds are strong, the eddies become more intense and are carried quite a distance downwind from the trees, hangars, buildings and obstructions causing them. In winds greater than 20 knots, mechanical turbulence is likely to have more effect on the lateral and horizontal axis of an airplane attempting to take off or land. The severity of this type of turbulence depends on the stability or instability of the air, the windspeed and the nature and shape of the obstruction causing the turbulence (see diagram 3).

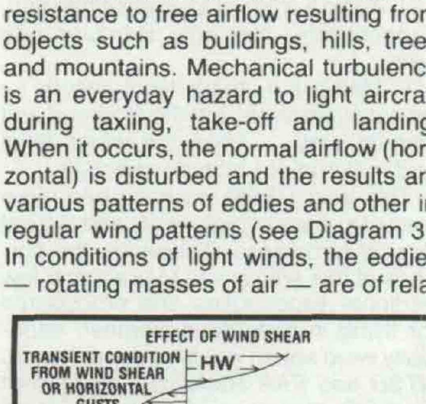


DIAGRAM 2

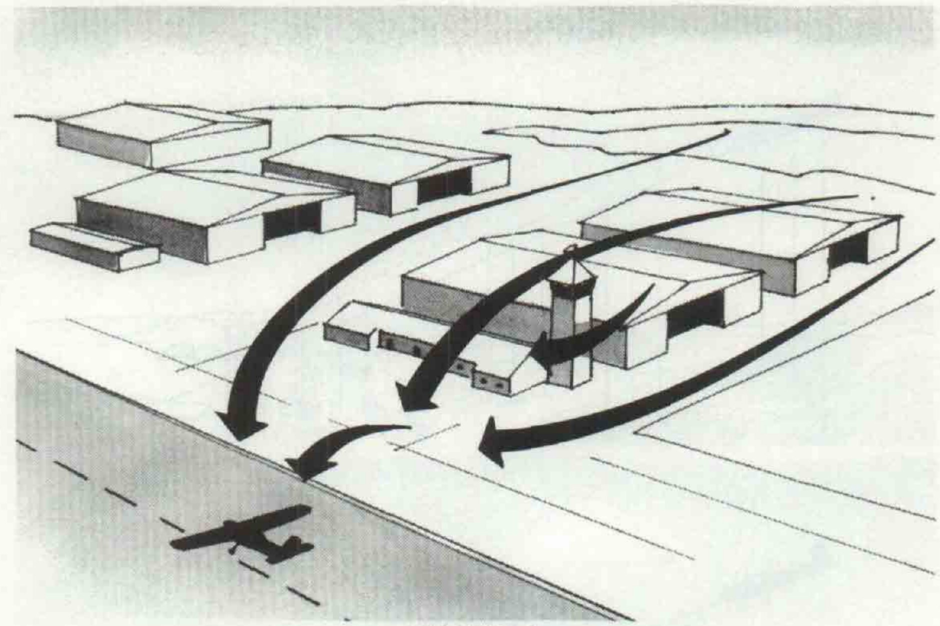


DIAGRAM 3

Thermal Turbulence

A steady wind is certainly of some benefit during landing in that it reduces the touchdown speed (ground speed). It also reduces the length of the landing roll; whereas, gusty wind conditions can be all that an inexperienced pilot can handle. Even a minor distraction could present a serious hazard to the inexperienced pilot.

Thermal turbulence is produced by differential surface heating or by atmospheric instability. Solar heating of different types of surfaces (green crops, brown crop stubble, gravel, water, trees, pavements, rivers, swamps, etc — see Diagram 4) produce different temperatures. The air immediately above each type of surface will be affected and will create updrafts and downdrafts of varying intensities. The uneven heating of the surface on a clear, sunny day, can cause eddies and gusts which can affect the approach and landing. However, the most violent gusts are associated with thunderstorms and line squalls which can present real problems to pilots, especially those with little experience. Remember, this type of turbulence can be uncomfortable even to experienced passengers. Attention may be needed, especially during an approach to a landing during downdrafts, to counter undershooting the runway (see Diagram 2). During an approach to a landing, the updrafts, downdrafts and horizontal gusts can have the following effects: 1) a sudden increase in airspeed, 2) a sudden decrease in airspeed, and 3) a sudden change in angle of attack. Therefore, in order to maintain proper control, the approach under gusts (updrafts/downdrafts) should be accomplished with partial flap. Also, anytime gusty conditions are encountered, add a few knots to your airspeed.

It is important to consider using a power assisted approach when landing in winds in excess of 20 knots. Turbulence is likely to have a noticeable effect on the flying characteristics of your airplane when attempting to take off or land.

Overshooting/Undershooting Runway

Pilot awareness is needed during times of turbulence to counter any tendency to overshoot or undershoot the runway. The proper term to use here is low level wind shear. This can effect the control of the aircraft's desired approach path and/or airspeed. Wind shear and turbulence are somewhat related, but they are not the same thing. It is entirely possible to have wind shear without having turbulence. Low level wind shear can play havoc with any size aircraft and a significant number of accidents have been caused by wind shear. It is usually produced by cold and warm fronts and sometimes by temperature inversions. The effects of wind shear are apparent when the wind speed changes faster than the aircraft. There will be some lag in airspeed to catch up to the new speed changes needed as the airplane accelerates or decelerates.

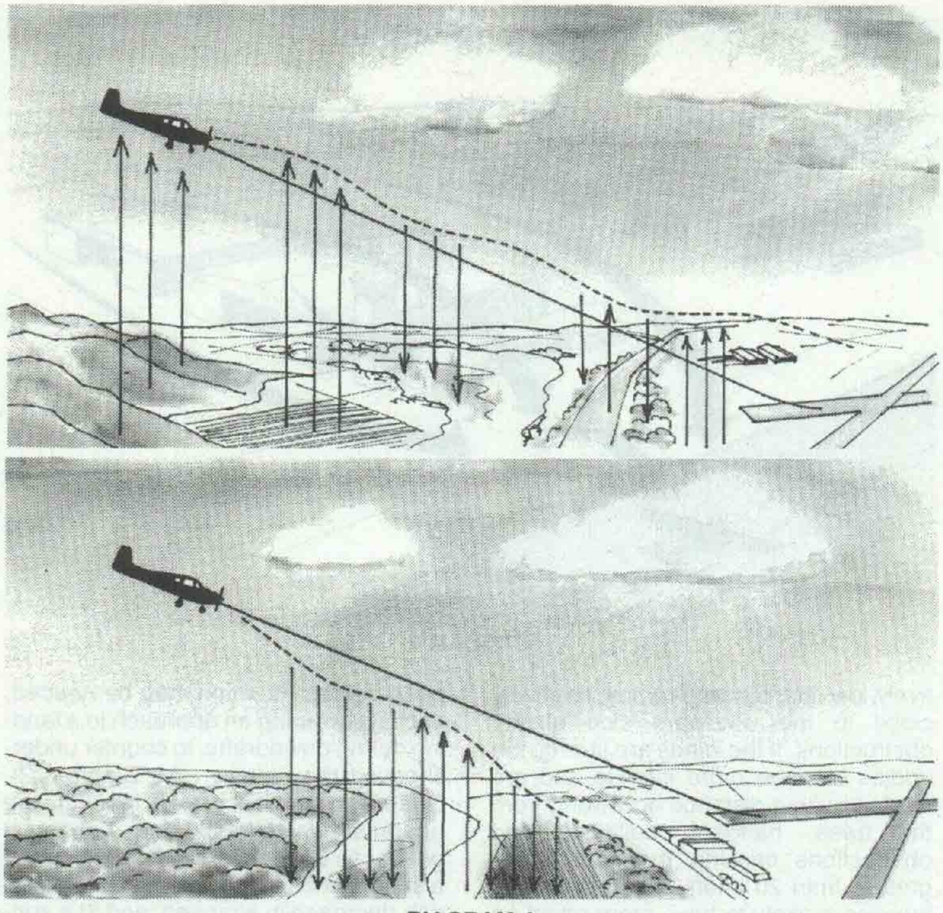


DIAGRAM 4

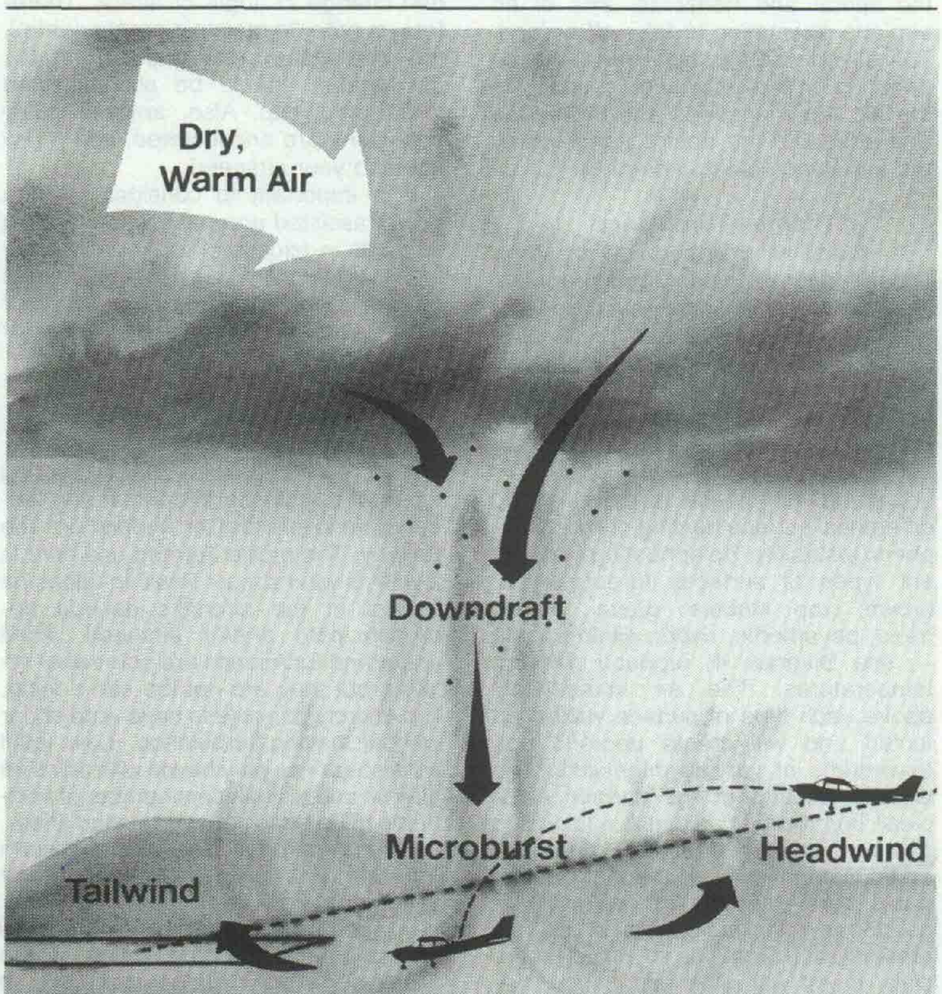


DIAGRAM 5

Here the effect of wind shear on aircraft control depends on the stability characteristics of the plane, its airspeed power, weight and power response of the engines.

In Diagram 5, we can see the effects of overshoot wind shear. Overshoot shear will have the initial effect of increasing airspeed; whereas, undershoot shear is caused by a decrease in headwind or tailwind relative to the airplane's flight path. Our lesson stresses that overshooting the flight path necessitates reducing power and undershoot shear can be handled by adding power. The important thing here is to stay on the glide path and controlling either types of shear with power. This, again, emphasizes the point that it is important to fly the desired flight path at all times.

Turbulence Penetration

Next, I wish to discuss turbulence penetration procedures. On a recent flight test, the private pilot applicant and I experienced moderate to severe turbulence which was not forecasted. Fortunately, when we encountered the turbulence we were performing a slow flight maneuver at 3000 ft. AGL. Our airspeed was much below (Va) maneuvering airspeed in the Cessna 152. After landing, the applicant and I discussed important procedures which need to be considered when encountering turbulence.

1. First of all, slow the aircraft below its maneuvering airspeed and adjust the power to maintain level flight.

2. Check the safety belt and harness for a snug fit and be sure to secure any loose articles in the airplane. (Both my applicant and I felt fortunate that we had our safety belts and shoulder harnesses tight.)

3. Flaps need to be in the up position to reduce the chance of a stall.

4. Avoid turning, if at all possible, and, if necessary, use only standard rate turns.

5. Maintain a steady flight attitude — do not overcontrol. Let the airspeed and altitude vary — keep the wings level and make minor attitude changes.

This year (1986) we have had more than our share of high winds and a great deal of turbulence. Therefore, the purpose of this article was to present a few personal experiences and procedures for flying in hazardous weather, especially wind shear, gusts and turbulence. NTSB and FAA statistics indicate that most light plane accidents and incidents are in high winds and gusts.

If you wish to contact the author for additional information, please write Harold Holmes, Department of Safety Studies Injury Research Laboratory, University of Wisconsin-Whitewater, Whitewater, WI 53190.