

**IFALPA AIRCRAFT DESIGN AND OPERATION (ADO) COMMITTEE MEETING**  
PALACE HOTEL, BERLIN, 17-19 JUN 2010

**AGENDA ITEM: A**           EXTERNAL REPRESENTATION  
                                  **ICAO INTL VOLCANIC ASH TF (IVATF)**  
                                  IFALPA BRIEFING LEAFLETS

PREPARED BY ARNAUD DU BÉDAT, IFALPA

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Please find attached three IFALPA Briefing Leaflets regarding Volcanic Ash operations.

## Airbus volcanic ash awareness advice

In its Flight Operations Briefing Notes (FOB) Airbus addresses the issue of operations in or near airspace contaminated with volcanic ash as follows. This FOB is part of a set of notes that provide an overview of the applicable standards, flying techniques and best practices, operational and human factors, suggested company prevention strategies and personal lines-of-defence related to major threats and hazards to flight operations safety. In addition this Briefing Leaflet contains the procedures revisions sent by Airbus in its Operators Information Telex (OIT) of 22 April 2010 following the eruption of Mt Eyjafjallajökull and subsequent closure of parts of European airspace.

### I Introduction

Flying through an ash cloud should be avoided by all means due to the extreme hazard for the aircraft. Experience has shown that damage can occur to aircraft surfaces, windshields and power plants. Aircraft ventilation, hydraulic, electronic and air data systems can also be contaminated. Partial or total engine power loss events caused by volcanic ash ingestion, while not frequent, are major safety concerns. Simultaneous power loss in all engines has occurred, where the crew succeeded in restarting the engines, after application of operational procedures.

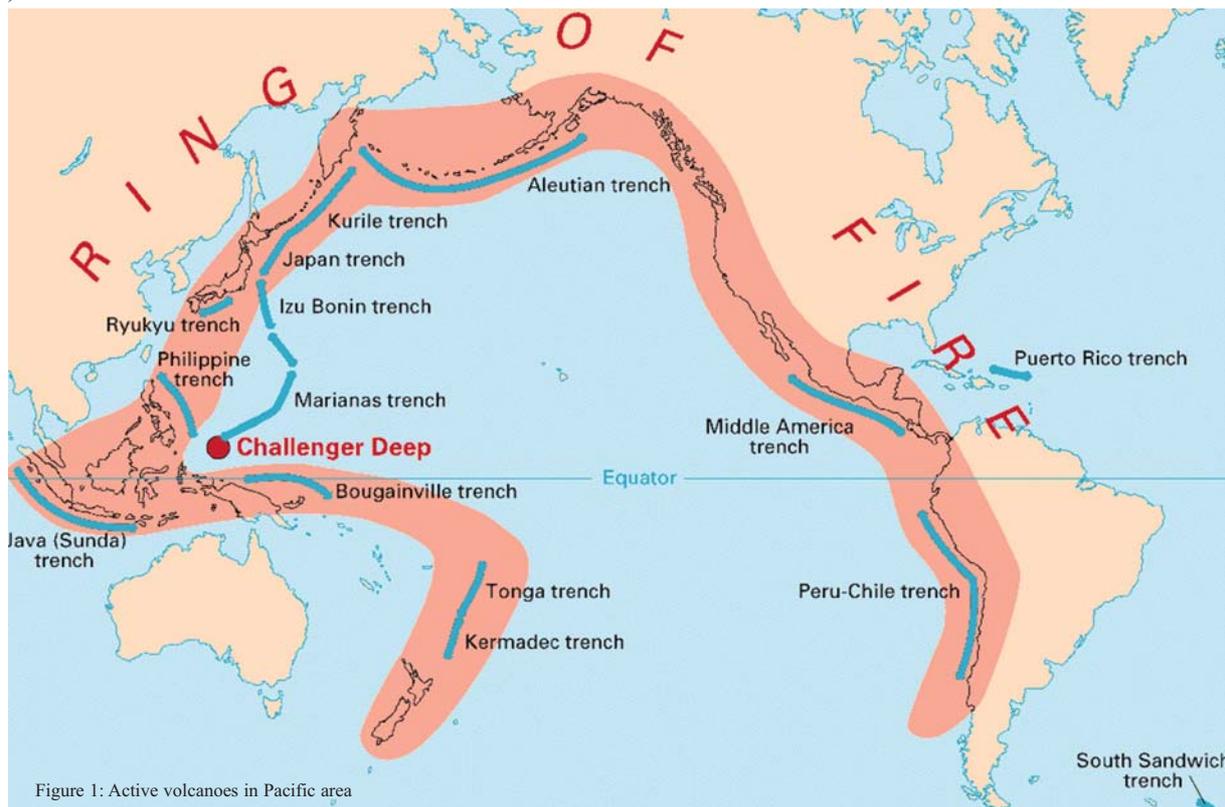
As weather radar is not effective in detecting volcanic ash clouds, crews must be informed by other means of the potential or effective presence of ash clouds on air routes.

The aim of this Flight Operational Briefing Note is to provide information about volcanic ash effects on aircraft, and operational guidelines, in order to help preventing a volcanic ash cloud encounter.

### II Background Information

#### II.1 Statistical Data

The Pacific region represents one of the biggest concentrations of volcanoes in the world, with over 100 active volcanoes (See Figure 1).



Active volcanoes are capable of sending volcanic ash up to altitudes greater than FL300 after explosive eruptions. Encounters affecting aircraft performance have occurred 2 400 NM from the ash source and up to 72 hours after an eruption. Over 80 aircraft have reported to have flown into volcanic ash cloud between 1980 and 2000, with consequences ranging from increased wear of engines to simultaneous power loss in all engines. Alert messages (volcanic ash SIGMET) are issued by a Meteorological Watch Office (MWO) for its area of responsibility. Nine Volcanic Ash Advisory Centers (VAAC) have been designated by international organizations to provide an expert advice to MWO regarding the location and expected movement of volcanic ash clouds (see Figure 2).

## II.2 Volcanic Ash Effects on Aircraft

### Components Abrasion

Volcanic ash comprises highly abrasive particles that may damage aircraft components, particularly forward facing surface of external parts and engine components. They are made of sharp rock fragments that will easily erode plastic, metal and even glass pieces. In service events show that aircraft may suffer from extensive damage after volcanic ash encounter. In some cases, all the following parts were removed and replaced, after they were sand blasted:

- ▶ Windshields
- ▶ Forward cabin windows
- ▶ Navigation and landing lights cover
- ▶ Wing, stabilizer and fin leading edges
- ▶ Engine nose cowls and thrust reversers
- ▶ All pitot and static probes.

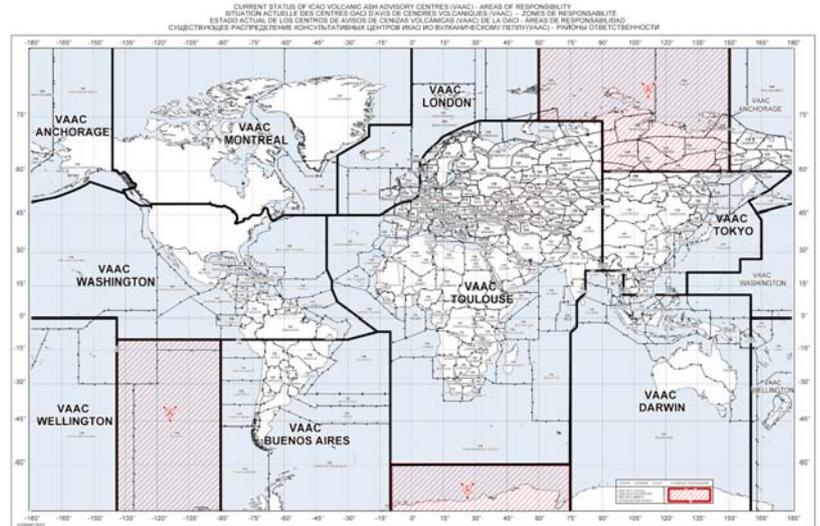


Figure 2: Volcanic Ash Advisory Centers areas of responsibility

### Engine Performance Deterioration

Ingestion of volcanic ash by engines may cause serious deterioration of engine performance due to erosion of moving parts and/or partial or complete blocking of fuel nozzles.

Volcanic ash contains particles, whose melting point is below engine internal temperature. In-flight, these particles will immediately melt if they go through an engine. Going through the turbine, the melted materials are rapidly cooled down, stick on the turbine vanes, and disturb the flow of high-pressure combustion gases. This disorder of the flow may stall the engine, in worst cases.

### Bleed, Air Data and Electronic Systems Contamination

Volcanic ash is made of very fine particles (down to 1 micron) that can easily penetrate all but the most tightly sealed enclosures. It may carry high static charge that makes it difficult to remove from electronic components.

Ash deposit easily absorbs water and can cause arcing, short circuits and intermittent failures of electronic components.

Dense ash deposit can clog bleed system filters and may lead to total bleed loss, with associated loss of cabin pressurization.

Pitot and static systems may also become obstructed by the dust.

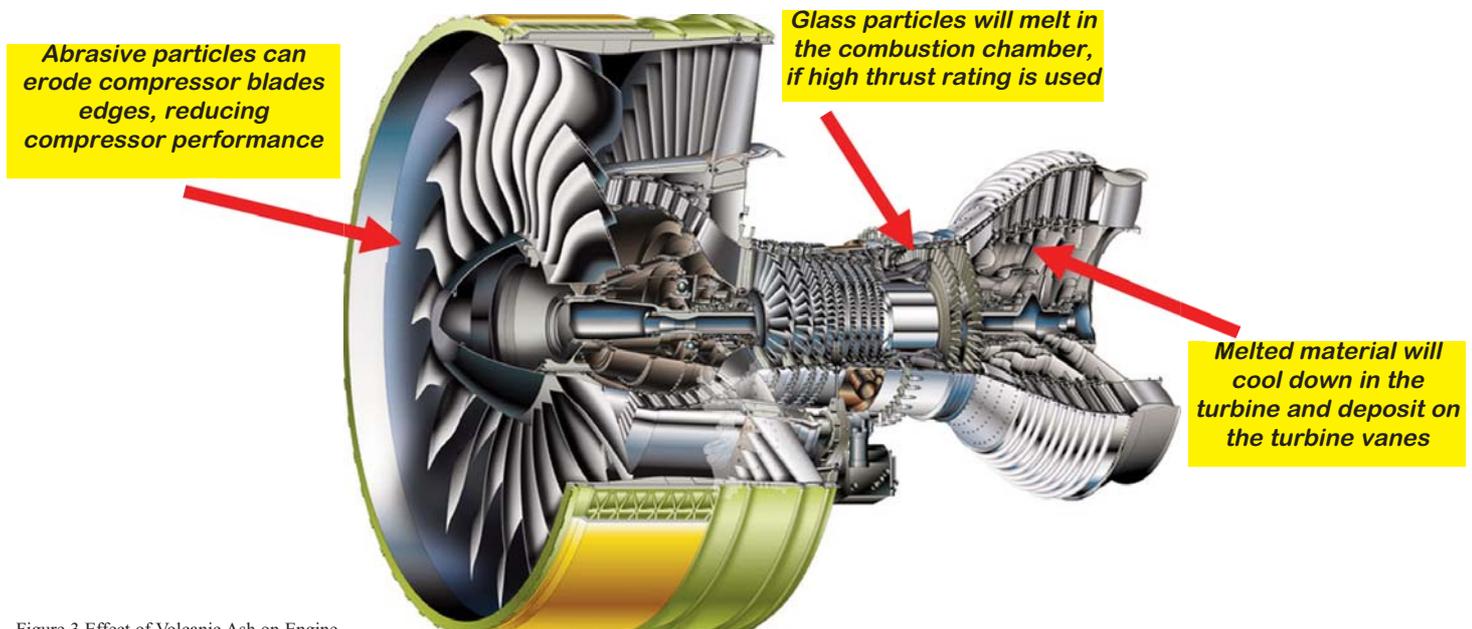


Figure 3 Effect of Volcanic Ash on Engine

### III Factors Involved in Volcanic Ash Cloud Encounter

The following factors have an influence on volcanic ash detection in flight and on the consequences of volcanic ash encounter.

#### III.1 Detection

Night and IMC flights are more favourable to ash cloud encounter, as dust clouds cannot be detected by airborne weather radars (see Flight Operations Briefing Note Optimum Use of the Weather Radar).

Low concentration of volcanic ash may not be detected by the crew.

Presence of the following elements can help recognize a volcanic ash cloud encounter:

- ▶ Acrid odour similar to electrical smoke
- ▶ Rapid onset of engine problems
- ▶ St. Elmo's fire
- ▶ Bright white/orange glow appearing in the engine inlets
- ▶ Dust and smell in the cockpit
- ▶ Outside darkness
- ▶ Airspeed fluctuation
- ▶ Landing lights casting sharp, distinct, shadows.

#### III.2 Consequences

Recent (within hours of eruption) volcanic clouds contain concentration of ash that can cause complete loss of engine power within one minute.

Engines operating at high thrust setting are more prone to suffer from ash deposit buildup in the turbine chamber, as internal engine temperature may exceed volcanic-glass material melting point.

In service events show that even low concentration of volcanic ash can cause expensive damage.

### IV Prevention Strategies and Operational Recommendations

Prevention strategies and lines-of-defence should be developed to address the risk of volcanic ash encounter.

#### IV.1 Flight Crew Awareness

The following communication links can be used to obtain timely up-dated information on the volcano eruptive activity:



##### *Volcanic Watch Function*

The Volcanic Watch Function consists in collecting, compiling, processing and up-dating detailed information regarding the active and pre-eruptive volcanoes likely to affect the company area of operation.

This function can be assigned to the following departments, as applicable:

- ▶ Flight Operations
- ▶ Flight Safety Office.

So as to assess the volcanic threat for each company route the following information sources and communication links can be used:

- ▶ Air Information Service (AIS), for active NOTAM's
- ▶ Meteorological Watch Offices, Airport Offices and Regional Area Forecast Centers for active SIGMET's
- ▶ On-site Aviation Authorities for additional information, such as data and maps related to the ash cloud observed and forecasted extension
- ▶ International organisations such as ICAO, IATA, IFALPA
- ▶ Inter-airlines agreements
- ▶ Company outside stations.

The Volcanic Watch Function provides synthesized and up-dated information to all operational departments (Flight Operations, Dispatch, Outside Stations etc) as follows:

- ▶ Map(s) of active volcanoes and hazard areas
- ▶ Relevant data to be included in the Pre-departure Area Briefing and Route Forecast
- ▶ Specific procedures for en-route information up-dating (e.g. HF company frequency, ACARS, en route FIS and ATC).



##### *Flight Crews Pre-flight Briefing and Documentation*

All flight crews, operating a flight to/from/through an area likely to be affected by volcanic activity, should be provided with the following information and documents on a systematic basis

- ▶ Map(s) of active volcanoes and hazards area
- ▶ ICAO special air-report of volcanic activity form (model VAR).

As dictated by current volcanic eruptive activity:

- ▶ Last active NOTAM's,
- ▶ Last active SIGMET's
- ▶ Data or map(s) reflecting the observed ash cloud location, extension and/or trajectory forecast
- ▶ Upper wind analysis and forecast at selected flight levels
- ▶ Satellite images.



#### *En-route Information Up-dating*

The activity of an erupting volcano usually features series of eruptions sometimes separated by only a few hours. En-route updating of the pre-flight briefing information is therefore of paramount importance to minimize the potential for volcanic ash cloud encounter. The following communication links can be used to obtain timely up-dated information on the volcano eruptive activity:

- ▶ Company FLIGHT WATCH frequency
- ▶ ACARS
- ▶ VOLMET broadcasts (SIGMETs)
- ▶ FLIGHT information Service (SIGMET's).

Detailed update should be solicited and obtained regarding the following aspects:

- ▶ Notification of new eruption(s)
- ▶ Location, height, extension and forecasted trajectory of volcanic ash cloud.
- ▶ Notification of airspace restrictions (closure of air routes, activation of contingency routes).



#### *Flight Crew Training*

- ▶ So as to build-up a flight crew mind-set regarding the volcanic ash threat, volcanic ash awareness should be addressed as part of the flight crew initial and recurrent training, as follows:
  - ▶ Understanding volcanic ash and volcanic ash clouds, as any other weather systems, and their threat to jet aircraft operation
  - ▶ Highlighting the published procedures related to volcanic ash cloud avoidance, recognition of encounter and encounter recovery
  - ▶ Placing a particular attention, during the simulator session related to the ALL ENGINE FLAME OUT procedure, to the slow engine acceleration characteristics to be expected upon engine restart after volcanic ash ingestion

Stressing the instrumental contribution of flight crew air reports and the use of the ICAO special air-report of volcanic activity form (model VAR).

## **IV.2 Operational Recommendations**

Flight crew operational procedures are published in respective aircraft manufacturers' documentation. Nevertheless, the following actions have been identified as being typical recommendations in case of volcanic ash encounter.



#### *On the Ground*

Operation from or to airports contaminated with volcanic ash should be avoided, if possible. Should volcanic ash exposure be unavoidable, the following recommendations and procedures should be applied:

- ▶ Whenever an aircraft is planned to stay over at an airport contaminated with volcanic ash, engine inlet covers as well as other protective covers and plugs should be installed
- ▶ Have the aircraft cleaned before departure
  - Ash may contaminate the lubricated parts, penetrate the seals or enter the engines gas path, air conditioning system, air data probes and other aircraft orifices.
- ▶ Dry crank the engines
  - Before starting the engines, ventilate them by dry cranking at maximum motoring speed for two minutes.
- ▶ Do not use windshield wipers for ash dust removal.
- ▶ Restrict ground use of APU to engine starts
  - Do not use APU for air conditioning and electrical power supply. Use external pneumatic supply for starting the engines, if it is available.
- ▶ Keep bleed valves closed for taxiing

- ▶ Taxi with minimum thrust
  - Advance the levers smoothly to the minimum required for breakaway. Avoid making sharp or high-speed turns. All engines taxi should be preferred, to minimize thrust level on each engine.
- ▶ Allow ash and dust (if present) to settle on runway before starting the takeoff roll
- ▶ Use the rolling takeoff technique if possible
- ▶ Consider the runway as wet (for dry ash) or contaminated with slush (wet ash) for takeoff/landing perf calculation
  - Braking efficiency may be degraded by the layer of ash on the runway.

### In Flight

If a volcanic eruption is reported while in flight, the flight should remain well clear of the affected area and, if possible stay on the upwind side of the volcanic dust (typically 20 NM upwind of the erupting volcano).

Should the volcanic ash encounter be unavoidable, the following general recommendations apply:

- ▶ Make a 180deg turn
  - Pilots should exit the cloud as quick as possible. Generally, a 180deg turn will result in the fastest cloud exit, due to the possible extension of such clouds over hundreds of nautical miles
- ▶ Decrease thrust
  - High thrust settings increase the risk of glass particles melting and associated ash deposit build-up in the turbine chamber. Thrust should therefore be decreased, if conditions permit.
- ▶ Don the crew oxygen masks (100%)
- ▶ Report to ATC
  - Any observation of volcanic activity or any encounter with a volcanic ash cloud should be reported by immediate radio transmission or/and by filling the ICAO special air-report of volcanic activity form (model VAR).
- ▶ Increase bleed demand (wing and engine anti-ice ON)
  - Increasing the bleed demand aims at increasing the fuel/air ratio in the engine combustor to limit the possibility of an engine surge and/or flameout.
- ▶ Start the APU
  - The APU GEN will be available to supply the electrical network in case of engine flameout.
- ▶ Monitor engine parameters and airspeed indications
  - The crew should be aware that volcanic ash may render airspeed indications unreliable.

## V Summary of Key Points

It is important to note the following key points:

- ▶ Airlines should provide exhaustive and updated information to crews flying in regions likely to be affected by volcano activity
- ▶ Flight crews should get updates of pre-flight information when en route
- ▶ Flight Crews should report to the ATC any observation of volcanic activity or any encounter with a volcanic ash cloud
- ▶ If encounter with volcanic ash cannot be avoided, the flight crew should immediately applied the procedure recommended by the aircraft manufacturers' documentation.

## VI Associated Flight Operations Briefing Notes

The following Flight Operations Briefing Note can also be reviewed:

- Optimum use of the weather radar

## VII Regulatory References

- ICAO Doc 9766 - Handbook On The International Airways Volcano Watch (IAVW) Operational Procedures And Contact List (2nd Edition)
- ICAO PANS ATM (Doc 4444) Appendix I – ICAO Special Air-report of Volcanic Activity Form (model VAR)

## VIII Airbus References

- A300/A310/A300-600 Flight Crew Operating Manual (FCOM) Bulletins - Volcanic Ash Advisory
- A300/A310/A300-600 FCOM - Procedures and Techniques - Inclement Weather Operation - Operation in Areas Contaminated by Volcanic Ash
- A320/A330/A340 FCOM - Supplementary Techniques - Adverse Weather - Operations in Volcanic Ash
- A320/A330/A340 Flight Crew Training Manual (FCTM) - Supplementary Information - Adverse Weather - Volcanic Ash

## IX Additional Reading Materials / Website References

- Volcanic Ash Advisory Centres (VAAC) (<http://aawu.arh.noaa.gov/vaac.php>)
- Volcano World (<http://volcano.und.edu/>)

FROM: AIRBUS CUSTOMER SERVICES TOULOUSE  
TO: ALL OPERATORS

OPERATOR INFORMATION TELEX - OPERATOR INFORMATION TELEX  
AND  
FLIGHT OPERATIONS TELEX - FLIGHT OPERATIONS TELEX

SUBJECT: AIRCRAFT EXPOSURE TO ICELANDIC VOLCANIC ASH

### 1 - PURPOSE

This OIT is intended to provide operators with Airbus recommendations

- \* to return aircraft back to service once European airspace, affected by current volcanic activity, is re-opened.
- \* to determine which inspections have to be applied depending on operational conditions.

### 2 - MAINTENANCE RECOMMENDATIONS TO RETURN AIRCRAFT TO OPERATION

Recommendations were provided in REF. 1 to apply Parking or Storage procedures as per REF.3 and REF.4 guidelines. Same references provide also guidelines to return the aircraft back to operation.

If the aircraft was exposed to ash contamination on ground, then REF.2 inspections should be carried out to return the aircraft back to flight condition.

### 3 - FLIGHT OPERATION RECOMMENDATIONS

Service providers are publishing Modelled Ash Concentration airspace zones. According to available information it appears that three zones are defined:

- Zone 1: Limited No-Fly zone.
- Zone 2: Potential Contamination Zone.
- Zone 3: Non Contaminated Airspace.

Respect the operational information given by authorities about the above mentioned zones. If the flight crew suspects or confirms volcanic ash encounter during the flight it should be reported in the aircraft technical log book.

There is no specific flight operation procedures required to ensure safe operation when flying in zones 2 and 3.

### 4 - MAINTENANCE RECOMMENDATION

#### 4.1- AIRFRAME

4.1.1 - If maintenance personnel observe potential volcanic ash damage, they should take action to confirm the nature of the contamination.

Typical ash exposure would manifest in abnormal erosion of surfaces like:

- Radom skin
- Windshield
- Navigation light glazing
- Ram air inlet
- Wing and stabilizers leading edge
- Air intake cowl
- APU inlet duct

If ash contamination is confirmed then REF.2 inspections should be carried out.

4.1.2 - In case of crew report of volcanic ash encounters during flight or inadvertent flight incursion in zone 1 (Limited No-Fly Zone) mentioned in paragraph 3, it is recommended to perform REF. 2 inspection before next flight.

#### 4.2 - ENGINES

No specific requirements to ensure safe operations on engines are foreseen after operation in zones 2 and 3 as described in paragraph 3. This statement should be confirmed shortly by engine manufacturers. Operators should contact directly engine manufacturers for further details if necessary. Communications REF.5 to 10 have been issued so far by Engine Manufacturers to Operators.

#### 5 - FOLLOW-UP

Airbus is actively participating in the Industry efforts to collect additional data. A sampling maintenance programme with selected operators will be carried out in coordination with the engine manufacturers. In addition, we encourage the operators and MRO's in reporting any positive findings of airframe or engine effects attributed to volcanic ash. Any valuable information will be provided, as soon as available, through further revision of this OIT/FOT. Questions about the technical content of this OIT/FOT are to be addressed to:

Mr. Frederic Molinier, SEES5,  
Phone +33/(0)5.62110918  
Fax +33/(0)5.61.93 36 14.  
E-mail: frederic.molinier@airbus.com

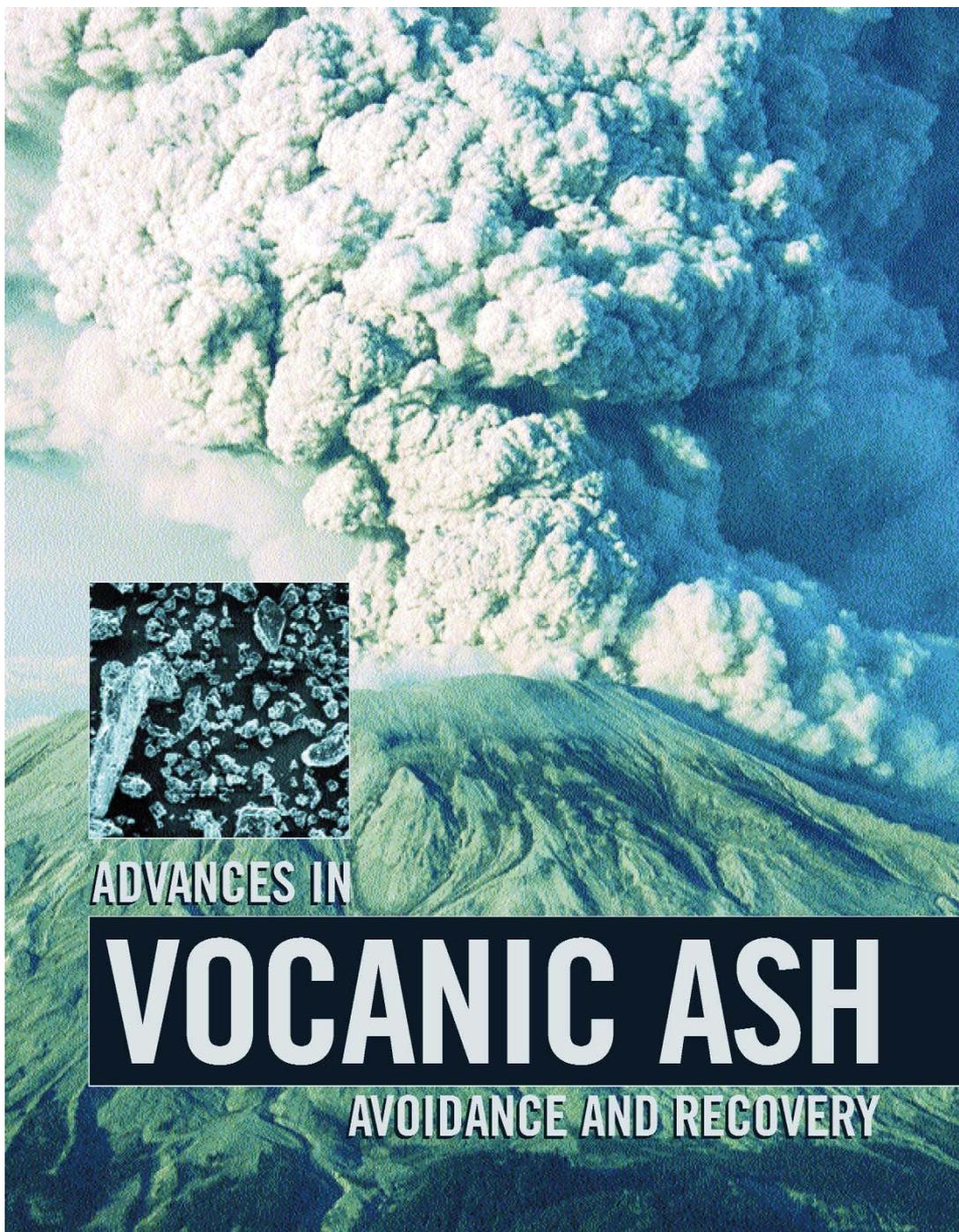
Questions about the operational content of this OIT/FOT are to be addressed to: For A300/A310/A300-600/A300-600ST  
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## Boeing Volcanic Ash Advice

This briefing leaflet is comprised of two parts the first is a selection of pages from the Boeing Commercial Airplanes publication Aero and deals with advances in volcanic ash avoidance and recovery the second part is based on the Flight Operations Technical Bulletin issued by the company on 21 April 2010.





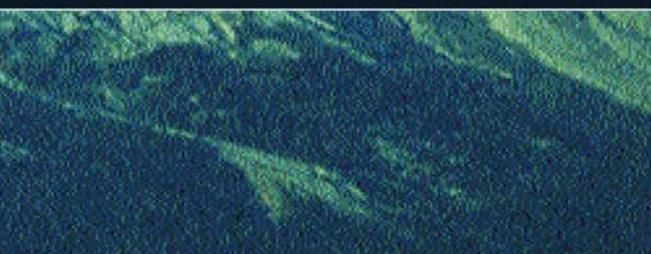
A commercial airplane encounter with volcanic ash can threaten safety of flight because of resulting conditions that range from windshield pitting to loss of thrust in all engines. Developments in technology and communication networks have significantly decreased the probability of such an encounter in the last several years. Despite these developments, however, a 737-700 recently flew through a volcanic ash cloud. Updated information about advancements made in ensuring safe operations and minimizing damage to the airplane during a volcanic ash encounter is now available to flight crews.

AERO  
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## SAFETY

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In the past 30 years, more than 90 jet-powered commercial airplanes have encountered clouds of volcanic ash and suffered damage as a result. The increased availability of satellites and the technology to transform satellite data into useful information for operators have reduced the number of volcanic ash encounters. However, further coordination and cooperation, including linking operators and their dispatchers to the network of government volcano observers, is required throughout the industry. Boeing has always advocated that flight crews avoid volcanic ash clouds or exit them immediately if an encounter occurs. The company also recommends specific procedures for flight crews to follow if they cannot avoid an encounter.

Flight crews will be better prepared to avoid volcanic ash clouds and take the appropriate actions during an encounter if they understand the following information:

1. Results of past events involving volcanic ash.
2. Resources available to help avoid ash encounters.
3. Specific flight crew actions required in response to encounters.

## 1 RESULTS OF PAST EVENTS INVOLVING VOLCANIC ASH

Significant ash encounters from the past include those involving such well-known volcanoes as Mt. Pinatubo, Mt. Redoubt, and Mt. St. Helens. The airplanes that encountered volcanic ash during these events and in the other events listed chronologically experienced varying degrees of damage.

### Mt. St. Helens, United States, 1980.

A 727 and a DC-8 encountered separate ash clouds during this major eruption. Both airplanes experienced damage to their windshields and to several systems, but both landed safely despite the windshield damage.

### Galunggung volcano, Indonesia, 1982.

Several 747s encountered ash from this eruption. One airplane lost thrust from all four engines and descended from 36,000 ft to 12,500 ft before all

four engines were restarted. The airplane, on a flight from Kuala Lumpur, Malaysia, to Perth, Australia, diverted to Jakarta and landed safely despite major engine damage. This airplane subsequently had all four engines replaced before returning to service. A few days after the initial encounters, another 747 flew into the ash cloud and suffered significant engine damage. This airplane also diverted to Jakarta and subsequently performed a successful two-engine landing.

### Mt. Redoubt, United States, 1989.

On a flight from Amsterdam to Anchorage, Alaska, a new 747-400 (only three months old with approximately 900 hr total flying time) encountered an ash cloud from the erupting Mt. Redoubt near Anchorage. All four engines ingested ash and flamed out. The crew successfully restarted the engines and landed safely at Anchorage.

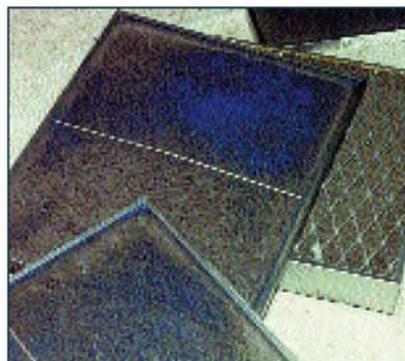
All four engines were replaced and many airplane systems also had to be repaired or replaced. For example, the airplane environmental control system was replaced (see below), the fuel tanks were cleaned, and the hydraulic systems were repaired. Several other airplanes encountered ash from this eruption, but most damage was minor because operators had been notified of the eruption. Some operators, such as Alaska Airlines, continued scheduled flights once they developed processes to safely identify where ash might be encountered. Although information was available about the Mt. Redoubt eruption, the channels for sharing this information were not well developed at the time (see "Alaska Airlines Procedures for Operating in Volcanic Ash Conditions" on p. 25).

### Mt. Pinatubo, Philippines, 1991.

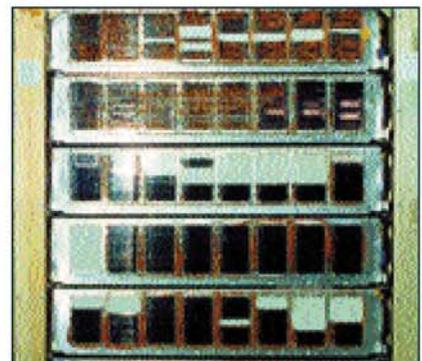
More than 20 volcanic ash encounters occurred after the Mt. Pinatubo eruption, which was the largest volcanic eruption of the past 50 years. The ability to predict where ash was to be found was challenging because of the enormous extent of the ash cloud. Commercial flights and various military operations were affected; one U.S.



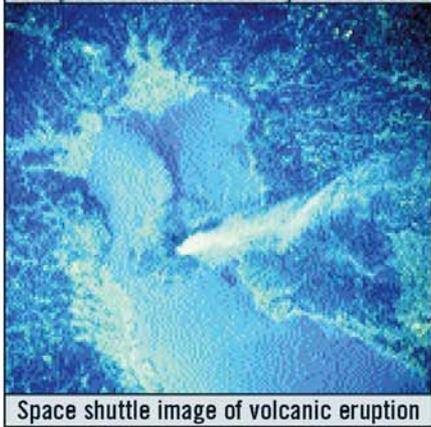
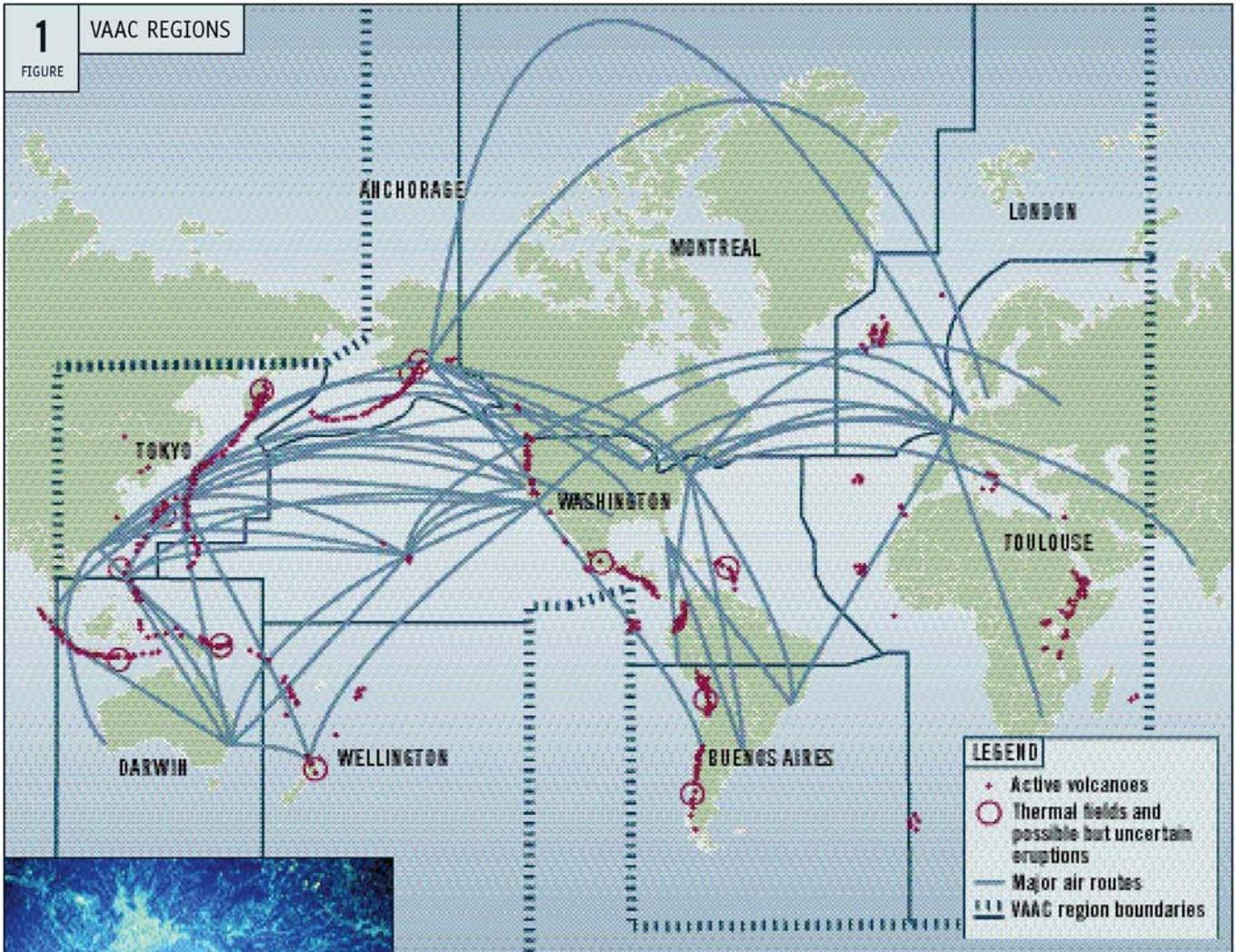
Engine damage from ash ingestion



Environmental control system damage



Electrical panel damage



Space shuttle image of volcanic eruption

operator grounded its airplanes in Manila for several days.

**Mt. Popocatepetl, Mexico, 1997.**

This volcano affected several flights in 1997 and 1998. Although damage was minor in most cases, one flight crew experienced significantly reduced visibility for landing and had to look through the flight deck side windows to taxi after landing. In addition, the airport in Mexico City was closed for up to 24 hr on several occasions during subsequent intermittent eruptions.

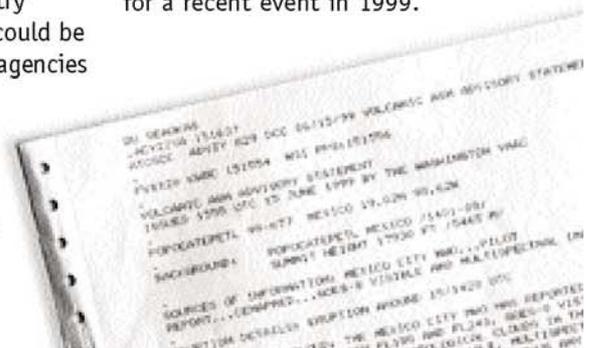
**2 RESOURCES AVAILABLE TO HELP AVOID ASH ENCOUNTERS**

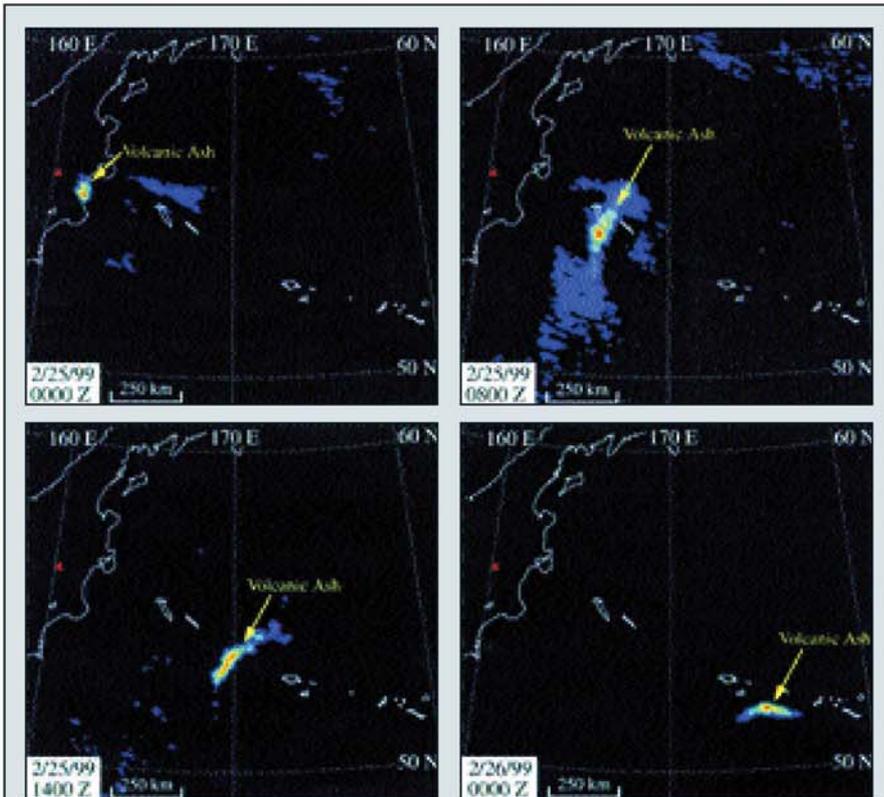
Although some information about volcanic eruptions has been available for many years, the aviation industry and volcanological community began a joint effort to find ways to avoid future encounters after the Mt. Redoubt eruption. At an international conference in Seattle, Washington, in July 1991, aviation industry members, meteorologists, and volcano scientists gathered to determine what volcano event information the aviation industry needed, how this information could be distributed, and who or which agencies should distribute it. The International Civil Aviation Organization (ICAO) had laid much of the foundation for the volcanic ash issue through its Volcanic Ash Warnings Study Group; see "ICAO

Activities on Volcanic Ash" on page 26.

One of the outcomes of this initial meeting is the availability of today's Volcanic Ash Advisory Centers (VAAC). The VAACs provide an important link among volcano observatories, meteorological agencies, air traffic control centers, and operators. A total of nine VAACs observe and report on a particular region of the world (fig.1).

One product of the VAACs is the Volcanic Ash Advisory Statement (VAAS). Below is an example of a VAAS for a recent event in 1999.





Geostationary operational environmental satellite detection and tracking of volcanic ash cloud from an eruption of Bezymianny volcano, Russia, that began at 7:00 a.m. on Feb. 24, 1999. The red triangle indicates the volcano location. Highest ash concentrations are indicated in orange and yellow. The blue areas on 0000Z and 0800Z are noise and do not indicate ash. The cloud was tracked at 15-min increments for 1,500 km until it dispersed beyond the limits of detection.

In addition to providing VAASs directly to the airlines, the VAACs also provide information to appropriate meteorological organizations that subsequently issue significant meteorological information (SIGMET) and other reports. The ICAO publication "International Airways Volcano Watch" (ICAO annex III) contains further information and contact names and numbers. Detailed information on the VAACs, including contacts for each of the nine centers, is available at <http://www.ssd.noaa.gov/VAAC/>.

Operators rely on the VAACs for information, and many operators maintain direct contact with volcano observatories within their flight domains. For instance, the Alaska Volcano Observatory (AVO) in Anchorage, with links to Fairbanks, issues a weekly bulletin by e-mail and fax detailing the activity of key volcanoes in Alaska. During periods of volcanic unrest and eruption, bulletins are

issued frequently as conditions change. Anyone can request to be placed on distribution for the bulletins. The AVO web site (<http://www.avo.alaska.edu/>) also provides updated information. For those without Internet access or unable

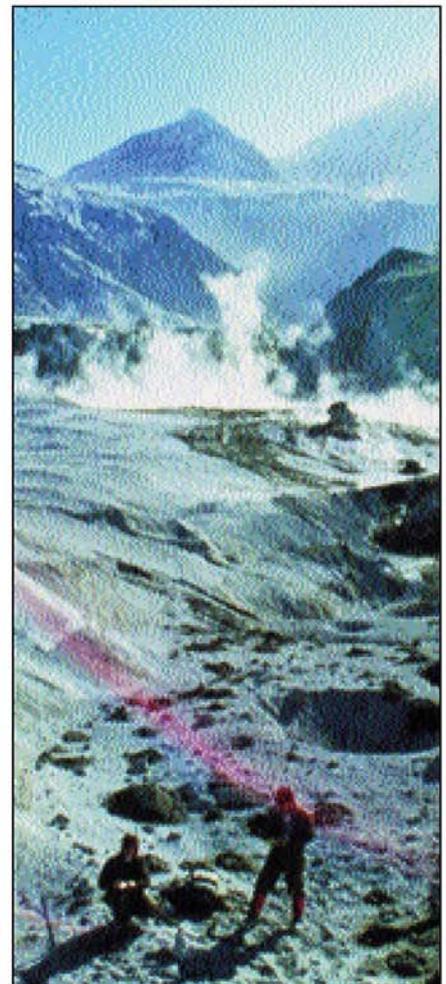


Reports can indicate whether the activity is steam, as shown above, or ash.

Right: Geologists from the AVO examine fresh pyroclastic flow from Mt. Redoubt, Mar. 23, 1990.

to access the site if it is overloaded during a crisis, the AVO daily telephone recording at 907-786-7477 provides brief updated information for air carriers. Finally, many operators maintain personal relationships with individuals in the volcano observatories that monitor volcanoes within a particular flight domain. For instance, Alaska Airlines maintains contact with key individuals at the AVO because a significant portion of Alaska's flight domain could be affected by Alaskan volcanoes.

Many other web sites provide information and links to other sources of volcano information (see "Volcanic Ash Resources" on p. 27). A wealth of printed information, such as the *Bulletin of the Global Volcanism Network* through the Smithsonian National Museum of Natural History in Washington, D.C., is also available. However, the information about current volcanic activity in these printed sources is often two to three months old.



### 3 SPECIFIC FLIGHT CREW ACTIONS REQUIRED IN RESPONSE TO ENCOUNTERS

Despite ongoing avoidance efforts, operators can still experience volcanic ash encounters. Guidance on the operational issues surrounding volcanic ash is divided into three aspects: avoidance, recognition, and procedures. The following information is general; flight crews should refer to their respective company's operating manuals for details.

#### 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 (see sidebar at bottom of p. 26).
- Dispatch also needs to identify alternate routes to help flight crews avoid airspace containing volcanic ash.
- Flight crews should stay upwind of volcanic ash and dust.
- Flight crews should note that airborne weather radar is ineffective for distinguishing ash and small dust particles.

#### Recognition.

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

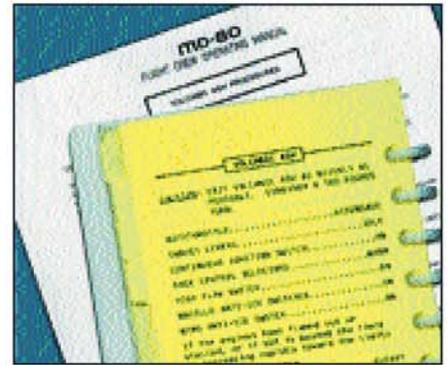
- **Odor.** When encountering a volcanic ash cloud, flight crews usually notice a smoky or acrid odor that can smell like electrical smoke, burned dust, or sulfur.
- **Haze.** Most flight crews, as well as cabin crew or passengers, see a haze develop within the airplane. Dust can settle on surfaces.
- **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 inlet.
- **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.

#### Procedures.

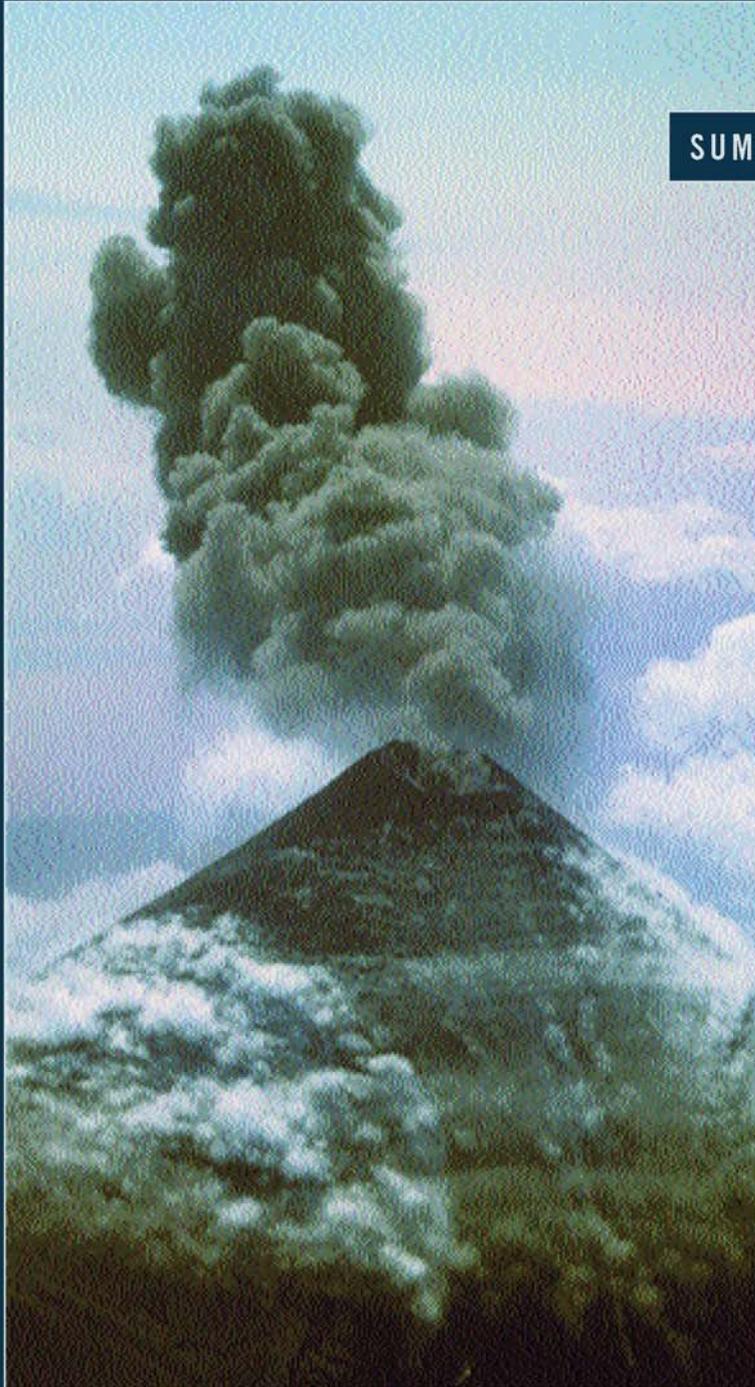
The following nine procedures are general recommendations. Each operator's flight operations manuals will include more specific directions.

1. **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.
2. **Turn the autothrottles off.** This prevents the engines from increasing thrust above idle. Ash debris in the engine can result in reduced surge margins, and limiting the number of thrust adjustments improves the chances of engine recovery.
3. **Exit the ash cloud as quickly as possible.** A 180-deg 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.
4. **Turn on engine and wing anti-ice devices and all air-conditioning packs.** These actions improve the



engine stall margins by increasing the flow of bleed air.

5. **If possible, start the auxiliary power unit (APU).** The APU can power systems in the event of a multiple-engine power loss. It can also be used to restart engines through the use of APU bleed air.
6. **If volcanic dust fills the flight deck, the crew may need to use oxygen.** Use flight deck oxygen at the 100 percent setting. Manual deployment of the passenger oxygen system is not required because it will deploy automatically if the cabin altitude exceeds 14,000 ft.
7. **Turn on the continuous ignition.** Confirm that autostart is on, if available. In the event that the engines flame out or stall, use appropriate procedures to restart the engines. 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, try restarting it again immediately. Flight crews should remember that the airplane may be out of the airstart envelope if the encounter occurs during cruise.
8. **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.
9. **Fly the airplane by monitoring airspeed and pitch attitude.** If necessary, follow the procedure for flight with unreliable airspeed.



## SUMMARY

Though the number of commercial airplane encounters with volcanic ash clouds has decreased significantly over the past several years, the potential for this type of event still exists. Efforts to advance knowledge about how to avoid and recover from these encounters have resulted in improved capability in these areas. By working with members of the volcanological community, the aviation industry has developed procedures to share information about events with flight crews, dispatchers, volcano scientists, and others. Volcano observatories that provide daily updates through e-mail messages or phone recordings have been established. In addition, a variety of Internet sources provide information that operators can tailor to their specific flight domains. Finally, flight operations procedures are documented and available to flight crews to help them respond immediately and appropriately to maintain the highest possible level of flight safety.

ALASKA AIRLINES  
PROCEDURES FOR

## OPERATING IN VOLCANIC ASH CONDITIONS

**A**laska Airlines has many active volcanoes within its flight domain. To prepare for an eruption and resulting encounter with volcanic ash, the airline has developed focused guidelines for flight operations when eruptions interfere with its route structures:

1. When in doubt, don't fly.
2. Use facts and data.
3. Identify the location of both the ash and clear areas.
4. Stay focused.

**1** WHEN IN DOUBT, DON'T FLY

The fundamental principle by which Alaska Airlines operates is knowing where to find the ash after a volcanic eruption. If unsure of the ash location, it will not allow its flight crews to fly through the eruption area. Though this approach is conservative, Alaska Airlines successfully and safely operated after the 1989 Mt. Redoubt eruption and other volcanic eruptions.

**2** USE FACTS AND DATA

Alaska Airlines has selected several information sources, uses Volcanic Ash Advisory Statements from the Volcanic Ash Advisory Centers, and is in direct communication with the Alaska Volcano Observatory. During a major eruption, Alaska Airlines will interview its own pilots as well as other operators' pilots about their observations on ash location. It has also established contacts on the ground that it can call for additional intelligence. These individuals include mayors



and police officers in villages and towns near the airline's flight paths. If Alaska Airlines receives inconsistent information, it double-checks and continually validates what appears to be correct.

**3** IDENTIFY THE LOCATION OF BOTH  
THE ASH AND CLEAR AREAS

Alaska Airlines tracks the ash by asking a number of questions:

- Where is the ash itself?
- Where is the volcanic source of the ash?
- What are the winds doing?
- What information is available from the volcanological community?
- What information do the reports from the pilots, selected contacts, and others contain?

Alaska Airlines then provides its pilots with information on where to fly and the reasons for not flying in certain areas.

**4** STAY FOCUSED

Ed Haeseker, manager of air traffic control for Alaska Airlines, worked during the Mt. Redoubt event with Tom Cufley, then chief pilot at Alaska Airlines. They found that a small team worked better than a large team, especially if the chief pilot provided information directly to the flight crew in the early days of the event. In addition, a small team can travel more quickly to the site where the greatest assistance is needed and remain focused on the key task: identifying where the ash is.

## ICAO ACTIVITIES ON VOLCANIC ASH

The International Civil Aviation Organization (ICAO) initiated a volcanic ash effort in 1982 after multiple volcanic ash encounters by 747 airplanes near Jakarta, Indonesia. The resulting organization, the Volcanic Ash Warnings Study Group, has worked since then to standardize the information provided to flight crews about volcanic eruptions.

In addition, ICAO formed the International Airways Volcano Watch (IAVW) in 1987. This effort formalized the international arrangements for monitoring and providing warnings to airplanes about volcanic ash in the atmosphere. ICAO annex III and the World Meteorological Organization (WMO) Technical Regulation C.3.1 introduced a requirement to disseminate information about volcanic ash to airplanes in the form of significant meteorological information (SIGMET) and notice to airmen (NOTAM).

The first WMO/ICAO workshop on volcanic ash hazards was held in Darwin, Australia, in 1995. Since then, a number of the designated Volcanic Ash Advisory Centers (VAAC) have come into full operation. A second workshop in Toulouse, France, in 1998 focused primarily on VAAC responsibilities and procedures.

More information about ICAO activities related to volcanic ash avoidance and encounters is available in the organization's document titled "Operational Procedures And List Of Operational Contact Points Between Vulcanological Agencies, Meteorological Watch Offices And Area Control Centres," or from the address to the right.

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**Chief - Meteorology**

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## VOLCANO ERUPTION WARNING COLOR CODES

Eruption warnings are issued in the form of color-coded information releases. Over the past 10 years, this method has proved to be effective for alerting the aviation community to potential volcanic ash.

ALERT COLOR CODE	VOLCANO ACTIVITY STATUS
Red	Volcanic eruption in progress. Ash plume or cloud reported above FL 250.
	Volcano dangerous, eruption likely, with ash plume or cloud expected to rise above FL 250.
Orange	Volcanic eruption in progress but ash plume or cloud not reaching nor expected to reach FL 250.
	Volcano dangerous, eruption likely, but ash plume or cloud not expected to reach FL 250.
Yellow	Volcano known to be active from time to time and volcanic activity has recently increased significantly, volcano not currently considered dangerous but caution should be exercised.
	After an eruption, i.e., change in alert to yellow from red or orange, volcanic activity has decreased significantly, volcano not currently considered dangerous but caution should be exercised.
Green	Volcanic activity considered to have ceased and volcano reverted to its normal state.

The responsible volcanological agency in the region where the volcano erupts should provide the area control center with (1) the color code for the level of alert indicating the status of activity of the volcano and (2) any change from a previous status of activity (e.g., "Red alert following yellow" or "Green alert following orange"). Source: ICAO—International Airways Volcano Watch.

## VOLCANIC ASH RESOURCES

Volcanic ash resources are available worldwide and in many forms

accessible to operators. Volcano observatories are located throughout the world, including the Alaska Volcano Observatory for information about North Pacific volcanoes and the Nordic Volcanological Institute for information about volcanic activity that could affect North Atlantic routes. Many of these observatories provide immediate eruption and volcanic ash updates to operators by fax, e-mail, telephone, or teletype. Information is also available on the World Wide Web at the following sites:

**The Smithsonian National Museum of Natural History Global Volcanism Program:** <http://www.volcano.si.edu/gvp/>

**The U.S. Geological Survey:** <http://www.usgs.gov/themes/volcano.html>

**The Airline Dispatcher Federation (a detailed paper about volcanic ash written by Leonard J. Salinas of United Airlines, Chicago, Illinois):**  
<http://www.dispatcher.org/library/VolcanicAsh.htm>

**The Committee on Earth Observation Satellites Disaster Management Support Project/Volcanic Hazards Management (an effort by the U.S. National Oceanic and Atmospheric Administration; information on tracking ash clouds):**

**The Istituto Internazionale di Vulcanologia (a summary of volcanoes in Italy):** <http://www.iiv.ct.cnr.it/>

**The Nordic Volcanological Institute (information about volcanoes in and around Iceland):** <http://www.norvol.hi.is/index.html>

**The Volcanological Society of Japan (eruption information, live images of Japanese volcanoes, and other information):**  
<http://hakone.eri.u-tokyo.ac.jp/kazan/VSJ1E.html>

**Current Eruptions in Japan (additional current information):**  
<http://hakone.eri.u-tokyo.ac.jp/vrc/erup/erup.html>

**Other sources of information include the following:**

The Boeing Company, *Airliner* magazine ("Vulcan's Blast," April-June 1990, and "Vulcan Returns: Volcanic Ash Effects on Airplanes Revisited," October-December 1991) and video ("Volcanic Ash Avoidance: Flight Crew Briefing").

U.S. Federal Aviation Administration, *Aviation Safety Journal* reprint ("The Volcano Threat to Aviation Safety").

Casadevall, T. J., ed. 1994. *The First International Symposium on Volcanic Ash and Aviation Safety: Proceedings Volume*. U.S. Geological Survey Bulletin 2047.

Casadevall, T. J., T. B. Thompson, and T. Fox. 1999. *World map of volcanoes and principal air navigation features*. U.S. Geological Survey Map I-2700.

*THE PRIMARY SOURCE FOR ANY VOLCANIC ERUPTION AND ASH INFORMATION IS A VOLCANIC ASH ADVISORY CENTER. THE OTHER SOURCES LISTED HERE MAY OFFER MORE DETAILED INFORMATION ON A PARTICULAR ERUPTION. – ED.*

**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

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 Airplanes; Chief Pilot - Flight Technical and Safety; Training and Flight Services; P.O. Box 3707; Mail Code 14-HA; Seattle, Washington 98124-2207; Phone (206) 544-9700; Facsimile (206)544-9687; SITA: SEABO7X Station 627.

**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 Eyjafjallajökull, 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.

 **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.

 **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.

 **Procedures**

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

 **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.

 **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.**

# Bombardier Volcanic Ash Guidance for CRJ series aircraft

*The guidance below is taken from the Supplementary Procedures sections of the CRJ Pilot's Operating Handbook (POH) (Vol 2 07-16-1 Rev 57 Apr 05/04 for the CRJ100/200 and Vol 2 07-16-1 Rev 8 Mar 12/04 for the CRJ700/900/1000).*

## Operation in Volcanic Ash/Dust

### 1 General

Flight operations in areas of known volcanic activity should be avoided. This consideration is most important during hours of darkness or daytime instrument meteorological conditions when volcanic ash/dust clouds may not be visible.

Flight planning considerations should include the review of pertinent NOTAMs, PIREPs and other directives concerning the status of volcanic activity when a flight is planned into areas of possible volcanic activity. When volcanic activity is currently reported, remain well clear of the area, or if possible stay on the upwind side of the volcanic ash.

### 2 Detection

The aeroplane's weather radar is not capable of detecting volcanic ash/dust clouds and is therefore not reliable under these circumstances. The presence of volcanic ash/dust may be indicated by:

-  Smoke or dust appearing in the flight compartment
-  An acrid odour similar to electrical smoke
-  Multiple engine malfunctions such as power loss, fluctuating RPM, stalls, increasing ITT's flameouts, etc.
-  At night, static discharges (also known as St. Elmo's fire or St. Elmo's light) can be observed around the windshield and/or windows, accompanied by a bright orange glow in the engine inlets.

### 3 Effects

Flight into volcanic ash/dust clouds can result in the degradation of aeroplane and engine performance. The adverse effects of volcanic ash/dust encounter are as follows:

-  Rapid erosion and damage to the internal components of the engines
-  Ash/dust build up and blockages of the guide vanes and cooling holes, which can cause surge, loss of thrust and or high ITT.
-  Ash/dust blockage of the pitot system which can result in erratic airspeed indications.
-  The abrasive nature of volcanic material can cause serious damage to the engines, wing and tail leading edge surfaces, windshields, landing lights, etc.
-  Volcanic ash/dust can also cause the windshield to become translucent, effectively reducing visibility.

#### 4 Corrective Actions

The best course of action to take is still avoidance. However, if volcanic ash/clouds may sometimes extend for hundreds of miles and an encounter could be unavoidable. As previously stated, volcanic ash/dust can cause engine malfunctions and the need to exit the area as quickly as possible cannot be over emphasised.

If an inadvertent encounter is experienced, the following procedures are recommended:

##### 1 Thrust

##### Reduce

*If altitude permits, engine thrust should be reduced to idle to maximise the engine stall margin and lower the ITT. This action would also reduce the build up of volcanic material on the turbine vanes.*

##### 2 Engine and wing anti ice

##### Activate

*This action will increase bleed air extraction from the engines and further improve the engine stall margin.*

##### 3 ITT

##### Monitor

Closely monitor the ITT and ensure that the limits are not exceeded

If the ITT should still increase even though the engine thrust is at idle:

##### 4 Affected engine

##### Shutdown

*If it becomes necessary to shutdown an engine to prevent exceeding ITT limits. Restart engine once it has cooled down. If the engine fails to start, repeated attempts should be made immediately. (Adhere to starter cranking limits as per LIMITATIONS, POWER PLANT – Starter Cranking Limits (Ground and Air)).*

*Note: A successful start may not be possible until the aeroplane is clear of the volcanic ash/dust, and the airspeed and altitude is within the air start envelope. Take note that engines can be very slow to accelerate to idle at high altitude and this could be interpreted as a failure to start or as an engine malfunction.*

After exiting the area of volcanic ash/dust cloud and the engine(s) restarted restore systems to normal operation. Inform ATC of encounter.