Know

A guide to the performance limitations of light aeroplanes.

THERE ARE MANY CASES OF failure to get airborne in the distance available, or collision with obstacles owing to inadequate climb which might have been avoided if the pilot was aware of the performance limits of the aircraft.

Many such accidents have occurred when operating from short strips, often taking-off or landing out of wind, or with sloping ground. Poor surfaces such as wet grass have also been common contributing factors.

Aeroplane performance is affected by aeroplane weight, aerodrome altitude, ambient temperature, flap setting and humidity. In addition, the MTOW is affected by wind, runway length, slope and surface.

Performance figures are given in a variety of publications. The appropriate document is specified in the Certificate of Airworthiness for the aircraft, and could be the flight manual or the pilot operating handbook.

Because the performance information given in handbooks and manuals is based on ideal conditions, it is wise to add a safety factor to the data in order to take account of less favourable conditions.

Take-off – aeroplane weight: The weight stated on the weight and balance sheet for the individual aeroplane must be used for calculations. The weight of individual aeroplanes of a given type can vary considerably, depending on the level of equipment carried. Do not use the example weight shown in the weight and balance section of the handbook.

Take-off distance will be increased by around 20 per cent for each 10 per cent increase in aeroplane weight (a factor of x 1.2).

Aerodrome altitude: Aeroplane performance deteriorates with an increase in altitude, and the pressure altitude at the aerodrome of departure should be used for calculations. This equates to the height shown on the altimeter on the ground at the aerodrome with the sub-scale set at 1,013hPa.

Take-off distance will be increased by about 10 per cent for each 1,000ft increase in aerodrome altitude (a factor of x 1.1).

Temperature: Aeroplane performance deteriorates with an increase in ambient temperature. Take-off distance will be increased by about 10 per cent for a 10°C increase in ambient temperature (a factor of x 1.1).

Wind: A tailwind increases the take-off distance by around 20 per cent for a tailwind component of 10 per cent of the lift-off speed (a factor of x 1.2). Where the data allow adjustment for wind, no more than 50 per cent of the headwind component and not less than 150 per cent of the tailwind component of the reported wind should be assumed. In some manuals this factoring is already included, and it is necessary to check the relevant section.

Slope: An uphill slope increases the ground run. The take-off distance will be increased by approximately 10 per cent for each 2 per cent of uphill slope (a factor of x 1.1)

Surface: Grass, soft ground or snow increase rolling resistance and therefore the ground run. A take-off should not be attempted in grass over 10 inches high.

For dry grass (under 8 inches), the take-off distance will be increased by about 20 per cent (a factor of 1.2). For wet grass (under 8 inches), the take-off distance will be increased by some 30 per cent (a factor of 1.3). For soft ground or snow, the take-off distance will be increased by approximately 25 per cent or more (a factor of at least x 1.25).

For surface and slope factors, remember that the increases shown are to the take-off distance to a height of 50ft. *The correction to the ground run will be greater.*

Flap setting: Read carefully any supplement attached to your manual, the take-off performance with or without the use of take-off flap shown in the main part of the manual may not be approved for use by aeroplanes on the Australian register.

Humidity: High humidity adversely affects performance and this is usually taken into account during certification; however, there may be a correction factor applicable to your aeroplane. Consult the manual.

Safety factors: CASA recommends a factor of between x 1.15 and x 1.25 (refer CAO 20.7.4). All of these factors are cumulative. Where several factors are relevant, they must be multiplied. The resulting distance required can seem surprisingly high.

For example, in still air on a level dry runway at sea level with an ambient temper-

…your limits

ature of 10°C, the take-off distance required to a height of 50ft (TODR) is 390m.

This should be multiplied by a safety factor of – say – 1.15, giving TODR of 449m. However, the same aeroplane in still air from a dry, grass strip (factor x 1.2) with a 2 per cent uphill slope (factor 1.1), 500ft above sea level (factor x 1.05) at 15°C (factor x 1.05) including the safety factor (factor x 1.33) will have a TODR of: 390 x 1.2 x 1.1 x 1.05 x 1.33 = 755m.

The pilot should ensure that, after applying all the relevant factors, including the safety factor, the take-off distance to a height of 50ft does not exceed the runway length available.

Climb: So that the aeroplane climb performance does not fall below the prescribed minimum, some manuals give take-off and landing weights that should not be exceeded at specific combinations of altitude and temperature.

Unless included in the limitations section, these weight restrictions are mandatory only for public transport flights. These weights are calculated using the altitude and temperature at the relevant aerodrome.

Where these limits are not given, the following procedures are recommended:

• At the expected take-off and landing weights the aeroplane should be capable of a rate of climb of 700ft/min if it has a retractable undercarriage, or 500ft/min if it has a fixed undercarriage.

The rates of climb should be assessed at the relevant aerodrome altitude and temperature in the en-route configuration at the en-route climb speed and using maximum continuous power.

• For an aeroplane with more than one engine, if conditions are such that during climb to, or descent from, the cruising altitude obstacles cannot be avoided visually, the aeroplane should be able to climb at 150ft/min with one engine inoperative, at the aerodrome altitude and temperature.

Landing – aeroplane weight: Landing distance will be increased by about 10 per cent for each 10 per cent increase in aeroplane weight (a factor of x 1.1)

Aerodrome altitude: Aeroplane performance deteriorates with an increase in pressure altitude. Landing distance will be increased by around 5 per cent for every 1,000ft increase in aerodrome pressure altitude (a factor of x 1.05).

Temperature: Aeroplane performance deteriorates with an increase in ambient temperature. Landing distance will be increased by 5 per cent for a 10°C increase in ambient temperature (a factor of x 1.05).

Wind: Landing distance will be increased by approximately 20 per cent for a tailwind component of 10 per cent of the landing speed (a factor of x 1.2).

Where the data allow adjustment for wind, it is recommended that not more than 50 per cent of the headwind component and not less than 150 per cent of the tailwind component of the reported wind be assumed. In some manuals this factoring is already included and it is necessary to check the relevant section.

Slope: A downwind slope increases the landing distance by about 10 per cent for each 2 per cent of downhill slope (a factor of x 1.1).

Surface: Grass or snow increase the ground roll, despite increased rolling distance, because brake effectiveness is reduced.

For dry grass (under 8 inches) the landing distance will be increased by some 20 per cent (a factor of x 1.2). For wet grass (under 8 inches) the landing distance will be increased by aboutn 30 per cent a factor of x 1.3).

For very short grass, the surface may be slippery and distances may increase by up to 60 per cent (a factor of x 1.6). For snow, the landing distance will be increased by 25 per cent or more (a factor of at least x 1.25).

Note that for surface and slope factors, the increases are to the landing distance from a height of 50ft. *The correction to the ground roll will be greater.*

If applicable, the appropriate multiplying factor should be applied to the landing distance available.

Again these factors are cumulative. When several factors are relevant they must be multiplied. As in the take-off case, the total distance required may seem surprisingly high.

For example, in still air on a level, dry runway with an ambient temperature of 10°C, an aeroplane requires a landing distance from a height of 50ft of 350m. This should be multiplied by the safety factor of 1.43 giving a landing distance required of 501m.

The same aeroplane landing in still air at a wet grass strip (factor 1.3) 500ft above sea level (factor x 1.025) at 20°C (factor x 1.05), including the safety factor (factor x 1.43) will require a landing distance of: 350 x 1.3 x 1.025 x 1.05 x 1.43 = 700m.

The pilot should always ensure that after applying all the relevant factors including the safety factor, the landing required from a height of 50ft does not exceed landing distance available.

Engine failure: the possibility of an engine failing during any phase of the flight should also be considered. Considerations should include one engine inoperative performance for multi-engined types and the glide performance of single-engined types.

Obstacles: It is essential to be aware of any obstacles likely to impede either the take-off or landing flight path and to ensure there is adequate performance available to clear them by a safe margin. Use an accurate topographical chart.

Aerodrome distances: For many aerodromes, information on available distances is published. At aerodromes where no published information exists, distances should be paced out. The pace length should be established accurately or assumed to be no more than 2.5ft. Slopes can be calculated if surface elevation information is available; if not, they should be estimated. Prior to take-off it might be helpful to taxi the aeroplane from one end of the strip to the other and take an altimeter reading at each end.

Most altimeters show differences down to 20ft. To find the slope, simply divide altitude difference by strip length and give the result as a percentage. For example, an altitude difference of 50ft on a 2,500ft strip indicates a 2 per cent slope. Be sure not to mix metres and feet in your calculation.