Appendix A

RECOMMENDED PROCEDURES FOR THE MITIGATION OF THE EFFECT OF VOLCANIC ASH ON AIRPORTS

taken from
"Mitigation of Volcanic Ash Effects on Aircraft Operating and Support Systems"
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(Part I, Chapter 5, 5.1.3.3 refers)

1. INTRODUCTION

1.1 Techniques for reducing the effects of volcanic ash can be grouped into three broad categories: (1) keeping the ash out, (2) controlling what gets in, and (3) disposing of the ash. These categories are more illustrative than discrete, and some mitigation techniques will apply in all three cases. Mitigation actions will be required on a continuous basis as long as ash is present. Settled ash is easily re-entrained into the atmosphere, and a 2-mm layer can be as troublesome as a 50-mm layer.

1.2 The most effective technique for reducing ash-related damage or upset to equipment is to avoid using the equipment: shut down, close up, keep inside, or seal the area until the ash can be removed. This tactic is acceptable only for short periods of time because operations must be resumed at some point. In any case, disposal techniques will not eliminate all of the ash. A residue will remain on the ground and will be blown into the air by wind, passing vehicles and aircraft take-offs. Thus, an accelerated and intensive program of inspection, maintenance, cleaning and monitoring will be necessary during and after the main part of ash deposition.

1.3 Cleaning the ambient air — and keeping it clean — is the key to reducing operation and maintenance problems. Blowing ash off of a circuit board is useless if the ash is fine enough to remain suspended for several minutes. The difficulty of attempting to perform maintenance tasks in an already ash-contaminated atmosphere is obvious. "Clean-room" procedures can be used to isolate an area and keep it free of ash, but only under ideal circumstances. Some equipment — aircraft engines, for example — are too large for such treatment. Tents or tarps can be used to reduce gross contamination. However, the fine particles of volcanic ash can penetrate very small openings and seams; it is this property that makes volcanic ash so damaging to critical equipment.

1.4 Some mitigation procedures may cause additional problems or may actually be counterproductive, depending on the circumstances. For example, adding filtration to a computer system will reduce the amount of ash contamination, but it will also decrease the air flow. The resulting rise in temperature may change the operating characteristics of sensitive components or even cause damage. Adding a larger fan would increase the air flow, but not all computers, especially smaller units, can be easily modified. Another example is the use of moisture to control ash. Wetting carpets will increase relative humidity and help to keep the ash down; however, wet or even damp volcanic ash is conductive.

1.5 No single technique will be absolutely effective; a combination of techniques has been found to provide the best results for managing volcanic ash. Constant monitoring and reassessment of ash effects and the mitigation process will be required to achieve the most effective balance between operational requirements and the desired level of damage limitation. The following sections summarize ash mitigation techniques for selected aircraft and support systems.

2. AIRCRAFT SYSTEMS

2.1 The basic mitigation tactic to protect aircraft systems is avoidance of exposure to ash. The airports and airfields surveyed after the Mt. St. Helens eruption simply shut down for the duration of the ash problem or until the ash had been removed. Airlines rerouted traffic away from ash-impacted airports.

2.2 Sealing aircraft seams, ports, vents and other openings with duct tape will keep out the bulk of the ash, especially if the aircraft is under cover. Maintaining positive pressure within aircraft components would help to keep ash out, but it is difficult, if not impossible, to pressurize an aircraft on the ground without damaging ground equipment. Techniques include:

a) blow or vacuum ash before washing, otherwise, ash tends to flow into ports, vents or control surfaces;

b) flush or wash residue, do not scrub or sweep;

c) wash gear, underside, air-conditioning intakes and engines;

d) check pH of aircraft/engine surfaces for acidity; and

e) neutralize acidic residue by adding petroleum-based solvent to the wash water.

2.3 All of the above techniques require large amounts of time, manpower and equipment. All have significant effects on the level and scope of continued operations. These techniques were tried under conditions of greatly reduced operating levels; however, there is some question as to their effectiveness during normal (or near-normal) operations. For example:

a) sealing an aircraft would take 4-5 hours, and removing all seals and tape would take 1-2 hours. It is very hard to seal an aircraft completely because of numerous ports, vents, seams and joints;

b) ash buildup in or around hatch seals could cause pressurization problems; and

c) fuel tank vents must be open during loading, unloading and transfer of fuel. If vents are plugged with ash, or if sealed, the tank could collapse. A 4-5 Psi vacuum is sufficient to cause collapse.

3. RUNWAYS

If aircraft operations are not suspended, runways must be continually cleaned as ash is resuspended by wind, aircraft take-off and ground vehicle movement. There is some disagreement on the proper use of water in cleaning runways. Some sources felt that water turns the ash to sludge (or causes it to harden), whereas others found it impossible to control the ash without wetting it first. Open-graded (popcorn surface) runways are to some extent self-cleaning because the engine blast on take-off will blow ash out of crevices. Basic techniques include:

a) wet ash with water trucks;

b) blade into windrows;

c) pick up with belt or front-end loaders;

d) haul to dump areas;

e) sweep and flush residue;

f) sweep/vacuum ash first, then flush with water (best for ramps, etc.);

g) push ash to runway edge and plow under or cover with binder such as Coherex or liquid lignin;

h) install sprinklers along edges of runway to control resuspension of ash from aircraft engine blast or wing-tip vortices; and

i) keep residue wet on taxiways and ramps.

Note.— The slippery nature of wet ash should be taken into account by pilots manoeuvring aircraft on the ground and during landing and take-off.

4. LANDING AIDS AND AIR TRAFFIC CONTROL

Protection of landing aids and air traffic control systems will require periodic cleaning, maintenance and monitoring. Also, turning off unnecessary equipment will reduce exposure. Exposed light and indicator systems, radar antennas and any equipment that requires cooling air are especially vulnerable to ash contamination and damage. Interruption of commercial power supplies will require backup generators, which are also vulnerable to ash damage. Techniques include:

a) replace antennas that have Teflon insulators. Because ash is hard to remove and will cause shorting, ceramic insulators should be used;

b) seal relay boxes and remove indicator units and light systems to prevent ash entry;

c) increase cleaning and maintenance of systems that cannot be sealed or that require cooling air;

d) vacuum or blow ash out and clean relays with contact cleaner;

e) use high-pressure water wash on exposed antenna rotor bearings and then relubricate;

f) cover exposed joints, seams and bearings;

g) seal buildings, control access, vacuum shoes and clothes; and

h) reduce operating levels: shut down unused equipment, reduce broadband displays to a minimum, and reduce cooling and power consumption.

5. GROUND SUPPORT EQUIPMENT

5.1 The consensus is that ground support equipment is the key to flight operations. If ground support equipment is unserviceable because of ash, aircraft cannot be operated. Unfortunately, there are more problems than solutions in the ash contamination of ground equipment.

5.2 Gas turbines, air compressors and air conditioners operate by ingesting large volumes of air. This equipment has only coarse filtration (or none at all), and extra filtration cannot be added without affecting operation. Using air conditioners to pressurize aircraft compartments would only blow ash into the aircraft and ruin the air conditioners in the process. Techniques include:

a) constant cleaning and maintenance;

b) do not wash equipment, because water turns ash to sludge and washes it into the equipment;

c) vacuum equipment;

d) change oil and filters more often; and

e) change design to include better filtration.

6. COMPUTER SYSTEMS

The most widely advised damage-prevention tactic is to shut down all computer and electronic systems until the ash has been completely removed from the area and from the equipment. Computer heads and disks, and any high-voltage circuits, are especially vulnerable to ash upset and damage. Ash on digital circuits will not cause much of a problem because of the low voltages involved. High-voltage or high-impedance circuits are very vulnerable to leakage caused by semi-conductive ash. Ash that is acidic is conductive as well as corrosive. Continual cleaning and aggressive protection of computer systems should allow for continued operation in all but the heaviest ash fallout. Techniques include:

a) clean and condition surrounding air to keep ash out of equipment;

b) cotton mat filters used in clean rooms were found to be best for filtering particles, but they reduce air flow. A solution is to use larger fans to maintain required air flow. Rack-mounted equipment can be modified to add a larger fan, but smaller instruments or components with a built-in fan would require a design change to increase fan capacity;

c) use fluted filters as a compromise, this increases surface area but reduces air flow by only about 20 per cent;

d) humidifying ambient air (e.g. wetting carpets) will help to control ash re-entrainment;

e) ash on equipment can be blown out with compressed air. If the air is too dry, static discharge could damage sensitive components (e.g. integrated circuits). If the air is too damp, the ash will stick. Relative humidity of 25-30 per cent is best for compressed air;

f) cleaning with a pressurized mixture of water and detergent and using a hot-water rinse is quite effective, however, this process requires at least partial disassembly;

g) ash may have a high static charge and be hard to dislodge, thus requiring brushing to dislodge particles;

h) accelerate filter change, use prefilters;

i) change to absolute filters, these will keep out particles down to 1 µm and smaller;

j) keep computer power on for filtration, but do not operate, especially disk drives;

k) maintain room-within-a-room configuration, restrict access, re-circulate air and accelerate cleaning of the critical area.

7. RADAR AND OPTICAL SYSTEMS

Most radar equipment in the heaviest ash-fall areas has to be shut down for the duration of severe ash contamination. Thus, few problems are likely aside from clean-up and control of residual ash. The simplest mitigation tactic is to cease operations. Clean-up techniques include:

a) repair and clean high-voltage circuits;

b) wash antenna rotor bearings, re-lubricate, and cover exposed bearings;

c) ash on optical components should be blown away or washed with copious amounts of water. Do not wipe, brush or nib, as this will abrade the optics;

d) take care not to wash ash into optical-instrument mounts on aircraft (e.g. sextant);

e) turn off non-essential radar equipment to reduce cooling load and power requirements;

f) transfer radar coverage to other facilities, combine sectors;

g) remove and replace camera bearings and clean gear drives; and

h) protect video tape from ash because it will cause “drop-outs” and scratches.

8. PLANNING FOR ASH MITIGATION

Techniques for reducing the impacts of volcanic ash are basically “low tech” and depend more on procedural approaches than on technical fixes. Also, they are quite labour and resource intensive. Normal stock of daily-use items such as filters, lubricants, spare parts, cleaning supplies, etc., may be expended much faster than they can be replaced through the normal reordering process. Prior planning is necessary to reduce the severity of ash effects. Planning actions include:

a) conduct a vulnerability analysis of equipment and facilities to determine which would be most impacted by ash, which are adequately protected, and which need long-term or expedient modification;

b) develop a priority list of facilities that must be kept in operation versus those that can be closed or shut down for the duration of ash fall;

c) ensure hazard-alert and information channels are properly maintained with the vulcanological/ geological agencies, and the meteorological service, local news media, and State and local governments;

d) establish plans and procedures for alerting and notification, reduced operations, accelerated maintenance, protection of critical facilities, and clean-up and disposal;

e) alert air traffic controllers and airport operations personnel to notify aircraft as soon as volcano “watch” and “warning” notices are received. Normal air traffic and weather radars cannot detect volcanic ash; therefore, relatively large “keep-out zones” should be established at night or during bad weather once the warning notice is issued. Personnel should also be alerted to the existence of fall-out beneath the clouds and lightning conditions, etc.;

f) stockpile spare parts for critical equipment, filters, sealing, cleaning and disposal equipment;

g) plan for extended clean-up and maintenance activities including 24-hour operations, augmentation of the work force, and training of clean-up crews; and

h) ensure that sufficient water and back-up power is available to support clean-up operations, should normal supply sources fail.

Ash clean-up operations may continue for weeks or months if multiple eruptions occur. Effective mitigation of volcanic ash effects depends on prior planning and preparation, mobilization of resources, and persistence.