



WORKING PAPER

**INTERNATIONAL AIRWAYS VOLCANO WATCH OPERATIONS GROUP
(IAVWOPSG)**

SEVENTH MEETING

Bangkok, Thailand, 18 to 22 March 2013

Agenda Item 5: Operation of the IAVW

5.1: Implementation of the IAVW, including the IAVW management reports

**FOLLOW-UP OF IVATF RECOMMENDATION 4/10 —
DEFINITIONS OF VISIBLE ASH AND DISCERNIBLE ASH FOR OPERATIONAL USE**

(Presented by the IUGG and WMO)

SUMMARY

This paper is in reference to IVATF Recommendation 4/10. Modifications are suggested to the definitions of the terms “visible ash” and “discernible ash” that were proposed at the fourth and final meeting of the IVATF in 2012. Action by the IAVWOPSG is in paragraph 4.

1. INTRODUCTION

1.1 Because the terms “visible ash” and “discernible ash” have been used to describe volcanic ash that should be avoided by aircraft, the definition of these terms needs careful articulation within an operational context. At the fourth and final meeting of the International Volcanic Ash Task Force (IVATF), a report of the Airworthiness Sub-Group (IVATF/4-DP/3) suggested working definitions of the two terms, and as a consequence, IVATF Recommendation 4/10 brought the following initial definitions forward to the IAVWOPSG for consideration:

Visible ash. Volcanic ash that can be observed by the human eye.

Discernible ash. Volcanic ash that can be detected by defined impacts on the aircraft or defined in-situ and/or using remote-sensing techniques.

1.2 Relevant to this issue is IVATF/2-WP/8 — *Understanding Visible Ash*, which provided some historical background on the usage of that term and presented some quantitative constraints on thresholds for observing and detecting ash. IVATF/2-WP/8 noted that the lower limit of ash-cloud visibility to the human eye (during the day with a blue sky background) varies over a considerable range of ash concentrations values — from ~0.1 to 10 mg/m³ — depending on factors such as particle size and geometrical extent of the cloud along the line of sight of the observer. Other factors also affect visibility

of ash clouds, such as position of the observer relative to the sun, strength/angle of sunlight, and presence of aerosol droplets and particles such as smoke or sand and dust that may be misidentified as ash. A recently published article entitled *On the Visibility of Airborne Volcanic Ash and Mineral Dust from the Pilot's Perspective in Flight*" (Weinzierl et al., 2012, Physics and Chemistry of the Earth, v. 45-46, p. 87-102, <http://dx.doi.org/10.1016/j.pce.2012.04.003>) also documents the difficulty of defining a lower concentration threshold for the visibility of an aerosol layer, noting that visual detectability depends on many parameters besides concentration.

1.3 Also of note is IVATF/4-WP/11 which considered the current status of satellite-based methods for determining ash-cloud microphysics. New data from recent volcanic eruptions suggests that mass loadings determined from infrared satellite sensors have a lower detection threshold of 0.2 g/m^2 ($\pm 0.115 \text{ g/m}^2$) under the most favourable conditions; for an ash cloud of 1 km mean thickness, the lower detection threshold for estimating ash concentrations from satellite would therefore be 0.2 mg/m^3 .

2. DISCUSSION

2.1 A positive aspect of the definition of visible ash suggested in section 1.1 above is that it conforms to the common understanding of "visible" as being observed by the human eye. However, the verb tense "can be" is problematic because it implies unconstrained future viewing conditions. As indicated by IVATF/2-WP/8 and Weinzierl et al. (2012), there is a considerable range of conditions under which ash can be seen by the human eye. For example, even in blue-sky conditions, a cloud that can be seen might be a thick cloud of lower concentration or a thin cloud of higher concentration. There is no unambiguous scientific basis for specifying what "can be seen." In particular, "visible" should *absolutely not* be considered as a proxy for the widely referenced concentration value of 2 mg/m^3 .

2.2 Accordingly, the following modified definition is suggested:

Visible ash. Volcanic ash ~~that can be~~ observed by the human eye.

Such observations include sightings of volcanic plumes and anomalously distinctive layers in the atmosphere, and dust-like particles in the cockpit or outside the windscreen (with the possibility of misidentification of dust, sand or smoke as ash). For pilots, this definition offers clear guidance related to what is actually observed by them and therefore is a useful term for tactical operational use.

2.3 In the definition of discernible ash in section 1.1 above, the emphasis is on non-visual detection. Defined impacts on/in aircraft are outlined in the Doc 9974 — *Flight Safety and Volcanic Ash*.

2.4 Near real-time satellite-based remote-sensing techniques are utilized by VAACs as the primary and agreed means of volcanic ash detection. Other remote-sensing techniques for volcanic ash detection, such as backscatter ceilometer and lidar data are being developed, while in-situ measurements (i.e. taken directly at the point of interest and in contact with the subject of interest) from suitably instrumented aircraft can provide additional detailed information on the dimensions and characteristics (e.g. ash concentration) of volcanic ash layers. Using such techniques and any volcanic ash aircraft reports (AIREPs), areas of volcanic ash can be analyzed and compared with ash dispersion model output of the same validity time. After such analysis and comparison, and following any necessary human adjustments, the dispersion model output can then be used to forecast the transport and dispersion of volcanic ash. It should be noted that the equivalent satellite-derived mass-loading detection threshold of 0.2 g/m^2 (from IVATF/4-WP/11), although not directly comparable to ash concentration, provides a *recognized quantitative constraint (lower threshold) for satellite-based remotely sensed discernible ash*;

this threshold may change over time as sensors and retrieval algorithms improve but is currently an agreed value.

2.4 Accordingly, the following modified definition is suggested:

Discernible ash. Volcanic ash ~~that can be~~ detected by defined impacts on/in the aircraft or ~~defined by agreed~~ in-situ and/or ~~using~~ remote-sensing techniques.

2.5 These definitions are observationally based. Evidence from previous eruptions shows that the analyzed and forecast areas of ash depicted by volcanic ash advisories most likely will enclose the areas of visible or discernible ash, with the closeness of correspondence affected by observational conditions and the nature of the eruption clouds. This strongly suggests that the VAAC advisory “threat areas” provides reliable strategic guidance relating to areas of airspace where volcanic ash may be encountered, and therefore where some form of safety risk-assessment and mitigation plan is required in preparation for a potential ash encounter (as ultimately evidenced by being “observed by the human eye” or “detected by defined impacts on/in aircraft”).

2.6 When the definitions of visible ash and discernible ash are finalized, they should be documented in the *Manual on Volcanic Ash, Radioactive Material and Toxic Chemical Clouds* (Doc 9691).

3. CONCLUSIONS

3.1 Both the terms “visible ash” and “discernible ash” have value for aviation use. The term “visible ash” is tactically useful to the flight crew while enroute. The term “discernible ash” is strategically useful to VAACs for forecasting the likely presence of ash and to the operators for use in flight operations planning. The term “visible ash” should only be used to describe the human-eye observation of volcanic ash and thereby be acknowledged as a purely qualitative definition. The term “discernible ash” applies to both qualitative aircraft related impacts and to quantitatively-based in-situ and remote sensing detection methods. If ash has been observed by the human eye or detected by impacts on/in the aircraft, then it is universally recognized that some form of reactive mitigating action should be taken. Whenever possible, VAACs will primarily use “agreed in-situ and/or remote sensing techniques” to underpin their analysis and production of volcanic ash forecast advisories upon which strategic planning decisions are then taken. It should also be reaffirmed that aircraft reports will continue to be used to help inform an analysis of any given situation.

3.2 In regard to this information provided in this paper, the group is invited to formulate the following draft conclusion:

Conclusion 7/xx — Definitions of visible ash and discernible ash for operational use

That:

- a) visible ash be defined as “volcanic ash observed by the human eye” and not be defined quantitatively by the observer;
- b) discernible ash be defined as “volcanic ash detected by defined impacts on/in aircraft or by agreed in-situ and/or remote sensing techniques”;
- c) VAACs use “agreed in-situ and/or remote sensing techniques” to underpin the production of volcanic ash forecast advisories; and
- d) the definitions resented in a) and b) above and use of the two definitions be included by the Secretary in Doc 9691.

4. ACTION BY THE IAVWOPSG

4.1 The IAVWOPSG is invited to:

- a) discuss the information in this paper; and
- b) decide on the draft conclusion proposed for the group’s consideration.

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