

CONCORDE ENGINE FAILURE MANAGEMENT

ENGINE FAILURE DURING TAKE-OFF PRIOR TO V₁

Action

When the failure is identified the Captain calls "abandon", closes the throttles, applies maximum footbrakes, holds the control column forward and applies full reverse thrust as quickly as possible on all engines.

The pilot should hold the control column forward initially, but the co-pilot should then confirm this by holding it forward during the application of reverse.

At 100kts reverse idle is selected on two engines so as to leave full reverse thrust on two "live" symmetrical engines until 75kts. Reverse idle is then selected on these remaining engines. At 40kts all engines are selected to forward idle.

Braking is the primary means of stopping but the aircraft is certified using reverse thrust in addition.

Note

Prior to take-off the pilot must be absolutely clear about what engine conditions will require him/her to abandon.

Once the take-off roll is underway with full thrust Flight Engineers must not announce minor or unimportant faults or instrument failures such as could cause confusion or risk unnecessary aborting of the take-off.

It is essential that a firm forward pressure is maintained on the stick to prevent the nose wheel leaving the ground.

ENGINE FAILURE DURING TAKE-OFF AFTER V_1

Action

When the failure is identified, contingency power on all engines is selected by the Flight Engineer. The T/O light on the engine rating mode annunciator is extinguished by this selection and the CTY light comes on steady.

Auto-contingency

A flashing CTY light indicates that the N_2 has fallen below 58% on an engine and that contingency power has been automatically selected on all engines. Contingency power should be then selected on all engines as a confirmatory action. The CTY light then stops flashing and become steady.

Rotation

If the failure occurs whilst the aircraft is on the runway, rotation is initiated at V_r at a slower rate than usual. The rate of pitch attitude increase should be controlled so as to achieve simultaneously the V_2 speed and the initial climb out attitude, θ_2 .

A slower rotation is required on three engines because the rate of increase of airspeed is noticeably less than on four engines and becomes even less after lift-off which occurs 2 or 3 knots before V_2 and at about 10 degrees pitch attitude.

Gear

The command "gear up" should be given when a positive climb is established. A positive climb should not be considered established until the radio altimeter is indicating more than 20 feet.

Failure to retract the gear causes a performance penalty of 400 fpm rate of climb.

Speed

On achieving the initial attitude θ_2 , the speed should be V_2 . This speed is maintained until commencing the horizontal acceleration to V_2+40 kts. When the gear is up, a small attitude increase of about 1 degree is required to maintain V_2 .

If however, after rotation to θ_2 , a speed higher than V_2 is achieved because the engine failure occurred at a speed close to V_2 or because the power loss was gradual, or because weight is not limiting, the higher speed gives a better climb-out gradient with less induced drag.

A rotation carried out too rapidly results in too low a speed and reduced performance margins; therefore any tendency to rotate too quickly must be corrected. However, if it happens and a speed below V_2 is obtained, this achieved speed must be maintained until the horizontal acceleration to V_2+40 kts is commenced.

Directional Control

Directional control should be maintained with rudder. As the speed increases following engine failure at V_1 or above, a reduction in the initial rudder application will be required for climb-out. After rotation when the initial climb-out is established, it is necessary to achieve

zero side-slip for the best engine-out performance. A small amount of bank (approximately 2 to 3 degrees) is then necessary to maintain a constant heading.

Power Limitations

Accurate timing of engine rating selections would ideally commence at the time of selection, but this is impractical for timing contingency rating following engine failure on take-off. The maximum time limitations will not be exceeded by using the time measured from the start of take-off as follows:

- After 3 minutes reselect take-off rating by selecting reheat.
- After 7.5 minutes select reheated climb power by selecting Flight Rating.
- After 22.5 minutes select reheats off.

Turns

Where possible; turns should be avoided because of the increased angle of attack required and the consequent increase in induced drag. However, a turn at V_2 with 15 degrees bank gives approximately the same climb performance as a conventional four-engine aircraft with one engine out and wings level.

En-route Climb Speed

The scheduled en route climb speed is V_{MO} . The acceleration from V_2+40 knots is made in level flight at 1500 feet.

When manoeuvring in terminal areas prior to fuel jettison a speed of 300 knots, not less, is recommended.

Performance

Concorde's performance is much more affected by speed and by turns than other aircraft.

Considering the graph "Take-off Climb Gradient Comparison", several relevant facts are apparent:

- In both cases Concorde has a much greater increase in climb gradient with increasing speed (i.e. it is more speed-sensitive) therefore if speed inadvertently exceeds V_2 , after an engine failure, hold that speed. Do not attempt to get back to V_2 .
- In the engine-out case Concorde gradient is 1% better than the subsonic aircraft at V_2 but at V_2-10 knots this advantage is virtually lost.
- The loss in performance due to engine failure is much greater in Concorde than the subsonic jet.

Drills

Engine failure prior to initial climb will be announced as "Engine Failure". When the aircraft is safely established in the climb attitude, the Flight Engineer should repeat the failure and identify the engine. The appropriate drill should then be called for. Memory drills should be performed slowly, the pilot and Flight Engineer announcing clearly the action to be taken so that each may monitor that the other's action is correct

ENGINE FAILURE SUBSONIC

Aircraft Behaviour

The reaction of the aircraft is similar to that of a subsonic aircraft and is corrected easily in the conventional manner.

The aircraft is flown with zero side-slip and a small bank angle is required to maintain constant heading.

Speed with One Engine Failed

The optimum speed for best range and for sustaining altitude is Mach 0.95 or V_{MO} if V_{MO} gives a Mach number less than 0.95.

When speed is reduced below $V_{REF}+50$, it is recommended that bank angles are limited to 20 degrees.

Double Engine Failure

The reaction of the aircraft is similar to that of a subsonic aircraft and it is corrected easily in the conventional manner.

The aircraft is flown with zero side-slip and a small bank angle to maintain a constant heading.

The change of yaw trim with power changes is more marked than in the three engine case.

Speed with Two Engines Failed

The optimum speed for best range and for sustaining altitude is Mach 0.80 or V_{MO} if V_{MO} gives a Mach number less than 0.80.

When a reduction in speed is necessary, 250kts is recommended where possible. In no case should speeds below $V_{REF}+50$ be used until manoeuvring is completed and the aircraft is on final approach.