DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Parts 27 and 29

[Docket No. 25287; Amdts. 27-25 and 29-29]

RIN 2120-AB35

Airworthiness Standards; Occupant Restraint in Normal and Transport Category Rotorcraft

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Final rule.

SUMMARY: These amendments to the airworthiness standards for normal and transport category rotorcraft add two dynamic crash impact design conditions for seat and occupant restraint systems and increase the static design load factors for seating devices and items of mass in the cabin or adjacent to the cabin as prescribed. These amendments also prescribe a shoulder harness for each occupant and adopt human impact injury criteria as a measure for occupant protection for dynamic crash impact conditions. These amendments, consistent with the present state of the art, significantly improve occupant protection for normal and transport category rotorcraft in a survivable emergency landing impact mode.

EFFECTIVE DATE: December 13, 1989.

FOR FURTHER INFORMATION CONTACT: Mr. J. H. Major, FAA, Regulations Group, ASW-111, Rotorcraft Directorate, Aircraft Certification Service, Fort Worth, Texas 76193-0111, telephone (817) 624-5117 or FTS 734-5117.

SUPPLEMENTARY INFORMATION:

Background

These amendments are based on Notice of Proposed Rulemaking (NPRM) No. 87-4 (52 FR 20938; June 3, 1987) which proposed to amend the rotorcraft airworthiness standards to improve occupant protection in normal and transport category rotorcraft for a survivable emergency landing impact. Notice No. 87-4 proposed to increase occupant protection and to assess the capability of the occupant restraint system and rotorcraft seats for a combined vertical and longitudinal dynamic test and for a primarily longitudinal dynamic test which are representative of emergency landing impact scenarios and to improve occupant protection from certain items of mass in an emergency landing impact. Occupant injury criteria were also proposed as unique pass/fail criteria for the seat and restraint system dynamic test conditions. The restraint system encompasses the seating device, cushions, and torso restraint system, also known as a safety belt and a shoulder harness. This rulemaking activity is one part of the FAA Aircraft Crash Dynamics program outlined in the **Federal Register** on September 21, 1984 (49 FR 37111).

In light of comments, the FAA reopened the comment period until May 6, 1988, and also announced in the **Federal Register** (53 FR 7579; March 8, 1988) that a public meeting would be held in Fort Worth, Texas, on April 20, 1988. The viewpoints presented by participants at the public meeting helped the FAA clarify the issues and counterproposals presented in response to the notice. A copy of the meeting transcript is contained in the docket for this rulemaking. All interested persons have been given an opportunity to participate in the making of these amendments and due consideration has been given to all matters presented. A number of nonsubstantive changes and minor changes of an editorial and clarifying nature have been made to the proposals based upon comments received and upon further FAA review. No comments were received relating to the preliminary regulatory evaluation economic impact summary contained in the notice or to the associated economic evaluation report filed in the docket. Except as indicated herein, the proposals contained in the notice have been adopted without change.

The proposals were based on the data, references, and conclusions contained in Report. No. DOT/FAA/CT-85/11, "Analysis of Rotorcraft Crash Dynamics for Development of Improved Crashworthiness Design Criteria," June 1985, and other data sources such as full-scale rotorcraft and small aircraft impact test reports some of which were contained in SP622, "Crash Dynamics of General Aviation Aircraft," April 1985, published by the Society of Automotive Engineers (SAE). A copy of each report is contained in the regulatory docket.

Since these two reports were published in 1985, additional reports and information have been published about dynamic tests of aircraft seats. Much of the information, data, and conclusions from these tests provides: (1) Basic aircraft impact response data; (2) seat and anthropomorphic test dummy (ATD) interface loads and motion; (3) human injury assessments and the relationships associated with the proposed impact conditions; and (4) assessments of aircraft seat design technology required to comply with the proposed criteria. This body of aircraft information, data, and test results is also applicable, in part, to rotorcraft designs and supports this rulemaking activity.

Two dynamic test conditions were proposed in Notice No. 87-4. One test is primarily a vertical impact condition with vertical and longitudinal loads to simulate ground impact following a high rate of vertical descent with the Rotorcraft level. This condition emphasizes occupant vertical loading and determines the effectiveness of design features provided to restrain and support the occupant and to attenuate or control the loads imposed on the occupant. This reduces the potential for spinal compressive injury in an impact of this type.

The second test, a longitudinal impact with yaw angle, simulates a horizontal impact with a ground level obstruction such as a sloped ground surface or rise. This test condition provides an assessment of the occupant restraint system, potential secondary head impact with structure, etc., and seat structural performance in this mode.

Any direct correlation or relationship between the two dynamic test conditions was not envisioned or intended. These two dynamic test conditions were derived from the civil rotorcraft accident study of Report No. DOT/FAA/CT-85/11 and other aforementioned data. These two test conditions represent the expected aircraft response to an emergency landing impact, measured at the cabin floor/seat attachment, which is transmitted to the occupant through the seat and torso restraint system. Accordingly, it was not intended to include a fuselage, landing gear, or a major part of the fuselage to demonstrate compliance with the proposed seat test standards.

Of course, for a seat that is an integral part of the rotorcraft structure, the test setup must include a sufficient part of the fuselage to duplicate the seat and the occupant restraint system for a proper test. These seat dynamic test conditions are consistent with the structural characteristics of present rotorcraft designs and with the general or typical operational emergency landing impact found. The tests also provide for measured and meaningful protection of occupants in normal and transport category rotorcraft. The occupant injury pass/fail criteria adopted in these amendments are the same as those proposed for small airplanes in Notice No. 86-19 (51 FR 44878; December 12, 1986) and adopted in Amendment 23-36 (53 FR 30802; August 15, 1988) and are compatible with those proposed in Notice No. 86-11

(51 FR 25982; July 17, 1986) and adopted in Amendment 25–64 (53 FR 17640; May 17, 1988) for transport airplanes. The injury criteria are also found in Advisory Circular AC 21–22, "Injury Criteria for Human Exposure to Impact," June 20, 1985.

A major concern addressed by the proposal for occupant injury and seat and torso restraint system pass/fail criteria is the secondary head impact which may inflict a debilitating injury and result in concussion and possible unconsciousness. The measurement proposed in Notice No. 87–4 is the head injury criteria (HIC) used in Federal Motor Vehicle Safety Standard No. 208 (49 CFR 571.208). The HIC must be applied when the results of the seat dynamic tests show that structure or other hard objects are within the anthropomorphic test dummy's (ATD) head strike envelope. This proposal uses a practical alternative dynamic seat test procedure rather than requiring tests with seats installed in the particular aircraft fuselage design. The head acceleration time history must be measured and recorded during the seat dynamic tests and then evaluated according to the HIC criteria whenever secondary head impact may occur. This allows testing of a seat and approval whenever installed for unique interior and cockpit arrangements.

Spinal injuries occurring during rotorcraft accidents are another concern. The frequency of serious spinal injuries versus the total frequency of serious injuries in survivable helicopter accidents is approximately 30 percent as shown in Figure 30 of Report No. DOT/FAA/CT–85/11.

The Dynamic Response Index (DRI) which is based on a single lumped-mass, damped-spring model of the spine and respective support mass has traditionally been used to predict probability of spinal injury in the performance evaluation of military airplane ejection seats. The DRI has been correlated with ejection seat testing and service experience to provide a level of confidence for this ejection seat application. However, there are inherent differences in function, geometry, dynamic pulse exposure, and occupant restraint between civil aircraft seats and military ejection seats. The difficulty of selecting the most representative acceleration measurement point in the occupant/seat systems makes direct application of the DRI questionable and difficult as a performance criterion for civil aircraft seats.

As reported in SAE Paper No. 850851, "Data for the Development of Criteria for General Aviation Seat and Restraint System Performance," April 1985, and as discussed in paragraph 6(c)(5) of AC 21–22, the pelvic and spinal lumbar compression load limitation of 1,500 pounds (6.7 kilo newtons) proposed in the notice is an appropriate limit to assure a low probability of spinal injury for rotorcraft as well as airplane occupants. The pelvic compressive load measured in the ATD is direct, easily measured, and requires no additional analysis or interpretation to determine compliance with the proposed standard. In addition, seat pan acceleration and an ATD spinal compression load measured in a test of military helicopter seats indicate an inordinate variation between the spinal load and seat pan acceleration. Therefore, seat pan accelerations are not a reliable prediction of spinal compression loads.

Localized cabin floor deformation can occur as a result of fuselage deformation in a survivable emergency landing impact. The simulated floor or seat rail displacement of 10° pitch and 10° roll will prove the ability of the seat and its floor or sidewall attachments to tolerate such structural deformation or displacement resulting from an impact. Seats integral with the fuselage or bulkhead-mounted (without tracks) rather than floor-mounted need not be deformed prior to conducting the dynamic tests. The simulated floor deformation specified for the dynamic tests is not intended to be a measure of the floor strength or deformation capability but is intended to demonstrate the tolerance of the seat and its attachments to accept floor deformation common to actual crashes.

The new static strength requirements of §§ 27.561 (b)(3) and (c) and 29.561 (b)(3) and (c) contain increased static design inertial load factors to provide an improved level of safety for seats and occupant restraint systems and for items of mass installed both inside the cabin and adjacent to the cabin, as prescribed. These new seat static design inertial load factors will supplement the seat and restraint system dynamic test standards in new §§ 27.562 and 29.562. Those items of mass outside of and adjacent to the cabin must be designed to an increased forward inertial load factor. This increased factor reduces the likelihood of attachment failure and subsequent penetration of the item of mass into the cabin.

The current static design inertial load factors for transport rotorcraft underfloor fuel tanks are retained in revised § 29.561(d). Revised fuel tank standards are deferred for further study and development of possible alternate means of rotorcraft fuel tank protection.

Discussion of Comments

General

Sixteen commenters from small and large U.S. helicopter manufacturers, foreign airworthiness authorities, foreign helicopter manufacturers, and other groups and individuals responded to the notice. All commenters agree with the FAA objective to improve occupant safety in an emergency landing impact, one recommends adoption of standards without lengthy delay, and several offer counterproposals and recommendations.

A commenter emphasizes that the proposal should not apply to rotorcraft designs presently in production or undergoing type certification. The new standards do not apply to rotorcraft for which application for type certification is made prior to the effective date or to derivatives of such rotorcraft for which an application for an amended type certificate is made after the effective date of these amendments.

Several commenters support the proposal for installation and mandatory use of a shoulder harness, also called an upper torso restraint. Three commenters also recommend installation and mandatory use of an upper torso restraint for all newly manufactured rotorcraft after a certain date. National Transportation Safety Board (NTSB) Recommendation No. A–85–70 recommends installation of a shoulder harness for each seat in rotorcraft manufactured after December 31, 1987. The FAA has initiated a separate rulemaking project which will respond to recommendations of the NTSB as well as the commenters relative to mandating shoulder harnesses in production rotorcraft. Therefore, no change is necessary for this amendment which applies only to wholly new rotorcraft designs for which a type certificate application is received after the effective date of this amendment. A commenter also recommends installation of new design seats with harnesses that meet the dynamic test standards, whenever the rotorcraft interior is refurbished for older rotorcraft. This recommendation is beyond the scope of this rulemaking activity.

A commenter objects to equal dynamic test standards for normal and transport category rotorcraft and refers to a public policy of higher or more stringent standards for transport category rotorcraft than those of normal category rotorcraft. The standards, which are equivalent for both categories, have been derived from the rotorcraft emergency landing impact and fuselage deformation characteristics of small and large rotorcraft which are based on accident and incident information of both categories.

The standards do, therefore, consider both categories in relation to size, weight, and other factors and rightfully afford the necessary protection for passengers in both cases.

The seat design standards reflect the crash impact pulse derived from the accident information and fuselage impact deformation data. These values do not differ markedly between small and large helicopters. The objective, to significantly improve occupant protection for small and large helicopters, is achieved by adoption of the proposed standards to simulate known impact conditions and to avoid exceeding human injury criteria.

It should be noted that the human impact injury criteria set out in AC 21-22 does not vary with respect to the category of aircraft.

Several commenters contend that the dynamic test standards are too severe and they object to the use of an ATD. They suggest the use of a simplified dynamic vertical drop test using a mass to simulate the occupant. In addition, they consider static strength substantiation for the longitudinal impact condition to be sufficient. Other commenters also object to the dynamic test standards because they believe that proving compliance is beyond the technical and financial capability of small companies. These and other commenters object to the proposed static design inertial factors for occupants and items of mass in the cabin, as well as those items external to the cabin, and recommend alternate factors. These concerns are addressed in the specific comments.

Specific Comments on the Proposals

The following comments are keyed to like-numbered proposals in Notice No. 87-4 and are presented in the same order as the corresponding amendments found in the rules portion of this document.

Proposal 2. Notice No. 87-4 proposed a revision to the introductory text of paragraph (b) of § 27.561 to remove the word "minor" before the words "crash landing." No comments were received on the introductory text, and it is adopted as proposed.

After further FAA review of proposed paragraph (b)(3), the subjects were reordered for emphasis and clarity. This editorial change places "each occupant" as the first subject and "each item of mass" as the second subject in this standard. As proposed, paragraph (b)(3) is also changed for clarity to refer to static load "factors" rather than "forces."

A commenter requests that the phrase "inside the cabin" be added after the phrase "items of mass" in proposed paragraph (b)(3) to define the scope of the standard for these items of mass. The FAA agrees, and the change has been incorporated to prevent confusion between the scope of paragraphs (b)(3) and (c). The FAA notes paragraph (c) refers to external items of mass or items outside of the crew and passenger compartments.

Comments on Static Load Factors of Proposal No. 2, Paragraph (b). Comments were received concerning the magnitude of the proposed increased static load factors, and a discussion of the comments follows.

A commenter recommends, in conjunction with an alternate guideline to the proposed seat dynamic tests, a static design guideline and an objective standard that contain lower inertial load factors than those proposed in Notice No. 87-4. The commenter acknowledges that this static design guideline is without supporting data but is based on his knowledge and intuitive conclusions. The same commenter also suggests more appropriate inertial load factors could be derived from a study of comparative static and dynamic tests of several seat designs.

Two other comments recommend adoption of lower inertial load factors. One referred to those proposed during the Rotorcraft Regulatory Review Program public meeting in December 1979. Another commenter forwarded a matrix or table of the inertia factors proposed in the recent rulemaking activity for rotorcraft and small and transport airplane seats, and states that the variation found in the factors for the different aircraft is not justified. The commenter suggests that the rotorcraft inertial factors are too high and should be lower.

One commenter proposes requiring structural capability to support and restrain a 170-pound pilot (or passenger) with a shoulder harness and safety belt for an 8g forward inertial load factor, combined with a 4g sideward inertial load factor, to approximate a 9g (combined) factor. The commenter proposes to omit the longitudinal/horizontal deceleration dynamic test proposed in the notice and rely on the noted static test or structural analysis results. The commenter, however, proposes a simplified dynamic vertical drop test and the longitudinal static load condition to dramatically improve crash survivability but permit small manufacturers to conduct meaningful tests and develop new model normal category helicopters. Three other commenters did not comment on the proposed static inertial load factors (or static strength factors), but they did propose an identical, simplified dynamic test for the vertical and longitudinal velocity change or impact condition and only static strength substantiation for the longitudinal impact condition. See Proposal 3 for further discussion.

Two commenters propose no reduction in the load factors proposed in the notice. One commenter agrees with the inertial factors proposed but suggests an 18g downward factor when compared to a 12g limit contained in Table 39 of Report No. DOT/FAA/CT-85/11. The FAA notes the 12g±1g limit is recommended in the report for the design "stroking factor" on new design rotorcraft seats to limit the occupant spinal loads. However, a 25g downward inertia factor is recommended in the report as a design load factor after the seat "strokes." One commenter specifically recommends no reduction in the proposed static and dynamic standards in the notice, contrary to the recommendations from other commenters.

FAA Response to Comments of Static Load Factors of Paragraph (b)

Many commenters note the expense of compliance but do not propose alternative standards. The FAA is also concerned about the cost of compliance with the new standards. A preliminary cost benefit analysis was prepared for the notice, and a final cost benefit analysis has been prepared for these amendments. A copy is filed in the docket. See the economic summary in this preamble for further information.

These comments were reviewed in conjunction with available data such as that contained in Report No. DOT/FAA/CT-85/11. The static inertial factors are needed to supplement the two seat and occupant ATD dynamic test conditions in §§ 27.562(b) and 29.562(b). The inertial factors in § 27.562(b)(3) are compatible with the dynamic load factors of §§ 27.562(b) and 29.562(b) and are supported by a review of rotorcraft accidents reported in Report No. DOT/FAA/CT-85/11.

Although the static load factors proposed in Notice 87-4 are greater than those recently adopted for transport airplanes, the rotorcraft factors should be greater because of the differences in size, configuration, and typical impact attitudes and conditions between these types of aircraft. These differences result in rotorcraft experiencing greater load factors during impact than typical transport airplanes. A recent study reported by Mr. G. Wittlin highlights the differences as discussed later. Accordingly, higher load factors were proposed in Notice 87–4 for rotorcraft for both dynamic tests and static tests. Static loading substantiation, by test or analysis, assures that necessary static structural strength of the seat and its attachments to the rotorcraft are provided to support dynamic tsting of the occupant restraint system. The static substantiation is a necessary supplement to dynamic testing which proves the performance of the seat and occupant restraint system, including secondary impact of the occupant's head, under rapid loading and load magnification due to dynamics of the system during the test. The static factors (i.e., structural strength requirements) are intended to provide sufficient strength for the seat and its attachments during dynamic testing and provide sufficient strength for the fuselage structure without dynamic testing. The FAA determined it is proper to not only impose the dynamic test standards but to impose static design standards to supplement the dynamic standards.

A technical paper entitled, "The Influence of Airplane Size and Crash Data Criteria," by Mr. G. Wittlin, was presented at the Flight Safety Foundation, Inc., Conference and Workshop on Occupant Safety, October 31 to November 3, 1988, at Arlington, Virginia. A copy of this paper is included in the docket. Table 8 in that paper contains a range of floor dynamic pulses as a function of four groups of airplane sizes ranging from general aviation to wide-body airplanes for both the vertical and longitudinal direction pulse determined from tests or parametric studies. Most present rotorcraft designs are comparable in size to the general aviation and commuter size airplanes for fuselage design and structural deformation characteristics and are further related to typical rotorcraft impacts that were included in Report No. DOT/FAA/CT–85/11. The pertinent information from the technical paper is summarized in Table 1.

TABLE 1.—PEAK LOAD FACTORS FOR FLOOR DYNAMIC PULSES FOR SMALL AIRPLANES

	Vertical direction	Longitudinal direction
General Aviation	33g peak	33g peak
Commuter	23g peak	17g peak

Narrow and wide body transport airplanes have significantly less deceleration forces in the vertical and horizontal direction and are not comparable to rotorcraft designs. For comparison, the rotorcraft standards in the amendments to §§ 27.562 and 29.562 require a peak of 30g for the downward case (vertical with horizontal component) and 18.4g for the horizontal case (longitudinal with yaw component). These dynamic condition values for rotorcraft standards compare favorably to the floor pulses in the table above for comparable-sized airplanes.

In summary, the static inertial design factors supplement the two dynamic test conditions. The 16g forward static design factor is needed to supplement the 18.4g dynamic standard and the 20g downward (vertical) static design factor relates to the 26g vertical component of the dynamic standard for seat strength and for backup or fuselage structural strength. Therefore, the static inertia factors of paragraph (b) are adopted as proposed.

Comments on Proposal 2, Paragraph (c). Three commenters recommend increasing the inertial load factors proposed in § 29.561(c) for items of mass outside the cabin as follows. One commenter states the inertial load factors proposed in paragraph (c) are too low and not consistent with those higher factors in paragraph (b) for interior items. Another commenter recommends an inertial load factor of 10g for both forward and downward directions as a proper design condition, while yet another commenter recommends 12g forward, 6 sideward, 12g downward, and retaining 1.5g upward.

The FAA agrees that higher factors will increase safety over those proposed by Notice No. 87–4 and are more compatible with the factors of amended § 27.561(b). Nevertheless, additional public notice and comment would be appropriate and necessary for the significant increase in the inertial factors recommended for attachment of external items of mass. Adopting higher inertial factor is beyond the scope of the notice; therefore, the inertial factors are adopted as proposed. However, the FAA will consider incorporating this suggestion into a future rule.

Proposal 3. New §§ 27.562 and 29.562 were proposed to add two dynamic test conditions and pass/fail criteria and to provide for acceptance of an alternate approach in place of the two physical tests. In Notice 87–4 the explanation for Proposal 3 contained justification for new §§ 27.562 and 29.562 being identical.

One commenter states public policy dictates a higher standard for transport category rotorcraft when compared to the normal category standards and proposes simplified tests for normal category rotorcraft. The FAA notes transport rotorcraft in certain cases comply with higher standards than normal category rotorcraft, yet many of the standards are identical and applied in the same manner, such as the current seat structural strength and design standards in §§ 27.561 and 29.561 and §§ 27.785 and 29.785. The impact conditions for normal and transport rotorcraft are also considered the same. Since §§ 27.562 and 29.562 concern strength or performance of the seats and occupant restraint systems during an emergency landing impact derived from rotorcraft characteristics and accident information, these objective performance standards recognize and consider implicitly practical differences in the types of rotorcraft and seats. Additionally, the size, construction, use, and performance of many normal and transport category rotorcraft are very similar since the division between the two categories is 6,000 pounds gross weight. The information from the technical paper, "The Influence of Airplane Size on Crash Data Criteria," by G. Wittlin, presented in Table 1 earlier, also supports the dynamic impact conditions. Since the human impact injury criteria are not dependent on the type of rotorcraft, the injury criteria of §§ 27.562 and 29.562 are identical. Further, the rotorcraft accident study contained in Report No. DOT/FAA/CT–85/11, Table 8, reveals that occupants in accidents involving small-size helicopters could benefit more than occupants of larger helicopters from improved occupant standards. Normal category rotorcraft also constituted about 86 percent of the total U.S. rotorcraft fleet in 1984 according to the Helicopter Association International. This percentage has not changed appreciably.

One commenter states that the dynamic tests are impractical and too costly, and several others contend the increase in certification expense and the technical expertise required to meet the proposed standards, if adopted, would be an insurmountable obstacle. However, no quantitative economic data or information was submitted to the docket to support these arguments. The final economic evaluation shows benefits exceed the costs of compliance and also in-service operation for normal category rotorcraft designs. The FAA notes that technical expertise is available, and seats with stroking capability are in service in civil rotorcraft.

Several other commenters state the added expense will curtail certification of new part 27 rotorcraft designs. Since estimated benefits exceed the costs, new designs should not be deterred. One commenter agrees with the proposed standard for transport rotorcraft but not for normal category rotorcraft. The benefits expected from the part 27 standards are more significant than those of the part 29 standards according to the economic evaluation.

Editorial changes have been made to paragraphs (a)(1) and (a)(2) for clarity and also to agree with Amendment 25–64 for transport airplanes. The amendment, as adopted, states the occupant "is exposed to the loads" rather than "experience ultimate dynamic loads."

A commenter states that only seats occupied for takeoff and landing should be subject to the dynamic tests. The FAA agrees, and paragraph (b) is revised to apply to "each seat type design or other seating device approved for occupancy during takeoff and landing." This is similar to recently adopted § 25.562(b) in Amdt. 25–64 and includes an editorial change to add "type design" to seats. Those seats not complying with these standards or the standards in §§ 27.561, 27.785, 29.561 and 29.785 must nevertheless comply with the flight load factors of the aircraft and must be placarded to prevent use of the seat during takeoff and landing. It is anticipated such "unique" seats will seldom be installed in rotorcraft.

Two commenters recommend the ATD should represent a nominal rather than a minimum weight of 170 pounds. The FAA agrees since the specification cited currently specifies the correct weight; therefore, the words "total minimum" to describe weight are removed from paragraph (b). In addition, the standard has been divided into two sentences to be parallel with § 25.562(b). The first sentence addresses the seats and an acceptable analysis rather than test alone. The second sentence addresses the previous comments on the ATD and includes the phrase "sitting in the normal upright position" to properly describe the ATD test position.

A commenter agrees with two dynamic seat tests but recommends adopting the two test conditions for transport airplanes contained in Notice 86–11 and adopted by Amdt. 25–64. These tests for airplanes have increased energy (higher velocity) but significantly decreased deceleration factors. The transport airplane standards represent a larger airplane fuselage having about 30 inches of structure that could crush and absorb the energy on impact. The two dynamic tests proposed in paragraph (b) are proper for rotorcraft fuselage characteristics and for the impact attitudes and speeds for a significant percentage of the accidents. According to the information in Report No. DOT/FAA/CT–85/11, the proposed velocities represent about 92 to 95 percent of the survivable accidents, the range of attitude encompassed in the proposal represents about 77 percent, and the pulse duration represents a fuselage crushing or deformation capability of approximately 9.7 inches. For smaller rotorcraft which do not have 9.7 inches of available fuselage structure to absorb the impact energy, energy absorption by any fixed landing gear failure is tacitly included in the standard. Therefore, the dynamic tests in paragraphs (b) (1) and (2) are adopted with the changes discussed. "Downward" velocity has been added to paragraph (b)(1) and "forward" velocity to paragraph (b)(2). The last sentence in each includes the word "floor" as the correct description for measuring deceleration.

Two commenters request a change to paragraph (b) to explicitly provide for the use of analysis supported by test. The FAA agrees since paragraph (d) was intended to allow use of a rational analysis supported by test as an option to the use of test alone. Paragraph (b), as adopted, includes a clause identical to that contained in § 25.562(b) stating dynamic tests or rational analysis based on dynamic tests of a similar type seat may be used. As a result of two comments, paragraph (d) is revised to apply to the entire section rather than to only paragraph (c).

A commenter suggests in place of proposed paragraph (b) for dynamic tests to require either: (1) A static design standard which would include mandatory upper torso restraint, consideration of floor flexibility or distortion, and energy absorbing features as equal to dynamic tests; or (2) simplified dynamic tests without an ATD. The test would call for measuring the acceleration factors on the seat pan using a mass simulating a 170-pound occupant for the test conditions contained in the notice. Specific proposed standards to accomplish the objectives cited by the commenter were not included. The FAA does not agree that a static test is sufficient to duplicate the occupant loads and motion occurring during a dynamic impact condition; therefore, the dynamic test standard is retained.

Three commenters offer a counterproposal to paragraphs (b) (1) and (2) for normal category rotorcraft. These commenters are concerned with small rotorcraft equipped with seats integral with the basic structure of the fuselage. Two of the small rotorcraft designs in use today have features on the flightcrew seats which allow stroking or seat displacement to limit the vertical loads during an impact. The effectiveness of these features for a specific impact condition is not known. The commenters propose static strength substantiation for the longitudinal impact case rather than dynamic test since static strength substantiation is considered sufficient. They propose one dynamic test—vertical with horizontal impact velocity for a resultant of 30 fps. An ATD would be replaced with a mass to simulate the occupant. The deceleration forces or inertial load factor measured on the mass would not be allowed to exceed 23g for more than 0.025 seconds total. In addition, their proposal would allow use of the landing gear and fuselage support structure and/or seat to absorb the energy and reduce the impact forces to 23g or less on the mass. A commenter states this dynamic test concentrates on spinal compression loads and further contends the error likely to occur in their counterproposal is less than the error from the tests contained in Notice 87–4 when using the ATD because in reality, rotorcraft occupant weight and size vary significantly from that of the ATD.

The FAA notes that the ATD represents a 50-percentile male. One of the three commenters refers to Report AD–A093784, December 1980, and AMCP 706–210 as the basis for the counterproposal. These commenters advocate the counterproposal as a practical means for small manufacturers to develop (and certify) new part 27 designs while improving occupant protection. One commenter also advocates static test alone rather than a dynamic test for the longitudinal impact case. Reduced static design inertial load factors are recommended rather than those contained in Notice 87–4. However, the commenter agrees with an increase from 9g to 16g forward factor for static strength substantiation if the proposed longitudinal dynamic test is not adopted. This commenter proposes a vertical impact test using an ATD and, in addition, a reduced severity test which equals that proposed for transport airplanes in Notice 86–11 and later adopted. One commenter states adopting dynamic tests and using an ATD, as proposed, would cause a total redesign and may result in abandoning current certification activity on a small, four-place helicopter.

The FAA notes that the cost benefit analysis shows the benefits derived, especially for smaller rotorcraft, exceed the costs as noted in the economic summary of this preamble. Two dynamic impact test conditions are necessary to properly assess the restraint and support of occupants so that the human injury impact criteria will not be exceeded. The criteria include the assessment of any secondary head impact with structure. The first part of this preamble contains a further description of the objectives and reasons for adopting the two dynamic impact test conditions.

One commenter supports the FAA analysis and agrees that the study in Report No. DOT/FAA/CT-85/11 indicates a need for vertical energy absorption to limit occupant spinal compression injuries. The third highest hazard reported was related to "vertebral" compression injuries resulting from high vertical forces commonly found in rotorcraft accidents. Tolerance to compressive injuries of the spine decreases as age increases, and civil aircraft occupants are typically (15 to 20 years) older than military aircraft occupants. The commenter further states most of the present energy absorbing seat and restraint system technology is based on military personnel and military aircraft designs or applications. The FAA notes the military rotorcraft criteria are too stringent for civil rotorcraft, and the FAA has previously published civil aircraft human impact injury criteria in AC 21-22. The commenter states that the dynamic tests proposed in Notice No. 87-4 should help in assuring the seat and occupant restraint system will function properly under dynamic (impact) conditions. The commenter further states the two dynamic test conditions proposed are similar to those recommended in Report No. DOT/FAA/CT-85/11, Table 39 and Figure 37, except less severe. The commenter recommends no further reduction from the proposals in Notice No. 87-4 and disagrees with other commenters who recommend that the FAA reduce the severity of the tests or delete the dynamic tests. The commenter further states that the FAA proposals address many of the major hazards that cause serious and fatal injuries in survivable accidents. The commenter supports the two proposed dynamic seat and occupant test standards as proper, well defined, and cost effective, while acknowledging that rotorcraft with integal seats may require expanded advisory material. The discussion for paragraph (b)(3) addresses "integral seat designs."

In summary, the two conditions in paragraphs (b) (1) and (2) are justified for normal and transport category rotorcraft and are based on a review of rotorcraft accident data as stated before. The standards in paragraphs (b) (1) and (2) are adopted with the additional description of velocity and floor deceleration noted previously.

Some commenters state the proposed standard does not recognize or allow the use of seats integral with the fuselage structure, which is typical of many small two or four-seat rotorcraft. The FAA agrees, and paragraph (b)(3) is revised to apply to nonintegral seats or to those seats "where floor rails or floor or sidewall attachment devices are used" to attach the seat to the airframe structure. Integral seats and bulkhead-mounted seats without floor or sidewall attachment devices and with continuous attachments such as rows of rivets or screws, etc., are excluded from the specific misalignment or preload in the test. A commenter recommends clear and specific guidance or advisory material to address integral seats and their dynamic tests. Advisory material for §§ 27.562 and 29.562 was previously drafted and comments invited (52 FR 20947; June 3, 1987). No comments were received. The recommended guidance information will be included in this advisory material which will be subject to further public review.

In addition, the explanation for the head impact criteria (HIC) equation stated in paragraph (c)(5) is adopted with a change that adds the word "form" to clarify that an ATD head form is used for the HIC.

Proposal 4. The notice proposed to revise § 27.785 by adding the static inertial load factors of § 27.561 and the dynamic conditions of § 27.562 to paragraph (a) as requirements to protect occupants from serious injury; to revise paragraph (b) to require each occupant seat, not just crew seats, to be equipped with a shoulder harness in conjunction with a safety belt (or torso restraint system per TSO C114); to revise paragraph (c) to require that the safety belt and shoulder harness have a single-point release; to revise paragraph (f) to use an occupant weight of at least 170 lbs; and to revise paragraph (g) to require a 60-40 percent safety belt-shoulder harness load distribution instead of the previous 60-60 distribution. The notice further proposed to add a new paragraph (i) defining the seating device system; a new paragraph (j) to allow controlled structural deformation or crushing of the seating device system to reduce occupant loads from the proposed emergency landing dynamic test conditions (the deformation or crushing must not interfere with rapid evacuation); and a new paragraph (k) to define a litter and its design and installation standards. Dynamic test standards were not proposed for litters and berths. Identical revisions were proposed for § 29.785.

Several commenters favor the FAA proposal to require a shoulder harness for each seat. Accordingly, paragraph (a) is adopted as proposed.

A commenter proposes using either the term "shoulder harnesses" or the term "torso restraint" exclusively, but not both. "Shoulder harnesses" is retained because the existing airworthiness and operating standards use that term generically; however, for clarification, a sentence is added to paragraph (b) describing torso restraint and upper torso restraint.

One commenter proposes to apply the requirements of paragraph (b) to front seat or row occupants only and to require other occupants to have only lap or safety belts. The commenter's proposal is based on the following: (1) Rotorcraft crashes involve high vertical acceleration forces and relatively low horizontal acceleration forces; (2) passengers in flight do not like the discomfort and movement restrictions of a shoulder harness; (3) passengers become nervous when required to wear a shoulder harness; (4) passengers may become entangled in a shoulder harness during emergency egress; (5) passengers in normal category commercial operations are unduly restricted by a shoulder harness; and (6) mandatory retrofit of shoulder harnesses in the existing rotorcraft fleet creates an undue economic burden.

Report No. DOT/FAA/CT-85/11 indicates that emergency landing horizontal or longitudinal accelerations, while less than the vertical accelerations, are still significant and require restraint and support of the occupant. The horizontal forces cause the upper body to rotate forward increasing the potential for secondary impact with structure. This phenomenon was reported to be a major cause of severe injuries or fatalities which would be significantly reduced with use of a harness. A shoulder harness or upper torso restraint also maintains proper spinal alignment or support and, thus, greatly reduces the potential for spinal injury during an impact with significant vertical forces. The docket contains a figure entitled, "Use of Upper Torso Restraint Expands the Onset of the Serious and Fatal Injury Envelopes," which shows graphically that a shoulder harness and safety belt significantly improve occupant protection. One commenter also submitted information showing whenever shoulder harnesses are installed, rotorcraft passengers surveyed use them 100 percent of the time. In addition, a single-point release is required for the safety belt and harness; the FAA is not aware of any signficant impediment to evacuation caused by a harness; and the FAA did not propose a "retrofit" standard in the notice. For these reasons, the shoulder harness requirement in paragraph (b) with the exception of an editorial change for clarification is adopted as proposed.

Another commenter proposes to remove all references in § 27.785 to the dynamic test of § 27.562. The FAA does not agree since removing the § 27.562 reference in paragraph (b) would create a more restrictive rule by eliminating use of the HIC to accept minor head impact. Another commenter proposes to remove the reference § 27.562(c)(5) in paragraph (b). The HIC in § 27.562(c)(5) allow head impact and are acceptable and essential quantitative standards or limitations that can be applied uniformly wherever the head impacts the interior structure associated with a particular installation. AC 21-22 contains further information on the HIC. The reference must be retained; therefore, paragraph (b) is adopted as proposed.

Another commenter proposes removal of the portion of paragraph (c) which requires a single-point release for both the lap belt and the shoulder harness. The commenter's concern is that the proposal would require designs that prevent uncoupling of the shoulder harness from the lap belt and further prevent passengers from assuming the "brace" position during an emergency landing. The FAA has determined that upper body movement and/or a secondary impact during an emergency landing impact is a primary cause of serious injury. The docket contains information previously referenced which shows significant improvement in occupant protection when a shoulder harness is used. A properly restrained occupant is, therefore, much less likely to experience injury than one in the "brace" position. The amendment, however, does not preclude safety belt and harness designs that feature uncoupling of the shoulder harness from the lap safety belt provided a single-point release is employed in the belt-harness design. A shoulder harness provides a significant improvement in occupant protection, as previously stated, and should be used during takeoff and landing. Therefore, proposed paragraph (c) is adopted without change.

A commenter recommends retaining the present 60/60 load distribution between the safety belt and harness in paragraph (g). The proposal to use a 60/40 distribution is based on SAE Aerospace standards and also accounts for 100 percent of the load. The application of 120 percent of the load is unnecessary and unrealistic in the light of this amendment. Therefore, the 60/40 distribution in paragraph (g) is adopted as proposed.

One commenter proposes that § 27.785 should be changed to specifically refer to paragraph (b) instead of the entire section. The FAA concurs, and § 27.561(b) is cited in paragraphs (a), (f), (f)(2), (g), and (k) for proper application of the standard.

Three other commenters propose to remove paragraph (f)(1) which refers to the pilot effort forces, since design conditions or loads applied by virtue of amended § 27.561(b) and new § 27.562 are considered sufficient seat design standards. The FAA does not agree because paragraph (f)(1) provides the minimum aft load design standard for the crew seat; therefore, paragraph (f)(1) is adopted as proposed.

A commenter wants to remove proposed paragraphs (i), (j), and (k) based on a recommended change to § 27.785(b) to remove reference to HIC. Since paragraph (b) is not changed, paragraphs (i) and (j) are necessary to complement the dynamic test standards and are, therefore, retained.

In addition to a recommendation to remove paragraph (k), two commenters state that proposed paragraph (k) is unclear regarding whether or not berths and litters making an angle greater than 15° with the rotorcraft longitudinal axis may be approved. The FAA chose 15° or less as the angle for which a padded headboard, etc., is required. Safety belts or straps without a padded headboard, etc., are acceptable for the remaining design conditions. That is, beyond a 15° angle the litter or berth must have the proper number and distribution of safety belts or straps to carry the specified static design loads for all directions. Berths and letters oriented at any angle with the rotorcraft longitudinal axis may be approved in accordance with the standards adopted. Paragraph (k) is clarified by dividing one sentence into three sentences that address litter orientation and the appropriate design requirements.

Proposal 6. The notice proposed a revision to § 29.561 that is equivalent to that proposed for § 27.561 except for the underfloor fuel tank standard in paragraph (d) which is unique to the part 29 standards. For general comments and editorial changes related to § 29.561, see Proposal 2.

In addition to the general comments, a comment was received specifically for § 29.561(b) and (c). The commenter recommends adoption of lower inertial load factors in paragraph (b) such as the factors adopted in Amdt. 25–64 for transport airplanes. These airplane inertial factors are 9.0g forward, 6.5g downward, 1.5g rearward, and so forth. The commenter also proposes to combine (vectorially) these inertial load factors but would limit the resultant to 9.0g in any direction. The commenter proposes an additional 1.33 factor for the forces that are imposed on the attachments of certain interior items of mass. If these comments are not adopted by the FAA, the commenter recommends combining (vectorially) whatever design inertial load factors are adopted rather than applying each factor separately.

The FAA notes that § 29.561 currently requires application of the load factor separately but the designer may choose to combine these factors vectorially into a resultant factor for structural substantiation. The static design inertial factors for transport airplanes proposed in Notice No. 86–11 consider the emergency landing impact characteristics for transport airplanes and are not appropriate for typical normal and transport category rotorcraft impact characteristics. The additional factor, 1.33, used in conjunction with the lower load factors for the attachments of certain interior items of mass is not necessary with adoption of the higher inertial factors proposed in the notice; i.e., the adopted criteria exceed that of the proposed change. In addition, the suggestion to combine (vectorially) the inertial factors but not to exceed 9.0g is, therefore, not adopted.

This same commenter also recommends a new paragraph (e) specifically to address an alternate approach in achieving an equivalent or greater level of occupant protection in relation to that contained in the commenter's proposed paragraph (b) change. The commenter proposes the following changes to paragraph (b): (1) to use the transport airplane inertial factors in Notice No. 86–11; (2) to combine vectorially two inertial factors not to exceed 9g when combined; and (3) to refer to the dynamic tests prescribed in § 29.562. That is, these three factors would replace the dynamic tests as a primary means of compliance. Section 21.21(b)(1) already provides a means to accept any alternative to a specific standard provided an equivalent level of safety is maintained. The FAA considers the commenter's proposed paragraph (e) unnecessary and, therefore, it is not adopted.

Two commenters recommend that static design factors for exterior items of mass in paragraph (c) be the same as those in paragraph (b) for interior items. Collapse of a partition or significant collapse of or penetration into the occupied cabin space has not been identified as a significant problem in survivable rotorcraft accidents according to the information in Table 26, Report No. DOT/FAA/CT-85/11. Thus, items of mass external to the crew or passenger cabin may be designed to factors less than those for internal items. This recommendation is not adopted. Another commenter states a partition (or bulkhead, etc.) separating the exterior items of mass from the transport rotorcraft cabin should be substantiated for the loads imposed by the items of mass attached to the partition. The FAA agrees that items of mass such as those described in the standard directly attached to a partition should not become detached. The standards provide for this substantiation.

One commenter recommends specific higher inertial factors for paragraph (c), that is, 12g forward, 6g sideward, 12g downward, while retaining 1.5g upward to reduce hazardous movement of high mass items that are described in their proposals. Adopting higher inertial load factors than those proposed is beyond the scope of the notice; therefore, the inertial factors are adopted as proposed.

Proposal 7. The notice proposed to add to § 29.562 a new dynamic test standard for occupant seats in transport rotorcraft that is identical § 27.562. The emergency landing impact conditions for transport rotorcraft are equivalent to normal category rotorcraft conditions. See the comments and FAA response in Proposal 3. Section 29.562 is adopted with the same changes as noted in Proposal 3.

Proposal 8. The notice proposed to amend §§ 29.783 (d) and (g) by removing the general reference to § 29.561(b)(3). The design factors in that section have been significantly increased but those factors are not necessary for door designs. Therefore, the specific factors in present § 29.561(b)(3) are added to paragraph (d), and paragraph (g) refers to paragraph (d) for the design factors. The factors in the standards are used to evaluate surrounding fuselage structural deformations and impose design features, where necessary, to minimize the probability of jamming external doors and integral stair doors as a result of a minor crash landing and thereby facilitate passenger egress.

One commenter contends that doors and exits should be subject to the same design load factors as the occupant restraint system. The FAA does not agree because experience has shown the design standards presently in use have been satisfactory and should be retained for door designs.

Two other commenters question why cargo doors, other than those used as emergency exits, must meet the requirements of § 29.783(d). Typical rotorcraft doors, whether cargo or exit, are usually qualified as passenger exits and, therefore, must comply. However, the FAA agrees that "cargo or service doors not suitable for use as an exit in an emergency" may be excluded from compliance with the standard. Section 29.783(d), as adopted, adds a clause excluding certain cargo and service doors. This clause for cargo and service doors was extracted, in part, from the transport airplane door standard of § 25.783(g).

Another commenter proposes a 9g static load factor, in any direction, for §§ 29.783 (d) and (g). As noted before, the present design load factors, such as 4g forward, etc., have provided an adequate level of safety since a significant adverse service history on doors does not exist. Therefore, the amendment is adopted with changes as discussed.

Proposal 9. The proposals for §§ 27.785 and 29.785 are identical. For comments and the FAA response related to proposed § 29.785, see Proposal 4. The occupant seat, safety belt, shoulder harness, berth or litter standards for transport and normal rotorcraft are standards not affected by the size of the rotorcraft. No one objected to the application of common standards. Therefore, § 29.785 is adopted with the same changes as discussed in Proposal 4.

Proposal 10. The notice proposed to amend § 29.809 by revising paragraph (e) to add reference to § 29.783(d) for the appropriate ultimate inertial load factors for exits as well as doors of transport rotorcraft. The current design factors for exits are maintained by the amendment. See the comments on Proposal 8 for further information.

One commenter recommends that paragraph (e) remain unchanged. The FAA disagrees because without the reference to § 29.783(d), "minor crash landing" factors would not be defined, thus creating the potential for nonstandard application.

A commenter states that the load factors proposed in paragraph (e) are inconsistent with those proposed for occupants in § 29.561(b)(3) which are much higher. The commenter recommends use of the emergency landing impact load factors in paragraph (e). Service history has shown that the load factors proposed in paragraph (e), such as 4g forward, provide an adequate level of safety to minimize the probability of jamming the emergency exits as a result of fuselage deformation. Therefore, the standard is adopted as proposed.

Economic Evaluation Summary

The FAA proposed to amend parts 27 and 29 of the FAR to require the installation of shoulder harnesses and seats incorporating energy attenuation features on all newly certificated rotorcraft. The amendments to improve occupant protection standards are the result of several specific proposals presented at the Rotorcraft Regulatory Review Conference in 1979, the recommendations of the NTSB, and the FAA aircraft crash dynamics program.

The FAA finds the amendments to §§ 27.561(c), 27.785(k), 29.561(c), 29.783, 29.785(k), and 29.809 will cause manufacturers to incur negligible testing costs in demonstrating compliance with these new standards. The FAA finds the remaining amendments will have a cost impact on manufacturers as well as operators.

For the purpose of the evaluation, those elements of amended §§ 27.561, 27.785, and new 27.562 having a cost impact have been examined as if they were a single amendment. The close interrelation of these amendments precludes clear separation. The amendments to §§ 29.561, 29.785 and new 29.562 having a cost impact have been evaluated in the same manner.

This evaluation indicates that adoption of the standards is expected to be cost beneficial. The final rule regarding shoulder harness and energy attenuating seats—the occupant restraint system—is expected to reduce fatalities and injuries sustained in otherwise survivable crashes from between 30 to 85 percent. The average annual monetary benefits of this final rule are estimated to be $770,600 while the average annual costs are estimated to be $411,900. The average annual net benefits of the final rule are expected to be $358,700 and the present value of these net benefits over 10 years is estimated to be $2.20 million.

International Trade Impact Analysis

The FAA has determined that this rule is not likely to result in a competitive trade advantage or disadvantage for U.S. manufacturers in domestic or foreign markets. Foreign manufacturers are expected to comply with the certification standards of their largest export customer, the United States. The FAA believes that to remain competitive in overseas markets, foreign vendors will export a similarly equipped rotorcraft to both the United States and third world countries. Foreign and U.S. manufacturers are expected to pass the new certification costs on to consumers in their domestic and foreign markets.

Regulatory Flexibility Determination

The FAA has determined that these amendments will not have a significant impact, positive or negative, on a substantial number of small entities. According to FAA criteria, a small helicopter manufacturer is one that is independently owned and operated and has fewer than 75 employees. Using these criteria, only one U.S. manufacturer is considered small. Therefore, it is not possible for this rule to impact a substanital number of small entities.

Federalism Implications

The regulations adopted herein do not have substantial direct effects on the states, on the relationship between the national government and the states, or on the distribution of power and responsibilities among the various levels of government. Therefore, in accordance with Executive Order 12612, it is determined that this amendment does not have sufficient federalism implications to warrant the preparation of a Federalism Assessment.

Conclusion

For the reasons discussed in the preamble, and based on the findings in the Regulatory Flexibility Determination and the International Trade Impact Analysis, the FAA has determined that these amendments are not major under Executive Order 12291. In addition, the FAA certifies that these amendments do not have a significant economic impact, positive or negative, on a substantial number of small entities under the criteria of the Regulatory Flexibility Act. These amendments are considered significant under DOT Regulatory Policies and Procedures (44 FR 11034; February 26, 1979). A regulatory evaluation of the amendments, including a Regulatory Flexibility Determination and Trade Impact Analysis, has been placed in the docket. A copy may be obtained by contacting the person identified under "FOR FURTHER INFORMATION CONTACT."

List of Subjects 14 CFR Parts 27 and 29:

Air transportation, Aircraft, Aviation Safety, Safety, Rotorcraft.

Adoption of the Amendment

Accordingly, parts 27 and 29 of the Federal Aviation Regulations (14 CFR parts 27 and 29) are amended as follows:

PART 27—AIRWORTHINESS STANDARDS: NORMAL CATEGORY ROTORCRAFT

1. The authority citation for part 27 continues to read as follows:

Authority: 49 U.S.C. 1344, 1354(a), 1355, 1421, 1423, 1425, 1428, 1429, and 1430; 49 U.S.C. 106(g) (Revised Pub. L. 97-449, January 12, 1983).

2. By amending § 27.561 by revising paragraphs (b) (introductory text), (b)(3), and (c) to read as follows:

§ 27.561 General.

* * * * *

(b) The structure must be designed to give each occupant every reasonable chance of escaping serious injury in a crash landing when—

* * * * *

(3) Each occupant and each item of mass inside the cabin that could injure an occupant is restrained when subjected to the following ultimate inertial load factors relative to the surrounding structure:

(i) Upward—4g.

(ii) Forward—16g.

(iii) Sideward—8g.

(iv) Downward—20g, after intended displacement of the seat device.

(c) The supporting structure must be designed to restrain, under any ultimate inertial load up to those specified in this paragraph, any item of mass above and/or behind the crew and passenger compartment that could injure an occupant if it came loose in an emergency landing. Items of mass to be considered include, but are not limited to, rotors, transmissions, and engines. The items of mass must be restrained for the following ultimate inertial load factors:

(1) Upward—1.5g.

(2) Forward—8g.

(3) Sideward—2g.

(4) Downward—4g.

3. By adding a new § 27.562 to read as follows:

§ 27.562 Emergency landing dynamic conditions.

(a) The rotorcraft, although it may be damaged in an emergency crash landing, must be designed to reasonably protect each occupant when—

(1) The occupant properly uses the seats, safety belts, and shoulder harnesses provided in the design; and

(2) The occupant is exposed to the loads resulting from the conditions prescribed in this section.

(b) Each seat type design or other seating device approved for crew or passenger occupancy during takeoff and landing must successfully complete dynamic tests or be demonstrated by rational analysis based on dynamic tests of a similar type seat in accordance with the following criteria. The tests must be conducted with an occupant, simulated by a 170-pound anthropomorphic test dummy (ATD), as defined by 49 CFR 572, subpart B, or its equivalent, sitting in the normal upright position.

(1) A change in downward velocity of not less than 30 feet per second when the seat or other seating device is oriented in its nominal position with respect to the rotorcraft's reference system, the rotorcraft's longitudinal axis is canted upward 60° with respect to the impact velocity vector, and the rotorcraft's lateral axis is perpendicular to a vertical plane containing the impact velocity vector and the rotorcraft's longitudinal axis. Peak floor deceleration must occur in not more than 0.031 seconds after impact and must reach a minimum of 30g's.

(2) A change in forward velocity of not less than 42 feet per second when the seat or other seating device is oriented in its nominal position with respect to the rotorcraft's reference system, the rotorcraft's longitudinal axis is yawed 10° either right or left of the impact velocity vector (whichever would cause the greatest load on the shoulder harness), the rotorcraft's lateral axis is contained in a horizontal plane containing the impact velocity vector, and the rotorcraft's vertical axis is perpendicular to a horizontal plane containing the impact velocity vector. Peak floor deceleration must occur in not more than 0.071 seconds after impact and must reach a minimum of 18.4g's.

(3) Where floor rails or floor or sidewall attachment devices are used to attach the seating devices to the airframe structure for the conditions of this section, the rails or devices must be misaligned with respect to each other by at least 10° vertically (i.e., pitch out of parallel) and by at least a 10° lateral roll, with the directions optional, to account for possible floor warp.

(c) Compliance with the following must be shown:

(1) The seating device system must remain intact although it may experience separation intended as part of its design.

(2) The attachment between the seating device and the airframe structure must remain intact, although the structure may have exceeded its limit load.

(3) The ATD's shoulder harness strap or straps must remain on or in the immediate vicinity of the ATD's shoulder during the impact.

(4) The safety belt must remain on the ATD's pelvis during the impact.

(5) The ATD's head either does not contact any portion of the crew or passenger compartment, or if contact is made, the head impact does not exceed a head injury criteria (HIC) of 1,000 as determined by this equation.

$$HIC = (t_2-t_1)\left[\frac{1}{(t_2-t_1)}\int_{t_1}^{t_2} a(t)dt\right]^{2.5}$$

Where: a(t) is the resultant acceleration at the center of gravity of the head form expressed as a multiple of g (the acceleration of gravity) and $t_2 - t_1$ is the time duration, in seconds, of major head impact, not to exceed 0.05 seconds.

(6) Loads in individual upper torso harness straps must not exceed 1,750 pounds. If dual straps are used for retaining the upper torso, the total harness strap loads must not exceed 2,000 pounds.

(7) The maximum compressive load measured between the pelvis and the lumbar column of the ATD must not exceed 1,500 pounds.

(d) An alternate approach that achieves an equivalent or greater level of occupant protection, as required by this section, must be substantiated on a rational basis.

4. By amending § 27.785 by revising paragraphs (a), (b), (c), (f), and (g) and by adding new paragraphs (i), (j), and (k) to read as follows:

§ 27.785 Seats, berths, safety belts, and harnesses.

(a) Each seat, safety belt, harness, and adjacent part of the rotorcraft at each station designated for occupancy during takeoff and landing must be free of potentially injurious objects, sharp edges, protuberances, and hard surfaces and must be designed so that a person making proper use of these facilities will not suffer serious injury in an emergency landing as a result of the static inertial load factors specified in § 27.561(b) and dynamic conditions specified in § 27.562.

(b) Each occupant must be protected from serious head injury by a safety belt plus a shoulder harness that will prevent the head from contacting any injurious object except as provided for in § 27.562(c)(5). A shoulder harness (upper torso restraint), in combination with the safety belt, constitutes a torso restraint system as described in TSO–C114.

(c) Each occupant's seat must have a combined safety belt and shoulder harness with a single-point release. Each pilot's combined safety belt and shoulder harness must allow each pilot when seated with safety belt and shoulder harness fastened to perform all functions necessary for flight operations. There must be a means to secure belts and harnesses, when not in use, to prevent interference with the operation of the rotorcraft and with rapid egress in an emergency.

* * * * *

(f) Each seat and its supporting structure must be designed for an occupant weight of at least 170 pounds considering the maximum load factors, inertial forces, and reactions between occupant, seat, and safety belt or harness corresponding with the applicable flight and ground load conditions, including the emergency landing conditions of § 27.561(b). In addition—

(1) Each pilot seat must be designed for the reactions resulting from the application of the pilot forces prescribed in § 27.397; and

(2) The inertial forces prescribed in § 27.561(b) must be multiplied by a factor of 1.33 in determining the strength of the attachment of—

(i) Each seat to the structure; and

(ii) Each safety belt or harness to the seat or structure.

(g) When the safety belt and shoulder harness are combined, the rated strength of the safety belt and shoulder harness may not be less than that corresponding to the inertial forces specified in § 27.561(b), considering the occupant weight of at least 170 pounds, considering the dimensional characteristics of the restraint system installation, and using a distribution of at least a 60-percent load to the safety belt and at least a 40-percent load to the shoulder harness. If the safety belt is capable of being used without the shoulder harness, the inertial forces specified must be met by the safety belt alone.

* * * * *

(i) Each seating device system includes the device such as the seat, the cushions, the occupant restraint system, and attachment devices.

(j) Each seating device system may use design features such as crushing or separation of certain parts of the seats to reduce occupant loads for the emergency landing dynamic conditions of § 27.562; otherwise, the system must remain intact and must not interfere with rapid evacuation of the rotorcraft.

(k) For the purposes of this section, a litter is defined as a device designed to carry a nonambulatory person, primarily in a recumbent position, into and on the rotorcraft. Each berth or litter must be designed to withstand the load reaction of an occupant weight of at least 170 pounds when the occupant is subjected to the forward inertial factors specified in § 27.561(b). A berth or litter installed within 15° or less of the longitudinal axis of the rotorcraft must be provided with a padded end-board, cloth diaphram, or equivalent means that can withstand the forward load reaction. A berth or litter oriented greater than 15° with the longitudinal axis of the rotorcraft must be equipped with appropriate restraints, such as straps or safety belts, to withstand the forward load reaction. In addition—

(1) The berth or litter must have a restraint system and must not have corners or other protuberances likely to cause serious injury to a person occupying it during emergency landing conditions; and

(2) The berth or litter attachment and the occupant restraint system attachments to the structure must be designed to withstand the critical loads resulting from flight and ground load conditions and from the conditions prescribed in § 27.561(b).

PART 29—AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY ROTORCRAFT

5. The authority citation for part 29 continues to read as follows:

Authority: 49 U.S.C. 1344, 1354(a), 1355, 1421, 1423, 1424, 1425, 1428, 1429, and 1430; 49 U.S.C. 106(g) (Revised Pub. L. 97–449, January 12, 1983).

6. By amending § 29.561 by revising paragraphs (b) (introductory text), (b)(3), (c), and (d) to read as follows:

§ 29.561 General.

* * * * *

(b) The structure must be designed to give each occupant every reasonable chance of escaping serious injury in a crash landing when—

* * * * *

(3) Each occupant and each item of mass inside the cabin that could injure an occupant is restrained when subjected to the following ultimate inertial load factors relative to the surrounding structure:

(i) Upward—4g.

(ii) Forward—16g.

(iii) Sideward—8g.

(iv) Downward—20g, after the intended displacement of the seat device.

(c) The supporting structure must be designed to restrain under any ultimate inertial load factor up to those specified in this paragraph, any item of mass above and/or behind the crew and passenger compartment that could injure an occupant if it came loose in an emergency landing. Items of mass to be considered include, but are not limited to, rotors, transmission, and engines. The items of mass must be restrained for the following ultimate inertial load factors:

(1) Upward—1.5g.
(2) Forward—8g.
(3) Sideward—2g.
(4) Downward—4g.

(d) Any fuselage structure in the area of internal fuel tanks below the passenger floor level must be designed to resist the following ultimate inertial factors and loads, and to protect the fuel tanks from rupture, if rupture is likely when those loads are applied to that area:

(1) Upward—1.5g.
(2) Forward—4.0g.
(3) Sideward—2.0g.
(4) Downward—4.0g.

7. By adding a new § 29.562 to read as follows:

§ 29.562 Emergency landing dynamic conditions.

(a) The rotorcraft, although it may be damaged in a crash landing, must be designed to reasonably protect each occupant when—

(1) The occupant properly uses the seats, safety belts, and shoulder harnesses provided in the design; and

(2) The occupant is exposed to loads equivalent to those resulting from the conditions prescribed in this section.

(b) Each seat type design or other seating device approved for crew or passenger occupancy during takeoff and landing must successfully complete dynamic tests or be demonstrated by rational analysis based on dynamic tests of a similar type seat in accordance with the following criteria. The tests must be conducted with an occupant simulated by a 170-pound anthropomorphic test dummy (ATD), as defined by 49 CFR 572, Subpart B, or its equivalent, sitting in the normal upright position.

(1) A change in downward velocity of not less than 30 feet per second when the seat or other seating device is oriented in its nominal position with respect to the rotorcraft's reference system, the rotorcraft's longitudinal axis is canted upward 60° with respect to the impact velocity vector, and the rotorcraft's lateral axis is perpendicular to a vertical plane containing the impact velocity vector and the rotorcraft's longitudinal axis. Peak floor deceleration must occur in not more than 0.031 seconds after impact and must reach a minimum of 30g's.

(2) A change in forward velocity of not less than 42 feet per second when the seat or other seating device is oriented in its nominal position with respect to the rotorcraft's reference system, the rotorcraft's longitudinal axis is yawed 10° either right or left of the impact velocity vector (whichever would cause the greatest load on the shoulder harness), the rotorcraft's lateral axis is contained in a horizontal plane containing the impact velocity vector, and the rotorcraft's vertical axis is perpendicular to a horizontal plane containing the impact velocity vector. Peak floor deceleration must occur in not more than 0.071 seconds after impact and must reach a minimum of 18.4g's.

(3) Where floor rails or floor or sidewall floor attachment devices are used to attach the seating devices to the airframe structure for the conditions of this section, the rails or devices must be misaligned with respect to each other by at least 10° vertically (i.e., pitch out of parallel) and by at least a 10° lateral roll, with the directions optional, to account for possible floor warp.

(c) Compliance with the following must be shown:

(1) The seating device system must remain intact although it may experience separation intended as part of its design.

(2) The attachment between the seating device and the airframe structure must remain intact although the structure may have exceeded its limit load.

(3) The ATD's shoulder harness strap or straps must remain on or in the immediate vicinity of the ATD's shoulder during the impact.

(4) The safety belt must remain on the ATD's pelvis during the impact.

(5) The ATD's head either does not contact any portion of the crew or passenger compartment or, if contact is made, the head impact does not exceed a head injury criteria (HIC) of 1,000 as determined by this equation.

$$HIC = (t_2 - t_1)\left[\frac{1}{(t_2 - t_1)}\int_{t_1}^{t_2} a(t)dt\right]^{2.5}$$

Where: $a(t)$ is the resultant acceleration at the center of gravity of the head form expressed as a multiple of g (the acceleration of gravity) and $t_2 - t_1$ is the time duration, in seconds, of major head impact, not to exceed 0.05 seconds.

(6) Loads in individual shoulder harness straps must not exceed 1,750 pounds. If dual straps are used for retaining the upper torso, the total harness strap loads must not exceed 2,000 pounds.

(7) The maximum compressive load measured between the pelvis and the lumbar column of the ATD must not exceed 1,500 pounds.

(d) An alternate approach that achieves an equivalent or greater level of occupant protection, as required by this section, must be substantiated on a rational basis.

8. By amending § 29.783 by revising paragraphs (d) and (g)(1) to read as follows:

§ 29.783 Doors.

* * * * *

(d) There must be reasonable provisions to prevent the jamming of any external doors in a minor crash as a result of fuselage deformation under the following ultimate inertial forces except for cargo or service doors not suitable for use as an exit in an emergency:

(1) Upward—1.5g.
(2) Forward—4.0g.
(3) Sideward—2.0g.
(4) Downward—4.0g.

* * * * *

(g) * * *

(1) The door, integral stair, and operating mechanism have been subjected to the inertial forces specified in paragraph (d) of this section, acting separately relative to the surrounding structure.

* * * * *

9. By amending § 29.785 by revising paragraphs (a), (b), (c), (f), and (g) and by adding new paragraphs (i), (j), and (k) to read as follows:

§ 29.785 Seats, berths, safety belts, and harnesses.

(a) Each seat, safety belt, harness, and adjacent part of the rotorcraft at each station designated for occupancy during takeoff and landing must be free of potentially injurious objects, sharp edges, protuberances, and hard surfaces and must be designed so that a person making proper use of these facilities will not suffer serious injury in an emergency landing as a result of the inertial factors specified in § 29.561(b) and dynamic conditions specified in § 29.562.

(b) Each occupant must be protected from serious head injury by a safety belt plus a shoulder harness that will prevent the head from contacting any injurious object, except as provided for in

§ 29.562(c)(5). A shoulder harness (upper torso restraint), in combination with the safety belt, constitutes a torso restraint system as described in TSO–C114.

(c) Each occupant's seat must have a combined safety belt and shoulder harness with a single-point release. Each pilot's combined safety belt and shoulder harness must allow each pilot when seated with safety belt and shoulder harness fastened to perform all functions necessary for flight operations. There must be a means to secure belt and harness when not in use to prevent interference with the operation of the rotorcraft and with rapid egress in an emergency.

* * * * *

(f) Each seat and its supporting structure must be designed for an occupant weight of at least 170 pounds, considering the maximum load factors, inertial forces, and reactions between the occupant, seat, and safety belt or harness corresponding with the applicable flight and ground-load conditions, including the emergency landing conditions of § 29.561(b). In addition—

(1) Each pilot seat must be designed for the reactions resulting from the application of the pilot forces prescribed in § 29.397; and

(2) The inertial forces prescribed in § 29.561(b) must be multiplied by a factor of 1.33 in determining the strength of the attachment of—

(i) Each seat to the structure; and

(ii) Each safety belt or harness to the seat or structure.

(g) When the safety belt and shoulder harness are combined, the rated strength of the safety belt and shoulder harness may not be less than that corresponding to the inertial forces specified in § 29.561(b), considering the occupant weight of at least 170 pounds, considering the dimensional characteristics of the restraint system installation, and using a distribution of at least a 60-percent load to the safety belt and at least a 40-percent load to the shoulder harness. If the safety belt is capable of being used without the shoulder harness, the inertial forces specified must be met by the safety belt alone.

* * * * *

(i) Each seating device system includes the device such as the seat, the cushions, the occupant restraint system and attachment devices.

(j) Each seating device system may use design features such as crushing or separation of certain parts of the seat in the design to reduce occupant loads for the emergency landing dynamic conditions of § 29.562; otherwise, the system must remain intact and must not interfere with rapid evacuation of the rotorcraft.

(k) For purposes of this section, a litter is defined as a device designed to carry a nonambulatory person, primarily in a recumbent position, into and on the rotorcraft. Each berth or litter must be designed to withstand the load reaction of an occupant weight of at least 170 pounds when the occupant is subjected to the forward inertial factors specified in § 29.561(b). A berth or litter installed within 15° or less of the longitudinal axis of the rotorcraft must be provided with a padded end-board, cloth diaphragm, or equivalent means that can withstand the forward load reaction. A berth or litter oriented greater than 15° with the longitudinal axis of the rotorcraft must be equipped with appropriate restraints, such as straps or safety belts, to withstand the forward reaction. In addition—

(1) The berth or litter must have a restraint system and must not have corners or other protuberances likely to cause serious injury to a person occupying it during emergency landing conditions; and

(2) The berth or litter attachment and the occupant restraint system attachments to the structure must be designed to withstand the critical loads resulting from flight and ground load conditions and from the conditions prescribed in § 29.561(b).

10. By amending § 29.809 by revising paragraph (e) to read as follows:

§ 29.809 Emergency exit arrangement.

* * * * *

(e) There must be means to minimize the probability of the jamming of any emergency exit in a minor crash landing as a result of fuselage deformation under the ultimate inertial forces in § 29.783(d).

* * * * *

Issued in Washington, DC, on November 3, 1989.

James B. Busey,

Administrator.

[FR Doc. 89–26532 Filed 11–9–89; 8:45 am]

BILLING CODE 4910-13-M