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DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 25

[Docket No. NM246; Special Conditions No. 25–231–SC]

Special Conditions: Embraer Model 170–100 and 170–200 Airplanes; Sudden Engine Stoppage; Operation Without Normal Electrical Power; Interaction of Systems and Structures

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Final special conditions.

SUMMARY: These special conditions are issued for the Embraer Model 170–100 and 170–200 airplanes. These airplanes will have novel or unusual design features when compared to the state of technology envisioned in the airworthiness standards for transport category airplanes. These design features are associated with engine size and torque load which affect sudden engine stoppage, electrical and electronic flight control systems which perform critical functions, and systems which affect the structural performance of the airplane. The applicable airworthiness regulations do not contain adequate or appropriate safety standards for these design features. These special conditions contain the additional safety standards that the Administrator considers necessary to establish a level of safety equivalent to that established by the existing airworthiness standards. Additional special conditions will be issued for other novel or unusual design features of the Embraer Model 170–100 and 170–200 airplanes.

EFFECTIVE DATE: April 10, 2003.

FOR FURTHER INFORMATION CONTACT: Tom Groves, FAA, International Branch, ANM–116, Transport Airplane Directorate, Aircraft Certification Service, 1601 Lind Avenue SW., Renton, Washington 98055–4056; telephone (425) 227–1503; facsimile (425) 227–1149.

SUPPLEMENTARY INFORMATION:

Background

On May 20, 1999, Embraer applied for a type certificate for its new Model 170 airplane. Two basic versions of the Model 170 are included in the application. The Model 170–100 airplane is a 69–78 passenger twin-engine regional jet with a maximum takeoff weight of 81,240 pounds. The Model 170–200 is a lengthened fuselage derivative of the 170–100. Passenger capacity for the Model 170–200 is increased to 86, and maximum takeoff weight is increased to 85,960 pounds.

Type Certification Basis

Under the provisions of 14 CFR 21.17, Embraer must show that the Model 170–100 and 170–200 airplanes meet the applicable provisions of 14 CFR part 25, as amended by Amendments 25–1 through 25–98.

If the Administrator finds that the applicable airworthiness regulations (*i.e.,* part 25, as amended) do not contain adequate or appropriate safety standards for the Embraer Model 170–100 and 170–200 airplanes because of novel or unusual design features, special conditions are prescribed under the provisions of § 21.16.

In addition to the applicable airworthiness regulations and special conditions, the Embraer Model 170–100 and 170–200 airplanes must comply with the fuel vent and exhaust emission requirements of 14 CFR part 34 and the noise certification requirements of 14 CFR part 36, and the FAA must issue a finding of regulatory adequacy pursuant to § 611 of Public Law 93–574, the ''Noise Control Act of 1972.''

Special conditions, as defined in 14 CFR 11.19, are issued in accordance with § 11.38 and become part of the type certification basis in accordance with § 21.17(a)(2), Amendment 21–69, effective September 16, 1991.

Special conditions are initially applicable to the model for which they are issued. Should the type certificate for that model be amended later to include any other model that incorporates the same novel or unusual design feature, or should any other model already included on the same type certificate be modified to incorporate the same novel or unusual design features, the special conditions would also apply to the other model under the provisions of § 21.101(a)(1), Amendment 21–69, effective September 16, 1991.

Novel or Unusual Design Features

The Embraer Model 170–100 and 170–200 airplanes will incorporate the following novel or unusual design features:

Engine Size and Torque Load

Since 1957, the limit engine torque load which is posed by sudden engine stoppage due to malfunction or structural failure'such as compressor jamming'has been a specific requirement for transport category airplanes. Design torque loads associated with typical failure scenarios were estimated by the engine manufacturer and provided to the airframe manufacturer as limit loads. These limit loads were considered simple, pure torque static loads. However, the size, configuration, and failure modes of jet engines have changed considerably from those envisioned when the engine seizure requirement of § 25.361(b) was first adopted. Current engines are much larger and are now designed with large bypass fans capable of producing much larger torque, if they become jammed.

Relative to the engine configurations that existed when the rule was developed in 1957, the present generation of engines is sufficiently different and novel to justify issuance of special conditions to establish appropriate design standards. The latest generation of jet engines is capable of producing, during failure, transient loads that are significantly higher and more complex than the generation of engines that were present when the existing standard was developed. Therefore, the FAA has determined that special conditions are needed for the Embraer Model 170–100 and 170–200 airplanes.

Electrical and Electronic Systems Which Perform Critical Functions

The Embraer Model 170–100 and 170–200 airplanes will have an electronic flight control system which performs critical functions. The current airworthiness standards of part 25 do not contain adequate or appropriate standards for the protection of this system from the adverse effects of operations without normal electrical power. Accordingly, this system is considered to be a novel or unusual design feature. Since the loss of normal electrical power may be catastrophic to the airplane, special conditions are proposed to retain the level of safety envisioned by 14 CFR 25.1351(d).

Interactions of Systems and Structures

The Embraer Model 170–100 and 170–200 airplanes will have systems that affect the structural performance of the airplane, either directly or as a result of a failure or malfunction. These novel or unusual design features are systems that can alleviate loads in the airframe and, when in a failure state, can create loads in the airframe. The current regulations do not adequately account for the effects of these systems and their failures on structural performance.

Discussion

Engine Size and Torque Loads

In order to maintain the level of safety envisioned in 14 CFR 25.361(b), a more comprehensive criterion is needed for the new generation of high bypass engines. These special conditions would distinguish between the more common seizure events and those rarer seizure events resulting from structural failures. For the rare but severe seizure events, the specified criteria allow some deformation in the engine supporting structure (ultimate load design) in order to absorb the higher energy associated with the high bypass engines, while at the same time protecting the adjacent primary structure in the wing and fuselage by providing a higher safety factor. The criteria for the more severe events would no longer be a pure static torque load condition, but would account for the full spectrum of transient dynamic loads developed from the engine failure condition.

Electrical and Electronic Systems Which Perform Critical Functions

The Embraer Model 170–100 and 170–200 airplanes will require a continuous source of electrical power for the electronic flight control systems. Section 25.1351(d), ''Operation without normal electrical power,'' requires safe operation in visual flight rule (VFR) conditions for a period of not less than five minutes with inoperative normal power. This rule was structured around a traditional design utilizing mechanical connections between the flight control surfaces and the pilot controls. Such traditional designs enable the flightcrew to maintain control of the airplane while taking the time to sort out the electrical failure, start engines if necessary, and re-establish some of the electrical power generation capability.

The Embraer Model 170–100 and 170–200 airplanes will utilize an electronic flight control system for the pitch and yaw control (elevator, stabilizer, and rudder). There is no mechanical linkage between the pilot controls and these flight control surfaces. Pilot control inputs are converted to electrical signals, which are processed and then transmitted via wires to the control surface actuators. At the control surface actuators, the electrical signals are converted to an actuator command, which moves the control surface.

In order to maintain the same level of safety as an airplane with conventional flight controls, an airplane with electronic flight controls, such as the Embraer Model 170, must not be time limited in its operation, including being without the normal source of electrical power generated by the engine or the Auxiliary Power Unit (APU) generators.

Service experience has shown that the loss of all electrical power generated by the airplane's engine generators or APU is not extremely improbable. Thus, it must be demonstrated that the airplane can continue safe flight and landing (including steering and braking on ground) after total loss of the normal electrical power with only the use of its emergency electrical power systems. These emergency electrical power systems must be able to power loads that are essential for continued safe flight and landing. The emergency electrical power system must be designed to supply electrical power for the following:

- Immediate safety, without the need for crew action, following the loss of the normal engine generator electrical power system (which includes APU power), and
- Continued safe flight and landing, and
- Restarting the engines.

For compliance purposes, a test of the loss of normal engine generator power must be conducted to demonstrate that when the failure condition occurs during night Instrument Meteorological Conditions (IMC), at the most critical phase of the flight relative to the electrical power system design and distribution of equipment loads on the system, the following conditions are met:

1. After the unrestorable loss of normal engine and APU generator power, the airplane engine restart capability must be provided and operations continued in IMC.

2. The airplane is demonstrated to be capable of continued safe flight and landing. The length of time must be computed based on the maximum diversion time capability for which the airplane is being certified. Consideration for speed reductions resulting from the associated failure must be made.

3. The availability of APU operation should not be considered in establishing emergency power system adequacy.

Interaction of Systems and Structure

The Embraer Model 170 has systems that affect the structural performance of the airplane. These systems can serve to alleviate loads in the airframe and, when in a failure state, can create loads in the airframe. This degree of system and structures interaction was not envisioned in the structural design regulations of 14 CFR part 25. These special conditions provide comprehensive structural design safety margins as a function of systems reliability.

Discussion of Comments

Notice of proposed special conditions No. NM246 for the Embraer Model 170–100 and 170–200 airplanes was published in the **Federal Register** dated February 3, 2003 (68 FR 5241). No comments were received, and the special conditions are adopted as proposed.

Applicability

As discussed above, these special conditions are applicable to the Embraer Model 170–100 and 170–200 airplanes. Should Embraer apply at a later date for a change to the type certificate to include another model incorporating the same novel or unusual design features, these special conditions would apply to that model as well under the provisions of § 21.101(a)(1), Amendment 21–69, effective September 16, 1991.

Under standard practice, the effective date of final special conditions would be 30 days after the date of publication in the **Federal Register**; however, as the certification date for the Embraer Model 170–100 and –200 is imminent, the FAA finds good cause to make these special conditions effective upon issuance.

Conclusion

This action affects only certain novel or unusual design features on the Embraer Model 170–100 and 170–200 airplanes. It is not a rule of general applicability, and it affects only the applicant who applied to the FAA for approval of these features on the airplane.

List of Subjects in 14 CFR Part 25

Aircraft, Aviation safety, Reporting and recordkeeping requirements.

■ The authority citation for 14 CFR part 25, for these special conditions, is as follows:

Authority: 49 U.S.C. 106(g), 40113, 44701, 44702, 44704.

PART 25—AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES

The Special Conditions

■ Accordingly, pursuant to the authority delegated to me by the Administrator, the following special conditions are issued as part of the type certification basis for Embraer Model 170–100 and 170–200 airplanes.

Sudden Engine Stoppage. In lieu of compliance with 14 CFR 25.361(b), the following special conditions apply:

1. For turbine engine installations: The engine mounts, pylons and adjacent supporting airframe structure must be designed to withstand 1g level flight loads acting simultaneously with the maximum limit torque loads imposed by each of the following:

a. Sudden engine deceleration due to a malfunction which could result in a temporary loss of power or thrust.

b. The maximum acceleration of the engine.

2. For auxiliary power unit installations: The power unit mounts and adjacent supporting airframe structure must be designed to withstand 1g level flight loads acting simultaneously with the maximum limit torque loads imposed by the each of the following:

a. Sudden auxiliary power unit deceleration due to malfunction or structural failure.

b.The maximum acceleration of the auxiliary power unit.

3. For an engine supporting structure: An ultimate loading condition must be considered that combines 1g flight loads with the transient dynamic loads resulting from each of the following:

a. The loss of any fan, compressor, or turbine blade.

b. Where applicable to a specific engine design, and separately from the conditions specified in paragraph 3.a., any other engine structural failure that results in higher loads.

4. The ultimate loads developed from the conditions specified in paragraphs 3.a. and 3.b. above must be multiplied by a factor of 1.0 when applied to engine mounts and pylons and multiplied by a factor of 1.25 when applied to adjacent supporting airframe structure.

Operation Without Normal Electrical Power. In lieu of compliance with 14 CFR 25.1351(d), the following special conditions apply:

It must be demonstrated by test or by a combination of test and analysis, that the airplane can continue safe flight and landing with inoperative normal engine and APU generator electrical power (in other words, without electrical power from any source, except for the battery and any other standby electrical sources). The airplane operation should be considered at the critical phase of flight and include the ability to restart the engines and maintain flight for the maximum diversion time capability being certified.

Interaction of Systems and Structures: In lieu of compliance with 14 CFR 25.1351(d), the following special conditions apply:

1. *General:* For airplanes equipped with systems that affect structural performance, either directly or as a result of a failure or malfunction, the influence of these systems and their failure conditions must be taken into account when showing compliance with the requirements of 14 CFR part 25, subparts C and D. The following criteria must be used for showing compliance with these special conditions for airplanes equipped with flight control systems, autopilots, stability augmentation systems, load alleviation systems, flutter control systems, and fuel management systems. If these special conditions are used for other systems, it may be necessary to adapt the criteria to the specific system.

a. The criteria defined herein address only the direct structural consequences of the system responses and performances and cannot be considered in isolation but should be included in the overall safety evaluation of the airplane. These criteria may in some instances duplicate standards already established for this evaluation. These criteria are only applicable to structures whose failure could prevent continued safe flight and landing. Specific criteria that define acceptable limits on handling characteristics or stability requirements when operating in the system degraded or inoperative modes are not provided in these special conditions.

b. Depending upon the specific characteristics of the airplane, additional studies that go beyond the criteria provided in these special conditions may be required in order to demonstrate the capability of the airplane to meet other realistic conditions, such as alternative gust or maneuver descriptions, for an airplane equipped with a load alleviation system.

c. The following definitions are applicable to these special conditions.

Structural performance: Capability of the airplane to meet the structural requirements of 14 CFR part 25.

Flight limitations: Limitations that can be applied to the airplane flight conditions following an in-flight occurrence and that are included in the flight manual (*e.g.*, speed limitations, avoidance of severe weather conditions, etc.).

Operational limitations: Limitations, including flight limitations that can be applied to the airplane operating conditions before dispatch (*e.g.*, fuel, payload, and Master Minimum Equipment List limitations).

Probabilistic terms: The probabilistic terms (probable, improbable, extremely improbable) used in these special conditions are the same as those used in § 25.1309.

Failure condition: The term failure condition is the same as that used in § 25.1309; however, these special conditions apply only to system failure conditions that affect the structural performance of the airplane (*e.g.*, system failure conditions that induce loads, lower flutter margins, or change the response of the airplane to inputs such as gusts or pilot actions).

2. *Effects of Systems on Structures.* The following criteria will be used in determining the influence of a system and its failure conditions on the airplane structure.

a. System fully operative. With the system fully operative, the following apply:

(1) Limit loads must be derived in all normal operating configurations of the system from all the limit conditions specified in subpart C, taking into account any special behavior of such a system or associated functions, or any effect on the structural performance of the airplane that may occur up to the limit loads. In particular, any significant nonlinearity (rate of displacement of control surface, thresholds, or any other system nonlinearities) must be accounted for in a realistic or conservative way when deriving limit loads from limit conditions.

(2) The airplane must meet the strength requirements of part 25 (static strength, residual strength), using the specified factors to derive ultimate loads from the limit loads defined above. The effect of nonlinearities must be investigated beyond limit conditions to ensure the behavior of the system presents no anomaly compared to the behavior below limit conditions.

However, conditions beyond limit conditions need not be considered when it can be shown that the airplane has design features that will not allow it to exceed those limit conditions.

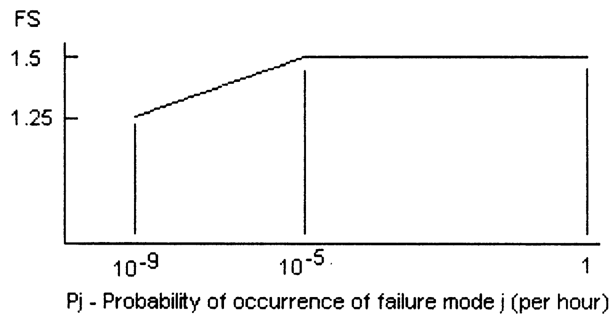
(3) The airplane must meet the aeroelastic stability requirements of § 25.629.

b. System in the failure condition. For any system failure condition not shown to be extremely improbable, the following apply:

(1) At the time of occurrence. Starting from 1-g level flight conditions, a realistic scenario, including pilot corrective actions, must be established to determine the loads occurring at the time of failure and immediately after failure.

(i) For static strength substantiation, these loads multiplied by an appropriate factor of safety that is related to the probability of occurrence of the failure are ultimate loads to be considered for design. The factor of safety (FS) is defined in Figure 1.

Figure 1
Factor of safety at the time of occurrence



(ii) For residual strength substantiation, the airplane must be able to withstand two-thirds of the ultimate loads defined in paragraph 2.(b)(1)(i) above.

(iii) Freedom from aeroelastic instability must be shown up to the speeds defined in § 25.629(b)(2). For failure conditions that result in speed increases beyond Vc/Mc, freedom from aeroelastic instability must be shown to increased speeds, so that the margins intended by § 25.629(b)(2) are maintained.

(iv) Failures of the system that result in forced structural vibrations (oscillatory failures) must not produce loads that could result in detrimental deformation of primary structure.

(2) For the continuation of the flight. For the airplane in the system failed state and considering any appropriate reconfiguration and flight limitations, the following apply:

(i) The loads derived from the following conditions at speeds up to Vc, or the speed limitation prescribed for the remainder of the flight, must be determined:

(A) The limit symmetrical maneuvering conditions specified in §§ 25.331 and 25.345.

(B) The limit gust and turbulence conditions specified in §§ 25.341 and 25.345.

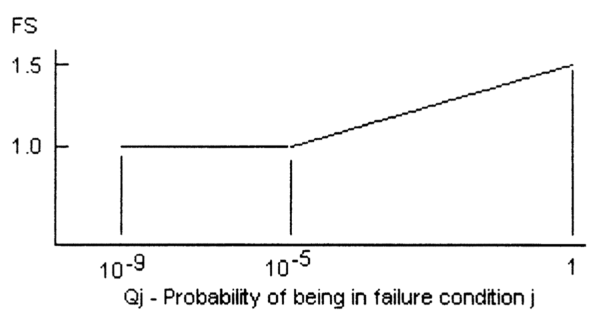
(C) The limit rolling conditions specified in § 25.349, and the limit unsymmetrical conditions specified in § 25.367 and § 25.427(b) and (c).

(D) The limit yaw maneuvering conditions specified in § 25.351.

(E) The limit ground loading conditions specified in §§ 25.473 and 25.491.

(ii) For static strength substantiation, each part of the structure must be able to withstand the loads defined in paragraph 2.(b)(2)(i) above, multiplied by a factor of safety depending on the probability of being in this failure state. The factor of safety is defined in Figure 2.

Figure 2
Factor of safety for continuation of flight



$Q_j = (T_j)(P_j)$ where:
T_j = Average time spent in failure condition j (in hours).
P_j = Probability of occurrence of failure mode j (per hour).

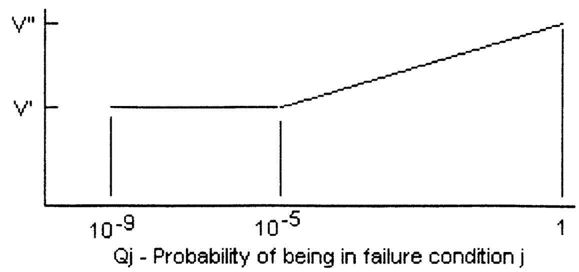
Note: If P_j is greater than 10^{-3} per flight hour, then a 1.5 factor of safety must be applied to all limit load conditions specified in subpart C.

(iii) For residual strength substantiation, the airplane must be able to withstand two thirds of the ultimate loads defined in paragraph 2.(b)(2)(ii) above.

(iv) If the loads induced by the failure condition have a significant effect on fatigue or damage tolerance, then their effects must be taken into account.

(v) Freedom from aeroelastic instability must be shown up to a speed determined from Figure 3. Flutter clearance speeds VI and VII may be based on the speed limitation specified for the remainder of the flight using the margins defined by § 25.629(b).

Figure 3
Clearance speed



VI = Clearance speed as defined by § 25.629(b)(2).
VII = Clearance speed as defined by § 25.629(b)(1).
$Q_j = (T_j)(P_j)$ where:
T_j = Average time spent in failure condition j (in hours).
P_j = Probability of occurrence of failure mode j (per hour).

Note: If P_j is greater than 10^{-3} per flight hour, then the flutter clearance speed must not be less than VII.

(vi) Freedom from aeroelastic instability must also be shown up to VI in Figure 3 above for any probable system failure condition combined with any damage required or selected for investigation by § 25.571(b).

(3) Consideration of certain failure conditions may be required by other sections of 14 CFR part 25, regardless of calculated system reliability. Where analysis shows the probability of these failure conditions to be less than 10^{-9}, criteria other than those specified in this paragraph may be used for structural substantiation to show continued safe flight and landing.

c. Warning considerations. For system failure detection and warning, the following apply:

(1) The system must be checked for failure conditions, not extremely improbable, that degrade the structural capability below the level required by 14 CFR part 25, or significantly reduce the reliability of the remaining system. The flightcrew must be made aware of these failures before flight. Certain elements of the control system, such as mechanical and hydraulic components, may use special periodic inspections, and electronic components may use daily checks, in lieu of warning systems, to achieve the objective of this requirement. These certification maintenance requirements must be limited to components that are not readily detectable by normal warning systems and where service history shows that inspections will provide an adequate level of safety.

(2) The existence of any failure condition, not extremely improbable, during flight that could significantly affect the structural capability of the airplane, and for which the associated reduction in airworthiness can be minimized by suitable flight limitations, must be signaled to the flightcrew. For example, failure conditions that result in a factor of safety between the airplane strength and the loads of 14 CFR part 25, subpart C below 1.25, or flutter margins below VII, must be signaled to the crew during flight.

d. Dispatch with known failure conditions. If the airplane is to be dispatched in a known system failure condition that affects structural performance, or affects the reliability of the remaining system to maintain structural performance, then the provisions of these special conditions must be met for the dispatched condition and for subsequent failures. Flight limitations and expected operational limitations may be taken into account in establishing Qj as the combined probability of being in the dispatched failure condition and the subsequent failure condition for the safety margins in Figures 2 and 3. These limitations must be such that the probability of being in this combined failure state and then subsequently encountering limit load conditions is extremely improbable. No reduction in these safety margins is allowed if the subsequent system failure rate is greater than 10^{-3} per hour.

Issued in Renton, Washington, on April 10, 2003.

Ali Bahrami,
Acting Manager, Transport Airplane Directorate, Aircraft Certification Service.

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BILLING CODE 4910–13–P

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 39

[Docket No. 2003–NM–15–AD; Amendment 39–13124; AD 2003–08–11]

RIN 2120–AA64

Airworthiness Directives; Boeing Model 747–100, –200B, –200F, –200C, –100B, –300, –100B SUD, –400, –400D, and –400F Series Airplanes; and Model 747SR Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule; request for comments.

SUMMARY: This amendment adopts a new airworthiness directive (AD) that is applicable to all Boeing Model 747–100, –200B, –200F, –200C, –100B, –300, –100B SUD, –400, –400D, and –400F series airplanes; and Model 747SR