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RECOMMENDATIONS FOR DE-ICING/ANTI-ICING OF AIRCRAFT ON THE GROUND

1 Introduction

1.1 This Circular is issued to advise operators of the minimum requirements for ground based aircraft de-icing/anti-icing methods with fluids and procedures to facilitate the safe operation of transport aircraft during icing conditions. This Circular does not specify requirements for particular aircraft types. The recommended holdover times with respect to ground de-icing are regularly revised and can be found in the AEA (Association of European Airlines, www.aea.be) booklet entitled, 'Recommendations for De-Icing/Anti-Icing of Aircraft on the Ground'. This Circular incorporates revised definitions together with additional de-icing information.

1.2 This Circular has therefore been published to:

(a) Advise operators of sources of information on holdover times for Type I, Type II, Type III and Type IV fluids;

(b) provide additional and revised definitions, notes and precautions;

(c) advise operators of experience from incidents;

(d) introduce information concerning infra-red and forced air technology;

(e) provide information on off-gate de-icing.

2 Sources of Further Guidance Material

2.1 It should be noted that there are other sources of guidance material associated with de-icing, over and above the information published by aircraft manufacturers and manufacturers of de-icing fluids. Aircraft type design organisations (manufacturers) normally publish de-icing procedures in the relevant aircraft Maintenance Manuals. They may also publish service bulletins, service letters or letters to operators to inform operators and engineering organisations of additional information, such as lists of approved fluids, feedback from other operators, de-icing techniques, etc.

Other sources of guidance material include:

(a) ICAO Doc 9640-AN/940 'Manual of Aircraft Ground De-Icing/Anti-Icing Operations';

(b) The Association of European Airlines (AEA) publish 'Recommendations for De-Icing/Anti-Icing of Aircraft on the Ground'. This document is published annually and is available on the Internet at www.aea.be;

(c) SAE International report number ARP 4737 'Aircraft De-Icing/Anti-Icing Methods with Fluids'. Available on the Internet at www.sae.org;

(d) CAA Winter Operations website: www.caa.co.uk/winteroperations;

(e) Ground Icing Training: http://aircrafticing.grc.nasa.gov/courses.html.

3 Information

3.1 Holdover protection is achieved by a layer of anti-icing fluid remaining on and protecting aircraft surfaces for a period of time. With a one-step de-icing/anti-icing procedure, the holdover time begins at the commencement of the application of de-icing/anti-icing fluid. With a two-step procedure, the holdover time begins at the commencement of the second (anti-icing) step. Should frozen deposits form/accumulate on an aircraft surface, the holdover time will have, in effect, run out.

3.2 The published holdover time is only a guideline because other variables can reduce or enhance the effectiveness of the fluid. These include high winds, jet blast, wet snow, heavy precipitation, aircraft skin temperature lower than outside air temperature and direct sunlight. The time of protection may be shortened and may reduce holdover times below the lowest time stated in the tables. Therefore, the indicated times should be used only in conjunction with a pre-take-off check.

3.3 Operators should include de-icing/anti-icing processes in their Quality Audit Programme to satisfy themselves that the service provided by contracted organisations is acceptable. The same applies for operators who have their own in-house de-ice/anti-ice services. The AEA booklet contains an example audit proforma, checklist and report.

3.4 If de-icing is completed off stand, it may not always be practicable to complete the Technical Log to include the de-icing activity. When de-icing is carried out after the Technical Log has been completed, and the tear-out copy has been removed, the operator should implement a procedure for de-icing operatives to advise the flight crew of the process, and to ensure that all the details and associated codes of the de-icing activity will be recorded. It should be noted that some aircraft types would still require a physical inspection upon completion of de-icing.

3.5 It is the operator's responsibility to ensure that de-icing/anti-icing fluids used are acceptable to the aircraft manufacturer, by type and proprietary brand names.

3.6 A number of de-icing fluids only have a two year shelf-life, yet shelf-life expiry dates are not in all cases marked on fluid containers. Should the dates not be found on fluid containers, they may be recorded on the fluid delivery notes. Clearly, fluids that have exceeded their shelf-life cannot be used.

4 Aircraft De-Icing/Anti-Icing Fluids

4.1 Fluids must meet the requirements of the applicable SAE or ISO performance specification including the derivation of holdover time. A number of different types of de-icing/anti-icing fluids are available, which fall into the following type classifications:

(a) **Type I Fluid (Unthickened) (SAE AMS 1424 or ISO 11075)**

This fluid has a high glycol content and low viscosity in its concentrated form. De-icing performance of the fluid is good. However, due to low viscosity, it provides only limited anti-icing protection during freezing precipitation. It is used predominantly for removing frozen deposits from aircraft surfaces, either as the first step in a two-step operation or where precipitation has stopped. With this type of fluid, no additional protection is provided by increasing the concentration of the fluid in the fluid/water mix.

(b) **Type II Fluid (Thickened) (SAE AMS 1428 or ISO 11078)**

This fluid generally has a lower glycol content in its concentrated form than Type I fluid due to the inclusion of a pseudo plastic thickening agent. This effectively means that when applied to the surface of an aircraft the viscosity is high, thus allowing the fluid to remain on and protect against freezing precipitation for a period of time. However, the increasing effect of the airflow over the wing during the take-off roll will effectively 'shear' the fluid, reducing its viscosity and allowing it to readily flow off the critical surfaces. With this type of fluid the holdover time can be extended by increasing the concentration of fluid in the fluid/water mix. Type II fluids are usually straw coloured.

(c) **Type III Fluid (Thickened) (SAE AMS 1428)**

Type III fluid is designed primarily for aircraft with low rotation/take-off speeds, and it may not require specialised low shear application and transfer equipment, but fluid manufacturers' guidance should be followed in this respect. When used for anti-icing, Type III fluids have holdover time guidelines typically less than those of a Type II fluid but significantly longer than those of Type I fluids.

(d) **Type IV Fluid (Thickened) (SAE AMS 1428)**

This fluid is similar in both composition and operation to Type II fluids. However, through the use of advanced thickening systems, it is able to provide longer holdover time than Type II fluids when used in concentrated form. As with Type II fluids the holdover time can be extended by increasing the concentration of fluid in the fluid/water mix. Type IV fluids are usually coloured green.

5 Definitions

5.1 For the purposes of this Circular, the following definitions apply:

De-Icing	Procedure by which frost, ice, slush or snow is removed from an aircraft in order to provide clear surfaces.
De-Icing Fluid	(a) Heated Water; (b) Type I fluid in accordance with SAE 1424 or ISO 11075; (c) Mixture of Type I fluid and water; (d) Type II fluid in accordance with SAE 1428 or ISO 11078; (e) Mixture of ISO Type II fluid and water; (f) Type IV fluid in accordance with SAE 1428; (g) Mixture of Type IV fluid and water.
Anti-Icing	Precautionary procedure which provides protection against the formation of frost or ice and accumulation of snow or slush on treated surfaces of the aircraft for a limited period of time (holdover time).
Anti-Icing Fluid	(a) Type I fluid in accordance with SAE 1424 or ISO 11075; (b) Mixture of ISO Type I fluid and water; (c) Type II fluid in accordance with SAE 1428 or ISO 11078; (d) Mixture of ISO Type II fluid and water; (e) Type III fluid in accordance with SAE 1428; (f) Type IV fluid in accordance with SAE 1428; (g) Mixture of Type IV fluid and water. ***Note:*** *Follow the appropriate AEA or fluid manufacturer's guidance with respect to fluid application temperatures.*
De-Icing/Anti-Icing	Combination of the two procedures described above. It may be performed in either one or two steps.
Holdover Time	Estimated time for which an anti-icing fluid will prevent the formation of frost or ice and the accumulation of snow on the protected surfaces of an aircraft, under specified weather conditions.
Check	An examination of an aircraft against the relevant standard by a trained and qualified person.

Freezing Conditions	Conditions in which the outside air temperature is below +3°C (37.4°F) and visible moisture in any form (such as fog with visibility below 1.5 km, rain, snow, sleet or ice crystals) or standing water, slush, ice or snow is present on the runway.
Frost/Hoar Frost	Ice crystals that form from ice saturated air temperatures below 0°C (32°F) by direct sublimation on the ground or other exposed objects.
Active Frost	Active frost is a condition when frost is forming. Active frost occurs when aircraft surface temperature is at or below 0°C (32°F), and at or below the dew point.
Freezing Fog	A suspension of numerous minute water droplets that freeze upon impact with ground or other exposed objects, generally reducing the horizontal visibility at the earth's surface to less than 1 km (5/8 mile).
Snow	Precipitation of ice crystals, most of which are branched, star-shaped or mixed with unbranched crystals. At temperatures higher than -5°C (23°F), the crystals are generally agglomerated into snowflakes.
Freezing Drizzle	Fairly uniform precipitation composed exclusively of fine drops (diameter less than 0.5 mm (0.02 ins)) very close together which freezes upon impact with the ground or other exposed objects.
Light Freezing Rain	Precipitation of liquid water particles which freeze upon impact with the ground or other exposed objects, either in the form of drops of more than 0.5 mm (0.02 ins) or smaller drops, which, in contrast to drizzle, are widely separated. Measured intensity of liquid water particles is up to 2.5 mm per hour (0.10 ins per hour) or 25 grams per dm^2 per hour with a maximum of 0.25 mm (0.01 ins) in 6 minutes.
Moderate and Heavy Freezing Rain	Precipitation of liquid water particles which freeze upon impact with the ground or other exposed objects, either in the form of drops of more than 0.5 mm (0.02 ins) or smaller drops, which, in contrast to drizzle, are widely separated. Measured intensity of liquid water particles is up to 2.5 mm per hour (0.10 ins per hour) or 25 grams per dm^2 per hour.
Cold-Soak Effect	The wings of an aircraft are said to be 'cold-soaked' when they contain very cold fuel as a result of having just landed after a flight at high altitude or from having been refuelled with very cold fuel. Whenever precipitation falls on a cold-soaked aircraft on the ground clear ice may form. The following factors contribute to cold-soaking: temperature and quantity of fuel in fuel cells, type and location of fuel cells, length of time at high altitude, temperature of refuelled fuel and time since refuelling.
Rain or High Humidity	Water forming ice or frost on the wing surface, when the temperature of the aircraft (on cold-soaked wing) wing surface is at or below 0°C (32°F).
Rain and Snow (Sleet)	Precipitation in the form of a mixture of rain and snow. For operation in light rain and snow (sleet) treat as light freezing rain.
Slush	Snow or ice that has been reduced to a soft watery mixture by rain, warm temperatures and/or chemical treatment.
Ice Crystals/Diamond Dust	A fall of unbranched ice crystals (snow crystals are branched) in the form of needles, columns or plates.
Ice Pellets	Precipitation of transparent (grains of ice) or translucent (small hail) pellets of ice, which are spherical or irregular, and which have a diameter of 5 mm (0.2 ins) or less. The pellets of ice usually bounce when hitting hard ground.
Snow Pellets	Precipitation of white and opaque grains of ice. These grains are spherical or sometimes conical; their diameter is about 2-5 mm (0.1-0.2 ins). Grains are brittle, easily crushed; they bounce and break on hard ground.
Snow Grains	Precipitation of very small white and opaque grains of ice. These grains are fairly flat or elongated; their diameter is less than 1 mm (0.04 ins). When the grains hit hard ground they do not bounce or shatter. Treat as snow for holdover time purposes.
Hail	Precipitation of small balls or pieces of ice with a diameter ranging from 5 to > 50 mm (0.2-2 ins) falling either separately or agglomerated.

6 Operational Considerations

6.1 The application of de-icing/anti-icing fluids must be in accordance with the aircraft manufacturer's practices and procedures.

6.2 The operator should comply with any operational requirements such as an aircraft mass decrease and/or an increased take-off speed when operating with a particular fluid applied to the aircraft. Thickened fluids are known to have caused loss of aerodynamic lift on, particularly, turbo-prop aircraft with rotation speeds of less than 100 kts. Turbo-jet aircraft have been similarly affected.

6.3 The operator should take into account any changes to flight handling procedures, stick force, rotation speed and rate, take-off speed, aircraft attitude etc, stipulated by the aircraft manufacturers associated with a particular fluid applied to the aircraft.

6.4 The limitations or handling procedures resulting from paragraphs 6.2 and 6.3 should be included in the flight crew pre-take-off briefing.

6.5 Operators of aircraft equipped with turbo-prop or low bypass engines should implement procedures to address the hazards associated with accumulation of snow/slush in engine intakes whilst parked. Procedures should address the need for fitment/ removal of intake blanks and visual checks.

6.6 Operators should take account of the practicalities of pre-flight inspection of intakes. Operators should consider the need to carry steps for this purpose.

6.7 Repetitive application of thickened fluids (SAE AMS 1428/ISO 11078) may lead to a build-up of residues in aerodynamically quiet areas such as balance bays, and on wing and stabiliser trailing edges and rear spars. This residue may rehydrate, and increase in volume to many times its original size during flight and freeze under conditions of certain temperature, high humidity and/or rain causing moving parts such as elevators, ailerons, and flap actuating mechanisms to stiffen or jam in flight. It may also form on exterior surfaces which can reduce lift and increase drag and stall speed, block or impede critical flight control systems, and cause aerials to malfunction.

6.8 Residues may also collect in hidden areas, around flight control hinges, pulleys on cables and in gaps, and inside flight control surfaces affecting water drainage and control balance.

6.9 Additional inspections may therefore be required to ensure that no build-up of residues has occurred in critical areas not visible from the ground. The operator should request guidance/instructions from the aeroplane manufacturer in order to establish

satisfactory procedures to prevent, detect and remove residues of dried fluid with the potential to cause any of the problems as described above. Appropriate inspection intervals should be established.

6.10 Operators should consider defining a policy on the use of two-step de-icing/anti-icing procedures preferably using hot water or unthickened fluids in the first step. Fluid selection should be based on dry-out and rehydration data supplied by manufacturers. Appropriate operational and maintenance/handling procedures should be established.

6.11 Information and training should be provided for in-house and contractors' staff. This should include appropriate flight safety information.

7 Subcontracting (see also ORO.GEN.205, AMC1 ORO.GEN.205 AND GM1 ORO.GEN.205)

7.1 The operator should ensure that the ground handling agency or de-icing subcontractor is aware of the de-icing/anti-icing requirements for a particular aircraft type. Such subcontracting is normally determined in accordance with the IATA Airport Handling Manual, Standard Ground Handling Agreement AHM810 Annex A Section 7 Aircraft Servicing paragraph 6.

7.2 The contract should address the:

(a) Provision of the fluid to be used (it must include the proprietary or brand name which must be one specified by the aircraft manufacturer);

(b) specific aircraft type requirements which will include the application of fluids to an aircraft, details of no spray areas, techniques, aircraft configuration, inspections etc;

(c) concentration, viscosity and degradation checks of fluids prior to use;

(d) supervision of the completion and performance of the de-icing/anti-icing operation;

(e) performance of a final inspection of the aircraft after the de-icing/anti-icing operation and informing the flight crew of the result.

8 Communications

8.1 Before the aircraft is to be treated with the flight crew on board, the ground crew should confirm with the flight crew, the type of fluid to be used, the extent of treatment and any aircraft type-specific procedures to be used.

8.2 The operator's procedure should include an anti-icing code, which indicates the process which has been applied to the aircraft. The code provides flight crew with the minimum details necessary to assess holdover time and confirms that the aircraft is clear of ice.

9 The Technical Log

9.1 An entry must be made in the aircraft technical log to record the process, even in the case of an interrupted or failed application (see EASA Part-M, AMC M.A.306(a), Section 3(vi)). EASA Part-M requires the time the de-icing commences, in the case of a one step process or the time at which the anti-icing process is commenced in a two step process, to be recorded in the aircraft technical log.

10 Pre-Take-Off Check

10.1 The commander should continually monitor the environmental situation after the performed de-icing/anti-icing treatment. Prior to take-off the commander should assess whether the applied holdover time is still appropriate and inspect the aircraft, to the extent possible, to ensure critical surfaces are clear of frozen contamination, especially any surfaces that have been de-iced/anti-iced. This check is normally done from inside the aircraft.

11 Pre-Take-Off Contamination Check

11.1 This check is normally conducted from outside the aircraft by visual and tactile inspection of the critical surfaces. This check shall be performed when the condition of the critical surfaces cannot be effectively assessed by a pre-take-off check. This may be due to the aircraft configuration, the prevailing visibility and lighting and the reliability of the viewable area as an indicator of the condition of non-viewable areas particularly when the holdover time has been exceeded.

11.2 The alternate means of compliance to a pre-take-off contamination check is a complete de-icing/anti-icing re-treatment of the aircraft.

12 Procedures

12.1 The operator should provide procedures for ground handling agencies, engineering personnel and flight crew, detailing processes, duties, and responsibilities for ground de-icing/anti-icing and associated ground handling tasks, such as intake blanking. De-icing/anti-icing techniques for intakes and undercarriage should be detailed. Those tasks contracted to ground handling agencies should be subject to regular quality reviews.

12.2 In the case of off-gate de-icing/anti-icing, the key elements to be considered are communication, inspection and records. The following should be considered for inclusion in procedures as applicable:

(a) The responsibility for determining the need for de-icing/anti-icing on the gate, and the means of communication to the commander;

(b) establishment of two-way communication with de-icing/anti-icing ground staff;

(c) key staff responsibilities, including post-treatment inspection;

(d) the procedure for ensuring deactivation of aircraft systems;

(e) the format and passing of de-icing/anti-icing codes;

(f) ground and flight deck record requirements.

13 Training Requirements

13.1 The operator should establish and provide appropriate initial and recurrent de-icing/anti-icing training for both flight and ground crew personnel. When de-icing/anti-icing is contracted out to ground handling agencies, the operator should ensure that their staff have also been suitably trained. In addition, training should address other procedures associated with winter operations, such as intake blanking and inspection methods.

14 Quality

14.1 The operator's Quality System should ensure that de-icing/anti-icing and winter ground handling activities are carried out in accordance with the operator's procedures at all stations where de-icing/anti-icing is carried out.

15 Application Limits

15.1 Under no circumstances may an aircraft that has been anti-iced receive a further coating of anti-icing fluid directly on top of the contaminated film. If an additional treatment is required before flight, a complete de-icing/anti-icing process must be performed to ensure that any residues from the previous treatment have been removed. In these circumstances anti-icing only is not permitted.

16 De-Icing/Anti-Icing Holdover Times

16.1 Refer to AEA document 'Recommendations for De-Icing/Anti-Icing of Aircraft on the Ground' which provides generic holdover time information (Latest edition available on the AEA Web site: www.aea.be). Fluid manufacturers provide brand-specific holdover time information. It is the operator's responsibility to ensure fluid holdover times have been measured/derived per the appropriate SAE or ISO specification as referred to in paragraph 4 of this Circular.

17 Experience from Incidents

17.1 The CAA Safety Data Department has records of a number of MORs associated with difficulties following aircraft ground de-icing. A review of those records highlights a number of trends of which operators should be aware.

Examples include:

- De-Icing crews being called back to the aircraft following flight crew and engineering inspection.
- Problems following de-ice fluids being sprayed into no-spray areas.
- Cabin crews advising flight crew of ice on upper surfaces of the wings.
- Differences between operator and contracted de-icing ground crews on the definition of a clean wing.
- Inadequate de-icing procedures and communication between de-icing crews and flight deck.
- Failures of de-icing equipment.
- Turbo-prop engine flameout during taxi and take-off due to snow accumulation in intakes.
- Inadequate ground support equipment available for pre-flight inspection of intakes.
- Problems associated with fluid residue rehydration.
- Incorrect or no fluid used in the de-icing rig.

17.2 It is therefore recommended that consideration is given to the foregoing when operations and maintenance procedures are reviewed.

18 Infra-red and Forced Air De-Icing Methods

18.1 These de-icing methods involve the removal of snow and ice using thermal methods, and require the subsequent application of anti-icing fluid. A disadvantage of this method is the loss of the first step removal of thickened (sleet) fluid residues (see paragraph 6). This Circular does not contain detailed requirements for these two techniques, therefore further information may be obtained from the sources detailed below.

18.2 Operators intending to utilise infra-red or forced air de-icing methods must comply with the aeroplane manufacturer's recommendations, and must establish appropriate procedures for use by flight crew and ground personnel. The operator's assigned Flight Operations Inspector should be informed of the intent to utilise these methods.

18.3 For infra-red de-icing, refer to SAE ARP 4737 section 6.2 for minimum requirements and cautions.

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