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Aircraft Design & Operation
Briefing Leaflet

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Airbus volcanic ash awareness advice

In its Flight Operations Briefing Notes (FOBN) Airbus addresses the issue of operations in or near airspace contaminated with volcanic ash as follows. This FOBN 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*).

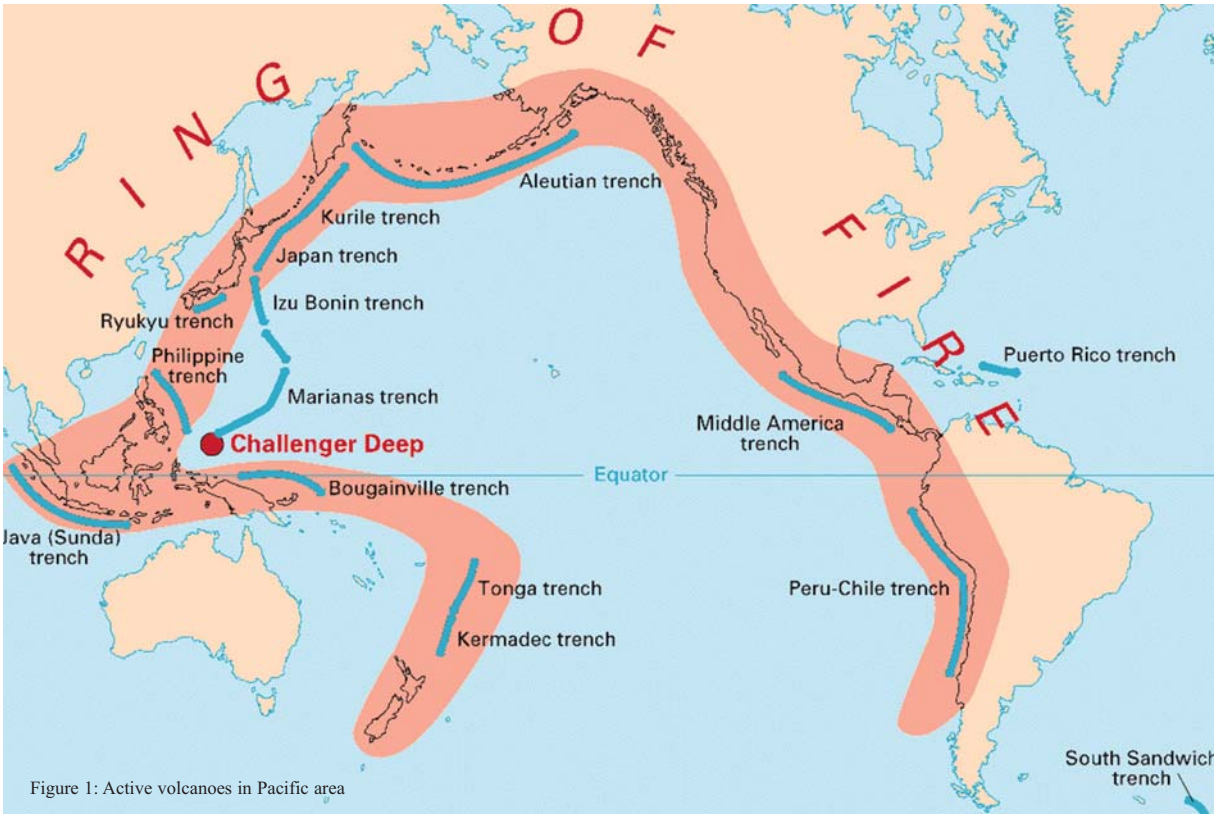

Figure 1: Active volcanoes in Pacific area

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.

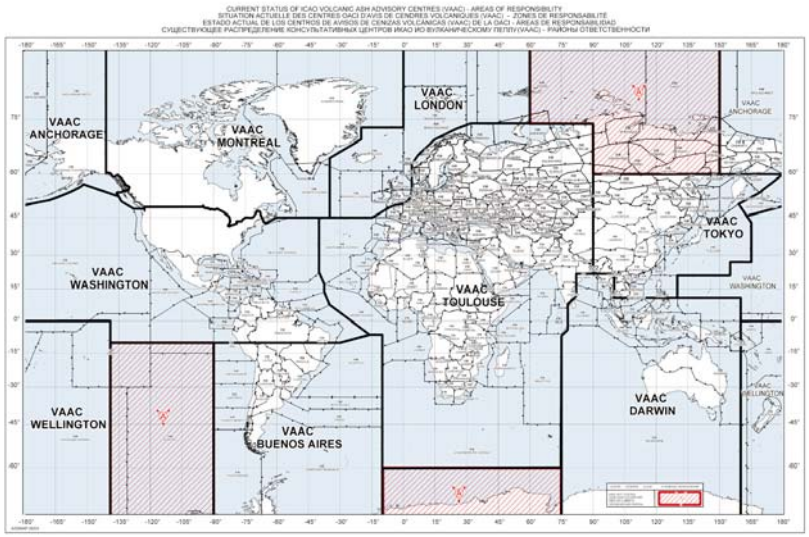

Figure 2: Volcanic Ash Advisory Centers areas of responsibility

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.

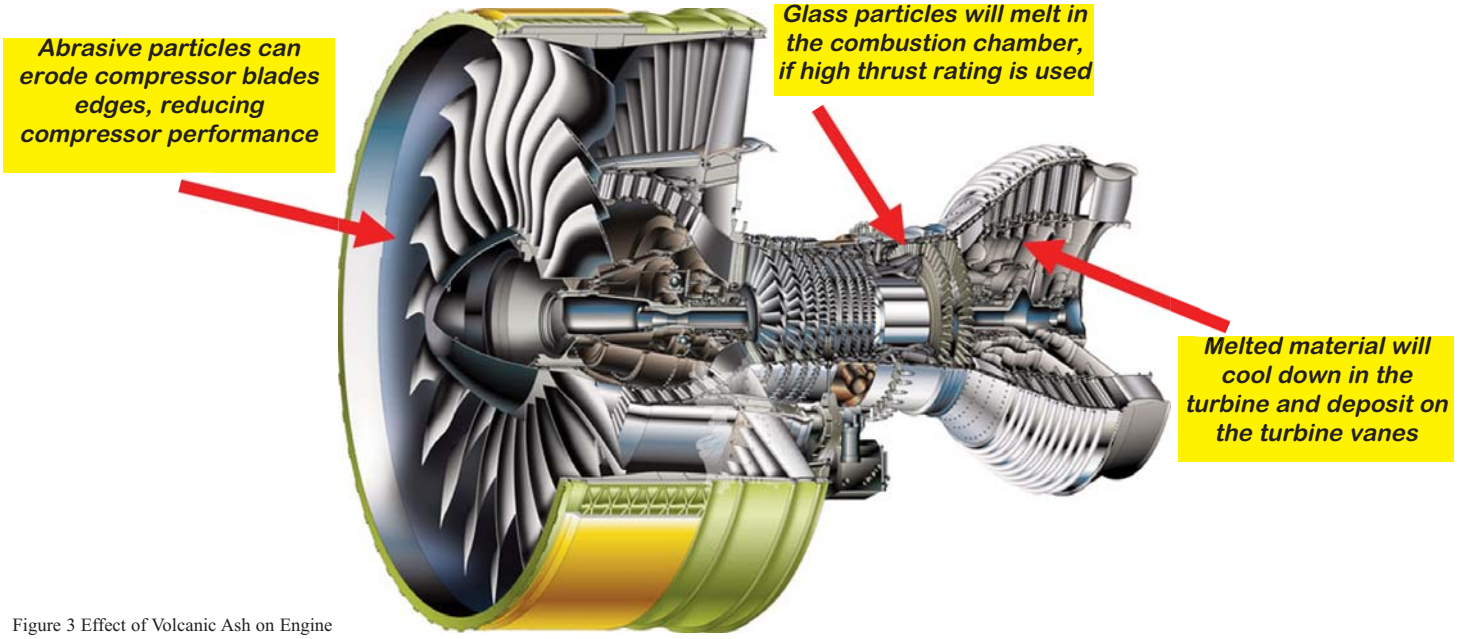

Figure 3 Effect of Volcanic Ash on Engine

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:

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