Design of a Test Bench for the Investigation of the Effect of Volcanic Ash on Aircraft Systems

Hazards Caused by Volcanic Ash

- **Volcanic ash deposits** on **air data sensors** may distort inflight pressure and/or temperature measurements, resulting in inaccurate velocity information. Especially in case of speed calculations erroneous values provoke unsafe flight conditions, as the aircraft may approach its stall or structural limit.
- Electrostatic charges are developed when volcanic ash particles strike the aircraft - **triboelectric charge transfer**. As a growing number of particles hit the aircraft, accumulation of charges causes a rise of the local potential. At a certain point these charges are bled off. This process, the so called **discharge**, typically occurs in form of coronas, streamers or arcs commonly known as St. Elmo's fire. All discharges produce **electric broadband noise** up to 1 GHz which might interfere with NAV/COM systems.
- Antenna abrasion due to the **abrasive nature** of volcanic ash is another hazard, as sensors and antennas are exposed to the volcanic ash-laden environment and may suffer distinct damage during particle contact. Functionality of individual systems may be impaired.

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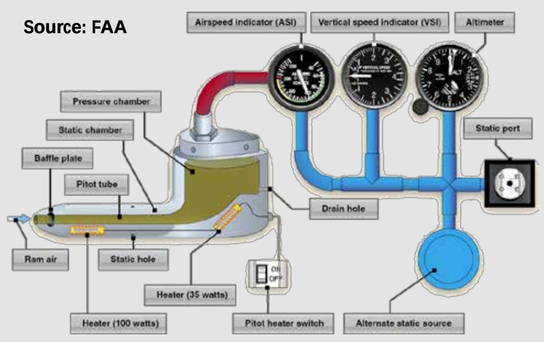
Electrostatic discharge (St. Elmo's fire) in form of a streamer across the cockpit windshield.

Source: FAA



Pitot tubes are used to determine the aircraft's speed. Blockage may produce critical flight conditions.

The Circumstances of an Encounter Determine the Magnitude of Possible Effects and Therefore Have to Be Investigated

The outlined hazards, provoked by **volcanic ash deposition**, **triboelectric charge transfer** and **abrasiveness**, are basically influenced by the encountered volcanic ash dose which in turn depends on the following three parameters:

- Airspeed (flow velocity)
  - Deposition ability
  - Charge Transfer
  - Abrasiveness
- Volcanic Ash Concentration
  - Deposition ability
  - Charge transfer
  - Abrasiveness
- Duration of Exposure
  - Deposition ability

Source: DLR

Additional parameters are:

- Chemical Composition of Volcanic Ash
  - Charge transfer
  - Abrasiveness
- Moisture Content of Volcanic Ash
  - Deposition ability
  - Charge transfer
- Volcanic Ash Particle Size
  - Deposition ability
  - Charge transfer
  - Abrasiveness

Source: U.S. Geological Survey, UCAR/COMET

Environmental aspects, such as temperature, pressure and humidity might also have a significant influence on the process of triboelectric charge transfer.

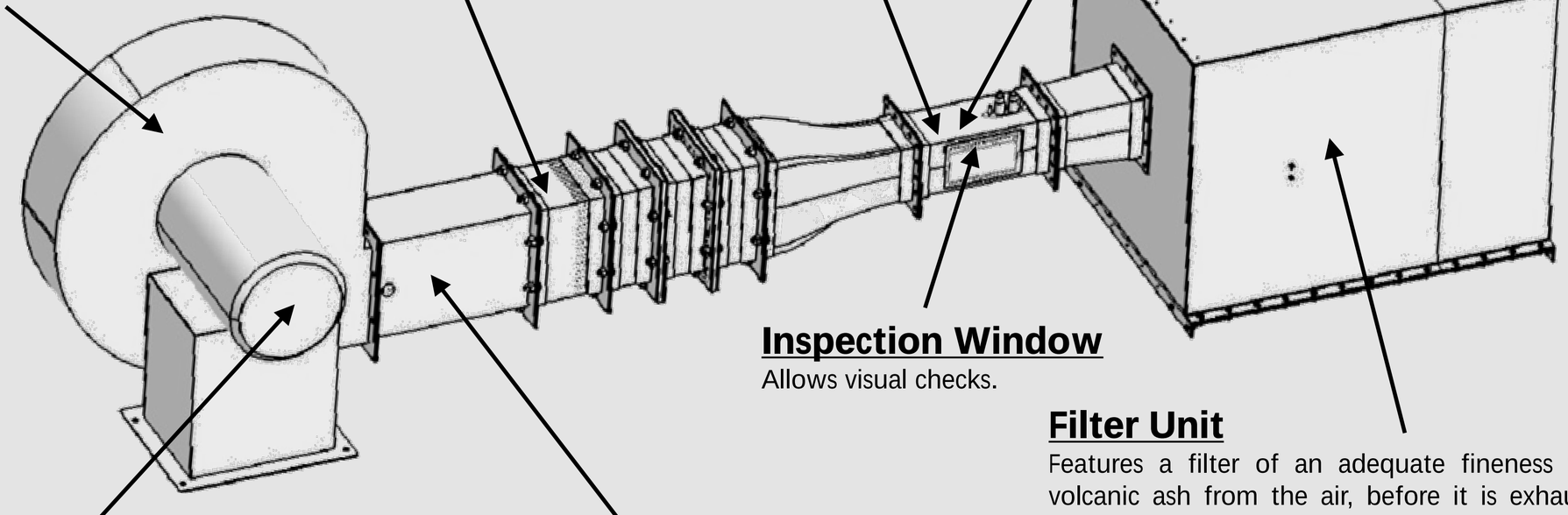
Conceptional Setup for a Detailed Investigation Regarding the Effect of Volcanic Ash on Aircraft Systems

Settling Chamber
Reduces turbulence within the flow to minimize measurement inaccuracies.

Experiment Support
The following investigations are supported:
- Deposition behavior of volcanic ash
- Charge transfer measurements
- Abrasiveness of volcanic ash samples

Test Section
Test objects are exposed to a well-defined volcanic ash-laden flow to reproduce inflight conditions.

Drive Unit
Provides an airstream with desired velocity. Velocity of this setup ranges from 0 to 70 m/s.



Inspection Window
Allows visual checks.

Filter Unit
Features a filter of an adequate fineness to remove all volcanic ash from the air, before it is exhausted into the environment. Filter can be manually exchanged to allow tests with other mineral dusts. Volcanic ash can be retrieved.

Operation Mode
Enables continuous variation of speed and experiment duration of several hours.

Particle Feeder Section
Volcanic ash particles or other dust samples are homogeneously injected into the airstream with an exactly defined mass concentration. For this purpose it is connected to a suitable particle generator. A concentration range from 0.1 to 20 mg/m³ is applicable.

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