AC NO: 00-50

DATE: 4/8/76

ADVISORY CIRCULAR

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

SUBJECT: LOW LEVEL WIND SHEAR

1. PURPOSE.

This Advisory Circular is intended to provide guidance for recognizing the meteorological situations that produce the phenomenon widely known as low level wind shear. It describes both preflight and in-flight procedures for recognizing this phenomenon as well as pilot techniques that minimize its effects on takeoffs and serve to preclude short or long landings.

2. REFERENCE.

Daniel F. Sowa, "Low Level Wind Shear, Its Effects on Approach and Climbout" *D.C. Flight Approach*, (June 1974), published by Douglas Aircraft Co.

3. BACKGROUND.

a. Wind shear is best described as a change in wind direction and/or speed in a very short distance in the atmosphere. Under certain conditions, the atmosphere is capable of producing some dramatic shears very close to the ground; for example, wind direction changes of 180 degrees and speed changes of 50 knots or more within 200 feet of the ground have been observed. This, however, is not something encountered every day. It is, in fact, the unusual. That's what makes it more of a problem. It has been said that wind cannot affect an aircraft once it is flying except for drift and groundspeed. This is true with steady winds or winds that change gradually. This isn't true, however, if the wind changes faster than the aircraft mass can be accelerated or decelerated.

b. The most prominent meteorological phenomena that cause significant low level wind shear problems are thunderstorms and certain frontal systems at or near the airport.

4. EFFECT OF WIND SHEAR—AIRCRAFT REACTION.

Basically, there are two potentially hazardous shear situations. First, a tailwind may shear to either a calm or headwind component. In this instance, initially the airspeed increases, the aircraft pitches up and the altitude increases (Figure 1). Second, a headwind may shear to a calm

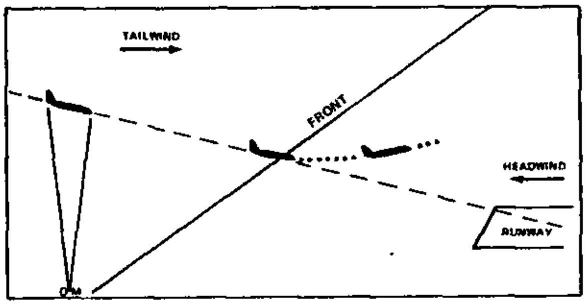

FIGURE 1

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or tailwind component. Initially, the airspeed decreases, the aircraft pitches down and the altitude decreases (Figure 2). Aircraft speed, aerodynamic characteristics, power/weight ratio, powerplant response time and pilot reactions along with other factors have a bearing on wind shear effects. It is important, however, to remember that shear can cause problems for ANY aircraft and ANY pilot.

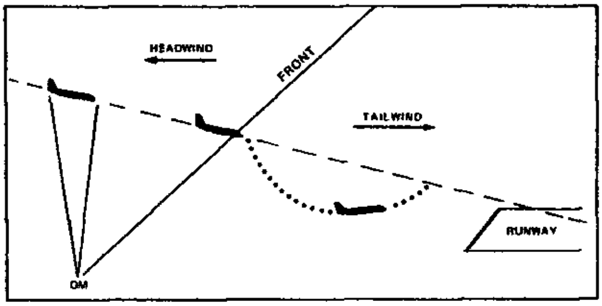

FIGURE 2

5. WIND SHEAR CAUSES.

a. Thunderstorms. The winds around a thunderstorm are complex. Wind shear can be found on all sides of a cell. The wind shift line or gust front associated with thunderstorms can precede the actual storm by up to 15 nautical miles. Consequently, if a thunderstorm is near an airport of intended landing or takeoff, low level wind shear hazards may exist (Figure 3).

b. Fronts. While the direction of the winds above and below a front can be accurately determined, existing procedures do not provide precise, current measurements of the height of the front above the airport. The following is a method of determining the approximate height of the front, with the consideration that wind shear is most critical when it occurs close to the ground.

(1) This occurs with a cold front just after the front passes the airport and for a short period thereafter. If the front is moving 30 knots or more, the frontal surface will usually be 5000 feet above the airport about three hours after the frontal passage.

(2) With a warm front, the most critical period is before the front passes the airport. Warm front shear may exist below 5000 feet for approximately six hours; the problem ceases to exist after the front passes the airport. Data compiled on wind shear indicate that the amount of shear in warm fronts is much greater than that found in cold fronts.

(3) Turbulence may or may not exist in wind shear conditions. If the surface wind under the front is strong and gusty, there will be some turbulence associated with wind shear.

6. SUMMARY.

a. Weather.

(1) If thunderstorms are observed at or near the airport, be alert for the possibility of wind

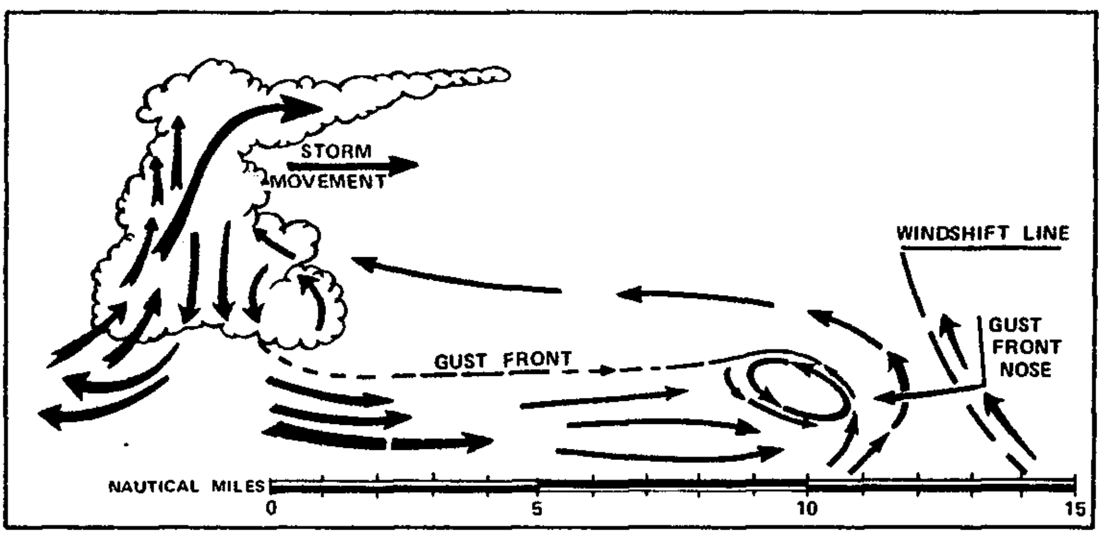

FIGURE 3

shear in the departure or arrival areas. Under these conditions, large changes in wind direction and speed can occur.

(2) Check the surface weather charts for frontal activity: (a) Determine the surface temperature difference immediately across the front; and (b) the speed at which the front is moving (a 10°F [5°C] or greater temperature differential, and/or a frontal speed of 30 knots or more, is an indication of the possible existence of significant low level wind shear).

(3) If frontal activity does exist: (a) Note the surface wind direction to determine the location of the front with respect to the airport; and (b) compare the surface wind direction and speed with the wind above the front to determine the potential wind shear during climbout or approach.

b. Aircraft Performance.

(1) *Departure Area.* Wind shear can create hazardous conditions during takeoff. The rule of thumb for the effect of wind shear on aircraft performance is as follows:

(a) An increasing headwind or decreasing tailwind when encountered will cause an increase in indicated airspeed. If the wind shear is great enough, the aircraft will initially pitch up due to the increase in lift. After encountering the shear, if the wind remains constant, aircraft groundspeed will gradually decrease and indicated airspeed will return to its original value. This situation would lead to increased aircraft performance. Normally, it should not cause a problem if the pilot is aware of how this shear affects the aircraft.

(b) The worst situation on departure occurs when the aircraft encounters an "altitude" wind on the other side of the front that is a tailwind or rapidly decreasing headwind. Taking off under these circumstances would lead to a decreased performance condition. An increasing tailwind or decreasing headwind, when encountered, will cause a decrease in indicated airspeed. If the wind shear is great enough, the aircraft will initially pitch down due to the decreased lift. After encountering the shear, if the wind remains constant, aircraft groundspeed will gradually increase and indicated airspeed will return to its original value.

(c) When the presence of wind shear is suspected for departure, the pilot should consider delaying takeoff until conditions are right. If the decision is made to take off, the pilot should determine the best direction for climbout to avoid a performance decreasing situation and request appropriate ATC clearance for departure. This preventive measure is the most effective way to combat wind shear during climbout. The flightcrew should be briefed on the weather situation and be prepared to assess sudden pitch attitude changes and, most importantly, rate of climb. When an unusually high rate of climb is encountered, control column forces should not be trimmed out with the stabilizer, and airspeed should be increased in anticipation of wind shearing out. A sudden decrease in headwind will cause a loss in airspeed equal to the amount of wind shear.

(2) *The Approach.* The probability of encountering wind shear during the approach should be assessed as described previously. The pilot should, however, supplement this information with a comparison of the latest wind directions and speeds at various stations in the vicinity of the destination. In the terminal area and during the approach, the pilot should monitor the navigation system wind, if the aircraft is so equipped, and compare it with the surface wind for a low level wind shear indication. When wind from the navigation system is not available during the approach, the difference of the navigation system groundspeed and the TAS should be compared with the surface headwind or tailwind component as a measure of shear. The pilot should: (a) Brief the flightcrew on possible shear conditions, (b) if runway length permits and you are anticipating a headwind to shear to a calm or tailwind, consider the use of a reduced certificated landing flap setting and add an increment of speed to the normal approach speed, (c) instruct the crew to monitor Power, Pitch Attitude, Airspeed, and Vertical Velocity. If higher than normal power is required and vertical velocity is lower than nor-

mal to maintain glide slope while wind on the surface is either a tailwind, calm or very light headwind, a shear may exist. Conversely, if lower than normal power is required and vertical velocity is higher than normal to maintain glide slope while wind on the surface is either a headwind, calm or very light tailwind, a shear may exist. During the approach, the power required and the vertical velocity are the most important and easily recognized parameters associated with the wind shear phenomenon, (d) back up the autothrottles manually or use manual thrust control. If autothrottles are used, be constantly aware of their response and do not allow the autothrottles to program an excessive thrust reduction during the approach when low level wind shear is forecast, anticipated or encountered.

(3) *Power Compensation.* The most hazardous consequences on approach occur when wind shear occurs close to the ground after power adjustments have been already made during the approach to compensate for wind. Figures 4 and 5 illustrate the situations when power is applied or reduced to compensate for the change in aircraft performance caused by wind shear.

(a) Consider an aircraft flying a 3° ILS on a stabilized approach at 140 knots IAS with a 20-knot headwind. Assume that the aircraft encounters an instantaneous wind shear where the 20-knot headwind shears away completely. At that instant, several things will happen: The airspeed will drop from 140 to 120 knots, the nose will begin to pitch down, and the aircraft will begin to drop below the glide slope. The aircraft will then be both slow and low—a "power deficient" state. The pilot may then pull the nose up to a point even higher than before the shear in an effort to recapture the glide slope. This will aggravate the airspeed situation even further until the pilot advances the power levers and sufficient time elapses at the higher power setting for the engines to replenish the power deficiency. If the aircraft reaches the ground before the power deficiency is corrected, the landing will be short, slow, and hard. However, if there is sufficient time to regain the proper airspeed and glide slope before reaching the ground, then the "Double reverse" problem arises. This is because the power levers are set too high for a stabilized approach in a no-wind condition. So, as soon as the power deficiency is replenished, the power levers must be pulled back even further than they were before the shear (because power required for a 3° ILS in no wind is less than for a 20-knot headwind). If the pilot does not quickly retard the power levers, the aircraft will soon have an excess of power—i.e.,

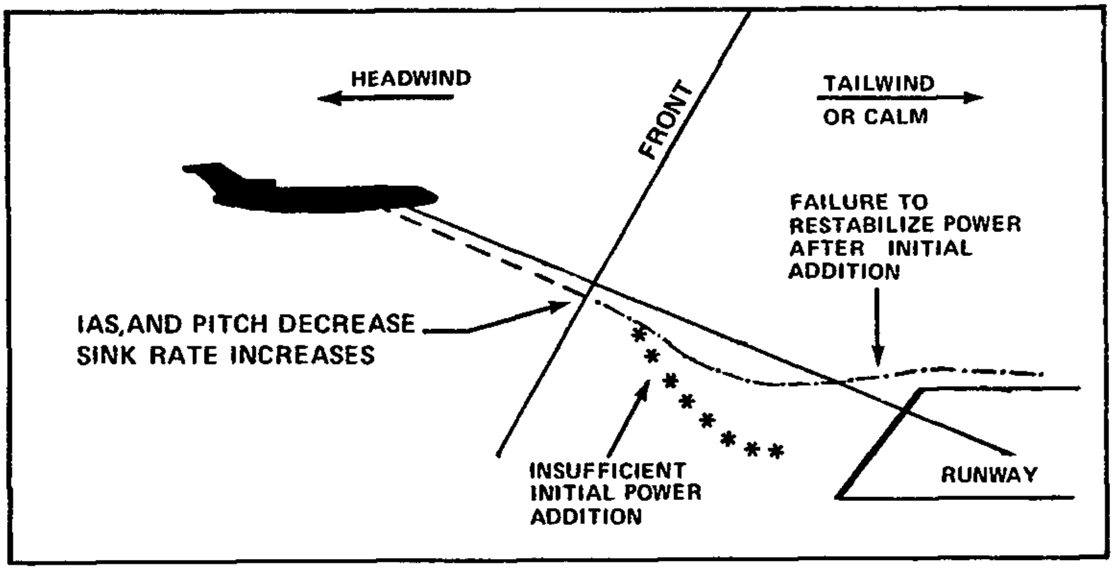

FIGURE 4.—Headwind Shearing to Tailwind or Calm

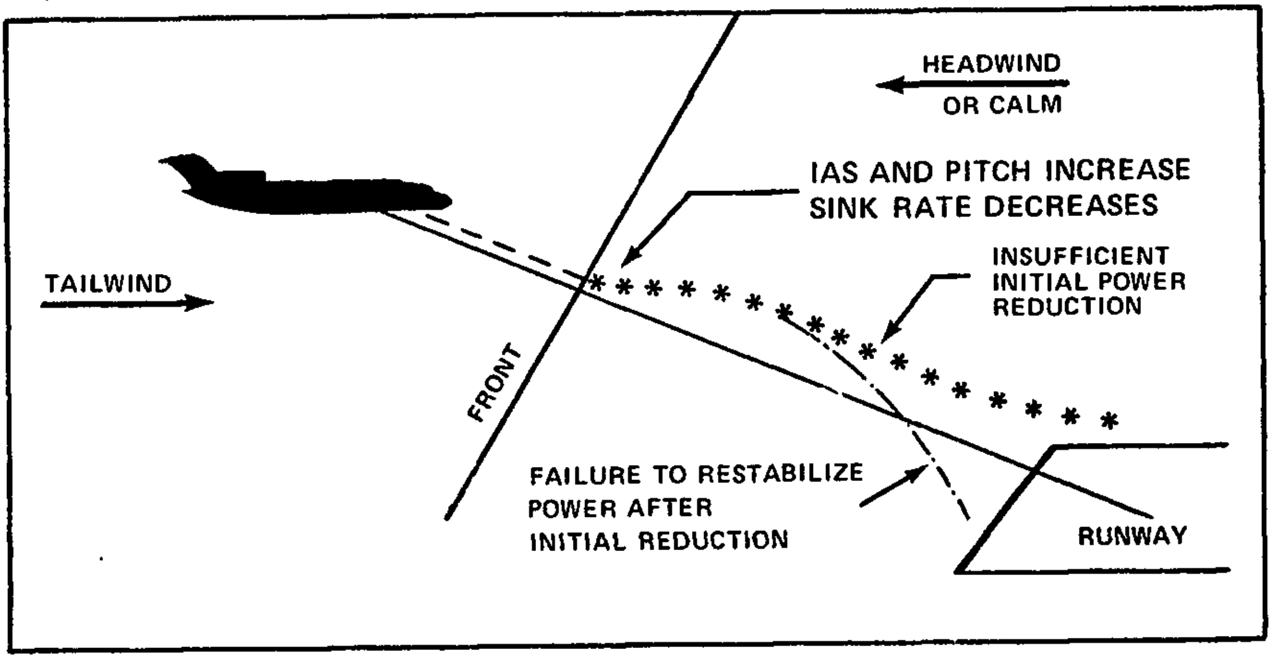

FIGURE 5.—Tailwind Shearing to Headwind or Calm

it will be high and fast and may not be able to stop in the available runway length (Figure 4).

(b) When on approach and in a tailwind condition that shears into a calm or headwind, the reverse of (a) is true. Initially, the IAS and pitch will increase and the aircraft will balloon above the glide slope. Power should initially be reduced to correct this condition or the approach may be high and fast with a danger of overshooting. However, after the initial power reduction is made and the aircraft is back on speed and glide slope, the "double reverse" again comes into play. An appropriate power increase will be necessary to restabilize in the headwind. If this power increase is not accomplished promptly, a high sink rate can develop and the landing may be short and hard (Figure 5).

(4) *Pilot Decisions.* Make a careful evaluation of all factors. While mild low level wind shear may be troublesome, large shear values can be very hazardous. On approach and when in doubt, or conditions are not right, execute a missed approach. When on the ground, be assured that conditions are right before takeoff.

7. REPORTING.

Often the latest, best information you can have concerning low level wind shear will come from other pilots' reports. Unusual airspeed fluctuations or power requirements and the altitude at which they occurred during approach or takeoff should be reported to the tower or nearest ground facility to aid other aircraft.

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Flight Standards Service