[4910-13]

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 25

[Docket No. FAA-2012-1246; Special Conditions No. 25-481-SC]

Special Conditions: Embraer S.A., Model EMB-550 Airplane; Interaction of Systems and Structures.

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Final special conditions.

SUMMARY: These special conditions are issued for the Embraer S.A. Model EMB-550 airplane. This airplane will have a novel or unusual design feature(s) associated with the interaction of systems and structures. The applicable airworthiness regulations do not contain adequate or appropriate safety standards for this design feature. 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.

DATES: Effective date: **[Insert date 30 days after date of publication in the *Federal Register*]**.

FOR FURTHER INFORMATION CONTACT: Todd Martin, FAA, Airframe and Cabin Safety Branch, ANM-115, Transport Airplane Directorate, Aircraft Certification Service, 1601 Lind Avenue SW, Renton, Washington, 98057-3356; telephone 425-227-1178; facsimile 425-227-1232.

SUPPLEMENTARY INFORMATION:

Background

On May 14, 2009, Embraer S.A. applied for a type certificate for their new Model EMB-550 airplane. The Model EMB-550 airplane is the first of a new family of jet airplanes designed for corporate flight, fractional, charter, and private owner operations. The aircraft has a conventional configuration with low wing and T-tail empennage. The primary structure is metal with composite empennage and control surfaces. The Model EMB-550 airplane is designed for 8 passengers, with a maximum of 12 passengers. It is equipped with two Honeywell HTF7500-E medium bypass ratio turbofan engines mounted on aft fuselage pylons. Each engine produces approximately 6,540 pounds of thrust for normal takeoff. The primary flight controls consist of hydraulically powered fly-by-wire elevators, aileron and rudder, controlled by the pilot or copilot sidestick.

The Model Embraer EMB-550 airplane is equipped with systems that, directly or as a result of failure or malfunction, affect its structural performance. Current regulations do not take into account loads for the airplane due to the effects of systems on structural performance including normal operation and failure conditions with strength levels related to probability of occurrence. Special conditions are needed to account for these features.

Type Certification Basis

Under the provisions of Title 14, Code of Federal Regulations (14 CFR) 21.17, Embraer S.A. must show that the Model EMB-550 airplane meets the applicable provisions of part 25, as amended by Amendments 25-1 through 25-127 thereto.

If the Administrator finds that the applicable airworthiness regulations (i.e., 14 CFR part 25) do not contain adequate or appropriate safety standards for the Model EMB-550 airplane because of a novel or unusual design feature, special conditions are prescribed under the provisions of § 21.16.

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 or similar novel or unusual design feature, the special conditions would also apply to the other model under § 21.101.

In addition to the applicable airworthiness regulations and special conditions, the Embraer S.A. Model EMB-550 airplane 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 under section 611 of Public Law 92-574, the "Noise Control Act of 1972."

The FAA issues special conditions, as defined in 14 CFR 11.19, in accordance with § 11.38, and they become part of the type-certification basis under § 21.17(a)(2).

Novel or Unusual Design Features

The Embraer S.A. Model EMB-550 airplane is equipped with systems that, directly or as a result of failure or malfunction, affect its structural performance. Current regulations do not take into account loads for the airplane due to the effects of systems on structural performance including normal operation and failure conditions with strength levels related to probability of occurrence. Special conditions are needed to account for these features.

These special conditions define criteria to be used in the assessment of the effects of these systems on structures. The general approach of accounting for the effect of system failures on structural performance would be extended to include any system in which partial or complete failure, alone or in combination with other system partial or complete failures, would affect structural performance.

Discussion

These airplanes are equipped with systems that, directly or as a result of failure or malfunction, affect its structural performance. Current regulations do not take into account loads for the aircraft due to the effects of systems on structural performance including normal operation and failure conditions with strength levels related to probability of occurrence. These special conditions define criteria to be used in the assessment of the effects of these systems on structures.

Special conditions have been applied on past airplane programs to require consideration of the effects of systems on structures. The regulatory authorities and industry developed standardized criteria in the Aviation Rulemaking Advisory Committee (ARAC) forum based on the criteria defined in Advisory Circular 25.672, *Active Flight Controls*, dated November 11, 1983. The ARAC recommendations have been incorporated in European Aviation Safety Agency (EASA) Certification Specifications (CS) 25.302 and CS 25 Appendix K. FAA rulemaking on this subject is not complete, thus the need for the special conditions.

The proposed special conditions are similar to those previously applied to other airplane models and to CS 25.302. The major differences between these proposed special conditions and the current CS 25.302 are as follows:

1. Both these special conditions and CS 25.302 specify the design load conditions to be considered. In paragraphs 2(a)(1) and 2(b)(2)(i) of these special conditions, the special conditions clarify that, in some cases, different load conditions are to be considered due to other special conditions or equivalent level of safety findings.
2. Paragraph 2(b)(2)(i) of these special conditions include the additional ground-handling conditions of §§ 25.493(d) and 25.503. These conditions are added in case the Embraer S.A. Model EMB-550 airplane has systems that affect braking and pivoting.
3. Both CS 25.302 and paragraph (2)(d) of these special conditions allow consideration of the probability of being in a dispatched configuration when assessing subsequent failures and potential "continuation of flight" loads. However, these special conditions also allow using probability when assessing failures that induce loads at the "time of occurrence," whereas CS 25.302 does not.

Discussion of Comments

Notice of proposed special conditions No. 25-12-16-SC for the Embraer S.A. Model EMB-550 airplanes was published in the *Federal Register* on November 28, 2012, (77 FR 70941). No comments were received, and the special conditions are adopted as proposed.

Applicability

As discussed above, these special conditions are applicable to the Embraer S.A. Model EMB-550 airplane. Should Embraer S.A. apply at a later date for a change to the type certificate to include another model incorporating the same novel or unusual design feature, the special conditions would apply to that model as well.

Conclusion

This action affects only certain novel or unusual design features on one model of airplanes. It is not a rule of general applicability.

List of Subjects in 14 CFR Part 25

Aircraft, Aviation safety, Reporting and recordkeeping requirements.

The authority citation for these special conditions is as follows:

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

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 S.A. Model EMB-550 airplanes to address the effects of systems on structures.

1. General interaction of systems and structures.

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 Title 14, Code of Federal Regulations (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, fuel management systems, and other systems that either directly or as a result of failure or malfunction affect structural performance. 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 only address 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 structure in which 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 mode are not provided in these special conditions.

(b) The following definitions are applicable to these special conditions.

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

(2) 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 and avoidance of severe weather conditions).

(3) 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).

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

(5) 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,

change the response of the airplane to inputs such as gusts or pilot actions, or lower flutter margins).

2. Effect on Systems and Structures. The following criteria are 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 (or defined by special condition or equivalent level of safety in lieu of those 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.

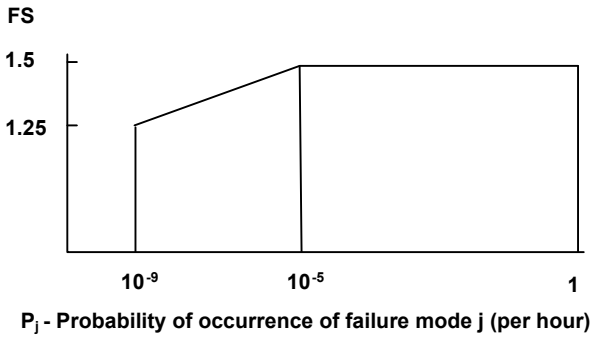

Figure 1: Factor of safety at the time of occurrence

(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) of these special conditions. For pressurized cabins, these loads must be combined with the normal operating differential pressure.

(iii) Freedom from aeroelastic instability must be shown up to the speeds defined in § 25.629(b)(2). For failure conditions that result in speeds beyond V_C/M_C, 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 (e.g., 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 (or conditions defined by special conditions or equivalent level of safety in lieu of the following special conditions) at speeds up to V_C/M_C, 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, 25.427(b), and 25.427(c).

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

(E) The limit ground loading conditions specified in §§ 25.473, 25.491, 25.493(d) and 25.503.

(ii) For static strength substantiation, each part of the structure must be able to withstand the loads in paragraph 2(b)(2)(i) of these special conditions. multiplied by a

factor of safety depending on the probability of being in this failure state. The factor of safety (FS) is defined in Figure 2.

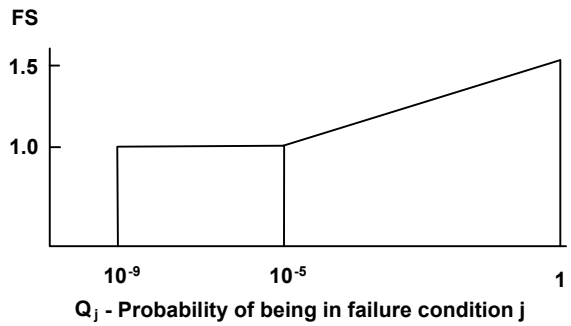

Figure 2: Factor of safety for continuation of flight

$Q_j = (T_j)(P_j)$ 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) of the special conditions. For pressurized cabins, these loads must be combined with the normal operating differential pressure.

(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 V' and V" may be based on the speed limitation specified for the remainder of the flight using the margins defined by § 25.629(b).

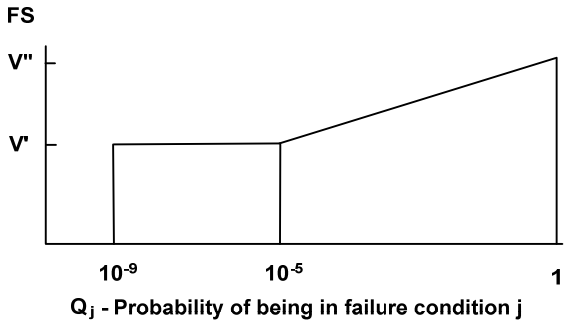

Figure 3: Clearance speed

V' = Clearance speed as defined by § 25.629(b)(2).
V" = 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 V".

(vi) Freedom from aeroelastic instability must also be shown up to V' 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) Failure indications. For system failure detection and indication, 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. As far as reasonably practicable, 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 detection and indication systems to achieve the objective of this requirement. These certification maintenance requirements must be limited to components that are not readily detectable by normal detection and indication 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 Subpart C below 1.25, or flutter margins below V", must be signaled to the flightcrew 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, including the provisions of paragraph 2(a) for the dispatched condition, and paragraph 2(b) for subsequent failures. Expected operational limitations may be taken into account in establishing P_j as the probability of failure occurrence for determining the safety margin in Figure 1 of these special conditions. Flight limitations and expected operational limitations may be taken into account in establishing Q_j 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 of these special conditions. 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 February 12, 2013.

Ali Bahrami
Manager, Transport Airplane Directorate
Aircraft Certification Service

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