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SAFETY NOTICE

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GROUND DE-/ANTI-ICING OF AEROPLANES; INTAKE/FAN-BLADE ICING AND EFFECTS OF FLUID RESIDUES ON FLIGHT CONTROLS

This guidance material regards aeroplane operations during known or expected icing conditions prior to flight, regarding extended ground operations / taxiing prior to flight during conditions of moderate to heavy freezing precipitation and regarding maintenance considerations. The Safety Notice is a direct response to an occurrence experienced by a San Marino operator.

This Safety Information Notice is for information only. Nevertheless, all operators, both commercial and non-commercial, should appropriately establish and implement the training, procedures and advice contained within this Notice.

1. Intake and Fan blade Icing

During extended ground operations/taxiing prior to flight in conditions of moderate to heavy freezing precipitation, it is possible for snow and slush to accumulate within the engine intake ducting and/or on the rear surfaces of engine compressor/ fan blades. Such accumulation(s) may not be visible to the crew, nor prevented by the use of engine anti-icing, especially when engines are operated at or close to ground idle rpm. Intake duct deposits and engine blade deposits may detach and be ingested by the engine(s) during the subsequent application of high power settings for take-off, with consequential adverse effects on engine operation, and possible flameout.

Ice accumulation on the surfaces of engine compressor/fan blades may severely affect the aerodynamic characteristics of the blade(s) and cause compressor stall, leading to surging and engine malfunctioning and/or reduced thrust. Several accidents have already occurred due to these phenomena.

1A Intake icing

This is, in part, caused by the design of engine intake / ducting on certain aircraft, whereby accumulations of snow and/or slush can occur in the engine air intake(s) during low power engine operations, such as taxiing after landing and also prior to take-off, in certain meteorological conditions. Relatively long/curved intake ducts/tracts are particularly prone to this phenomenon.



This phenomenon is most likely to occur to susceptible aircraft during precipitation of heavy snow or rain at temperatures close to 0°C before and after engine start. In such cases, the use of engine anti-ice system may be ineffective in preventing accumulations forming in engine intakes.

It is also likely that such deposits may not be visible or apparent to pilots and ground staff, particularly so in the case of high-mounted engines. Also, in some cases, accumulation will not take place until after engine start. This situation may be masked by the fact that the de/anti-icing treatment of the rest of the airframe is still effective, with frozen deposits not yet forming on the treated areas.

The consequences of unrecognised intake icing will only become evident during high power engine running (i.e. during take-off), when it can be too late to take precautionary actions.

1B. Ice accumulation on the rear face of engine compressor / fan blades

This phenomenon is most likely to occur in susceptible engines during precipitation of heavy snow or rain at temperatures close to 0°C before and after engine start. In such cases, the use of engine anti-ice system may be ineffective in preventing accumulations forming on the rear faces of blades. It is also likely that such deposits may not be visible or apparent to pilots and ground staff, particularly so in the case of high-mounted engines. Also, in some cases, accumulation will not take place until after engine start (rotating parts striking super-cooled droplets).

Note: Compressor/fan blade icing may have occurred during the previous approach/taxi in. In this case, such accumulations may be detected during a subsequent pre-flight inspection (PFI). The potential for re-occurrence during any subsequent operation of engine(s) must be recognised and precautionary measures taken.

Alternatively, accumulations may occur after engine-start on previously inspected and “clean” blades. Such occurrences will therefore not be detected during PFI, nor during normal idle/low power running of engines during ground manoeuvring.

In such cases, it is vital that the potential for blade icing is fully understood by responsible staff and appropriate countermeasures are employed, as recommended by the aircraft manufacturer.

The consequences of unrecognised blade icing will only become evident during high power engine running (i.e. during take-off), when it can be too late to take precautionary actions.

2. Recommendations

In the first instance, manufacturers’ recommendations, where given, should be followed. In cases where guidance is not provided, operators should liaise with manufacturers and other qualified entities to obtain advice in order to develop suitable procedures.

It is recommended that operators take appropriate action to recognise and address these phenomena in their Operations Manuals and to give suitable advice, guidance and training to pilots and ground staff. Good coordination between Operations and Maintenance is essential, in



particular with regard to maintenance inspections (in conjunction with the maintenance programme and manufacturer's recommendations).

Although these phenomena are known to affect certain turbine powered aircraft, it should be borne in mind that certain piston-engine powered aircraft could be susceptible to these phenomena, too.

3. Ground De- / Anti-Icing of Aeroplanes

Any deposit of frost, ice, snow or slush on the external surfaces of an aeroplane may drastically affect its flying qualities because of reduced aerodynamic lift, increased drag, modified stability and control characteristics. Furthermore, freezing deposits may cause moving parts, such as elevators, ailerons, flap actuating mechanism etc., to jam and create a potentially hazardous condition. Propeller / engine / APU / systems performance may deteriorate due to the presence of frozen contaminants to blades, intakes and components. Also, engine operation may be seriously affected by the ingestion of snow or ice, thereby causing engine stall or compressor damage. In addition, ice / frost may form on certain external surfaces (e.g. wing upper and lower surfaces, etc.) due to the effects of cold fuel / structures, even in ambient temperatures well above 0°C.

The procedures established by the operator for de-icing and / or anti-icing in accordance with CAR OPS 1.345 - are intended to ensure that the aeroplane is clear of contamination so that degradation of aerodynamic characteristics or mechanical interference will not occur and, following anti-icing, to maintain the airframe in that condition during the appropriate holdover time.

The de-icing and/or anti-icing procedures should therefore include requirements, including type-specific, taking into account manufacturer's recommendations and cover:

- (a) Contamination checks, including detection of clear ice and under-wing frost.

Note: limits on the thickness / area of contamination published in the AFM or other manufacturers' documentation should be followed;

- (b) De-icing and / or anti-icing procedures including procedures to be followed if de-icing and / or anti-icing procedures are interrupted or unsuccessful;
- (c) Post treatment checks;
- (d) Pre take-off checks;
- (e) Pre take-off contamination checks;
- (f) The recording of any incidents relating to de-icing and/or anti-icing; and
- (g) The responsibilities of all personnel involved in de-icing and/or anti-icing.



Under certain meteorological conditions de-icing and / or anti-icing procedures may be ineffective in providing sufficient protection for continued operations. Examples of these conditions are freezing rain, ice pellets and hail, heavy snow, high wind velocity, fast dropping OAT or any time when freezing precipitation with high water content is present. No Holdover Time Guidelines exist for these conditions.

4. Reference Material

Material for establishing operational procedures can be found, for example, in:

- ▶ ICAO Doc 9640-AN/940 "Manual of aircraft ground de-icing/anti-icing operations";
- ▶ ISO 11075 (*) ISO Type I fluid;
- ▶ ISO 11076 (*) Aircraft de-icing/anti-icing methods with fluids;
- ▶ ISO 11077 (*) Self propelled de-icing/anti-icing vehicles-functional requirements;
- ▶ ISO 11078 (*) ISO Type II fluid;
- ▶ AEA "Recommendations for de-icing/anti-icing of aircraft on the ground";
- ▶ AEA "Training recommendations and background information for de-icing/anti-icing of aircraft on the ground";
- ▶ EUROCAE ED-104/SAE AS 5116 Minimum operational performance specification for ground ice detection systems;
- ▶ SAE ARP 4737 Aircraft de-icing/anti-icing methods;
- ▶ SAE AMS 1424 Type I fluids;
- ▶ SAE AMS 1428 Type II, III and IV fluids;
- ▶ SAE ARP 1971 Aircraft De-icing Vehicle, Self-Propelled, Large and Small Capacity;
- ▶ SAE ARD 50102 Forced air or forced air/fluid equipment for removal of frozen contaminants;
- ▶ SAE ARP 5149 Training Programme Guidelines for De-icing/Anti-icing of Aircraft on Ground.

(*) *The revision cycle of ISO documents is infrequent and therefore the documents quoted may not reflect the latest industry standards.*



5. Terminology

Terms used in the context of this Safety Information Notice have the following meanings. Explanations of other definitions may be found elsewhere in the documents listed in 4 above. In particular, meteorological definitions may be found in ICAO Doc.9640.

- (a) Anti-icing. The procedure that provides protection against the formation of frost or ice and accumulation of snow on treated surfaces of the aeroplane for a limited period of time (holdover time).
- (b) Anti-icing fluid. Anti-icing fluid includes but is not limited to the following:
 - (1) Type I fluid if heated to min 60°C at the nozzle;
 - (2) Mixture of water and Type I fluid if heated to min 60°C at the nozzle;
 - (3) Type II fluid;
 - (4) Mixture of water and Type II fluid;
 - (5) Type III fluid;
 - (6) Mixture of water and Type III fluid;
 - (7) Type IV fluid;
 - (8) Mixture of water and Type IV fluid.

Note: On uncontaminated aeroplane surfaces Type II, III and IV anti-icing fluids are normally applied unheated.

- (c) Clear ice. A coating of ice, generally clear and smooth, but with some air pockets. It forms on exposed objects, the temperature of which are at, below or slightly above the freezing temperature, by the freezing of super-cooled drizzle, droplets or raindrops.
- (d) Conditions conducive to aeroplane icing on the ground. Freezing fog, freezing precipitation, frost, rain or high humidity (on cold soaked wings), mixed rain and snow and snow.
- (e) Contamination. Contamination in this context is understood as all forms of frozen or semi-frozen moisture such as frost, snow, slush, or ice.
- (f) Contamination check. Check of aeroplane for contamination to establish the need for de-icing.
- (g) De-icing. The procedure by which frost, ice, snow or slush is removed from an aeroplane in order to provide uncontaminated surfaces.



(h) De-icing fluid. Such fluid includes, but is not limited to, the following:

- (1) Heated water;
- (2) Type I fluid;
- (3) Mixture of water and Type I fluid;
- (4) Type II fluid;
- (5) Mixture of water and Type II fluid;
- (6) Type III fluid;
- (7) Mixture of water and Type III fluid;
- (8) Type IV fluid;
- (9) Mixture of water and Type IV fluid.

Note: De-icing fluid is normally applied heated to ensure maximum efficiency.

- (i) De-icing/anti-icing. This is the combination of de-icing and anti-icing performed in either one or two steps.
- (j) Ground Ice Detection System (GIDS). System used during aeroplane ground operations to inform the ground crew and / or the flight crew about the presence of frost, ice, snow or slush on the aeroplane surfaces.
- (k) Holdover time (HOT). The estimated period of time for which an anti-icing fluid is expected to prevent the formation of frost or ice and the accumulation of snow on the treated surfaces of an aeroplane on the ground in the prevailing ambient conditions.
- (l) Lowest Operational Use Temperature (LOUT). The lowest temperature at which a fluid has been tested and certified as acceptable in accordance with the appropriate aerodynamic acceptance test whilst still maintaining a freezing point buffer of not less than:
- (1) 10°C for a type I de-icing/anti-icing fluid,
 - (2) 7°C for type II, III or IV de-/anti-icing fluids.
- (m) Post treatment check. An external check of the aeroplane after de-icing and / or anti-icing treatment accomplished from suitably elevated observation points (e.g. from the de-icing equipment itself or other elevated equipment) to ensure that the aeroplane is free from any frost, ice, snow, or slush.



- (n) Pre-take-off check. An assessment normally performed from within the flight deck, to validate the applied holdover time.
- (o) Pre-take-off contamination check. A check of the treated surfaces for contamination, performed when the hold-over-time has been exceeded or if any doubt exists regarding the continued effectiveness of the applied anti-icing treatment. It is normally accomplished externally, just before the commencement of the take-off run.
- (p) Residues. An accumulation of repetitive de-icing fluid that might be re-hydrated or dried and may lead to a subsequent formation / build-up of a residue in aerodynamically quiet areas and possibly putting at risk the free movements of parts such as elevators, ailerons, flap actuating etc.

6. Fluids

- (a) Type I fluid. Due to its properties, Type I fluid forms a thin, liquid-wetting film on surfaces to which it is applied which, under certain weather conditions, gives a very limited holdover time. With this type of fluid, increasing the concentration of fluid in the fluid / water mix does not provide any extension in holdover time.
- (b) Type II and type IV fluids contain thickeners which enable the fluid to form a thicker liquid-wetting film on surfaces to which it is applied. Generally, this fluid provides a longer holdover time than Type I fluids in similar conditions. With this type of fluid, the holdover time can be extended by increasing the ratio of fluid in the fluid/water mix.
- (c) Type III fluid: a thickened fluid intended especially for use on aeroplanes with low rotation speeds.

Fluids used for de-icing and / or anti-icing should be acceptable to the operator and the aeroplane manufacturer. These fluids normally conform to specifications such as SAE AMS 1424, 1428 or equivalent. Use of non-conforming fluids is not recommended due to their characteristics not being known.

7. Communications

- (a) Before aeroplane treatment

When the aeroplane is to be treated with the flight crew on board, the flight and ground crews should confirm the fluid to be used, the extent of treatment required, and any aeroplane type specific procedure(s) to be used. Any other information needed to apply the HOT tables should be exchanged.

- (b) Anti-icing code

The operator's procedures should include an anti-icing code, which indicates the treatment the aeroplane has received. This code provides the flight crew with the minimum details necessary to estimate a holdover time (see para 6 below) and confirms



that the aeroplane is free of contamination. The procedures for releasing the aeroplane after the treatment should therefore provide the Commander with the anti-icing code. Anti-icing Codes to be used (examples):

- (1) "Type I" at (start time) – To be used if anti-icing treatment has been performed with a Type I fluid;
- (2) "Type II/100" at (start time) – To be used if anti-icing treatment has been performed with undiluted Type II fluid;
- (3) "Type II/75" at (start time) – To be used if anti-icing treatment has been performed with a mixture of 75% Type II fluid and 25% water;
- (4) "Type IV/50" at (start time) – To be used if anti-icing treatment has been performed with a mixture of 50% Type IV fluid and 50% water.

Note: When a two-step de-icing/anti-icing operation has been carried out, the Anti- Icing Code is determined by the second step fluid. Fluid brand names may be included, if desired.

(c) After Treatment

Before reconfiguring or moving the aeroplane, the flight crew should receive a confirmation from the ground crew that all de-icing and / or anti-icing operations are complete and that all personnel and equipment are clear of the aeroplane.

8. Holdover Protection

- (a) Holdover protection is achieved by a layer of anti-icing fluid remaining on and protecting aeroplane surfaces for a period of time. With a one-step de-icing / anti-icing procedure, the holdover time (HOT) begins at the commencement of de-icing / anti-icing. With a two-step procedure, the holdover time begins at the commencement of the second (anti-icing) step. The holdover protection runs out:
 - (1) At the commencement of take-off roll (due to aerodynamic shedding of fluid) or
 - (2) When frozen deposits start to form or accumulate on treated aeroplane surfaces, thereby indicating the loss of effectiveness of the fluid.
- (b) The duration of holdover protection may vary subject to the influence of factors other than those specified in the holdover time (HOT) tables. Guidance should be provided by the operator to take account of such factors which may include:
 - (1) Atmospheric conditions, e.g. exact type and rate of precipitation, wind direction and velocity, relative humidity and solar radiation and



- (2) The aeroplane and its surroundings, such as aeroplane component inclination angle, contour and surface roughness, surface temperature, operation in close proximity to other aeroplanes (jet or propeller blast) and ground equipment and structures.
- (c) Holdover times are not meant to imply that flight is safe in the prevailing conditions if the specified holdover time has not been exceeded. Certain meteorological conditions, such as freezing drizzle or freezing rain, may be beyond the certification envelope of the aeroplane.
- (d) The operator should publish in the Operations Manual the holdover times in the form of a table or diagram to account for the various types of ground icing conditions and the different types and concentrations of fluids used. However, the times of protection shown in these tables are to be used as guidelines only and are normally used in conjunction with pre-take-off check.
- (e) References to usable HOT tables may be found in the 'AEA recommendations for de- / anti-icing aircraft on the ground'.

9. Procedures to be Used

Operator's procedures should ensure that:

- (a) When aeroplane surfaces are contaminated by ice, frost, slush or snow, they are de-iced prior to take-off; according to the prevailing conditions. Removal of contaminants may be performed with mechanical tools, fluids (including hot water), infra-red heat or forced air, taking account of aeroplane type-specific requirements.
- (b) Account is taken of the wing skin temperature versus OAT, as this may affect:
 - (1) The need to carry out aeroplane de-icing and / or anti-icing; and
 - (2) The performance of the de-icing / anti-icing fluids.
- (c) When freezing precipitation occurs or there is a risk of freezing precipitation occurring, which would contaminate the surfaces at the time of take-off, aeroplane surfaces should be anti-iced. If both de-icing and anti-icing are required, the procedure may be performed in a one or two-step process depending upon weather conditions, available equipment, available fluids and the desired holdover time. One-step de-icing / anti-icing means that de-icing and anti-icing are carried out at the same time using a mixture of de-icing / anti-icing fluid and water. Two-step de-icing / anti-icing means that de-icing and anti-icing are carried out in two separate steps. The aeroplane is first de-iced using heated water only or a heated mixture of de-icing / anti-icing fluid and water. After completion of the de-icing operation a layer of a mixture of de-icing / anti-icing fluid and water, or of de-icing/anti-icing fluid only, is to be sprayed over the aeroplane surfaces. The second step will be applied, before the first step fluid freezes, typically within three minutes and, if necessary, area by area.



- (d) When an aeroplane is anti-iced and a longer holdover time is needed / desired, the use of a less diluted Type II or Type IV fluid should be considered.
- (e) All restrictions relative to Outside Air Temperature (OAT) and fluid application (including, but not necessarily limited to temperature and pressure), published by the fluid manufacturer and / or aeroplane manufacturer, are followed. Procedures, limitations and recommendations to prevent the formation of fluid residues are followed.
- (f) During conditions conducive to aeroplane icing on the ground or after de-icing and / or anti-icing, an aeroplane is not dispatched for departure unless it has been given a contamination check or a post treatment check by a trained and qualified person. This check should cover all treated surfaces of the aeroplane and be performed from points offering sufficient accessibility to these parts. To ensure that there is no clear ice on suspect areas, it may be necessary to make a physical check (e.g. tactile).
- (g) The required entry is made in the Technical Log.
- (h) The Commander continually monitors the environmental situation after the performed treatment. Prior to take-off he performs a pre-take-off check, which is an assessment whether the applied HOT is still appropriate. This pre-take-off check includes, but is not limited to, factors such as precipitation, wind and OAT.
- (i) If any doubt exists as to whether a deposit may adversely affect the aeroplane's performance and / or controllability characteristics, the Commander should require a pre-take-off contamination check to be performed in order to verify that the aeroplane's surfaces are free of contamination. Special methods and / or equipment may be necessary to perform this check, especially at night time or in extremely adverse weather conditions. If this check cannot be performed just prior take-off, re- treatment should be applied.
- (j) When re-treatment is necessary, any residue of the previous treatment should be removed and a completely new de-icing / anti-icing treatment applied.
- (k) When a Ground Ice Detection System (GIDS) is used to perform an aeroplane surfaces check prior to and/or after a treatment, the use of GIDS by suitably trained personnel should be a part of the procedure.

10. Special Operational Considerations

- (a) When using thickened de-icing / anti-icing fluids, the operator should consider a two-step de-icing/anti-icing procedure, the first step preferably with hot water and / or non thickened fluids.
- (b) The use of de-icing / anti-icing fluids has to be in accordance with the aeroplane manufacturer's documentation. This is particular true for thickened fluids to assure sufficient flow-off during take-off.



- (c) The operator should comply with any type-specific operational requirement(s) such as an aeroplane mass decrease and/or a take-off speed increase associated with a fluid application.
- (d) The operator should take into account any flight handling procedures (stick force, rotation speed and rate, take-off speed, aeroplane attitude etc.) laid down by the aeroplane manufacturer when associated with a fluid application.
- (e) The limitations or handling procedures resulting from c and / or d above should be part of the flight crew pre take-off briefing.

11. Special Maintenance Considerations

(a) General

The operator should take proper account of the possible side-effects of fluid use. Such effects may include, but are not necessarily limited to, dried and / or re-hydrated residues, corrosion and the removal of lubricants.

(b) Special considerations due to residues of dried fluids

The operator should establish procedures to prevent or detect and remove residues of dried fluid. If necessary the operator should establish appropriate inspection intervals based on the recommendations of the airframe or engine manufacturers and / or own experience:

(1) Dried fluid residues.

Dried fluid residue could occur when surfaces have been treated but the aircraft has not subsequently been flown and not been subject to precipitation. The fluid may then have dried on the surfaces;

(2) Re-hydrated fluid residues.

▶ Repetitive application of thickened de-icing / anti-icing fluids may lead to the subsequent formation / build-up of a dried residue in aerodynamically quiet areas, such as cavities and gaps. This residue may re-hydrate if exposed to high humidity conditions, precipitation, washing, etc., and increase to many times its original size / volume. This residue will freeze if exposed to conditions at or below 0°C. This may cause moving parts such as elevators, ailerons, and flap actuating mechanisms to stiffen or jam in flight.

▶ Re-hydrated residues may also form on exterior surfaces, which can reduce lift, increase drag and stall speed.



- ▶ Re-hydrated residues may also collect inside control surface structures and cause clogging of drain holes or imbalances to flight controls.
 - ▶ Residues may also collect in hidden areas: around flight control hinges, pulleys, grommets, on cables and in gaps;
- (c) Operators are strongly recommended to request information about the fluid dry-out and re-hydration characteristics from the fluid manufacturers and to select products with optimised characteristics;
 - (d) Additional information should be obtained from fluid manufacturers for handling, storage, application and testing of their products.
 - (e) Special attention, if necessary, should be paid during the pre-flight, especially when performed by ground handling organisation on behalf of the crew.
 - (f) Inspections should be addressed in the maintenance programme in order to describe what and when to inspect.
 - (g) Maintenance organisations should have the proper documentation: how to inspect, tolerances or acceptable residue development, how to remove and to clean, tools to be used etc.
 - (h) The Safety and Quality policy, Maintenance procedures and Quality system should include considerations for icing. Special procedures and audits / organisational reviews should be performed by skilled personnel.

12. Training

An operator should establish appropriate initial and recurrent de-icing and / or anti-icing training programmes (including communication training) for flight crew and those of his ground crew who are involved in de-icing and / or anti-icing.

These de-icing and / or anti-icing training programmes should include additional training if any of the following will be introduced:

- (a) A new method, procedure and/or technique;
- (b) A new type of fluid and/or equipment; and
- (c) A new type(s) of aeroplane.

Coordination between Operations and Maintenance must be enhanced, in particular for the maintenance inspections to be performed and the log book to be filled in. Operators should ensure that contracted maintenance staff is well aware of the concern and appropriately trained, for both line and base maintenance.



This safety notice will remain in effect until advice has been received to the contrary.



Eng. Marco Conti
Director General

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