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33.68		Justificativa
RBAC 33 Emenda 33-33	**RBAC 33 Emenda 33-34**	
§ 33.68 Induction system icing. Each engine, with all icing protection systems operating, must— (a) Operate throughout its flight power range (including idling) without the accumulation of ice on the engine components that adversely affects engine operation or that causes a serious loss of power or thrust in continuous maximum and intermittent maximum icing conditions as defined in appendix C of Part 25 of this chapter; and (b) Idle for 30 minutes on the ground, with the available air bleed for icing protection at its critical condition, without adverse effect, in an atmosphere that is at a temperature between 15° and 30 °F (between −9° and −1 °C) and has a liquid water content not less than 0.3 grams per cubic meter in the form of drops having a mean effective diameter not less than 20 microns, followed by a momentary operation at takeoff power or thrust. During the 30 minutes of idle operation the engine may be run up periodically to a moderate power or thrust setting in a manner acceptable to the Administrator.	**33.68 Induction system icing.** Each engine, with all icing protection systems operating, must: (a) Operate throughout its flight power range, including the minimum descent idle rotor speeds achievable in flight, in the icing conditions defined for turbojet, turbofan, and turboprop engines in Appendices C and O of part 25 of this chapter, and Appendix D of this part, and for turboshaft engines in Appendix C of part 29 of this chapter, without the accumulation of ice on the engine components that: (1) Adversely affects engine operation or that causes an unacceptable permanent loss of power or thrust or unacceptable increase in engine operating temperature; or (2) Results in unacceptable temporary power loss or engine damage; or (3) Causes a stall, surge, or flameout or loss of engine controllability. The applicant must account for in-flight ram effects in any critical point analysis or test demonstration of these flight conditions. (b) Operate throughout its flight power range, including minimum descent idle rotor speeds achievable in flight, in the icing conditions defined for turbojet, turbofan, and turboprop engines in Appendices C and O of part 25 of this chapter, and for turboshaft engines in Appendix C of part 29 of this chapter. In addition: (1) It must be shown through Critical Point Analysis (CPA) that the complete ice envelope has been analyzed,	O regulamento evoluiu para tratar de “supercooled large drop”, “mixed phase” e “ice crystal icing” para os motores turbofan, turbojato e turboélice. Essa emenda 34 foi publicada juntamente com a emenda 140 do RBAC 25, que trouxe essas novas condições de formação de gelo para serem tratadas no nível da aeronave.

	and that the most critical points must be demonstrated by engine test, analysis, or a combination of the two to operate acceptably. Extended flight in critical flight conditions such as hold, descent, approach, climb, and cruise, must be addressed, for the ice conditions defined in these appendices. (2) It must be shown by engine test, analysis, or a combination of the two that the engine can operate acceptably for the following durations: (i) At engine powers that can sustain level flight: A duration that achieves repetitive, stabilized operation for turbojet, turbofan, and turboprop engines in the icing conditions defined in Appendices C and O of part 25 of this chapter, and for turboshaft engines in the icing conditions defined in Appendix C of part 29 of this chapter. (ii) At engine power below that which can sustain level flight: (A) Demonstration in altitude flight simulation test facility: A duration of 10 minutes consistent with a simulated flight descent of 10,000 ft (3 km) in altitude while operating in Continuous Maximum icing conditions defined in Appendix C of part 25 of this chapter for turbojet, turbofan, and turboprop engines, and for turboshaft engines in the icing conditions defined in Appendix C of part 29 of this chapter, plus 40 percent liquid water content margin, at the critical level of airspeed and air temperature; or (B) Demonstration in ground test facility: A duration of 3 cycles of alternating icing exposure corresponding to	

the liquid water content levels and standard cloud lengths starting in Intermittent Maximum and then in Continuous Maximum icing conditions defined in Appendix C of part 25 of this chapter for turbojet, turbofan, and turboprop engines, and for turboshaft engines in the icing conditions defined in Appendix C of part 29 of this chapter, at the critical level of air temperature.

(c) In addition to complying with paragraph (b) of this section, the following conditions shown in Table 1 of this section unless replaced by similar CPA test conditions that are more critical or produce an equivalent level of severity, must be demonstrated by an engine test:

TABLE 1—CONDITIONS THAT MUST BE DEMONSTRATED BY AN ENGINE TEST

Condition	**Total air temperature**	**Supercooled water concentrations (minimum)**	**Median volume drop diameter**	**Duration**
1. Glaze ice conditions	21 to 25 °F (−6 to −4 °C)	2 g/m^3	25 to 35 microns	(a) 10-minutes for power below sustainable level flight (idle descent).

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					(b) Must show repetitive, stabilized operation for higher powers (50%, 75%, 100%MC).	
	2. Rime ice conditions	−10 to 0 °F (−23 to −18 °C)	1 g/m^3	15 to 25 microns	(a) 10-minutes for power below sustainable level flight (idle descent).	
					(b) Must show repetitive, stabilized operation for higher powers (50%, 75%,	

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					100%MC).	
	3. Glaze ice holding conditions (Turbojet, turbofan, and turboprop only)	Turbojet and Turbofan, only: 10 to 18 °F (−12 to −8 °C)	Alternating cycle: First 1.7 g/m^3 (1 minute), Then 0.3 g/m^3 (6 minute)	20 to 30 microns	Must show repetitive, stabilized operation (or 45 minutes max).	
		Turboprop, only: 2 to 10 °F (−17 to −12 °C)				
	4. Rime ice holding conditions (Turbojet, turbofan, and turboprop only)	Turbojet and Turbofan, only: −10 to 0 °F (−23 to −18 °C)	0.25 g/m^3	20 to 30 microns	Must show repetitive, stabilized operation (or 45 minutes max).	

	Turboprop, only: 2 to 10 °F (−17 to −12 °C)			

(d) Operate at ground idle speed for a minimum of 30 minutes at each of the following icing conditions shown in Table 2 of this section with the available air bleed for icing protection at its critical condition, without adverse effect, followed by acceleration to takeoff power or thrust. During the idle operation, the engine may be run up periodically to a moderate power or thrust setting in a manner acceptable to the Administrator. Analysis may be used to show ambient temperatures below the tested temperature are less critical. The applicant must document any demonstrated run ups and minimum ambient temperature capability in the engine operating manual as mandatory in icing conditions. The applicant must demonstrate, with consideration of expected airport elevations, the following:

TABLE 2—DEMONSTRATION METHODS FOR SPECIFIC ICING CONDITIONS

Condition	Total air temperature	Supercooled water concentrations (minimum)	Mean effective particle diameter	Demonstration

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1. Rime ice condition	0 to 15 °F (−18 to −9°C)	Liquid—0.3 g/m^3	15-25 microns	By engine test.
2. Glaze ice condition	20 to 30 °F (−7 to −1 °C)	Liquid—0.3 g/m^3	15-25 microns	By engine test.
3. Snow ice condition	26 to 32 °F (−3 to 0 °C)	Ice—0.9 g/m^3	100 microns (minimum)	By test, analysis or combination of the two.
4. Large drop glaze ice condition (Turbojet, turbofan, and turboprop only)	15 to 30 °F (-9 to -1 °C)	Liquid—0.3 g/m^3	100 microns (minimum)	By test, analysis or combination of the two.

(e) Demonstrate by test, analysis, or combination of the two, acceptable operation for turbojet, turbofan, and turboprop engines in mixed phase and ice crystal icing conditions throughout Appendix D of this part, icing envelope throughout its flight power range, including minimum descent idling speeds.

QUADRO COMPARATIVO

33.77		Justificativa
RBAC 33 Emenda 33-33	**RBAC 33 Emenda 33-34**	
§ 33.77 Foreign object ingestion—ice. (a)–(b) [Reserved] (c) Ingestion of ice under the conditions of paragraph (e) of this section may not— (1) Cause a sustained power or thrust loss; or (2) Require the engine to be shutdown. (d) For an engine that incorporates a protection device, compliance with this section need not be demonstrated with respect to foreign objects to be ingested under the conditions prescribed in paragraph (e) of this section if it is shown that— (1) Such foreign objects are of a size that will not pass through the protective device; (2) The protective device will withstand the impact of the foreign objects; and	33.77 Foreign object ingestion—ice. (a) Compliance with the requirements of this section must be demonstrated by engine ice ingestion test or by validated analysis showing equivalence of other means for demonstrating soft body damage tolerance. (b) [Reserved] (c) Ingestion of ice under the conditions of this section may not— (1) Cause an immediate or ultimate unacceptable sustained power or thrust loss; or (2) Require the engine to be shutdown. (d) For an engine that incorporates a protection device, compliance with this section need not be demonstrated with respect to ice formed forward of the protection device if it is shown that— (1) Such ice is of a size that will not pass through the protective device; (2) The protective device will withstand the impact of the ice; and (3) The ice stopped by the protective device will not obstruct the flow of induction air into the engine with a resultant sustained reduction in power or thrust greater than those values defined by paragraph (c) of this section. (e) Compliance with the requirements of this section must be demonstrated by engine ice ingestion test under the following ingestion conditions or by validated analysis	Apesar de não mencionar explicitamente SLD, mixed phase ou ice crystals, a alteração no 33.77 foi motivada pela criação dos novos apêndices O do RBAC 25 (SLD) e D do RBAC 33 (mixed phase e ice crystals). A alteração faz parte do “pacote” da emenda 34

QUADRO COMPARATIVO

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(3) The foreign object, or objects, sped by the protective device will not obstruct the flow of

induction air into the engine with a resultant sustained reduction in power or thrust greater than

those values required by paragraph (c) of this section.

(e) Compliance with paragraph (c) of this section must be shown by engine test under the following

ingestion conditions:

(1) Ice quantity will be the maximum accumulation on a typical inlet cowl and engine face resulting

from a 2-minute delay in actuating the anti-icing system; or a slab of ice which is comparable in

weight or thickness for that size engine.

(2) The ingestion velocity will simulate ice being sucked into the engine inlet.

(3) Engine operation will be maximum cruise power or thrust.

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showing equivalence of other means for demonstrating soft body damage tolerance.

(1) The minimum ice quantity and dimensions will be established by the engine size as defined in Table 1 of this section.

(2) The ingested ice dimensions are determined by linear interpolation between table values and are based on the actual engine's inlet hilite area.

(3) The ingestion velocity will simulate ice from the inlet being sucked into the engine.

(4) Engine operation will be at the maximum cruise power or thrust unless lower power is more critical.

TABLE 1—MINIMUM ICE SLAB DIMENSIONS BASED ON ENGINE INLET SIZE

Engine Inlet Hilite area (sq. inch)	Thickness (inch)	Width (inch)	Length (inch)
0	0.25	0	3.6
80	0.25	6	3.6
300	0.25	12	3.6
700	0.25	12	4.8
2800	0.35	12	8.5
5000	0.43	12	11.0

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<td>(4) The ingestion will simulate a continuous maximum icing encounter at 25 degrees Fahrenheit.</td>
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<tr><td>7000</td><td>0.50</td><td>12</td><td>12.7</td></tr>
<tr><td>7900</td><td>0.50</td><td>12</td><td>13.4</td></tr>
<tr><td>9500</td><td>0.50</td><td>12</td><td>14.6</td></tr>
<tr><td>11300</td><td>0.50</td><td>12</td><td>15.9</td></tr>
<tr><td>13300</td><td>0.50</td><td>12</td><td>17.1</td></tr>
<tr><td>16500</td><td>0.5</td><td>12</td><td>18.9</td></tr>
<tr><td>20000</td><td>0.5</td><td>12</td><td>20.0</td></tr>
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Apêndice C ao RBAC 33		Justificativa
RBAC 33 Emenda 33-33	**Emenda 33-34**	
	14 CFR Part 33	
Apêndice C: Inexistente	Reserved	O apêndice C foi adicionado e reservado.

Apêndice D ao RBAC 33		Justificativa
RBAC 33 Emenda 33-33	**Emenda 33-34**	
	14 CFR Part 33	
Apêndice D: Inexistente	Appendix D to Part 33—Mixed Phase and Ice Crystal Icing Envelope (Deep Convective Clouds) The ice crystal icing envelope is depicted in Figure D1 of this Appendix.	O apêndice D faz parte do “pacote” da emenda 34, que impôs aos motores novas condições de formação de gelo a serem consideradas: fase mista e cristais de gelo.

QUADRO COMPARATIVO

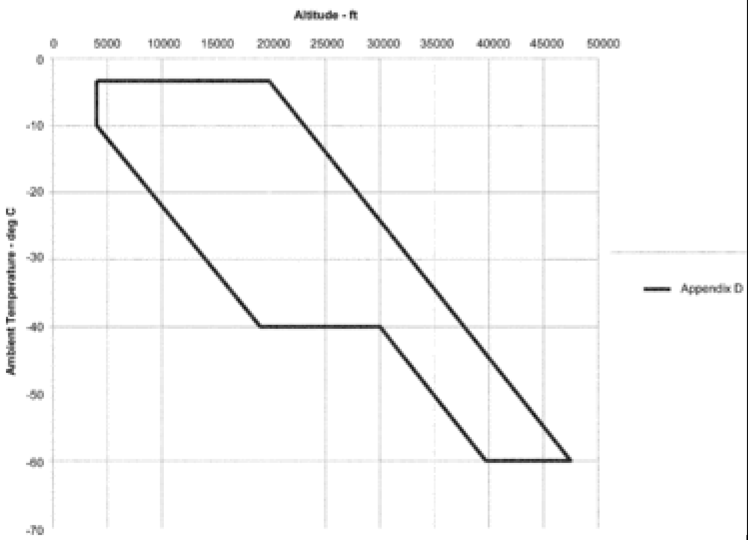
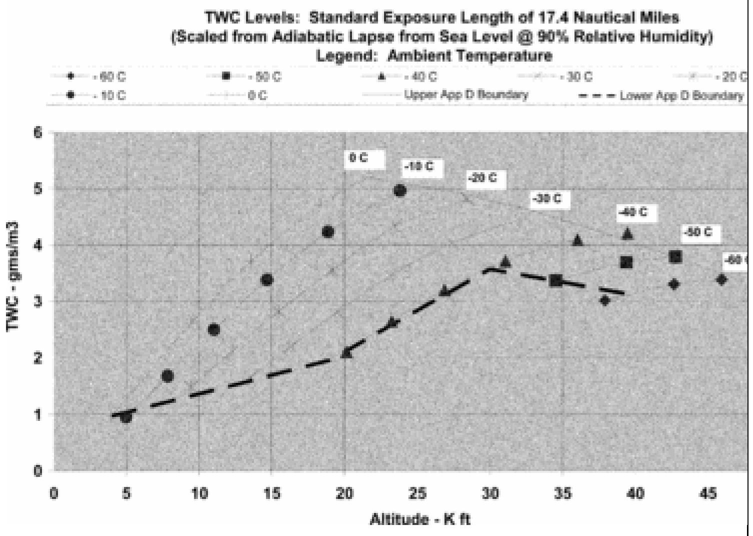
	FIGURE D1 — Convective Cloud Ice Crystal Envelope  Within the envelope, total water content (TWC) in g/m^3 has been determined based upon the adiabatic lapse defined by the convective rise of 90% relative humidity air from sea level to higher altitudes and scaled by a factor of 0.65 to a standard cloud length of 17.4 nautical miles. Figure D2 of this Appendix displays TWC for this distance over a range of ambient temperature within the boundaries of the ice crystal envelope specified in Figure D1 of this Appendix.	É no apêndice D que tais condições da natureza são descritas.

FIGURE D2 — Total Water Content



Ice crystal size median mass dimension (MMD) range is 50-200 microns (equivalent spherical size) based upon measurements near convective storm cores.

The TWC can be treated as completely glaciated (ice crystal) except as noted in the Table 1 of this Appendix.

TABLE 1—SUPERCOOLED LIQUID PORTION OF TWC

Temperature range—deg C	Horizontal cloud length—nautical miles	LWC—g/m^3

0 to −20	≤50	≤1.0
0 to −20	Indefinite	≤0.5
< −20		0

The TWC levels displayed in Figure D2 of this Appendix represent TWC values for a standard exposure distance (horizontal cloud length) of 17.4 nautical miles that must be adjusted with length of icing exposure.

FIGURE D3 — Exposure Length Influence on TWC