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DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 25

[Docket No. NM357; Special Conditions No. 25–347–SC]

Special Conditions: Boeing Model 737–900ER series airplanes; Interaction of Systems and Structures

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Final special conditions.

SUMMARY: This special condition is issued for the Boeing Model 737–900ER 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. This special condition contains 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:* March 19, 2007.

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SUPPLEMENTARY INFORMATION:

Background

On June 5, 2002, The Boeing Company, PO Box 3707, Seattle, Washington 98124, applied for an amendment to Type Certificate No. A16WE, to include the new Model 737–900ER. The Model 737–900ER, which is a derivative of the Model 737–900 currently approved under A16WE, is a large transport airplane with two flight crew and the capacity to carry 215 passengers. The airplane is powered by two CFMI CFM56–7 series turbofan engines.

Type Certification Basis

Under the provisions of § 21.101, Boeing must show that the Model 737–900ER meets the applicable provisions of 14 CFR part 25, as amended by Amendments 25–1 through 25–108, except for earlier amendments as agreed upon by the FAA. These regulations will be incorporated into the Type Certificate No. A16WE after type certification approval of the 737–900ER.

In addition, the certification basis includes other regulations, special conditions and exemptions that are not relevant to this proposed special condition. Refer to Type Certificate No. A16WE for a complete description of the certification basis for this model airplane.

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 737–900ER because of a novel or unusual design feature, special conditions are prescribed under the provisions of § 21.16.

In addition to the applicable airworthiness regulations and special conditions, the Model 737–900ER 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.

The FAA issues special conditions, as defined in § 11.19, they are published for comment under § 11.38, and they become part of the type certification basis under § 21.101.

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, or should any other model already included on the same type certificate be modified to incorporate the same or similar novel or unusual design feature, the special conditions would also apply to the other model under § 21.101.

Novel or Unusual Design Features

The Model 737–900ER airplane will incorporate novel or unusual design features. This special condition addresses equipment that may affect the airplane's structural performance, either directly or as a result of failure or malfunction.

This proposed special condition is identical or nearly identical to those previously required for type certification of other Boeing airplane models. The special condition was derived initially from standardized requirements developed by the Aviation Rulemaking Advisory Committee (ARAC), comprised of representatives of the FAA, Europe's Joint Aviation Authorities (now replaced by the European Aviation Safety Agency), and industry.

Discussion

In addition to the requirements of part 25, subparts C and D, the following special condition applies:

Interaction of Systems and Structures

The Boeing Model 737–900ER is equipped with systems that may affect the airplane's structural performance either directly or as a result of failure or malfunction. The effects of these systems on structural performance must be considered in the certification analysis. This analysis must include consideration of normal operation and of failure conditions with required structural strength levels related to the probability of occurrence.

Discussion of Comments

Notice of proposed special conditions No. 25–06–11–SC for Boeing Model 737–900ER airplanes was published in the **Federal Register** on October 31, 2006 (71 FR 63718). A combined set of comments was received from the United States Air Force and the United States Navy.

As noted previously, special conditions are prescribed under the provisions of § 21.16 when current regulations ''do not contain adequate or appropriate safety standards * * * because of a novel or unusual design feature.''

For several decades, transport category airplanes have employed automatic and electronic flight control systems, including load alleviation systems, flutter suppression systems, and stability augmentation systems. Failures in any of these systems may affect how the airplane will respond to maneuver, gust, and high speed conditions. That is, the loads introduced to the airplane may increase as a result of failures in these systems, or the flutter capability of the airplane may be reduced.

Since current regulations do not specify design loads criteria, including a safety factor for system failures, a special condition is needed to address such failures. To address the effects of system failures on the structural and flutter capability of the airplane, the FAA developed a special condition, which has been applied in essentially the same form since 1989, and which is proposed for the Boeing Model 737–900ER.

Comment 1: The commenters recommended that the proposed special condition not be implemented as a general rule.

FAA response: At this time we are not implementing the proposed special condition as a general rule. The ''Conclusion'' section of the proposed special condition (No. 25–06–11–SC) states that ''This action affects only certain novel or unusual design features on one model of airplane. It is not a rule of general applicability.'' We are considering rulemaking to incorporate this special condition into 14 CFR part 25. If we do propose changes to 14 CFR part 25 the public will have the opportunity to comment on that rulemaking action. We have not changed this special condition as a result of this comment.

Comment 2: The commenters recommended that systems failures be addressed individually and that exceptions to existing standards and rules be reviewed on a case-by-case basis.

FAA response: We do not agree with this recommendation. Although the proposed special condition allows the use of safety factors of less than 1.5, we do not regard this as an exception to the current regulation. The current CFR regulation does not specify design loads criteria, including a safety factor, for system failures. This is why special conditions are needed. We have not changed this special condition as a result of this comment.

Comment 3: The commenters noted that Figure 1 in the proposed special condition, which is a plot of safety factor versus failure probability, shows that for failure occurrences more frequent than 10^{-5} per flight hour, the factor of safety is equal to 1.5 and cannot be reduced. However, the text of the proposed rule indicates in several places that this probability threshold is 10^{-3}.

FAA response: We infer that the commenters are suggesting there are errors in the proposed special condition and that the text should be revised to change the 10^{-3} references to 10^{-5}. We do not agree that the references to 10^{-3} in the text are errors. The three references to 10^{-3} in the text of the proposed special condition do not apply to Figure 1. The first two references to the 10^{-3} probability threshold are notes that apply only to Figures 2 and 3 of the proposed special condition. The third reference to 10^{-3} applies to subsequent failures following dispatch with a known failure. We have not changed this special condition as a result of this comment.

Comment 4: The commenters are concerned that the definition of the term ''Q_j = Probability of being in a failure condition,'' is too vague and that the probability of being in a failure mode has to be more clearly defined to avoid potential loopholes. The term appears in the proposed special condition as follows: ''Q_j = Probability of being in a failure condition, which is defined as P_j = Probability of failure occurrence multiplied by T_j = Average time spent in failure condition.'' The concern is that an artificially low value of T_j would result in an inappropriate value of Q_j. As an example, for a spoiler failure on landing approach, the Q_j variable would be very small since you only spend a few minutes in that condition.

FAA response: We believe that the definitions of probability and exposure time are sufficiently clear, and that their use is appropriate in this special condition. The term T_j applies to ''continuation of flight'' failures, and thereby accounts for the maximum possible exposure period of the failure. If a failure is not detected, then T_j equals the average latency period for that failure mode. This results in a high value of T_j (potentially hundreds of hours), a high value of Q_j, and little or no reduction of the safety factor. If the failure was detected, then its exposure would be limited and its effects mitigated by pilot actions. In this case, a reduced value of Q_j and a corresponding reduced safety factor is appropriate.

Comment 5: The commenters stated that the net effect of the proposed special condition would be a reduction in reliability when compared to the current practice for defining failure condition safety factors. The commenters also stated that the current practice has a historical track record of success. The commenters also noted that the allowed reduction of the safety factor is not analytically nor empirically justified.

FAA response: We do not believe that this special condition reduces reliability or structural integrity when compared to the current practice for defining failure condition safety factors. The current regulation does not specify design loads criteria, including a safety factor, for system failures. Special conditions are needed to define these criteria. Also, the intent of this special condition has been applied for over ten years. Prior to this special condition we outlined similar criteria in Advisory Circular 25.672–1, *Active Flight Controls*, dated November 15, 1983.

While not analytically precise, we believe that reduced safety factors for low probability events are justified. Safety factors provide an additional margin above limit load capability. For low probability events, less margin is needed because these events will occur less often. For high probability events, more margin is needed, therefore, the full 1.5 safety factor is required. The relationship between the probability and the severity of a failure condition is similar to that used in a system safety assessment: High probability events must only have minor consequences, whereas low probability events may have major or hazardous consequences. In all cases, the objective is that no failure or combination of failures may be catastrophic.

Comment 6: The commenters recommended that the process to be used to determine the reliability of a system be defined. The commenters also recommended that for each airplane model, the airframe manufacturer document all of the systems and structure subject to the proposed special conditions.

FAA response: We believe that the process for determining the reliability of a system is well defined in this special condition because the special condition states that the failure condition and probabilistic terms are the same as those defined in § 25.1309, *Equipment, systems, and installations.* That regulation's advisory material, Advisory Circular 25.1309–1A, *System Design and Analysis*, dated June 21, 1988, provides an acceptable process for determining the reliability of systems (that is, their probability of failure).

We also note that as part of the certification process, airframe manufacturers are required to document the systems and structures subject to this special condition.

Comment 7: The commenters stated that in Figure 3 of the proposed special condition, it is not clear how the flutter clearance speed should be determined when the probability of being in a failure condition, Q_j, is between 1 and 10^{-5}.

FAA response: Figure 3 of this special condition shows that when the probability of being in the failure condition, Q_j, is equal to one, the flutter clearance speed is V″, which is the speed as defined by § 25.629(b)(1). (This is the same as the clearance speed with no failures.) When $Q_j = 10^{-5}$, the clearance speed is V′, which is the clearance speed with failures, as defined by § 25.629(b)(2). If Q_j is between 1 and 10^{-5}, then the clearance speed varies linearly between V″ and V′. This can be calculated as $V = V'' + 0.2(\log Q_j)(V''-V')$.

Comment 8: The commenters noted that the United States Air Force threshold for allowing a reduced clearance speed is 10^{-7} per flight hour. A note accompanying Figure 3 in the proposed special conditions indicates that the flutter clearance speed may not be less than V″ if P_j is greater than 10^{-3} per flight hour. V″ is the clearance speed with no failures, which includes a 15% margin on the design dive speed, V_D/M_D. The commenters suggested that the 10^{-7} per flight hour threshold is more appropriate than the 10^{-3} per flight hour threshold because the flutter analysis may inaccurately predict a critical flutter mechanism under a failed condition. The commenters also pointed out that failure conditions are not typically flutter tested in flight.

FAA response: We believe that the flutter clearance speeds for failures are adequate as defined. Flutter clearance speeds for failure cases are defined in both § 25.629 and in these special conditions. The flutter clearance speed for failure cases defined in § 25.629 has not changed significantly since Amendment 25–0, issued in 1965. The service history on products certificated to Amendment 25–0, or later, has been acceptable regarding the effects of failures on flutter. The flutter clearance speed defined in these special conditions exceeds that defined in § 25.629 (and is therefore more conservative) for all failure conditions whose probability is greater than 10^{-5}.

No changes were made to these special conditions as a result of these comments. The special conditions are adopted as proposed.

Applicability

As discussed above, this special condition is applicable to the Boeing Model 737–900ER. Should Boeing apply at a later date for a change to the type certificate to include another model incorporating the same novel or unusual design feature, this special condition would apply to that model as well.

Effective Upon Issuance

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 Boeing Model 737–900ER is imminent, the FAA finds that good cause exists to make this special condition effective upon issuance.

Conclusion

This action affects only certain novel or unusual design features on one model of airplane. 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 Condition

■ 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 Boeing Model 737–900ER airplanes.

Interaction of Systems and Structures

In addition to the requirements of part 25, subparts C and D, the following proposed special condition would apply:

a. 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 part 25, subparts C and D. Paragraph b, below, must be used to evaluate the structural performance of airplanes equipped with these systems.

b. Interaction of Systems and Structures.

(1) General: The following criteria must be used for showing compliance with this special condition for interaction of systems and structures and with § 25.629 for airplanes equipped with flight control systems, autopilots, stability augmentation systems, load alleviation systems, flutter control systems, and fuel management systems.

(a) The criteria defined herein address only the direct structural consequences of the system responses and performances. They 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 applicable only 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 this special condition.

(b) Depending upon the specific characteristics of the airplane, additional studies may be required that go beyond the criteria provided in this special condition 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 this paragraph.

Structural performance: Capability of the airplane to meet the structural requirements of 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 and avoidance of severe weather conditions).

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, and extremely improbable) used in this 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, this special condition applies 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) Effects of Systems on Structures.

(a) *General.* The following criteria will be used in determining the influence of a system and its failure conditions on the airplane structure.

(b) *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 used 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 non-linearity (rate of displacement of

control surface, thresholds or any other system non-linearities) 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 non-linearities must be investigated beyond limit conditions to ensure that 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.

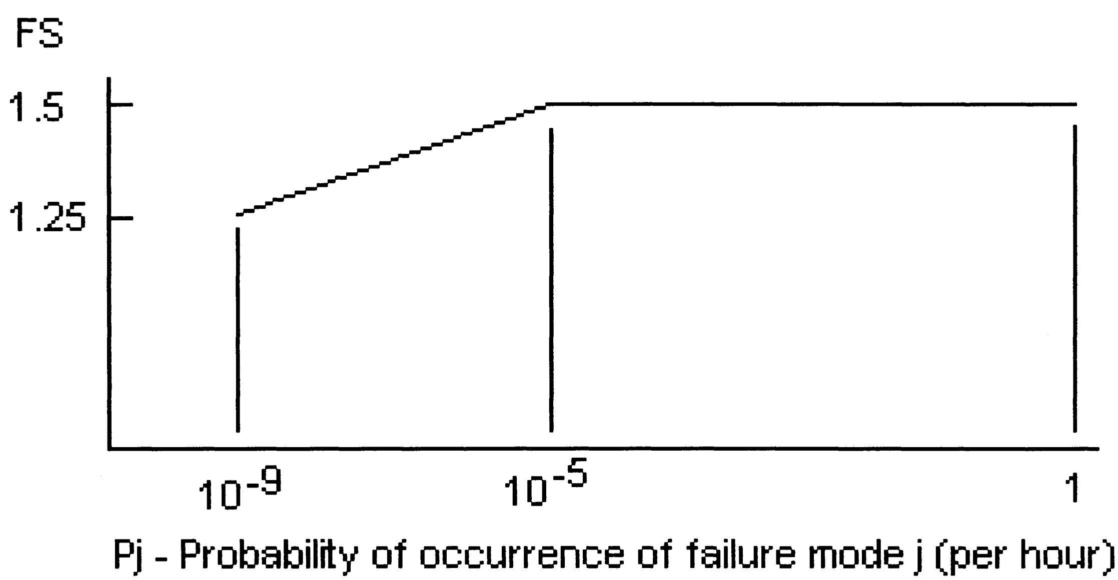
(c) *System in the failure condition.* For any system failure condition not shown to be extremely improbable, the following apply:

(1) At the time of occurrence. Starting from 1g 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 (c)(1)(i) of this section. 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 speed increases beyond V_C/M_C, freedom from aeroelastic instability must be shown to those 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 (or used in lieu of the following 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 in 25.345.

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

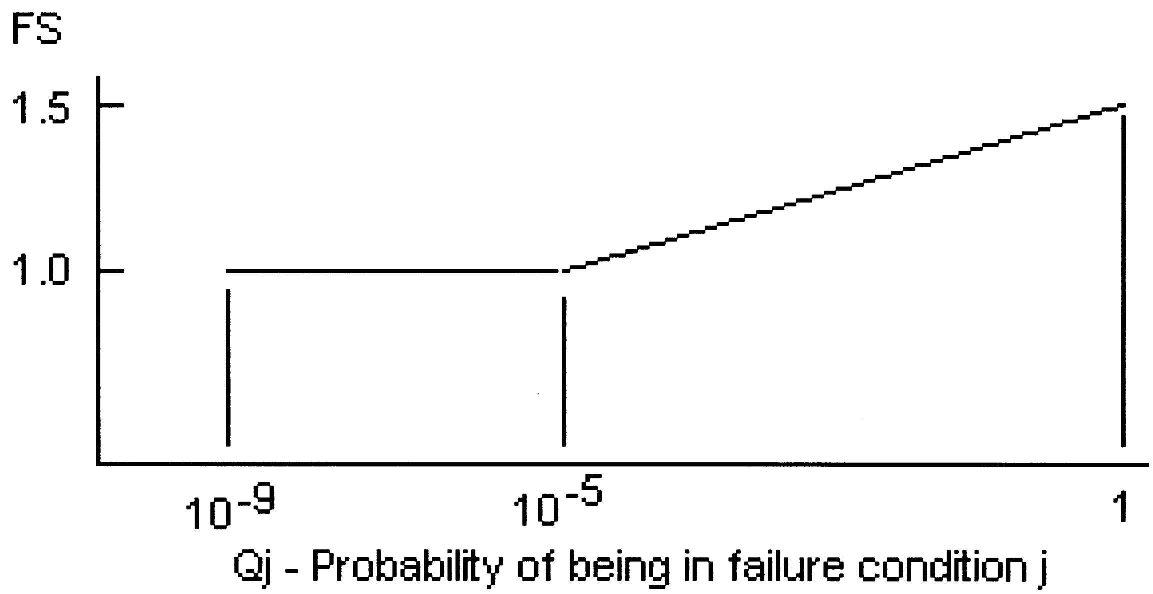
(D) the limit yaw maneuvering conditions specified in § 25.351.

(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 in paragraph (c)(2)(i) of this special condition 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.

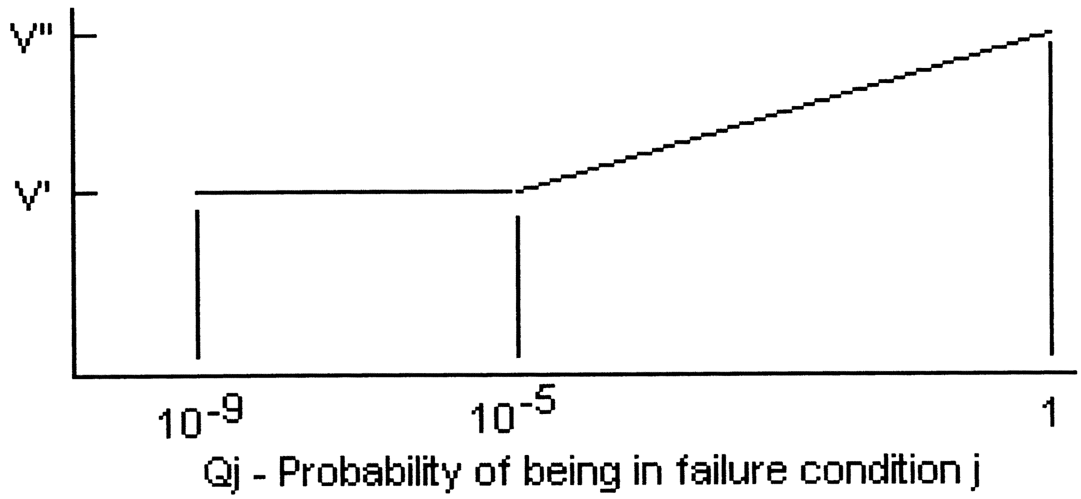
(iii) For residual strength substantiation, the airplane must be able to withstand two thirds of the ultimate loads defined in paragraph (c)(2)(ii). For pressurized cabins, these loads must be defined combined with the normal operating differential pressure.

(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 this Part, 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.

(d) *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 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 warning systems to achieve the objective of this requirement. These certification maintenance requirements must be limited to components the failures of which 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 part 25, subpart C, below 1.25 or flutter margins below V″ must be signaled to the crew during flight.

(e) *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 this Special Condition must be met, including the provisions of paragraph (b), for the dispatched condition and paragraph (c) 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. 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. 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 1E–3 per flight hour.

Issued in Renton, Washington, on March 19, 2007.

Ali Bahrami,

Manager, Transport Airplane Directorate, Aircraft Certification Service.

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