Volcanic Ash

Risk Management

GE Aviation Perspective on Operations in a Volcanic Ash Environment

Roger Dinius
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Volcano Eruption Impacts Air Travel & Commerce

• April 15th eruption closed a large part of European airspace
  • Airspace re-opened 21st
• Impacted Travelers, & Cargo
• GE Aviation worked to support the UK CAA, FAA, & customers
• Limited data on long term impact from low levels of volcanic ash on engines
  • Used all available ingestion data
• Focused on maintaining safe operations
Volcanic Ash Impacts On Turbomachinery
Engine damage correlates with cloud age, particle size

Altitude of encounter vs. distance from volcano

Wind

Particle size

Concentration

Chemistry

Time

Distance from volcano (nautical miles)

Distance

Height

Concentration

Particle size

Fallout

Time

Wind

Height

Distance

Concentration

Particle size

Fallout

Chemistry

No damage

Damage w/o immediate operational effect

IFSD
Volcanic Ash Operations in Japan

- Sakura-jima is an active volcano
  - ~1,000 eruptions in past year
- Kagoshima Airport located ~15 miles north of Sakura-jima volcano
  - 250 flight deviations this past April due to visible volcanic ash
  - ~5 days a year ash falls on airport impacting operations
- One airline operates 50 flights a day into Kagoshima
  - Their standard practice is to avoid visible ash
  - Deviate flight path based on meteorological forecast.
    - Required for IMC & Night operations
  - No engine problems reported while avoiding visible ash
London VAAC Process

- UK Weather Service (MET Office) produces ash cloud prediction for Iceland’s volcanic activity
- Model based on volcanic activity, weather conditions, visible and infrared satellite imagery

2010 EUR/NAT Contingency Plan (July 2010):
- Area of High Contamination … Black Zone
  – Predicted concentration > 4 mg/m³
- Area of Medium Contamination … Grey Zone
  – Predicted concentration from 2 mg/m³ up to 4 mg/m³
- Area of Low Contamination … Red Zone
  – Predicted concentration from 0.2 mg/m³ up to 2 mg/m³
OEM Support of Operators

- Guidance on operations in Volcanic Ash environment
- Recommend tactical response to a volcanic ash encounter
- Recommend maintenance
  - Following a volcanic ash encounter
  - Following operations in a potentially contaminated environment
- Technical support of hardware condition following volcanic ash exposure
  - Technical Representatives
  - Call center for Operators
- Qualitative Risk Assessment information

Volcanic Ash Operational Risk Management

<table>
<thead>
<tr>
<th>Volcanic Ash Condition</th>
<th>Low Risk</th>
<th>Medium Risk</th>
<th>High Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area free of particulate volcanic ash</td>
<td>Area of multiple incurred volcanic ash</td>
<td>Area of visible volcanic ash or fallout ash concentrations of ≥ 2 mg/cm³</td>
<td></td>
</tr>
<tr>
<td>Flight Operations</td>
<td>Normal Flight Ops</td>
<td>Normal Flight Ops in day VMR only; use flight ops based on current local information</td>
<td>No unauthorized flight into areas of visible ash or concentrations ≥ 2 mg/cm³</td>
</tr>
<tr>
<td>Maintenance</td>
<td>No extra requirements</td>
<td>If volcanic ash is encountered, follow guidance in AOW</td>
<td>If volcanic ash is encountered, follow AAMM, SB &amp; AOW’s</td>
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<tr>
<td>Risk Abatement</td>
<td>Immediately exit area of visible ash if encountered, follow EASA or equivalent authorities</td>
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GE/CFM Recommendations

Reference All Operators Wires: CF34-2010-06, CT7-2010-04, 10/CF6/013, 10/GE90/004

GE issued a combined All Operators Wire (AOW) on 18 May 2010 to reinforce GE recommendations for operation in areas of predicted volcanic ash

- AOW was issued in response to recent circumstances in Europe

- Fundamental recommendation – worldwide - is to avoid visible ash

Similar AOW’s issued by CFM for CFM engines
GE Recommendations
Reference All Operators Wires: CF34-2010-06, CT7-2010-04, 10/CF6/013, 10/GE90/004

GE recommendations - Maintenance

• If the aircraft was flown through visible ash … do AMM special inspection for volcanic ash ingestion

• If the aircraft was not flown through visible ash and flown through predicted ash contaminated environments… do AMM walk around inspection of inlet and exhaust
  – If no evidence of ash ingestion (accumulated ash or erosion) … no action required
  – If evidence of ash seen … do AMM special inspection for volcanic ash ingestion

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Operation in Areas of Volcanic Ash – Summary

GE recommends flight planning using responsible meteorological (MET) office volcanic ash advisories, and other sources of flight planning information such as FAA Flight Service Stations.

GE also recommends avoiding flight through visible ash clouds.

Positive industry experience when operators avoid visible volcanic ash, defined as 2 mg/m$^3$.

Flight into predicted ash concentrations of higher than 2 mg/m$^3$ may be undertaken at operators’ discretion, provided flight into visible ash clouds is avoided.

Follow current AMM maintenance requirements when operating in areas of potential volcanic ash encounters.
ICAO Volcanic Ash Task Force

- GE/CFM are supporting task force
- GE is not supportive of an “ash rule”
  - There is no “safety case” to drive it
- Summary of airworthiness tasks:
  - Review current flight crew guidance
  - Review current maintenance & inspection guidance
  - OEM’s support of operators in next crisis
  - Define characteristics of ash that may impact aircraft
  - Assess airworthiness considerations of threat
  - Develop guidance for States to allow flight into ash contaminated areas
  - Establish a risk management approach to operations in volcanic ash contaminated areas
  - Study certification implications
## Volcanic Ash Operational Risk Management

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Inadvertent Encounter
Risk Abatement

- In all cases, if an area of visible (discernable) volcanic ash is encountered, the recommended action is to exit the airspace.
- Follow Airplane Maintenance Manual recommended inspection & maintenance practices.

| Risk Abatement | Immediately exit area of visible ash environment, if inadvertently encountered. Follow ICAO manual 9691 paragraph 4.4.1, or approved airframe operations manual procedures. |
Area of Light Concentration of Volcanic Ash Risk Management

- Normal Operations
  - Flight path free from predicted volcanic ash
- Normal Maintenance

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Visible Volcanic Ash OR High Measured Ash Risk Management

- **Restricted Operations**
  - No recommended intentional flight into visible volcanic ash

- **Maintenance**
  - Recommended guidance in AOW
  - SB & AMM inspections

- **Visible ash = 2mg/m³ Concentration**
  - Interim definition, used during 2010 UK crisis

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Area of Forecast Volcanic Ash Risk Management

- Actively Managed Operations
  - Day VMC
    - Avoid visible (discernable) volcanic ash
  - Night & IMC
    - Avoid areas of predicted volcanic ash > 2mg/m³ (visible)

- Maintenance
  - No ash encountered
    - Recommended AOW guidance
  - Ash encountered
    - Follow AMM, SB & AOW inspections

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Volcanic Ash Operational Risk Management

Normal Flight Ops in day VMC only, plan flight to avoid visible ash based on current information.

- Use best available information to maximize airspace utilization
- Over flight of ash acceptable with appropriate risk management

Avoid flight in area of predicted volcanic ash (>2 mg/m$^3$ or VMC visible) at night or in IMC

- Use best available information to maximize airspace utilization
  - Day time VMC observations or measurements critical to clearing airspace within advisory area.
- Absence of measurements or observations defaults to avoidance of advisory area.

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| Maintenance | Normal maintenance requirements | If no volcanic ash is encountered, follow guidance in AOM | If volcanic ash is encountered, follow AMM, SB & AOM's |

| Risk Abatement | Immediately exit area of visible ash environment, if inadvertently encountered. Follow ICAO manual 9691 paragraph 4.4.1, or approved airframe operations manual procedures. |

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Takeaways

- Industry experience is good when operators avoid visible volcanic ash
- We continue to support operators in the area of volcanic ash, to maintain safe operation
- GE/CFM are supporting the IVATF
- Operational definitions of volcanic ash, expected operations in this environment and research is required to support a quantitative risk assessment

GE/CFM will continue to work with operators and the aviation industry to support safe flight and ongoing understanding of the world-wide volcanic ash threat