[4910-13]

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 25

[Docket No. NM362; Special Conditions No. 25-354A-SC]

Special Conditions: Boeing Model 787-8 Airplane; Interaction of Systems and Structures, Electronic Flight Control System-Control Surface Awareness, High Intensity Radiated Fields (HIRF) Protection, Limit Engine Torque Loads for Sudden Engine Stoppage, and Design Roll Maneuver Requirement.

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Amended special conditions

SUMMARY: These amended special conditions are issued to the Boeing Model 787-8 airplane. This airplane 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 include limit engine torque loads for sudden engine stoppage. Special Conditions No. 25-354-SC was issued on July 18, 2007, addressing, in part, this condition. We have determined that more clarification is needed on the limit engine torque loads for sudden engine stoppage special conditions, and have therefore added a new requirement. This additional requirement has been applied, via special conditions, to other programs. Since applicable airworthiness regulations, including those contained in Special Conditions No. 25-354-SC, do not contain adequate or appropriate safety standards for this particular design feature, these amended special conditions contain the additional safety standards which the Administrator finds necessary to establish a level of safety equivalent to that established by the

existing standards.

EFFECTIVE DATE: August 8, 2011**.**

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SUPPLEMENTARY INFORMATION:

Background

On March 28, 2003, Boeing applied for an FAA type certificate for its new Boeing Model 787-8 passenger airplane. The Boeing Model 787-8 airplane will be an all-new, two-engine jet transport airplane with a two-aisle cabin. The maximum takeoff weight will be 476,000 pounds, with a maximum passenger count of 381 passengers. Special Conditions No. 25-354-SC was issued on July 17, 2007, to address interaction of systems and structures, electronic flight control system control surface awareness, HIRF protection, limit engine torque loads for sudden engine stoppage, and design roll maneuver requirements. Since then, it was determined more clarification was needed on the limit engine torque loads for sudden engine stoppage special conditions.

Discussion

The limit engine torque loads for sudden engine stoppage special conditions, issued as part of Special Conditions No. 25-354-SC., distinguishes between the more common, less severe engine failure events, and those rare events resulting from structural failures. Paragraph (a) defines limit load conditions for the less severe events, and paragraph (c) defines the ultimate load conditions for the more severe structural failure events.

Compliance with paragraph (a) includes, by definition, assessment of deformation at limit load, as well as assessment of structural integrity at ultimate load. However, since paragraph (c) is defined as an ultimate load condition, it only requires assessment of structural integrity at ultimate load, and does not require assessment of deformation.

New paragraph (e), therefore, is added to the special condition to require assessment of deformation for the structural failures defined in paragraph (c).

Type Certification Basis

Under provisions of 14 Code of Federal Regulations (CFR) 21.17, Boeing must show that Boeing Model 787-8 airplanes (hereafter referred to as "the 787") meet the applicable provisions of 14 CFR part 25, as amended by Amendments 25-1 through 25-117, except §§ 25.809(a) and 25.812, which will remain at Amendment 25-115. If the Administrator finds that the applicable airworthiness regulations do not contain adequate or appropriate safety standards for the 787 because of a novel or unusual design feature, special conditions are prescribed under provisions of 14 CFR 21.16.

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 Boeing Model 787-8 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 787 must comply with the fuel vent and exhaust emission requirements of 14 CFR part 34 and the noise certification requirements of part 36. In addition, the FAA must issue a finding of regulatory adequacy pursuant to section 611 of Public Law 92-574, the "Noise Control Act of 1972."

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

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.

Novel or Unusual Design Features

The 787 will incorporate a number of novel or unusual design features. Because of rapid improvements in airplane technology, the applicable airworthiness regulations do not contain adequate or appropriate safety standards for these design features. These special conditions for the 787 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.

Most of these special conditions are identical or nearly identical to those previously required for type certification of the Model 777 series airplanes.

Most of these special conditions were 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. In the case of some of these requirements, a draft notice of proposed rulemaking has been prepared but no final rule has yet been promulgated.

Additional special conditions will be issued for other novel or unusual design features of the 787 in the near future.

1. INTERACTION OF SYSTEMS AND STRUCTURES

The 787 is equipped with systems that affect the airplane's structural performance, either directly or as a result of failure or malfunction. That is, the airplane's systems affect how it responds in maneuver and gust conditions, and thereby affect its structural capability. These systems may also affect the aeroelastic stability of the airplane. Such systems represent a novel and unusual feature when compared to the technology envisioned in the current airworthiness standards. A special condition is needed to require consideration of the effects of systems on the structural capability and aeroelastic stability of the airplane, both in the normal and in the failed state.

This special condition requires that the airplane meet the structural requirements of subparts C and D of 14 CFR part 25 when the airplane systems are fully operative. The special condition also requires that the airplane meet these requirements considering failure conditions. In some cases, reduced margins are allowed for failure conditions based on system reliability.

2. ELECTRONIC FLIGHT CONTROL SYSTEM: Control Surface Awareness

With a response-command type of flight control system and no direct coupling from cockpit controller to control surface, such as on the 787, the pilot is not aware of the actual surface deflection position during flight maneuvers. This feature of this design is novel and unusual when compared to the state of technology envisioned in the airworthiness standards for transport category airplanes. These special conditions are meant to 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. Some unusual flight conditions, arising from atmospheric conditions or airplane or engine failures or both, may result in full or nearly full surface deflection. Unless the flightcrew is made aware of excessive deflection or impending control surface deflection limiting, piloted or auto-flight system control of the airplane might be inadvertently continued in a way that would cause loss of control or other unsafe handling or performance situations.

These special conditions require that suitable annunciation be provided to the flightcrew when a flight condition exists in which nearly full control surface deflection occurs. Suitability of such an annunciation must take into account that some pilot-demanded maneuvers, such as a rapid roll, are necessarily associated with intended full or nearly full control surface deflection. Simple alerting systems which would function in both intended and unexpected control-limiting situations must be properly balanced between providing needed crew awareness and avoiding nuisance warnings.

3. HIGH INTENSITY RADIATED FIELDS (HIRF) PROTECTION

The 787 will use electrical and electronic systems which perform critical functions. These systems may be vulnerable to high-intensity radiated fields (HIRF) external to the airplane. There is no specific regulation that addresses requirements for protection of electrical and electronic systems from HIRF. Increased power levels from radio frequency transmitters and use of sensitive avionics /electronics and electrical systems to command and control the airplane have made it necessary to provide adequate protection.

To ensure that a level of safety is achieved that is equivalent to that intended by the regulations incorporated by reference, special conditions are needed for the 787. These special conditions require that avionics/electronics and electrical systems that perform critical functions be designed and installed to preclude component damage and interruption of function because of HIRF.

High-power radio frequency transmitters for radio, radar, television, and satellite communications can adversely affect operations of airplane electrical and electronic systems. Therefore, immunity of critical avionics/electronics and electrical systems to HIRF must be established. Based on surveys and analysis of existing HIRF emitters, adequate protection from HIRF exists if airplane system immunity is demonstrated when exposed to the HIRF environments in either paragraph (a) OR (b) below:

(a) A minimum environment of 100 volts rms (root-mean-square) per meter electric field strength from 10 KHz to 18 GHz.

(1) System elements and their associated wiring harnesses must be exposed to this environment without benefit of airframe shielding.

(2) Demonstration of this level of protection is established through system tests and analysis.

(b) An environment external to the airframe of the field strengths shown in the table below for the frequency ranges indicated. Immunity to both peak and average field strength components from the table must be demonstrated.

Frequency	Field Strength (volts per meter)	
	Peak	Average
10 kHz -100 kHz	50	50
100 kHz-500 kHz	50	50
500 kHz-2 MHz	50	50
2 MHz-30 MHz	100	100
30 MHz-70 MHz	50	50
70 MHz-100 MHz	50	50
100 MHz-200 MHz	100	100
200 MHz-400 MHz	100	100
400 MHz-700 MHz	700	50
700 MHz-1 GHz	700	100
1 GHz-2 GHz	2000	200

2GHz-4 GHz	3000	200
4 GHz-6 GHz	3000	200
6 GHz-8 GHz	1000	200
8 GHz-12 GHz	3000	300
12 GHz-18 GHz	2000	200
18 GHz-40 GHz	600	200

Field strengths are expressed in terms of peak root-mean-square (rms) values over the complete modulation period.

The environment levels identified above are the result of an FAA review of existing studies on the subject of HIRF and of the work of the Electromagnetic Effects Harmonization Working Group of ARAC.

4. LIMIT ENGINE TORQUE LOADS FOR SUDDEN ENGINE STOPPAGE

The 787 will have high-bypass engines with a chord-swept fan 112 inches in diameter. Engines of this size were not envisioned when § 25.361, pertaining to loads imposed by engine seizure, was adopted in 1965. Worst case engine seizure events become increasingly more severe with increasing engine size because of the higher inertia of the rotating components.

Section 25.361(b)(1) requires that for turbine engine installations, the engine mounts and supporting structures must be designed to withstand a "limit engine torque load imposed by sudden engine stoppage due to malfunction or structural failure." Limit loads are expected to occur about once in the lifetime of any airplane. Section 25.305 requires that supporting structures be able to support limit loads without detrimental permanent deformation, meaning that supporting structures should remain serviceable after a limit load event.

Since adoption of § 25.361(b)(1), the size, configuration, and failure modes of jet engines have changed considerably. Current engines are much larger and are designed with large bypass fans. In the event of a structural failure, these engines are capable of producing much higher transient loads on the engine mounts and supporting structures.

As a result, modern high bypass engines are subject to certain rare-but-severe engine seizure events. Service history shows that such events occur far less frequently than limit load events. Although it is important for the airplane to be able to support such rare loads safely without failure, it is unrealistic to expect that no permanent deformation will occur.

Given this situation, ARAC has proposed a design standard for today's large engines. For the commonly-occurring deceleration events, the proposed standard requires engine mounts and structures to support maximum torques without detrimental permanent deformation. For the rare-but-severe engine seizure events such as loss of any fan, compressor, or turbine blade, the proposed standard requires engine mounts and structures to support maximum torques without failure, but allows for some deformation in the structure.

The FAA concludes that modern large engines, including those on the 787, are novel and unusual compared to those envisioned when § 25.361(b)(1) was adopted and thus warrant a special condition. This special condition contains design criteria recommended by ARAC.

5. DESIGN ROLL MANEUVER REQUIREMENT

The 787 is equipped with an electronic flight control system that provides control of the aircraft through pilot inputs to the flight computer. Current part 25 airworthiness regulations account for "control laws," for which aileron deflection is proportional to control stick deflection. They do not address any nonlinearities[2] or other effects on aileron actuation that may be caused by electronic flight controls. Therefore, the FAA considers the flight control system to be a novel and unusual feature compared to those envisioned when current regulations were adopted. Since this type of system may affect flight loads, and therefore the structural capability of the airplane, special conditions are needed to address these effects.

This special condition differs from current requirements in that it requires that the roll maneuver result from defined movements of the cockpit roll control as opposed to defined aileron deflections. Also, this special condition requires an additional load condition at design maneuvering speed (V_A), in which the cockpit roll control is returned to neutral following the initial roll input.

This special condition differs from similar special conditions applied to previous designs. This special condition is limited to the roll axis only, whereas previous special

[2]A nonlinearity is a situation where output does not change in the same proportion as input.

conditions also included pitch and yaw axes. A special condition is no longer needed for the yaw axis because § 25.351 was revised at Amendment 25-91 to take into account effects of an electronic flight control system. No special condition is needed for the pitch axis because the applicant's proposed method for the pitch maneuver takes into account effects of an electronic flight control system.

Applicability

As discussed above, these special conditions are applicable to the 787. Should Boeing apply at a later date for a change to the type certificate to include another model on the same type certificate incorporating the same novel or unusual design features, these special conditions would apply to that model as well.

Conclusion

This action affects only certain novel or unusual design features of the 787. It is not a rule of general applicability U.S.C. 106(g), 40113, 44701, 44702, 44704.

List of Subjects in 1 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 Amended Special Conditions

Accordingly, pursuance to the authority delegated to me by the Administrator, the following amended special conditions (which adds paragraph (e) to Special Condition No. 4) are issued as part of the type certification basis for the Boeing Model 787-8 airplane regarding limit engine torque loads for sudden engine stoppage.

1. INTERACTION OF SYSTEMS AND STRUCTURES

The Boeing Model 787-8 airplane is equipped with systems which affect the airplane's structural performance either directly or as a result of failure or malfunction. The influence of these systems and their failure conditions must be taken into account when showing compliance with requirements of subparts C and D of part 25 of Title 14 of the Code of Federal Regulations. The following criteria must be used for showing compliance with this special condition for airplanes equipped with flight control systems, autopilots, stability augmentation systems, load alleviation systems, flutter control systems, fuel management systems, and other systems that either directly or as a result of failure or malfunction affect structural performance. If this special condition is used for other systems, it may be necessary to adapt the criteria to the specific system.

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

(b) Depending on 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 capability of the airplane to meet other realistic conditions such as alternative gust conditions or maneuvers for an airplane equipped with a load alleviation system.

(c) The following definitions are applicable to this special condition.

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

(2) Flight limitations: Limitations that can be applied to the airplane flight conditions following an in-flight failure occurrence and that are included in the flight manual (speed limitations or avoidance of severe weather conditions, for example).

(3) Operational limitations: Limitations, including flight limitations, that can be applied to the airplane operating conditions before dispatch (fuel, payload, and master minimum equipment list limitations, for example).

(4) Probabilistic terms: Terms (probable, improbable, extremely improbable) used in this special condition which are the same as those probabilistic terms used in § 25.1309.

(5) Failure condition: Term that is the same as that used in § 25.1309. The term failure condition in this special condition, however, applies only to system failure conditions that affect structural performance of the airplane. Examples are system failure conditions that induce loads, change the response of the airplane to inputs such as gusts or pilot actions, or lower flutter margins.

Note: Although failure annunciation system reliability must be included in probability calculations for paragraph (f) of this special condition, there is no specific reliability requirement for the annunciation system required in paragraph (g) of the special condition.

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

(e) 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 of 14 CFR part 25 (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 degree of nonlinearity in rate of displacement of control surface or 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 for static strength and 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 if the applicant demonstrates 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.

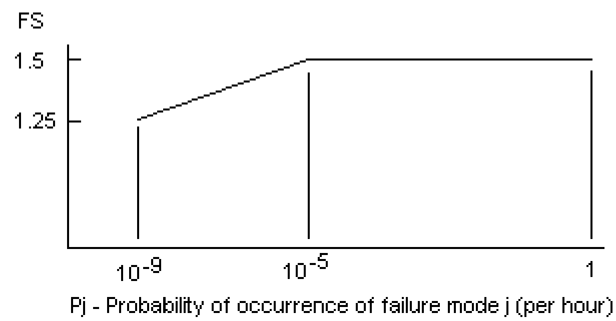
(f) System in the failure condition. For any system failure condition not shown to be extremely improbable, the following apply:

(1) Establishing loads at the time of failure. Starting from 1-g level flight conditions, a realistic scenario, including pilot corrective actions, must be established to determine 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 related to 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 subparagraph (f)(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 design cruise speed or design cruise mach number (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 (oscillatory failures) must not produce loads that could result in detrimental deformation of primary structure.

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

(i) 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 § 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 in paragraph (f)(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

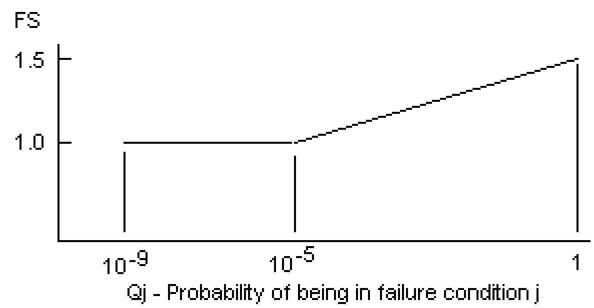
Factor of safety for continuation of flight

$Q_j = (T_j)(P_j)$ where:

T_j = Average time spent in failure condition j (in hours)

Pj = Probability of occurrence of failure mode j (per hour)

Note: If Pj 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–Structure, of 14 CFR part 25.



(iii) For residual strength substantiation, the airplane must be able to withstand two thirds of the ultimate loads defined in paragraph (f)(2)(ii) of this special condition. 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 the effects of these loads 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).

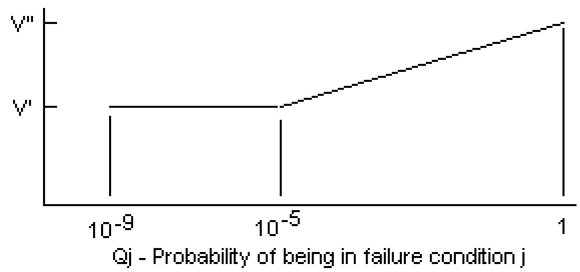
V" = Clearance speed as defined by § 25.629(b)(1).

Qj = (Tj)(Pj) where:

Tj = Average time spent in failure condition j (in hours)

Pj = Probability of occurrence of failure mode j (per hour)

Note: If Pj 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.

(g) <u>Failure indications.</u> 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 of the airplane 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, instead of detection and indication systems to achieve the objective of this requirement. Such certification maintenance inspections or daily checks must be limited to components on which faults 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 crew during flight.

(h) 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 (e) for the dispatched condition, and paragraph (f) for subsequent failures. Expected operational limitations may be taken into account in establishing Pj 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 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.

2. ELECTRONIC FLIGHT CONTROL SYSTEM: Control Surface Awareness

In addition to compliance with §§ 25.143, 25.671, and 25.672, the following special condition applies.

(a) The system design must ensure that the flightcrew is made suitably aware whenever the primary control means nears the limit of control authority. This indication should direct the pilot to take appropriate action to avoid the unsafe condition in accordance with appropriate airplane flight manual (AFM) instructions. Depending on the application, suitable annunciations may include cockpit control position, annunciator light, or surface position indicators. Furthermore, this requirement applies at limits of control authority, not necessarily at limits of any individual surface travel.

(b) Suitability of such a display or alerting must take into account that some pilot-demanded maneuvers are necessarily associated with intended full performance, which may require full surface deflection. Therefore, simple alerting systems, which would function in both intended or unexpected control-limiting situations, must be properly balanced between needed crew awareness and nuisance factors. A monitoring system which might compare airplane motion, surface deflection, and pilot demand could be useful for eliminating nuisance alerting.

3. HIGH INTENSITY RADIATED FIELDS (HIRF) PROTECTION

(a) Protection from Unwanted Effects of High-intensity Radiated Fields.

Each electrical and electronic system which performs critical functions must be designed and installed to ensure that the operation and operational capabilities of these systems to perform critical functions are not adversely affected when the airplane is exposed to high intensity radiated fields external to the airplane.

(b) For the purposes of these Special Conditions, the following definition applies. Critical Functions: Functions whose failure would contribute to or cause a failure condition that would prevent continued safe flight and landing of the airplane.

4. LIMIT ENGINE TORQUE LOADS FOR SUDDEN ENGINE STOPPAGE

In lieu of § 25.361(b) the Boeing Model 787-8 must comply with the following special condition.

(a) 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:

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

(2) The maximum acceleration of the engine.

(b) 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 each of the following:

(1) Sudden auxiliary power unit deceleration due to malfunction or structural failure.

(2) The maximum acceleration of the power unit.

(c) For 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:

(1) Loss of any fan, compressor, or turbine blade.

(2) Where applicable to a specific engine design, any other engine structural failure that results in higher loads.

(d) The ultimate loads developed from the conditions specified in paragraphs (c)(1) and (c)(2) are to 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.

(e) Any permanent deformation that results from the conditions specified in paragraph (c) must not prevent continued safe flight and landing.

5. DESIGN ROLL MANEUVER REQUIREMENT

In lieu of compliance to § 25.349(a), the Boeing Model 787-8 must comply with the following special condition.

The following conditions, speeds, and cockpit roll control motions (except as the motions may be limited by pilot effort) must be considered in combination with an airplane load factor of zero and of two-thirds of the positive maneuvering factor used in design. In determining the resulting control surface deflections, the torsional flexibility of the wing must be considered in accordance with § 25.301(b):

(a) Conditions corresponding to steady rolling velocities must be investigated. In addition, conditions corresponding to maximum angular acceleration must be investigated for airplanes with engines or other weight concentrations outboard of the fuselage. For the angular acceleration conditions, zero rolling velocity may be assumed in the absence of a rational time history investigation of the maneuver.

(b) At V_A, sudden movement of the cockpit roll control up to the limit is assumed. The position of the cockpit roll control must be maintained until a steady roll rate is achieved and then must be returned suddenly to the neutral position.

(c) At V_C, the cockpit roll control must be moved suddenly and maintained so as to achieve a roll rate not less than that obtained in paragraph (b).

(d) At V_D, the cockpit roll control must be moved suddenly and maintained so as to achieve a roll rate not less than one third of that obtained in paragraph (b).

Issued in Renton, Washington, on June 23, 2011.

Original signed by Ali Bahrami

Ali Bahrami
Manager, Transport Airplane Directorate
Aircraft Certification Service, ANM-100