

Doc 9974
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Flight Safety and Volcanic Ash

Risk management of flight operations with known or forecast
volcanic ash contamination

Approved by the Secretary General
and published under his authority

First Edition — 2012



International Civil Aviation Organization

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AMENDMENTS

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FOREWORD

This document provides guidance which States may recommend to operators and regulatory authorities where volcanic ash contamination may be a hazard for flight operations. The underlying assumption is that individual operators are responsible for such operations under the oversight of their respective State regulatory authority. The guiding principle for such operations is the use of a safety risk management approach, as described in this document.

This document is based principally on work undertaken by the ICAO International Volcanic Ash Task Force (IVATF) in 2010 and 2011 and inputs from members of the ICAO Operations Panel and is published to make existing information available as soon as possible. Several relevant initiatives remain underway and outcomes may be introduced, as appropriate, as they are completed.

Among the ongoing initiatives which may have relevance to the volcanic ash safety risk management approach is the information provided by the volcanic ash advisory centres (VAAC) within the framework of ICAO's international airways volcano watch. Work is underway to correlate the forecast output of the nine designated VAACs with the current avoidance guidance* to operators found in the *Manual on Volcanic Ash, Radioactive Material and Toxic Chemical Clouds* (Doc 9691) and the *Handbook on the International Airways Volcano Watch (IAVW) — Operational Procedures and Contact List* (Doc 9766) and to harmonize the content of the VAAC advisory information at regional interfaces. Work is also underway to enhance the information available to aircraft in flight and at the aerodrome to ensure utmost safety and optimal efficiency.

In the interests of flight safety, in the event of a volcanic eruption, distribution of this document is encouraged. It may not be offered for sale or used commercially without written permission from ICAO.

This document is published by ICAO following a collaborative endeavour among stakeholders with the objective of improving safety for flight operations in the event of a volcanic eruption. An arrangement of collaboration has been signed denoting the valued contribution and endorsement, including the use of the logo on this document, with the following organizations: Airports Council International (ACI), Civil Air Navigation Services Organisation (CANSO), International Air Transport Association (IATA), International Coordinating Council of Aerospace Industries Associations (ICCAIA), International Federation of Air Line Pilots' Associations (IFALPA) and International Federation of Air Traffic Controllers' Associations (IFATCA).



* Current avoidance guidance refers to visible or discernable ash. There is a need to define these terms in a manner that facilitates their use both at dispatch and in the en route phase of flight (such as quantitative descriptors). This information is considered central to any operational procedures intended to be applied when flying in airspace subject to volcanic ash.

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GLOSSARY

Acronyms

AIREP	Air Report
AML	Aircraft Maintenance Log or equivalent, e.g. Aircraft Technical Log
AOC	Air Operator Certificate
ASHTAM	Special series NOTAM notifying a change in activity of a volcano, a volcanic eruption and/or volcanic ash cloud that is of significance to aircraft operations
ASR	Air Safety Report – used by an operator to document its safety incidents
ATC	Air Traffic Control
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
ATS	Air Traffic Services
CAA	Civil Aviation Authority
EDTO	Extended Diversion Time Operations
IAVW	International Airways Volcano Watch
IVATF	International Volcanic Ash Task Force (of ICAO)
LIDAR	Light Detection and Ranging: an optical remote sensing technology counting among its capabilities that of detecting and measuring volcanic ash particle size and density
MEL	Minimum Equipment List
MET	Meteorology or Meteorological
MWO	Meteorological Watch Office
NOTAM	A notice distributed by means of telecommunication containing information concerning the establishment, condition or change in any aeronautical facility, service, procedure or hazard, the timely knowledge of which is essential to personnel concerned with flight operations
PMA	Parts Manufacturer Approval
SIGMET	Information concerning en-route weather phenomena which may affect the safety of aircraft operations
SMM	<i>Safety Management Manual</i> (ICAO Doc 9859)
SMS	Safety Management System
STC	Supplemental Type Certificate
TCH	Type Certificate Holder
VAA	Volcanic Ash Advisory
VAAC	Volcanic Ash Advisory Centre
VAG	Volcanic Ash Advisory in graphical form
VAR	Volcanic Activity Report from aircraft (the real-time part of the VAR is issued in the same manner as an AIREP Special)
VMC	Visual meteorological conditions
VOLCEX	Regular ICAO volcanic ash exercises to validate and improve regional volcanic ash contingency plans and procedures.

Definitions

Accountable executive. The individual within a CAA-approved organization who is accountable to that CAA for ensuring that the safety standards required by regulation, and any additional standards specified by the organization, are met on an ongoing basis by the organization.

Affected area. A volume of airspace, an aerodrome or another area on the ground, identified by VAA/VAG and/or SIGMET as being affected by known or forecast volcanic cloud contamination.

(Aircraft) Operator. In the context of this document, references to the (aircraft) operator refer to those operators subject to ICAO Annex 6 — *Operation of Aircraft*, Parts I, II and III being operators of aeroplanes or helicopters authorized to conduct international commercial air transport operations or involved in international general aviation.

Danger area. In the context of volcanic ash cloud contamination, a volume of airspace identified by NOTAM as being affected by levels of known or forecast volcanic cloud contamination which States judge merit publication to operators.

Service provider. In the context of this document, includes approved training organizations, aircraft operators and approved maintenance organizations, organizations responsible for type design and/or manufacture of aircraft, air traffic service providers, aerodromes, MWOs and VAACs.

State of Registry. The State on whose register the aircraft is entered.

State of the Operator. The State in which the operator's principal place of business is located or, if there is no such place of business, the operator's permanent residence.

Volcanic ash. Comprised of minerals unique to the volcanic eruption. Minerals common to most volcanic ash are silica together with smaller amounts of the oxides of aluminium, iron, calcium and sodium. The glassy silicate material is very hard and extremely abrasive. Its melting point is below jet engine burner temperature which introduces additional hazards. (Refer to Section 2.1 of ICAO's *Manual on Volcanic Ash, Radioactive Material and Toxic Chemical Clouds* (Doc 9691)).

Volcanic cloud. The sum of the material ejected from a volcano into the atmosphere and transported by winds aloft. It comprises volcanic ash, gases and chemicals¹ (Refer to Section 2.1 of ICAO's *Manual on Volcanic Ash, Radioactive Material and Toxic Chemical Clouds* (Doc 9691)).

1. Although the specific material being referred to used to be the ash contained in the volcanic cloud, it is understood that other elements of the cloud may also be undesirable to operate through.

Chapter 1

INTRODUCTION

1.1 Volcanic ash consists mostly of sharp-edged, hard glass particles and pulverized rock. It is very abrasive and, being largely composed of siliceous materials, has a melting temperature below the operating temperature of modern turbine engines at cruise thrust. A volcanic ash cloud may be accompanied by gaseous solutions of sulphur dioxide (which when combined with water create sulphuric acid), chlorine (which when combined with water create hydrochloric acid) and other chemicals which are corrosive to the airframe and are hazardous to health. Given these facts, it is self evident that volcanic ash in the atmosphere may pose a serious hazard to aircraft in flight. Thus, aircraft should avoid volcanic ash encounters.

1.2 Volcanic ash forecasts serve to levy the probability, when performing a safety risk assessment, of the hazard of an aircraft encountering volcanic ash. The risk may be mitigated using effective in-flight procedures. This document establishes guidelines which States may recommend to aircraft operators and regulatory authorities to adopt in order to assess the safety risk of flight operations in areas forecast to be affected by volcanic ash or aerodromes contaminated with volcanic ash.

ASH ENCOUNTER INDICATORS

1.3 In day visual meteorological conditions (VMC) a precursor to a volcanic ash encounter will likely be a visual indication of a volcanic ash cloud or haze. If a flight crew observes a cloud or haze suspected of containing volcanic ash they should be aware that a volcanic ash encounter is imminent and they should take action to avoid the contaminated airspace.

1.4 Indicators that an aircraft is encountering volcanic ash are related principally to the following:

- *Odour.* When encountering volcanic ash, flight crews usually notice a smoky or acrid odour that can smell like electrical smoke, burnt dust or sulphur.
- *Haze.* Most flight crews, as well as cabin crew or passengers, see a haze develop within the aircraft cockpit and/or cabin. 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-coloured 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.

1.5 Any of these indicators should suffice to alert the flight crew of an ash encounter, and appropriate action should be taken to vacate the contaminated airspace as safely and expeditiously as possible.

THE HAZARD

1.6 The abrasiveness of volcanic ash¹ can be very detrimental to aircraft. The following non-exhaustive list provides examples of what can be expected in the event of an ash encounter which may affect:

- a) the immediate safety of an aircraft:
 - the malfunction or failure of one or more engines leading not only to reduction, or complete loss, of thrust but also to failures of electrical, pneumatic and hydraulic systems. Volcanic ash contains particles whose melting point is below modern turbine engine burner temperature; these particles then fuse in the turbine section reducing the throat area and its efficiency leading to engine surge and possibly flame-out;
 - the blockage of pitot and static sensors resulting in unreliable airspeed indications and erroneous warnings;
 - windscreens rendered partially or completely opaque; and
 - contamination of cabin air requiring crew use of oxygen masks.
- b) the longer term safety and costs affecting the operation of aircraft:
 - erosion of external aircraft components;
 - reduced electronic cooling efficiency and, since volcanic ash readily absorbs water, potential short circuits leading to a wide range of aircraft system failures and/or anomalous behaviour;
 - flight crew manoeuvring for volcanic cloud avoidance which may potentially conflict with other aircraft in the vicinity;
 - deposits of volcanic ash on a runway resulting in a degradation of braking performance, especially if the volcanic ash is wet; in extreme cases, this can lead to runway closure; and
 - aircraft ventilation and pressurization systems becoming heavily contaminated. In particular, cleaning or replacement may be required in response to air cycle machine contamination and abrasion to rotating components, ozone converter contamination and air filter congestion.

ASH ENCOUNTER AVOIDANCE RESOURCES

1.7 The behaviour of erupting volcanoes ranges from the quiet, steady effusion of lava to highly explosive eruptions. The larger scale eruptions may eject many cubic kilometres of glass particles and pulverized rock (volcanic ash) and corrosive/hazardous gases high into the atmosphere, potentially over a wide area for timescales ranging from hours to weeks or even months. Volcanic eruptions may present a direct threat to the safety of aircraft in flight and major

1. Although the specific material being referred to is the ash contained in the volcanic cloud, it is understood that other elements of the cloud may also be undesirable to operate through and cause additional hazards.