

DCA24LA330

OPERATIONAL FACTORS

Attachment 4

Southwest Airlines B737 Operating Manual [Excerpts]

April 24, 2025

B737 AIRCRAFT OPERATING MANUAL

Non-Normal

Initiate Evacuation

After the aircraft has come to rest, proceed to assigned ditching stations and deploy slides/rafts. Evacuate as soon as possible, ensuring all Passengers are out of the aircraft.

Note: Be careful not to rip or puncture the slides/rafts. Avoid drifting into or under parts of the aircraft. Remain clear of fuel-saturated water.

5.5 Engines, APU

Revised: 04/11/2022

This section provides information on the non-normal procedures contained in *QRH* NNC 7 Engines, APU.

5.5.1 Aborted Engine Starts

Revised: 04/11/2022

The decision to abort an engine start could be based on any pertinent factor noted by the Flight Deck Crew. One of the primary concerns during engine start is the possibility of start limit temperature exceedance.

While there are numerous possible causes to abort an engine start, some of the most common are associated with potential engine damage and include the following:

- The N_1 or N_2 does not increase or increases very slowly after the EGT increases.
- There is no oil pressure indication by the time that the engine is stable at idle.
- The EGT does not increase by 15 seconds after the engine start lever is moved to IDLE detent.
- The EGT quickly nears or exceeds the start limit.

If the EGT start limit was not exceeded, the Captain should evaluate relevant factors such as tailwind conditions, air source, improper bleed, pack, or anti-ice configuration to determine if an additional start attempt is warranted. If a subsequent start is attempted, leave the ignition switch in the same position as in the first start attempt. If the second start is not successful due to lack of ignition, contact Dispatch and Maintenance Control. If the EGT start limit was exceeded, a second start attempt is not authorized until maintenance action is complete. Return to the gate and notify Dispatch and Maintenance Control of the event. During this coordination, an Aircraft Logbook discrepancy entry regarding the start, noting the maximum EGT reached and the duration of the temperature exceedance, must be made.

Maintenance will determine the engine inspection requirements. Under certain conditions, Maintenance may determine that the engine inspection can be deferred. If the inspection is to be deferred, the Pilots must ensure the deferral and any associated restrictions are annotated in the Aircraft Logbook prior to flight.

5.5.2 Start Valve Open

Revised: 04/11/2022

The START VALVE OPEN alert indicates the start valve fails to close.

If the start switch does not automatically return to OFF, and placing the ENGINE START switch to OFF corrects the condition, the Engine Starter Auto Cutout feature may have failed. For dispatching requirements, refer to *MEL* 80.

5.5.3 Engine Oil System Indications

Revised: 04/11/2022

Oil pressure is considered as the most significant of several oil system indicators. Oil temperature, oil quantity, and oil pressure indications enable the Flight Crew to recognize a deteriorating oil system. While engine operation is governed by both oil pressure and oil temperature limits, there is no minimum oil quantity limit. Therefore, there is no low oil quantity NNC in the *QRH*.

If abnormal oil quantity indications are observed, check oil pressure and oil temperature. If oil pressure and oil temperature indications are normal, operate the engine normally. Accomplish the appropriate NNC for any non-normal oil pressure or oil temperature indications.

5.5.4 Engine Failure or Shutdown

Revised: 03/28/2024

Engine failure is recognized by a loss of thrust on an engine, coinciding readings on the respective engine instruments, and possibly significant yaw. If an engine failure is accompanied by a fire warning, N_1 indicating zero, an abnormal engine vibration, or (**MAX**) smoke in the flight deck or cabin, accomplish the ENGINE FIRE or Engine Severe Damage or Separation quick reference steps from the Quick Reference Card and *QRH* NNC 8 Fire Protection.

The decision to shut down an engine for precautionary reasons should not be based on a single event. If abnormal engine indications such as excessive vibration (indicating severe engine damage), or engine limit exceedances persist, refer to the

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appropriate checklist. If a single engine instrument displays uncorrelated abnormal indications, an instrument malfunction may be indicated. The Pilots must consider all relevant indications prior to taking action. Further action, including engine shutdown, should only be taken as directed by the applicable checklist.

If consideration is given to a restart attempt, the affected engine should indicate N1 rotation, no fire, and no abnormal vibration. Signs of engine damage, such as excessive engine vibration, may preclude a restart attempt. Oil quantity indication as low as zero is normal if the windmilling N₂ RPM is below 8 percent and a start may be attempted.

CAUTION: If an engine fails after start is complete, do not attempt a restart on the ground.

5.5.5 Engine Failure vs. Engine Fire After Takeoff

Revised: 10/30/2023

The Engine Failure or Shutdown checklist is normally accomplished after the flaps are retracted and as conditions permit.

In the case of an engine fire, when the aircraft is under control with gear retracted and a safe altitude attained (minimum 400 ft AGL), accomplish the appropriate quick reference steps.

Reference items should be accomplished on a non-interfering basis with other normal duties after the flaps have been retracted and conditions permit.

5.5.6 Engine-Out Familiarization

Revised: 09/28/2023

Engine-out controllability is excellent during takeoff roll and after liftoff. Minimum control speed in the air is below V_R and V_{REF}.

Rudder and Lateral Control

Under instrument conditions, the instrument scan is centered around the attitude indicator. Roll is usually the first indication of an asymmetric condition. Roll control (ailerons) should be used to hold the wings level or maintain the desired bank angle.

Stop the yaw by smoothly applying rudder at the same rate that thrust changes. When the rudder input is correct, only a small amount of control wheel displacement is necessary. Refine the rudder input as required and trim the rudder so the control wheel remains approximately level.

When the rudder is trimmed to level the control wheel, the aircraft maintains heading. A small amount of bank toward the operating engine may be noticeable on the bank indicator. The slip/skid indicator is displaced slightly toward the operating engine.

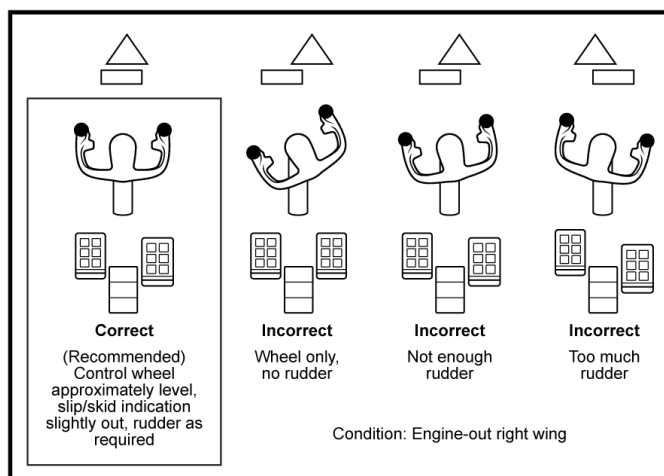
If the aircraft is trimmed with too much control wheel displacement, full lateral control is not available and spoilers on one wing may be raised, which increases drag.

Make turns at a constant airspeed and hold the rudder displacement constant. Do not attempt to coordinate rudder and lateral control in turns. Rudder pedal inputs produce roll due to yaw and induce the Pilot to counter rudder oscillations with the opposite control wheel.

If an engine failure occurs with the autopilot engaged, manually position the rudder to approximately center the control wheel and add thrust. Trim the rudder to relieve rudder pedal pressure.

[Figure 5.12 Rudder and Lateral Control Inputs](#) shows correct and incorrect use of the rudder.

Figure 5.12 Rudder and Lateral Control Inputs



Engine-Out Characteristics

If not thrust limited, apply additional thrust, if required, to control the airspeed. The total two engine fuel flow existing at the time of engine failure may be used initially to establish a thrust setting at low altitude. If performance is limited (high altitude), adjust aircraft attitude to maintain airspeed while setting maximum continuous thrust.

Note: Autothrottle should not be used when an engine is inoperative.

5.5.7 Engine Tailpipe Fire

Revised: 04/11/2022

Engine tailpipe fires are typically caused by engine control malfunctions that result in the ignition of pooled fuel. These fires can be damaging to the engine and have caused unplanned evacuations.

If a tailpipe fire is reported, Pilots should accomplish the Engine Tailpipe Fire checklist in *QRH* NNC 8 Fire Protection without delay. Pilots should consider the following when dealing with this situation:

- Motor the engine as the primary means of extinguishing the fire.
- Prevent an inappropriate evacuation by notifying Flight Attendants without significant delay.
- Communicate with ramp personnel and the tower to determine the status of the tailpipe fire and to request fire extinguishing assistance.

The ENGINE FIRE or Engine Severe Damage or Separation checklist is inappropriate because the engine fire extinguishing agent is not effective against a fire inside the tailpipe.

5.5.8 Loss of Engine Thrust Control

Revised: 04/11/2022

Engine response to a loss of engine thrust control varies from engine to engine. Malfunctions have occurred in-flight and on the ground. The major challenge Pilots face when responding to this malfunction is recognizing the condition and determining which engine has malfunctioned. The Engine Limit or Surge or Stall checklist on the QRC and in *QRH* NNC 7 Engines, APU is written to include this type of malfunction. This condition can occur during any phase of flight.

The failure of engine or fuel control system components or loss of thrust lever position feedback has caused loss of engine thrust control. Control loss may not be immediately evident since many engines fail to some fixed RPM or thrust lever condition. This fixed RPM or thrust lever condition may be very near the commanded thrust level and therefore difficult to recognize until the Pilot attempts to change thrust with the thrust lever. Other engine responses include shutdown, operation at low RPM, or thrust at the last valid thrust lever setting (in the case of a thrust lever feedback fault) depending on altitude or air/ground logic. In all cases, the affected engine does not respond to thrust lever movement or the response is abnormal.

Since recognition may be difficult, if the loss of engine control is suspected, Pilots should continue the takeoff or remain airborne until the appropriate checklist can be accomplished. This helps with directional control and may preclude an inadvertent shutdown of the wrong engine. In some conditions, such as during low speed ground operations, immediate engine shutdown may be necessary to maintain directional control.

5.5.9 Loss of Thrust on Both Engines

Revised: 04/11/2022

Dual engine failure is a situation that demands prompt action, regardless of altitude or airspeed. The attitude systems may momentarily become inoperative with OFF flags in view. Be prepared to transition to the standby horizon. The aircraft may slowly depressurize. Additionally, there is no V_{MO}/M_{MO} protection. As a reference, at 220 kt the aircraft will glide approximately 30 NM for each 10,000 ft of altitude loss.

Accomplish the Quick Reference Card items and establish the appropriate airspeed to immediately attempt a windmill restart. There is a higher probability that a windmill start will succeed if the restart attempt is made as soon as possible (or immediately after recognizing an engine failure) to take advantage of high engine RPM. Use of higher airspeeds and altitudes below 30,000 ft improves the probability of a restart. Loss of thrust at higher altitudes may require descent to a lower altitude to improve windmill starting capability.

The in-flight start envelope defines the region where windmill starts were demonstrated during certification. It should be noted that this envelope does not define the only areas where a windmill start may be successful. The Loss of Thrust on Both Engines checklist is written to ensure that Pilots take advantage of the high RPM at engine failure regardless of altitude or airspeed. Initiate the Loss of Thrust on Both Engines checklist before attempting an APU start for the reasons identified above. If the windmill restart is not successful, an APU start should be initiated as soon as practical to provide electrical power and starter assistance during follow-on engine start attempts.

During a windmill restart, EGT may exceed the limit for engine start. A hung or stalled in-flight start is normally indicated by stagnant RPM and increasing EGT. During start, engines may accelerate to idle slowly; action should not be taken if RPM is increasing and EGT is not near or is rapidly approaching the limit.

Note: When electrical power is restored, do not confuse the establishment of APU generator power with the establishment of engine generator power at idle RPM and advance the thrust lever prematurely.

5.5.10 High Engine Vibration

Revised: 04/11/2022

Certain engine failures, such as fan blade separation or ice accumulation, can cause high levels of airframe vibration. If fan blade icing is suspected, a minimum of 80 percent N_1 for one second is required to remove ice from the fan blades. If high AVM indications are accompanied by other abnormal engine indications (excessive vibration, severe engine damage, and/or engine limit exceedances) the appropriate checklist should be referenced. Further action, to include engine shutdown, should only be taken as directed by the applicable checklist.

Although the airframe vibration may seem severe, it is extremely unlikely that the vibration will damage the aircraft structure or critical systems. However, the vibration should be reduced as soon as possible by reducing airspeed and descending. As altitude and airspeed change, the aircraft may transition through various levels of vibration. In general, vibration levels decrease as airspeed decreases; however, at a given altitude, vibration may temporarily increase or decrease as airspeed changes.

If vibration remains unacceptable, descending to a lower altitude (terrain permitting) allows a lower airspeed and normally lower vibration levels. Vibration will likely become imperceptible as airspeed is further reduced during approach.

The impact of a vibrating environment on human performance is dependent on a number of factors, including the orientation of the vibration relative to the body. People working in a vibrating environment may find relief by leaning forward or backward, standing, or otherwise changing their body position.

Once airframe vibration is reduced to acceptable levels, Pilots must evaluate the situation and determine a new course of action based on weather, fuel remaining, and available airports.

5.5.11 Landing with One Engine at Reduced Thrust

Revised: 04/11/2022

Several checklists that cover engine vibration or abnormal engine indications (e.g., Engine High Vibration, ENGINE OVERHEAT) call for operating an engine at a reduced thrust setting. These lower thrust settings reduce the engine's generated heat and RPM. These reductions in operating parameters might clear an associated warning light, but continued operation at or below the required thrust reduction will be necessary. Engine Limit or Surge or Stall checklist is an example of an exception where slowly advancing the thrust lever back toward normal settings is allowed.

If operation at significantly reduced thrust is required to accomplish the objectives of the checklist, consideration should be given to landing using the One Engine Inoperative Landing checklist, even though both engines are running. Use of this checklist configures the aircraft and prepares the Flight Deck Crew for the possibility of an engine failure during the approach. This will significantly reduce the need for a possible go-around due to lack of preparedness, thereby allowing the Flight Deck Crew to continue the approach and landing.

5.5.12 Engine Failure During Approach

Revised: 06/23/2022

Engine failure during final approach with the flaps in the landing position requires a rapid situational assessment by the Flight Deck Crew. Distance remaining to touchdown, meteorological conditions, and aircraft weight are key considerations when assessing the most appropriate action.

A correct evaluation by the Flight Deck Crew, along with the necessary adjustments to aircraft thrust and configuration, stabilizes the event. The following options are available:

- Continue flaps 30° or 40°
- Continue flaps 15°
- Execute a go-around

Continue Flaps 30° or 40°

Increase thrust on the operative engine, as required, to maintain airspeed and glide path. If sufficient thrust is available, the approach may be continued with landing flaps 30° or 40°.

Note: The aircraft may not be able to maintain a normal glideslope under adverse conditions (e.g., high headwinds, heavy weights).

Continue Flaps 15°

If the approach is continued and sufficient thrust is not available for landing flaps 30° or 40°, the approach may be continued flaps 15°. Increase thrust on the operative engine, as required, to maintain airspeed and glide path. Retract the flaps to position 15° and accelerate to:

- **(-700)** $V_{REF} + 15$
- **(-800)(MAX8)** $V_{REF} + 20$

If time and conditions permit, move the Ground Proximity Flap Inhibit switch to FLAP INHIBIT.

If the aircraft is already configured for a flaps 15° landing, maintain a minimum of $V_{REF} 15 + 5$.

Execute a Go-Around

If the decision is to go-around from a flaps 30° or 40° approach, verify maximum go-around thrust is set and select flaps 15°. Maintain $V_{REF} 30$ or 40 plus wind additive (5 kt-minimum) speed and limit bank angle to 15° until initial maneuvering is complete and a safe altitude is reached.

Note: $V_{REF} 30$ or 40 plus wind additive at flaps 15° may result in an airspeed that provides less than full maneuver margin (top of the amber band).

If the decision is to go-around from a flaps 15° approach, maintain $V_{REF} 15 + 5$, retract flaps to position 1°, and continue the one engine inoperative go-around. $V_{REF} + 5$ is approximately equal to V_2 for flaps 1°.

5.6 Fire Protection and Smoke/Fumes on the Aircraft

Revised: 04/11/2022

Flight Attendants notify the Flight Deck Crew of any occurrence of smoke, fire, or fumes in the cabin and attempt to identify, extinguish, and isolate the source.

Lavatory Smoke Detector Activation

Flight Attendants report the activation of a lavatory smoke detector to the Flight Deck Crew regardless of cause.

Reference to the Quick Reference Card Smoke, Fire or Fumes non-normal checklist is not required if notified that the lavatory smoke detector activation was from:

- Cigarette smoke (including verification that the smoking materials have been extinguished)
- A portable electronic smoking device
- An aerosol
- An erroneous activation

Refer to *FOM* 21.6.7 Smoking Policies for follow-on action, as appropriate. The flight may continue to the destination.

If the lavatory smoke detector fails to silence and reset after the smoke or aerosol has dissipated, the Flight Attendants, after consulting with the Flight Deck Crew, may be directed to reset the smoke detector manually (refer to [16.8.3 Lavatory Smoke Detector Reset](#) for additional information).

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3.8 Engines and APU

Revised: 04/11/2022

CAUTION: Do not exceed redline or red arc limitations.

CAUTION: Be aware of the red illumination in the specific engine instrument display, indicating an overspeed/overtemperature condition.

3.8.1 Engines

Revised: 04/11/2022

AFM L

Table 3.13 General Engine Limits

Max RPM	Redline
N ₁	
N ₂	
Max EGT TO/GA (5 minutes)	Redline
Max Ground Start EGT	Redline
Oil Temp	Redline
Max	Amberband
(NG) 45 minutes	Amberband
(MAX) 15 minutes	Amberline
Max Continuous	
Oil Pressure	Redline
Min	

AFM L (MAX) After starting, oil temperature rise to at least 31°C must be indicated before setting takeoff thrust.

AFM L

Table 3.14 Specific Engine Limits

	(NG)	(MAX)
Max RPM		
N ₁	104.0% (104.7% for 20 seconds)	104.3%
N ₂	105.0%	117.5%
Max EGT TO/GA		
5 minutes	950°C	1,038°C
30 seconds	N/A	1,048°C
Max Continuous EGT	925°C	1,013°C
Ground Start EGT	✓ 725°C	753°C
Oil Temp		
Min for Starting	N/A	-40°C
Max	155°C	N/A
45 minutes	140°-155°C	N/A
15 minutes	N/A	155°C
Max Continuous	140°C	140°C
Oil Pressure		
Min	13 psi	17 psi ^①

1. If engine oil pressure is in the yellow band with takeoff thrust set, do not takeoff.

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Limitations

AFM L For takeoffs with the EECs in the alternate mode:

- Reduced thrust is not allowed.
- Both EECs must be selected alternate.

AFM L Ignition must be on for takeoff and landing.

Note: Oil pressure digital readouts must be in white band for takeoff.

Note: The digital readouts display amber or red if limits are exceeded.

3.8.2 Engine Stabilization and Cooldown

Revised: 04/11/2022

R On the first flight of the day, operate engines at or near idle, after rollback, for a minimum of five minutes prior to applying takeoff thrust.

✓ **L** Prior to applying takeoff thrust, operate engines at or near idle, after rollback, for a minimum of:

- **(NG)** 2 minutes
- **(MAX)** 3 minutes

✓ **L** Prior to shutdown, operate engines at or near idle for a minimum of:

- **(NG)** 1 minute
- **(MAX)** 3 minutes

R (NG) When operational conditions permit, engines should be operated at or near idle for three minutes prior to shutdown.

3.8.3 Starter Duty Cycle

Revised: 04/11/2022

L **Table 3.15 Starter Duty Cycle**

	(NG)	(MAX)
Normal Start:	2 minutes ON, 10 seconds OFF between start attempts.	3 minutes ON, 10 seconds OFF between start attempts.
Motoring (fuel off):	15 minutes	5 minutes. A minimum of 5 minutes is needed between the first two extended engine motorings.

3.8.4 Minimum Engine Oil Quantity

Revised: 09/28/2023

L **Table 3.16 Minimum Engine Oil Quantities**

	(NG)	(MAX)
Departure from a non-maintenance base/station.	60 percent	66 percent
Departure from a Maintenance base/station.	70 percent	70 percent
The Captain must arrange for engine oil servicing when terminating at a non-maintenance base/station.	< 65 percent	< 70 percent

Note:

- Low oil quantity alerts may be experienced during initial takeoff and climb with oil quantities less than:
 - **(NG)** 65 percent
 - **(MAX)** 70 percent

3.8.5 Reverse Thrust

Revised: 04/11/2022

✓ **AFM L** Intentional selection of reverse thrust in flight is prohibited.

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Limitations

AFM L Backing the aircraft with reverse thrust is prohibited.

AFM L Do not attempt go-around after thrust reverser deployment on landing.

L Use of reverse thrust during taxi to reduce speed is not authorized.

L Takeoff and landing are not authorized if either thrust reverser is inoperative and the runway is contaminated with clutter or the braking action is less than 5-GOOD.

L Dispatch from/to runways less than 45 m wide is not allowed with rudder pedal nose wheel steering inoperative or one thrust reverser inoperative.

P Reverse thrust, if operative, must be used on all landings at a minimum of detent 2 unless a higher level is specified.

3.8.6 Auxiliary Power Unit (APU)

Revised: 04/11/2022

AFM L

Table 3.17 APU Limitations

✓ Max Altitude for Operation	41,000 ft
✓ Max Altitude Electric Only	41,000 ft
✓ Max Altitude Bleed Air Only	17,000 ft
✓ Max Altitude Bleed Air & Electric	10,000 ft

L APU bleed valve must be closed when:

- Ground air is connected and isolation valve is OPEN.
- Engine Bleed Valve #1 is OPEN.
- Isolation valve and Engine Bleed Valve #2 are OPEN.

Note: Thrust must be limited to idle with the DUAL BLEED light illuminated.

L APU bleed valve may be OPEN during engine start provided engine power is not above idle.

L Wait 90 seconds between APU start attempts.

L If the APU fails to start after the third attempt, call Dispatch and Maintenance. Do not attempt a fourth start.

L After the APU GEN OFF BUS light extinguishes, and prior to positioning the battery switch OFF, wait approximately:

- **(NG)** 2 minutes
- **(MAX)** 5 minutes

P Do not start the APU while airborne unless required by a *QRH* procedure or by PWB performance considerations.

L After stabilized, the APU must be operated for two minutes before being used as a bleed air source.

3.9 Flight Controls

Revised: 06/23/2022

AFM L

Table 3.18 Takeoff Flap Settings

Flap Setting	Setting Authorization
1	Authorized
2	Not Authorized
5	Authorized
10	Authorized
15	Authorized
25	Authorized

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Table 16.3 Photoluminescent Charge and Operational Durations (Sky Interior)

First Flight of the Day with Bin Doors Closed (White BRIGHT)	Maximum Duration Allowed (Hours)	Additional Steps to Follow for Charging Credit
5-minute charge	3.5	a) Close overhead bin doors during charging.
10-minute charge	5	b) Cabin activity is limited to minor aisle traffic or Crew and personnel.
15-minute charge	7.5	
First Flight of the Day with Bin Doors Open No Passengers (White BRIGHT)	Maximum Duration Allowed (Hours)	Additional Steps to Follow for Charging Credit
10-minute charge	5	a) Bin doors can be open during charging.
15-minute charge	7.5	b) Cabin activity is limited to minor aisle traffic or Crew and personnel.
Quick Turn with Bin Doors Open and Passengers in Seats (White BRIGHT)	Maximum Duration Allowed (Hours)	Additional Steps to Follow for Charging Credit
10-minute charge	5	a) Charging must begin prior to previous discharge duration ending.
15-minute charge	7.5	b) Bin doors can be open during charging. c) Passenger loading and unloading periods cannot be included in the charge time. Passengers can be seated on the aircraft.
Continuous Flight	Maximum Duration Allowed (Hours)	Additional Steps to Follow for Charging Credit
	No limit if ceiling and sidewall light stays on	If the Attendant Control Panel loses communication with the ceiling and sidewall lights, these lights will change to a default medium white. Flight duration can be extended continuously.

16.1.9 (-800) No Tail Stand Procedure

Revised: 09/28/2023

[FO Bulletin 24-26](#)

The No Tail Stand Procedure is used in either of the following situations:

- When charter operations are conducted and a tail stand is not available (refer to Charter Operations Checklist).
- When deplaning all Passengers at an offline airport.

Brief the Flight Attendants as soon as practical if either of these conditions can be anticipated and advise them to use the No Tail Stand Procedure and deplane the last six rows of Passengers first.

This notification directs the Flight Attendants to accomplish the following:

- Ensure the last six rows of Passengers deplane first.
- Allow the remaining Passengers to deplane.

16.2 Air Systems

Revised: 04/11/2022

This section contains information on air systems.

16.2.1 Engine Bleeds Off Takeoff

Revised: 04/11/2022

Use the following procedure when making an Engine Bleeds Off takeoff with the APU operating.

Use this procedure to increase ATOG, increase initial climb performance, or improve runway-stopping margin with the APU operating.

Right Pack Switch AUTO
Isolation Valve Switch CLOSE
Left Pack Switch AUTO/HIGH

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Left Engine Bleed Air Switch OFF
APU Bleed Air Switch ON
Right Engine Bleed Air Switch OFF
The right bleed switch may be left ON prior to completing the Before Takeoff checklist to allow better cabin air conditioning.

16.2.2 Unpressurized Takeoff

Revised: 04/11/2022

Use the following procedure when making an Engine Bleeds Off takeoff with the APU inoperative.

Air Conditioning Pack Switches AUTO
Isolation Valve Switch CLOSE
Bleed Air Switches OFF

16.2.3 Reconfiguring Following a Bleeds Off or Unpressurized Takeoff

Revised: 04/11/2022

At or above minimum cleanup altitude, complete the following:

(PM) If a bleeds-off or unpressurized takeoff was performed, reconfigure the packs and bleeds.

Bleeds off takeoff—At not less than minimum cleanup altitude, after the flaps are up, at climb thrust, perform the following steps. Following each step, note the appropriate pressure indication change before continuing.

Right Engine Bleed Air Switch ON

If engine failure occurs, do not position engine bleed air switches on until clear of obstacles.

(CA) If the pressurization panel is beyond reach, assume aircraft control and direct the First Officer to reconfigure the system.

Following an unpressurized takeoff, plan to begin reconfiguring the aircraft pressurization panel prior to 2,000 ft AAE.

When Cabin Rate of Climb Indicator Stabilizes:

APU Bleed Air Switch OFF (N/A for Unpressurized Takeoff)

Left Engine Bleed Air Switch ON

ISOLATION VALVE Switch AUTO

(CA) APU OFF, As Required

The APU has built-in cooling circuitry and may be switched off without delay.

(PM) Verify the aircraft is cleaned up and pressurizing properly.

16.2.4 Engine Bleeds Off Landing Procedure

Revised: 04/11/2022

When below 10,000 ft, if additional thrust for improved aircraft performance is needed or desired, and the APU is operative, complete the following:

APU Start

Right Air Conditioning Pack Switch AUTO

ISOLATION VALVE Switch CLOSE

Left Air Conditioning Pack Switch AUTO

Left Engine Bleed Air Switch OFF

APU Bleed Air Switch ON

Right Engine Bleed Air Switch OFF

16.2.5 Unpressurized Landing Procedures

Revised: 04/11/2022

When below 10,000 ft, if additional thrust for improved aircraft performance is needed or desired, and the APU is inoperative, complete the following:

Engine Bleed Air Switches OFF

Normally, the engine bleed switches should be turned off when beginning the final approach turn or at the FAF. When beginning the final approach, avoid high rates of descent for Passenger comfort.

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5.14.1 Bird Strikes

Revised: 04/11/2022

Bird strikes are common in aviation. Most bird strikes occur below 500 ft AGL. This section details bird strikes that affect the engines.

Recent studies of bird strikes reveal that approximately 50 percent of reported engine bird strikes damage the engine(s). The risk of engine damage increases proportionally with the size of the bird and increased engine thrust settings. When a bird strike damages the engine, the most common indications are significant vibrations due to fan blade damage and an EGT increase.

Note: After any bird strike, the aircraft must be inspected by Maintenance.

Preventative Strategies

Airports are responsible for bird control and should provide adequate wildlife control measures. If large birds or flocks of birds are reported or observed near the runway, Pilots should consider the following:

- Delay the takeoff or landing when fuel permits. Advise the tower and wait for airport action before continuing.
- Take off or land on another runway that is free of bird activity, if available.

To prevent or reduce the consequences of a bird strike, Pilots should consider the following:

- If possible, at lower altitudes, avoid leveling off for extended periods of time just above or just below cloud layers.
- Be extremely vigilant if birds are reported on final approach.
- Plan for additional landing distance to account for the possibility of no thrust reverser use if a bird strike occurs.

Note: The use of weather radar to scare the birds has not been proven effective.

Pilot Action for a Bird Strike During Takeoff

If a bird strike occurs during takeoff, the decision to continue or reject the takeoff is made by using the criteria in [5.18.7 Rejected Takeoff \(RTO\)](#).

Pilot Action for a Bird Strike During Approach or Landing

If the landing is assured, continue the approach to land. If more birds are encountered, fly through the bird flock and land.

If engine ingestion is suspected, limit reverse thrust on landing to the amount needed to stop on the runway. Reverse thrust may increase engine damage, especially when engine vibration or high EGT is indicated.

5.15 Maneuvers

Revised: 04/11/2022

This section provides information on the non-normal procedures contained in [5.18 Non-Normal Maneuvers](#).

5.15.1 Overspeed

Revised: 04/11/2022

V_{MO}/M_{MO} is the aircraft maximum certified operating speed and should not be exceeded intentionally. However, Pilots can occasionally experience an inadvertent overspeed. Aircraft have been flight tested beyond V_{MO}/M_{MO} to ensure that smooth Pilot inputs return the aircraft safely to the normal flight envelope.

During cruise at high altitude, wind speed or direction changes may lead to overspeed events. Although autothrottle logic provides for more aggressive control of speed as the aircraft approaches V_{MO}/M_{MO} , there are some conditions that are beyond the capability of the autothrottle system to prevent short-term overspeeds.

When correcting an overspeed during cruise at high altitude, avoid reducing thrust to idle, which results in slow engine acceleration back to cruise thrust and may result in over-controlling the airspeed or a loss of altitude. If autothrottle corrections are not satisfactory, deploy partial speedbrakes slowly, until a noticeable reduction in airspeed is achieved. When the airspeed is below V_{MO}/M_{MO} , retract the speedbrakes at the same rate as they were deployed. The thrust levers can be expected to advance slowly to achieve cruise airspeed; if not, they should be pushed up more rapidly.

During descents at or near V_{MO}/M_{MO} , most overspeeds are encountered after the autopilot initiates capture of the VNAV path from above or during a level-off when the speedbrakes were required to maintain the path. In these cases, if the speedbrakes are retracted during the level-off, the aircraft can momentarily overspeed. During descents using speedbrakes near V_{MO}/M_{MO} , delay retraction of the speedbrakes until after the VNAV path or altitude capture is complete. Flight Deck Crews routinely climbing or descending in wind shear conditions may wish to consider a 5-10 kt reduction in climb or descent speeds to reduce overspeed occurrences. This has a minimal effect on fuel consumption and total trip time.