BRITISH AIRWAYS
Flight Operations

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BOEING COMMERCIAL AIRPLANES

FLIGHT OPERATIONS TECHNICAL BULLETIN

NUMBER:	707-16-1	777-44
	B-717-16-01	787-17
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	747-8-9	MD-11-16-01
	757-89	MD-80-16-01
	767-92	MD-90-16-01

DATE: August 24, 2016

SUBJECT: Lithium Battery Fires on the Flight Deck

ATA NO: 0200-00

APPLIES TO: All 707, 717, 727, 737, 747, 757, 767, 777, 787, DC-8, DC-9, DC-10, MD-10, MD-11, MD-80, and MD-90 Airplanes

REASON: To provide information about lithium battery fires on the flight deck and methods for addressing them.

BACKGROUND INFORMATION

Lithium batteries are commonly used to power consumer Portable Electronic Devices (PED) such as laptop computers, camcorders, tablets, readers, mobile phones, pagers, electronic cigarettes, and hover boards. They are also used to power airplane equipment such as portable Emergency Locator Transmitters (ELT), inflatable seat belts, and as a backup for emergency lighting.

There are two types of lithium batteries, lithium metal (non-rechargeable, i.e., disposable) and lithium ion (rechargeable). Both types are capable of overheating.

Overheating can be caused by a short circuit, overcharge, rapid discharge, extreme temperatures, mishandling, or an internal defect. Overheating can cause a thermal runaway, which is a chemical reaction within the battery that causes the internal temperature and pressure to rise. When one cell in a battery overheats, it can produce enough heat (up to 900°C, 1652°F) to cause adjacent cells to overheat. This can cause a lithium battery fire to flare repeatedly as each cell overheats. The result can be multiple releases of flammable electrolyte and, in the case of lithium metal batteries, multiple releases of molten burning lithium.

As with any smoke, fire, or fumes situation, the use of Protective Breathing Equipment (PBE), particularly when using Halon or Halon replacement fire extinguishers, may be appropriate.

Lithium Metal Batteries (BA NOTE - these are not carried on BA flight decks)
The cells in lithium metal batteries are made with metallic lithium.

Metallic lithium is extremely flammable and cannot be extinguished with typical hand-held extinguishers used on transport category aircraft. However, hand-held extinguishers can be used to prevent a subsequent thermal runaway.

A thermal runaway in a lithium metal cell is, typically, more severe than a thermal runaway in a lithium ion cell. A lithium metal cell releases a flammable electrolyte mixed with molten lithium metal, accompanied by a pressure pulse. Cells with more energy produce larger pressure pulses. This combination can result in an explosion that can spread the fire and cause severe bodily injury.

Lithium Ion Batteries
The cells in lithium ion batteries have an anode made from a metal oxide composite containing lithium ion, and a cathode made from a specialized carbon material. Charge and discharge of the lithium ion battery is facilitated by the movement of lithium ions in an electrolytic solution.

Laptop computers and other battery-operated devices are often powered by one or more battery packs that contain multiple lithium ion batteries or cells. The individual batteries or cells are not visible as they are encased in a plastic housing.

Lithium ion cells are flammable and capable of self-ignition.

A thermal runaway in a lithium ion cell is, typically, less severe than a thermal runaway in a lithium metal cell. A lithium ion cell releases a flammable electrolyte, accompanied by a pressure pulse. Lithium ion cells do not release molten lithium.

OPERATING INFORMATION

Each operator should identify the type(s) of lithium batteries carried on and located in the flight deck, and create a firefighting plan for each type.

WARNING: Dependent on the energy in the battery, a standard burn bag may not contain a lithium battery fire. *

Fighting a fire that contains either lithium metal or lithium ion battery cells requires (a) extinguishing the fire, (b) moving the device out of the flight deck, if possible, and (c) cooling the remaining cells to prevent or stop a thermal runaway.

Extinguish the Fire

It is important to take action as soon as a malfunctioning device is identified, preferably before the device catches fire. If there is no risk of injury, the first course of action should be to turn off, unplug, or remove power from the device.

Good Crew Resource Management (CRM) should include positively passing control from the Pilot Flying (PF) to the Pilot Monitoring (PM), if needed.

WARNING: If a PED is dropped, do not move a seat to locate it. If the seat hits the PED, it could damage the battery and cause a fire.

Fires can occur under floor panels, above ceiling panels, or in equipment compartments. Signs of fire include odors, hot spots, or visible smoke. Attempt to locate the source of the fire. Feel the suspected area(s) with the back of the hand to reduce injury.

WARNING: Use care to avoid damaging primary structure and windows, and injuring personnel.

Use the crash axe, if needed, to access a lithium battery fire under, above, or behind a panel. Initially, a small hole can be made in a panel and a fire extinguisher can be discharged through the hole to knock down the fire before completely opening the panel and exposing the fire to cabin air. The use of water under, above, or behind a panel containing electrical wiring or electrical components is not recommended.

* There are commercially-available solutions to contain lithium battery fires. An internet search for “lithium battery fire containment” yields multiple solutions. The Boeing Company has not evaluated any of these solutions for their effectiveness in containing lithium battery fires.

Use a Halon, Halon replacement, or water fire extinguisher to extinguish the fire and prevent the spread of the fire to other flammable materials. Water can react with the small amount of metallic lithium in a lithium metal battery but it is still the most effective agent for cooling the remaining cells, stopping thermal runaway, and preventing additional flare-ups. Do **not** use a specialized dry powder to extinguish the fire as this may increase the likelihood that additional battery cells will reach thermal runaway.

WARNING: Do not use ice to cool a device with burning lithium batteries or cover the device with a blanket or towel. Ice and other materials insulate the device, increasing the likelihood that additional battery cells will reach thermal runaway.

<u>Move the Device Out of the Flight Deck, If Possible</u>
The Captain must determine the safest course of action; moving the device out of the flight deck or leaving the device on the flight deck.

WARNING: Do not attempt to pick up or move a smoking or burning device, unless properly protected from the fire.

If the Captain decides to move the device, protective gloves, clothing, or other materials on the flight deck can be used to reduce the potential for injury. If a device can't be picked up, the crash axe can be used to push or pull the device from the flight deck.

<u>Cool the Remaining Cells to Prevent or Stop a Thermal Runaway</u>
Immediately after the fire is extinguished and the device is moved from the flight deck, if possible, a crewmember should douse the device with water, a water-based extinguishing agent, or other non-alcoholic liquid to cool the battery and prevent additional battery cells from reaching thermal runaway. Consider the use of a metal container such as a galley cart or toilet bowl for this purpose.

The device should be monitored for the rest of the flight.

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BOEING COMMERCIAL AIRPLANES

FLIGHT OPERATIONS TECHNICAL BULLETIN

NUMBER: 737- 11-1R1
747- 11-62R1
757- 11-81R1
767- 11-83R1
777- 11-32R1
787- 06-01R1

DATE: August 25th, 2017

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SUBJECT: Ice Crystal Icing

ATA NO: 0200-00

APPLIES TO: 737, 747, 757, 767, 777, 787

BACKGROUND

This bulletin summarizes current Boeing information about engine power loss and damage events associated with flight in ice crystal icing conditions. This problem most frequently affects aircraft flying over tropical regions but is not limited to those areas. In 2008, Boeing recorded three events in the United States, two near Chicago O'Hare airport and one near New York's Kennedy airport. All three were at high altitude in convective* weather associated with the remnants of tropical storms which had lost energy but were still producing heavy rain on the ground.

Ice crystal icing affects engine models differently. Engines on Boeing aircraft have experienced flameouts, surges, high vibrations, and compressor damage due to ice impacting the fan blades.

- * Convection occurs when warm moist air rises in an unstable atmosphere. As the air rises, it expands and cools, and water vapor within it condenses to form clouds. Thunderstorms are one type of convective weather that can lift moisture to the tropopause where winds spread the cloud into a recognizable anvil shape. Convective updrafts lift high concentrations of water above the freezing level where the water freezes, and grows to hailstones or falls as rain.

Flight crews are not always aware that the engines have been damaged as a result of flight in convective weather containing ice crystals. Data gathered from pilot reports, flight data, and meteorological studies were used to develop the best practices summarized in this bulletin. Our understanding of the ice crystal icing phenomenon and its flight deck effects is evolving. This bulletin may be updated as more information becomes available.

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1.0 A New Threat

Until now, ice crystals at high altitude have not been thought of as a threat to aircraft because they do not lead to airframe icing. However, the industry has identified a condition in which solid ice particles can cool interior engine surfaces through melting and ice build-up. When the ice sheds, it can result in engine power loss or damage. Symptoms of a power loss can be a surge, flameout, or high vibration. Typically, the engine power loss has occurred at high altitude, in clouds, as the aircraft is flying over an area of convective weather where little or no weather radar returns were observed at the flight altitude. In other cases, flight altitude radar returns were observed and pilots followed standard thunderstorm avoidance procedures. Despite pilot avoidance of weather radar returns, engine power losses have occurred. Avoidance of ice crystals is a challenge because they are not easily identified.

2.0 Pilot Reports

Here is a sample report for an ice crystal icing event.

> **J502 YYJ288/30**
> **1420L, FL 350, B747**
> **Intermittent IMC to 330 then IMC up to and at 370.**
> **TAT approximately zero (0).**
> **Winds 330/19, light to moderate turbulence, no icing.**
> **Remarks: TAT indicator wrong. Rain on windscreen at 370 (impossible), suspect ice crystals due to the sound. Heavy returns 5 to 7000 feet below us. Saw tops above 41K before going IMC. No returns at our higher altitude. Got ATC reroute to pass north of heavy returns ahead and below. (passing waypoint) Turbulence increased, asked flight attendants to be seated. Appears Engine 1 rolled back briefly, then recovered.**

3.0 Indications of Ice Crystal Icing

Breaking down the above report and analyzing the weather in similar incidents has increased our confidence in the following traits associated with ice crystal icing:

3.1 In clouds at high altitude

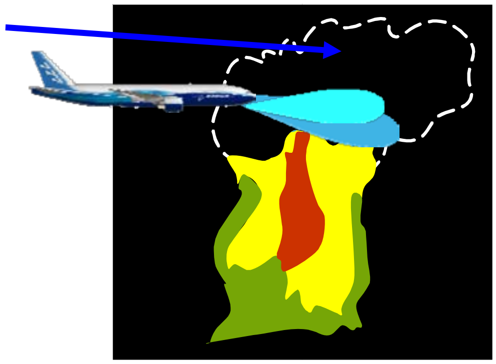
- All pilots report being ***in clouds*** when the ice crystal-induced engine power loss events occur.
- More than 60% of these events occur in the Asia-Pacific region, in a tropical environment, where warm air can hold more moisture. This air rises and cools, forming clouds containing a great amount of ice ***at high altitude***.

3.2 No weather radar returns at flight level

- This ice is thought to be concentrated in very small particles, the size of baking flour - a ***poor reflector of radar energy*** despite the density.

3.3 Heavy weather radar returns below flight level

- From event weather radar analysis, events consistently occur when the aircraft is in Instrument Meteorological Conditions **(*IMC) and over-flying an area which would be amber or red*** on the pilot's weather radar. Ice that has been lifted to high altitude eventually falls through the freezing level and begins to melt. These wet particles are much more reflective and therefore visible (amber or red) to radar. These clouds can be identified by pilots if they ***manually tilt the radar down*** to scan below the freezing level.



3.4 Traversing clouds with tops at high altitude

- Often these clouds lift condensed water to high altitude, even penetrating the tropopause. It is in these ***updraft areas*** where the highest ice crystal concentrations can be encountered.

3.5 No airframe icing

- Ice crystals bounce off cold surfaces such as the airframe, which is why airframe icing is usually not noted. These small particles may accumulate in stagnation areas, so it is possible that a small concentration might be noted on the leading edge of the wiper post.

3.6 Appearance of rain

- Another key indicator of ice crystal conditions is the ***appearance of rain*** on the windscreen at high altitudes. From pilot reports and flight data we have concluded that when small ice crystals in high concentrations hit the heated windscreen, they melt and give the appearance of rain, even when the ambient temperature is too cold for liquid to exist. Several interviewed pilots explained that ice crystals ***sound different*** than typical rain.

3.7 TAT near zero

- For the engineer reviewing event data, the ***TAT anomaly*** (TAT reading near zero °C) is a good indication that an aircraft has flown through ice crystals. This unusual behavior is created when ice crystals collect in the area where the sensor element resides. Some ice crystals melt and the sensor measures icewater at 0° Celsius. This effect depends on the aircraft model, where the TAT
probe is installed on the fuselage, and how TAT is displayed in the cockpit. There are many variations in the Boeing fleet and some aircraft are more susceptible to the TAT anomaly than others.

3.8 Only light to moderate turbulence

- Meteorologists tell us that even though these clouds reach the tropopause, when they form in a tropical environment, they are not as powerful as those that form over land (which more commonly have lightning) and, therefore, they have lower updraft velocities, resulting in only **light to moderate turbulence**.

3.9 Other clues

Pilot reports from events vary and not all the symptoms noted above are reported in every event.

- Another effect which is associated with ice crystals striking the airframe is **St. Elmo's Fire**.
- Several reports referred to increases in **temperature and humidity** in the cockpit preceding the TAT anomaly. This was only present while in IMC and is likely another cue that ice crystals were present.

4.0 Industry Efforts

The industry is working to improve engine capability in ice crystals. There is still much to be understood, including the weather threat and the details of the ice formation inside the engines. Efforts to close the knowledge gap have long timescales, and the ability to apply practical technology to allow robust simulation of these conditions is many years away. Hence in the near term, there has been a focus on providing better information to flight crews in the cockpit to help with weather avoidance.

5.0 Research

Very few instrumented research flights have been made in convective clouds. Very little is known about the concentrations and sizes of ice crystals in these clouds. Knowing the severity of the atmosphere is a key to designing an engine to operate in these clouds. To address this need, a team of government and industry members known as the High Ice Water Content (HIWC) Partnership plans to conduct an instrumented flight program in 2012. At the same time, work is ongoing to better understand the physics of engine ice crystal icing, and develop test facilities where engines can be tested.

Recently, airlines have brought pilot reports and flight data to Boeing's attention where the aircraft TAT is in disagreement with the engine inlet temperature. We believe this can occur in ice crystal icing conditions. A study of TAT anomalies, as well as TAT and engine inlet temperature disagreement, may provide more insight into the type of convection that causes engine power loss and damage events. One interesting finding is that the TAT anomaly is occurring at a higher frequency than previously realized.

Boeing continues to enhance its understanding of what kind of weather causes engine events so the best information can be provided to flight crews. Each engine event is carefully evaluated from a meteorological and engine diagnostic standpoint so that, in the future, we can provide better information to operators.

6.0 Key Points for Flight Crews

6.1 Recognize weather conducive to ice crystal formation

Ice crystals are most frequently found in areas of visible moisture above altitudes normally associated with icing conditions. They are indicated by one or more of the following:

- Rain on the windscreen at temperatures too cold for liquid water to exist, due to ice crystals melting on the heated windows.
- Aircraft TAT remains near 0 degrees C.

- Areas of light to moderate turbulence.
- No significant radar returns at aircraft altitude.
- Heavy rain below the aircraft, identified by amber and red on weather radar.
- Cloud tops reaching above typical cruise levels (above the tropopause).

Note: There is no significant airframe icing. The icing conditions detection system (if installed) is not designed to detect ice crystal icing, only supercooled droplets.

6.2 Avoid ice crystal icing conditions

During flight in IMC, avoid flying directly above significant amber or red radar returns, even with no returns at aircraft altitude.

Use the weather radar manual tilt and gain functions to assess weather radar reflectivity below the aircraft flight path.

6.3 Ice crystal icing suspected

Exit ice crystal icing conditions. Request a route change to minimize time above red and amber radar returns.

7.0 More Information

For more general information please see the MyBoeingFleet web pages below:

☐ **Air France Training Module**

Ice Crystals at High Altitude: Engine Powerloss, TAT and Pitot Anomalies
[A 15 minute computer based training module for flight crews. Follow:
"Flight Operations", "Events, Training & Resources", "Safety Tools & Training Aids", "Ice Crystals at High Altitude".]

☐ **Symposium Briefing**

Ice Crystal Threat
["Flight Operations", "Past Flight Operations Conference Presentations", "More", "Regional Operations Conferences" (2008), "Ice Crystal Threat".]

☐ **AERO magazine**

Engine Power Loss in Ice Crystal Conditions ["Archive", "2007, 4th Quarter"]
Avoiding ConvectiveWeather Linked to Ice-crystal Icing Engine Events ["Archive", "2010, 1st Quarter"]

8.0 Ice Crystal Ice Threat - Frequently Asked Questions

Q1. How many engine events have been recorded?

There are more than 100 events in an industry database. This number includes events on Boeing aircraft, events involving engines on other manufacturers' aircraft, a commuter aircraft, and a business jet. In some cases, Boeing has been successful in making procedural changes which have eliminated engine power loss events on some engines.

Q2. How does ice form on warm engine surfaces?

The physics of ice crystal accumulation in the engine is not completely understood, but the mechanism is thought to be the following: Ice particles enter the engine and bombard a warm surface. Thus, a mixture of liquid and ice particles exist on the surface. The liquid slows down the incoming ice particles long enough for heat transfer to take place. Heat is removed from the metal until the freezing point is reached and ice begins to form. This phenomenon means ice accumulation can occur well behind the fan in the engine core. Ice shed from compressor surfaces can cause engine instability such as surge, flameout, or engine damage.

Q3. To date, what is the maximum internal engine surface temperature at which ice has formed?

Industry data has shown that an engine at cruise power, with engine surfaces near 100°F (38°C) before entry into cloud, was able to build up ice.

Q4. Are these events mostly at low power settings?

No. Engine power loss and damage events have been experienced both at high power, cruise conditions and low power, descent conditions.

Q5. Does increasing thrust help prevent ice build up?

Unlike conventional icing (supercooled liquid water), which builds up on cold engine surfaces, ice crystal icing can occur on engine surfaces that are initially warmer than freezing. When power is increased, the engine surfaces that are susceptible to the formation of ice change but ice formation is not eliminated. Further, if on descent, setting higher power would result in a slower descent and longer exposure to the threat.

Q6. In what temperature range do ice crystals exist?

Ice crystals exist from temperatures just below 0°C to well below -40°C. Note that convective storms have strong mixing effects so all supercooled liquid is efficiently converted to ice or ice crystals, even near freezing temperatures.

Q7. Explain the significance of ice crystal mass concentration compared to supercooled liquid?

For engine certification, the engine is exposed to a maximum of 2 g/m^3 (grams per cubic meter) of supercooled liquid droplets. In these conditions, ice builds up on the front of the engine – the fan, spinner, and core splitter fairing. When ice sheds, some of it will pass harmlessly through the fan duct. Measurements suggest that convective clouds can hold up to 8 g/m^3 of ice crystals. Not only is that four times the mass of supercooled liquid but ice is also able to form on core engine surfaces.

Q8. Why do some engines stall, some flameout, and some have damage?

The ice crystal icing phenomenon is not completely understood. Every engine also has different margins in its compressor and combustor, plus different geometry. The combination of design margins and geometry seem to result in different effects on each engine.

Q9. In these conditions, should engine anti-ice be turned on for all aircraft?

Not for all aircraft. Engine anti-ice supplies heat to the cowl and, in these conditions, that is not where ice is forming. Engine anti-ice also has other effects: Accelerating the engine to approach idle, providing ignition, and promoting a higher fuel-to-air ratio in the combustor. We have recommended using engine anti-ice for only those engines where we believe these effects are beneficial – those engines that have a power loss during low power. If the power loss or damage problem occurs during cruise, none of these effects prevent icing-related power loss.

Q10. What about turning on engine ignition?

On engines without auto-relight protection, continuous ignition could help the engine recover more quickly if the combustor flames out.

Q11. Would the relights be faster if the engine is at approach/high idle?

Yes, as long as ignition is available.

Q12. Are events still happening?

Yes. Across the industry, there is roughly one power loss and one damage event every four months.

Q13. At what altitudes have events been identified?

We have seen events from 9,000 feet up to 41,000 feet, all above the freezing level in a convective storm.

Q14. Are both large and small turbofan engines affected?

Yes. In the 1990s, commuter aircraft suffered rollbacks due to ice accumulation “blocking” the core. This phenomenon has not happened on large turbofan engines because the sizes of the engine passages make it more difficult to build up enough ice to block the core. Most of the large turbofan engine events are a result of ice building up and shedding, causing a surge, flameout or damage.

Q15. Do all engines recover?

As of today, all large turbofan engines have recovered. Commuter aircraft engines were not restarted until the ice melted at lower altitude. On large turbofan engines which have suffered power losses, all have been restarted quickly. Once the ice has shed, the engine is immediately able to restart.

Q16. Are both low and high bypass ratio engines affected?

Yes. We have events on older, low bypass engines as well as on brand new, large high bypass ratio turbofan engines.

Q17. Are deteriorated engines more susceptible?

Not necessarily, we have had events on old and new engines.

Q18. Why aren’t there flight crew procedures for all engine types?

Not all engines have ice crystal ‘problems' and the behavior of engines with problems differ. We provide engine-related procedures for only those engines where they are needed.

Q19. What is the TAT anomaly?

The aircraft Total Air Temperature (TAT) probe erroneously reporting zero °C can be an indication of ice crystals in the atmosphere.

This anomaly is due to ice crystals building up in the area near the sensor element, where ice crystals are partly melted by the heater, causing the zero °C reading. In some cases, TAT has “flat-lined” at zero during a descent and may be noticeable to pilots. In other cases, the error is more subtle and may not be a reliable indicator to provide early warning to pilots of high concentrations of ice crystals.

Although TAT is an engine control system parameter, the TAT anomaly has not been determined to be a contributor to the surge, stall or flameout events. Under these conditions, the engine control system compensates for the loss of TAT. Note that the 757 has never had a TAT anomaly event due to its location on the fuselage.

Q20. Can we tell flight crews to use the TAT anomaly to avoid iced crystal icing conditions?

The TAT anomaly is not a reliable indicator of ice crystal icing conditions because it does not occur on all aircraft and it sometimes occurs after the engine event.

Q21. Is anyone building an ice crystal detector?

Boeing and the industry are working to develop better methods of detecting ice crystals.

Q22. What is the industry doing to better understand this problem?

An industry committee has developed a Technology Plan which includes:

- Improved instrumentation to measure atmospheric conditions
- Flight trials to characterize ice crystals (particle size, concentration and extent)
- Fundamental physics testing of ice accumulation and shedding □Improving engine test methods and facilities

Government and industry partnerships are funding this work.

Q23. What is the FAA doing to make sure engines are capable of operating in ice crystal icing?

The FAA is a partner in the technology plan mentioned above. In addition, the FAA has new regulations under review.

Q24. If I have had an ice crystal icing event, would Boeing be interested in hearing about it, and receiving data?

Boeing would greatly appreciate hearing details of the event. We have a questionnaire (included in this bulletin) you can fill out. In addition, if the flight data is still available, we have a standard request for engine and airplane data, including questions for the pilots. This would be very valuable to our continued investigation

9.0 Ice Crystal Encounter Pilot Questionnaire

Most information about ice crystal icing has been gathered from meteorological studies, airline-provided pilot reports, and flight data. If you suspect you've experienced an ice crystal encounter, even if it hasn't resulted in an engine event, we'd like to hear about it. In addition, it would be helpful to receive Flight Data Recorder (FDR) or Quick Access Recorder (QAR) data, if available.

Please complete the questionnaire on the following pages or online at https://active.boeing.com/Surveys/Ice_Crystal_Icing/. It should take less than 10 minutes of your time.

If you have had more than one encounter, please complete a questionnaire for each encounter.

Thank you in advance for your assistance.

Ice Crystal Encounter Pilot Questionnaire

Ice crystals have been associated with engine power loss, vibration, and damage. Power loss can be a surge, stall, flameout, or failure to respond to throttle input.

Please review the Engine Anomalies in Part 1 and the Conditions Associated with Ice Crystal Encounters in Part 2. If you have experienced an engine anomaly in IMC *or* one or more of the conditions, please answer the Questions about Ice Crystal Encounters in Part 3.

Part 1. Engine Anomalies

- Engine surge or stall (may have been momentary)
- Engine failed to respond to thrust lever inputs (may have been momentary)
- Engine flameout
- Engine vibration

Part 2. Conditions Associated with Ice Crystal Encounters

- No ice detected on Rosemount ice detector
- Aircraft in the vicinity of convective clouds or thunderstorms
- TAT anomaly (or TAT / T12 disagree)
- Flight above freezing level
- No weather radar returns at the event location
- Tropical atmosphere
- Visible moisture
- Light to moderate turbulence
- No observation of significant airframe icing
- Heavy rain or rain on the windscreen at SAT below -20°C
- St. Elmo's Fire
- Lightning
- Sounds of precipitation

Part 3. Questions about Ice Crystal Encounters
Please take a few minutes to provide as much of the following information as possible about your experience. Feel free to include any additional information you think may be of interest.

1. Did any of the following engine anomalies occur during the event?

	Yes	No / Don't know
Engine surge or stall (may have been momentary; engine may have recovered automatically)		
Engine failed to respond to thrust lever inputs (may have been momentary; engine may have recovered automatically)		

Engine flameout (may have been momentary)		
Engine vibration		
Other (please describe below)		

Additional comments:

____

____

2. Please provide information about the event.

Aircraft Type ____
Engine Type ____
Date ____
Time (UTC) ____
Location (latitude/longitude,
nearest waypoint or navaid) ____
Altitude ____
Temperature (SAT °C) ____

3. Was the flight in the vicinity of convective clouds or thunderstorms?

No / Don't know
Yes (please indicate the location of the weather in relation to the aircraft)

Additional comments:

____

____

4. Was the flight through visible moisture or in Instrument Meteorological Conditions (IMC) at the time of the event?

No / Don't know
Yes (please describe)

Additional comments:

____

____

5. Was there rain on the windscreen or ice melting on the heated windscreen?

No / Don't know
Yes (please describe)

Additional comments:

____

____

6. If the aircraft was equipped with an ice detector, did it indicate ice?

No / Don't know
Yes
Not equipped with an ice detector

Additional comments:

____

____

7. Was there a TAT anomaly (TAT reading zero or tending toward zero erroneously)?

No / Don't know
Yes (please explain)

Additional comments:

____

____

8. Were there any radar returns in the area?

No / Don't know
Yes (please provide the location [above or below, in front of, behind], size, color, and any additional information describing the returns)

Additional comments:

____

____

9. Were there any sounds of precipitation?

No / Don't know
Yes (please describe)

Additional comments:

10. Was there any visible airframe icing?

No / Don't know
Yes (please describe the icing type and severity)

Additional comments:

11. Was there any turbulence?

No / Don't know
Yes (please describe the turbulence)

Additional comments:

12. Was there any lightning?

No / Don't know
Yes

Additional comments:

13. Was St. Elmo's Fire visible?

No / Don't know
Yes

Additional comments:

14. Was the cockpit warmer or more humid than normal?

No / Don't know
Yes

Additional comments:

15. Was there any smell in the cockpit?

No / Don't know
Yes (please describe)

Additional comments:

16. Did the autothrottle automatically disconnect?

No / Don't know
Yes (please describe)

Additional comments:

17. Please provide any additional information about the event to help us better understand this weather phenomenon.

____
____
____
____

Thank you for taking the time to complete the questionnaire.

If you have any questions or would like to provide additional information, contact Melissa Bravin at melissa.m.bravin@boeing.com.

10.0 Information for Dispatchers

10.1 *On IR satellite image*

Look for large (>180KM) region of cloud tops at or above the altitude of the tropopause

Events typically happen in deep convection identified on an IR satellite image by a large round or oval “enhanced” region of cloud on the order of 180 km or greater. The enhanced region is where cloud tops are at the tropopause* temperature (obtained from nearest observed or forecast sounding see figure B) or colder. Approximately 80% of the events we’ve seen have occurred in mesoscale convective systems (MCS*).

10.2 *Warm season thunderstorms*

ISA +5 to +20C

The events are often found in MCSs with a tropical-like moist atmosphere. Events are occurring with equal frequency over land and water. A majority of the events tropical and subtropical regions, but they can occur anywhere convection is found. The temperature profiles are 5 to 20C warmer than ISA during events showing that this is a warm season or warm climate phenomena. The events recorded in 20082010 in the USA occurred in remnants of hurricanes and tropical storms.

10.3 *Storm cloud top temperatures*

Typically from -55C and colder (elevations above typical cruise altitudes)

Infrared cloud top temperatures were measured and recorded for each event location. As a result of the analysis, the median cloud top temperature was found to be -63C, the middle half of events had cloud top temperatures ranging from -55 C to -70 C, the maximum temperature was -44 C, and the minimum was 87 C

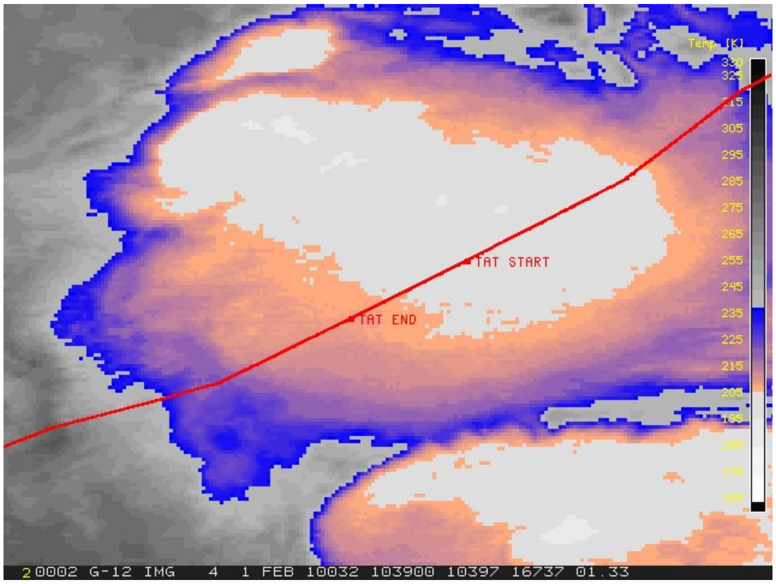


Figure A: Enhanced infra-red satellite image showing clouds at or above the tropopause in grey and white colors. The airplane track is shown in red. An engine damage event occurred during a TAT anomaly, noted by TAT start and TAT end notations. In the flight deck, the flight crew observed an auto-throttle disconnect associated with the TAT anomaly.

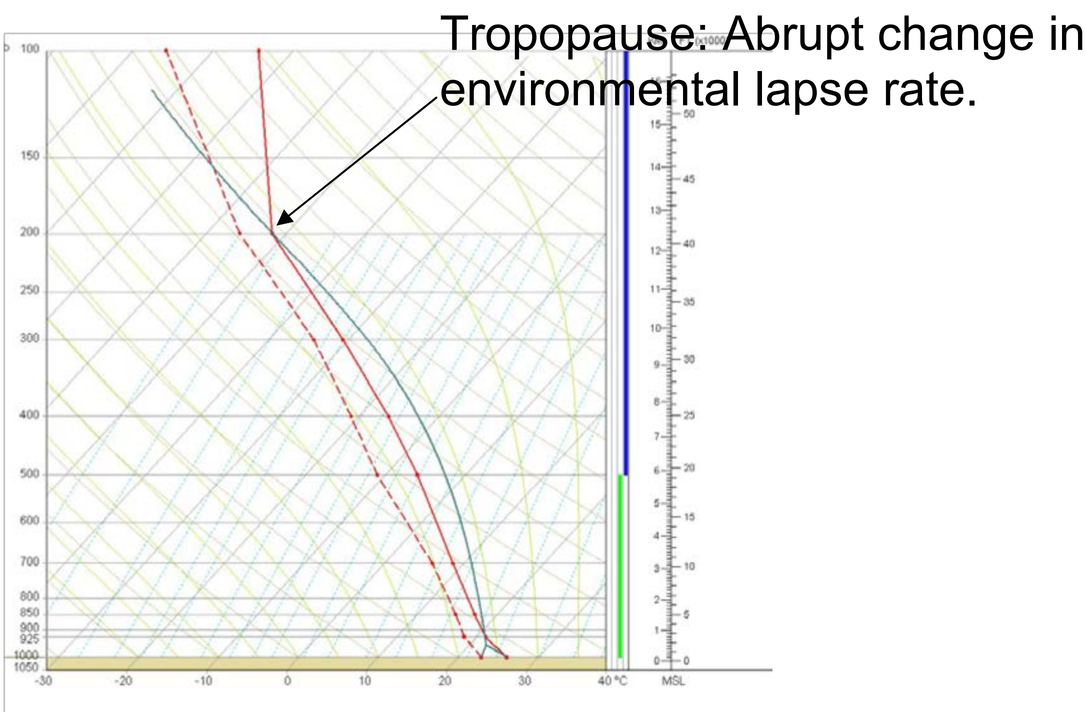


Figure B: An average sounding compiled from engine power loss and damage events up through 2009

10.4 Moderate and/or Heavy rain below the freezing level (> 30dbz)

Radar data from events show that below the aircraft there was heavy rain identified by greater than 5.5 mm/hr (30 dBZ) or amber or red on the on board weather radar (1 mm/hr = 23 dBZ, 10 mm/hr = 37 dBZ, and 100 mm/hr = 50 dBZ)

10.5 From the flight deck: Little or no radar at flight level (<20dbz)
Little to no radar reflectivity is typically detected at flight level during events. Reflectivity values have ranged from 10-25 dBZ at the engine event altitudes. Pilots can only detect 20+ dBZ, which make these areas mostly transparent to pilots.

10.6 Be aware of CAPE, Lifted Index* and Precipitable Water* values along the route*
A study of environmental parameters indicates engine events occur with moderate instability (median CAPE of 1,141 J/kg & median lifted index of -3.7), high moisture (median precipitable water of 2.3”) The highest risk areas will be MCS’s that occur within an environment that has PW values of 2” or greater.

10.7 Guidance for flight crews:
Avoid flying over the deepest convection in IMC, at temperatures below freezing. Pilots should also be advised to avoid flying down shear from convective cells in-cloud, at temperatures below freezing, especially if light returns (20-29 dBZ on aircraft weather radar).

10.8 Summary of Key Points for Dispatchers
- MCS with clouds over tropopause height 180km in size
- ISA +5 and greater
- Cloud top temps < -55
- Moderate and/or Heavy rain below the freezing level (> 30dbz)
- Precipitable Water values of 2” or greater

Forecasters should be aware of any MCS’s along the route and minimize (or avoid) routes through enhanced cold cloud top regions.

10.9 What the flight crews will notice and actions to take
- Little or no radar at flight level (<20dbz)
- Amber and red returns below the flight level

Advise pilots to tilt radar down and scan below airplane. Highest risk areas will have a combination of heavy rainfall below aircraft (likely no returns at flight level) and enhanced infrared region on satellite within MCS.

*10.10 Glossary**
Tropopause: The boundary between the troposphere and stratosphere, usually characterized by an abrupt change of lapse rate. The change is in the direction of increased atmospheric stability from regions below to regions above the tropopause. Its height varies from 15 to 20 km (9 to 12 miles) in the Tropics to about 10 km (6 miles) in polar regions. In polar regions in winter it is often difficult or impossible to determine just where the tropopause lies, since under some conditions there is no abrupt change in lapse rate at any height. It has become apparent that the tropopause consists of several discrete, overlapping “leaves,” a multiple tropopause, rather than a single continuous surface. In general, the leaves descend, step-wise, from the equator to the poles.

Mesoscale Convective System (MCS): A cloud system that occurs in connection with an ensemble of thunderstorms and produces a contiguous precipitation area on the order of 100 km or more in horizontal scale in at least one direction. An MCS exhibits deep, moist convective overturning contiguous with or embedded within a mesoscale vertical circulation that is at least partially driven by the convective overturning.

Convective Available Potential Energy (CAPE): The maximum energy available to an ascending parcel, according to parcel theory. On a thermodynamic diagram this is called positive area, and can be seen as the region between the lifted parcel process curve and the environmental sounding, from the parcel's level of free convection to its level of neutral buoyancy.

Lifted Index (LI): is the temperature difference between an air parcel lifted adiabatically Tp(p) and the temperature of the environment Te(p) at a given pressure height in the troposphere (lowest layer where most weather occurs) of the atmosphere, usually 500 mb. When the value is positive, the atmosphere (at the respective height) is stable and when the value is negative, the atmosphere is unstable.

Precipitable Water: is the depth of the amount of water in a column of the atmosphere if all the water in that column were precipitated as rain. As a depth, the precipitable water is measured in millimeters or inches.

BOEING COMMERCIAL AIRPLANE GROUP

FLIGHT OPERATIONS TECHNICAL BULLETIN

NUMBER: 747-400-61

DATE: December 13, 2010

These bulletins provide information which may prove useful in airline operations or airline training. This information will remain in effect depending on production changes, customer-originated modifications, and Service Bulletin incorporation. Information in these bulletins is supplied by the Boeing Company and may not be approved or endorsed by the FAA at the time of writing. Applicable documentation will be revised as necessary to reflect the information contained in these bulletins. For further information, contact Boeing Commercial Airplane Group, Chief Pilot, Flight Technical, P.O. Box 3707, Mail Stop 20-95, Seattle, WA, USA 98124-2207, Phone (206) 544-9612, Fax (206) 544-4747.

SUBJECT: Undetected Erroneous Radio Altitude

ATA NO: 34-33

APPLIES TO: 747-400

Background Information

Operators have reported events in which one or more of the three installed Low Range Radio Altimeters (LRRAs) produce undetected erroneous altitude. These events are presumed to occur because of one or more of the following reasons:

- Leakage of signal
- Cross talk between the antennas
- Loose connector
- Disturbed co-axial cable length
- A faulty LRRA

Airplane Effects

Single Erroneous Altitude Reading

If one LRRA provides an erroneous altitude reading, the airplane effects may include any of the following:

- Erroneous radio altitude displayed on the captain's or first officer's Primary Flight Display (PFD)
  Note: Erroneous altitude from the center LRRA will not be evident to the flight crew.
- Unavailability of autothrottle wakeup protection
- Annunciation of NO LAND 3 EICAS message
- Potential false, missing, nuisance, loss of:

  - Ground Proximity Warning System (GPWS) alerts
  - Landing configuration warnings
  - Speedbrake alerts
  - Traffic Alert and Collision Avoidance System (TCAS) alerts
  - Predictive windshear alerts
  - Lateral and vertical ILS deviation warnings
  - Decision Height alert

<u>Multiple Erroneous Altitude Readings</u>
If multiple LRRAs provide erroneous altitude readings, the airplane effects may include any of the following, in addition to those listed above:

- Erroneous radio altitude displayed on one, or both, of the PFDs
- Autothrottle retard if retard option selected and autothrottle engaged in SPD mode.
- Inhibiting of Autopilot Flight Director System (AFDS) engagement of TOGA (pitch and roll) during go-around
- Unavailability of some VNAV autothrottle modes if retard option selected and autopilot not engaged
- Annunciation of NO LAND 3 or NO AUTOLAND EICAS message
- Autopilot disconnect
- Flight Directors (F/Ds) bias-out-of-view
- Inhibiting of autopilot engagement
- If the autopilot is disengaged and both flight directors are turned off, subsequent selection of either flight director switch could engage the AFDS into TOGA for takeoff
- During autopilot coupled approach, yaw engagement may occur early or late, glideslope tracking performance may be degraded, the autopilot may request autothrottle retard early or late, and transition to flare mode could be early or late, and with degraded performance
- Activation of WINDSHEAR SYS and WINDSHEAR PRED EICAS messages

Boeing Recommendations

Whether in automated or manual flight, flight crews must carefully monitor primary flight instruments (airspeed, attitude etc.) for aircraft performance and the flight mode annunciation for autoflight modes.

During approach, the pilot flying should keep one hand on the thrust levers, even with the autothrottle engaged.

If the left and right LRRA disagree significantly, or if either one appears to be providing an erroneous altitude reading, disengage the automation. Note that the center LRRA condition is not evident to the flight crew.

Do not use the autoland system if either the left or right LRRA appears to be providing an erroneous altitude reading.

General Guidelines

Crew Resource Management (CRM) involves the effective use of all available resources to operate a flight safely. It is important that all flight deck crewmembers identify and communicate any situation that appears potentially unsafe or out of the ordinary. Experience has proven that the most effective way to maintain safety of flight and resolve these situations is to combine the skills and experience of all crewmembers in the decision making process to determine the safest course of action.

Situational awareness, or the ability to accurately perceive what is going on in the flight deck, requires ongoing questioning, monitoring, crosschecking, communication, and refinement of perception.

Early intervention prevents unsatisfactory airplane performance or a degraded flight path.

When the automatic systems as described above do not perform as expected, the Pilot Flying (PF) should reduce the level of automation to ensure proper control of the airplane is maintained.

The PF should not attempt to restore higher levels of automation until after aircraft control is assured.

Flight crew must ensure the proper configuration for the phase of flight. Time may be required in order to assess the situation, take corrective action and resolve the discrepancy; therefore a go-around, holding, or additional maneuvering may be necessary. Flight path control and monitoring of instruments must never be compromised.

Non-Normal Situation Guidelines

When a non-normal situation occurs, the following guidelines apply.

- NON-NORMAL RECOGNITION:
  - The crewmember recognizing the malfunction calls it out clearly and precisely.
- MAINTAIN AIRPLANE CONTROL:
  - It is mandatory that the Pilot Flying (PF) fly the airplane.
- ANALYZE THE SITUATION:
  - Any further action should only be initiated after the malfunctioning system has been positively identified.

Additional Information

Any occurrences of erroneous display data, even if intermittent, should be reported to maintenance.

More information can be found in the Boeing 747 Flight Crew Training Manual (FCTM) and Flight Crew Operations Manual (FCOM). Operators may want to review the following:

747 FCTM
1. Chapter 1 - Crew Resource Management
2. Chapter 1 - Callouts
3. Chapter 1 - AFDS Guidelines
4. Chapter 5 - Approach Briefing
5. Chapter 5 - Stabilized Approach Recommendations

747 FCOM
1. NP11 - Autopilot Flight Director Systems (AFDS) Procedures
2. Chapter 4 - Automatic Flight System Description
3. Chapter 10 - Flight Instruments, Displays System Description
4. Chapter 15 -Warning Systems System Description

BOEING COMMERCIAL AIRPLANES

FLIGHT OPERATIONS TECHNICAL BULLETIN

NUMBER: 707-10-1
727-10-1
737-10-1
747-18 (747-100/200/300)
747-59 (747-400/-8)
757-78
767-80
777-28
787-2

DATE: April 21, 2010

SUBJECT: Specific Flight Crew Actions Required in Response to Volcanic Ash Encounters

ATA NO: 05-50

APPLIES TO: All 707, 727, 737, 747, 757, 767, 777, 787, DC-8, DC-9, DC-10, MD-10, MD-11, MD-80, and MD-90 Airplanes

REFERENCES:
/A/ Boeing Multi-Operator Message MOM-MOM-10-0277-01B Dated 16 April 2010 GMT
/B/ AERO Magazine No. 9, 1st Quarter 2000
/C/ Boeing Multi-Operator Message MOM-MOM-10-0280-01B Dated 19 April 2010 GMT
/D/ Boeing Multi-Operator Message MOM-MOM-10-0281-01B Dated 21 April 2010 GMT

BACKGROUND:

As a result of volcanic ash from the Eyjafjallajoekull, Iceland area, all flights in and out of the United Kingdom and several other European countries have been suspended. Flight operations may be impacted for several months. The Reference /A/ message is a guide to operators and covers both airplane protection during this event and the actions necessary to return airplane to service following potential volcanic ash contamination.

This message is for dispatchers, flight followers, and flight crews and is a synopsis of the Reference /B/ article. Further, ground operation considerations and precautions have been added. The following information is general in nature; flight crews should refer to their company's operating manuals for more details.

OPERATING INFORMATION:

Operational guidance about volcanic ash is divided into three parts: Avoidance, Recognition, and Procedures.

1. Avoidance

Preventing flight into potential ash environments requires planning in these areas:

- Dispatch needs to provide flight crews with information about volcanic events, such as potentially eruptive volcanoes and known ash sightings, that could affect a particular route.
- Dispatch needs to identify alternate routes to help flight crews avoid airspace containing volcanic ash.
- Dispatch also needs to identify escape routes in the event of an unplanned descent due to an engine failure or cabin depressurization.
- Flight crews should stay upwind of volcanic ash and dust.
- Flight crews should remember that airborne weather radar is ineffective in distinguishing ash from small dust particles.

2. Recognition

Indicators that an airplane is penetrating volcanic ash are related to odor, haze, changing engine conditions, airspeed, pressurization, and static discharges.

- **Odor.** When encountering a volcanic ash cloud, flight crews usually notice a smoky or acrid odor that can smell like electrical smoke, burned dust, or sulfur.
- **Haze.** Most flight crews, as well as cabin crews and passengers, see a haze develop within the airplane. Dust can settle on surfaces.
- **Changing engine conditions.** Surging, torching from the tailpipe, and flameouts can occur. Engine temperatures can change unexpectedly and a white glow can appear at the engine inlets.
- **Airspeed.** If volcanic ash fouls the pitot tube, the indicated airspeed can decrease or fluctuate erratically.
- **Pressurization**. Cabin pressure can change, including possible loss of cabin pressurization.
- **Static discharges.** A phenomenon similar to St. Elmo's fire or glow can occur. In these instances, blue-colored sparks can appear to flow up the outside of the windshield or a white glow can appear at the leading edges of the wings or at the front of the engine inlets.

3. Procedures

Procedures are divided into two parts: In-flight Operations and Ground Operations at Airports Impacted by Volcanic Ash.

A. In-flight Operations

Flight crews should do the *Volcanic Ash* non-normal checklist in the Quick Reference Handbook (QRH). This checklist includes the following information:

- **Exit the ash cloud as quickly as possible.** A 180-degree turn out of the ash cloud using a descending turn is the quickest exit strategy. Many ash clouds extend for hundreds of miles, so assuming that the encounter will end shortly can be false. Climbing out of the ash could result in increased engine debris buildup as the result of increased temperatures. The increased engine buildup can cause total thrust loss.
- **If volcanic dust fills the flight deck, the flight crew may need to use oxygen.** Use flight deck oxygen at the 100 percent setting. If requested by the cabin crew, the flight crew may consider manual deployment of the passenger oxygen system. Flight crews should remember that the passenger oxygen system will deploy automatically if the cabin altitude exceeds 14,000 ft.
- **Turn the autothrottle(s) off.** This prevents the autothrottle(s) from increasing thrust. Ash debris in the engine can result in reduced surge margins and limiting the number of thrust adjustments improves the chances of engine recovery.
- **If conditions allow, reduce thrust to idle immediately.** By reducing thrust, engines may suffer less buildup of molten debris on turbine blades and hot-section components. Idle thrust allows engines to continue producing electrical power, bleed air for pressurization, and hydraulic power for airplane control.
- **Turn on continuous ignition, if available.**
- **If an engine flames out or stalls, attempt to restart the engine(s).** Confirm that autostart is on, if available. During restart, the engines may take longer than normal to reach idle thrust due to the combined effects of high altitude and volcanic ash ingestion. If an engine fails to start, immediately try restarting it again. Flight crews should remember that the airplane may be out of the airstart envelope if the encounter occurs during cruise.
- **Turn on engine and wing anti-ice devices, and all air conditioning packs.** These actions improve the engine stall margin by increasing the flow of bleed air.
- **Start the Auxiliary Power Unit (APU), if available.** The APU can power systems in the event of a dual/multiple engine power loss. It can also be used to restart engines using APU bleed air. Flight crews should remember that multiple APU start attempts can shorten battery life.
- **Monitor engine Exhaust Gas Temperature (EGT)**. Because of potential engine debris buildup, the EGT can climb excessively. The flight crew should prevent EGT exceedances. Shut down the engine and restart it if the EGT is approaching limits similar to a hung start.
- **Monitor airspeed and pitch attitude.** Watch for abnormal indications from pitot static system indicators. If necessary, follow the non-normal checklist for flight with unreliable airspeed.

B. Ground Operations at Airports Impacted by Volcanic Ash

- **Protect the airplane from ash.** For ground operations originating at airports impacted by volcanic ash, the Reference /A/ message advises operators to take special precautions to protect airplanes from the adverse effects of volcanic ash.

- **Remove ash from the airplane prior to flight.** Prior to flight, the operator must ensure that critical components such as inlets, probes, and static ports are free of volcanic ash. Volcanic ash will be similar in appearance to talcum powder. If ash is detected on or in the vicinity of a parked airplane, Boeing suggests that operators clean the areas of the airplane where ash is present, including the fuselage crown, horizontal surfaces, inlets, and exposed chrome common to the landing gear, to remove all traces of ash. Boeing strongly advises against water or detergent washing of the engine gaspath as this can cause accumulation of foreign material in the engine cooling flow passages. Operators should follow the engine manufacturer's recommendations for engine gaspath cleaning. Operators should pay special attention to the removal of volcanic ash from engine and APU inlets; areas around probes, ports, vents and drain holes; as well as ram air ducts and all windows. Operators should be aware that airplane washing processes, without proper sealing of ports and tubes, can introduce ash debris or water into pitot static systems. If there are no signs of volcanic ash, normal operations may be conducted.
- **Remove all covers and blanking material prior to flight.** Flight crews should ensure that all materials used to mask or blank inlets, probes, and ports are removed.
- **Determine safe ground routing.** After an airplane is free from any volcanic ash contamination, the operator should coordinate with the local airport authority to determine which ramps, taxiways and runways are clear of ash contamination. This information must be passed to flight crews prior to beginning ground operations.
- **Prior to departure, flight crews should review the airspeed unreliable, volcanic ash, single engine failure, dual/multiple engine failure, and engine in-flight start non-normal checklists.**

BOEING COMMERCIAL AIRPLANE GROUP

FLIGHT OPERATIONS TECHNICAL BULLETIN

NUMBER: 747-400-56 R1
DATE: October 31, 2007

This bulletin provides information, which may prove useful in airline operations or airline training. The information provided in this bulletin is not critical to flight safety. The information may not apply to all customers; specific effectivity can be determined by contacting The Boeing Company. This information will remain in effect depending on production changes, customer-originated modifications, and Service Bulletin incorporation. Information in this bulletin is supplied by the Boeing Company and may not be approved or endorsed by the FAA at the time of writing. Appropriate formal documentation will be revised, as necessary to reflect the information contained in this bulletin. For further information, contact Boeing Commercial Airplane Group, Chief Pilot - Training, Technical, and Standards, Flight Crew Operations, P.O. Box 3707, Mail Code 14-HA, Seattle, Washington 98124-2207; Phone (206) 655-1400; Facsimile (206) 655-3694; SITA: SEABO7X Station 627.

SUBJECT: New Smoke, Fire or Fumes Non-Normal Checklist

Revised to add additional information and to send the bulletin to a larger distribution list.

ATA NO: 26-00

APPLIES TO: All 747-400 Airplanes

REASON: To provide background information about the new **Smoke, Fire or Fumes** unannunciated non-normal checklist that will replace two unannunciated non-normal checklists, **Smoke/Fumes Air Conditioning** and **Smoke/Fire/Fumes Electrical**. This Technical Bulletin also provides background information about associated changes to the **Smoke or Fumes Removal** non-normal checklist.

BACKGROUND INFORMATION:

The Flight Safety Foundation (FSF) sponsored an industry-wide initiative to improve non-normal checklist procedures for unannunciated smoke, fire or fumes events. Two documents, ***Smoke/Fire/Fumes Philosophy and Definitions*** and ***Smoke/Fire/Fumes Checklist Template,*** were written by industry specialists representing airplane manufacturers, operators, and professional pilot organizations. These documents were published in the FSF ***Flight Safety Digest*** dated June 2005. Boeing has created a new Smoke, Fire or Fumes non-normal checklist based on these industry guidelines.

The following information is attached for your review and reference:

1. Airplane Flight Manual and Quick Reference Handbook Publication Dates
2. FSF *Flight Safety Digest* Article Excerpts
    A. Smoke/Fire/Fumes Definitions
    B. Smoke/Fire/Fumes Philosophy
    C. Smoke/Fire/Fumes Checklist Template
3. Smoke/Fire/Fumes Checklist Template (With Rationale)
4. **Smoke, Fire or Fumes** Checklist Example
5. **Smoke or Fumes Removal** Checklist Example
6. Frequent Asked Questions (FAQ)

For more information about the industry-wide initiative, please contact:

Flight Safety Foundation
601 Madison Street, Suite 300
Alexandria, Virginia, USA 22314-1756
Telephone: +1 (703) 739-6700
Fax: +1 (703) 739-6708

For more information about the new 747 **Smoke, Fire or Fumes** and **Smoke or Fumes Removal** checklists, please contact Boeing Flight Operations Engineering at:

Phone: (206) 662-7600
Fax: (206) 662-7612
Email: flightops.engineering@boeing.com

For copies of this Technical Bulletin for other Boeing models, please refer to the MyBoeingFleet web site:

http://flightops.web.boeing.com/bulletins/techbulletin/

Airplane Flight Manual and Quick Reference Handbook Publication Dates

The following table details the release dates for the new Smoke, Fire or Fumes checklist for each Boeing model. The Airplane Flight Manual (AFM) release date refers to the first approval for each model. Boeing will add the new procedure to each operator's AFM as it is revised for another reason; when Boeing does an all-operator revision; or when a specific operator requests that their AFM be updated.

Model	AFM Release Date	QRH Release Date
737-200	**September 5, 2007**	**October 9, 2007**
737-300/-400/-500	**April 30, 2007**	**December 7, 2007**
737-600/-700/-800/-900	**April 30, 2007**	**September 24, 2007**
737 BBJ	**April 30, 2007**	**October 31, 2007**
747-100/-200/-300/SP	**June 30, 2007**	**October 1, 2007**
747-400	**July 18, 2007**	**October 1, 2007**
757	**August 10, 2007**	**November 20, 2007**
767	**August 20, 2007**	**August 17, 2007**
777	**May 30, 2007**	**December 10, 2007**

FSF *Flight Safety Digest* Article Excerpts

<u>**Note**</u>: Some of the following excerpts contain edits to improve clarity. Also, Boeing information is enclosed in brackets.

<u>**Smoke/Fire/Fumes Definitions**</u>

Confirmed to be extinguished: The smoke/fire/fumes source is visually confirmed to be extinguished.

Continued flight: Once a fire or a concentration of smoke/fumes is detected, continuing the flight to the planned destination is not recommended, unless the source of the smoke/fire/fumes is confirmed to be extinguished and the smoke/fumes are dissipating.

Diversion may be required: Establishes the mindset that a diversion may be required.

Land at the nearest suitable airport: Commence diversion to the nearest suitable airport. The captain should also evaluate the risks associated with the approach, landing and landing roll.

[Please refer to Chapter 8 of the Flight Crew Training Manual for further Boeing guidance on "Landing at the Nearest Suitable Airport".]

Landing is imminent: The airplane is close enough to landing that the remaining time must be used to prepare for the approach and landing. Doing further smoke/fire/fumes elimination steps would delay landing.

Land immediately: Proceed immediately to the nearest landing site. Conditions have deteriorated and the risks associated with the approach, landing or landing roll are exceeded by the risk of the on-board situation. "Land immediately" implies immediate diversion to a runway. However, the smoke/fire/fumes situation may be severe enough that the captain should consider an overweight landing, a tailwind landing, an off-airport landing, or a ditching.

Crew: For the purposes of this document, the term "crew" includes all flight and cabin crew members.

Smoke/Fire/Fumes Philosophy

General

- The entire crew must contribute to the solution.
- For any smoke/fire/fumes event, time is critical.

- The *Smoke/Fire/Fumes Checklist:*
  - Addresses unannunciated smoke/fire/fumes events, i.e., smoke/fire/fumes events not annunciated to the flight crew by airplane detection systems;
  - Does not replace annunciated checklists (e.g., cargo smoke) or address multiple smoke/fire/fumes events;
  - Includes considerations to support decisions for immediate landing (e.g., an overweight landing, a tailwind landing, a ditching, a forced off-airport landing);
  - Systematically identifies and eliminates possible sources of smoke/fire/fumes.
- At the beginning of a smoke/fire/fumes event, the crew should consider all of the following:
  - Protecting themselves (e.g., oxygen masks, smoke goggles);
  - Communication, (e.g., with the crew and air traffic control);
  - Diversion;
  - Assessing the smoke/fire/fumes situation and available resources.

Initial Steps for Source Elimination

- It may not be possible to accurately identify the smoke source due to ambiguous cues, such as in the case of multiple sources.

  [It may not be possible to determine the difference between electrical smoke and air conditioning smoke by sense of smell. This is the reason that one Smoke, Fire or Fumes checklist will replace the **Smoke/Fumes Air Conditioning** and **Smoke/Fire/Fumes Electrical** checklists.]

- Annunciated smoke checklists have been accomplished, but the smoke/fire/fumes source may not have been eliminated.
- Rapid extinguishing and elimination of the source is a key to preventing the increase in severity of the smoke/fire/fumes event.
- Initial checklist steps that remove the most probable smoke/fire/fumes sources and reduce risk must be immediately available to the crew. These steps are determined by model-specific historical data or analysis by the airplane manufacturer.
- Initial steps:
  - Should be quick, simple and reversible;
  - Should not require analysis by the crew;
  - Will not make the situation worse or inhibit further investigation of the situation after the initial steps are complete.

Timing for Diversion/Landing

- Smoke/fire/fumes checklists should not delay diversion.
- Crews should anticipate diversion as soon as a smoke/fire/fumes event occurs and should be reminded in the checklist to consider a diversion.
- After the initial steps for smoke/fire/fumes source elimination, the checklist should direct diversion unless the smoke/fire/fumes source is visually identified, confirmed to be extinguished and the smoke/fumes are dissipating.
- The crew should consider an immediate landing anytime the situation cannot be controlled.

Smoke or Fumes Removal

- The decision of when to do the **Smoke or Fumes Removal** non-normal checklist must be based upon a threat being presented to the passengers or crew.
- The *Smoke or Fumes Removal* non-normal checklist is done only after the fire has been extinguished or if the smoke/fumes present the greatest threat.
- Smoke/fumes removal steps should be identified clearly as removal steps and the checklist should be easily accessible (e.g., modular, shaded, separate, standalone).
- The crew may need to be reminded to remove smoke/fumes.
- The crew should be directed to return to the **Smoke/Fire/Fumes** checklist after smoke/fumes removal if the **Smoke/Fire/Fumes** checklist was not completed.

Additional Steps for Source Elimination

- Additional steps aimed at smoke/fire/fumes source identification and elimination:
  - Are subsequent to the initial steps for source eliminations and the diversion decision;
  - Are accomplished as time and conditions permit, and should not delay landing;
  - Are based on model-specific historical data or analysis by the airplane manufacturer.
- The crew needs checklist guidance to systematically isolate possible sources of smoke/fire/fumes.

Smoke/Fire/Fumes Checklist Template	
Step	**Action**
1	Diversion may be required.
2	Oxygen masks (if required) .... On, 100%
3	Smoke goggles (if required) .... On
4	Crew and cabin communications .... Establish
5	Manufacturer's initial steps[1] .... Accomplish
Anytime smoke or fumes become the greatest threat, accomplish *Smoke or Fumes Removal Checklist*.	
6	Source is immediately obvious and can be extinguished quickly: • If yes, go to **Step 7**. • If no, go to **Step 9**.
7	Extinguish the source. If possible, remove power from affected equipment by switch or circuit breaker on the flight deck or in the cabin.
8	Source is visually confirmed to be extinguished: • If yes, consider reversing manufacturer's initial steps. Go to **Step 17**. • If no, go to **Step 9**.
9	Remaining minimal essential manufacturer's action steps .... Accomplish [These are steps that do not meet the "initial steps" criteria but are probable sources.][2]
10	Initiate a diversion to the nearest suitable airport while continuing the checklist.
Warning: If the smoke/fire/fumes situation becomes unmanageable, consider an immediate landing.	
11	Landing is imminent: • If yes, go to **Step 16**. • If no, go to **Step 12**.
12	XX system actions[3] .... Accomplish [Further actions to control/extinguish source.] If dissipating, go to **Step 16**.
13	YY system actions .... Accomplish [Further actions to control/extinguish source.] If dissipating, go to **Step 16**.
14	ZZ system actions .... Accomplish [Further actions to control/extinguish source.] If dissipating, go to **Step 16**.
15	Smoke/fire/fumes continue after all system-related steps are accomplished: Consider landing immediately. Go to **Step 16**.
16	Review **Operational Considerations**.
17	Accomplish *Smoke or Fumes Removal Checklist,* if required.
18	Checklist complete.

Operational Considerations

[These items appear after "checklist complete." This area should be used to list operational considerations, such as an overweight landing, a tailwind landing, a ditching, a forced off-airport landing, etc.]

Notes

1. These aircraft-specific steps will be developed and inserted by the aircraft manufacturer.
2. Bracketed text contains instructions/explanations for the checklist author.
3. "XX," "YY" and "ZZ" are placeholders for the environmental control system, electrical system, in-flight entertainment system and/or any other systems identified by the aircraft manufacturer.

Smoke/Fire/Fumes Checklist Template (With Rationale)

The following describes the rationale for the in- Smoke/Fire/Fumes (SFF) Checklist Template steps. The rationale includes the purpose of the step and the reason for its sequential placement in the checklist.

Protect the flight crew then assess the situation

1	Diversion may be required.
Rationale	This step establishes the mindset that a diversion may be required. We use the word "may" because the crew should not initiate a diversion before a preliminary assessment of the fire/source. This step is placed at the beginning of the checklist to immediately establish that a diversion may be required.

2	Oxygen Masks (If required) …………………………....ON, 100%
3	Smoke Goggles (If required) ……………………................ON
Rationale	These steps protect the flight crew from smoke inhalation and fume absorption. Oxygen masks are on at 100% so the oxygen supply does not mix with the smoke or fumes. Steps are early in the checklist to ensure the flight crew is protected immediately after smoke/fumes detection. Steps are separate because they may be separate devices. The flight crew should don oxygen masks anytime smoke/fumes are detected on the flight deck. The trigger to don masks is the smoke not the checklist. The steps are not recall nor are they required because oxygen masks and smoke goggles may not be required for all smoke events. We rely on flight crew judgment to decide when to don the devices. The "if required" statement also permits airlines to be flexible in training when to don the masks or to leave the timing decisions to the flight crew's discretion.

4	Crew and Cabin Communications ………………....Establish
Rationale	This step initiates timely coordination and communication between the flight and cabin crew. The step is placed after steps 2 and 3 to not delay donning of oxygen masks and goggles, if required. The communication with cabin crew is made explicit because the cabin crew is an important resource for assisting the flight crew with source identification and confirmation of elimination.

Source elimination steps

5	Manufacturer's initial steps ………….…….. Accomplish (1)
Rationale	These steps quickly isolate probable ignition sources based on historical fleet data or analysis. The flight crew is expected to take action without delay and without assessment. The steps are placed early in the checklist to immediately isolate probable sources to reduce the risk of event escalation.

Smoke Removal Reminder	Anytime smoke or fumes become the greatest threat, accomplish the Smoke or Fumes Removal checklist.
Rationale	Smoke removal should be accomplished only when the smoke/fumes are the greatest threat or when the source is confirmed extinguished. Smoke removal may change the airflow and make the situation worse by fanning a source or it may mask the source. Smoke removal steps must be clearly identified and be easy to find. The removal steps may be left out of the checklist to keep the checklist uncluttered and short.
Issue	All manufacturers need to review their smoke removal checklists to ensure compatibility with the new SFF checklist.

6	The source is immediately obvious and can be extinguished quickly: If Yes, Go to Step **7**. If No, Go to Step **9**.
Rationale	This step is an immediate assessment of the source and situation without waiting for the effect of initial actions. The crew must determine if the source is extinguishable. The outcome of the assessment is a decision to extinguish the source or initiate a diversion.

7	Extinguish the source. If possible, remove power from affected equipment by switch or circuit breaker on the flight deck or in the cabin.
Rationale	After the source is identified, the crew should use all available resources to actively extinguish the source. This step comes after the source is identified.

8	The source is visually confirmed to be extinguished: If Yes, Consider reversing manufacturer's initial steps, and Go to Step **17**. If No, Go to Step **9**.
Rationale	The crew must confirm that the source is extinguished. The outcome of the assessment is a decision that the source is extinguished or to continue the checklist. This step is placed early in the checklist to prevent escalation of the event.

9	Remaining minimal essential manufacturer's action steps....Accomplish [These are steps that do not meet the "initial steps" criteria but are probable sources] (2)
Rationale	Additional manufacturer action steps that do not meet the "initial actions" criteria outlined in the SFF philosophy. For example, steps that make the cabin dark or may interfere with source identification. No further assessment should be made prior to diversion.

10	Initiate a diversion to the nearest suitable airport while continuing the checklist.
Rationale	The cockpit crew should not delay a diversion if the source remains unknown or cannot be extinguished. The step is placed here to turn the airplane toward a suitable airport.

Warning	If the SFF situation becomes unmanageable, consider an immediate landing.
Rationale	The purpose of this warning is to remind the crew that an immediate landing may be required if the situation deteriorates. The step is placed after the initial source elimination steps have been done, but before the additional source elimination steps which may be lengthy.

Additional source elimination steps

11	Landing is imminent: If Yes …………….. Go to Step **16**. If No ………………Go to Step **12**.
Rationale	If landing is imminent, the crew should stop the checklist and focus on landing the airplane without the added workload and distraction of doing this checklist. This step is placed here because all probable source isolation steps have been accomplished.

12	XX system actions ………….. Accomplish (3) [Further actions to control/extinguish source.] If dissipating ………………… Go to Step **16**.
13	YY system actions ………….. Accomplish [Further actions to control/extinguish source.] If dissipating ………………… Go to Step **16**.
14	ZZ system actions ………….. Accomplish [Further actions to control/extinguish source.] If dissipating ………………… Go to Step **16**.
Rationale	Additional source identification and isolation guidance may be required when the airplane is far from a suitable landing site. These steps are placed here to systematically isolate an unknown source. These steps come late in the checklist after the diversion has been initiated because they may take time. The sequence of the steps is determined by the severity of the hazard each poses to the airplane.

15	Smoke/fire/fumes continue after all system-related steps are accomplished: **Consider Landing Immediately** Go to Step **16**.
Rationale	This is the final assessment step in the checklist. The outcome of the assessment is an immediate landing or landing at a suitable airport if the additional steps have identified and isolated the source.

Follow-up actions

16	Review Operational Considerations.
Rationale	Operational considerations provide information to support crew decision making. The flight crew may need to be reminded to review considerations that may affect continued flight operations and decisions. Operational considerations may vary by airplane model and may be lengthy so should be provided outside of the checklist.

17	Accomplish the Smoke or Fumes Removal checklist, if required.
Rationale	This step reminds the cockpit crew to remove smoke or fumes. This step is best accomplished after the source has been isolated and extinguished.

18	Checklist complete.
Rationale	This step indicates there are no more steps in the checklist.

Operational Considerations

These items appear after “checklist complete.” This area is used to list operational considerations, such as an overweight landing, a tailwind landing, a ditching, a forced off-airport landing, etc.

Notes

(1) These aircraft-specific steps will be developed and inserted by the aircraft manufacturer.
(2) Bracketed text contains instructions/explanations for the checklist author.
(3) “XX”, “YY”,and “ZZ” are placeholders for the environmental control system, electrical system, in-flight entertainment system and/or any other systems identified by the aircraft manufacturer.

Smoke, Fire or Fumes Checklist Example (747-400)

Note: This checklist is an example for planning purposes only. It may not reflect the configuration of your airplanes. Do not use this checklist in your documentation.

SMOKE, FIRE OR FUMES

Condition: **Smoke, fire or fumes is identified**

Diversion may be needed.

Oxygen masks (as needed) . . . . ON, 100%

Smoke goggles (as needed) . . . . ON

Crew and Cabin communications . . . . Establish

Instruct cabin crew to turn on cabin night lighting.

UTILITY POWER SWITCHES (Both). . . . . OFF

APU SELECTOR . . . . OFF

PASSENGER SIGNS . . . . ON

Anytime the smoke or fumes becomes the greatest threat, do the SMOKE OR FUMES REMOVAL checklist.

If the source of the smoke, fire or fumes is both obvious and can be extinguished quickly:

Source . . . . Isolate and extinguish

If possible, remove power from the affected equipment by switch or circuit breaker in the flight deck or cabin.

If both of the following are true:

- **The source is visually confirmed to be extinguished, and**
- **The smoke or fumes are decreasing**

Continue the flight at the Captain's discretion.

Restore unpowered items at the Captain's discretion.

Do the SMOKE OR FUMES REMOVAL checklist if needed.

■ ■ ■ ■

Initiate a diversion to the nearest suitable airport while continuing the checklist.

Consider an immediate landing if the smoke, fire or fumes situation becomes uncontrollable.

Do not delay landing in an attempt to complete all of the following steps.

ISOLATION VALVE SWITCHES . . . . OFF
[Isolates left and right sides of the bleed air system.]

PACK 2 CONTROL SELECTOR . . . . OFF

Wait 2 minutes unless the smoke or fumes are increasing.
[Allows time for the smoke or fumes to clear.]

If the smoke or fumes continue or are increasing:

PACK 3 CONTROL SELECTOR . . . . OFF

Wait 2 minutes unless the smoke or fumes are increasing.
[Allows time for the smoke or fumes to clear.]

If the smoke or fumes continue or are increasing:

PACK 3 CONTROL SELECTOR . . . . NORM

PACK 1 CONTROL SELECTOR . . . . OFF

RIGHT ISOLATION VALVE SWITCH . . . . ON

If the smoke or fumes stop:

LEFT ISOLATION VALVE SWITCH . . . . ON

PACK 2 CONTROL SELECTOR . . . . NORM

Wait 2 minutes unless the smoke or fumes are increasing.
[Allows time for the smoke or fumes to clear.]

If the smoke or fumes continue or are increasing:

ISOLATION VALVE SWITCHES . . . . ON

PACK 1 CONTROL SELECTOR . . . . NORM

Consider an immediate landing.

Do the SMOKE OR FUMES REMOVAL checklist if needed.

Do not accomplish the following checklists:
ELEC UTIL BUS L, R
FUEL OVRD 2, 3 FWD
FUEL PUMP 2, 3 FWD
CARGO DET AIR
TEMP ZONE
TRIM AIR OFF

■ ■ ■ ■

Smoke or Fumes Removal Checklist Example (747-400)

Note: This checklist is an example for planning purposes only. It may not reflect the configuration of your airplanes. Do not use this checklist in your documentation.

SMOKE OR FUMES REMOVAL

Condition: **Smoke or fumes removal is needed.**

Do this checklist only when directed by the SMOKE, FIRE OR FUMES checklist.

Do not delay landing in an attempt to complete the following steps.

FLIGHT DECK DOOR . . . . CLOSE
[Prevents smoke or fumes from penetrating onto the flight deck.]

EQUIPMENT COOLING SELECTOR . . . . OVRD
[Attempts to discharge smoke or fumes overboard by using the equipment cooling override mode.]

If the smoke or fumes persists or is severe, and the smoke or fumes source is determined to be on the flight deck:

SMOKE EVACUATION HANDLE . . . . PULL
Pulling the smoke evacuation handle when the smoke or fumes source is not on the flight deck may pull the smoke or fumes onto the flight deck.

Return to the SMOKE, FIRE OR FUMES checklist and do the remaining steps.

■ ■ ■ ■

If the smoke or fumes is severe and the smoke or fumes source is determined to be in the cabin:

LANDING ALTITUDE SWITCH . . . . MAN

LANDING ALTITUDE CONTROL. . . . . SET 8000-8500 FEET
Set landing altitude between 8000 and 8500 to command cabin altitude to 8,000 feet.

EQUIPMENT COOLING SELECTOR. . . . . NORM

DESCENT . . . . ACCOMPLISH

Level off at the lowest safe altitude or 8,500 feet, whichever is higher.

OUTFLOW VALVE MANUAL SWITCHES . . . . ON

OUTFLOW VALVES MANUAL CONTROL . . . . OPEN

AIRSPEED . . . . 200 KIAS OR LESS

DOORS TO BE OPENED . . . . .DETERMINE

If the smoke or fumes concentration is determined to be in the forward section of the cabin, a door 1 or door 2 and a door 4 or door 5 must be opened.

If the smoke or fumes concentration is determined to be in the aft section of the cabin, open a door 2 only.

Direct personnel to open door(s).

Position mode selector handle to MANUAL and rotate and secure handle in the 12 o'clock position.

When the smoke or fumes is evacuated:

Direct personnel to close door(s).

Position mode selector handle to AUTO. The forward door must be closed before closing the aft door.

Return to the SMOKE, FIRE OR FUMES checklist and do the remaining steps.

■ ■ ■ ■

Frequently Asked Questions (FAQ)

1) Q: Does "cabin" crew need to be mentioned after crew?

A: Boeing mentions "Cabin Crew" to account for those airlines that may interpret "crew" as being only the flight deck crew.

2) Q: Are we changing the statement "plan to land at nearest suitable airport" in all checklists to "diversion may be needed"?

A: No. The step "Diversion may be needed" in the Smoke/Fire/Fumes checklist is intended to establish a mindset with the crew that they may need to divert soon. It does not yet direct the crew to divert. There is another step in the checklist that directs a diversion. This is the first time that Boeing has a step in a QRH that simply establishes a mindset with the crew.

3) Q: What if the smoke source is a 737 Display Electronics Unit (DEU), for example? The checklist steps do not completely isolate all electrical buses.

A: The current checklist steps match Boeing's philosophy on airplane de-powering during smoke/fire/fumes events. Further de-powering the airplane adds an undesirable loss of system capability (e.g. essential navigation and communications systems, cargo fire detection, anti-skid). Boeing has no history of the essential systems being the source of smoke or fire. Boeing's philosophy is to not give guidance to further de-power the airplane beyond the checklist steps, as it can possibly do more harm than good. This philosophy is also stated in a Boeing Aero magazine article, dated April 2001. Please refer to the following link for more information:

http://www.boeing.com/commercial/aeromagazine/aero_14/inflight_story.html#4

4) Q: Why is there no longer a step to turn off the Recirculation Fans on many of the new smoke/fire/fumes checklists?

A: On some Boeing airplanes the Recirculation Fans are powered by the Utility Buses. The new Smoke/Fire/Fumes philosophy directs the crew to turn off the Utility Buses during the initial steps, on some Boeing models. Thus, a separate step to turn off the Recirculation Fans is not needed. Several Boeing models or electrical configurations will still have a separate step to turn off the Recirculation Fans.

5) Q: Has Boeing considered moving deferred items earlier in the SMOKE, FIRE OR FUMES checklist to expedite action? Ground evacuation is one example.

A: Boeing does not believe it is necessary to have deferred items in the SMOKE, FIRE OR FUMES checklist. For example, the quick action EVACUATION checklist is on the cover of the QRH for quick reference. Also, deferred items are unique to Boeing. One intent of the Smoke, Fire or Fumes checklist is to be as common as possible across the entire industry

6) **Q:** I like the idea of a single combined checklist for air conditioning smoke and electrical smoke. What if air conditioning smoke causes other smoke alerts to annunciate at the same time?

   A: If any of the annunciated cargo fire warnings display, the crew should do those checklists also. Right now, the scope of the new Smoke, Fire or Fumes checklist revision activity is for ***unannunciated*** smoke/fire/fumes events.

7) **Q:** What does "Restore unpowered items at the Captain's discretion" mean? Does this refer to items switched off in the checklist steps, or items switched off because they were suspected to be the source of the smoke? What if the crew inadvertently switches the smoke source back on?

   A: If the smoke/fire source has been visually confirmed to be out - 100% sure - and the Captain decides to continue flight, then the crew can turn the Utility Switches back on. Several other models, such as 777 or 737, have additional switches that were turned off in the initial steps, so this checklist step can refer to several different switches depending on the model. We are trying to balance the intent of this with minimizing checklist wording and complexity. Boeing expects the Captain to use good judgment and decide which of the switches can be turned back on if he/she is sure they were not the source of the smoke.

8) **Q:** Does the statement "Consider an immediate landing if the smoke, fire or fumes situation becomes uncontrollable" mean an off-airport landing? If not, then what is the purpose of the statement, since the crew is already diverting to the nearest suitable airport per the previous checklist step.

   A: "Immediate Landing" has a specific definition in the ***Smoke/Fire/Fumes Philosophy and Definitions***. It is published in the QRH introduction section at each model FCOM revision cycle and will be published in a revision to AC120-80.

   "Land immediately: Proceed immediately to the nearest landing site. Conditions have deteriorated and the risks associated with the approach, landing or post-landing are exceeded by the risk of the on-board situation. "Land immediately" implies immediate diversion to a runway. However, the smoke/fire/fumes situation may be severe enough that the captain should consider an overweight landing, a tailwind landing, an off-airport landing, or a ditching."

9) **Q:** "Consider an immediate landing" is not standard wording for Boeing checklists (normally "plan to land at nearest suitable airport"). Is this intentional? Does this mean get the airplane on the ground now (even if off-airport)?

   A: Please refer to the previous answer.

10) Q: The current 747-400 SMOKE/FIRE/FUMES ELECTRICAL checklist has steps associated with fuel management. The entire checklist section beginning with "If CTR wing tank pump switches ON" is deleted from the new SMOKE, FIRE OR FUMES checklist. Is this intentional? The utility bus switches are selected OFF, so why don't the checklist steps for fuel management still apply?

A: These checklist steps are for fuel balancing. The left-side Center Fuel Tank Pump is powered by Utility Bus 2, which will be turned off in an earlier step. We determined that the worst case scenario would be a very slow fuel imbalance when the Utility Buses are turned off. At this time, the flight crew will already have begun their diversion to the nearest suitable airport. The airplane should land long before a fuel imbalance could become a problem. The fuel management steps add considerable complexity to an already long checklist and the steps are not essential.

11) Q: Why isn't "Plan to land at the nearest suitable airport" the first step in any smoke/fire/fumes procedure before any type of troubleshooting? Wording should stress the importance of descending and landing as soon as possible.

A: Boeing agrees that landing as soon as possible is appropriate for ***some*** smoke/fumes events. Boeing also believes that it is undesirable to divert unnecessarily for a non-threatening smoke/fire/fumes incident that is easily identified, contained, and visually confirmed by the crew to be extinguished (e.g. burned food in a galley oven or a wastepaper basket fire).

The new checklist is designed so the crew gets to the diversion step very quickly, if necessary, after doing the initial steps. Care was taken during checklist development to ensure the initial checklist steps do not delay the crew from getting to the diversion step, if necessary. Boeing feels this is the proper balance between initiating a diversion in a timely manner, when necessary, and minimizing unnecessary diversions.

Besides the economic and passenger considerations of unnecessary diversions, consideration was given to the potential safety ramifications of unnecessarily landing an airplane at an unfamiliar airport during marginal weather. Boeing procedures balance timely direction to land as soon as possible, and still allow the Captain's judgment to prevent unnecessary diversions.

12) Q: Since the APU is not normally running, why is there a step to turn off the APU Bleed Air Switch or APU Selector in the checklists' "Manufacturer's Initial Steps"?

A: Historical data shows APU bleed air as the cause of some smoke events for each Boeing model. It also meets the other criteria for Manufacturer's Initial Steps:

1. Can be done quickly and without analysis
2. Is reversible
3. Has little or no impact on safe operation of the aircraft

All Boeing models, except the 767, have procedures or Supplementary Procedures that can result in the APU running during flight. The step was also included in the 767 checklist since we intend for this checklist to be applicable for use during ground operations such as a smoke event during an extended engine out taxi with the APU running.

BOEING COMMERCIAL AIRPLANE GROUP

FLIGHT OPERATIONS TECHNICAL BULLETIN

NUMBER: **737-05-2**
747-400-54
757-74
767-74
777-20

DATE: **November 15, 2005**

SUBJECT: AFDS Mode Control Panel (MCP) Faults

ATA NO: 22

APPLIES TO: 737-300/400/500/600/700/800/900/BBJ, 747-400, 757, 767, 777

BACKGROUND

Several operators have reported in-flight events where various Autopilot Flight Director System (AFDS) pitch or roll modes, such as LNAV, VNAV or HDG SEL, became un-selectable or ceased to function normally. Typically, these types of faults do not generate a failure annunciation to the flight crew and may be caused by an MCP hardware (switch) problem. This bulletin provides crews with guidance to temporarily resolve or work around such faults.

OPERATING INFORMATION

If an AFDS anomaly is observed where individual pilot-selected AFDS modes are not responding normally to MCP switch selections, attempt to correct the problem by disconnecting the autopilot and selecting both flight director switches to OFF. This will clear all engaged AFDS modes. When an autopilot is re-engaged or a flight director switch is selected ON, the AFDS default pitch and roll modes should engage. The desired AFDS pitch and roll modes may then be selectable. If the above action does not correct the fault condition, desired flight path can be maintained by selecting an alternate pitch or roll mode. Examples are included in the following table:

Inoperable or Faulty Autopilot Mode	Suggested Alternate Autopilot Mode or Crew Technique
HDG SEL or HDG HOLD	Set desired heading, disconnect AFDS and manually roll wings level on the desired heading, and re-engage the AFDS. The AFDS will hold the established heading.
LNAV	Use HDG SEL (or TRK SEL on 777 airplanes) to maintain the airplane track on the magenta FMC course.
VNAV SPD or VNAV PTH (climb or descent)	Use FLCH (LVL CHG on 737 airplanes) or V/S (or FPA on 777 airplanes). Note: V/S (or FPA on 777 airplanes) should be selected for descent on final approach.
VNAV PTH (cruise)	Use altitude hold. If altitude hold is not directly selectable, use FLCH (LVL CHG for 737 airplanes) to automatically transition to altitude hold.
LOC	Use LNAV and monitor and fly the approach referencing localizer raw data.
G/S	Use V/S (or FPA on 777 airplanes) or VNAV PTH to descend on an ILS approach, and monitor and fly the approach referencing glideslope raw data.

BOEING COMMERCIAL AIRPLANE GROUP

FLIGHT OPERATIONS TECHNICAL BULLETIN

NUMBER: 747-400-53

DATE: November 11, 2005

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SUBJECT: **TWO ENGINE Approach and Landing**

ATA NO:

APPLIES TO: 747-400

Reason: To explain the revision to the TWO ENGINES INOPERATIVE non-normal checklist, and the TWO ENGINES INOPERATIVE Approach profile.

Background Information

Originally, the 747-400 QRH included a TWO ENGINE INOPERATIVE non-normal checklist which read as follows –

TWO ENGINES INOPERATIVE

Condition: Two engine landing required.
Autothrottle inoperative
LANDING PREPARATION:
Use flaps 25 VREF 25 for landing
PACK CONTROL SELECTORS….. TWO PACKS OFF
GROUND PROXIMITY FLAP OVERRIDE SWITCH….. OVRD
Use flaps 1 for go-around; commit point is gear extension.
Plan to fly final approach with gear down and flaps 10.
Plan to extend flaps to 20 at 500 feet and flaps to 25 when touchdown target is assured.

Additionally, in the maneuvers section of the QRH, the two engine inoperative approach flight pattern profile was included in the ILS Flight pattern along with the four and three engine procedures. This single flight pattern page, with procedures for three different situations (All engines, 1 engine inoperative and 2 engines inoperative) was fairly intricate and involved and could be misinterpreted.

The current 2 engine inoperative profile directly conflicted with the Boeing philosophy of a stabilized approach. Therefore Boeing engineers and pilots conducted a review of the 2 engine inoperative performance during approach and go-around and revised the flight profile to enable flight crews to establish a stabilized approach by 1000 feet AGL. Simulator evaluations also provided for a go-around procedure (if absolutely necessary)

The revised TWO ENGINES INOPERATIVE non-normal checklist reads as follows:

TWO ENGINES INOPERATIVE

Condition: Two engine landing required
Autothrottle inoperative.
LANDING PREPARATION:
Commit point is gear extension
Use flaps 25 VREF 25 for landing
PACK CONTROL SELECTORS…..TWO PACKS OFF

Extend landing gear and select flaps 20 at glideslope intercept, or approximately 2 miles prior to the FAF.
Approaching 1000 feet AGL select flaps 25 and center rudder trim.

If Go-Around required:
The use of TO/GA is not recommended
Set go-around thrust, flaps 20
Landing gear…..UP
Retract flaps to 1 on schedule, climb at VREF + 60

The "Commit Point" is still gear extension. Selection of flaps 20 and gear down at glidesope intercept more closely aligns to the normal ILS profile. In the event there is no ILS, the flight crew will select flap 20 and gear down approaching the FAF. The GROUND PROXIMITY FLAP OVERRIDE SWITCH….. OVRD step is deleted because GPWS logic is satisfied by selection of flaps 25 approaching 1000 feet, and the annunciation "TOO LOW FLAPS" will not be triggered.
Use of the autopilot and autobrakes is recommended. The flight crew will now select flaps 25, center the rudder and complete the landing checklist approaching 1000 feet AGL allowing flight crew to achieve a "stabilized approach" per Boeing recommendations. Having the rudder centered prior to autopilot disconnect will minimize flight path deviations prior to touchdown.

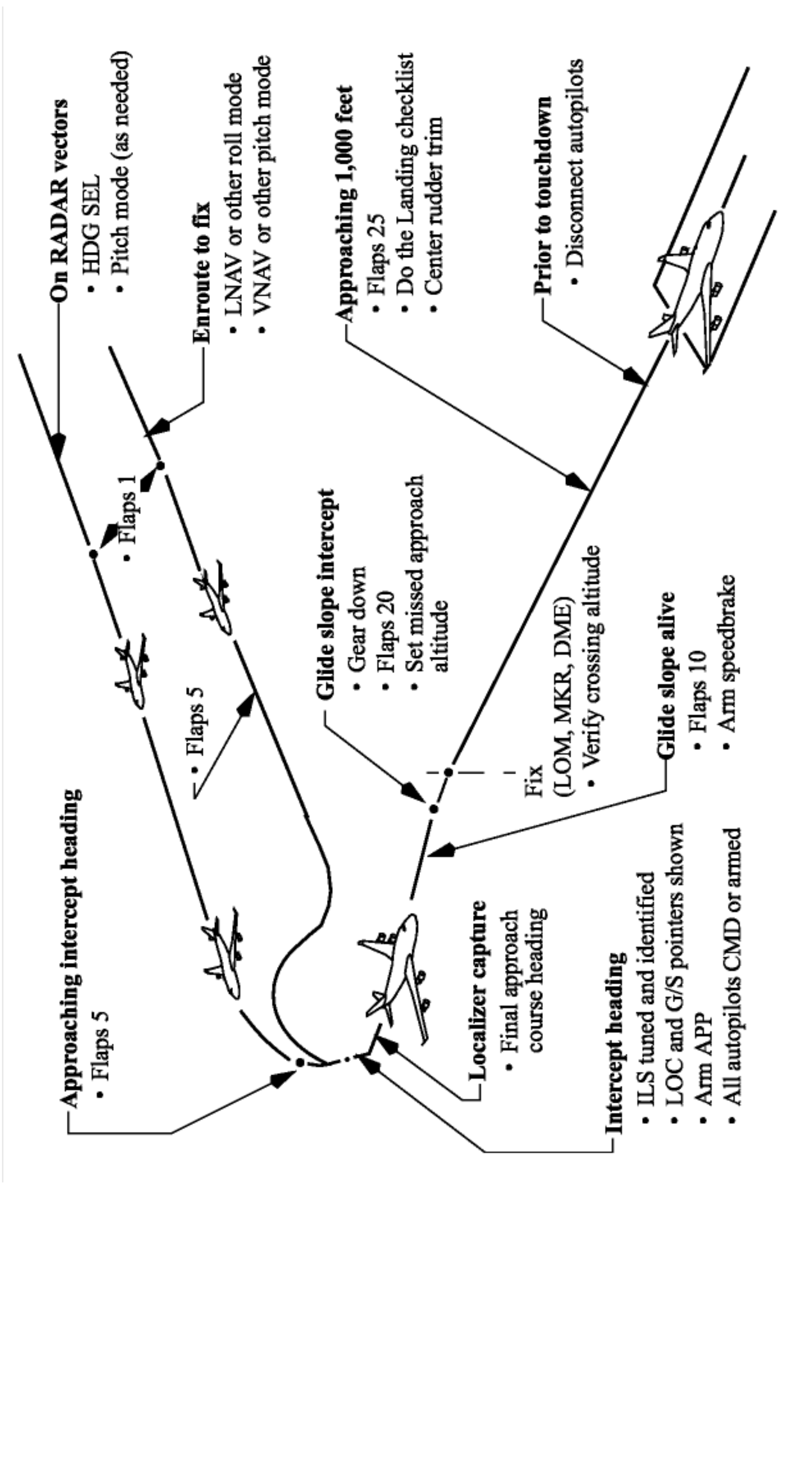
The flight patterns in the Maneuvers Section of the QRH will include two separate profiles for an ILS approach. The first profile will show the flight pattern(s) for the ILS Approach-Normal/One Engine Inoperative and the second profile will show the flight pattern for the ILS Approach- Two Engines Inoperative. This change will minimize the complexity of having all profiles described on a single page.

If a Go-Around is absolutely necessary, the use of the TOGA switch is not recommended. The "If Go-Around required:" step in the revised NNC highlights necessary actions. Specific details that are common to a normal go-around , such as "ensure positive rate of climb" before raising landing gear, were omitted for brevity. Additional techniques in the event of a go-around (as described in the Flight Crew Training Manual) are included for clarity:

> "If a go-around is absolutely necessary, increase thrust to go-around thrust at a rate that does not exceed the rudder's capability to maintain directional control. The pilot must control yaw with rudder and trim. Some rudder pedal pressure may be required even with full rudder trim. Descend if needed to increase speed and retract flaps to flaps 1 on schedule. Slowly increase pitch attitude to maintain flaps 1 speed and transition from a descent to a climb. Complete the go-around procedure.
>
> During an approach with two engines inoperative on the same side, it is possible to be at an airspeed below minimum control speed when the go-around is initiated. In this event, thrust should be applied with rudder application and a slight bank into the operating engines while establishing a descent for faster acceleration. Stop the outboard thrust lever advance just before full rudder travel and then set the inboard engine to go-around thrust…
>
> During acceleration with two engines inoperative on one side, at and above aileron lockout speed, the autopilot may not have sufficient aileron authority to maintain desired bank. If this occurs, the airplane must be manually flown."

We recommend airlines adopt this change in procedure to achieve a stabilized 2 engine inoperative approach. Boeing understands this change will have a significant impact on flight crew training. We consider the previous procedure acceptable until transition to the new procedure is accomplished via the normal training/check flight cycle.

ILS Approach - Two Engines Inoperative



BOEING COMMERCIAL AIRPLANE GROUP

FLIGHT OPERATIONS TECHNICAL BULLETIN

NUMBER: 747-400-52
767-73
777-16

DATE: November 12, 2004

SUBJECT: **Flight Deck Security Door Smoking Solenoid**

ATA NO: **52-51**

APPLIES TO: **747-400, 767, 777**

There are reports that the flight deck door lock solenoid has been a source of smoke. The smoke is due to an overheated solenoid caused by a high level of electrical current supplied to the solenoid.

The door should easily and smoothly operate to the fully closed position. Once closed there are two levels of electrical current provided to the solenoid during door locking operation. A higher current to the solenoid drives the lock pin from the unlocked position into the locked position. Once locked, a lower current level to the solenoid holds the pin locked.

Improper installation of the door assembly may cause a preloading of the door lock. Energizing the solenoid in this condition prevents the lock pin from extending to activate an internal micro switch which removes the higher current. This could eventually lead to solenoid overheating and smoking. Momentary power interruption, such as during electrical power transfer, also may allow the door to partially open and could lead to a jammed lock pin and an overheated solenoid.

A smoking solenoid condition can be avoided by ensuring the LOCK FAIL light is extinguished any time the flight deck door is closed and the FLT DK DOOR lock selector is in AUTO. The light should be checked following a power interrupt or normal flight deck entry/exit. A future change will add thermal protection to the solenoid to shutoff power in the event of overheating.

BOEING COMMERCIAL AIRPLANE GROUP

FLIGHT OPERATIONS TECHNICAL BULLETIN

NUMBER: 747-400-51
DATE: May 1, 2004

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SUBJECT: **WINDOW DAMAGE Non-Normal Checklist**

ATA NO: **56-10**

APPLIES TO: 747-400

Reason: To explain the revision to the WINDOW DAMAGE non-normal checklist.

Background Information

Originally, the 747-400 QRH included a WINDOW ARCING/DELAMINATION/SHATTERED/CRACKED non-normal checklist which included the information – Delamination and/or shattering of the outer glass ply does not affect the structural integrity of the window. During the conversion to the 777 Operations Manual format and publishing system, this information was deleted to standardize the 747-400 procedure with the 777 version.

Shortly thereafter, a 747-400 flight crew experienced a cracked flight deck window and diverted the flight. When reporting the incident to Boeing, the airline pointed out that if the information had still been in the QRH, the crew might have decided to continue to original destination rather than divert.

As a result, Boeing revised the window procedures and attempted to standardize as much as possible between the 747-400/757/767/777. The 737s have different windows and different checklists, so they were not affected. The 747-400/757/767/777 all had information that delamination/shattering, or cracking of the outer pane does not affect pressurization capability of the window. The title WINDOW DAMAGE was used for commonality.

A 747-400 operator recently asked what a crew should do for a damaged middle or inner pane. Any single damaged pane does not affect ability of the window to carry operational pressures. Boeing reviewed the checklist again in response to this question. Some windows can have all of the structural panes damaged and carry operational pressure loads, but not all windows. Other than running a fingernail along the window to feel for cracking of the inner pane, it can be difficult to tell which or how many panes are damaged. The checklist originally referred only to the outer pane since that was the pane most likely to be damaged. A review of recent window malfunctions included examples of middle, inner, and multiple pane damage.

The newly revised WINDOW DAMAGE checklist does not require the flight crew to determine how many or which panes are damaged. If the window deforms, or an air leak is observed, then the crew descends to a lower altitude. Flight deck windows may deform 1/4-1/2 inch (6-13mm) normally. A deformation greater than this is obvious. Descending to a lower altitude reduces cabin pressure differential. This reduces stress on the window. Descending to an altitude <u>above</u> the cabin altitude results in some outward cabin differential pressure on the window. This pressure counters some of the inward air load pressure, which also helps to alleviate stress on the window. Leveling off at or above 10,000 feet minimizes exposure to bird strike hazards.