APPENDIX O – SUPERCOOLED LARGE DROP ICING CONDITIONS

ED Decision 2015/008/R

Appendix O consists of two parts. Part I defines Appendix O as a description of supercooled large drop (SLD) icing conditions in which the drop median volume diameter (MVD) is less than or greater than 40 µm, the maximum mean effective drop diameter (MED) of Appendix C continuous maximum (stratiform clouds) icing conditions. For Appendix O, SLD icing conditions consist of freezing drizzle and freezing rain occurring in and/or below stratiform clouds. Part II defines ice accretions used to show compliance with CS-25 specifications.

[Amdt 25/16]

Part I – Meteorology

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Appendix O icing conditions are defined by the parameters of altitude, vertical and horizontal extent, temperature, liquid water content, and water mass distribution as a function of drop diameter distribution.

(a) Freezing Drizzle (Conditions with spectra maximum drop diameters from 100 µm to 500 µm):

(1) Pressure altitude range: 0 to 6 706 m (22 000 feet) MSL.

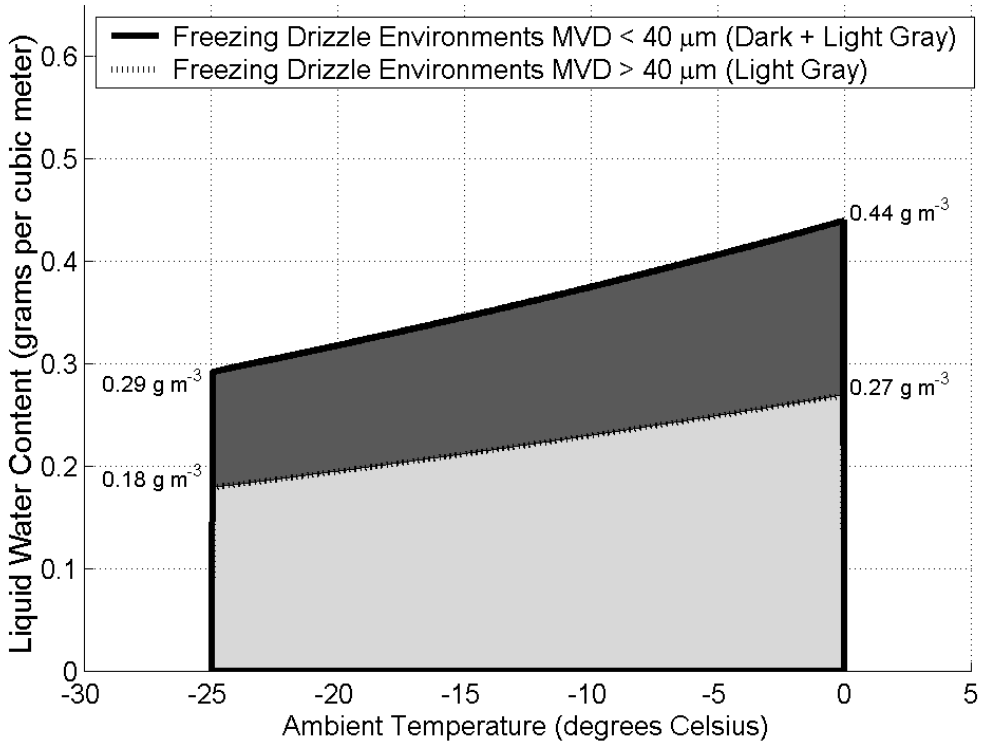
(2) Maximum vertical extent: 3 656 m (12 000 feet).

(3) Horizontal extent: standard distance of 32.2 km (17.4 nautical miles).

(4) Total liquid water content:

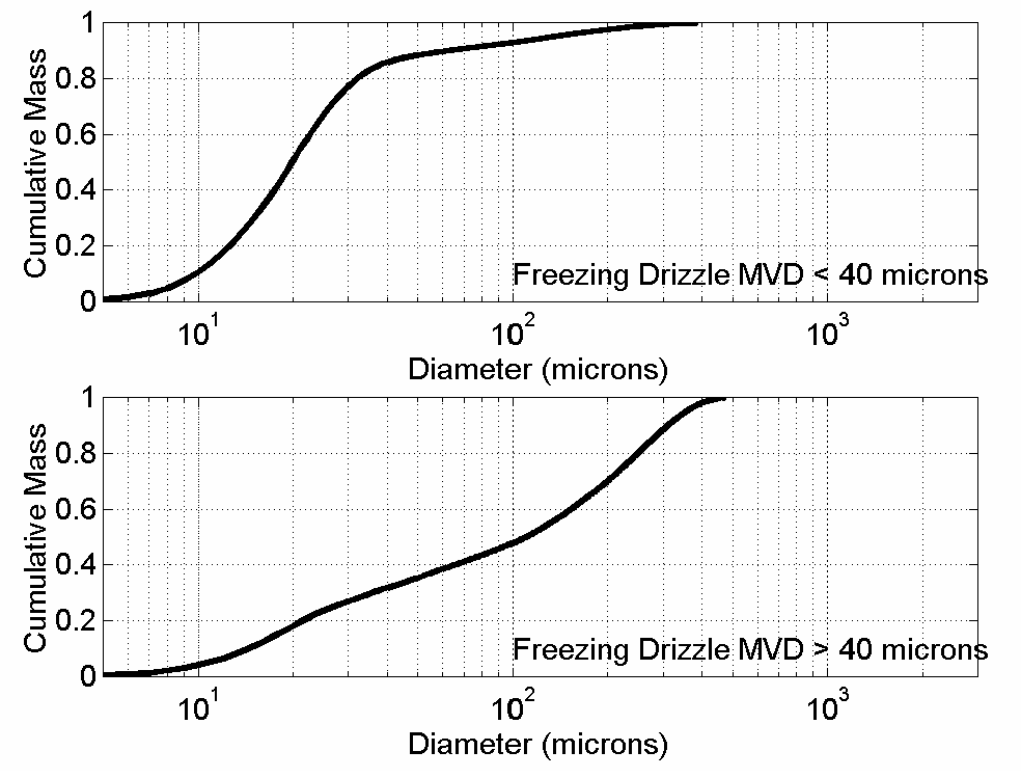
Note: Liquid water content (LWC) in grams per cubic meter (g/m^3) based on horizontal extent standard distance of 32.2 km (17.4 nautical miles).

Figure 1 – Appendix O, Freezing Drizzle, Liquid Water Content



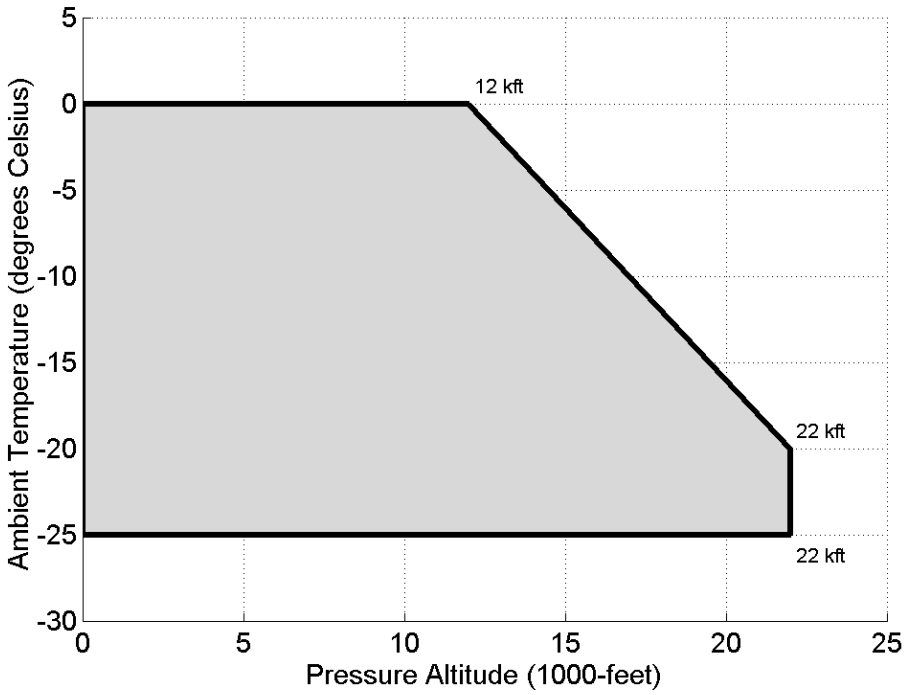
(5) Drop diameter distribution:

Figure 2 – Appendix O, Freezing Drizzle, Drop Diameter Distribution



(6) Altitude and temperature envelope:

Figure 3 – Appendix O, Freezing Drizzle, Altitude and Temperature



(b) Freezing Rain (Conditions with spectra maximum drop diameters greater than 500 µm):

(1) Pressure altitude range: 0 to 3656 m (12000 ft) MSL.

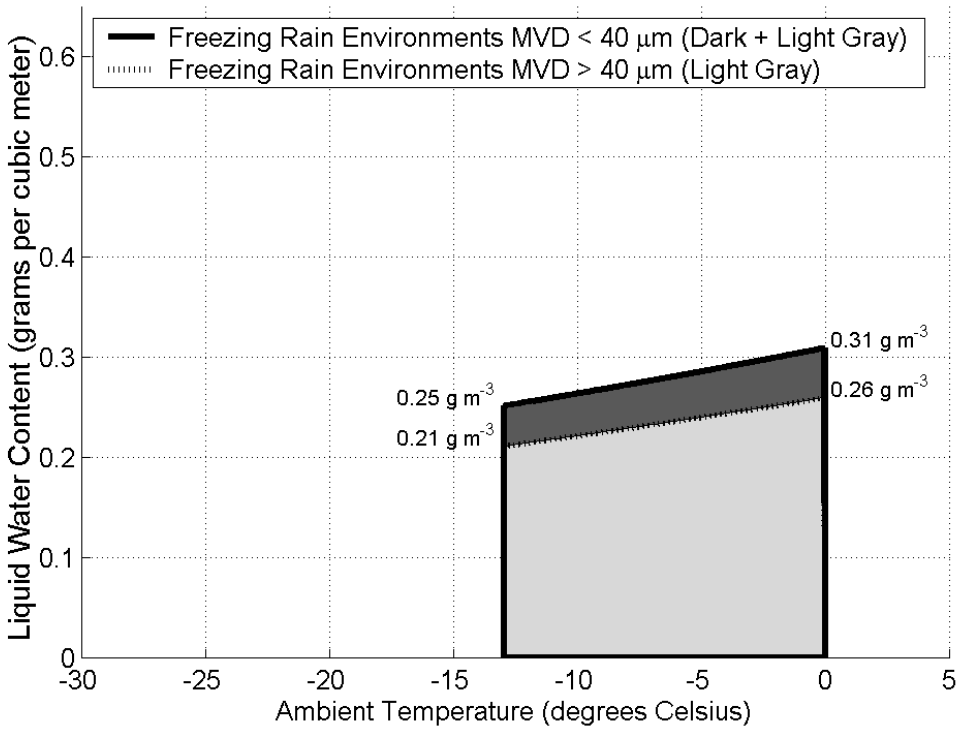
(2) Maximum vertical extent: 2134 m (7000 ft).

(3) Horizontal extent: standard distance of 32.2 km (17.4 nautical miles).

(4) Total liquid water content:

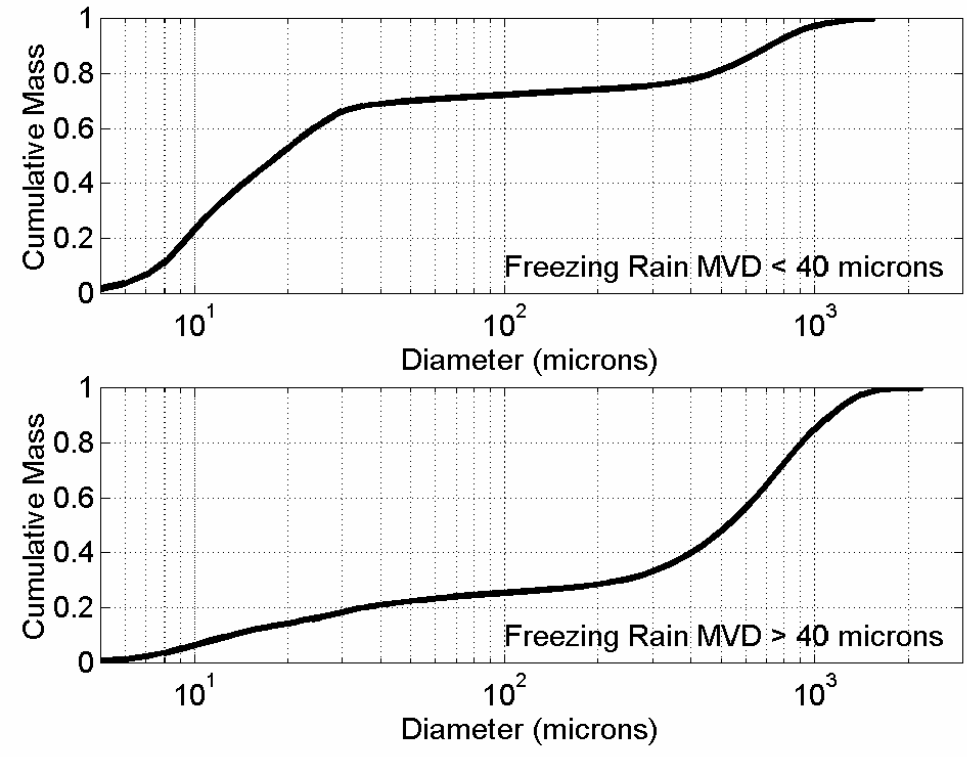
Note: LWC in grams per cubic meter (g/m^3) based on horizontal extent standard distance of 32.2 km (17.4 nautical miles).

Figure 4 – Appendix O, Freezing Rain, Liquid Water Content



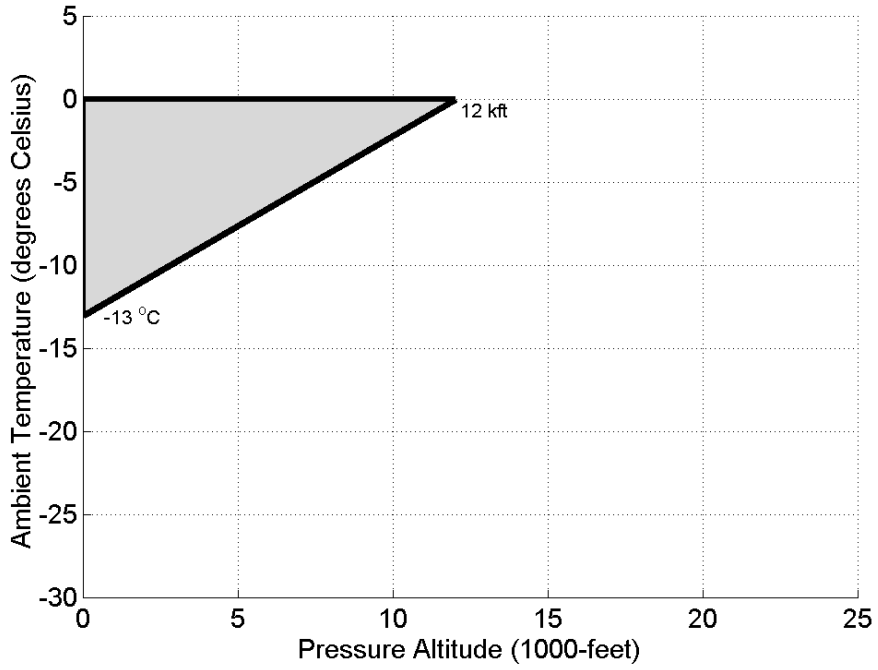
(5) Drop diameter distribution:

Figure 5 – Appendix O, Freezing Rain, Drop Diameter Distribution



(6) Altitude and temperature envelope:

Figure 6 – Appendix O, Freezing Rain, Altitude and Temperature



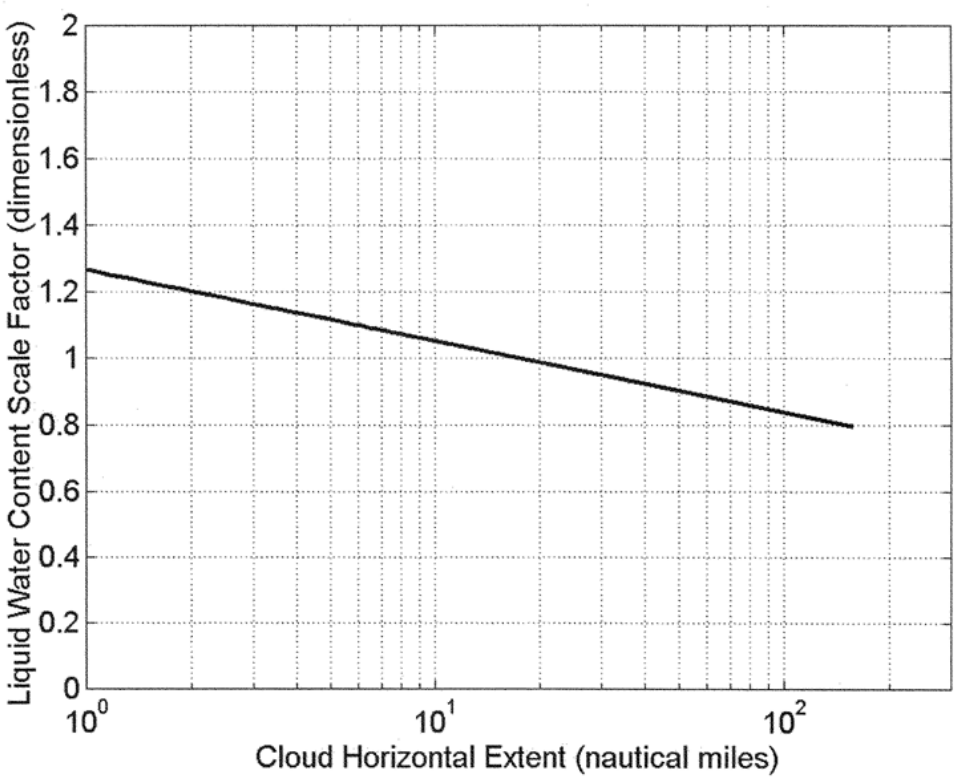
(c) Horizontal extent

The liquid water content for freezing drizzle and freezing rain conditions for horizontal extents other than the standard 32.2 km (17.4 nautical miles) can be determined by the value of the liquid water content determined from Figure 1 or Figure 4, multiplied by the factor provided in Figure 7, which is defined by the following equation:

$S = 1.266 – 0.213 \log_{10}(H)$

Where S = Liquid Water Content Scale Factor (dimensionless) and H = horizontal extent in nautical miles

Figure 7 – Appendix O, Horizontal Extent, Freezing Drizzle and Freezing Rain



[Amdt 25/16]

Part II – Airframe ice accretions

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(a) General.

The most critical ice accretion in terms of aeroplane performance and handling qualities for each flight phase must be used to show compliance with the applicable aeroplane performance and handling qualities requirements for icing conditions contained in Subpart B. Applicants must demonstrate that the full range of atmospheric icing conditions specified in part I of this appendix have been considered, including drop diameter distributions, liquid water content, and temperature appropriate to the flight conditions (for example, configuration, speed, angle-of-attack, and altitude).

(1) For an aeroplane certified in accordance with CS 25.1420(a)(1), the ice accretions for each flight phase are defined in part II, paragraph (b) of this appendix.

(2) For an aeroplane certified in accordance with CS 25.1420(a)(2), the most critical ice accretion for each flight phase defined in part II, paragraphs (b) and (c) of this appendix, must be used. For the ice accretions defined in part II, paragraph (c) of this appendix, only the portion of part I of this appendix in which the aeroplane is capable of operating safely must be considered.

(3) For an aeroplane certified in accordance with CS 25.1420(a)(3), the ice accretions for each flight phase are defined in part II, paragraph (c) of this appendix.

(b) Ice accretions for aeroplanes certified in accordance with CS 25.1420(a)(1) or (a)(2).

(1) En-route ice is the en-route ice as defined by part II, paragraph (c)(3), of this appendix, for an aeroplane certified in accordance with CS 25.1420(a)(2), or defined by part II, paragraph (a)(3), of Appendix C, for an aeroplane certified in accordance with CS 25.1420(a)(1), plus:

(i) Pre-detection ice as defined by part II paragraph (b)(5) of this appendix; and

(ii) The ice accumulated during the transit of one cloud with a horizontal extent of 32.2 km (17.4 nautical miles) in the most critical of the icing conditions defined in part I of this appendix and one cloud with a horizontal extent of 32.2 km (17.4 nautical miles) in the continuous maximum icing conditions defined in Appendix C.

(2) Holding ice is the holding ice defined by part II, paragraph (c)(4), of this appendix, for an aeroplane certified in accordance with CS 25.1420(a)(2), or defined by part II, paragraph (a)(4) of Appendix C, for an aeroplane certified in accordance with CS 25.1420(a)(1), plus:

(i) Pre-detection ice as defined by part II, paragraph (b)(5) of this appendix; and

(ii) The ice accumulated during the transit of one cloud with a 32.2 km (17.4 nautical miles) horizontal extent in the most critical of the icing conditions defined in part I of this appendix and one cloud with a horizontal extent of 32.2 km (17.4 nautical miles) in the continuous maximum icing conditions defined in Appendix C.

(iii) Except the total exposure to holding ice conditions does not need to exceed 45 minutes

(3) Approach ice is the more critical of the holding ice defined by part II, paragraph (b)(2) of this appendix, or the ice calculated in the applicable paragraph (b)(3)(i) or (ii) of part II of this appendix:

(i) For an aeroplane certified in accordance with CS 25.1420(a)(2), the ice accumulated during descent from the maximum vertical extent of the icing conditions defined in part I of this appendix to 610 m (2 000 feet) above the landing surface in the cruise configuration, plus transition to the approach configuration, plus:

(A) Pre-detection ice, as defined by part II, paragraph (b)(5) of this appendix; and

(B) The ice accumulated during the transit at 610 m (2 000 feet) above the landing surface of one cloud with a horizontal extent of 32.2 km (17.4 nautical miles) in the most critical of the icing conditions defined in part I of this appendix and one cloud with a horizontal extent of 32.2 km (17.4 nautical miles) in the continuous maximum icing conditions defined in Appendix C.

(ii) For an aeroplane certified in accordance with CS 25.1420(a)(1), the ice accumulated during descent from the maximum vertical extent of the maximum continuous icing conditions defined in part I of Appendix C to 610 m (2 000 feet) above the landing surface in the cruise configuration, plus transition to the approach configuration, plus:

(A) Pre-detection ice, as defined by part II, paragraph (b)(5) of this appendix; and

(B) The ice accumulated during the transit at 610 m (2 000 feet) above the landing surface of one cloud with a horizontal extent of 32.2 km (17.4 nautical miles) in the most critical of the icing conditions defined in part I of this appendix and one cloud with a horizontal extent of 32.2 km (17.4 nautical miles) in the continuous maximum icing conditions defined in Appendix C.

(4) Landing ice is the more critical of the holding ice as defined by part II, paragraph (b)(2) of this appendix, or the ice calculated in the applicable paragraph (b)(4)(i) or (ii) of part II of this appendix:

(i) For an aeroplane certified in accordance with CS 25.1420(a)(2), the ice accretion defined by part II, paragraph (c)(5)(i) of this appendix, plus a descent from 610 m (2 000 feet) above the landing surface to a height of 61 m (200 feet) above the landing surface with a transition to the landing configuration in the icing conditions defined in part I of this appendix, plus:

(A) Pre-detection ice, as defined in part II, paragraph (b)(5) of this appendix; and

(B) The ice accumulated during an exit manoeuvre, beginning with the minimum climb gradient required by CS 25.119, from a height of 61 m (200 feet) above the landing surface through one cloud with a horizontal extent of 32.2 km (17.4 nautical miles) in the most critical of the icing conditions defined in part I of this appendix and one cloud with a horizontal extent of 32.2 km (17.4 nautical miles) in the continuous maximum icing conditions defined in Appendix C.

(ii) For an aeroplane certified in accordance with CS 25.1420(a)(1), the ice accumulated in the maximum continuous icing conditions defined in Appendix C, during a descent from the maximum vertical extent of the icing conditions defined in Appendix C, to 610 m (2 000 feet) above the landing surface in the cruise configuration, plus transition to the approach configuration and flying for 15 minutes at 610 m (2 000 feet) above the landing surface, plus a descent from 610 m (2 000 feet) above the landing surface to a height of 61 m (200 feet) above the landing surface with a transition to the landing configuration, plus:

(A) Pre-detection ice, as described by part II, paragraph (b)(5) of this appendix; and

(B) The ice accumulated during an exit manoeuvre, beginning with the minimum climb gradient required by CS 25.119, from a height of 61 m (200 feet) above the landing surface through one cloud with a horizontal extent of 32.2 km (17.4 nautical miles) in the most critical of the icing conditions defined in part I of this appendix and one cloud with a horizontal extent of 32.2 km (17.4 nautical miles) in the continuous maximum icing conditions defined in Appendix C.

(5) Pre-detection ice is the ice accretion before detection of Appendix O conditions that require exiting per CS 25.1420(a)(1) and (a)(2). It is the pre-existing ice accretion that may exist from operating in icing conditions in which the aeroplane is approved to operate prior to encountering the icing conditions requiring an exit, plus the ice accumulated during the time needed to detect the icing conditions, followed by two minutes of further ice accumulation to take into account the time for the flight crew to take action to exit the icing conditions, including coordination with air traffic control.

(i) For an aeroplane certified in accordance with CS 25.1420(a)(1), the pre-existing ice accretion must be based on the icing conditions defined in Appendix C.

(ii) For an aeroplane certified in accordance with CS 25.1420(a)(2), the pre-existing ice accretion must be based on the more critical of the icing conditions defined in Appendix C, or the icing conditions defined in part I of this appendix in which the aeroplane is capable of safely operating.

(c) Ice accretions for aeroplanes certified in accordance with CS 25.1420(a)(2) or CS 25.1420(a)(3).

For an aeroplane certified in accordance with CS 25.1420(a)(2), only the portion of the icing conditions of part I of this appendix in which the aeroplane is capable of operating safely must be considered.

(1) Take-off ice is the most critical ice accretion on unprotected surfaces, and any ice accretion on the protected surfaces appropriate to normal ice protection system operation, occurring between the end of the take-off distance and 122 m (400 feet) above the take-off surface, assuming accretion starts at the end of the take-off distance in the take-off maximum icing conditions defined in part I of this appendix.

(2) Final take-off ice is the most critical ice accretion on unprotected surfaces, and any ice accretion on the protected surfaces appropriate to normal ice protection system operation, between 122 m (400 feet) and either 457 m (1 500 feet) above the take-off surface, or the height at which the transition from the take-off to the en-route configuration is completed and V_{FTO} is reached, whichever is higher. Ice accretion is assumed to start at lift-off the end of the take-off distance in the icing conditions defined in part I of this appendix.

(3) En-route ice is the most critical ice accretion on the unprotected surfaces, and any ice accretion on the protected surfaces appropriate to normal ice protection system operation, during the en-route flight phase in the icing conditions defined in part I of this appendix.

(4) Holding ice is the most critical ice accretion on the unprotected surfaces, and any ice accretion on the protected surfaces appropriate to normal ice protection system operation, resulting from 45 minutes of flight within a cloud with a 32.2 km (17.4 nautical miles) horizontal extent in the icing conditions defined in part I of this appendix, during the holding phase of flight.

(5) Approach ice is the ice accretion on the unprotected surfaces, and any ice accretion on the protected surfaces appropriate to normal ice protection system operation, resulting from the more critical of the:

(i) Ice accumulated in the icing conditions defined in part I of this appendix during a descent from the maximum vertical extent of the icing conditions defined in part I of this appendix, to 610 m (2 000 feet) above the landing surface in the cruise configuration, plus transition to the approach configuration and flying for 15 minutes at 610 m (2 000 feet) above the landing surface; or

(ii) Holding ice as defined by part II, paragraph (c)(4) of this appendix.

(6) Landing ice is the ice accretion on the unprotected surfaces, and any ice accretion on the protected surfaces appropriate to normal ice protection system operation, resulting from the more critical of the:

(i) Ice accretion defined by part II, paragraph (c)(5)(i), of this appendix, plus ice accumulated in the icing conditions defined in part I of this appendix during a

descent from 610 m (2 000 feet) above the landing surface to a height of 61 m (200 feet) above the landing surface with a transition to the landing configuration, followed by a go-around at the minimum climb gradient required by CS 25.119, from a height of 61 m (200 feet) above the landing surface to 610 m (2 000 feet) above the landing surface, flying for 15 minutes at 610 m (2 000 feet) above the landing surface in the approach configuration, and a descent to the landing surface (touchdown) in the landing configuration; or

(ii) Holding ice as defined by part II paragraph (c)(4) of this appendix.

(7) For both unprotected and protected parts, the ice accretion for the take-off phase must be determined for the icing conditions defined in part I of this appendix, using the following assumptions:

(i) The aerofoils, control surfaces, and, if applicable, propellers are free from frost, snow, or ice at the start of take-off;

(ii) The ice accretion begins at lift-off;

(iii) The critical ratio of thrust/power-to-weight;

(iv) Failure of the critical engine occurs at V_{EF}; and

(v) Crew activation of the ice protection system is in accordance with a normal operating procedure provided in the Aeroplane Flight Manual, except that after beginning the take-off roll, it must be assumed that the crew takes no action to activate the ice protection system until the aeroplane is at least 122 m (400 feet) above the take-off surface.

(d) The ice accretion before the ice protection system has been activated and is performing its intended function is the critical ice accretion formed on the unprotected and normally protected surfaces before activation and effective operation of the ice protection system in the icing conditions defined in part I of this appendix. This ice accretion only applies in showing compliance to CS 25.143(j) and 25.207(h).

(e) In order to reduce the number of ice accretions to be considered when demonstrating compliance with the requirements of CS 25.21(g), any of the ice accretions defined in this appendix may be used for any other flight phase if it is shown to be at least as critical as the specific ice accretion defined for that flight phase. Configuration differences and their effects on ice accretions must be taken into account.

(f) The ice accretion that has the most adverse effect on handling qualities may be used for aeroplane performance tests provided any difference in performance is conservatively taken into account.

[Amdt 25/16]