Part III—Engine and Aircraft Handling

Chapter 2—Handling in Flight

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1 Engine handling

Engine life is affected by the frequency and extent of temperature changes caused by increasing or decreasing thrust, therefore, to prolong engine life and to maintain performance, throttle movement should be smooth and changes in thrust as few as possible. Slam decelerations to IDLING may be made at all altitudes.
▶◀
Slam accelerations should be avoided but in an emergency, can be made from any throttle setting up to 50,000 feet. Above this altitude surge followed by flame-out may result from rapid throttle opening; in air temperatures up to ISA + 20°C surging will not be encountered when opening up from idling RPM provided that the time for throttle movement is greater than 3 seconds from fully closed to fully open. At higher temperatures the throttles should be opened slowly at altitudes above 50,000 feet if surge and flame-out are to be avoided.

NOTE: Temperatures in excess of ISA + 20°C are extremely unlikely at altitudes above 50,000 feet, and ISA + 20°C will only be encountered on a limited number of occasions in very high latitudes during the summer.

2 Engine RPM

(*a*) Thrust should not be reduced from TAKE-OFF by means of the TAKE-OFF/CRUISE selector switch alone. Before moving the switch to CRUISE the throttles should be closed to reduce JPT below 615°C. Then, after setting the switch to CRUISE, the throttles may be opened to obtain the desired thrust. If maximum cruise thrust is required, open the throttles fully.

(*b*) Similarly, when increasing thrust from the CRUISE setting to TAKE-OFF, the throttles should be closed until the RPM begin to fall before the TAKE-OFF/CRUISE selector switch is set to TAKE-OFF. The throttles can then be opened fully.

(*c*) The selector switch must be set to TAKE-OFF when entering the circuit, thus ensuring that full power is available for an overshoot.

3 JPT's

(*a*) The JPT limiters must always be switched ON unless they are proved to be defective. They are capable of keeping the JPT within ±5°C of the selected limitation when controlling, but regular checks should be made for excessive temperatures, especially when taking-off in high ambient temperatures, climbing, and changing power at high altitudes. Jet pipe temperature limits are critical and care should be taken to avoid exceeding them.

▸◂

(*b*) Simultaneous " runaway " of all four limiters cannot be caused by a single fault. A " runaway " of one limiter would, in ISA sea-level conditions, reduce the thrust of the affected engine by about 35%. When operating in an emergency under very critical take-off conditions (i.e. high weight, high temperature, marginal runway length), it may be desirable to override the limiters for take-off to remove the risk of a failure.

(*c*) It should be realised that under varying ambient conditions and with the JPT limiters working properly, each engine will not necessarily be indicating the same RPM and JPT as the others. An engine may reach its governed RPM before it reaches the JPT limit or vice versa. However, to be within the limits set by the manufacturers, in steady conditions with all engines at the same demanded thrust, no engine should be more than 30°C hotter than the mean of the others or more than 2% RPM slower than the mean of the others.

(*d*) *Symptoms of malfunction*

(i) If the JPT or RPM of any engine falls outside the limits of 30°C above or 2% RPM below the others, or alternatively, if the RPM and/or JPT are fluctuating continuously, either the engine is malfunctioning or its JPT limiter is unserviceable, or more air is being bled from this engine than the others.

(ii) The following is the recommended procedure to discover whether the engine is at fault.

1 Check AC supplies to limiter (No. 1 or No. 3 inverter). (Two engines affected.)

2 Check ENGINE AIR switches all OPEN.

3 Check CABIN AIR switches both OPEN. (Two engines affected).

4 Check wing and engine anti-icing control switches as required. (Two engines affected).

(iii) If the fault is not cleared, select 95% RPM by manual use of the throttles.

(iv) Switch the limiters to OVERRIDE and, if after two minutes the engine is still outside these limits, it must be assumed that the engine is unserviceable and it is advisable to shut it down as it may have suffered damage to its compressor, combustion system, or turbine. If, however, the engine RPM and JPT come within the above limits with the JPT switched to OVERRIDE it is probable that the limiter is defective.

(v) Having discovered the extent of the malfunction, the original engine settings may be restored and it is preferable, whenever possible, to have the limiters switched ON.

3A Oil temperatures (Mod. 1996)

◂ (*a*) Warning of a No. 5 bearing failure is given by a rise in oil temperature some time in advance of the actual failure. Provided that recordings of RPM, oil temperature and time of recording are made every 10 minutes, any such rise will be noticed in time for the appropriate action to be taken.

(*b*) As the oil temperatures vary greatly with changes of RPM and slightly with changes of atmospheric temperature, a rise in the temperature of any one engine can only be detected, during the normally changing conditions of flight, by reference to the other engines at the same RPM.

(*c*) Even at the same RPM there are differences between the four oil temperatures, and these are established by the periodic ground running of the engines. Although these differences vary with changing atmospheric conditions during flight, any rise of temperature will be apparent, but careful interpretation of the pattern provided by the recordings is required to establish the true rise.

(*d*) If, when all engines are at the same RPM, the oil temperature of one shows a true rise of 15°C or more than 10°C for more than 5 minutes above that of any other engine, then it must be flamed out and not relit except in a case of extreme emergency. ▸

(*e*) A temperature rise of between 10°C and 15°C that becomes 10°C or less within 5 minutes is acceptable.

(*f*) During a climb or a descent, the difference of temperature between engines is more pronounced. When a reading is taken under these conditions, the subsequent reading should be taken under conditions of stabilised RPM and altitude.

4 Engine idling speeds

Idling speed varies with altitude and forward speed, increasing with aircraft speed. The idling speeds under varying flight conditions are listed in the table below:

Condition	% RPM
Static sea-level idling	32
Approach idling	43
Idling at 50,000 feet	78
Windmilling speed at 200 knots	14 at 35,000 feet

5 Flying controls

(*a*) Aileron forces are light and do not vary with speed. At speeds below 150 knots the rate of roll is comparatively low but increases with speed and above 200 knots is very good. Elevator forces vary with speed and are generally fairly high. Rudder forces are light at low speeds but become very heavy at high speed where it is difficult to make even small deflections. The controls are unharmonised, the aileron forces being light in comparison with the elevators.

(*b*) The above remarks refer to control movement with artificial feel in operation. Feel relief should not normally be selected in flight except before landing after a failure of feel at the high value (see Part V, Chap. 2, para. 2(*c*)).

6 Trimming

(*a*) Care is needed to trim the aircraft accurately. The best results are achieved if small increments of trim are applied and time is given for them to take effect before any adjustments are made.

(*b*) *Changes of trim*

Raising and lowering undercarriage	Negligible	
Airbrakes (low drag) .	Slight nose-down	increasing with speed
Airbrakes (high drag) .	Nose-down	increasing with speed
Airbrakes (in) . .	Nose-up	
Bomb-doors (open) .	Slight nose-down, with buffeting	
Bomb-doors (closed) .	Slight nose-up	

7 Airbrake characteristics

At high airspeeds at lower altitudes, the airbrakes are very effective and cause only mild buffet in the HIGH DRAG position but, at high mach numbers, the buffet in the HIGH DRAG position is unpleasant. At low airspeeds the airbrakes are much less effective but do assist during the approach and landing. The airbrakes take approximately five seconds to move from IN to MEDIUM, and a further two seconds from MEDIUM to HIGH DRAG.

8 High speed flight

NOTE: When flying at high indicated airspeeds or high indicated mach numbers it is essential that frequent comparisons be made between the readings of the 1st pilot's and co-pilot's airspeed indicators and machmeters. Should a fault develop in the pitot-static supplies to either instrument panel it might result in the maximum speed limitations being inadvertently exceeded.

(*a*) There are no unusual characteristics when flying the aircraft at high airspeeds, but great care is needed not to exceed the G limitations. To avoid structural fatigue, as little flying as possible should be carried out at low level or in areas of turbulence when flying at high speed. It is very easy to exceed the speed limitations, even in a climb.

(*b*) *At high mach numbers*

(i) *Auto-mach trimmers inoperative*

With the auto-mach trimmer inoperative the aircraft should not normally be flown at speeds in excess of 0·9M, and in any case not above 0·95M. As speed is increased beyond 0·9M there is a progressive nose-down change of trim and at 0·95M a heavy two-handed pull is required to check the aircraft. To effect a recovery close the throttles completely, and pull back on the control column. As speed reduces, the reversal of trim can be very rapid, therefore the elevator trimmer should only be used with extreme caution.

(ii) *Auto-mach trimmer operative*
At speeds in excess of 0·86M the auto-mach trimmer will begin to apply up-elevator although the magnetic indicator will not show white until 0·88M. A slight nose-up change of trim will occur therefore, as speed increases from 0·86M to 0·93M, which can be easily held and trimmed out. From 0·93M to 0·95M there is a rapid nose-up change of trim which can be held with a heavy single-handed push force. At the maximum permitted speed of 0·95M, all the controls are effective and responsive, but the elevator forces are heavy. The auto-mach trimmer is set to reach the end of its travel at 0·99M, but experience has shown that errors in setting and calibration can cause these limits to vary by plus or minus 0·02M. If the aircraft is accelerated beyond the auto-mach trimmer's authority, a sudden nose-down change of trim will occur which will require a heavy two-handed pull on the control column to correct.

9 Pitch and yaw dampers inoperative

(*a*) *Pitch dampers*
There is a marked deterioration of the natural damping in pitch at speeds in excess of 0·95M and pilot-induced oscillations may occur above this speed, if the pitch dampers are unserviceable. These oscillations will be of such a frequency that any attempt at control on the part of the pilot will only aggravate the situation, and they should be allowed to die out naturally as speed is decreased.

(*b*) *Yaw damper*
No limitation is imposed should the yaw damper become inoperative.

10 Approach to the stall

(*a*) Stalling is not permitted and speed must not be reduced below the onset of pre-stall buffet, and in any case not below the threshold speed for the weight, less 5 knots.

(*b*) The following description of the approach to the stall applies generally, but the degree of lateral and directional instability may vary in different aircraft. The buffet present with airbrakes extended may mask the onset of pre-stall buffet.

(*c*) At high angles of attack, the rudder is masked by the mainplane. This results in a reduced rudder response and larger than normal rudder movement will be required to maintain directional control. If speed is reduced below the onset of pre-stall buffet, the aircraft will become laterally and directionally unstable. The rate of descent will be approximately 2,000 feet per minute. If speed is further reduced by pulling the control column fully back, the aircraft will yaw and the nose will drop. The aircraft will roll in the direction of the yaw. The rate of descent will increase and may be as much as 5,000 feet per minute. The control column should be moved forward immediately to recover. During recovery, a reverse roll will occur if rudder has been applied to correct yaw.

11 Stalling in turns

It is not possible to stall the aircraft in turns at speeds in excess of 165 knots, unless the G limitations are exceeded. Below this speed, buffet occurs as the control column is pulled back, and there is a tendency for the aircraft to roll. The aircraft may roll either way. This rolling tendency can be held by aileron but no attempt should be made to increase the acceleration beyond this point. At high altitudes, the loading in the turn should not be increased after the onset of the initial buffet.

12 Flight in turbulent air

Flight in turbulent air should be avoided, but if this is not possible, the speed should be maintained between 170 and 230 knots, preferably at 200 knots.

13 Flight in icing conditions

(a) Take-off

Engine anti-icing

In cold damp weather (+3°C or below and with 90% more humidity, or visibility less than 1,000 yards in mist or fog), immediately before take-off, run the engines at 60% or more for one minute with the system switched on. Carry out the take-off and, when airborne and clear of icing conditions, switch the system off.

(b) Climb

It is considered that in the climb condition with the anti-icing systems on, icing presents no safety hazard, but to minimise possible range losses caused by ice formation behind the heated areas of the wing leading edges, speed should be reduced to 250 knots and the aircraft climbed to clear the icing layer. Engine RPM should not be reduced.

(c) Level flight

In level flight, at high altitudes, the systems provide protection against light icing and, at low altitudes (below 10,000 feet) against:

(i) Freezing rain occurring below cloud as supercooled water droplets at temperatures between 0°C and minus 4°C.

(ii) Maximum continuous icing in temperatures down to minus 6°C at 250 knots or minus 12°C at 350 knots.

(iii) Slight icing at 240 knots and below.

(d) Descent

(i) *Engine anti-icing*

During the descent the engine RPM should be maintained above 55%.

(ii) *Airframe anti-icing*

The system should be switched on and the descent made through the icing layer at the maximum rate, in order to minimise the time spent under icing conditions. Any hold-off should normally be made at an altitude higher than the prevailing layer, except where the icing layer is high, i.e. tropical summer conditions. Under these circumstances, a flight plan which allows hold-off below the icing layer may be advisable. After descent do not close the airbrakes, since they may have collected ice and, in these circumstances, retraction may be impossible or damage to the wing structure may result.

14 Descending

(a) Cruise descent

Descent using the airspeeds quoted in the Operating Data and with throttles fully closed is theoretically the most economic method of losing height, but the improvement in range is marginal, and is easily lost through inaccuracies of navigation. The rate of descent, particularly at high altitude, is small and the time to descend from high altitude is over an hour.

(b) Normal descent

Close the throttles, select MEDIUM airbrakes, and maintain a speed of 250 knots. These settings achieve a comfortable rate of descent at the correct speed for the standard let-down.

(c) Rapid descent

Before descending warn the crew and have all loose articles stowed. Close the throttles, extend HIGH DRAG airbrake, and dive the aircraft at 0·90M/300 knots. (250 knots below 20,000 feet.) The descent is steep, and initially the buffet is heavy. If the rate of descent exceeds 10,000 ft/min., fuel tank pressurisation should be switched off.


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