

WPR22LA251

OPERATIONAL FACTORS

Attachment 9

Corporate Air Airplane Operating Manual [Excerpts]

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FLIGHT OPERATIONS MANUAL – VOLUME 1

MANUAL CONTROL

REVISION RECORD

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OPERATING BULLETINS

WIND SHEAR

The following is background and supporting information for improved understanding of shear and its effect on performance. Although the following uses Shorts 3-60 *numbers* in a few examples (flap positions, climb rates, etc.), the subject is otherwise fully applicable to all types in the Corporate Air fleet.

General

Wind never blows from a constant direction or speed for more than short periods, even in the most stable conditions. Shear is nothing more than a *change* in wind component, and since a change in *either* wind direction or speed changes the component, the airplane is always affected by shear. It's fascinating to observe the continuous display of wind speed and direction on an INS-, IRS-, or GPS-equipped airplane and see the airplane's response to just half a knot change in wind component. This ever-present kind of shear is benign; it's the sudden and large changes in component that cause the mischief.

Shear causes a loss (or gain) of airspeed every time the wind component changes. While shear is often thought of as a horizontal wind effect, vertical wind components are involved as well. Aside from the "downward" effect of a downdraft ("microburst," "downburst"), as it nears the ground, it spreads out horizontally, affecting airspeed, thus lift.

Meteorological Conditions

In a study of 51 shear events, 33% were associated with convective activity (thunderstorms, rain/snow showers), the next most common occurring near fronts. The strength of shear associated with fronts is related to the speed of frontal movement and the temperature difference across the front. A front moving 30 knots or more, or with a temperature difference of 20°F or more, will almost always have strong shear.

The most hazardous shear is associated with the "downburst," which may have in its core (about a mile in diameter) vertical winds up to 7,000 FPM. When the down-flowing air nears the surface, it spreads out horizontally to a diameter of about 2 miles, with the strongest gusts about 100 feet above the ground. A downburst usually lasts from 2 to 5 minutes, although several different downbursts can occur over a relatively short period or distance.

Warm front shear is probable when ceiling and visibility are restricted with some kind of precipitation (rain, drizzle, etc.), and strong gusty winds indicate turbulence in the shear. When surface winds are from an easterly direction (30 through 120°) and pressure is falling rapidly, significant shear is likely.

Cold front shear is probable with northwesterly surface winds (270 through 360°) with pressure rising rapidly.

Gust front shear is common with thunderstorm activity. High base thunderstorms with VIRGA, light surface winds, surface temperatures above 75°, and an OAT/DP spread more than 35° often spawn microbursts in dry climates (as at Denver).

Calm or light surface winds with large drift angles on approach—or an abnormal descent



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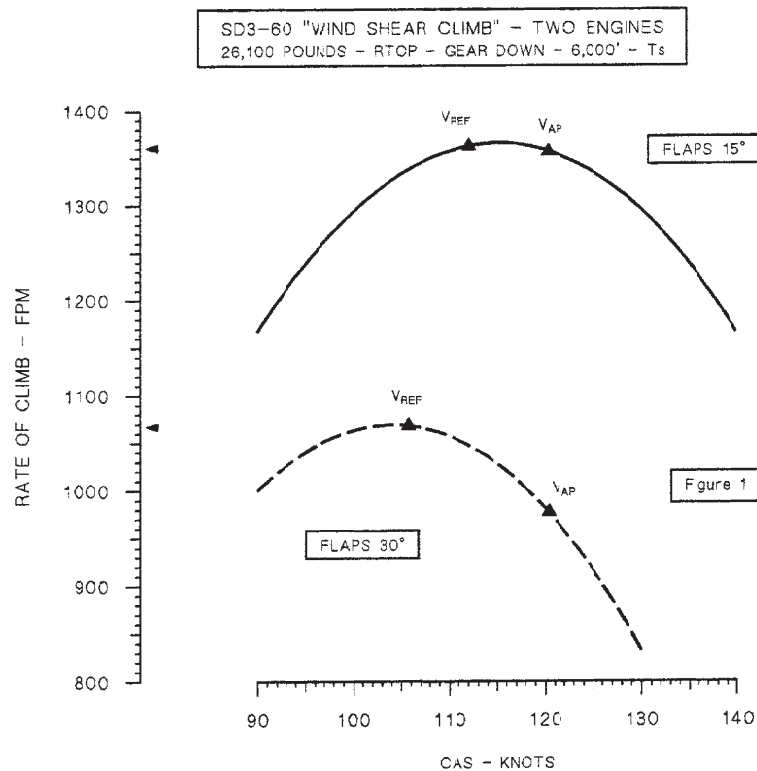
rate on the glide slope—indicate that shear exists between the airplane and the runway. Probably the best “cockpit clue” on approach is a relatively sudden increase in IAS, with the airplane “ballooning” above the glide slope. When this occurs, the temptation to make a large thrust reduction must be resisted; the sudden IAS increase is almost always followed by a sudden decrease. The initial speed increase occurs on entering the outflow as the downdraft nears the ground and flattens out, becoming a sudden headwind component. The opposite effect (sudden airspeed loss) is almost certain to follow as the airplane traverses the “center” of the downflow and moves into the outflow tailwind.

Effects on Performance

There are basically two kinds of shear: “performance-increasing” and “performance-decreasing.”

Performance-increasing shear occurs:

- with a sudden increase in headwind component,
- when going from a tailwind to a headwind, or
- when going from a calm wind to a headwind.





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The opposite conditions—suddenly increased tailwind, going from headwind to tailwind, or from calm to a tailwind—are “performance-decreasing.”

In many shear encounters, only 5 to 15 seconds are available to recognize a performance-decreasing situation and take necessary action. Although most shear accidents occur on approach, that is small comfort when in the grip of a strong downburst after liftoff.

When shear is present at takeoff, acceleration during the ground roll may be very low, and speed may stagnate or even decrease. The result is an increase in liftoff distance, and rotation *below* V_R may be necessary. Shear also may cause a momentary *increase* in acceleration, but this is almost always followed shortly by the opposite—and unfavorable—effects.

After liftoff, shear may reduce climb performance, or even turn it into a descent. During an approach, shear can turn a normal descent into one well beyond normal limits. Because of this it's important that there is a good understanding of climb performance.

Figure 1 shows climb rate in the “windshear climb” configuration—gear down, flap positions 15 and 30°. Note especially that:

- Climb capability is much greater with 15° flaps than with 30°. ¹
- V_{REF} is essentially the speed for best climb rate with either flap position.
- Climb rate drops off more and more sharply at speeds above V_{REF} , *especially with flaps at 30°.*

The lowest speeds used in line operations— V_2 and V_{REF} —should be considered as “barriers” below which one would not go in normal operation. But there is nothing sacred about either V_2 or V_{REF} , and going to lower speeds may be the only thing that will save your bacon in severe shear.

V_2 is not necessarily the speed for optimum gradient, optimum rate, or optimum anything; it's simply the speed at which takeoff engine-out gradients were certified. It is usually at or near 120% of stall speed, but can be almost anything at or above 120%, depending on how the airplane was certified. It is 120% on the -R airplane and 122% on the -AR at the higher weights, but will be as high as 125% (-R) to 130% (-AR) in the lower area of the weight envelope.

V_{REF} is simply—and somewhat arbitrarily—130% of the stall speed, and again nothing more than the speed at the 50-foot height used in landing distance certification.

¹ In any shear having a downflow greater than 1070 FPM—and any shear worthy of the name does—the airplane with 30° flaps, under the conditions of Figure 1, will crash, while the one with 15° will not. This is *one* of the primary reasons Corporate Air policy requires landing with APPROACH flaps for all fleet types for all normal operations.



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If it becomes necessary to convert a speed at or below V_2 or V_{REF} to climb (or a reduced descent rate), it should be handled much like a landing flare. The extra lift should not be taken out all at once, but only as much as needed to stop the descent. There should be no attempt to regain lost speed until terrain contact is no longer a factor, and gear and flap position should not be changed until the descent has been arrested and enough climb achieved to ensure obstacle clearance.

If “caught” in strong shear and still losing altitude even at RTOP power, it may be possible to outclimb the shear with a *slow* decrease in speed (increase in pitch) below normal limits.² Though good climb performance is available below V_2 and V_{REF} , such speeds should be used only in emergency.

² It's comforting to know that even if the shear cannot be outclimbed, the airplane will crash in the most “favorable” manner—under control and at the lowest possible speed.