The volcano ash from Eyjafjallajokull Iceland mid April 2010 and possible impact on a piston powered general aviation aircraft

The ash in order to get transported from Iceland to the European continent must have a very low equivalent diameter (small size and low density, resulting in low drop velocity) or it will fall down to earth and the Atlantic Ocean rather rapidly.
Ash coming into the European continent may have particle size about 1-10 microns (1 micron is equivalent to one thousandth of a millimeter) or smaller, so it should actually be called dust. This form of dust has its maximum altitude of about 35.000 feet. An aircraft flying above is safe. The reason is that the exhaust of the ash is still inside the troposphere because the energy of the volcano plume is limited.

While weather in one map shows the ash cloud from ground and up to FL 200 and a second map from FL 200 to FL 350, the prediction of what is happening below FL 200 in general is incorrect or unknown for lower altitudes, i.e. from ground up to 5000 feet GND.

For an updated map over the ash cloud and ash concentrations (new version published every 6th hour) go to: http://www.metoffice.gov.uk/aviation/vaac/vaacuk_vag.html
http://www.metoffice.gov.uk/corporate/pressoffice/2010/volcano/ashconcentration

If the cloud is invisible for human eye in a clear dry sky below 5000 feet GND one can say that such an area may be safe. This is because on altitudes from ground up to 5000 feet GND there is anyhow a large amount of various other particles and normal dust with particle size around 1-10 microns.

The ash particles are coming to the European mainland mainly in the form of silica, (silicon dioxide, SiO_2, quartz), i.e. as a “sand dust”. However, if heated up to > 1000 degrees C. the silica may transform into a sort of glass material with an ability to cut, polish and in certain ways attach.

Such a transformation may only take place in a turbine engine and may cause severe hazard to such engines. Modern turbine engines may permanently have up to 1600 degrees C. in their hottest engine parts.

This means however that such a transformation should not happen in a piston powered aircraft engine even if actual combustion temperature there could well be above 2000 degrees C. This is due to the extreme short time for the actual combustion which will not allow sufficient time for the silica to become transformed.

Eventually the dust will come down to the earth together with precipitation, and the soil will handle the dust in the same way as ordinary dust. Only if the ash comes down on the soil in the form of visible ash or dust it may make harm specifically to animals that may get the dust into their bodies when eating grass etc. The breathing of visible dust into human bodies could also be harmful.
Ash or high amounts of dust may contain small amounts of fluoride (mainly hydrogen fluoride, HF). Fluoride may be found in small amounts in tooth-paste in order to reduce caries.

Dust or ash on a painted surface may cause damage to that surface. Always clean without delay aircraft surfaces with plenty of clean water. Polish and wax afterwards.

Affects on non-pressurized piston powered aircraft flying close to surface on the European mainland, when the ash cloud is invisible in clear dry sky and when there is no abnormal smell

Affects on a piston engine
The ash in the form of ordinary **dry** dust and particle size around 1-10 microns may pass through the engine air-inlet filter and mix with the oil inside the engine after combustion. The engine oil filter may take care of parts of this dust but the majority of it may end up in the engine oil – in the same way as ordinary dust, lead deposits (from AVGAS 100 LL) and carbon deposits (from ordinary engine combustion) will do.
The dust may mix or get attached to other dust and form larger particles and as such may be trapped inside the oil filter. If for any reason the oil filter gets clogged, modern piston aircraft engines have an override valve allowing the contaminated oil to be distributed in the engine.

There is a theoretical possibility of more engine wear – but this is nothing that will affect the engine immediately. Any extra wear is a gradual story in the same way as for those who are located in areas with frequent sand storms or in general with dirty air as in industrial centre areas. Changing engine oil more frequently than before should handle this issue properly.

Affects on pitot tube, air sensing units, air gyros
Dry volcano ash or dust with a particle size of 1-10 microns and in the form of silica is for these systems nothing else and should have no other characteristics than ordinary sand or dirt dust. Current systems are usually prepared to handle such situations.

Affects on propeller, wing leading surfaces, antennas, windshields etc
The affect may be the same as when flying through ordinary dust or dirt.
Yes - some tarnishing on leading surfaces may gradually happen but should not be worse than ordinary wear and tear. The propeller can be affected and polished but any decrease in performance will be marginal and gradual, assumed a particle size of 1-10 microns.
This should be valid as long as the particles are dry and the concentration of particles is so low that the ash is invisible.
Under certain circumstances and in darkness a corona discharge, a halo, may be seen around the propeller and wing tips when flying in air with volcano ash. This is nothing dangerous and can be observed also in clean air and is called precipitation static. If the aircraft is not properly equipped with static discharge wicks, radio reception for ADF can be interfered and other radio signals as well might be blocked for reception in the aircraft. If unlucky complete loss of VHF-communications, erroneous magnetic compass readings (30 degree error), high pitched squeal on audio, motor boat sound on audio, loss of all avionics, erratic instrument readouts, weak transmissions and poor receptivity of radios may occur. Dust and ash may also penetrate the aircraft electronic systems such as alternator, radios and navigation instruments.

Affects on the pilots and the passengers
There is nothing a person can do if the dust is not visible and there is no smell.
You have to live with it as you have to do with ordinary dust, dirt, pollen and nano particles in the air.
If exposed for longer periods – yes – there will be problems in the same way as if you were living in a dusty environment or inside an industrial centre area.
Ash and dust normally invisible may show up around flashes from strobe-lights also during day-time. If an area of dust and ash is penetrated it is likely that such particles will enter the aircraft cabin. Ash and dust may contain fluoride which in high concentration is toxic and may harm skin and eyes.
The dust may also contain small amounts of rare metals that may cause allergic reactions. Such particles as such are usually not toxic.
Gases may also be spread around with the air. Such gases may have an acrid or sulphurous odour. If the dust is combined with an odour, for example sulphur, breathing such air shall be avoided as it may cause respiratory problems. The concentration of such toxic gases and high concentration of fluoride on the European mainland and about 3000 kilometres (1800 nautical miles) from Iceland should however be so small that they may be negligible for ordinary healthy persons.

Do not fly in precipitation, near rainy clouds or in IMC.
Rain and water falling through the sky from high altitudes will *collect* the dust from the contaminated air. This means that the concentration of dust will dramatically increase at lower altitudes during precipitation. Water and snow in the form of precipitation falling through the air may mix with the dust as well as with moisture and form a sort of a “clay”. Such clay may get trapped in engine air-inlet/induction filters. Fuel injected piston engines usually have air filters that manually can be by-passed by the pilot or automatically will arrange a by-pass of the air (for example in Piper 31 and most Lycoming TIO 540 engines) if the filter is getting clogged. For carburetor engines a bypass of the ordinary air filter can usually be made by using carburettor heat. In both cases unfiltered air usually then will enter the combustion area and may cause excessive engine wear. Particles in the combustion area (inside the cylinders) may also attach to spark plugs and cause them to mal-function. Any such problems will easily be noticeable by a ruff engine. Under such conditions landing of the aircraft should take place without delay. Excessive leaning for a very short time may clear a clogged spark plug.
Ash or dust mixed with water or moisture may clog the pitot tube. In such a case the shown airspeed will decrease. Approximately known airspeed without an air-speed meter may be maintained through correct manifold pressure, propeller RPM and pitch and known angle of attack.

If the static air pressure inlet for any reason gets clogged this will result in incorrect altimeter data and airspeed. Most aircraft have an alternate static air pressure valve located under the instrument panel that may be manually operated.
If usage of the alternate static air pressure does not solve the problem the glass to the vertical speed meter can be broken in order to get the system to work properly.

Consequently -- do not fly near rainy clouds or when it is raining or in clouds where there is ash or dust in the air! Do not fly in IMC or during darkness.

Post flight activities
After each flight for which volcano ash or dust has been predicted or encountered a careful inspection of the aircraft shall be made by the pilot. The airframe and cabin shall be searched for any potential impact of the ash. Take a fine white moistened soft cloth and move easily around the aircraft body and inside in the cabin trying to trap any particles. Volcano dust or ash on the cloth is a sign that penetration into contaminated areas has taken place and that precautionary activities must take place.
Observe if any wear has taken place of aircraft leading edges or the wind-shield. Visually inspect the pitot tube, static air inlet, engine air inlet/induction filters, fuel tank vents etc for damage, dust or dirt.
The engine compartment should be inspected and any wear by ash or dust on plug cables, electrical cables, fuel lines, oil hoses and other cables, wires and lines accessories etc shall be noted.

If particles are found on the cloth or damage or wear inside the engine compartment or any other damages are found inform the responsible mechanic without delay and report any ash related incidents to a reporting scheme run by your civil aviation authority. Make appropriate notes in the aircraft flight log.

If found appropriate or in any doubt about the airworthiness of the aircraft , ground the aircraft until an inspection by a mechanic has taken place. Such an inspection should among others include a borescope inspection of the cylinders, inspection of the air- and engine oil - filters. An inspection report should be accomplished and airworthiness declaration shall been given at the end of the inspection.

Is it safe to fly?
No-one can say that anything is 100 % safe. We are exposed to known and unknown particles in the air everyday and all the time.
Even if the particles from the current eruption may be known, future and eruptions unknown at the time of writing this article may exhaust other type of particles and particle sizes.

Do perform an extensive pre-planning of the flight, including a special pre-inspection of the aircraft if flown recently in volcano dust. Consult among others precipitation and moisture data, SIGMET, AIC, NOTAM and the previous named WebPages from the London Meteorological Office. It is also quite common for authorities to assign restricted or dangerous areas where volcano dust and ash are present. Special rules and regulations may also apply for aircraft maintenance, flight operations and access to the airspace. Based on the registry of your aircraft, the CAA of the country of aircraft registration may assign certain restrictions. So if your aircraft has a US registration but is operated in Europe you have to follow US regulations and regulations in the country (FIR) you intend to fly in.

For this particular volcano eruption Eurocontrol has assigned three different flying zones (Reference: Swedish AIC 8 2010.**)**

Zone 1 Limited No-Fly Zone is an Area with a High Density Volcanic Ash Contamination. A “No fly zone” - which includes the main area/core of the volcanic fallout, with an additional buffer zone. The area is established on the basis of meteorological conditions

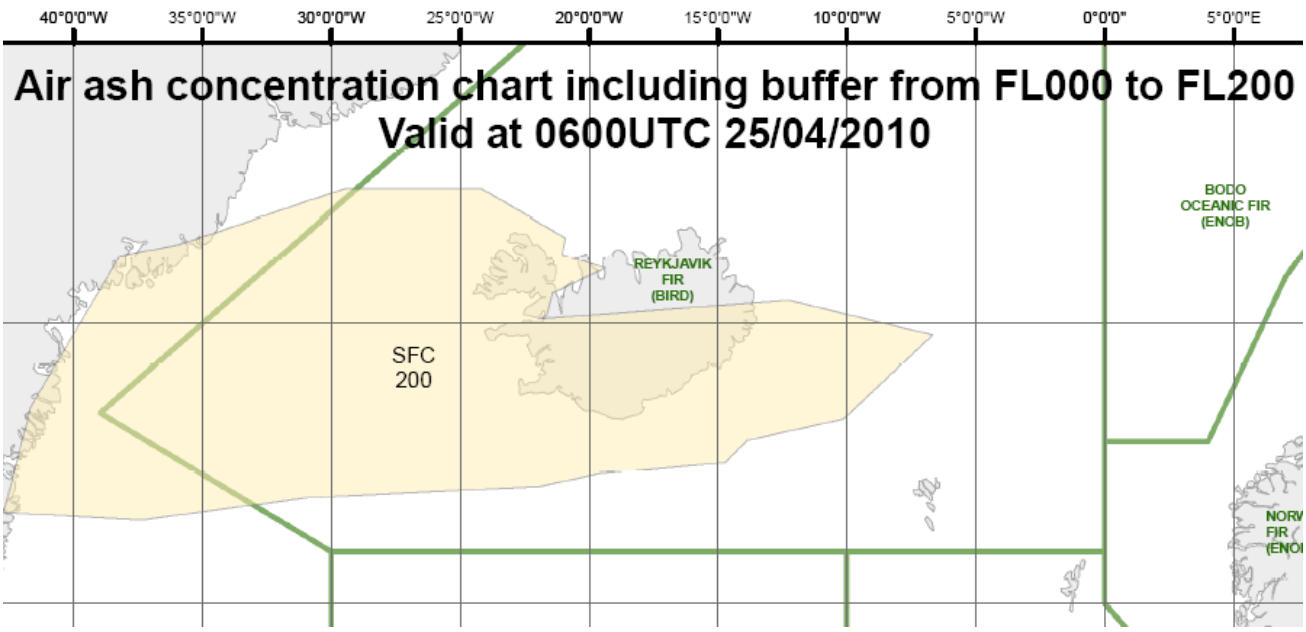
where wind direction, humidity etc. will result in a high intensity of particles. Associated airspace restrictions/closures will be notified by NOTAM.

Zone 2: Potential Contamination Zone is an Area with a Low Density Volcanic Ash Contamination.
An area outside Zone 1 where flying can be conducted when actual conditions, risk assessment and test(s) can establish, that flights can be conducted at an acceptable level of safety and requires prior permission from the operators Authority. Areas affected by volcanic ash will be notified by SIGMET. Prerequisites and requirements for flying in this area are given below.

Zone 3: Non-Contaminated Airspace is an Area Free of Volcanic Ash Contamination.
An area - free of contamination - where flights can be conducted without restrictions or special prerequisites.

Zone 1 is established by Volcanic Ash Advisory Centre (VAAC) and administrated by the Central Flow Management Unit (CFMU).

Information about zone 1 **inclusive by Eurocontrol calculated buffer zones** can be obtained from
HTTP://WWW.LFV.SE/LINKS/NOP-PUBLIC-PORTAL
or https://www.cfmu.eurocontrol.int/PUBPORTAL/gateway/spec/index.html
(Go to Network headline news – Volcanic ash)

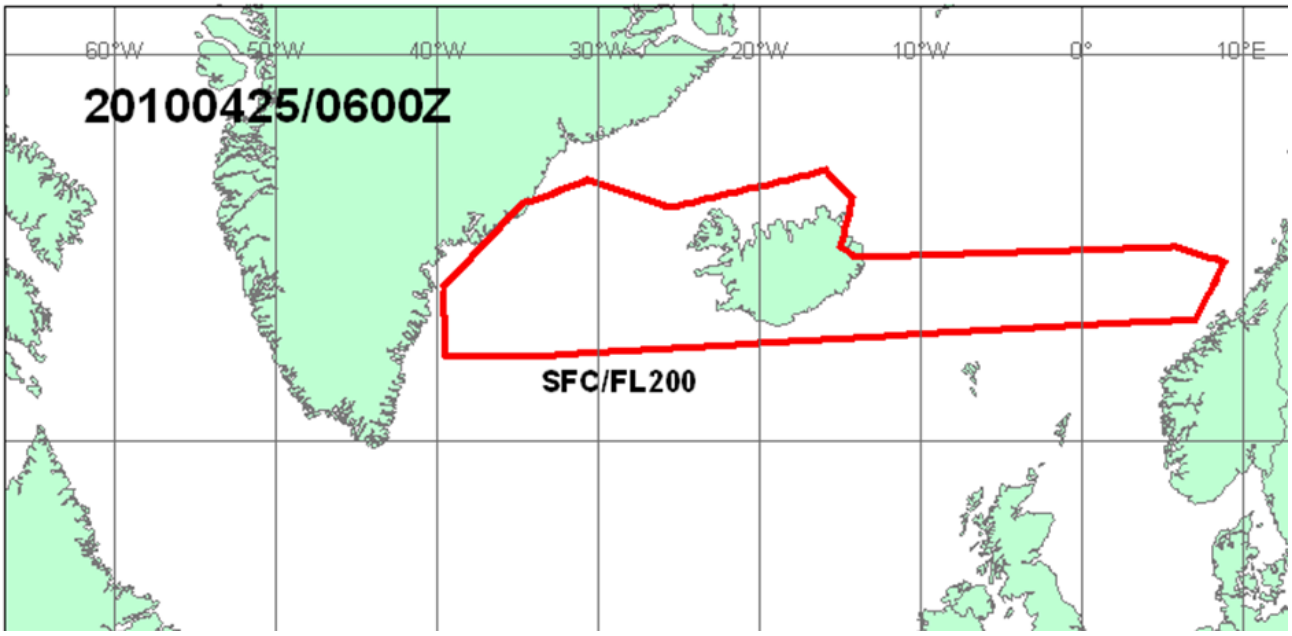


Above example: Zone 1 **(no flying zone)** April 25 at 06.00 UTC from surface up to FL200 **inclusive buffer zones** marked with yellow.

Zone 2 is established as a contaminated zone published by the VAAC and forms the basis of the current *restrictions, not including restrictions for Zone 1.*

Information about Zone 2 and without concentrations of ash can be obtained from:
HTTP://WWW.LFV.SE/LINKS/VAAC-LONDON or
http://www.metoffice.gov.uk/aviation/vaac/vaacuk_vag.html

As no information is given about concentrations, the Zone 2 as drawn below **also contains** Zone 1.

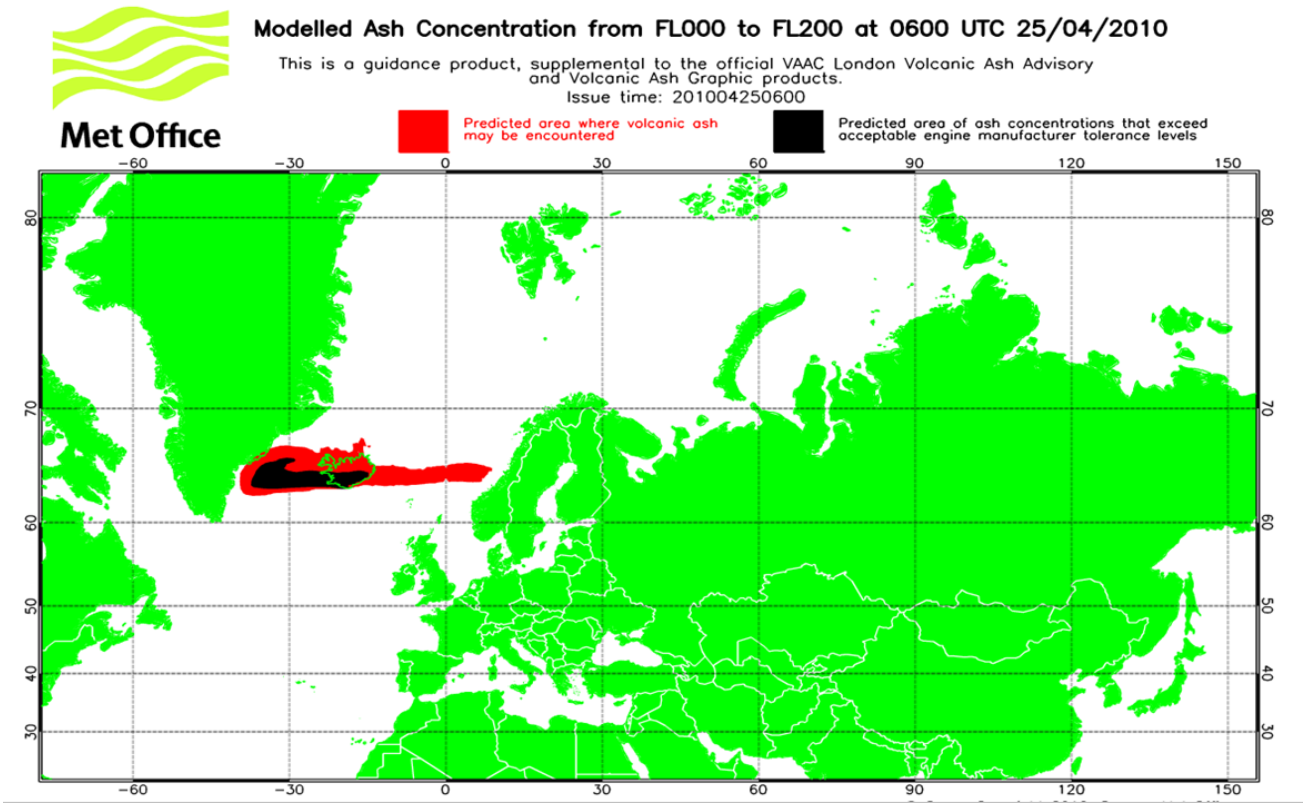


Above example shows area with volcano ash and dust **without concentrations** – so this map **includes** both Zone 1 and Zone 2 from surface up to FL 200.

For the forecast of ash <u>concentrations</u> you have to go to:

http://www.metoffice.gov.uk/corporate/pressoffice/2010/volcano/ashconcentration

That map (example below) will show you Zone 1 and Zone 2 **<u>without the buffer zones</u>** (which are calculated by Eurocontrol see earlier Zone 1 map) and is a guidance product.



Red is essentially Zone 2 and black Zone 1. **<u>Zone 1 is only calculated based on experience with turbine engines.</u>**

The Zone 1 and 2 may be over-flown in accordance with the considerations stated below. After the VAAC (Volcanic Ash Advisory Centre) has issued the +6, +12, +18 hrs forecasts of contaminated areas, SIGMETs and NOTAMs based on the VAAC forecast will be issued.

In Sweden aircraft without turbine engine/s, i.e. gliders, balloons and ***piston powered*** together with military, coastguard, police, ambulance may fly at own risk in Zone 1 and Zone 2 without special permission.

A special assessment shall always be made before intentionally flying into and in a Zone 1. Risks and costs may be prohibitive.
All charts a presented above a calculations based on models. There is no guarantee they represent the real and actual situation. It could be much worse and a Zone 3 may actually be a Zone 2.

If you enter a volcano ash cloud execute immediately a descending 180-degree turn to leave the cloud and transmit a report to the nearest ATS unit. A precautionary landing should be made at the nearest suitable airport if it is suspected that the engine has been adversely affected or there is aircraft damage.

We are always exposed to known and unknown risks.
It is always up to the individual to decide what he or she wants to do and what risks that could be accepted. Conduct your own risk assessment and develop operational procedures to address any remaining risks.

For low altitude daytime VMC flights in piston powered aircraft in Zone 2 above the European mainland, about 1800 nautical miles away from the active volcano Eyjafjallajokull*, with no visible ash or dust clouds, no rain in a clear dry sky and no abnormal smell in the air, such flights should pose no other challenge than the challenge you have for any other flight.*

But the decision to go or not to go is as always up to the pilot in command.

Disclaimer
This article has been written in best faith. The intention is not to encourage anyone to go out and fly who is not prepared to take full responsibility thereof.
The information herein has been put together basically from experience from operating piston powered aircraft in dirty and dusty environments. Also experience from flights close to forest fires has been included. This article is intended to be informative but does not claim to contain all information necessary for conducting a safe flight. Actually some information herein might not correspond to a real life situation with ash and dust from this particular volcano. No one has all information about the ash, the dust and its consequences for aviation.