Task Assignment

[4910-13]

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

Aviation Rulemaking Advisory Committee; Emergency Evacuation Subcommittee; Performance Standards Working Group

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of establishment of Performance Standards Working Group.

SUMMARY: Notice is given of the establishment of a Performance Standards Working Group by the Emergency Evacuation Subcommittee of the Aviation Rulemaking Advisory Committee. This notice informs the public of the activities of the Emergency Evacuation Subcommittee of the Aviation Rulemaking Advisory Committee.

FOR FURTHER INFORMATION CONTACT: Mr. William J. (Joe) Sullivan, Executive Director, Emergency Evacuation Subcommittee, Aircraft Certification Service (AIR-3), 800 Independence Avenue, SW., Washington, D.C. 20591, Telephone: (202) 267-9554; FAX: (202) 267-9562.

SUPPLEMENTARY INFORMATION: The Federal Aviation Administration (FAA) established an Aviation Rulemaking Advisory Committee (56 FR 2190, January 22, 1991) which held its first meeting on May 23, 1991 (56 FR 20492, May 3, 1991). The Emergency Evacuation Subcommittee was established at that meeting to provide advice and recommendations to the Directors, FAA Aircraft Certification and Flight Standards Services, on regulatory standards for the purpose of enhancing the ability of passengers to quickly and safely evacuate an aircraft in an emergency. At its first meeting on May 24, 1991 (56 FR 20492, May 3 1991), the subcommittee established the Performance Standards Working Group.

Specifically, the working group's task is the following:

Task: The Performance Standards Working Group is charged with making a recommendation to the Emergency Evacuation Subcommittee concerning whether new or revised standards for emergency evacuation can and should be stated in terms of safety performance rather than as specific design requirements. Specifically, the working group should address the following issues as a minimum:

A. Can standards stated in terms of safety performance replace, supplement, or be an alternative to any or all of the current combination of design and performance standards that now address emergency evacuation found in Federal Aviation Regulations Parts 25 and 121?

B. If a performance standard is recommended, how can the FAA evaluate a minor change to an approved configuration, or a new configuration that differs in either a minor or a major way from an approved configuration?

Reports: The working group will develop any combination of the following as it deems appropriate:

1. A draft notice of proposed rulemaking proposing new standards stated in terms of safety performance with supporting economic

and other required analysis, together with any other collateral documents the working group determines appropriate; or

2. For existing rules where performance standards are not recommended, a report stating the rationale for those recommendations.

3. Recommended organizational structure(s) and time line(s) for completion of this effort, including rationale.

The Performance Standards Working Group will be comprised of experts from those organizations having an interest in the task assigned to it. A working group member need not necessarily be a representative of one of the organizations of the parent Emergency Evacuation Subcommittee or of the full Aviation Rulemaking Advisory Committee. An individual who has expertise in the subject matter and wishes to become a member of the working group should write the person listed under the caption **"FOR FURTHER INFORMATION CONTACT"** expressing that desire and describing his or her interest in the task and the expertise he or she would bring to the working group. The request will be reviewed with the subcommittee chair and working group leader, and the individual advised whether or not the request can be accommodated.

The Secretary of Transportation has determined that the formation and use of the Aviation Rulemaking Advisory Committee and its subcommittees are necessary in the public interest in connection with the performance of duties imposed on the FAA by law. Meetings of the full committee and any subcommittees will be open to the public except as authorized by section 10(d) of the Federal Advisory Committee Act. Meetings of the Performance Standards Working Group will be not be open to the public, except to the extent that individuals with an interest and expertise are selected to participate. No public announcement of working group meetings will be made.

Issued in Washington, DC, on July 8, 1991.

/s/

William J. Sullivan
Executive Director
Emergency Evacuation Subcommittee
Aviation Rulemaking Advisory Committee

James T. Likes
Director
Payload Systems
Engineering Division

Boeing Commercial Airplane Group
P.O. Box 3707, MS 0R-LA
Seattle, WA 98124-2207

Action: ARM
cc A. R.

February 6, 1996

(Reg. one for me to read)

Mr. Anthony J. Broderick
Associate Administrator for Regulations and Certification, (AVR-1)
Department of Transportation
Federal Aviation Administration
800 Independence Avenue, S.W.
Washington, D.C. 20591

BOEING

Dear Mr. Broderick:

I am enclosing a draft copy of a proposed Advisory Circular (AC) on Emergency Evacuation certification. This draft AC is the result of several years of concerted effort to provide guidance that would allow for safer conduct of emergency evacuation tests and give more specific guidance relative to the use of analysis where adequate test data already exists.

This draft is the concluding work on the original task statement to determine if a means could be found to make emergency evacuation tests safer while continuing to ensure that verification of an airplane's evacuation capability is not compromised.

A report titled "Emergency Evacuation Requirements and Compliance Methods That Would Eliminate or Minimize the Potential for Injury to Full Scale Evacuation Demonstration Participants", dated January 1993 was forwarded to you by separate letter. This report was the foundation for the subsequent work and was approved at the June 28, 1993 meeting of the ARAC Emergency Evacuation Issues Area by a vote of 11 in favor, 1 not in favor.

Subsequently, a draft Notice of Proposal Rulemaking titled "Revision of Emergency Evacuation Demonstration Procedures to Improve Participant Safety" was forwarded to your office which would revise certain subparagraphs of FAR 25.803 and 121.291. This draft NPRM was approved unanimously at the Emergency Evacuation Issues meeting of November 18, 1993.

The draft AC being submitted as part of this letter was originally submitted to the Emergency Evacuation Issues Group by the Performance Standards Working Group who had voted in favor of the draft AC except for one abstention: however, the members of the Emergency Evacuation Issues group deadlocked by a vote of 7 to 7 as to whether to submit the draft AC to the FAA. As a result of this vote, I elected to return the draft AC to the PSWG to see if it could be revised sufficiently to obtain full concurrence. That effort led to a meeting of the EEIG in which the

BOEING

Performance Standards Working Group again submitted a draft AC with additional revision. The Emergency Evacuation Issues Group again could not reach concurrence. Since numerous meetings by the PSWG had been held in an effort to resolve differences and achieve consensus, I elected to submit this draft AC without having achieved consensus.

In accordance with the ARAC operating procedures relative to consensus, I'm forwarding, in addition to the draft AC, a summary of the opposing viewpoints and the PSWG disposition of these comments.

As Assistant Chairman of the ARAC Emergency Evacuation Issues area, I'm disappointed with our inability to achieve consensus. It is equally disturbing since this draft AC had its origin from a report approved by the EEIG.

I'm forwarding the draft AC to you for consideration in replacing the existing AC since I believe that it provides a substantial improvement to the existing certification guidelines and will enhance our ability to ensure safer emergency evacuations. It is also noteworthy that it has the endorsement from the JAA, Transport Canada and FAA representatives plus representatives from the ATA, AIA, AECMA, RAA and others. As such, we should not lose an opportunity to make a positive gain in improving airplane evacuation for the traveling public.

Sincerely,

James T. Likes

James T. Likes
Assistant ARAC Chair
Emergency Evacuation Issues

Enclosures: (2)

cc: Mr. Dan Salvano
Mr. Lew Lebakken

Acknowledgement Letter

U.S. Department
of Transportation

**Federal Aviation
Administration**

800 Independence Ave.. S.W.
Washington, D.C. 20591

MAR 26 1996

Mr. James T. Likes
Aviation Rulemaking Advisory Committee
Boeing Commercial Airplane Group
P.O. Box 3707, M/S OR-LA
Seattle, WA 98124-2207

Dear Mr. Likes:

Thank you for your February 6 letter forwarding a draft Advisory Circular (AC) on Emergency Evacuation Certification. The draft was developed and recommended by the Performance Standards Working Group of the Aviation Rulemaking Advisory Committee (ARAC), but ARAC could not achieve consensus on it.

I, too, am disappointed that a consensus could not be reached by ARAC; but I am aware of, and appreciate, the significant effort made to do so. Because an agreement was not reached, the Federal Aviation Administration will need to pursue this issue separately. In that effort, we will use the draft you supplied, and the information provided by the dissenters, to determine what changes to the current AC are needed to enhance emergency evacuation participants' safety.

I would like to thank the aviation community, and particularly the Performance Standards Working Group, for its commitment to ARAC and its interest in this matter.

Sincerely,

Anthony J. Broderick
Associate Administrator for
Regulation and Certification

cc: Frank Tiangsing, ANM-114

Recommendation Letter

James T. Likes
Director
Payload Systems
Engineering Division

Boeing Commercial Airplane Group
P.O. Box 3707 MS 0R-LA
Seattle WA 98124-2207

February 8, 1996

Mr. Anthony J. Broderick
Associate Administrator for Regulations and Certification, (AVR-1)
Department of Transportation
Federal Aviation Administration
800 Independence Avenue, Southwest
Washington, D. C. 20591

Dear Mr. Broderick:

BOEING

While the work on the draft AC 25.803-1X Emergency Evacuation Certification, transmitted to you with my letter of February 6, 1996, consumed the majority of the efforts of the Performance Standards Working Group, a significant amount of time was spent on the subject of Performance Standards: the establishment of a clearer understanding of what they are and how they interrelate in the subject of evacuation was undertaken, and a report was generated which is enclosed with this letter. This report from the PSWG was submitted to the ARAC Emergency Evacuation Issues Group and, subsequently, approved by that group at the November 1994 meeting to be used by the PSWG as guidance in preparing Performance Standards.

As a result of the concluding activity on AC 25.803-IX, the PSWG has established the following initial areas to develop Performance Standards to improve the existing regulation:

- Passenger and crew information sign
- Escape slide visibility
- Slide/raft portability
- Distance between exits
- Exit ratings

It is my sincere hope, that with these activities underway using the enclosed report as guidance, we can make some concrete progress in generating Performance Standards in these areas. I would also request, that unless critical to safety, no new or revised rules be issued on these listed areas that might duplicate or void their effort.

Sincerely,

James T. Likes
Assistant ARAC Chair
Emergency Evacuation Issues

Enclosure

cc: Dan Salvano
Allison Johnson

U.S. Department
of Transportation
**Federal Aviation
Administration**

800 Independence Ave., S.W.
Washington, D.C. 20591

MAR 26 1996

Mr. James T. Likes
Aviation Rulemaking Advisory Committee
Boeing Commercial Airplane Group
P.O. Box 3707, M/S OR-LA
Seattle, WA 98124-2207

Dear Mr. Likes:

Thank you for your February 8 letter regarding the subject of performance standards and performance-based regulations. You enclosed a copy of a Performance Standards Generating System for Transport Category Aircraft being used by the Aviation Rulemaking Advisory Committee (ARAC) in the area of emergency evacuation issues. You also provided a list of initial areas for which the Performance Standards Working Group hopes to develop proposed performance-based standards.

I appreciate the information you provided. The information will be given to the appropriate offices of responsibility within the Federal Aviation Administration. There are some rulemaking actions already underway that are too far along to discard (e.g., Type and Number of Passenger Emergency Exits, and Revised Access to Type III Exits). Nonetheless, I look forward to any recommendations ARAC may make on the issues you identified. I would encourage continued dialogue through both ARAC and other channels to keep all interested parties informed of the progress being made and issues being addressed.

I want to thank ARAC, and particularly the Performance Standards Working Group, for its interest in this regard. I look forward to your proposed performance-based standards.

Sincerely,

Anthony J. Broderick
Associate Administrator for
Regulation and Certification

cc: Frank Tiangsing, ANM-114

Recommendation

EMERGENCY EVACUATION CERTIFICATION ANM-110 25.803-1X August 1, 1995

1. PURPOSE. This advisory circular (AC) provides guidance on means, but not the only means, of compliance with the Federal Aviation Regulations (FAR)concerning: (1) conduct of full-scale emergency evacuation demonstrations, and (2) use of analysis and tests in lieu of conducting an actual demonstration. Throughout this AC, any reference to an analysis, which is to be used to satisfy the emergency evacuation requirements of the FAR, refers to a formal analysis document supported by data from tests or demonstrations.

2. RELATED FAR SECTIONS.

a. Section 25.803, Emergency evacuation, of 14 CFR part 25 as amended through Amendment 25-79 .

b. Appendix J to part 25 - Emergency Demonstration, as amended through Amendment 25-79.

c. Section 121.291, Demonstration and emergency evacuation procedures, of 14 CFR part 121, as amended through Amendment 121-233 .

3. BACKGROUND.

a. The requirements for emergency evacuation demonstrations were first established in part 121 (§ 121.291) of the FAR by Amendment 121-2, effective March 3, 1965. Operators were required to conduct full-scale evacuation demonstrations with a time limit of two minutes using 50 percent of the exits. The purpose of the demonstration was to validate the crewmembers' ability to execute the established emergency evacuation procedures and to ensure realistic assignment of functions to the crew. A full-scale demonstration was required upon: initial introduction of a type and model of airplane into passenger-carrying operation; an increase in passenger seating capacity of five percent or greater; or, a major change in the cabin interior that would affect emergency evacuation.

b. The requirement for the airplane manufacturer to conduct an evacuation demonstration for airplanes having a seating capacity of more than 44 passengers was established in part 25 (§ 25.803) by Amendment 25-15, effective October 24, 1967. The time limit for the manufacturer's demonstration was established at 90 seconds, and the part 121 time limit was reduced to 90 seconds. It was considered that the manufacturer's demonstration would show the basic capability of a new airplane and, as before, the part 121 demonstration was intended to account for crew training and adequate crew procedures. Therefore, the demonstration conditions were somewhat different.

With the addition of the requirement for a full-scale demonstration in part 25, § 25.803(d) gave conditions for analysis in lieu of demonstration. Section 25.803(d) stated that the demonstration need not be repeated for a change in the interior arrangement or a passenger capacity change of not more than five percent, or both, if it could be substantiated by analysis that the passengers could be evacuated in 90 seconds. At that time, analysis was used for decreases in passenger capacity when an airplane was reduced in size. Generally, the analysis was based on a full-scale demonstration for the larger airplane. Analyses were also used for increases of less than five percent.

c. Since Amendment 25-15, numerous full-scale demonstrations have been conducted by the manufacturers for both type certification and operational requirements. These demonstrations provided data on evacuation rates, escape system performance, and the behavior of evacuees (passengers and crewmembers who evacuate the airplane) during the demonstration.

d. By Amendments 25-46 and 121-149, effective December 1, 1978, § 25.803 was revised to allow a means other than actual demonstration to show the evacuation capability of the airplane and to replace the existing part 25 demonstration conditions with conditions that would satisfy both part 25 and part 121 so one demonstration would serve both requirements. Part 25 was changed to match the conditions in part 121.

Amendment 25-46 removed the five percent limitation on analysis from § 25.803(d). It was proposed in Notice 75-26, that analysis or a combination of analysis and tests be used to show evacuation capability. Amendment 25-46 dropped the provision which allowed analysis alone and required a combination of analysis and tests to assure approvals would be based on sufficient test data. It was considered that sufficient data may not be available in the case of a completely new airplane model or a model which had major changes or a considerably larger passenger capacity than a previously approved model. Thus, the requirement that the Administrator find the data used in the analysis acceptable was intended to preclude approvals which might be based on insufficient test data to support the proposed analysis.

e. Amendment 121-176, effective January 18, 1982, allowed a part 121 certificate holder to use the results of a part 25 demonstration or the part 121 demonstration of another operator to show compliance with § 121.291. This amendment also eliminated the five percent limit from part 121 because the manufacturer would have already shown compliance with § 25.803 and the partial demonstration required by § 121.291 would show that the carrier's procedures, training program and maintenance program are adequate.

f. The conduct of emergency evacuation demonstrations and the use of analysis in lieu of a full-scale demonstration were discussed at the Public Technical Conference held by the FAA in September 1985, in Seattle, Washington. These items were later discussed in detail at working group meetings. As a result of a paragraph by paragraph review of § 25.803(c), the FAA concluded that it was necessary to formalize policy on conduct of an evacuation demonstration and to clarify items of concern expressed by the group members. Most of the guidance presented in the original version of this AC, and much of the guidance in this revised version, is consolidated from existing FAA policy or the consensus of the working group. In those areas where no consensus could be reached, for example the use of analysis in lieu of full-scale demonstration, the FAA has decided how best to implement the regulations.

g. Amendment 25-72 to part 25 revised § 25.803 by moving the conditions under which an emergency evacuation demonstration was to be run from § 25.803(c) to a new Appendix J to part 25. Additionally, other sections of part 25 were relocated to group requirements more logically. To facilitate the transition to these new locations, the previous section call outs will be included in angle brackets("{}") immediately after the new section call outs.

h. Amendment 25-79 revised Appendix J by revising the age/gender mix to be used when running an emergency evacuation demonstration, by prohibiting flightcrew assistance, and by allowing the use of stands or ramps for descending from overwing exits only when the airplane is not equipped with an off-wing descent means.

i. Amendment 121-233 revised § 121.291 to allow demonstrations in compliance with § 25.803 in effect on or after December 1, 1978, and not just in effect on December 1, 1978, to satisfy the requirements of § 121.291.

j. The FAA established the Aviation Rulemaking Advisory Committee (ARAC) on January 22, 1991, to provide advice and recommendations to the FAA concerning the full range of the FAA's safety-related rulemaking activity. The ARAC, in turn, established a Performance Standards Working Group to study the rules involving emergency evacuation to see if they could be restated in terms of performance standards. A second task was given to the group to recommend revisions to the existing emergency evacuation demonstration requirements and compliance methods to eliminate or minimize injury for participants (persons performing the roles of either passengers or crewmembers in an evacuation demonstration). In January 1993, the working group forwarded a report, "Emergency Evacuation Requirements and Compliance Methods that Would Eliminate or Minimize the Potential for Injury to Full Scale Evacuation Demonstration Participants," to the ARAC. The ARAC accepted the report and forwarded it to the FAA. The recommendations for revising the compliance methods associated with the demonstration have been incorporated into this AC. Additional recommendations involved revisions to Appendix J of part 25. At such time as these recommendations are adopted into Appendix J, additional guidance will be provided as necessary.

4. <u>OBJECTIVE OF THE RULE</u>.

a. A full-scale demonstration is conducted to assess the evacuation capability of the airplane and, when compliance with paragraph g of Appendix J {§ 25.803(c)(7)(i)} regarding compliance with § 121.291 is requested, to also demonstrate the effectiveness of crew training and emergency procedures. Appendix J to part 25 {Section 25.803(c)} specifies the conditions for conduct of the evacuation demonstration.

b. The objective of the analysis allowed by § 25.803(c) {§ 25.803(d)} is to show that the airplane can be evacuated within 90 seconds under the conditions specified in Appendix J {§ 25.803(c)}. The use of analysis can eliminate the running of full-scale demonstrations where adequate knowledge is already available from previous full-scale demonstrations or other smaller-scale tests . A decrease in the number of full-scale demonstrations will reduce the number of participants subjected to possible injury.

5. <u>DETERMINATION OF WHETHER ANALYSIS OR A DEMONSTRATION IS REQUIRED FOR A NEW AIRPLANE TYPE OR A NEW CONFIGURATION OF AN EXISTING AIRPLANE TYPE</u>.

a. Each new airplane type and each change in airplane design of an existing airplane type that may have an effect on the emergency evacuation capability of the airplane should be evaluated for its impact on compliance with § 25.803, either by full-scale demonstration or by a combination of tests and analysis if appropriate.

b. The following are examples of design changes that should be evaluated for their effect on evacuation capability:

(1) A change in type, number or location of exits.

(2) An increase in passenger capacity above that listed on the type certificate data sheet.

(3) Changes in passenger distribution within the cabin area that would increase the number of passengers expected to use an exit pair to a number greater than the exit rating of the exit pair.

(4) Classifying an exit as an "excess" exit in accordance with the requirements of § 25.807(d)(6)(i) {§ 25.807(c)(6)}.

(5) Installation of escape slides or other assist means not previously approved for that model airplane.

(6) Changes to the passenger cabin configuration that reduce the passengers' access to any emergency exit below the access that was provided in the certification demonstration . Examples of such changes include partitions, galleys, etc., that restrict: the flow of passengers merging from

an aisle and cross aisle; the crew's ability to determine which exits are operable; or the crew's ability to balance the passenger flow among the active exits.

c. Testing (component, system, or full-scale) should be conducted when insufficient data exist for an analysis, as discussed in section 7.

d. A decision process for determining whether analysis or a demonstration is required for a new configuration is depicted in Figure 1.

DECISION PROCESS

AS DEFINED IN AC 25.803-1a

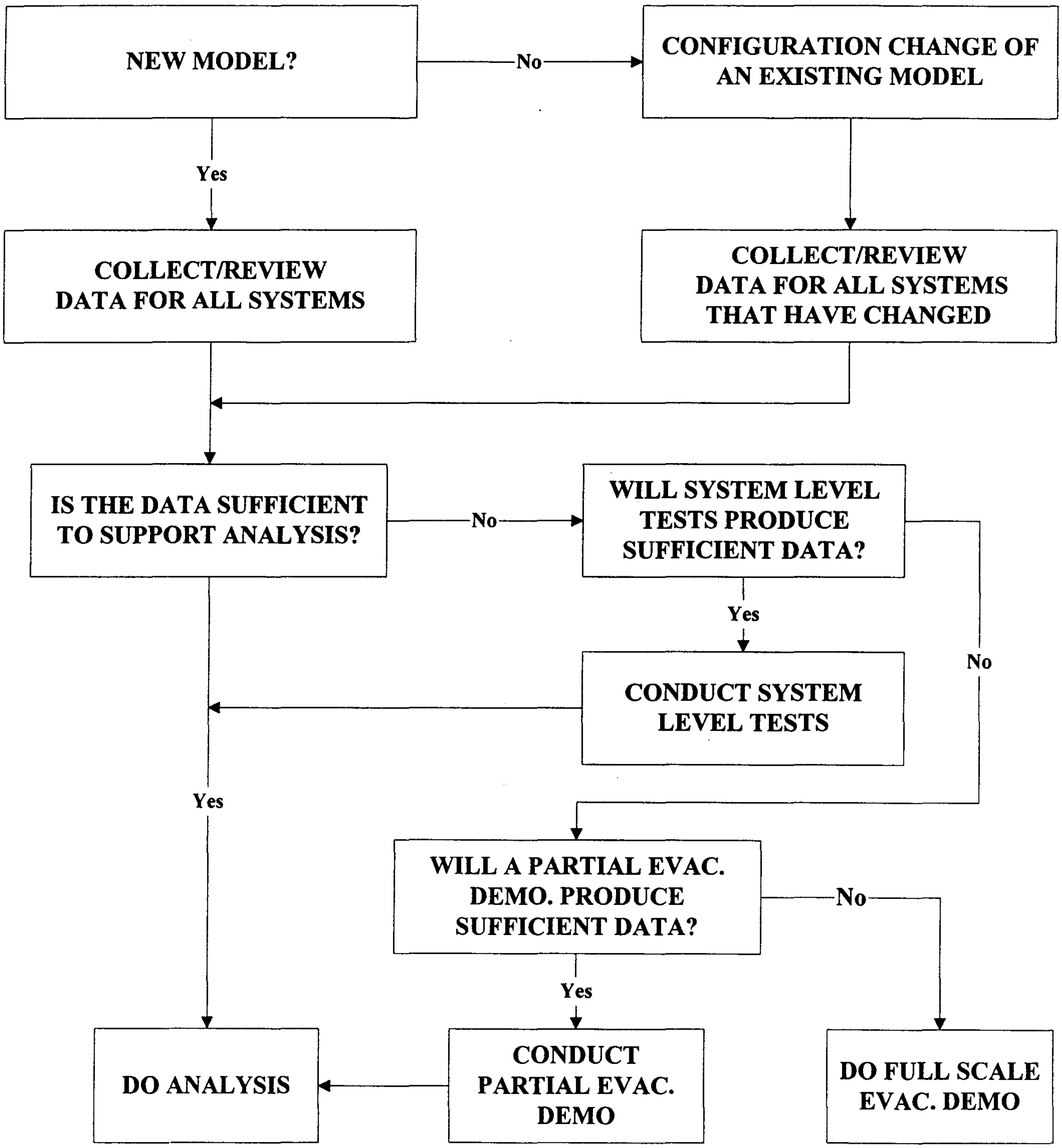

Figure 1

e. The determination whether a demonstration or formal analysis is required is made by the FAA. The applicant can participate in this decision process by preparing a proposal for either running a demonstration or preparing an analysis. If the proposal is to do an analysis, the applicant should indicate the source(s) of the data for the analysis.

6. GUIDANCE FOR DEMONSTRATING COMPLIANCE WITH § 25.803(c) AND APPENDIX J USING AN ACTUAL DEMONSTRATION.

a. Section 25.803(c) and Appendix J. The following is intended to provide uniform standards for conducting demonstrations to make demonstration results as directly comparable as is practical.

(1) Upon determination that an actual demonstration will be required, the applicant should prepare a plan that outlines such details as time and place for the demonstration, demonstration vehicle configuration, and crew training program. This plan should be submitted to the FAA as soon as possible to allow the FAA time to review, request necessary changes, and approve the plan and to arrange for participation of the appropriate FAA organizations.

(2) The phrase "The maximum capacity... for which certification is requested," refers to the airplane model presented for certification.

(3) All passengers and crewmembers used in the demonstration must be evacuated to the ground or to an off-wing ramp (if applicable) within 90 seconds to constitute a successful demonstration. Seats, including restraint systems, adequate for purposes of the demonstration, must be provided for all passengers. (For example, a 5-place seat assembly may be used to seat 6 passengers, if the 6 passengers can be accommodated and 6 restraint systems are installed and used.) The limits of § 25.807(d) or (e) {§ 25.807(c) or (d)} may not be exceeded. Partial credit, equal to or less than the number of evacuees on the ground at 90 seconds, may be granted by the FAA if all passengers and crewmembers used in the demonstration have not been evacuated by that time. For example, if an aircraft is equipped with four pairs of Type A exits, the maximum seating configuration allowed by § 25.807(d) {§ 25.807(c)} provides for 440 passengers. If certification is requested for 440 passengers plus crewmembers, that number of passengers and crewmembers must be provided seating in the airplane and they must evacuate the airplane in 90 seconds for a successful demonstration. If, in the demonstration, only 420 passengers evacuate the airplane within the 90 second time limit, the FAA may allow credit for no more than 420 passengers.

(4) Federal Aviation Administration observers should be stationed inside the airplane at expected critical locations, and outside the airplane at each exit to be used. Airplanes which do not have space for adequate onboard observation should provide interior video coverage to compensate for the absence of official witnesses.

(5) The airplane should be configured with the minimum aisle, crossaisle, and passageway clearances expected to be type certificated. (Configuration changes reducing clearances below

those demonstrated may require substantiation.) This may require combining features of more than one interior configuration. The airplane interior need not be representative of a specific operational configuration for the purposes of the demonstration. For example, galleys and other furnishings may be simulated by mockups; seats need not have a Technical Standard Order (TSO) authorization, etc. The interior configuration should be FAA-approved, as a demonstration configuration, prior to the demonstration, and should be described in sufficient detail to allow a conformity inspection.

(6) The phrase "including the number of crewmembers required by the operating rule" refers to the minimum number of flight crewmembers listed in the Airplane Flight Manual (AFM) and the minimum number of flight attendants required by § 121.391 for the passenger seating capacity to be demonstrated. The observer seats need not be occupied for the demonstration.

(7) If the demonstration fails, the demonstration should not be repeated until the applicant has had time to identify the cause(s) and institute corrective measures. The FAA should be informed of the cause(s) of the failed demonstration and the corrective action(s) taken by the applicant before the demonstration is repeated. Different groups of passengers and crewmembers should be used in repeat demonstrations.

(8) Participants in the demonstration should be encouraged to wear long sleeve shirts, full length pants and low heel shoes in order to reduce the occurrence and severity of injury. If emergency escape slides are used in the demonstration, gloves should be distributed to the participants in order to reduce abrasions to the hands caused by contact with the slide surfaces.

(9) Flight attendants are a critical element in the conduct of a safe, efficient, evacuation. These crew members initiate the evacuation, direct the evacuation process at usable exits, direct passengers away from unusable exits, and provide passenger management within the cabin, all with the safety of the participants as a foremost consideration. Flight attendants should be cautioned about the "demonstration" nature of the evacuation and the importance of minimizing the potential for injury by using passenger management techniques which are consistent with airline training programs.

(10) Thorough internal and external video/movie documentation may be beneficial for acquiring data, explaining anomalies, or identifying causes of failed demonstrations.

(11) A test abort signal system is recommended.

b. <u>Paragraph c of Appendix J {Section 25.803(c)(3)}</u>.

(1) If the airplane is equipped with an off-wing assist means, it should be used during the demonstration in lieu of stands or ramps.

(2) Safety personnel stationed outside the airplane to help in preventing injury, should not position any assist means (e.g., slides or ramps) following its deployment or otherwise interfere or assist in the evacuation process except as necessary to prevent injury to a participant.

[Note: The FAA may assess time penalties (i.e., add to the total evacuation time at any specific exit) if it is determined that the intervention by safety personnel significantly accelerated completion of the demonstration.]

(3) Safety personnel stationed on the wing of an airplane equipped with removable exit hatches may accept the hatches if they are passed out of the exit opening. The hatches must be at least halfway out of the airplane before the safety personnel may assist. The safety personnel may not encourage, by word or gesture, the person in the cabin to hand the exit hatch to them.

c. <u>Paragraph e of Appendix J {Section 25.803(c)(5)}</u>. The emergency descent devices used in the demonstration should be those intended to be in the airplane type design. If the descent device is a slide, the slide certification program should have progressed to the point where the system is reliable and can be expected to perform safely during the demonstration.

d. <u>Paragraph g of Appendix J {Section 25.803(c)(7)}</u>.

(1) Evacuation demonstrations conducted to meet the requirements of § 25.803(c) only, i.e., to demonstrate the evacuation capability of the airplane, need not use regularly scheduled crewmembers (see sub-paragraph 6.e. for a definition of regularly scheduled crewmembers). Therefore, there are no crew training requirements specific to the operating rules, i.e. part 121, for the demonstration.

[Note: Airplanes which have been shown to meet § 25.803(c) only, may need to have a full-scale emergency evacuation demonstration conducted which satisfies § 121.291 before being allowed into part 121 operations.]

(2) Evacuation demonstrations intended to meet the requirements of § 25.803(c) and § 121.291(a)(1) should use regularly scheduled line crewmembers. These demonstrations are conducted to demonstrate the evacuation capability of the airplane and to demonstrate the effectiveness of the crewmembers' emergency training program and evacuation procedures.

[Note: These procedures, successfully demonstrated, should not be revised in service without due consideration of the possible impact on the emergency evacuation capability of the airplane.]

(3) Flight attendants should be seated at cabin locations consistent with § 121.391 at the start of the demonstration.

(4) The normal demonstration start signal is the interruption of ground power to the airplane, as evidenced by the extinguishing of normal cabin lighting.

(5) Following the demonstration start signal, the flight crew should delay evacuating the flight deck by a time equivalent to that required to accomplish appropriate emergency operating procedures.

(6) Crewmembers in excess of the number required for the demonstration should be available so that the FAA can select the crew that will participate in the demonstration. Crewmembers that are not selected may be considered by the FAA for participation in any subsequent demonstrations that may be conducted.

e. Paragraph g of Appendix J {Section 25.803(c)(7)(i)}. In order to be considered a "regularly scheduled line crew," the crew should meet the following requirements:

(1) The crew should be trained in specific duties related to an emergency evacuation in accordance with an FAA-approved training program (for evacuation demonstration purposes). This training program need not be a complete flight attendant training program but should be an emergency evacuation training program similar in content and duration to the emergency evacuation portion of training programs approved under part 121 . Reference paragraph r of Appendix J {§ 25.803(c)(19)}.

(2) If the crew to be used for the demonstration has been previously trained under an operator's FAA-approved program, additional training may be given when the airplane model or layout to be demonstrated differs from the one used by that operator. Training in exit operation and passenger management is especially important for a demonstration of a new model airplane. This training should be similar in content and duration to the training received by a flight attendant when an operator adds a new model airplane to their operating certificate. The crew should not be trained for specific demonstration conditions, except that specific training should be given which relates to the safety of the participants prior to and during the demonstration. This specific safety training should relate to initiating and recognizing the signal for emergency termination of the demonstration and emergencies related to the demonstration site. The FAA should be provided with documentation describing all special training that was given in preparation for the demonstration.

(3) If the demonstration is not successful and flight attendant procedures are changed in order to successfully conduct a repeat demonstration, the changes in procedures should be fully documented and added to the training program.

(4) The training required for a successful demonstration should be the basis for the training program of all operators utilizing the demonstration for compliance with § 121.291(a)(1).

(5) The crew to be used in the demonstration should participate as required crewmembers on a regular basis and should not be instructors, supervisory personnel, safety representatives from worker organizations, or anyone else who may be expected to have knowledge of evacuation demonstrations beyond that of an average crewmember.

(6) Crewmembers from more than one operator may be used in the demonstration.

f. Paragraph h of Appendix J {Section 25 803(c)(8)}. The term "normal health" means that participants should be free of medical conditions or physical limitations that could affect the demonstration results or increase the chance of injury to themselves or others.

g. Paragraph h of Appendix J {Section 25.803(c)(8)}. The following two age and sex distributions have been found to be acceptable to the FAA in lieu of the distribution stipulated in paragraph h of Appendix J (§ 25.803(c)(8). (In both groups, results which include a fraction should be rounded up to the next whole number.)

Age and Sex	Percent of Total Passengers
Group 1:	
21-50	Not to exceed 80%
51-59	At least 15%
60+	At least 5%
Any age female	At least 32%
51-59 female	At least 6%
60+ female	At least 1.5%
Group 2:	
18-50	Not to exceed 75%
51-60	At least 25%
Any age female	At least 32.5%
51-60 female	At least 10%

h. Paragraph h(4) of Appendix J {Section 25.803(c)(8)(iv)}. The life size dolls should be of appropriate size and weight to simulate an infant two years old or younger.

i. Paragraph h(5) of Appendix J {Section 25.803(c)(8)(v)}. In addition to those persons prohibited by the regulation, persons involved in the design or type certification of escape systems, development of emergency evacuation crew training, or those who have previously conducted evacuation demonstrations should not be used as passengers for the demonstration.

j. Paragraph i of Appendix J {Section 25.803(c)(9)}. Passenger seating for the demonstration should be random. One method for ensuring this is for passengers to be allowed to select their own seats. Employees of the applicant may not be allowed to sit next to exits unless they have no specific knowledge which would affect the outcome of the demonstration. Federal Aviation Administration observers may, at their discretion, reseat passengers.

k. Paragraph k of Appendix J {Section 25.803(c)(11)}. Simulated carry-on luggage in the form of small suitcases, gym bags, airplane flight bags, briefcases, etc., filled with clothes or newspaper, that will fit under a passenger seat should be placed in the main aisle(s) with approximately one bag per seat row for each aisle. Also, some bags should be placed in the cross aisles and passageways, and pillows and blankets should be scattered in the main aisle(s).

l. Paragraph l of Appendix J {Section 25.803(c)(13}.

(1) Neither the crew nor passengers should hear or otherwise receive any indication that the demonstration is about to begin. The first indication to participants should be the extinguishing of the normal cabin lighting.

(2) If safety devices or any other equipment external to the airplane could indicate which exits are to be used in the demonstration, passengers and crew should enter the airplane through a tunnel or other means that will prevent them from seeing that indication.

(3) Placement of video cameras inside the airplane should not indicate which exits are to be used in the demonstration. This may require installation of cameras at all exits.

(4) Mechanical methods of exit deactivation which are not perceptible to crew or passengers prior to attempting to operate the exit should be used. If exit deactivation is indicated by a visible signal (e.g., by a red light outside the exit) the indication should not be visible from inside the airplane until after the demonstration has begun.

(5) If one or more of the exits must be mechanically deactivated after the airplane has been boarded, care should be taken to prevent the crew from becoming aware of the deactivation by sounds or other indications.

(6) For those airplanes equipped with emergency descent means, the means should be installed at inactive exits as well as active exits if the airplane is normally equipped with them.

m. Paragraph m of Appendix J {Section 25.803(c)(14)}. The following are guidelines for the applicant to obtain informed consent from participants in the demonstration and still comply with the intent of paragraph m of Appendix J {§ 25.803(c)(14)}. These guidelines are not intended to be a complete list or meet specific legal requirements. The applicant is responsible for obtaining informed consent and for complying with all applicable local, state and federal laws and regulations regarding the protection of humans employed in demonstrations of this nature.

(1) The applicant should seek consent under circumstances that provide the prospective participants sufficient opportunity to freely consider whether or not to participate in the demonstration. Coercion or undue influence to participate in the demonstration is not permitted.

(2) The prospective participants should be informed of the purpose of the demonstration and the expected duration of their participation. They should also be given a description of any logistical procedures to be followed before and after the demonstration. Details of the demonstration parameters, e.g., time limits , active exit percentages, etc. should not be disclosed, but the approximate number of participants in the demonstration may be revealed.

(3) The prospective participants should be given a description of any reasonably foreseeable risks or discomforts which may be encountered in the demonstration, such as the type or probability of injury when using an escape slide. Participants may also be informed of any techniques and/or equipment that will be used to limit the discomfort or injury such as protective clothing, emergency abort procedures for the demonstration, pads around the slides, availability of restrooms, etc.

(4) Prospective participants should be informed of any direct benefits to them (e.g., pay, meals, etc.) and of benefits to society (e.g., improved safety by demonstrating the emergency evacuation capability of the airplane) that would result from their participation.

(5) Prospective participants should also be informed of any compensation and/or medical treatments that will be available if injury should occur. They should also be informed of the procedure for acquiring these services, and where further information may be obtained.

(6) Prospective participants should be informed that participation is voluntary, that refusal to participate will involve no penalty, and that a participant may discontinue participation at any time prior to the beginning of the demonstration without penalty or loss of benefits to which the participant is otherwise entitled.

(7) Prospective participants should be informed of the consequences of a decision to withdraw from the demonstration at any given time and the procedures for orderly termination of participation. This explanation should include the consequences of attempting to withdraw after the demonstration has started, e.g., the possibility of being pushed out of the airplane if the participant stops at the exit.

(8) The prospective participants should be given the opportunity to ask questions, and be provided information on whom to contact for answers to future questions and how to withdraw from the demonstration.

(9) After participants have been fully informed, they should provide written informed consent to express their understanding and willingness to participate.

n. Paragraph n of Appendix J {Section 25.803(c)(15)} The passengers may be told that they are evacuating an airplane via the escape slides, if applicable, and to follow the instructions of the crew, but a description of the location or operation of the exits, the conduct of the demonstration, or additional information not in the passenger briefings required by §§ 121.333(f), 121.571(a), 121.573 (a), (c) and (d), and 121.585(h) and (i) should not be given. Passengers, seated within and including 3 rows of any exit may not have the benefit of prior practice in exit or escape system operation or knowledge of the demonstration airplane configuration, since passengers are not expected to be trained.

o. Paragraph p of Appendix J {Section 25.803(c)(17)}. In order for the active exits to be representative of all of the required emergency exits on the airplane, one exit from each pair should be used. Flightcrew exits, ventral exits, tail-cone exits, and exits in the side of the fuselage that are not part of a pair should not be used for the demonstration (even if additional passenger capacity has been granted), except for ventral and tail-cone exits used in conjunction with an exit on the side that has been determined to be equivalent to an exit pair, such as the aft exits on the MD-81 and 82. (The MD-81 and MD-82 have a tail-cone exit and a Type I exit which is located on the left-hand side of the fuselage, aft of the wing. The FAA has determined that these two exits form an exit pair.)

p. Paragraph s of Appendix J {Section 25.803(c)(20)}.

(1) The restriction on the acceptance rate of the stand or ramp is considered to be met, if the width of the stand or ramp is not greater than the width of the escape route required by § 25.810(c).

(2) The demonstration is complete when the last evacuee (passenger or crew) has cleared the assist means and has both feet on the ground or ramp (if provided at the off-wing exit). Typically, the entry to the ramp is coincident with the area on the wing where evacuees, led by required markings on the wing, would slide or jump to the ground.

7. GUIDANCE FOR DEMONSTRATING COMPLIANCE WITH § 25.803(c) {§ 25.803(d)} USING A COMBINATION OF ANALYSIS AND TESTING

a. Regulatory Background.

(1) The preamble to Amendment 25-46 makes it clear that adequate test data are a prerequisite for using analysis instead of conducting a full-scale emergency evacuation demonstration to substantiate airplane evacuation capability. It is intended that the analysis be a conservative prediction of the results that would be achieved if a full-scale demonstration were conducted. As such, the assumptions used should be conservative, e.g., using average evacuee flow rates through exits rather than the best flow rate achieved in previous demonstrations.

(2) Full-scale demonstrations should be required when the effects on evacuation performance of configuration changes identified in paragraph 5.b. cannot be substantiated by component and/or system test and analysis.

b. Technical Basis for the Analytical Approach.

(1) The analytical approach for substantiation of evacuation system capability should be based on available performance data from formal tests. Documentation of the analysis should establish credibility by identifying elements of the evacuation system, (e.g., features of the interior arrangement, door sizes, egress assist means, and relative door locations), citing applicable tests of record involving similar or identical elements, and then applying the recorded, verifiable

performance data to the new configuration in a valid manner. Additionally, data from unsuccessful full-scale demonstrations should be carefully scrutinized before being used, to ensure that the failure has not biased the data.

(2) Graphical representations and a detailed description of the airplane interior configuration emphasizing the emergency evacuation provisions are essential and are required for database development. A detailed configuration description should lead into and justify the use of the certification demonstrations and any other tests that are included in the database.

(3) The certification basis that applies to the specific model in question and those of other models that will be used, should be clearly stated in the analysis. The resulting implications should be thoroughly reviewed and discussed.

(4) Any special condition, exemption, or equivalent safety finding that applies to the evacuation systems of the subject configuration, or any configuration for which data will be presented, should be discussed and referenced or included as an appendix to the analysis document.

c. The Airplane Configuration.

(1) The configuration should be described in detail. If the configuration is a derivative of an existing, previously certified configuration, the primary differences should be clearly stated in terms of passenger capacity and evacuation capability.

(2) Features of the passenger cabin interior arrangement and evacuation system (such as aisles and cross-aisles, exit passageways, attendant assist spaces, doors and emergency hatches, etc.) significant to the analysis should be presented in the form of diagrams or formally controlled drawings in an appropriate scale. Those features that require special attention in the analysis may warrant use of supplemental drawings or diagrams.

(3) The cabin arrangement and evacuation system components should be depicted and described in enough detail to establish a useful historical record. Such descriptions should include, as applicable, the location, operation, and dimensions of the cabin and its features that are significant to evacuation:

- seats (passenger and flight attendant)
- aisles and passageways
- exits
- emergency egress assist means
- flight attendant assist spaces
- monuments, including the aspect of visual obstruction
- safety equipment
- lighted signs and emergency lighting
- any other cabin characteristics affecting evacuation

(4) Features of the airplane exterior which affect evacuation (such as engines and wing flaps) should be described in detail. Exterior features and the evacuation system they affect should be presented in the form of diagrams or formally controlled drawings in an appropriate scale.

d. Similar Features in Previously Demonstrated Airplanes. Where the configuration is a derivative model of a configuration certified by a full-scale demonstration, common features need to be clearly identified and discussed. Typically, some door and assist-to-ground systems are likely to remain unchanged or very similar in derivative models evolved from a baseline configuration. Interior features may be unchanged within complete or major parts of cabin zones.

e. Unique Features of the Configuration.

(1) Comparative drawings should be used to focus attention on configuration differences as well as similarities. The features that are unique to the configuration should receive a great deal of attention. If, for instance, a new door system is to be installed in a production model derivative, the effects of this change should be documented. Data from "similar" door systems demonstrated in other airplane models are obvious sources. To use these data, a strong case for "similarity" must exist and be developed in the analysis. For example, dimensional parameters of the unique features should match those of the demonstrated, certificated systems. Performance data from those systems would then be included in the analysis to ensure the new configuration meets the regulations.

(2) When a new installation changes some specific features of an earlier installation and, therefore, changes system performance, the change should be substantiated. Performance data from both the earlier installation and the new installation should be provided in the analysis.

(3) If evacuation system certification data (from a test conducted by the applicant and witnessed by FAA personnel) with apparent relevance to the subject configuration has been purposely excluded from the analysis, the reason(s) for excluding these data should be documented.

f. Flight Attendant Requirements. The required minimum number of flight attendants is established by § 121.391(a). As stated in § 121.391(b), when the number of flight attendants used during a full-scale airplane evacuation demonstration for certification exceeds the minimum number stipulated by regulation, the number of flight attendants in excess of the minimum number required in § 121.391(a) must be added to the number of flight attendants required by § 121.391(a) for any seating capacity. The required number of flight attendants and their seating provisions should be indicated on an appropriate configuration diagram.

g. Interior Configuration Overview. A discussion of how the subject configuration satisfies the intent of §§ 25.807 and 25.813 is an important part of the evacuation capability analysis and should receive appropriate emphasis. These sections define the various passenger emergency exit types, stipulate the required number and types of exits necessary to accommodate passenger seating capacities, and set forth requirements for accessibility and location of exits. The analysis should directly address the issue of passenger distribution and exit capability distribution within the cabin. When physical constraints, e.g., body structure, wing and engine location, prevent appropriate geometrical uniformity of exit placement, compensating factors that enhance evacuation capability should be discussed.

h. Exit Distribution Uniformity. The geometric distribution of the exits, rated capacities of the exit types provided, and seating densities of the various cabin zones should be documented. The geometric distribution of exit openings is obvious when depicted to scale on a drawing. Uniform distribution of the exits relative to passenger distribution may not be immediately obvious. One means for addressing adequate exit distribution uniformity, taking passenger distribution into account, is provided in Advisory Circular 25.807-1, Uniform Distribution of Exits.

i. Historical Data Foundation for the Analysis. Analysis to determine evacuation capability depend on the existence of applicable demonstration or test data that are formally recorded and verifiable. Applicability and validity are governed by evacuation system component similarity and conditions of test conduct. Conditions called out in Appendix J to part 25 and § 121.291 are the best qualifiers for screening existing evacuation performance data to be applied to the subject configuration. All such data should be addressed in the analysis. Results from partial evacuation demonstrations and developmental or qualification tests should be used to fill data gaps where no full-scale evacuation demonstration precedents can be cited for elements of the subject configuration; these partial demonstrations or tests should be shown to have been run under appropriate conditions.

j. Applicable Previous Full Scale Demonstrations. The full-scale certification demonstrations that are offered in support of the analysis need to be identified and described. Include the date and location of the demonstration, the airplane model involved, the passenger and crew complements, and the regulation upon which the demonstration was based (part 25 and/or part 121). The description should address the elements of paragraphs 7.c and 7.f. If applicability is not obviously indicated by the airplane model, the reason for including the demonstration should be clearly stated.

k. Applicable Subsystem Developmental, Qualification and Certification Tests.

(1) Tests other than full-scale emergency evacuation demonstrations that are included as data sources for the analysis, should be specifically identified and discussed. Reasons for their inclusion should be clearly stated. As an example, deployment/inflation time data for a new slide or slide/raft could be introduced and substituted into an evacuation event sequence (time line) for a system that is otherwise identical. This would be acceptable because slide or slide/raft deployment and inflation, once initiated, is independent of further human intervention and insensitive to the test conditions of Appendix J .

(2) Similarly, Latin Square testing (see Appendix 4 of Advisory Circular 25-17, Transport Airplane Cabin Interiors Crashworthiness Handbook) can be used to compare the performance capability of a new escape system or systems component against the known capability of an existing system or component.

(3) Additionally, a test method referred to as a "platform" test has been used to assess the crew's ability to manage flow of passengers for a given interior configuration. In that test, evacuees exited onto platforms positioned at the sill heights of the floor level exits rather than onto escape slides. Due to the limited prior use of this test method, appropriate test conditions and pass/fail criteria need to be established for each new situation.

(4) The formal test reports and supplemental record (movie film or video tape) of subsystem testing should be referenced in the analysis and available for FAA review.

l. Elements of Time Required for Evacuation.

(1) A formula suited to the evacuation capability analysis task and accepted as credible and correct by the FAA has been established. It is based on an escape system time line or sequence of events that can be readily observed in film or video tape coverage of full-scale evacuation demonstrations.

(2) The total evacuation time through a given exit can be defined by the following expression:

$$T_{Total} = T_{Exit\ Prep} + T_{Exit\ Flow}$$

where:

T_{Total} = Total evacuation time for the exit, equal to the time interval from demonstration initiation until the last evacuee arrives on the ground or on a stand at an overwing exit as allowed by paragraph c of Appendix J.

$T_{Exit\ Prep}$ = Time for exit preparation, equal to the time interval from demonstration initiation until the first evacuee arrives on the ground or on a stand at an overwing exit, including:

-- flight attendant or passenger reaction time, as appropriate,
-- exit opening,
-- descent device deployment, and inflation to the point of being usable (if applicable),
-- first evacuee hesitation time (defined as the elapsed time between when the device becomes ready for use and when definite contact with the device, with motion toward the ground, has been achieved by the first evacuee), and
-- time for initial evacuee to traverse to the ground (using the descent device, if applicable), or on a stand at an overwing exit.

$T_{Exit\ Flow}$ = Time of exit flow, equal to the time interval from first evacuee on the ground or on a stand at an overwing exit to last evacuee on the ground or on a stand at an overwing exit.

m. Database to Support the Analysis.

(1) Pertinent data values from the tests and demonstrations discussed in paragraphs 7.k and 7.l should be organized into a "database" for the analysis. The database should identify the source of each data point to the degree necessary for independent verification. For evacuation system certification demonstrations, the identifying parameters should include (as a minimum):

- airplane model (and operator, if applicable)
- date of demonstration
- governing regulations, i.e., part 25 or part 121
- exit identification

(2) When the data value used in the analysis is an interval of time between two observed events, the event times, in addition to the time intervals, should be included in the "database." The events are observable and can be verified directly, whereas the intervals are derived from the event times. A single tabulation of all events necessary to support the analysis provides a centralized "database" and is more amenable to verification and understanding.

(3) In the event a dataset contains an unusual event affecting interval time, such as an evacuee jumping out prior to full inflation of the descent device, or descent devices deflating during the demonstration, those data should be adjusted as appropriate. Such adjustments should be documented.

(4) When data values from multiple tests or demonstrations are available, average performance is used in the analysis. Flow rate data are transformed to time intervals per evacuee by taking the reciprocal, then the intervals are averaged to yield the average interval per evacuee.

n. Data Presentation (Organization). Several event times in the database may need to be processed to yield the numerical values for evaluating the evacuation time of the subject configuration. Organizing the respective database values according to time element of the evacuation process provides a convenient means to show the data and the process. The data presentation section of an analysis should contain a subsection for each time element of the evacuation time line that requires reduction or processing of database event data, e.g. Table 1.

Table 1

DATABASE PRESENTATION EXAMPLE

757-200 CERTIFICATION DEMONSTRATION DATA

	Door 1L	Door 2L	Door 4L
Exit Prep. Time (sec.)	8.1	11.8	10.0
Flow rate (epm)	70.8	68.7	52.0
Time per evacuee (sec.)	.847	.873	1.154

epm = evacuees per minute

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o. Time for Exit Preparation.

(1) The time for exit preparation needs to be determined. If part of an exit system has been upgraded or otherwise changed since the full-scale evacuation demonstration(s), it may be necessary to revise the exit preparation time from that observed in previous demonstrations to use in the analysis. $T_{Exit\ Prep}$ can be determined by timed tests of the new system or by summing the separate elements of $T_{Exit\ Prep.}$ Any adjustment should be fully documented.

(2) Exit preparation includes opening the exit and deploying any installed assist device. If the external assist device is an inflatable slide or slide/raft, the device is considered deployed when it exhibits the rigidity necessary to safely sustain a load (stable and fully extended) although it may not necessarily be touching the ground. When the subject configuration includes the same basic exit system as formerly demonstrated, a straightforward tabulation of values applicable to that exit system should be presented. The average(s) should be shown and identified accordingly.

(3) "Hesitation time" may be defined as the interval of time when the assist means (if required, usually a slide) is ready for use and the egress of the first evacuee. It may simply be the time necessary for the first evacuee to respond to the flight attendant's command, or it may include a reluctance to jump. The analysis should account for hesitation by measuring the time that elapses when the slide is perceived as inflated and fully extended (though not necessarily on the ground) until the first evacuee starts descent on the slide. A suitable hesitation time may be derived by averaging all hesitation data values.

(4) Some off-wing escape systems may prompt a modification to the analysis technique to properly account for first evacuee hesitation. Overwing door opening or hatch removal may trigger a slightly delayed deployment and inflation of the off-wing inflatable. The first evacuee could emerge through the exit to the wing or wing ramp surface in advance of the off-wing slide

being ready for use. Depending on available data, the evacuation capability analysis for some such systems should be based on first evacuee on the ground.

(5) After accounting for hesitation and doorway egress, the time for the first evacuee to travel from the point of contact with the slide or overwing ramp to the ground must be added to the time line. Average values, if used, should be noted. The descent device traverse time should include the on slide and on ground event times from which the traverse time interval is derived.

p. Time for Exit Flow.

(1) The period of evacuee flow through an exit system, $T_{\text{Exit Flow}}$, depends on flow rate and number of evacuees. Flow rates used in the analysis are those established by earlier demonstrations and tests and converted to intervals as described in paragraph 7.m.4. $T_{\text{Exit Flow}}$ is then derived by multiplying the number of evacuees allocated to the exit minus one (n-1) by the average interval established for each evacuee.

(2) A dependable and accurate technique to determine flow rate from film or video tape is to: (a) select a stable point or plane of reference in the flow path field of view; (b) record the event times for passage of first and last evacuees, thus determining the time of flow; and (c) calculate the flow rate (in evacuees per unit of time) by dividing the count of evacuees minus one by the flow time. The flow time starts with the first evacuee at the reference point. The remaining evacuees pass the reference point during the flow period. One evacuee, therefore, is subtracted from the total evacuee count to determine flow rate when a fixed-point or plane of reference technique is used.

q. Evacuee Allocation to Exits. The allocation of evacuees to exits should be established and illustrated on a configuration drawing. The allocation should be consistent with the demonstrated capability of the same or similar exit systems and with the distribution of exits and passenger seating relative to the exits. The illustration should convey the substance of an emergency evacuation plan that flight attendants, and flight deck personnel (for certain part 25 applications only) work to achieve with the subject configuration. The goal of the plan is to get everyone out as soon as possible. Passenger management techniques employed in the analysis need to be substantiated by records of earlier demonstrations and/or tests.

r. Flight Crew and Flight Attendant Duties. The crew members' positions during takeoff and landing and their primary and secondary duty stations during an emergency should be indicated on a suitable configuration diagram. Their duties should be described in the analysis. Demonstration or test data should be cited that substantiates the ability of crew members to travel to their duty stations. Procedures which would require a flight attendant to bypass an exit (other than one in the immediate vicinity of the flight attendant's seat) to get to his/her primary or secondary duty station should not be proposed.

[Note: Flight crew participation is limited to certain part 25 applications only.]

s. Passenger Management The definition of "passenger management" for purposes of this advisory circular is the directing of passengers to active exits by flight attendants after initiation of the evacuation. The goal of passenger management is to minimize the total time for evacuation while ensuring passenger safety.

To address passenger management, the applicant should show that similar flight attendant duties (see paragraph 7.r), allocation of evacuees to exits (see paragraph 7.q), and cabin configuration (see paragraph 7.c) have resulted in a successful full-scale evacuation demonstration(s) or equivalent test(s).

[Note 1: Bypass of an active exit, when included in the analysis, should be based on bypass accomplished during a full-scale demonstration.]

[Note 2: When exit systems are not symmetrically located or different performance characteristics have been identified for cross cabin exits, the analysis should address the most critical exit of each exit pair.]

t. Total Evacuation Time Calculations.

(1) Utilizing the data, formula, and analytical techniques described above, the total evacuation time per exit as described in paragraph 7.l can be determined for the configuration.

(2) A configuration diagram, annotated with the calculated evacuation times and evacuee counts near the exits used can be used to provide a graphic summary of results. A single configuration diagram could satisfy the multiple purposes of depicting exits used, passenger and crew allocation to exits (cabin division lines) and the resulting evacuation times per exit.

u. Success Criteria.

(1) If the results of the total evacuation time calculations are less than 90 seconds, the analysis has shown that the airplane can be evacuated under the demonstration conditions established by Appendix J of part 25 or section a to Appendix D of part 121, within the time criterion contained in § 25.803(c) and § 121.291(a), respectively.

(2) The applicant should then prepare an evaluation of the additional evacuation capability (time margin) of each exit that was used in the analysis.

(a) The following formula may be used to determine the available time margin for the airplane configuration being reviewed:

$$\text{Time margin} = \sum_{i=1}^{n} (90 - T_{\text{Total Exit } i})$$

where:

$T_{\text{Total Exit } i}$ = Total evacuation time for the exit

n = Total number of exits used

The available time margin calculated using the above formula should be 9 or more seconds. The time interval of 9 seconds (10% of the current standard of 90 seconds) was based on the demonstrated capability of today's transport category aircraft.

(b) An alternative to the margin calculations shown above, as a means of showing conservatism in the analysis, would be to use exit flow rates less than the calculated average and exit preparation times greater than the calculated average. The amount of performance degradation can be a calculated number such as the value of a standard deviation. The average evacuee flow rate would be reduced (thereby increasing the time of exit flow) and the average exit preparation time would be increased by the respective calculated values. If, however, the data used to derive the standard deviations is widely scattered resulting in a large value for the standard deviation, the applicant may choose to use the slowest rate or longest exit preparation time instead.

v. <u>Initial Coordination of Analysis</u>. As a general guideline, evacuation analyses should be informally coordinated as early as possible with the FAA certificating office prior to formal submittal to ensure that all significant factors have been addressed.

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Manager, Transport Airplane Directorate
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F:\HOME\FT\AC\25-803XR.DOC
4/14/93:
5/17/93:
5/19/93: (based on writing team meeting 5/18-19/93)
7/9/93: (based on writing team meeting 7/7-8/93, converted to standard format without bold/italics or strikeouts, also took part 6 and made it into 6 and 7 and added headings to paragraphs in 7)
7/12/93: minor change to pages 7 and 8 (age/sex mixes)
7/19-20/93: revised per comments from Stacho/Kuttler/Young/Rees/Gardlin
8/9/93: revised per comments from PSWG mtg no. 14 - other changes still to come - due at writing group meeting 9/20/93- added bold and [] for identification of changes.
9/22/93: revised per writing team meeting 9/20/93 and PSWG mtg 9/21-22/93
[originally done in Word Perfect, converted to Word 3/10/94]
5/16/94: revised per writing team meeting 5/10-11/94 in Long Beach (note 25.803X4.DOC is the version with revision marks, 25.803X5.DOC is the version with the revision marks deleted and all the Parts changed to parts except at the start of sentences plus a few changes done on 5/17)
6/8/94 Changes from 5/25-26/94 meeting
6/15/94 Franks revisions to 6/8/94 version
7/15/94 Incorporates Meg Leith's editorial changes
7/18/94 Franks edits
7/29/94 Revisions per PSWG mtg on 7/26-27/94 (xJ is mark-up with revision lines, xK is clean version)
8/10/94 (Revision per FT edits, changes only saved in xk.doc)
9/14/94 Revised to standardize usage of "passenger," "participant," and "evacuee." Also added definitions for participant and evacuee in the body of the text. 25-803XL.DOC has revision lines included. 25-803.XM does not have revision lines.
9/23/94 Revision 25.803XN reflects the changes accepted at the PSWG meeting of 9/20-21/94 basically from FAA Directorate comments. This revision includes revision lines.
9/23/94 Revision 25.803XO is the same as 25.803XN except the revision lines are deleted. Note that this includes a small revision to k(6) on page 12 per Doug Anderson, done on 10/3/94.
11/3/94 Revision 25.803XP per changes from ACTT mtg of 11/3/94 with revision marks.
11/9/94 Revision 25.803XQ per changes from the ACTT mtg of 11/3/94 without the revision marks.
5/23/95 Revision 25.803XR per changes from meeting between the ACTT and the EEIG "Group of 7" in D.C. May 17-18, 1995 - this version includes the revision marks.
6/12/95 Revision 25.803XS per changes from the 6/6-8/95 PSWG meeting in Paris - revised 6.b.2 after discussions with ANM-7.
7/31/95 Revision 25.803XT is the "S" version without revisions.
8/1/95 Revision 25.803XU is the mark-up per the 7/25-27/95 PSWG meeting in D.C.
8/1/95 Revision 25.803XV is the same as XU except no revision marks

PERFORMANCE STANDARDS WORKING GROUP RESPONSES TO COMMENTS FROM ORGANIZATIONS OPPOSED TO THE DRAFT REVISION TO ADVISORY CIRCULAR (AC) 25.803-1

Note: The team preparing these responses determined that the most expeditious manner to respond was to ascertain the essence of the objections the commenter had against the draft AC revision and to respond accordingly. Comments which were not relevant to the discussion of what should or should not be included in the AC and why, were not considered.

AFA:

COMMENT: "Our primary concern is with the validity of the basic assumption upon which the analytical procedure in the draft AC is based, i.e., that any airplane cabin configured so that each of the 'minimum' evacuation-related requirements of the FARs, considered individually, is met or exceeded will have satisfactory emergency evacuation performance and therefore does not require a full scale evacuation demonstration... The proposed analytical method also fails because the variables of passenger flow management are not adequately considered... It is passenger flow management that should form 'the mortar that binds the evacuation analysis together' rather than the questionable assumption that successful evacuations only depend on the design of the mechanical provisions for evacuation... Undefined terms, such as similar cabin configuration, similar flight attendant duties, and equivalent test make the approach untenable... The proposed analytical procedure considers each element in isolation from the other elements, and does not provide adequate safeguards that the system performance will be demonstrated."

RESPONSE: The AFA characterization of the basic assumption upon which the analytical procedure of the draft AC is based fails to consider the requirements for test data that substantiate the evacuation capability of the airplane. Only through the application of such data can compliance with § 25.803 be shown. Neither the design requirements alone, nor only passenger management activities, can affirm the evacuation capability of the airplane. The "mortar" of the process is the applicant's ability to integrate all relevant data to form an accurate representation of the airplane's evacuation system capability and to present this model to the FAA. While the model represents a serialized (but not isolated) process, its tenability for any specific airplane will be the responsibility of the FAA to judge, and the combined requirements of paragraphs 7.b, 7.c, 7.e, 7.g, 7.i, 7.q, 7.r, and 7.s ensure an adequate basis to make such judgments.

ALPA:

COMMENT: "Specifically, it (the AC) presents specific guidelines for the use of data from emergency evacuation demonstrations of only vaguely related aircraft in the analytical approval process of a subject aircraft... Only vague references to 'appropriate tests', to provide 'sufficient data', with 'when appropriate' language... We do not support the vague manner implied in the proposed analysis process... we have called for the analysis to be conservative (but) this has only been given lip service in this proposed AC... this proposed AC is vague and would not even lend itself to a validation process because it is not specific in regards to the process of determining applicability of the data and processing of the data."

RESPONSE: The terms "sufficient data, appropriate tests, and when appropriate" are, in fact, open to interpretation. However, while ALPA cites certain paragraphs to support their argument, these paragraphs fail to disclose the full range of context the AC provides. Other paragraphs -7.a, 7.b, 7.c(3), 7.d, 7.e, 7.i, 7.j, 7.k(1), 7.k(2), 7.k(4), and 7.m- all reference specific requirements that data must meet to be usable. Appropriate tests are defined in paragraphs 7.i, 7.j, and 7.k; these requirements are similarly specific. The analytical method to be applied is also not vague, as paragraphs 7.l, 7.m, 7.o, 7.p, 7.t, and 7.u describe the mathematical algorithm that must be applied and the success criteria that must be achieved to certificate any airplane through analysis. The conservatism required of the data and results (using arithmetic averages) used to support analysis is based on historical precedent and does not vary from current FAA practices. Validation of such results from the analytical process will depend not only on the specific sources and applicability of the data offered in support of an analysis (as required in the paragraphs cited above), but again depends on the demonstrated ability of the FAA to judge the worthiness of the applicant's analytical model. As the proposed analytical process is more specific and deterministic than previous guidance has required, statistical validity should improve relative to current certification requirements.

ACAP:

COMMENT: "Although the draft AC is intended to offer guidance on using analysis as a 'conservative prediction of the results that would be achieved if a full-scale demonstration were conducted' (Sect 7.a.1), it later strays from this goal, permitting plainly non-conservative estimators such as average evacuee flow rates. .. While the draft AC contains much good material, mostly on improving evacuation demonstration procedures, ACAP believes it also includes several significant threats to the interests of the traveling public, and therefore opposes its adoption."

RESPONSE: See the response about conservatism to the same comment voiced by ALPA above. Similarly, the application of the AC towards certification of any candidate airplane has been shown above to be the province of the FAA. While easily decried, potential threats to the traveling public are something taken seriously by the FAA, and for the FAA to allow such threats to materialize through misuse of the analytical process described in the AC is beyond the scope that this, or any other AC, could assure. However, the need for compliance with the many specific guidelines that have been included in this AC is designed to assist the FAA in assuring that any such misuse cannot occur. Unfortunately, the commenter did not identify what the significant threats were and, therefore, they cannot be specifically addressed.

IAPA:

COMMENT: "IAPA believes that using analysis in lieu of a full-scale demonstration is counterproductive to ensuring a safe as possible evacuation of the aircraft in an emergency situation. (although) We realize any demonstration has its limitations due to the difficulty in reproducing actual emergency conditions."

RESPONSE: The IAPA realizes the lack of correlation between demonstrations and actual emergency evacuations, but calls for them anyway. Actual full-scale evacuation demonstrations have a history of producing injuries themselves - thus, the attempt to produce an analytical equivalent. It is likely that a single full-scale demonstration could not provide the statistical confidence in evacuation system performance that could be derived from analysis of the average performance of passengers in multiple demonstrations of similar systems. It is the lack of such data that should drive full-scale evacuation demonstrations.

ADF:

COMMENT: "Appropriateness of analysis and the data used to complete the analysis appears to be subject to individual packaging and presentation and the willingness of the FAA Certificate Office making the decision. This appears to allow significant inconsistency from one case to the next... which overall could lead to less than the highest possible level of safety... Use of airline and (aircraft) manufacturers employees as permitted in past demonstrations, along with briefings provided to those participants, does not constitute a valid sample and the resultant data base may also lead to analysis that may not be valid"

RESPONSE: The specific requirements that the data and success criteria must meet to comply with the AC provide a level of rigor that has not been heretofore explicit. Such rigor should eliminate many of the concerns about inconsistency, although individual packaging and presentation of data will be required of the applicant(s). Only through such packaging can an applicant make its case for certification, but all applicants will probably not exhibit the same degree of sophistication in such endeavors. Utilization of company employees has similar specific limitations that attempt to eliminate potential biases in favor of the applicant; a similar case could be made about allowing frequent flyers to participate in evacuation demonstrations. However, elimination of such participants would deny that many airplane passengers have extensive flying histories and know much about airplanes. Only knowledge about the new model or configuration has been considered prejudicial.

IPA:

COMMENT: "The proposed AC, in my opinion, is too vague and would allow introduction of aircraft into revenue service without providing the protection the trusting public deserves...there should be a validation period where analytical and actual full scale demonstrations are done in parallel to verify the predicted performance of an aircraft's emergency systems and the passenger and crew interactions."

RESPONSE: The concerns about vagueness and statistical validity have been addressed above; the implication of analysis based on data derived from multiple demonstrations and airplane tests is for a greater degree of trust in the safety of airplanes. The area of passenger behavior is interesting, though, as the IPA makes it sound like one such demonstration of passenger behavior will somehow shed light on all the other passengers that might fly on the airplane. Passenger and crew interactions will depend on the specific individuals involved, and as stated above, it is an integral factor in evacuation demonstration outcomes. (Reference the single passenger in the B-777 full-scale demonstration.) Again, it is likely that data derived from multiple demonstrations of similar systems would provide greater confidence of evacuation system performance than a single full-scale demonstration would assure.

IBT:

COMMENT: "We are staunchly opposed to this AC which will, in effect, circumvent the public rulemaking process by permitting analysis for virtually all aircraft certifications in lieu of the presently required full-scale emergency evacuation demonstration... we do not accept the underlying promise of the proposed analytical method, i.e., that any aircraft configured so that each of the 'minimum' evacuation-related requirements of the FARs, considered individually, is met or exceeded will have satisfactory emergency evacuation performance and therefore does not require a full-scale emergency evacuation demonstration... the proposed analytical method does not include an accurate and reliable assessment of passenger flow management, nor other factors involving the interface of equipment, crew, and passengers which will impact evacuation."

RESPONSE: Inasmuch as this AC does not change any of the requirements for the evacuation demonstration as specified in the FARs, there is, in fact, no rulemaking involved. All other concerns have been addressed above.

FAA Action

AVIATION RULEMAKING ADVISORY COMMITTEE
EMERGENCY EVACUATION ISSUES GROUP
PERFORMANCE STANDARDS WORKING GROUP
UMBRELLA CONCEPT TEAM

PERFORMANCE STANDARDS GENERATING SYSTEM FOR TRANSPORT CATEGORY AIRCRAFT

FINAL REPORT

SEPTEMBER 1994

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II. UMBRELLA CONCEPT TEAM CHARTER

The Umbrella Team Task Objective is to develop a performance standards generating system that provides the *Performance Standards Working Group* with the tools to specify aircraft design goals and operating procedures in terms of aircraft system performance. The performance standards generating system will include:

- A set of instructions on how to develop a generic performance standard.
- A detailed outline of the evacuation process defined in terms of the functions required of the aircraft evacuation subsystem.
- A detailed application of the performance standards generating system to a subgoal (function) of the evacuation process.
- An appropriate example of a performance-based regulation and its related performance standard.

The Purpose of the performance standard(s) is to provide guidance to the aviation community which forms the basis for Federal Aviation Regulations and:

- Enhances safety through emphasis on critical functions
- Clarifies regulatory intent
- Increases design latitude
- Eliminates inconsistencies in rules and their application
- Encourages uniformity and simplicity of operation
- Improves cost-effectiveness

The Scope of the Umbrella Team Task is to consider the Aircraft System functions required in evacuations, leading to the development of guidance for implementing performance standards to support regulation of Aircraft System elements which impact or participate in these functions.

III. EXECUTIVE SUMMARY

This document is intended to provide a new way of looking at the rules and regulations that guide the manufacture, certification, and operation of transport category aircraft. This new way will consider the aircraft as an integrated system made of many subsystems. These subsystems work together to perform aircraft ***functions***, such as flight control, communication, and emergency evacuation. The subsystems may thus be thought of as ***functional assemblies*** working to achieve aircraft requirements, such as flight, payload transport, safety. These requirements may be thought of as the aircraft system ***functional goals***. The rules governing the aircraft functional assemblies are designed to ensure that the functions achieve the goals, rather than specifying the form of the aircraft subsystems, since specifying form alone might not provide the functional integrity required. Together, the goals and functions form the bases of the Aircraft System performance standards, which themselves become the bases of regulations.

Each of the Aircraft System performance standards must, therefore, define one or more functional goals for the aircraft to achieve. The functional goals should be specified in operational terms that describe the most important aspects of aircraft system performance that must be attained. These are the critical aspects of the goals and they frame the intent of the goal and suggest what types of functions could be used to best achieve it. The function chosen will, in turn, suggest specific criteria that could be used to identify whether the critical aspects have been adequately addressed and, thus, whether the goal had been achieved. These criteria will also be used to establish certification test requirements for specific aircraft system functional assemblies.

Thus, Aircraft System functions are all the things that an aircraft must do to successfully accomplish its goals. In developing performance standards, these functions should be organized from top-to-bottom, from complex to simple, to clarify the importance of their relationships. Each higher level function must be broken down into the lower level functions that work together to accomplish the higher level function. In this way, higher level functions become the goals for lower level functions. This approach should be reiterated to the lowest level of function above the level at which a function is dependent on a particular design approach (e.g. prescribing the function required of fiber optic cables rather than copper wires for communication subsystems). As the higher-level functions become goals for lower functions, the criteria used to verify their suitability for achieving higher goals now become critical aspects for the lower goals to address.

Within this context, the Aircraft System is not just a collection of parts, but combinations of aircraft structure, physical hardware, and the people on board and on the ground. These Aircraft System components (structure, hardware, people) will be known as "elements" in this document and should be thought of as forming the functional assemblies that achieve the functional goals. Specific performance requirements for the elements are derived from the criteria relevant to the function in which the element is engaged. As different elements could be used to perform the same function, specific performance requirements for any element would depend on the method the element uses to achieve the intended function. Each aircraft system element is also likely to be combined in multiple functional assemblies performing multiple functions. As such, additional functional requirements for any element would also depend on the relationship of that element to others combined in the functional assembly(s). Therefore, different functional requirements would be produced, depending on the relevant assembly.

Allocation of Aircraft System elements toward required functions is often a competitive process. Such competition should be managed in such a way as to optimize total Aircraft System function to the extent possible. Therefore, in addition to the rules that ensure that any particular goal is being attained appropriately, a comprehensive set of priorities must also be established to resolve potential conflicts produced by competitive goals and functions. These priorities impose timing and/or ordering constraints that are based on safety and efficiency, and they provide the functional integration that the "Systems Approach" to performance-based rulemaking demands. Through this process, Aircraft System performance standards become a tool to maximize aircraft system safety and performance.

The remainder of this document describes more fully the method outlined above and provides guidance for the creation of performance standards for the aircraft emergency evacuation subsystem and its constituent elements. The organization of this document will conform to that established in the Umbrella Team Task Objectives on page three. Firstly, however, a glossary of terms is provided, followed by a description of a theoretical Aircraft System. Then a set of instructions on how to develop generic Aircraft System performance standards follows. After describing how to write generic performance standards, the document provides a detailed outline of the evacuation process, including the critical aspects related to that process. Also included are examples of an existing performance-based regulation and its relevant performance standard.

IV. GLOSSARY OF TERMS

Critical Aspects: Characteristics of performance that must be achieved to ensure that the functional goal has been attained.

Egress: The process of evacuee management and escape.

Element: An item of structure, equipment, personnel or procedure.

Escape: Movement of evacuees from the seats to the ground and/or water.

Evacuee: An occupant who leaves the aircraft without external assistance in response to a threat.

Evacuee management: The process of guiding aircraft occupants from their seats to the ground and/or water.

Evacuation Process: The emergency process by which aircraft occupants leave the aircraft in response to an emergent threat. The process may be partitioned into three stages:

Pre-Evacuation Stage: The period during the evacuation process that starts with the identification of an emerging threat and ends when the evacuation stage starts.

Evacuation Stage: The period during the evacuation process that starts when the first evacuee exits an opening in the fuselage and ends when the last evacuee reaches the ground or water.

Post-Evacuation Stage: The period during the evacuation process that starts after the evacuation stage and ends when the threat is neutralized or the evacuees are rescued (not to exceed expected response time).

Function: An activity for which an element or functional assembly exists or is created; an activity which must be performed to achieve a functional goal.

Functional Assembly: A dynamic combination of aircraft elements performing coordinated functions in the service of Aircraft System Functional Goals.

Functional Goal: Desired functional characteristics or operations that any Aircraft System element would manifest.

Guidance: A function that provides information to evacuees.

Information transfer: The process by which the output of one element or functional assembly affects the operation of another.

Life Support: Post-escape maintenance of evacuee well-being.

Performance-based Regulation: A Federal Aviation Regulation that specifies a performance criterion as (at least) part of its regulatory language. It should have an accompanying performance standard to provide guidance about the intent of the rule.

Performance Standard(s): The Functional Goals of the Aircraft System specified in objective functional verification criteria relevant to the elements used to form the functional assemblies of the Aircraft System.

Pre-Evacuation Survival: The process of maintaining the ability of the occupants to evacuate the aircraft.

Threat: An indication of impending danger or harm that may lead to an aircraft evacuation or alter its course.

Threat Assessment: The process of evaluating information about emerging danger or harm and its potential effects.

Verification Criteria: Operationally defined critical aspects of goals; usually related to the results of certification testing for the function being addressed.

V. THE BASIS OF AIRCRAFT SYSTEM PERFORMANCE STANDARDS

A. THE AIRCRAFT IS A DYNAMIC SYSTEM DESIGNED TO ACHIEVE ORGANIZED GOALS

The Aircraft System is a dynamic entity in which elements are combined in aircraft subsystems to perform the functions that are required to meet Aircraft System *Functional Goals* such as flight, payload transport, and safety.

The Aircraft System Functional Goals are all the functional characteristics and operations that a fully functioning Aircraft System would manifest. These Goals are hierarchically arranged and form the requirements and boundaries for the Aircraft System *Functions.*

B. THE AIRCRAFT SYSTEM HAS HIERARCHICAL FUNCTION

The Aircraft System Functions are all the discrete and integrated functions the Aircraft System must perform to accomplish Aircraft System Functional Goals. These Functions range from simple discrete functions performed by single Aircraft System elements to compound and complex higher-order functions made of hierarchically organized discrete and integrated functions. The complexity of the Function is generally related to the complexity of the Aircraft System elements (combined into subsystems) required to achieve the Functional Goal. In the most exemplary state, Aircraft System Functions are the embodiment of the Functional Goals.

C. AIRCRAFT SYSTEM ELEMENTS FORM FUNCTIONAL ASSEMBLIES

The Aircraft System Elements are all the components that together form a functional Aircraft System. These elements include Aircraft structural hardware, ancillary aircraft equipment, crew / passengers, and external elements such as maintenance personnel, Air Traffic Control, and Airport Rescue. Any single element of the Aircraft System may provide multiple Aircraft System functions through participation in multiple Aircraft Subsystems. Elements and subsystems performing coordinated functions in the service of the Aircraft System functional goals are considered as *functional assemblies* that must be regulated by the Aircraft System *Performance Standards* and associated regulations.

The ***Aircraft System Performance Standards*** describe the Functional Goals in *operational terms* to provide a guiding concept to regulate design of the Aircraft System, through specification of the Functional Goal *Critical Aspects,* the Function *Verification Criteria,* and the Aircraft Element *Performance Success Criteria (see Figure 1).* The Performance Standards model the hierarchical Aircraft System functional organization in which higher-order functional goals emphasize the most comprehensive and important requirements of the Aircraft System; subsystem functions are defined by lower-level verification criteria that specify how a particular Aircraft subsystem must perform to adequately achieve its intended functions. Element performance requirements are defined by performance success criteria that exist to ensure that element performance can be built upon to attain higher-level functions and functional Goals. Performance standards for the Aircraft System and its sub-systems cannot be defined without consideration of the multiple higher-order functions required to achieve the Functional Goals; similarly, performance standards for individual elements cannot be defined without allowing for the multiple functions for which a particular element may be responsible (see Figure 2).

The fully functional Aircraft System optimizes performance of all its elements and subsystems to achieve the full set of Aircraft System functional goals. The hierarchical organization of Aircraft System Functional Goals must be designed to maximize safe, effective performance of the Aircraft System. However, competition for Aircraft System resources will always be produced whenever Aircraft System elements and subsystems serve multiple functional goals. Such competition typically reduces the maximum effectiveness and efficiency that the Aircraft System may achieve. The Aircraft System performance standards manage this competition through a rule-based hierarchy of safety and performance criteria. Higher-order Aircraft System functions take precedence in relation to subordinate functions; compound, and then discrete, functions are allocated resources to the extent that higher-order functions are not decremented. Thus, the Aircraft System performance standards control resource competition by regulation of Aircraft System elements and subsystems as functional assemblies, not merely as configural components of a large, complex structure.

DEVELOPMENTAL PATH FOR PERFORMANCE STANDARDS

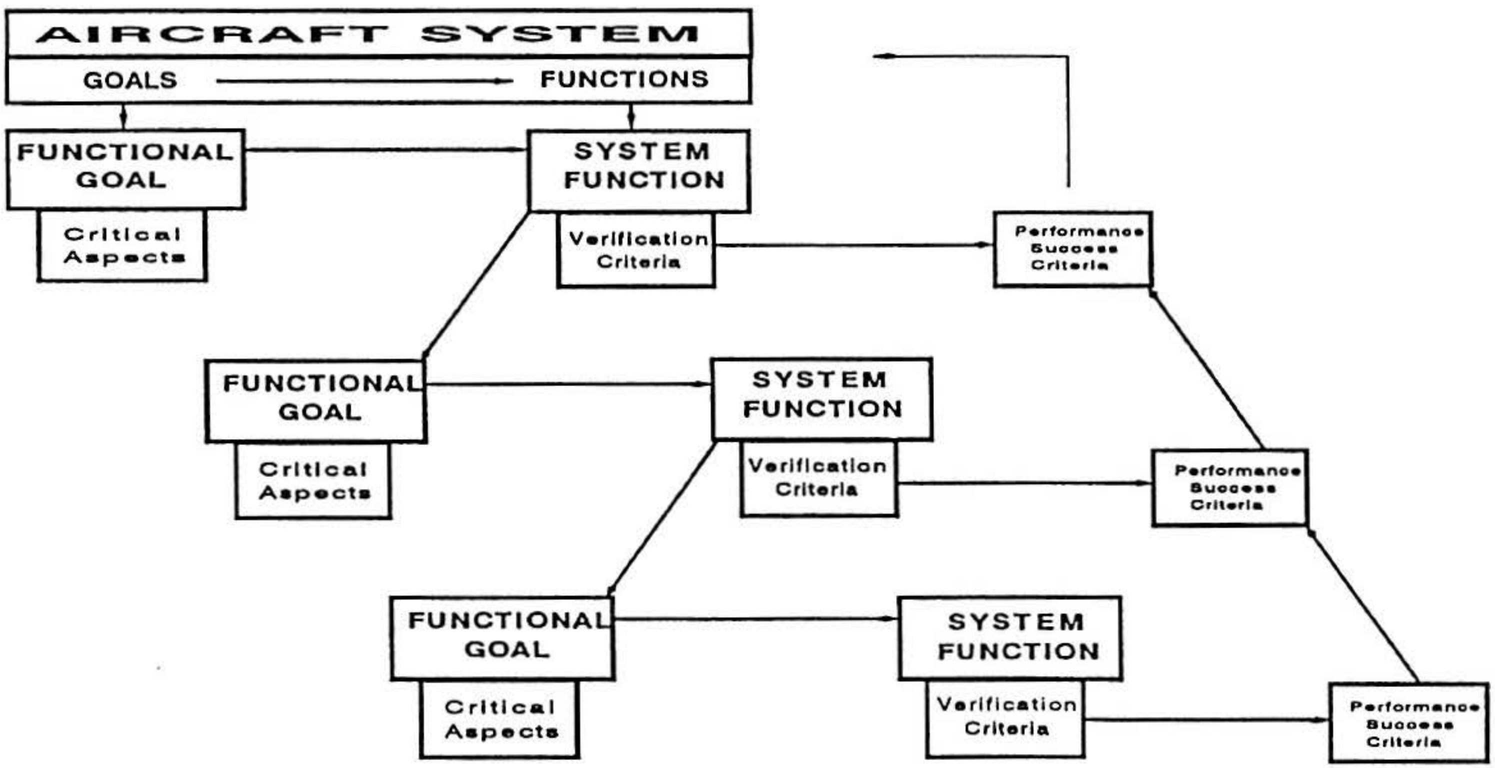


FIGURE 1

HIERARCHICAL ORGANIZATION OF FUNCTIONS AND ASSEMBLIES

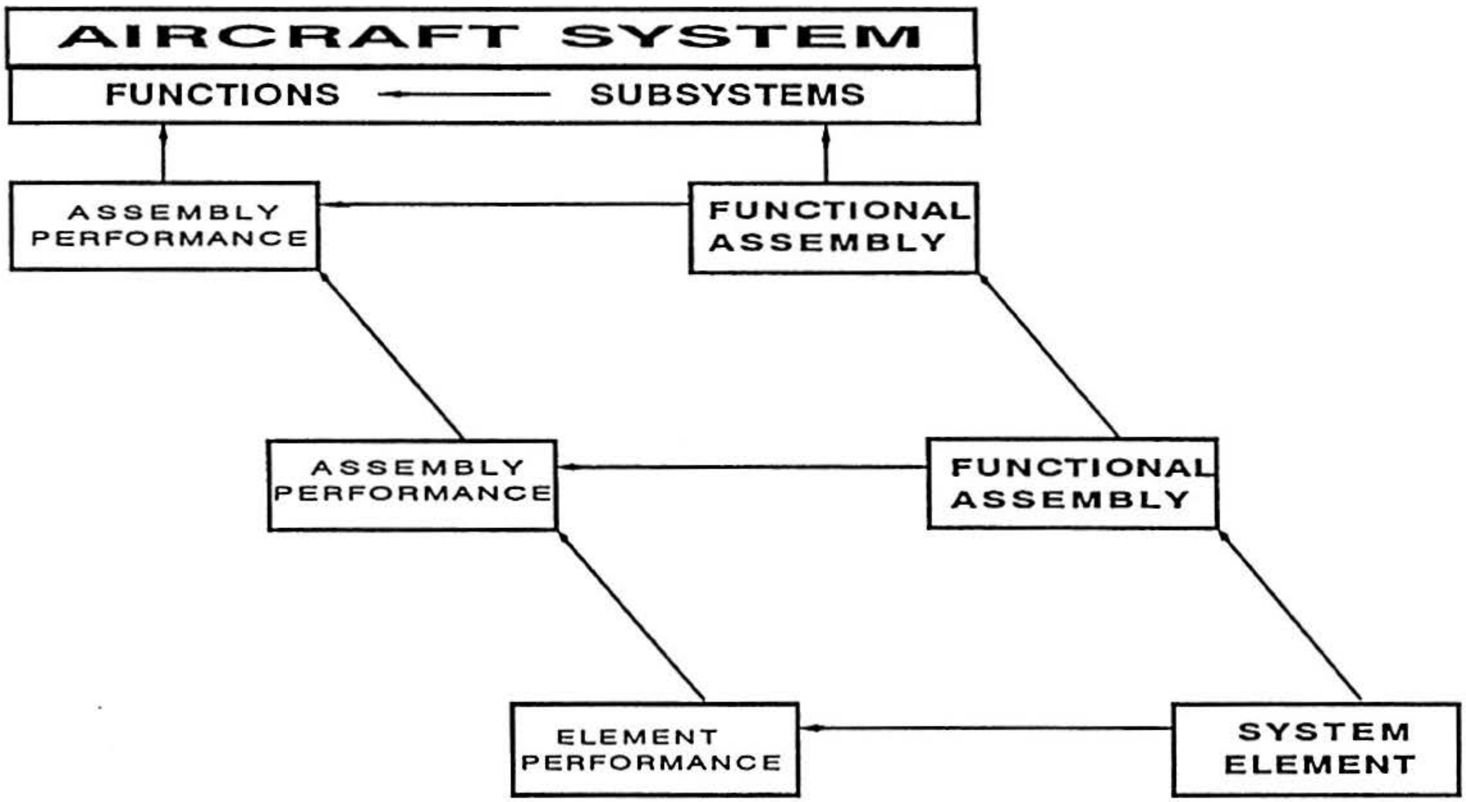


FIGURE 2

VI. DEVELOPMENT OF AIRCRAFT SYSTEM PERFORMANCE STANDARDS

A. Develop the Aircraft System Functional Goal Hierarchy

1. ***Establish the Aircraft System Functional Goals.*** Knowing what the aircraft systems must achieve, not what they should be, is the issue. Start with the highest-order Functional Goals the Aircraft System must achieve and work toward lower levels of importance and complexity.

2. ***Identify the Critical Aspects*** of each Functional Goal. This provides the foundation for decisions about which Aircraft System Functions will be required to meet the Functional Goals. Each critical aspect embodies a particular attribute of the Functional Goal that addresses its intent, and these attributes provide the basis for establishing the verification criteria by which Functions can be shown to have achieved the Functional Goal.

3. ***Identify Potential Conflicts,*** if any, which require modifications in the Functional Goals to eliminate or minimize effects on safety and performance. Use this step to ensure that goals are realistic.

4. ***Establish rules to govern the Functional Goals and resolve conflicts.*** This step sets the hierarchy by which functional goals and their critical aspects must be prioritized (ordered by importance and / or time) to maximize safety and performance.

Note: Phase of aircraft operation must be considered in this regard, as flight requirements produce a different functional hierarchy than do ground operations.

B. Develop the Aircraft System Function Hierarchy

1. ***Establish the Aircraft System Functions*** needed to achieve Aircraft System Functional Goals. Higher-order functions must be established first; as these functions, in turn, become functional goals for lower-order functions. This process continues until a single, lowest-order function can achieve its lowest-order Functional Goal.

2. Identify the Verification Criteria for each Function. These criteria address the relevant Functional Goal critical aspects, providing the foundation for decisions about what types of Aircraft System functional assemblies could be used to perform the necessary functions. The verification criteria should establish (in performance terms) what the Aircraft System functional assemblies must do to ensure that the functional goals have been achieved; i.e., results from functional assembly tests will be compared to these verification criteria to determine if the test was successful. (These criteria will require regulatory approval).

3. Identify Potential Function Conflicts to allow modifications in the Function Set, where appropriate and allowable, to eliminate or minimize effects on safety and performance. Where conflicting functions must remain, strict criteria must be established to assure acceptable means of resolution when actual functional conflicts occur.

*4. **Establish rules to govern the functions and resolve conflicts.*** This step sets the hierarchy by which the functions are prioritized (ordered by time and / or importance) to maximize safety and performance.

C. Develop Conceptual Aircraft System Functional Assemblies

1. Propose Potential Aircraft System Functional Assemblies (Subsystems) to perform the required Aircraft System Functions generated above in section B. Start with the highest-order functions to be accomplished and work toward lower levels of complexity.

*2. **Analyze the ability of the functional assemblies, individually and in combination, to perform in accordance with the function verification criteria.*** Ascertain that the individual functional assembly outputs perform as required and do not conflict with other functional assembly outputs to impair the sysytem in achieving other functional goals.

3. Identify Potential Conflicts created by organizing functional assemblies. Conflicts may occur where: 1) multiple functional assemblies compete for finite Aircraft System resources, 2) a single functional assembly is required to perform multiple functions that compete for time or other system resources, or 3) a single functional assembly is intended to be utilized for multiple functions, but its design cannot accommodate them all. Through this process the characteristics of particular functional approaches are evaluated for effectiveness relative to the hierarchy of functions necessary. This provides the basis for application of appropriate design principles to accommodate the multiple functions.

4. Establish rules to govern the utilization of functional assemblies and resolve conflicts. This step addresses the priority of functions established to meet the functional goals. Where potential conflicts in utilization of functional assemblies have been identified, these rules determine the allocation of resources toward required functions. For example, alternate or redundant functional assemblies may be required where conflicts exist; similarly, alternate functional approaches to attaining Functional Goals may be required.

D. Assign Aircraft System Elements to Functional Assemblies

1. Propose Aircraft System elements to form the required Aircraft System functional assemblies. Analyze the ability of these elements to form the functional assemblies necessary to perform in accordance with the verification criteria and meet Aircraft System functional goals. Start with the lowest-order functional assemblies to be created and work toward higher levels of complexity.

2. Establish element performance success criteria that indicate compliance with Functional Goal verification criteria previously identified for each required function. Use the Conceptual Aircraft System Functional Hierarchy and Conceptual Aircraft System Functional Assemblies Hierarchy as the guide. (The specific success criteria will require regulatory approval).

3. Identify potential conflicts created by organizing potential elements into functional assemblies. Conflicts may occur where: 1) a single element is required to perform in multiple functional assemblies that compete for its time, or 2) a single element is intended to be utilized for multiple functions, but its design cannot accommodate them all.

4. Establish rules to govern the utilization of elements to resolve conflicts. This step addresses the priority of Aircraft System resource allocation in forming functional assemblies. Where potential conflicts in utilization of system elements have been identified, these rules determine the allocation of elements to functional assemblies. For example, alternate or redundant elements and subsystems may be required; similarly, alternate or more effective elements may be required.

VII. APPLICATION TO AIRCRAFT SYSTEMS

A. *Establish specific test methods* that show the element and / or subsystem performance is in compliance with the relevant performance success criteria for that element or subsystem. Use the Conceptual Aircraft System Functional verification criteria and Conceptual Aircraft System element performance success criteria as the guide. (The specific test methods will require regulatory approval).

B. *Verify (empirically) the performance of Aircraft System elements and subsystems (functional assemblies)* according to the approved test methods to show compliance with the Aircraft System Functional Goal verification criteria. Start with the lowest-order elements to be tested and work toward higher levels of complexity. Full scale certification testing would be the last step in the verification process. Verify the performance ability of Aircraft System elements by analysis and/or similarity only with empirical data shown to be applicable and appropriate to the Aircraft System(s) and Performance Standard(s) in question.

VIII. APPLICABILITY TO EXISTING VERSUS NEW AIRCRAFT SYSTEMS

The application of the foregoing performance standards development process to development and regulation of Aircraft Systems is different, depending on whether the Aircraft System exists currently or is to be newly created. Application to new Aircraft Systems would potentially allow the entire process to be used as an alternative to current regulations, as certification decisions could be based on the entire new set of performance-based regulations. This process would work particularly well with Aircraft System concepts outside the range of current transport category aircraft designs. A complete set of performance-based regulations would also allow easier replacement of the current design-based regulations.

However, regulation of existing Aircraft Systems (and those currently being designed) has generally been based on specification of design standards. Such standards have generally required the "proper form" of specific Aircraft System elements. Although the form has generally been related to function, this approach has often produced small regard for the multiple functional assemblies in which elements must participate to perform multiple functions. It has also often discouraged adaptation of novel elements or element designs (functional solutions) toward Aircraft System functional goals, which themselves have not been systematically addressed. Using performance-based regulations and performance standards to control addition of new elements or application of new element designs to these Aircraft Systems could produce problems where newly defined functional goals require functions that have had no previously defined functional assemblies. In this situation, application of the performance standards generating system would have to be modified. Development of generic Aircraft System Functional Goal / Function sets that would apply to all currently certificated aircraft would still be necessary, and generic functional assemblies to accomplish these goals and functions would have to be envisioned. However, the design, manufacture and testing of existing elements will already have been completed in accordance with current requirements, without necessary regard for element performance. Establishment of functional assemblies that incorporated existing elements into new functional assemblies would likely produce conflicts or performance deficiencies for the existing elements, even though certification by the old regulations would still be valid for the initial purpose of the element. To ensure that the configurational and functional capabilities of specific elements (and functional assemblies) are adequate for both the old requirements and the newly identified goals and functions, additional certification test methods and success criteria would need to be developed and the performance of existing elements would need to be verified. Thus, development and application of performance standards for existing Aircraft Systems will necessarily produce additional regulatory requirements that do not currently exist. This effect will necessitate additional coordination between the regulatory authority and the responsible manufacturer / operator when using this hybrid approach.

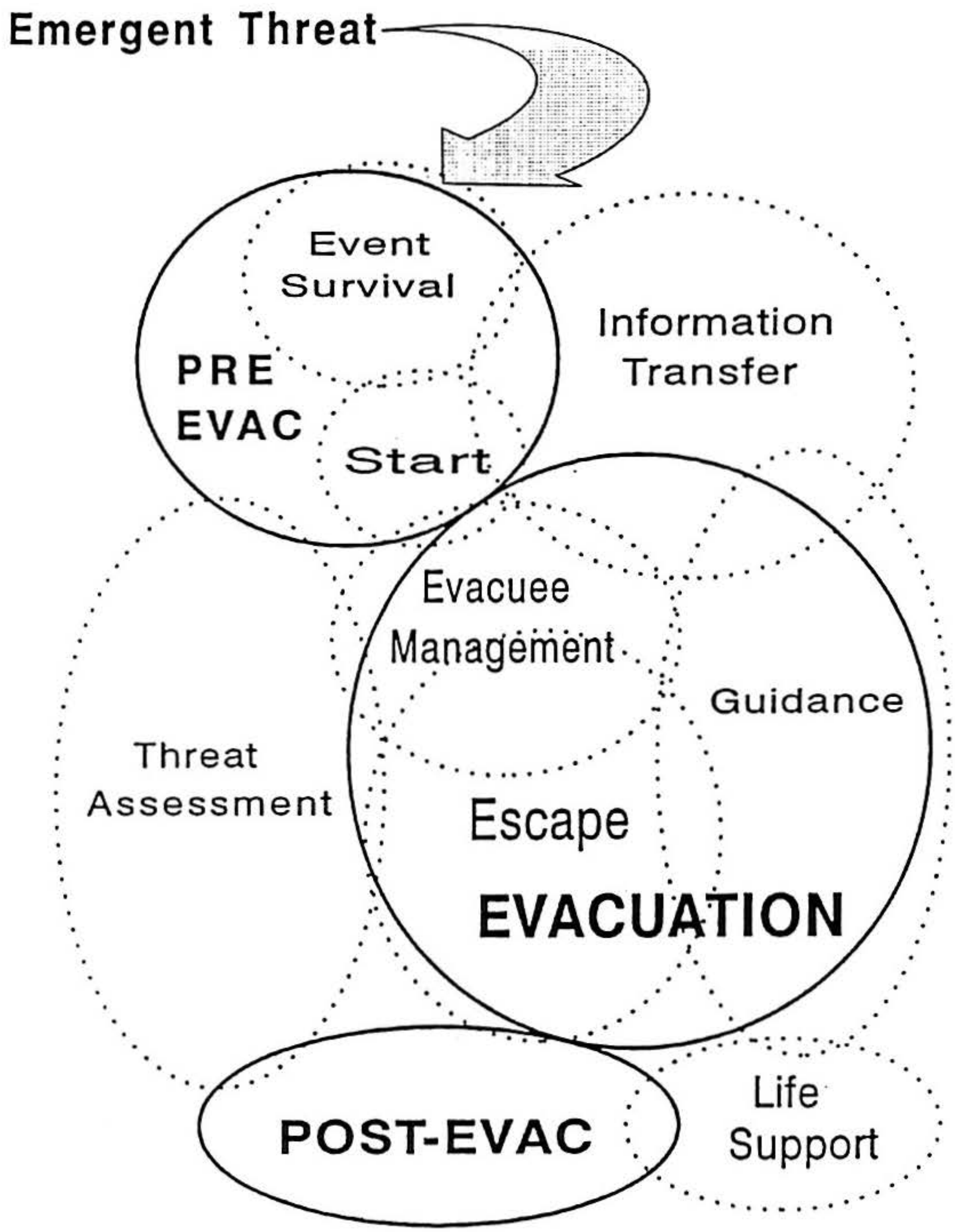
IX. CONCEPTUAL AIRCRAFT SYSTEM HIERARCHY

FUNCTIONAL GOALS	*FUNCTIONS*	*SYSTEM ELEMENTS*
FLIGHT		
	Propulsion	Engines
		Fuel Systems
	Maneuvarability	Cockpit controls
		Control surfaces
		Instrumentation
PAYLOAD TRANSPORT		
	Ingress	Passenger seating
	Cargo Loading	Overhead bins
	Weight/Balance	Cargo holds
SERVICE DELIVERY		
	Reservations	Marketing
	Ticketing	Terminal personnel
	In-Flight Service	Cockpit/Cabincrew
	Baggage Handling	Ground crew
MAINTAINABILITY		
	Engineering	Engineering staff
	Documentation	Technical writers
	Scheduling	Logistics staff
	Maintenance	Mechanics
SAFETY		
	Communication	ATC Communications
		Aircraft Interphone
		Megaphones
		Placards
	Environmental Control	Pressurization
		Fresh Air Handling
		Heating & cooling
		Lighting
	Emergency Abatement	Warning Instrumentation
		Emergency Equipment
		Crew Procedures

X. CONCEPTUAL AIRCRAFT EVACUATION SUBSYSTEM HIERARCHY

FUNCTIONAL GOALS	*FUNCTIONS*	*SYSTEM ELEMENTS*
SAFETY		
Emergency Abatement		
	Crash Prevention	Warning Instrumentation
		Crew Procedures
		Flight Controls
		Engines
	Fire control	Warning Instrumentation
		Fire blocking / hardening
		Water spray system
	Evacuation	*Evacuation elements*
	Evacuation Sub-Functions	
	Threat Assessment	Instrumentation
		Crew Procedures
		Passengers
	Pre-Evacuation Survival	Crashworthiness
		Crew Procedures
		Information Cards
	Information Transfer	Communications
		Crew Procedures
	Guidance	Interior Config.
		Crew Procedures
		Lighting
		Placards / signs
	Evacuee Management	Interior Config.
		Monuments
		Aisles
		Pathways
		Communications
		Crew Procedures
	Escape	Interior Config.
		Egress path
		Aisles
		Exits
		Descent means
	Life Support	Crew Procedures
		Equipment
		Life vests/rafts
		Smoke hoods
		Medical Kits
		Survival Kits
		Rescue Personnel

XI. INTERRELATED EVACUATION PROCESS FUNCTIONS



XII. APPLICATION OF THE PERFORMANCE STANDARDS GENERATING SYSTEM TO AIRCRAFT EVACUATION SUBSYSTEM FUNCTION

A. DEFINE POSITION IN THE AIRCRAFT SYSTEM FUNCTIONAL HIERARCHY

Identification of the position of the Evacuation Goal / Function within the Aircraft System Functional Goal Hierarchy is necessary in this case because the conceptual Aircraft System has not been developed as a whole. Care must be taken to ensure that goals and functions established for the evacuation subsystem do not conflict with higher-level and peer functions.

SAFETY is the Highest-Order Functional Aircraft System Goal (Equal to Flight, Payload Transport, etc.)

SAFETY FUNCTIONAL GOAL CRITICAL ASPECTS

(NOT LISTED HERE)

EMERGENCY ABATEMENT is a First-order Functional Sub-Goal of Safety ***and*** the Highest-order Function related to potential emergencies (equal to communication and environmental control, etc.)

EMERGENCY ABATEMENT CRITICAL ASPECTS

(NOT LISTED HERE)

EVACUATION is a Second-order Functional Goal of Safety ***and*** a First-order Function of Emergency Abatement (equal to fire control, crash prevention, etc.)

B. IDENTIFY EVACUATION GOAL CRITICAL ASPECTS

EVACUATION FUNCTION CRITICAL ASPECTS

(NOT NECESSARILY ALL-INCLUSIVE):

1. Coherent with Airworthiness (Presents no hazards)
2. Minimizes resource utilization conflicts
3. Is logistically sound (Well-organized, efficient, effective)
4 Minimizes procedural complexity.

5. Is Always Available (Evacuation System is Ready)
6. Is Self-Optimizing (Flexible, Responsive to Changing Conditions)

C. DEFINE EVACUATION SUB-GOALS AND CRITICAL ASPECTS

1. THREAT ASSESSMENT: The process of evaluating information about emerging danger or harm and its potential effects.

Threat Assessment Critical Aspects:

1. Ready
2. Timely
3. Reliable
4 Accurate
5. Informative
6. Continuous
7. Efficient
8.Accommodating
9. Organizing
10. Available
11. Standardized

2. PRE-EVACUATION SURVIVAL: The process of maintaining the ability of the occupants to evacuate the aircraft.

Pre-Evacuation Survival Critical Aspects

1. Safe
2. Accommodating
3. Reliable
4. Easily ended to start escape

3. INFORMATION TRANSFER: The process by which the output of one element or system affects the operation of another.

Information Transfer Critical Aspects

1. Informative
2. Accurate
3. Effective
4. Organizing
5. Reliable

6. Continuously available
7. Efficient
8. Purposeful
9. Standardized
10. Interior System independent

4. GUIDANCE: The process of providing necessary evacuation information to evacuees.

Guidance Critical Aspects

1. Informative
2. Accommodating
3. Accurate
4. Safe
5. Reliable
6. Parsimonious (Simple and obvious)
7. Standardized
8. Self-availing

5. EVACUEE MANAGEMENT: The process of guiding aircraft occupants from their seats to the ground and/or water.

Evacuee Management Critical Aspects

1. Reliable
2. Effective
3. Efficient
4. Coherent
5. Timely
6. Parsimonious (Simple and obvious)
7. Organizing
8. Self-optimizing
9. Accommodating
10. Motivating
11. Easily done
12. Minimal crew workload
13. Interior System Independent
14. Minimal reliance on procedures

6. ESCAPE: Movement of evacuees from the seats to the ground and/or water.

Escape Critical Aspects

1. Safe
2. Effective
3. Reliable
4. Accommodating
5. Accessible
6. Timely
7. Informative
8. Self-optimizing
9. Available
10. Redundant
11. Parsimonious
12. Ergonomically-tuned
13. Accurate
14. Self-organizing
15. Standardized
16. Moves evacuees away from aircraft

7. LIFE SUPPORT: Post-escape maintenance of evacuee well-being.

Life Support Critical Aspects

1. Safe
2. Accomodating
3. Informative
4. Accessible
5. Reliable
6. Appropriate for intended function
7. Non-interfering with escape

XIII. APPLICATION OF THE PERFORMANCE STANDARDS GENERATING SYSTEM TO THREAT ASSESSMENT SUBSYSTEM FUNCTION

A. DEVELOP THE THREAT ASSESSMENT FUNCTIONAL GOAL HIERARCHY

1. IDENTIFY THREAT ASSESSMENT FUNCTIONAL GOALS

The threat assessment functional goals include **detection and evaluation of a potential hazard** in time to allow appropriate action.

2. IDENTIFY CRITICAL ASPECTS FOR THREAT ASSESSMENT GOALS

1. Ready
2. Timely
3. Reliable
4. Accurate
5. Informative
6. Continuous
7. Efficient
8. Accommodating
9. Organizing
10. Available
11. Standardized

3. IDENTIFY POTENTIAL THREAT ASSESSMENT FUNCTIONAL GOAL AND CRITICAL ASPECT CONFLICTS

Goal conflicts could exist when a threat assessment functional goal conflicts with any higher-level or peer-level goal. Conflicts among critical aspects could also exist which affect the functional goals. The goals and critical aspects may thus be interdependent on each other. For example, evaluations of potential hazards may need to be continuous so that detection of an actual hazard can be as timely as necessary.

4. ESTABLISH RULES TO RESOLVE THREAT ASSESSMENT FUNCTIONAL GOAL AND CRITICAL ASPECT CONFLICTS

Example:

1. Threat Assessment Goals may not conflict with higher-level goals.
2. Prioritize (as necessary) threat assessment functional goals and their critical aspects.
3. Phase of Aircraft operation imposes additional constraints and requirements on threat assessment.

B. ESTABLISH THREAT ASSESSMENT FUNCTIONS TO MEET FUNCTIONAL GOALS

1. IDENTIFY THREAT ASSESSMENT FUNCTIONS

The need for specific threat assessment functions depends on what the potential threats will be. Thus, identification of the potential threats is the first step.

PRE-EVACUATION THREATS

a. Fires : Visible - In-cabin, lavatory; Hidden - engine, cargo, in-wall

b Potential Crash:

Loss of Propulsion
Fuel loss
Engine Malfunction
Electrical Failure

Loss of Flight control

Pilot Error
Electromechanical failure
Hydraulic failure

Structural Damage
Mechanical Failure

Landing Gear

Adverse Conditions

Weather
Poor landing conditions
Terrain
Water

c. Terrorist Action

Bombs
Hi-jacking

d. Unplanned passenger-initiated egress

THREATS DURING EVACUATION

a. Fires

In-cabin\
Outside (Doors inop?)
Smoke/Fumes

b. Water

c. Blocked/Obstructed pathways

Exits

Exit not opened

Equipment failure
Operational error

Exit open but unusable
Threat exists outside exit
Operational error makes exit inop

aisles
passageways

d. Panic/Fighting

Aggressive behavior
Passive (freezing) behavior

e. Inappropriate exit opening

f. Descent device failure / delayed availability

THREATS AFTER EVACUATION

a. Fire
b. Hostile environment

Weather (Temperature, Moisture, etc.)
Terrain

Mountains, desert, etc.

Water (Ocean)
Animals

c. Insufficient life support supplies

Food/Potable Water
Medical

d. Inappropriate Human Behavior

Panic
Aggressive Behavior (Fighting)

2. ESTABLISH THREAT ASSESSMENT FUNCTIONS VERIFICATION CRITERIA

Verification criteria that address the specific threat assessment critical aspects must be developed to ensure that the function is adequate for accomplishing the goal.

EXAMPLE: Verification criteria for ***timeliness*** could be of two types. Fixed numerical values could be used; however, this type of criterion would lead to a static performance standard. A more flexible criterion would be based on the ability of the Aircraft System to tolerate the threat, and this type of standard could evolve based on new materials technologies, etc.

3. IDENTIFY POTENTIAL THREAT ASSESSMENT FUNCTION CONFLICTS

Conflicts may be produced when threat assessment functions interfere with the accomplishment of higher-order and peer-level goals, or when one function interferes with another.

EXAMPLES:
1. Gathering too much information about a single potential threat could impair the ability to adequately analyze the information.
2. Gathering information simultaneously about more than one potential threat could confuse the system.

4.ESTABLISH RULES TO RESOLVE THREAT ASSESSMENT FUNCTION CONFLICTS

Rules to resolve the potential threat assessment conflicts address the situation where functions conflict because of the way they are accomplished or because the results of the function provide information transfer that is not adequately usable to achieve a higher-level function / goal.

EXAMPLES
1. Pick a meaningful data sampling interval and resolution to optimize analysis of threat assessment information.
2. Choose information sampling techniques that reduce confusability.

C. PROPOSE THREAT ASSESSMENT FUNCTIONAL ASSEMBLIES

Conceptual functional assemblies must be developed that can perform the required threat assessment functions. This step includes the general types of elements that would be used to accomplish the functions.

1. PROPOSE AIRCRAFT SYSTEM FUNCTIONAL ASSEMBLIES TO PERFORM THE THREAT ASSESSMENT FUNCTIONS

Catalog the required threat assessment functions and propose functional assemblies to be devoted to each function.Describe the types of elements that would be used to form the functional assemblies.

2. ESTABLISH PERFORMANCE CRITERIA FOR THREAT ASSESSMENT FUNCTIONAL ASSEMBLIES

Using the threat assessment functional goal critical aspects and function verification criteria, derive the individual and multiple performances these functional assemblies must achieve.

3. IDENTIFY POTENTIAL THREAT ASSESSMENT FUNCTIONAL ASSEMBLY CONFLICTS

Identify conflicts produced by the proposed performances of the functional assemblies, both individually and in combination. The conflicts could produce decrements in attainment of higher-order or peer-level functional goals, as well as impair accomplishment of threat assessment functions. Such conflicts will generally result from competition for Aircraft System resources.

4. ESTABLISH RULES TO RESOLVE THREAT ASSESSMENT FUNCTIONAL ASSEMBLY CONFLICTS

Rules to resolve threat assessment functional assembly conflicts will generally address the competition for resources which causes the conflict.

EXAMPLES:
1. The most severe threat will get the most resources.
2. The most severe threat will be dealt with first.
3. No threat should be ignored.

D. ASSIGN AIRCRAFT SYSTEM ELEMENTS TO THREAT ASSESSMENT FUNCTIONAL ASSEMBLIES

1. SELECT ACTUAL AIRCRAFT SYSTEM ELEMENTS TO FORM THE PROPOSED FUNCTIONAL ASSEMBLIES

EXAMPLE: An *external view* function has been identified as necessary to accomplish threat assessment. The threat assessment functional assembly proposed for this function includes a flight attendant using a view port mounted in the exit door. In addition to specifying the flight attendant duties relevant to this function, the specific type of view port required for the function must be chosen.

2. ESTABLISH SUCCESS CRITERIA FOR THE PERFORMANCE OF THREAT ASSESSMENT ELEMENTS

The performance success criteria should be coherent with the threat assessment functional goal critical aspects and threat assessment function verification criteria.

EXAMPLE: The performance success criteria for the flight attendant will include the ability to accomplish the duties as required. The success criteria for the view port will provide for a vertical viewing angle of 90 degrees (centered at a 45 degree angle to the ground) and a horizontal viewing angle of 120 degrees (centered on the view port).

3. IDENTIFY POTENTIAL THREAT ASSESSMENT ELEMENT CONFLICTS

Such conflicts are likely to be created as a result of multiple roles the aircraft system elements perform within the Aircraft System functional hierarchy and because of multiple roles within threat assessment and other Aircraft System functional assemblies.

EXAMPLES:

1. The flight attendant has multiple simultaneous duties that conflict at the time the view port should be used, rendering the flight attendant inadequate to perform all the required functions.
2. The emergency battery system has too much load to function for the time required.

4. ESTABLISH RULES TO RESOLVE THREAT ASSESSMENT ELEMENT CONFLICTS

Such rules could produce changes in assignment of elements to multiple functional assemblies, they could produce the need for redundant Aircraft System elements devoted to threat assessment, or they could require enhanced function of existing elements.

EXAMPLE:

1. The flight attendant duties should be prioritized to overcome the conflict. Alternatively, another flight attendant could be employed for this function, or another element (such as a video camera) could be used which relieved the flight attendant of the conflicting duty.

2. Increase battery size or provide an alternate battery for certain of the systems.

XIV. APPLICATION TO THE AIRCRAFT THREAT ASSESSMENT SUBSYSTEM

A. DEVISE TEST METHODS FOR THE THREAT ASSESSMENTELEMENTS

The test methods will be structured to ensure that the empirical evidence answers whether the elements and functional assemblies perform in accordance with the performance success criteria.

B. VERIFY PERFORMANCE OF THE THREAT ASSESSMENT SUBSYSTEM

Verification of element and functional assembly performance will always require empirical evidence gathered through testing. Requests for certification by analysis or similarity must be supported by such empirical evidence gathered on like elements, using test methods analogous and equivalent to the test methods specified in the performance standard.

XV. APPENDIX A

PERFORMANCE-BASED REGULATION

EMERGENCY LANDING CONDITIONS

25.561 General

(a) The airplane, although it may be damaged in emergency landing conditions on land or water, must be designed as prescribed in this section to protect each occupant under those conditions.

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

(1) Proper use is made of seats, belts, and all other safety design provisions;

(2) The wheels are retracted (where applicable); and

(3) The occupant experiences the following ultimate inertia forces acting separately relative to the surrounding structure:

(i) Upward, 3.0g

(ii) Forward, 9.0g

(iii) Sideward, 3.0g on the airframe; and 4.0g on the seats and their attachments.

(iv) Downward, 6.0g

(v) Rearward, 1.5g

(c) The supporting structure must be designed to restrain, under all loads up to those specified in paragraph (b)(3) of this section, each item of mass that could injure an occupant if it came loose in a minor crash landing.

(d) Seats and items of mass (and their supporting structure) must not deform under any loads up to those specified in paragraph (b)(3) of this section in any manner that would impede subsequent rapid evacuation of occupants.

25.562 Emergency landing dynamic conditions.

(a) The seat and restraint system in the airplane must be designed as prescribed in this section to protect each occupant during an emergency landing condition when-

(1) Proper use is made of seats, safety belts, and shoulder harnesses provided for in the design; and

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

(b) Each seat type design 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 each of the following emergency landing conditions. The tests must be conducted with an occupant simulated by a 170-pound anthropomorphic test dummy, as defined by 49 CFR Part 572, Subpart B, or its equivalent, sitting in the normal upright position.

(1) A change in downward vertical velocity (Δv) of not less than 35 feet per second, with the airplane's longitudinal axis canted downward 30 degrees with respect to the horizontal plane and with the wings level. Peak floor deceleration must occur in not more than 0.08 seconds after impact and must reach a minimum of 14g.

(2) A change in forward longitudinal velocity (Δv) of not less than 44 feet per second, with the airplane's longitudinal axis horizontal and yawed 10 degrees either right or left, whichever would cause the greatest likelihood of the upper torso restraint system (where installed) moving off the occupant's shoulder, and with the wings level. Peak floor deceleration must occur in not more than 0.09 seconds after Impact and must reach a minimum of 16g. Where floor rails or floor fittings are used to attach the seating devices to the test fixture, the rails or fittings must be misaligned with respect to the adjacent set of rails or fittings by at least 10 degrees vertically (i.e., out of Parallel) with one rolled 10 degrees.

(c) The following performance measures must not be exceeded during the dynamic tests conducted in accordance with paragraph (b) of this section:

(c) The following performance measures must not be exceeded during the dynamic tests conducted in accordance with paragraph (b) of this section:

(1) Where upper torso straps are used for crewmembers, tension loads in individual straps must not exceed 1,750 pounds. If dual straps are used for restraining the upper torso, the total strap tension loads must not exceed 2,000 pounds.

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

(3) The upper torso restraint straps (where installed) must remain on the occupant's shoulder during the impact.

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

(5) Each occupant must be protected from serious head injury under the conditions prescribed in paragraph (b) of this section. Where head contact with seats or other structure can occur, protection must be provided so that the head impact does not exceed a Head Injury Criterion (HIC) of 1,000 units. The level of HIC is defined by the equation:

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

Where: t_1 is the initial integration time, t_2 is the final integration time, and a(t) is the total acceleration vs. time curve for the head strike, and where (t) is in seconds, and (a) is in units of gravity.

6) Where leg injuries may result from contact with seats or other structure, protection must be provided to prevent axially compressive loads exceeding 2,250 pounds in each femur.

7) The seat must remain attached at all points of attachment, although the structure may have yielded.

(8) Seats must not yield under the tests specified in paragraphs (b)(l) and (b)(2) of this section to the extent they impede rapid evacuation of the occupants.

XVI. APPENDIX B

PERFORMANCE STANDARD

SAE The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE STANDARD

SAE AS8049 REV. A

Issued 1990-03
Revised Proposed Draft

Submitted for recognition as an American National Standard

PERFORMANCE STANDARD FOR SEATS IN CIVIL ROTORCRAFT AND TRANSPORT AIRPLANES

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1. SCOPE:

1.1 General:

This SAE Aerospace Standard (AS) defines minimum performance standards, qualification requirements, and minimum documentation requirements for passenger and crew seats in civil rotorcraft and transport airplanes. The goal is to achieve comfort, durability, and occupant protection under normal operational loads and to define test and evaluation criteria to demonstrate occupant protection when a seat/occupant/restraint system is subjected to statically applied ultimate loads and to dynamic impact test conditions set forth in the applicable Federal Aviation Regulations (FAR) Part 25, 27, or 29.

This AS also provides guidance for design by enumerating certain design goals to enhance comfort, serviceability, and safety. Guidance for test procedures, measurements, equipment, and interpretation of results is presented to promote uniform techniques and to achieve acceptable data.

While this AS addresses system performance, responsibility for the seating system is divided between the seat supplier and the installation applicant. The seat supplier's responsibility consists of meeting all the seat system performance requirements and obtaining and supplying to the installation applicant all the data prescribed by this AS. The installation applicant has the ultimate system responsibility in assuring that all requirements for safe seat installation have been met.

1.2 Applicability:

This AS addresses the performance criteria for seat systems requiring dynamic testing to be used in civil rotorcraft and transport airplanes. These criteria do not apply to seats certified solely on the basis of static test or analysis.

1.3 Seat Types:

This AS covers all passenger and crew seats for use in aircraft type-certificated in the following categories shown in Table 1:

TABLE 1 - Seat Type Categories

Seat Type	Aircraft Category	Applicable FAR
A	Transport Airplane	Part 25
B	Normal Rotorcraft	Part 27
B	Transport Rotorcraft	Part 29

2. REFERENCES:

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

2.1.1 SAE J211 Instrumentation for Impact Tests

2.2 FAR Publications:

Available from FAA, 800 Independence Avenue, SW, Washington, DC 20591.

2.2.1 Code of Federal Regulations, Title 14 Part 21 Certification Procedures for Products and Parts

2.2.2 Code of Federal Regulations, Title 14 Part 25 Airworthiness Standards: Transport Category Airplanes

2.2.3 Code of Federal Regulations, Title 14 Part 27 Airworthiness Standards: Normal Category Rotorcraft

2.2.4 Code of Federal Regulations, Title 14 Part 29 Airworthiness Standards: Transport Category Rotorcraft

2.2.5 Code of Federal Regulations, Title 49 Part 572 Anthropomorphic Test Dummies

2.3 Order of Precedence:

In the event of a conflict between the text of this AS and the references cited herein, the text of this AS shall take precedence. Nothing in this AS, however, shall supersede applicable laws and regulations.

3. GENERAL DESIGN:

3.1 Guidance:

Section 3.1 provides the designer with information that experience has shown enhances comfort, serviceability, and safety. Satisfactory designs may include features that differ from this guidance material.

3.1.1 Attention should be given to ergonomic, utility, and comfort aspects of seats commensurate with the intended use and duration of flight.

3.1.2 Comfortable support and protective retention of the occupant should be provided under all conditions throughout the aircraft performance envelope, including movement on the surface, takeoff, landing, and emergency flight maneuvers.

3.1.3 Crew seats and restraints should accommodate adult occupants encompassing the 1.57 m (5 ft 2 in) to the 1.9 m (6 ft 3 in) occupant.

3.1.4 Passenger seats and restraints should accommodate occupants encompassing the 2-year old child to the 99th-percentile male occupant. The restraint attachments and lengths should be adjustable to function properly in safely retaining this range of occupants.

3.1.5 The seat system should be designed to absorb energy where practical. Brittle failure should be avoided. Failures of joints and attachments should not occur first in the primary load path of the structure.

3.1.6 If the seat design incorporates energy absorbing features through deformation or stroking, shields or other means should be provided in the seat design to maintain clearances for the deformation or stroking.

3.1.7 The seat design should include provisions to minimize static electricity buildup.

3.1.8 [Left intentionally blank]

3.1.9 Crew restraint systems, while fastened, should neither significantly impede access to controls nor prevent crews from performing their duties.

3.1.10 The seat system should be designed so that the primary structural elements can be readily inspected to detect wear, deterioration or any other condition that would degrade safety.

3.1.11 Restraint system anchorages should provide self-aligning features. If self-aligning features are not provided, the static and dynamic tests in this AS should be conducted with the restraints and anchorages positioned in the most adverse configuration allowed by the design. The anchorage system should minimize the possibility of incorrect installation or inadvertent disconnection of the restraints.

3.1.12 All members of the primary structure should be protected to minimize deterioration from environmental factors. Members should be protected or designed to accommodate deterioration without compromise of safety or function. The design should address loss of strength caused by vibration, humidity, dissimilar metals, in-service impact damage, and other expected conditions, including spillage, exposure to cleaning agents, or dirt.

3.1.13 Materials should be selected that minimize smoke and toxic gas emissions in the presence of fire.

3.1.14 On passenger seats which use studs or other fittings for attachment of the seat to seat tracks or fittings, anti-rattle designs or devices should be considered to reduce wear on the seat tracks or fittings.

3.1.15 All exposed portions of the seat and restraint system should be free from projections and sharp edges that could catch or damage the occupant's clothing or cause injury.

3.1.16 Electrical or electronic devices incorporated in a seat should be provided with appropriate shielding and provisions to minimize electromagnetic interference.

3.2 Requirements:

This section provides additional requirements for a seat and restraint system design which are not described elsewhere in this AS.

3.2.1 Seat systems shall be designed to provide impact protection for the occupant at seat adjustment positions, orientations, and locations allowed to be occupied during takeoff and landing.

3.2.2 Seat elements shall be designed so that, when evaluated under the test conditions of this AS, they do not leave hazardous projections that could significantly contribute to occupant injury or impede rapid evacuation.

3.2.3 Quick-release type fittings, adjustment handles, and buttons shall be designed, installed, and protected such that their positions can be verified, and incorrect installation or inadvertent activation is unlikely.

3.2.4 [Left intentionally blank]

3.2.5 Electrical or electronic devices incorporated in a seat shall be supplied with grounding.

3.2.6 Adjustable features (seat swivel, back recline, and stowage of movable tables, armrests, footrests, etc.) shall be designed so that they can be returned by the occupant to the positions required for takeoff and landing without release of occupant restraints. In addition, these items shall not deploy under dynamic impact test conditions of this AS in a manner that could significantly contribute to serious occupant injury or impede rapid egress of any aircraft occupant.

3.2.7 When an underseat baggage restraint is incorporated in a seat, it shall be designed to restrain at least 90 N (20 lb) of stowed items per passenger place under the test conditions of this AS in a manner that will not significantly impede rapid egress from the seat.

3.2.8 The cushions and occupant restraint system shall minimize submarining of the occupant or slippage of the restraint when evaluated under the dynamic impact test conditions of this AS.

3.2.9 The seat structure, cushions, and occupant restraint shall be considered to act as a total system. Any substitution of these elements shall be made only on the basis of additional tests or rational analysis based on test.

3.2.10 Rearward facing seats shall be designed with a back height sufficient to provide 930 mm (36.5 in) of support for the occupant as measured from the seat reference point (SRP) to the top of the seat back. If a separate headrest is provided, a maximum gap of 100 mm (4 in) can exist between the bottom of the headrest and the top of the seat back, provided that the height of the headrest is sufficient to provide head support for the intended range of occupant size. If there is a gap between the seat back surface and the BRP/SRP waterline, it shall be no more than 100 mm (4 in). Measurements shall be taken along the seat back tangent line. (See Figures 1A and 1B for the definition, determination, and use of SRP.)

3.2.11 Seat track fitting locking devices shall readily indicate positive engagement and locking when installed in the aircraft environment (carpets, track covers, etc.).

3.3 Materials and Workmanship Requirements:

3.3.1 Materials shall be of a quality that experience or tests have demonstrated to be suitable for use in aircraft seats.

3.3.2 Workmanship shall be consistent with high-grade aircraft manufacturing practice.

3.3.3 Magnesium alloys shall not be used.

3.4 Fire Protection Requirements:

3.4.1 The cushion system, covering and upholstery and all other exposed material used in the seat shall have self-extinguishing properties as specified in the applicable FAR.

3.4.2 Where required by the FAR, cushion systems shall be tested and shall meet the fire protection provisions of Appendix F, Part II of FAR Part 25 or shall be demonstrated by analysis (similarity) to provide equivalent protection.

3.4.3 If ashtrays are installed in or attached to the seat, they shall be self-contained, completely removable types. The ashtray housing shall be fire resistant and sealed to prevent burning materials from falling into seat structure in case the ashtray is missing. Ashtrays in folding armrests shall be designed to preclude release of burning material when the armrest is folded with or without the ashtray lid closed.

3.4.4 Electrical components in a seat shall have provisions to preclude initiation of a fire from overheating.

3.4.5 If oxygen generators are incorporated into a seat, provisions shall be made to preclude initiation of a fire due to the heat produced by the generator. The adequacy of the design shall be demonstrated.

3.4.6 If in-arm food trays are installed, the bottom of the cavity should be open to prevent accumulation of waste. If it is not possible to provide an adequate opening, the cavity shall be sealed.

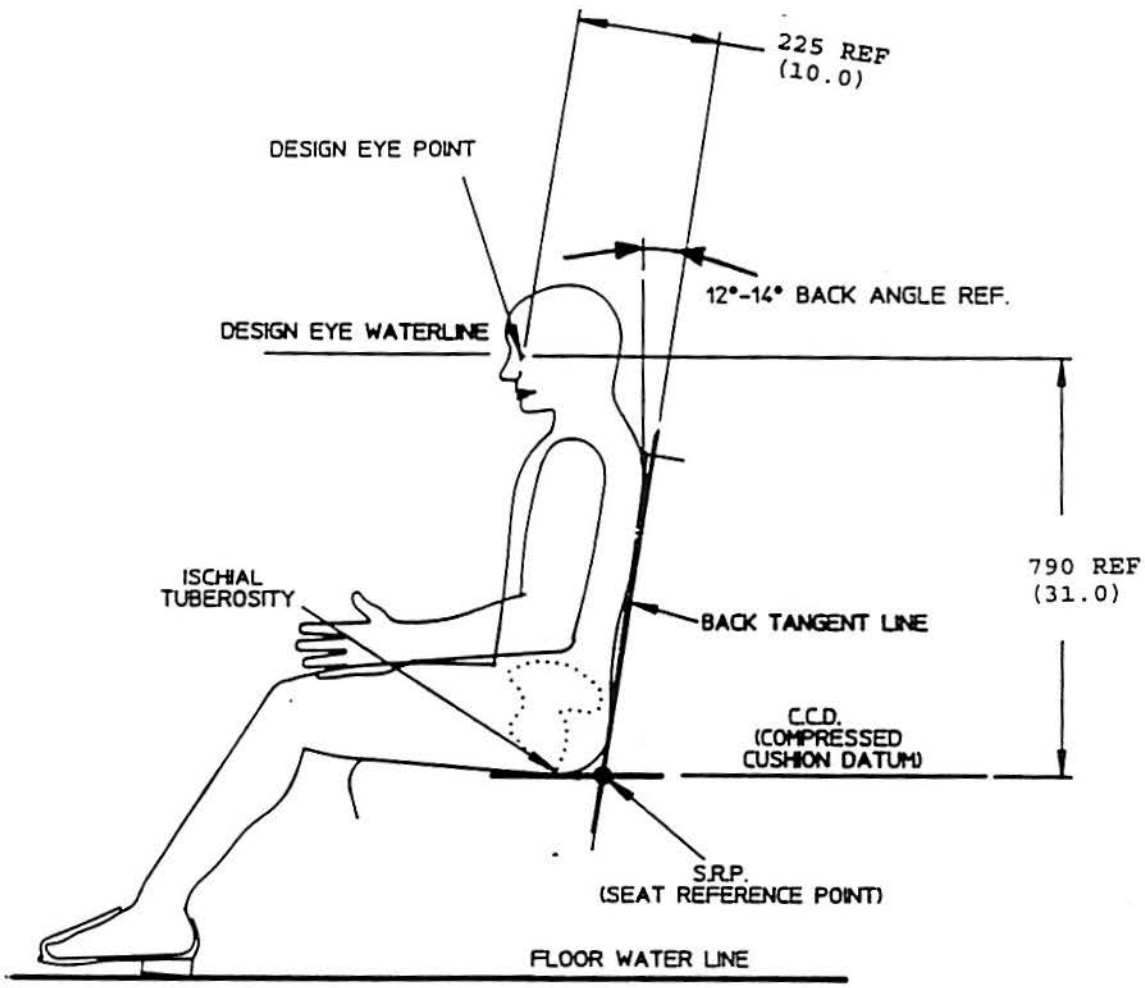
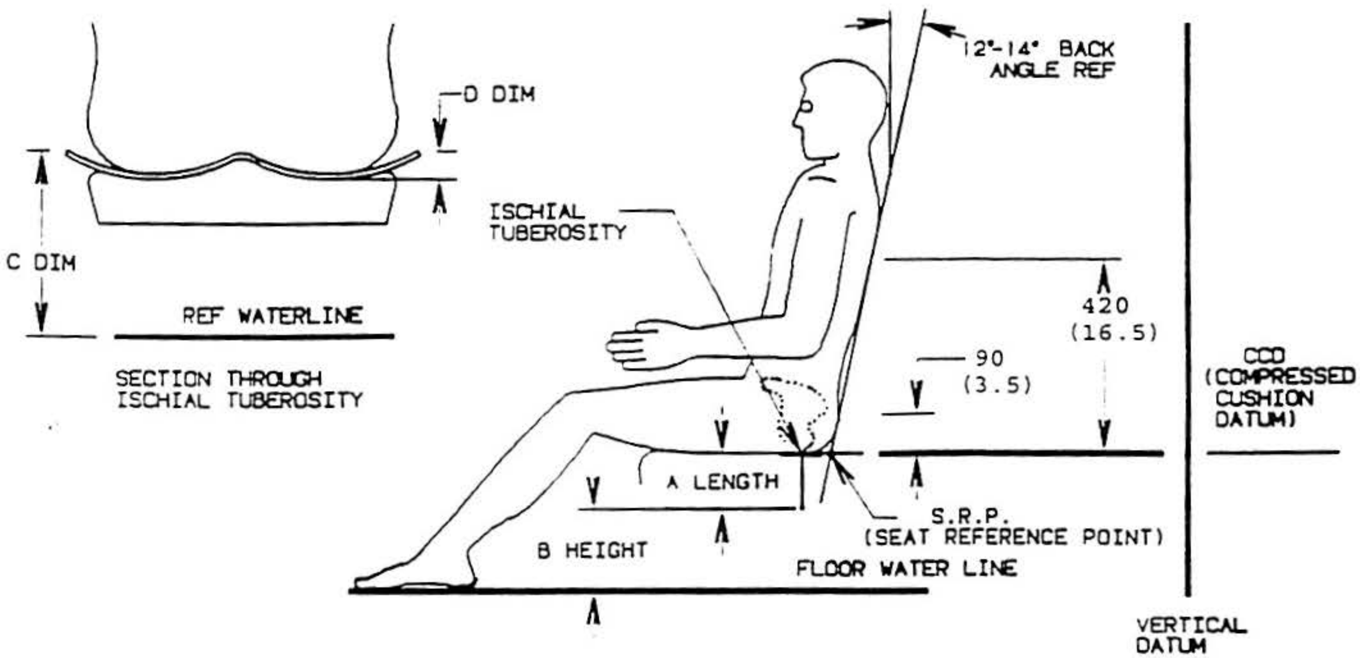


FIGURE 1A - Terminology and Dimensions for 50th Percentile Male



PROCEDURE FOR ESTABLISHING SRP:

1. PLACE A 75 TO 80 KG (160 TO 180 LB) SUBJECT OR ANTHROPOMORPHIC TEST DUMMY (ATD) ON A SEAT (FIGURE 1B).
2. LOCATE AND MARK A POINT ON THE CUSHION DIRECTLY UNDER AN ISCHIAL TUBEROSITY.
3. DRILL A HOLE VERTICALLY THROUGH THE SEAT PAN CUSHION AND STRUCTURE AT THAT POINT AND INSERT A HEADED PIN OF LENGTH "A".
4. PLACE THE SUBJECT ON THE SEAT AND MEASURE FROM A REFERENCE WATERLINE TO THE LOWER END OF THE PIN ("B" HEIGHT).
5. THE ADDITION OF THIS HEIGHT "B" AND THE PIN LENGTH "A" ESTABLISHES THE COMPRESSED CUSHION DATUM FROM THE REFERENCE WATERLINE.

   NOTE: STEPS 3, 4, AND 5 MAY BE REPLACED BY THE USE OF APPROXIMATELY 6 MM (.25 IN) DIAMETER SOFT BAR (LEAD, SOFT SOLDER, OR FUNCTIONAL EQUIVALENT) PLACED ACROSS THE SEAT AT THE MARK ON THE SEAT PAN CUSHION (LOCATED IN STEP 2) AS FOLLOWS:

   A. PLACE THE SUBJECT ON THE SEAT ENSURING THAT THE SOFT BAR DEFLECTS VERTICALLY
   B. ENSURE THAT THE TOP ENDS OF THE SOFT BAR ARE AT A COMMON HEIGHT AND NOTE THE HEIGHT FROM A REFERENCE WATERLINE - DIMENSION "C'.
   C. REMOVE THE SUBJECT AND MEASURE THE DEFLECTION OF THE SOFT BAR FROM THE TOP AT THE ENDS TO THE POINT OF MAXIMUM DEFLECTION - DIMENSION "D".
   D. THE COMPRESSED CUSHION DATUM IS ESTABLISHED BY SUBTRACTING HALF THE SOFT BAR DIAMETER 3 MM (.125 IN) AND THE DEFLECTION (DIMENSION "D") FROM THE END HEIGHT (DIMENSION "C")

6. INSERT TWO ROUND BARS HORIZONTALLY BETWEEN THE SUBJECT'S BACK AND THE SEAT BACK CUSHION AT 89 MM (3.5 IN) AND 419 MM (16.5 IN) VERTICALLY ABOVE THE CCD AND DETERMINE THEIR POSITIONS FROM A VERTICAL DATUM.
7. PLOT THE TWO POSITIONS WITH THE CCD AND ESTABLISH THE SRP AT THEIR INTERSECTION

   NOTE: STEPS 6 AND 7 MAY BE REPLACED BY THE USE OF A SOFT BAR IN A AMNNER SIMILAR TO THAT DESCRIBED IN STEPS A TO C ABOVE.

FIGURE 1B

3.5 Allowable Permanent Deformations:

Allowable permanent deformations sustained by a seat subjected to the ultimate static tests or dynamic impact tests of this AS are specified below. Permanent seat deformations shall be measured on the critically loaded seat after both static and dynamic tests. Significant measuring points shall be identified and marked on the test seat, and their positions measured in the lateral, vertical, and longitudinal directions relative to fixed points on the test fixture. Measurement of the selected points shall be recorded before and after the tests. For dynamic tests, if floor deformations are applicable, consistency in pre and posttest measurements shall be maintained. If the pretest measurements are made before floor deformations are applied, the posttest measurements shall be made after floor deformations have been removed. Conversely, if the pretest measurements are made after floor deformations are applied, the posttest measurements shall be made before removal of floor deformations.

3.5.1 Longitudinal Direction: The longitudinal permanent deflection of a Type A seat shall not exceed 75 mm (3.0 in) and a Type B seat shall not exceed 100 mm (4.0 in). The measurement shall be made at the forward-most hard point(s) of the seat at a height up to and including the armrest or 635 mm (25 in) above the floor for seats without armrests.

3.5.2 Downward Direction: There is no limitation on downward permanent deformation provided it can be demonstrated that the feet or legs of occupants will not be entrapped by the deformation.

3.5.3 Seat Rotation: The seat bottom rotational permanent deformation shall not result in an angle that exceeds 20° pitch down or 35° pitch up from the horizontal plane. This rotational deformation shall be measured between the fore and aft extremities of the seat pan at the centerline of each seat bottom (Figure 2A). Rotation of the seat pan shall not cause entrapment of the occupant.

3.5.4 Sideward Direction: The sideward permanent deformation, towards an aisle, of a seat shall not exceed 40 mm (1.5 in) at heights below 635 mm (25 in) above the floor, and shall not exceed 50 mm (2.0 in) at heights 635 mm (25 in) or more above the floor. Height above the floor is determined prior to imposing the floor deformation of 5.3.3.

3.5.5 Other Deformation Limits: The most forward surface of a seat back must not deform to a distance greater than one half the original distance to the forward-most hard structure on the seat (see Figure 2B). The posttest measurement may be made with the seat back returned to its pretest upright or structurally deformed position using no more than the original seat back breakover forces.

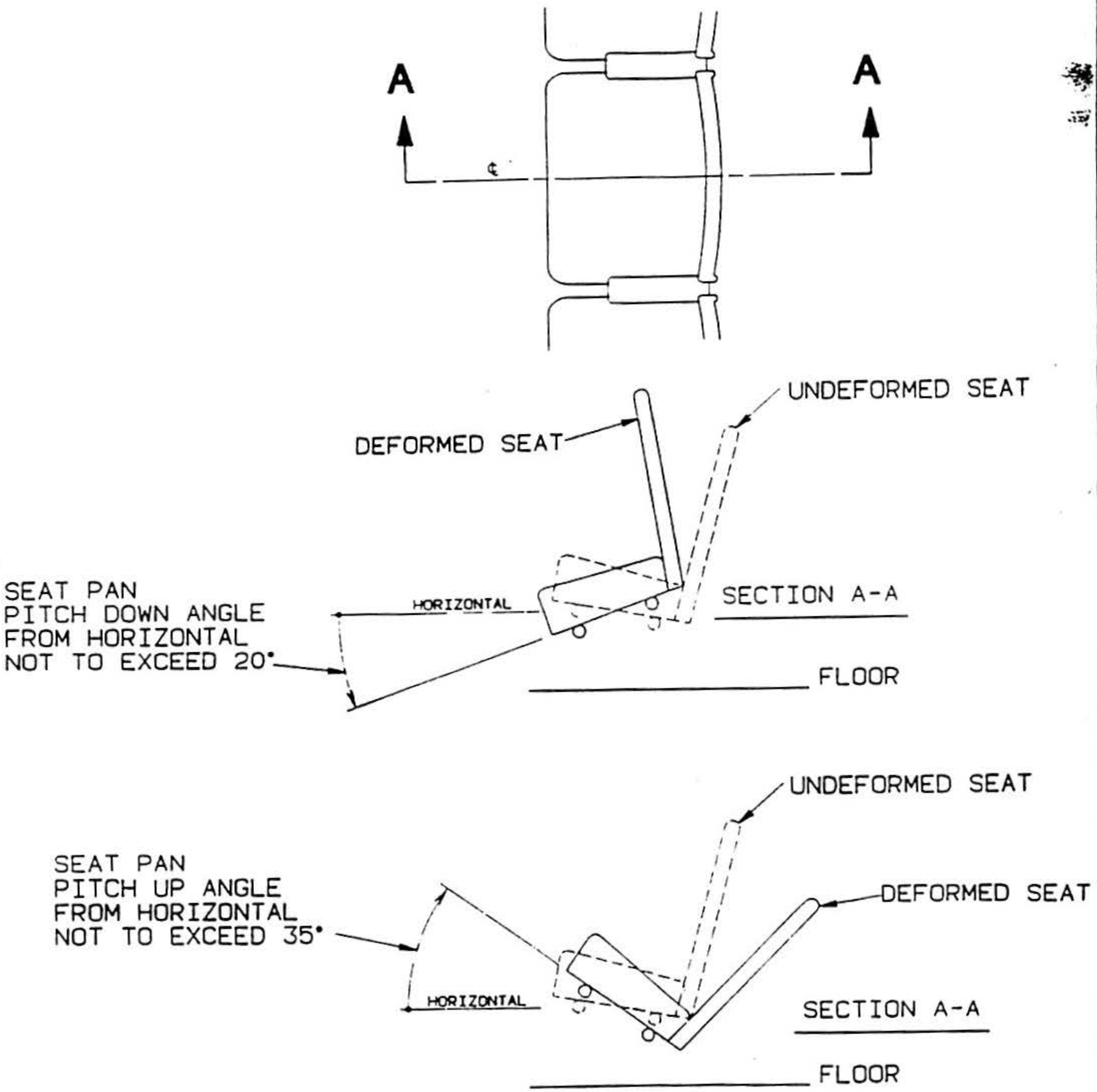
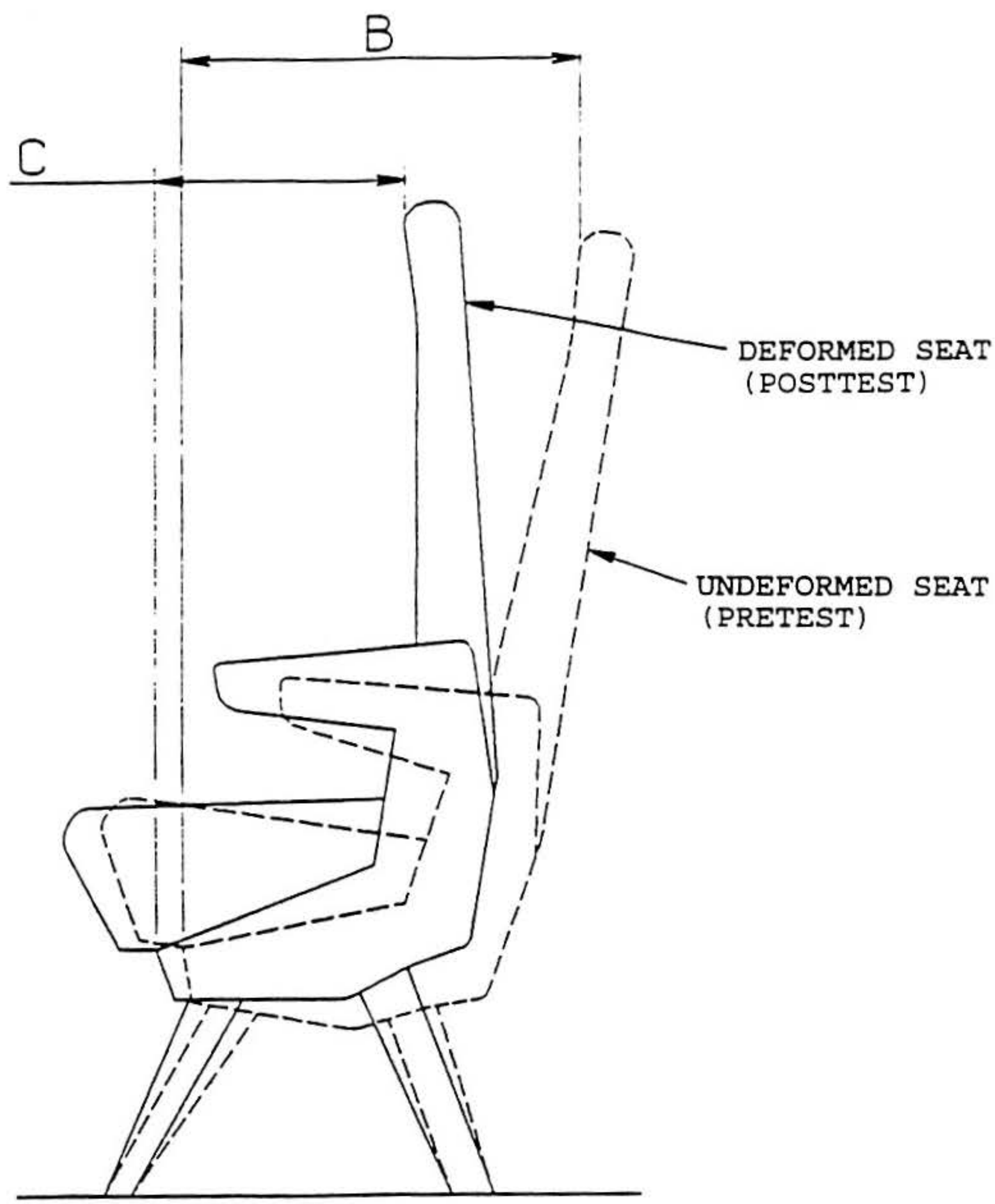


FIGURE 2A - Maximum Posttest Seat Pan Rotation



DIMENSION "C" MUST BE
AT LEAST 50% OF DIMENSION "B"

FIGURE 2B - Maximum Seat Back Permanent Deformation

Note: Applicable for Forward Facing Seats Only.

3.5.6 Stowable Seats: A stowable seat (manual or automatic) installed near exits or in exit paths must stow posttest and remain stowed without interfering with the exits or exit paths. The permanent deformation shall not exceed 40 mm (1.5 in) from the pretest upright position. A posttest stowage force not to exceed 45 N (10 lb) above the original stowage force may be used to stow the seat prior to measurement of permanent deformation.

4. STRENGTH:

All seats qualified for occupancy during takeoff and landing shall be capable of withstanding, within the criteria defined below, both statically and dynamically applied loading.

4.1 Static Strength:

Seats shall be designed and demonstrated by test or appropriate analysis to withstand the ultimate load factors specified in Table 2. Forces representing the sum of each occupant weight of 750 N (170 lb), plus the complete seat weight which includes all trim and accessories, plus the total weight of any item of mass (e.g., underseat baggage, stowage compartment weight plus weight of contents, etc.) restrained by the seat, all multiplied by the appropriate load factor from Table 2, shall be applied to the seat (see 5.1.7 and 5.1.9). The forward, side, down, up, and aft loads shall be applied separately for at least 3 s without failure. Static strength shall be demonstrated under all variations of seat occupancy and adjustments which produce critical loading of any structural member.

TABLE 2 - Ultimate Load Factors

Direction (Relative to Aircraft	Type A Seat (Transport Airplane) Factor	Type B Seat (Rotorcraft) Factor
Forward	9.0	16.0
Sideward	4.0[1][2]	8.0
Upward	3.0[2]	4.0
Downward	6.0[2]	20.0[3]
Rearward	1.5	

[1] Includes 1.33 fitting factor.
[2] Increase these load factors as necessary for reduced weight gust/flight loads or landing requirements.
[3] Load to be applied after stroking of the seat energy absorbing system.

4.1.1 Pilot and Co-Pilot Loads: Pilot and co-pilot seats shall be designed to withstand the ultimate rearward load of 4.45 KN (1000 lb) applied 200 mm (8 in) above the SRP to provide for the application of pilot forces to the flight controls.

4.1.2 Limit Loads: All seat systems shall be capable of withstanding limit loads in the upward and downward directions without any detrimental permanent deformations. Pilot seats shall additionally be capable of withstanding a 3 kN (670 lb) aftward limit load without any detrimental permanent deformation.

4.1.3 Attachments: The strength of the seat attachments to the aircraft structure and the pelvic restraint or upper torso restraint attachments to the seat or aircraft structure shall be 1.33 times the ultimate loads specified in Table 2 (except as noted for Type A seat sideward).

4.1.4 Casting Factors: If castings are used in the construction of the seat, the castings shall have a factor of safety and related inspection requirements in accordance with the applicable portions of FAR Section 25.621, 27.621, or 29.621. If a fitting is or contains a casting, the casting will be statically tested to the higher of the casting factor of safety or the 1.33 fitting factor for emergency landing conditions loads or the 1.15 factor for ground or flight loads, but not the combination of factors.

4.2 Dynamic Strength/Occupant Protection:

The seat structure, cushions, and occupant restraint, as a system, shall be designed and demonstrated by test or appropriate analysis based on test of a similar type system to withstand the dynamic impact test conditions prescribed in 5.3 and meet the pass/fail criteria of 5.4.

5. QUALIFICATION TESTS:

Initial qualification of a seat shall be performed by static and dynamic tests. Subsequent qualifications related to design changes to seats of a similar type may be performed by rational analysis based on existing qualification test data.

5.1 Static Qualification Tests:

5.1.1 The test seat shall be complete to the extent that the primary structure, the occupant restraint system, and the seat attachment fittings to the aircraft are accurately represented. Items that are not part of the seat primary structure, the omission of which will not alter the test and pass/fail criteria, may be excluded from the test article, but their weight must be included when determining the static loads.

5.1.2 A body block shall be installed in each occupant place that will be loaded and shall be restrained by the occupant restraint. The body blocks shown in Figures 3, 4, 5A, and 5B are satisfactory for static test purposes. They may be refined or modified if desired; however, the resultant load application point for each static test shall comply with 5.1.6 (Table 3).

5.1.3 For the application of down loads, representative distributed loading of the seat pan (as opposed to loading rigid boundary members) must be achieved.

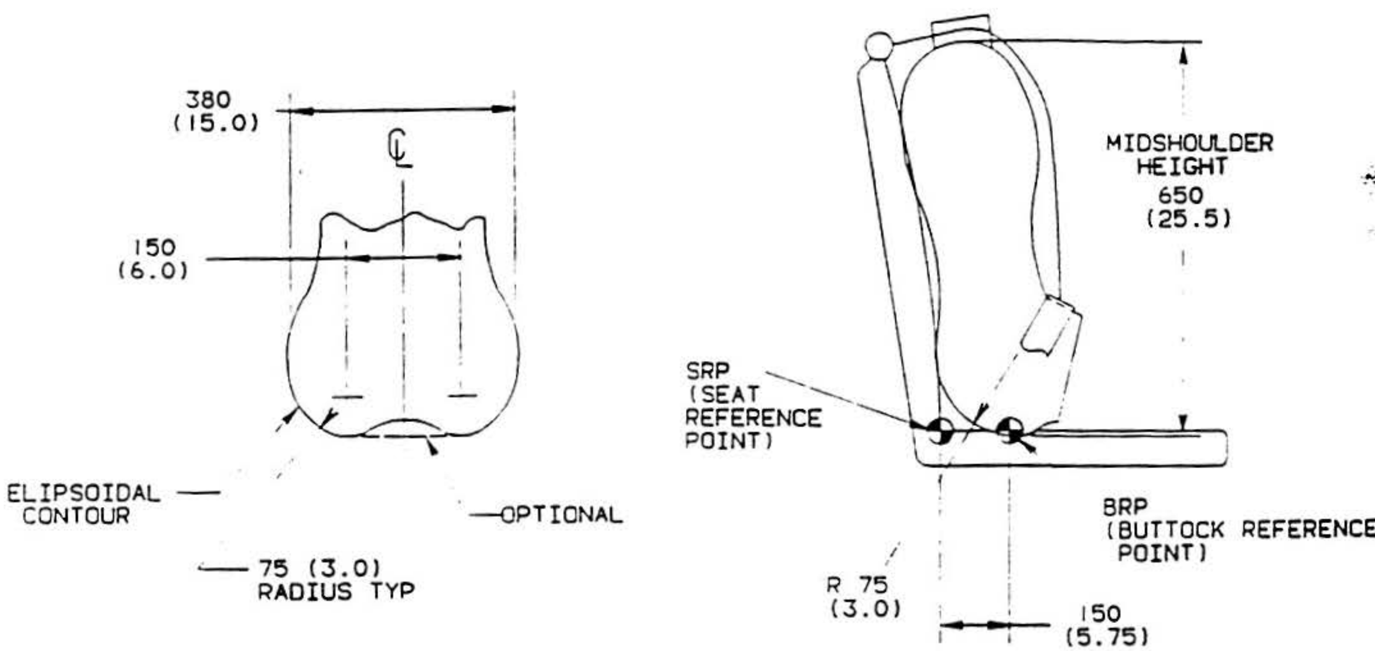


FIGURE 3 - Optional Body Block for Static Testing

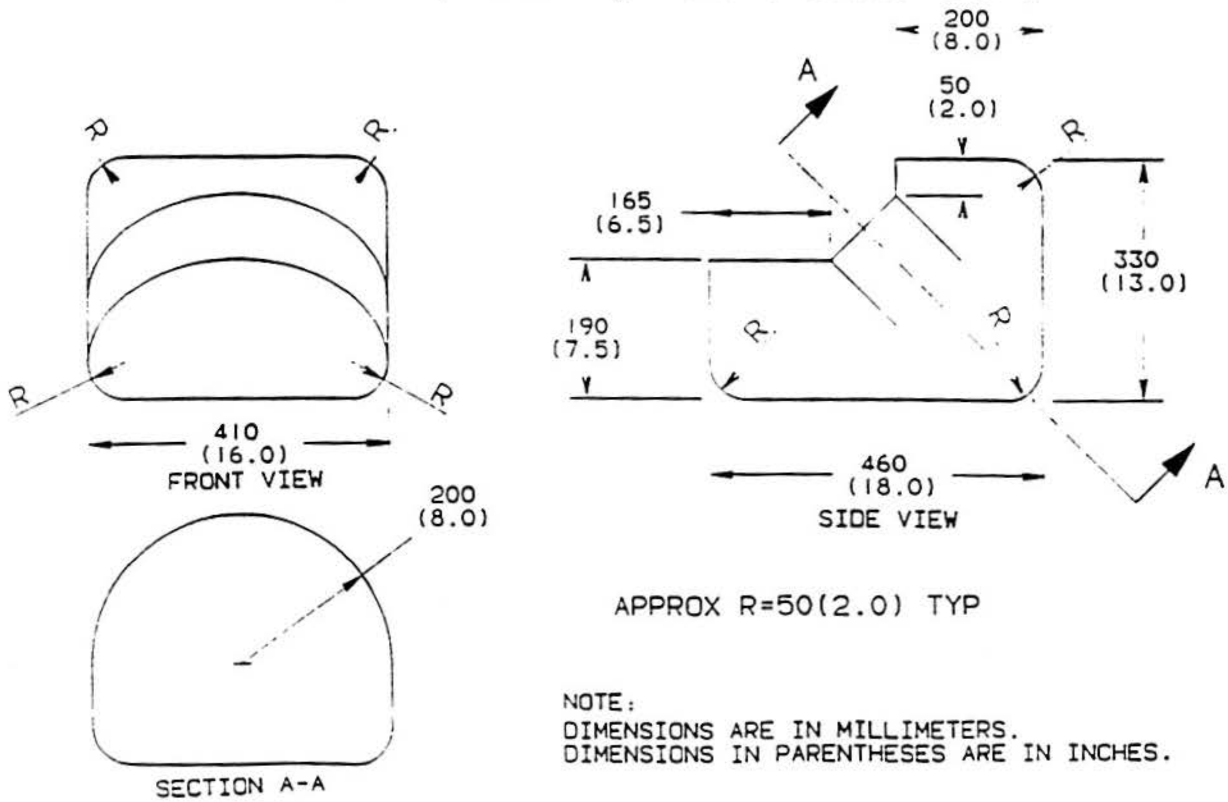
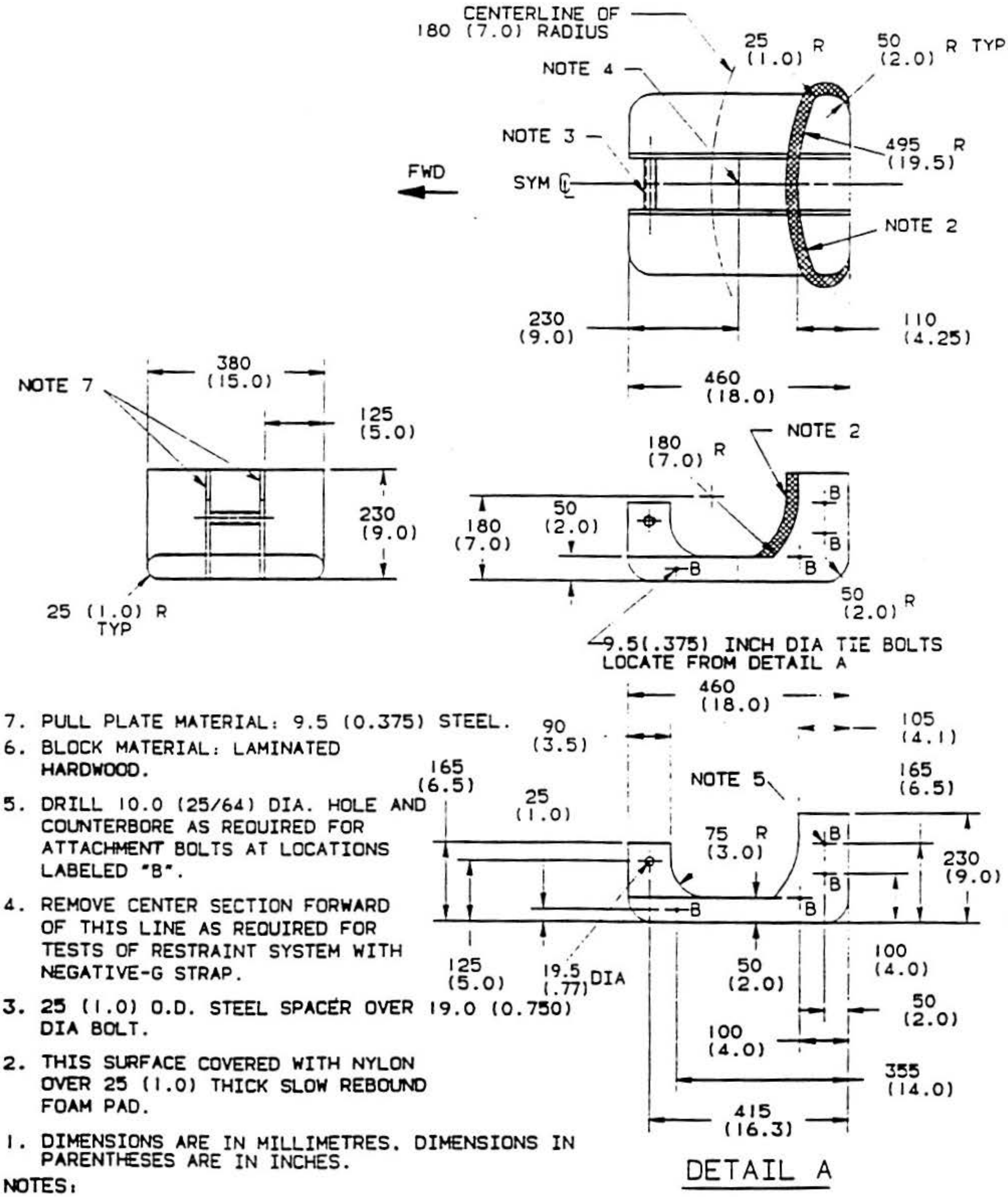


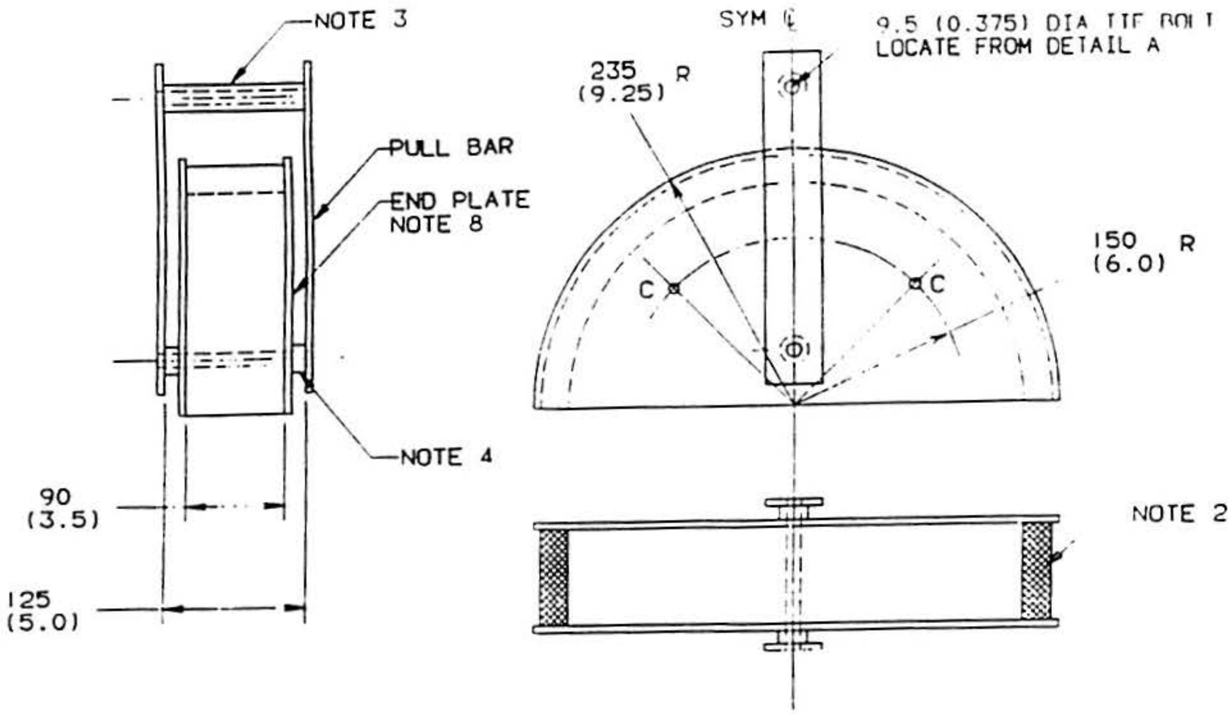
FIGURE 4 - Optional Body Block for Static Testing

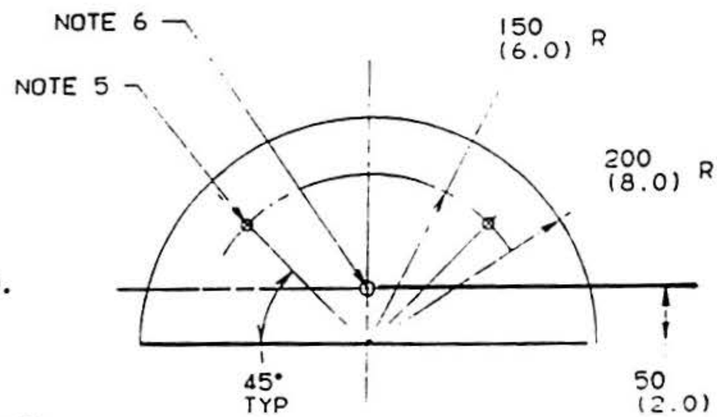


7. PULL PLATE MATERIAL: 9.5 (0.375) STEEL.
6. BLOCK MATERIAL: LAMINATED HARDWOOD.
5. DRILL 10.0 (25/64) DIA. HOLE AND COUNTERBORE AS REQUIRED FOR ATTACHMENT BOLTS AT LOCATIONS LABELED "B".
4. REMOVE CENTER SECTION FORWARD OF THIS LINE AS REQUIRED FOR TESTS OF RESTRAINT SYSTEM WITH NEGATIVE-G STRAP.
3. 25 (1.0) O.D. STEEL SPACER OVER 19.0 (0.750) DIA BOLT.
2. THIS SURFACE COVERED WITH NYLON OVER 25 (1.0) THICK SLOW REBOUND FOAM PAD.
1. DIMENSIONS ARE IN MILLIMETRES. DIMENSIONS IN PARENTHESES ARE IN INCHES.

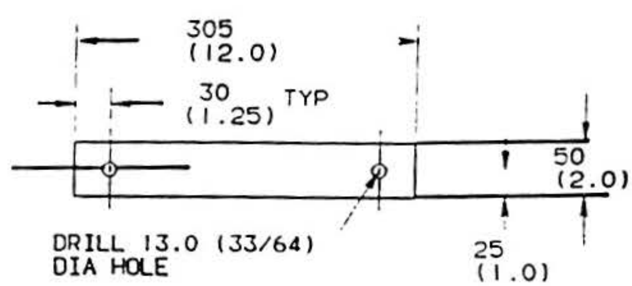
NOTES:

FIGURE 5A - Lower Torso Block





DETAIL A -CORE



DETAIL B -PULL BAR (NOTE 8)

8. END PLATE AND PULL BAR MATERIAL: 6.5 (0.25) STEEL.
7. CORE MATERIAL: LAMINATED HARDWOOD.
6. DRILL 13 (33/64) DIA. HOLE THRU END PLATE AND CORE.
5. DRILL 10 (25/64) DIA. HOLE AT LOCATIONS LABELED "C" THRU END PLATE AND CORE.
4. 13.0 (0.50) LONG X 25 (1.0) O.D. STEEL SPACER (2 PLACES) OVER A 13.0 (0.50) DIA BOLT.
3. 127 (5.0) LONG X 25 (1.0) O.D. STEEL SPACER OVER A 12.5 (0.50) DIA BOLT.
2. THIS SURFACE COVERED WITH NYLON OVER 25 (1.0) THICK SLOW REBOUND FOAM PAD.
1. DIMENSIONS ARE IN MILLIMETERS. DIMENSIONS IN PARENTHESES ARE IN INCHES.

NOTES:

FIGURE 5B - Upper Torso Block

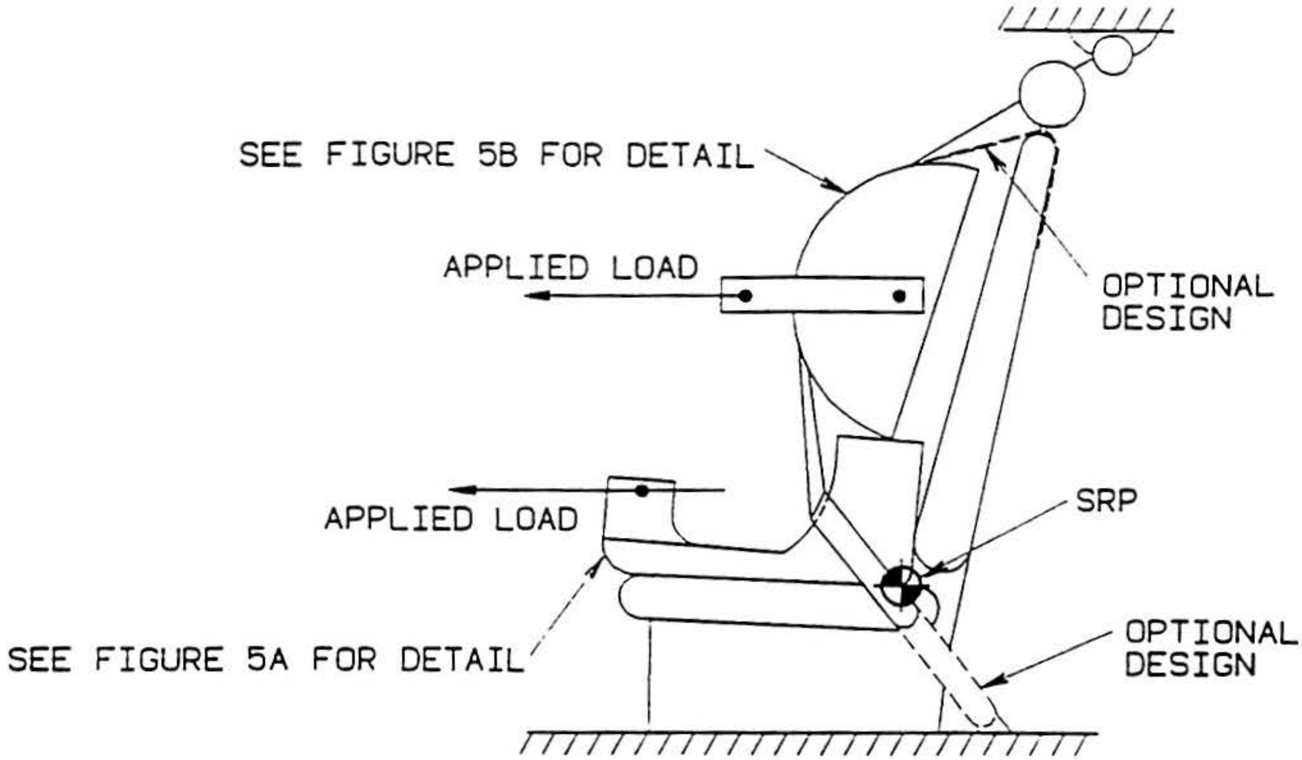


FIGURE 5C - Optional Combined Pelvic and Upper Torso Static Test

5.1.4 For forward or side loads, the body block shall be placed either on the actual bottom cushion or on a nonrigid foam block representative of the bottom cushion. For the side load, the back cushion or a nonrigid foam block representing the back cushion shall be in place.

5.1.5 Forward loads on seat backs of rearward-facing seats and rearward loads on seat backs of forward-facing seats shall be applied by a body block as shown in Figure 3, or by a rigid block with the same back dimensions. The back cushion or an equivalent nonrigid foam block shall be placed between the body block and the back structure to distribute the load over the seat back rather than just the rigid boundary structure.

5.1.6 Static resultant load application points are summarized in Table 3.

TABLE 3 - STATIC RESULTANT LOAD APPLICATION POINTS

Load	Forward-Facing Seat	Sideward-Facing Seat	Rearward-Facing Seat
Down	Evenly over seat bottom	Evenly over seat bottom	Evenly over seat bottom
Side	270 mm (10.5 in) up from SRP 215 mm (8.5 in) forward of SRP	270 mm (10.5 in) up from SRP	270 mm (10.5 in) up from SRP 215 mm (8.5 in) forward of SRP
Up	215 mm (8.5 in) forward of SRP	215 mm (8.5 in) forward of SRP	215 mm (8.5 in) forward of SRP
Forward	270 mm (10.5 in) up from SRP	270 mm (10.5 in) up from SRP 215 mm (8.5 in) forward of SRP	270 mm (10.5 in) up from SRP
Rearward	270 mm (10.5 in) up from SRP	270 mm (10.5 in) up from SRP 215 mm (8.5 in) forward of SRP	270 mm (10.5 in) up from SRP

5.1.7 Loads due to stowed articles under the seat or due to other stowage compartments that are part of the seat, and their contents, shall be applied simultaneously with the loads due to the occupant and the seat.

5.1.8 Devices used for indicating applied static loads shall be calibrated by comparison with known standard loads.

5.1.9 The load due to any item of mass, including the seat, that is not restrained by the occupant restraint system, may be applied in a representative manner at the c.g. of the mass.

5.1.10 If occupant restraint systems are not attached to the seat structure, the occupant restraint system shall be attached to the test fixture at points which are equivalent in location to those in the aircraft. The static loads shall then be applied as specified in this section.

5.1.11 When a seat is to be installed or adjusts to face in more than one direction, tests shall be made to substantiate the seat strength for all intended positions.

5.1.12 When testing a vertically or horizontally adjustable seat, the most critical seat position(s) shall be selected for each test condition.

5.1.13 The distribution of the forward static loads applied to a seat which uses upper torso restraint shall be 40% through the upper torso restraint and 60% through the pelvic restraint. Using the body block shown in Figure 3 or the optional test setup in Figure 5C may be acceptable.

5.1.14 When a seat incorporates pelvic and upper torso restraints, static testing or rational analysis shall be performed with only the pelvic restraint effective, as well as with both pelvic and upper torso restraints effective. In both cases the load application points shall be as specified in Table 3.

5.1.15 After each test load is removed, measurements of permanent deformation, if any, shall be recorded.

5.2 Static Test - Pass/Fail Criteria:

The static tests shall demonstrate the following:

5.2.1 The seat is capable of supporting the limit loads without detrimental permanent deformation. At any load up to limit loads, deformation may not interfere with safe operation.

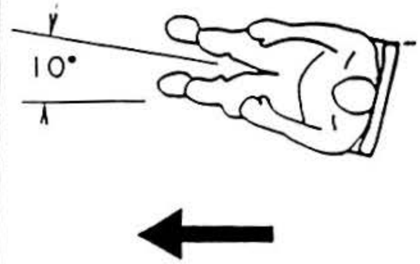
5.2.2 The seat structure must be able to support ultimate loads without failure for at least 3 s. If it can be shown that failure of an armrest on a seat assembly does not reduce the degree of safety afforded the occupant, such failure will not be cause for rejection.

5.2.3 After application and release of ultimate loads, as described in 5.2.2, the seat permanent deformation limitations of 3.5 and its subparagraphs are met.

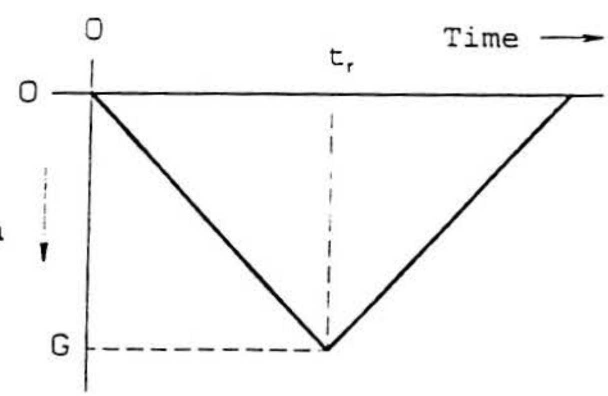
5.3 Dynamic Qualification Tests:

This section specifies the dynamic tests to satisfy the requirements of this AS.

5.3.1 Dynamic Impact Test Parameters: A minimum of two dynamic impact tests shall be performed. The test facility shall provide a means of constraining the movement of the test fixture to translational motion parallel to the arrow indicating the inertial load throughout the test (Figures 6 and 7).

	TEST 1	TEST 2
Illustration shows a forward-facing seat Inertial load shown by arrow		
Min V_i m/s (ft/s)	10.67 (35)	13.41 (44)
Max t_r s	0.08	0.09
Min G.	14	16
Deform floor:		
Degrees roll	0	10
Degrees pitch	0	10

Test Pulse Simulating Aircraft Floor Deceleration-Time History:



t_r = Rise time
V_i = Impact velocity

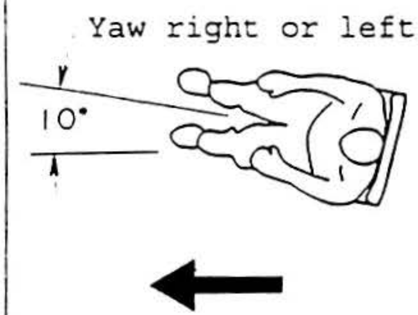
FIGURE 6. - Type A Seat/Restraint System Dynamic Tests

Illustration shows a forward-facing seat

Inertial load shown by arrow

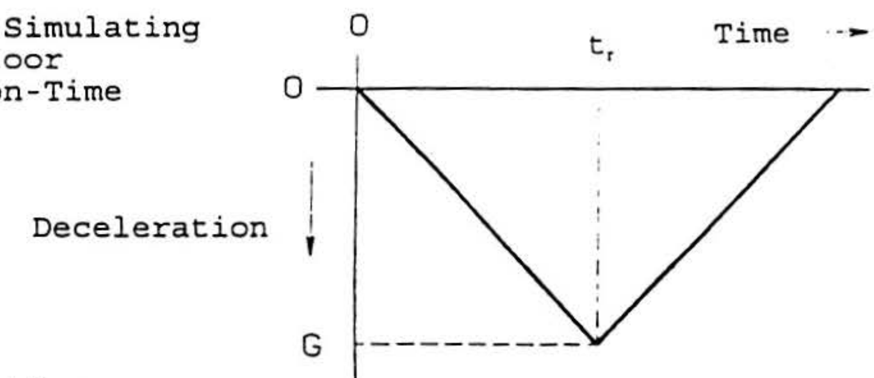
TEST 1

TEST 2



	TEST 1	TEST 2
Min V_i m/s (ft/s)	9.14 (30)	12.80 (42)
Max t_r s	0.031	0.071
Min G.	30	18.4
Deform floor:		
Degrees roll	10	10
Degrees pitch	10	10

Test Pulse Simulating Aircraft Floor Deceleration-Time History:



t_r = Rise time
V_i = Impact velocity

FIGURE 7 - Type B Seat/Restraint System Dynamic Tests

5.3.1.1 Test 1 (Figures 6 and 7), as a single row test, determines the performance of the system in a test condition where the predominant impact force component is along the spinal column of the occupant, in combination with a forward impact force component. This test evaluates the structural adequacy of the seat, critical pelvic/lumbar column forces, and permanent deformation of the structure under downward and forward combined impact loading and may yield data on Anthropomorphic Test Dummy (ATD) head displacement, velocity, and acceleration time histories.

5.3.1.2 Test 2 (Figures 6 and 7), as a single row seat test, determines the performance of a system in a test condition where the predominant impact force component is along the aircraft longitudinal axis and is combined with a lateral impact force component. This test evaluates the structural adequacy of the seat, permanent deformation of the structure, the pelvic restraint and upper torso restraint (if applicable) behavior and loads, and may yield data on ATD head displacement, velocity, and acceleration time histories and the seat leg loads imposed on the seat tracks or attachment fittings.

5.3.1.3 For seats placed in repetitive rows, an additional test condition, using seats in tandem placed at representative fore and aft distance between the seats (seat pitch), similar to Test 2 with or without the floor deformation directly evaluates head and femur injury criteria (the floor deformation is required if the test also demonstrates structural performance). These injury criteria are dependent on seat pitch, seat occupancy, and the effect of hard structures within the path of head excursions in the -10 to +10° yaw attitude range of the Test 2 conditions. The test procedure using the appropriate data obtained from Test 2 as described in 5.3.6.6 may be an alternative to multiple row testing.

5.3.1.4 Test 2 for Type A seats and Tests 1 and 2 for Type B seats require simulating aircraft floor deformation by deforming the test fixture, as prescribed in Figures 6 and 7, prior to applying the dynamic impact test conditions. The purpose of providing floor deformation for the test is to demonstrate that the seat/restraint system will remain attached to the airframe and perform properly even though the aircraft and/or seat are severely deformed by the forces associated with a crash.

5.3.2 Occupant Simulation: An ATD representing a 50th percentile male as defined in 49 CFR Part 572, Subpart B, or an equivalent shall be used to simulate each occupant. An equivalent ATD shall provide the same response to the test conditions of the AS as the specified ATD. The ATDs shall be calibrated and periodically inspected for proper function. Modification of these ATDs is necessary, as outlined in 5.3.2.1, to record the compressive load between the pelvis and the lumbar column of the ATD.

5.3.2.1 To measure the axial compressive load between the pelvis and lumbar column due to vertical impact as well as downward loads caused by upper torso restraints, a load (force) transducer shall be inserted into the ATD pelvis just below the lumbar column. This modification is shown in Figure 8. The illustration shows a commercially available femur load cell, with end plates removed, that has been adapted to measure the compression load between the pelvis and the lumbar column of the ATD.

A femur load cell is selected because of its availability in most test facilities and its ability to measure the compression forces without errors due to sensitivity to shear forces and bending or twisting moments which are also generated during the test. To maintain the correct seated height of the ATD the load cell must be fixed in a rigid cup which is inserted into a hole bored in the top surface of the ATD pelvis. The interior diameter of the cup provides clearance around the outside diameter of the load cell, so that loads are transmitted only through the ends of the cell. If necessary, ballast shall be added to the pelvis to maintain the weight of the original (unmodified) assembly.

Alternative approaches to measuring the axial force transmitted to the lumbar spinal column by the pelvis are acceptable if the method:

a. Accurately measures the axial force and is insensitive to moments and forces other than that being measured

b. Maintains the intended alignment of the spinal column and the pelvis, the correct seated height, and the correct weight distribution of the ATD

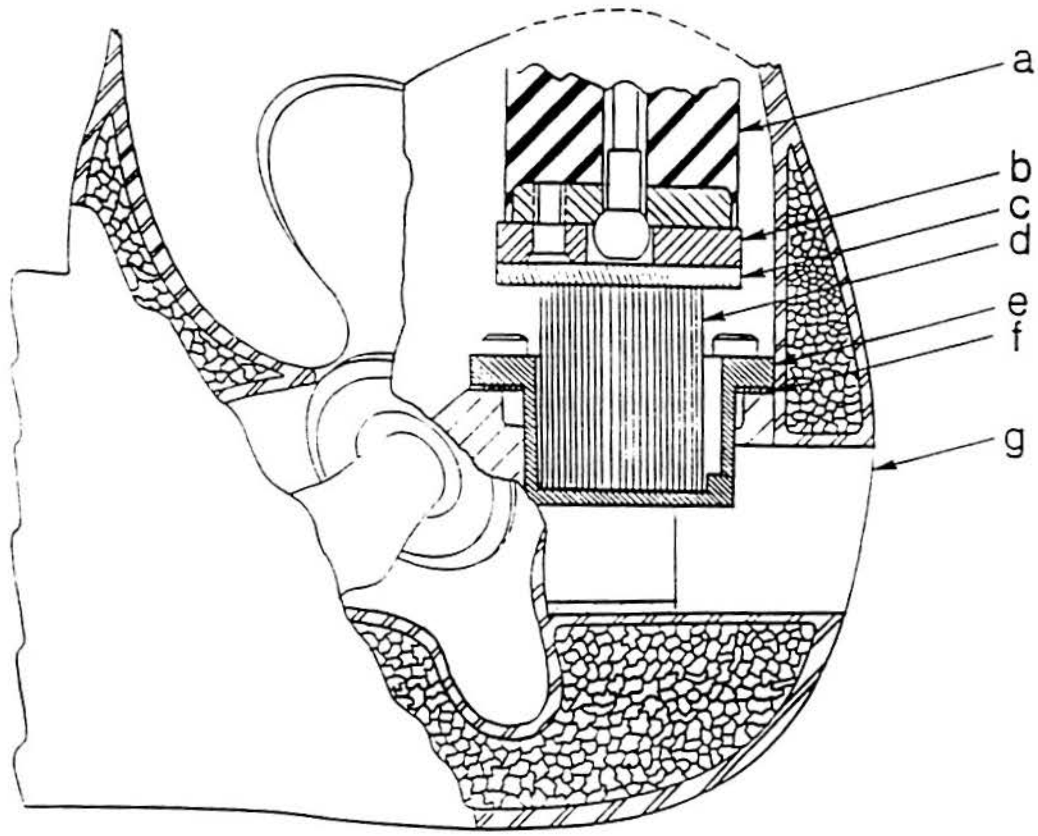
c. Does not alter the other performance characteristics of the ATD

5.3.2.2 To prevent failure of the clavicle used in Part 572 Subpart B ATDs due to flailing, a clavicle of the same shape but of higher strength material can be substituted.

5.3.2.3 Submarining indicators such as electronic transducers, may be added on the ATD pelvis. These are located on the anterior surface of the ilium of the ATD pelvis without altering its contour and indicate the position of the pelvic restraint as it applies loads to the pelvis. These indicators can provide a direct record that the pelvic restraint remains on the pelvis during the test, and eliminate the need for careful review of high-speed camera images to make that determination.

5.3.2.4 ATDs shall be maintained at a temperature range between 19 to 26 °C (66 to 78 °F) and at a relative humidity from 10 to 70% for a minimum of 4 h prior to and during testing.

5.3.2.5 Each ATD should be clothed in form-fitting cotton stretch garments and size 45 (11E) shoes weighing about 11 N (2.5 lb).



This illustration shows an acceptable adaptation of a femur load cell (d) at the base of the ATD lumbar spine (a). The load cell is in line with the centerline of the lumbar spine, and set below the top surface of the pelvis casting to maintain the seated height of the ATD. A rigid adapter cup (e) is fabricated to hold the load cell and a hole is bored in the ATD pelvis to accept the cup. Clearance must be provided between the walls of the adapter cup and the load cell for the wires leading from the cell. The bottom of the load cell is bolted to the adapter cup. Adapter plates having similar hole patterns in their periphery are fabricated for the lower surface of the lumbar spine (b) and the upper surface of the load cell (c). These plates are fastened to the lumbar spine and load cell with screws through holes matching threaded holes in those components, and are then joined together by bolts through the peripheral holes. The flange on the adapter cup has a bolt hole pattern which matches that on the pelvis. The cup is fastened to the pelvis using screws to the threaded holes in the pelvis. Spacers (f) may be placed under the flange of the cup to obtain the specified ATD seating height. Additional weight should be placed in the cavity below the adapter cup to compensate for any weight lost because of this modification. The instrument cavity plug (g) is cut to provide clearance for the adapter cup and added weight.

FIGURE 8 - Installation of Pelvic-Lumbar Spine Load Cell in Part 572B ATD

5.3.3 Test Fixtures: A test fixture is required to position the test article on the sled or drop carriage of the test facility and takes the place of the aircraft's floor structure. It does not need to simulate the aircraft floor flexibility. It holds the attachment fittings or floor tracks for the seat, and provides the floor deformation if needed for the test; it provides anchorage points if necessary for the restraint system; it provides floor or footrest for the ATD; and it positions instrument panels, bulkheads, or a second row of seats, if required.

5.3.3.1 Floor Deformation Fixtures: For the typical seat with four seat legs mounted in the aircraft on two parallel tracks, the floor deformation test fixture shall consist of two parallel beams: a pitch beam that pivots about a lateral (y) axis and a roll beam that pivots about a longitudinal (x) axis (see Figure 9A for a schematic representation). The beams can be made of any rigid structural form: box, I-beam, channel, or other appropriate cross section. The pitch beam shall be capable of rotating in the x-z plane up to $\pm 10°$ relative to the longitudinal (x) axis. The roll beam shall be capable of $\pm 10°$ roll about the centerline of floor tracks or fittings. A means shall be provided to fasten the beams in the deformed positions.

5.3.3.2 Load Transducer Installation: The pitch and roll beams shall have provisions for installing individual load transducers at each seat leg attachment point capable of measuring three reaction forces and, if necessary (see 5.3.3.3), three reaction moments. The load transducers shall have provisions to install floor track or other attachment fittings on their upper surface in a manner that does not alter the above-floor strength of the track or fitting.

5.3.3.3 Aircraft Floor Track or Attachment Fitting Simulation: An example of the minimum required representation of a floor track is shown in Figure 9A, detail A, for one type of seat track. The track or other attachment fittings must be representative of those used in the aircraft. Alternatively, three components of reaction forces and three components of reaction moments shall be measured during dynamic tests. These six components shall be applied simultaneously, by a separate static or dynamic test, to a track or attachment fitting used on an aircraft, or to a more critical track or attachment fitting than that used on an aircraft, to demonstrate that the loads measured in the dynamic impact test will not fail the track or attachment fitting used on an aircraft.

5.3.3.4 Seat Installation and Floor Deformation Procedure: The test seat shall be installed on the parallel beams of the deformation fixture so that the rear seat leg attachment point is near the pitch beam axis of rotation. The seat positioning pins or locks shall be fastened in the same manner as would be used in the aircraft, including the adjustment of antirattle mechanisms, if provided. The remainder of the test preparations shall then be completed (ATD installation and positioning, instrumentation installation, adjustment and calibration, camera checks, etc.).

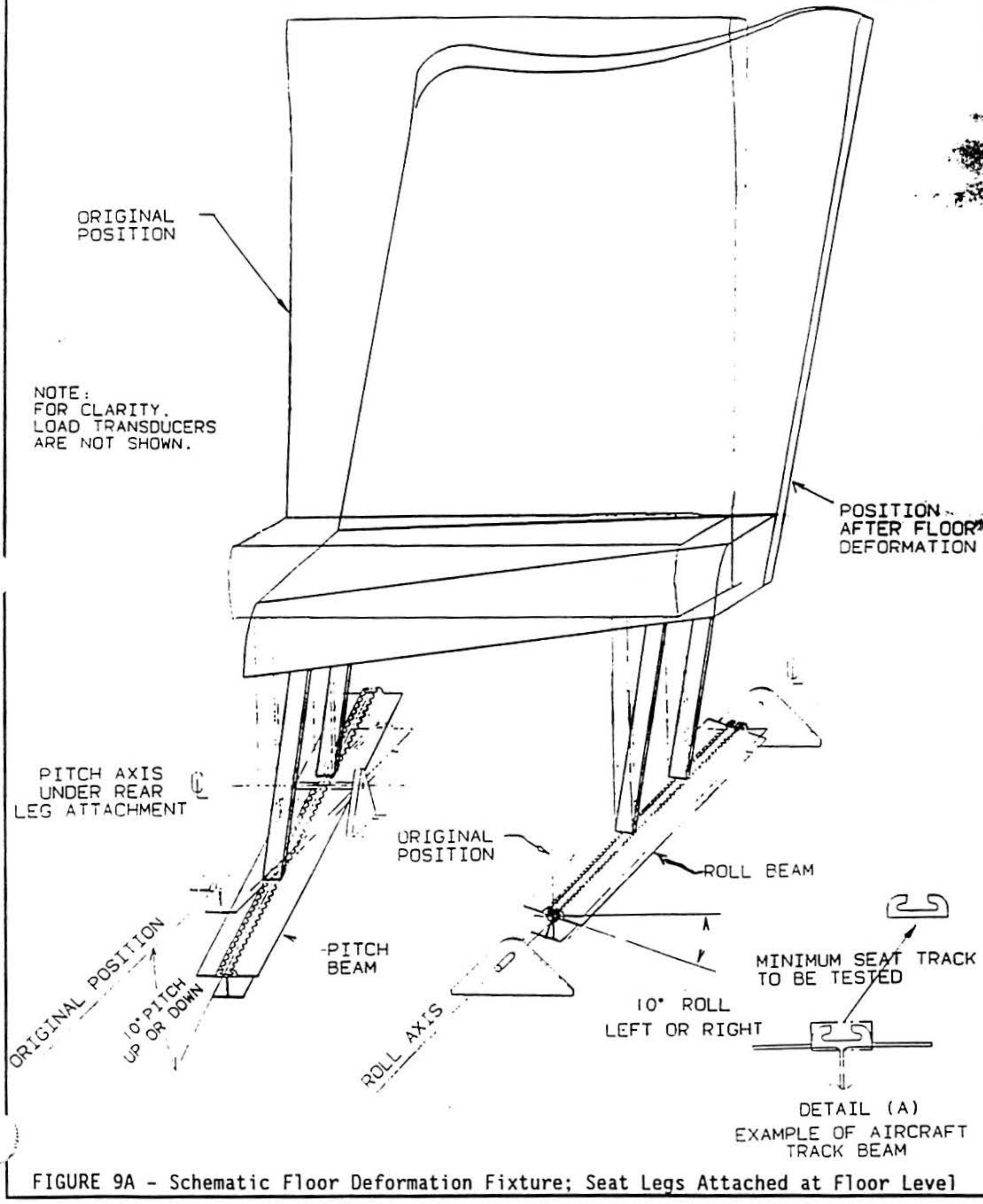


FIGURE 9A - Schematic Floor Deformation Fixture; Seat Legs Attached at Floor Level

5.3.3.4 (Continued):

The floor deformation shall be accomplished as the final action before the test. The roll beam shall be rotated 10° and locked in place, and then the pitch beam shall be rotated 10° and locked in place. Each direction of rotation shall be selected to produce the most critical loading condition on the seat and floor track or fitting.

5.3.3.5 Other Mounting Configuration Constraints: The preceding discussion described the fixture and floor deformation procedure that would be used for a typical seat that uses four seat legs (i.e., four attachments to the aircraft floor). These test procedures are not intended to be restricted only to those seat configurations, but shall be adapted to seats having other designs. Special test fixtures may be necessary for those different configurations.

The following methods, while not covering all possible seat designs, shall be followed for the more common alternatives:

a. Aircraft seats with three legs (i.e., three floor attachment points) may have one central leg in front or back of the seat, and one leg on each side of the seat. The central leg shall be held in its undeformed position as deformation is applied to the side legs.

b. Seats that mount solely to a bulkhead will not be subjected to deformation prior to the test. The test seat shall be attached to a rigid bulkhead or an actual bulkhead panel. If a test fixture with a rigid bulkhead is used, the seat/restraint system shall attach to fittings installed in a test panel equivalent to those in the actual installation.

c. Seats that are attached to both the floor and a bulkhead shall be tested on a fixture that positions the bulkhead surface in a plane through the axis of rotation of the pitch beam. The bulkhead surface shall be located perpendicular to the plane of the floor (the aircraft floor surface, if one were present) in the undeformed condition, or in a manner appropriate to the intended installation. Either a rigid bulkhead simulation or an actual bulkhead panel can be used. If a test fixture with a rigid bulkhead simulation is used, the seat restraint system shall attach to fittings installed in a test panel equivalent to those used in the actual installation. The seat shall be attached to the bulkhead and the floor in a manner representative of the aircraft installation, and the floor shall then be deformed as described in 5.3.3.4.

d. Seats that are mounted between sidewalls or to the sidewall and floor of an aircraft shall be tested in a special test fixture to simulate aircraft fuselage cross-section deformation during a severe crash as follows: Brackets shall be provided to attach the seat to the test fixture at the same level above the fixture floor representing the installation above the aircraft floor.

5.3.3.5 (Continued):

A sidewall bracket shall be located on the roll beam. Then the beams shall be rotated to produce the most critical loading condition (sidewall rotates outward), resulting in the combined angular and translational deformation as shown in Figure 9B.

e. Seats that are cantilevered from one sidewall without connection to other structure are not subject to floor deformation. A determination shall be made whether sidewall deformations could be expected which could generate a condition critical for seat performance in a crash. If sidewall deformation is likely, the entire sidewall attachment plane, or the attachment points, shall be deformed in a manner to represent the sidewall deformation. Either a rigid sidewall simulation or an actual sidewall panel may be used. If a test fixture with a rigid sidewall simulation is used, the seat/restraint system shall be attached to fittings installed in a test panel equivalent to those used in the actual installation.

5.3.3.6 Multiple Row Test Fixtures: In tests of passenger seats that are normally installed in repetitive rows in the aircraft, head and knee impact conditions are best evaluated through tests that use at least two rows of seats. These conditions are usually critical only in Test 2. This test allows direct measurements of the head and femur injury data.

a. The fixture shall be capable of setting the aircraft longitudinal axis at a yaw angle of -10 and +10°. The fixture should also allow adjustment of the seat pitch.

b. To allow direct measurement of head acceleration for head injury assessment for a seat installation where the head of the occupant is within striking distance of structure, a representative impact surface may be attached to the test fixture in front of the front row seat at the orientation and distance from the seat representing the aircraft installation.

5.3.3.7 Other Fixture Applications: Test fixtures shall provide a flat foot rest for ATDs used in tests of passenger seats and crewmember seats that are not provided with special foot rests or foot operated aircraft controls. The surface of the foot rest shall be covered with carpet (or other appropriate material) and be at a position representative of the undeformed floor in the aircraft installation. Test fixtures used for evaluating crew seats that are normally associated with special foot rests or foot operated controls shall simulate those components. Test fixtures may also be required to provide guides or anchors for restraint systems or for holding instrument panels or bulkheads if necessary for the planned tests. If these provisions are required, the installation shall represent the configuration of the aircraft installation and be of adequate structural strength.

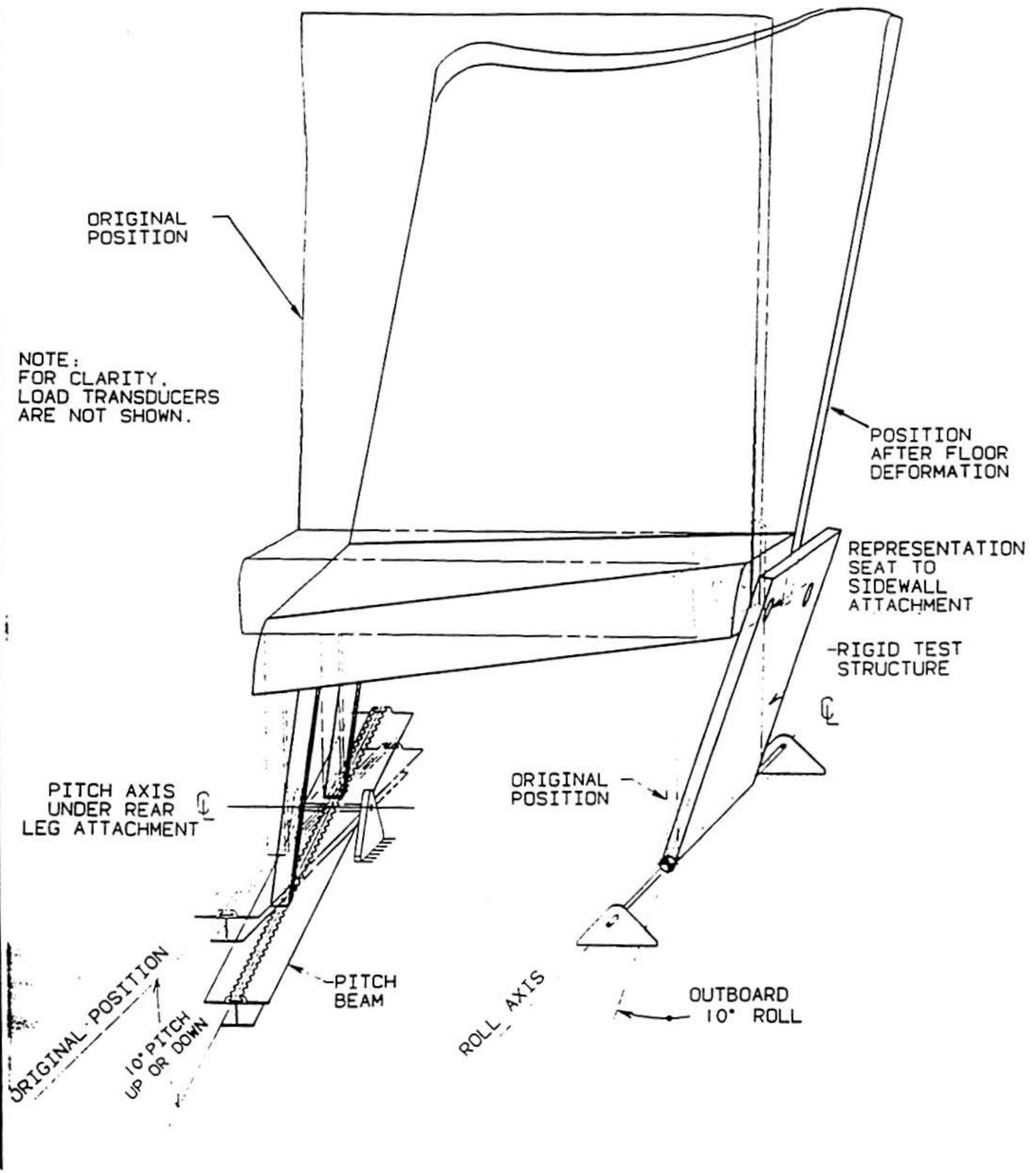


FIGURE 9B - Schematic Test Fixture; Side Wall Mounted Seat

5.3.4 Instrumentation: Electronic and photographic instrumentation systems shall be used to record data for qualification of seats. Electronic instrumentation shall measure the test environment, and measure and record data required for comparison of performance to pass/fail criteria.

Photographic instrumentation shall document overall results of tests, confirming that the pelvic restraint remains on the ATD's pelvis, that the upper torso restraint straps remain on the ATD's shoulder during impact and documenting that the seat does not deform as a result of the test in a manner that would impede rapid evacuation of the aircraft by the occupants and that the seat remains attached to the floor.

5.3.4.1 Electronic Instrumentation: Electronic instrumentation shall be accomplished in accordance with SAE J211. In this practice, a data channel is considered to include all of the instrumentation components from the transducer through the final data measurement, including connecting cables and any analytical procedures that could alter the magnitude or frequency content of the data. Each dynamic data channel is assigned a nominal channel class that is equivalent to the high frequency limit for that channel, based on a constant output/input ratio versus frequency response plot which begins at 0.1 Hz (+1/2 to -1/2 dB) and extends to the high frequency limit (+1/2 to -1 dB). Frequency response characteristics beyond this high frequency limit are also specified. When digitizing data, the sample rate should be at least five times the -3 dB cutoff frequency of the presample analog filters. Since most facilities set all presample analog filters for Channel Class 1000, and since the -3 dB cutoff frequency for channel class 1000 is 1650 Hz, the minimum digital sampling rate would be about 8000 samples per second. For the dynamic tests discussed in this AS, the dynamic data channels shall comply with the following channel class characteristics:

a. Sled or drop tower vehicle acceleration shall be measured in accordance with the requirements of Channel Class 60, unless the acceleration is also integrated to obtain velocity or displacement, in which case it shall be measured in accordance with Channel Class 180 requirements.

b. Belt-restraint system and seat attachment reaction loads shall be measured in accordance with the requirements of Channel Class 60.

c. ATD head accelerations used for calculating the Head Injury Criterion (HIC) shall be measured in accordance with the requirements of Channel Class 1000.

d. ATD femur forces shall be measured in accordance with Channel Class 600.

e. ATD pelvic/lumbar column force shall be measured in accordance with the requirements of Channel Class 600.

5.3.4.1 (Continued):

f. The full scale calibration range for each channel shall provide sufficient dynamic range for the data being measured.

g. Digital conversion of analog data shall provide sample resolution of not less than 1% of full scale input.

5.3.4.2 Photographic Instrumentation: Photographic instrumentation shall be used for documenting the response of the ATDs and the test items to the dynamic test environment. Both high speed and still image systems should be used.

a. High speed cameras that provide data used to calculate displacement or velocity shall operate at a minimum nominal speed of 500 frames per second. Photo instrumentation methods shall not be used for measurement of acceleration. The locations of the cameras and of targets or targeted measuring points within the field of view shall be measured and documented. Targets shall be at least 1/100 of the field width covered by the camera and shall be of contrasting colors or shall contrast with their background. The center of the target shall be easily discernible. Rectilinearity of the image shall be documented. If the image is not rectilinear, appropriate correction factors shall be used in the data analysis process.

   A description of photographic calibration boards or scales within the camera field of view, the camera lens focal length, and the make and model of each camera and lens shall be documented for each test. Appropriate digital or serial timing shall be provided on the image media. A description of the timing signal, the offset of timing signal to the image, and the means of correlating the time of the image with the time of electronic data shall be provided. A rigorous, verified analytical procedure shall be used for data analysis.

b. Cameras operating at a nominal rate of 200 frames per second or greater may be used to document the response of ATDs and test items if measurements are not required. For example, actions such as movement of the pelvic restraint system webbing off of the ATD's pelvis can be observed by documentation cameras placed to obtain a "best view" of the anticipated event. These cameras shall be provided with appropriate timing and a means of correlating the image with the time of electronic data.

5.3.4.2 (Continued):

c. Still image cameras shall be used to document the pretest installation and the posttest response of the ATDs and the test items. At least four pictures shall be obtained from different positions around the test items in pretest and posttest conditions. Where an upper torso restraint system is installed, posttest pictures shall be obtained before moving the ATD. For additional posttest pictures, the ATD's upper torso may be rotated to its approximate upright seated position so that the condition of the restraint systems may be better documented, but no other change to the posttest response of the test item or the ATD shall be made. The pictures shall document that the seat remained attached at all points of attachment to the test fixture.

Still pictures may also be used to document posttest yielding of the seat for the purpose of showing that it would not impede the rapid evacuation of the aircraft occupants. The ATD should be removed from the seat in preparation for still pictures used for that purpose. Targets or an appropriate target grid should be included in such pictures, and the views should be selected so that potential interference with the evacuation process can be determined. For tests where the ATD's head impacts a fixture or another seat back, pictures shall be taken to document the head contact areas.

5.3.5 Selection of Test Articles: Many seat designs compose a family of seats that have the same basic structural design but differ in detail. For example, a basic seat frame configuration can allow for several different seat leg locations to permit installation in different aircraft. If these differences are of a nature that their effect can be determined by rational analysis, then the analysis can determine the most critical configuration. As a minimum, the most highly stressed configuration shall be selected for the dynamic tests so that the other configurations could be accepted by comparison with that configuration.

5.3.5.1 In all cases, the test article must be representative of the final production article in all structural elements, and shall include the seat, seat cushions, restraints and armrests. It must also include a functioning position adjustment mechanism and correctly adjusted breakover (if present). Food trays or any other service or accoutrement that are part of the seat design must be representative of the final production item if they influence seat stiffness or head impact. Otherwise they and any other items of mass that are carried on or positioned by the seat structure such as weights simulating luggage carried by luggage restraint bars [90 N (20 lb) per passenger place], fire extinguishers, survival equipment, emergency equipment etc. need only be representative masses. If these items of mass are placed in a position that could limit the function of an energy absorbing feature in the test article, they should be of representative shape and stiffness as well as weight. Representative masses must be retained by the seat during the test. This AS does not establish operational requirements for equipment attached to the seat system.

5.3.5.2 The following additional items shall be considered in choosing test articles and the manner of loading:

a. If a multiple place seat incorporates energy absorbing or load limiting features that are necessary to meet the test criteria or other requirements, a partially occupied seat may adversely affect the performance of that seat. In such a case it shall be shown, by rational analysis or additional testing, that the seat will continue to perform as intended even with fewer occupants.

b. If different configurations of the same basic design incorporate load carrying members, especially joints or fasteners, that differ in detail design, the performance of each detail design shall be demonstrated in a dynamic test. Experience has shown that small details in the design often cause problems in meeting the test performance criteria.

c. Additional dynamic impact testing may be required for a seat with features that could affect its performance even though the test may not be the most critical case based on structural performance; e.g., if in one of the design configurations the restraint system attachment points are located so that the pelvic restraint is more likely to slip above the ATD's pelvis during the impact. That configuration shall also be dynamically tested even though the structural loading might be less than the critical configuration in a family of seats.

5.3.6 Selection of Test Conditions: The tests shall achieve the most critical conditions.

5.3.6.1 For multiple place seats, a rational structural analysis shall be used to determine the number and seat location for the ATDs and the direction for seat yaw in Test 2 to provide the most critical seat structural test. This will usually result in unequally loaded seat legs. The floor deformation procedure shall be selected to increase the load on the highest loaded seat leg and to load the floor track or fitting in the most severe manner.

5.3.6.2 If multiple row testing is used to gather data to assess head and femur injury protection in passenger seats, the seat pitch shall be selected so that the head would be most likely to contact a hard structure in the forward seat row. The effect of the 10° yaw in Test 2, the seat back breakover, and front seat occupancy shall be considered. Results from previous tests or rational analysis may be used to estimate the head strike path of similar seats in similar installations.

5.3.6.3 If nonsymmetrical upper torso restraints (such as single diagonal shoulder belts) are used in a system, they shall be installed on the test fixture in a position representative of that in the aircraft and which would most likely allow the ATD to move out of the restraint. For example, in a forward-facing crew seat equipped with a single diagonal shoulder belt, the seat should be yawed in Test 2 in a direction such that the belt passes over the trailing shoulder.

5.3.6.4 If a seat has vertical or horizontal adjustments, it shall be tested in the position that produces the most critical loads on the seat structure (typically the highest vertical position). Only positions allowed for takeoff and landing need be considered. Seat adjustments that do not have a significant effect on structural loading (e.g., thigh support angle, lumbar support, armrest and headrest positions) shall be tested in the design positions for the 50th-percentile male occupant, unless special requirements dictate the positions allowed for takeoff and landing.

5.3.6.5 Floor deformation need not be considered in assessing the consequence of seat deformation relative to the possible impairment of rapid evacuation of the aircraft. After a test, the pitch and roll floor beams may be returned to their neutral positions and the necessary measurements made to determine possible impairment of the evacuation process.

5.3.6.6 In some cases, it may not be possible to measure data for head impact injury during the basic test of the seat and restraint system. The design of the surrounding interior may not be known to the designer of the seat system, or the system may be used in several applications with different interior configurations. In such cases, the head strike path and the head velocity along the path shall be documented. This will require careful placement of photo instrumentation cameras and location of targets on the ATD representing the ATD's head center of mass so that the necessary data can be obtained. These data can be used by the interior designer to ensure either that head impact with the interior will not take place or that, should any unavoidable head impacts occur, they can be evaluated using HIC measurements in subsequent subsystem tests.

5.3.7 Installation of Instrumentation: Professional practice shall be followed when installing instrumentation. Care shall be taken when installing the transducers to prevent deformation of the transducer body which could cause errors in data. Lead-wires shall be routed to avoid entanglement with the ATD or test article, and sufficient slack shall be provided to allow motion of the ATD or test article without breaking the lead-wires or disconnecting the transducer. Calibration procedures shall consider the effect of long transducer lead-wires. Head accelerometers and femur load cells shall be installed in the ATD in accordance with the ATD specification and the instructions of the transducer manufacturer. The load cell between the pelvis and the lumbar column shall be installed either in accordance with the approach shown in Figure 8 of this AS or in a manner that will provide equivalent data (5.3.2.1).

5.3.7.1 If an upper torso restraint is used, the tension load shall be measured in a segment of webbing between the ATD shoulders and the first contact of the webbing with hard structure (the anchor point or a webbing guide). Restraint webbing shall not be cut to insert a load cell in series with the webbing, since that will change the characteristics of the restraint system. Load cells that can be placed over the webbing without cutting are commercially available. They shall be placed on free webbing to minimize contact with hard structure, seat upholstery, or the ATD during

5.3.7.1 (Continued):

the test. They shall not be used on double-reeved webbing, multiple-layered webbing, locally stitched webbing, or folded webbing unless it can be demonstrated that these conditions do not cause errors in the data. These load cells shall be calibrated using a length of webbing of the type used in the restraint system. If the placement of the load cell on the webbing causes the restraint system to sag, the weight of the load cell can be supported by light string or tape that will break away during the test.

5.3.7.2 Since load cells are sensitive to the inertial forces of their own internal mass, to the mass of fixtures located between them and the test article, as well as to forces applied by the test article, it may be necessary to compensate the test data for that inaccuracy if the error is significant. Data for such compensation will usually be obtained from an additional dynamic test that replicates the load cell installation but does not include the test article.

5.3.8 Procedure to Set Up the Test:

5.3.8.1 The test fixture shall be oriented as required for the given test conditions.

5.3.8.2 Each seat shall be installed in the test fixture and secured in a manner representative of its intended use.

5.3.8.3 Each ATD shall be placed in the seat in a uniform manner to enhance reproducible results. The following suggested procedures have been found to be adequate by previous experience.

a. The friction in a limb joint shall be set so that it barely restrains the weight of the limb when extended horizontally.

b. The ATD should be placed in the center of the seat, in as nearly a symmetrical position as possible.

c. The ATD's back should be against the seat back without clearance. This condition can be achieved if the ATD legs are lifted as it is lowered into the seat. Then, the ATD is pushed back into the seat back as it is lowered the last few inches into the seat pan. Once all lifting devices have been removed from the ATD, it should be rocked slightly to settle it in the seat.

d. The ATD's knees should be separated approximately 100 mm (4 in).

e. The ATD's hands should be placed on the top of its upper legs, just behind the knees. If tests on crew seats are conducted in a mockup that has aircraft controls, the ATD's hands should be lightly tied to the controls.

5.3.8.3 (Continued):

f. All seat adjustments and controls shall be set as indicated in 5.3.6.4. If a seat has special requirements dictating its position, adjustment, orientation, etc. for take-off or landing, the test seat shall represent those conditions.

g. The feet shall be in the appropriate position for the type and usage of a seat being tested (flat on the floor, on control pedals or on a 45° footrest for flightcrew systems). The feet shall be placed so that the centerlines of the lower legs are approximately parallel, unless the need for placing the feet on aircraft controls dictates otherwise.

5.3.8.4 For tests where the ATD's head is expected to impact a fixture or another seat back, the head and face of the ATD may be treated with a suitable material to mark head contact areas. The material used must not reduce the resulting HIC values.

5.3.8.5 The restraint system adjustment shall be made as follows. The restraint system shall not be tightened beyond the level that could reasonably be expected in use and the emergency locking device (inertia reel) shall not be locked prior to the impact. Automatic locking retractors shall be allowed to perform the webbing retraction and automatic locking function without assistance. Care shall be taken that emergency locking retractors which are sensitive to acceleration do not lock prior to the impact test because of preimpact acceleration applied by the test facility. If comfort zone retractors are used, they shall be adjusted in accordance with instructions given to the user of the restraint system.

If manual adjustment of the restraint system is required, slack shall be removed but the restraint system shall not be adjusted so that it is unduly tight. The webbing force applied to manually adjusted upper torso restraint shall be just sufficient to remove slack. Preload in the restraint system shall be checked and adjusted just prior to the floor deformation phase of the test.

If the system is tested in other than a "horizontal floor" position: the restraint should be properly adjusted with the seat in the "horizontal floor" position and with webbing transducers installed (if required); the webbing marked to indicate the correct adjustment point; and the restraint again adjusted to that same point when the system and ATD are installed in the appropriate dynamic test orientation.

5.3.8.6 Floor deformations, if applicable, shall be applied with the load measuring instrumentation functioning so as to record the imposed loads at attachment points.

5.3.9 Data Analysis:

5.3.9.1 General: All data obtained in the dynamic tests should be reviewed for errors. Baseline drift, ringing, and other common electronic instrumentation problems should be detected and corrected before the tests. Loss of data during the test is readily observed in a plot of the data versus time and is typically indicated by sharp discontinuities in the data, often exceeding the amplitude limits of the data collection system. If these occur early in the test in essential data channels, the data should be rejected and the test repeated. If they occur late in the test, after the maximum data in each channel has been recorded, the validity of the data should be carefully evaluated, but the maximum values of the data may still be acceptable for the tests described in this AS. The HIC does not represent simply a maximum data value, but represents an integration of data over a varying time base. The head acceleration measurements used for that computation are not acceptable if errors or loss of data are apparent in the data at any time from the beginning of the test until the ATD and all test articles are at rest after the test.

5.3.9.2 Impact Pulse Shape. Data for evaluating the impact pulse shape is obtained from an accelerometer that measures the acceleration in the direction parallel to the inertial response shown in Figures 6 and 7 of this AS. The impact pulses intended for the tests discussed in this AS have an isosceles triangle shape. These ideal pulses are considered minimum test conditions. Since the actual acquired test pulses will differ from the ideal, it is necessary to evaluate the acquired test pulses to insure the minimum requirements are satisfied.

Five properties of the ideal pulse which must be satisfied by the acquired test pulse are (referring to Figures 6 and 7):

Pulse shape: isosceles triangle
Greq: peak deceleration required by test condition
Treq: rise time required by test condition
V: total velocity change required by test condition
Vtr: velocity change required during Treq. (Vtr = V/2)

A graphical technique can be used to evaluate pulse shapes which are not precise isosceles triangles. Appendix A presents the graphical method of evaluating the acquired pulse, the recorded test sled acceleration versus time.

For the acquired pulse to be acceptable, the following five criteria must be met:

a. The magnitude of the peak value for the acquired pulse, Gpk, must be greater than or equal to Greq.

b. The actual rise time, Tr = $T_2 - T_1$, must be less than or equal to Treq.

5.3.9.2 (Continued):

c. The result of integrating the acquired pulse during the interval from $t = T_1$ to $t = T_3$ must be equal to or greater than Vtr, one-half of the required velocity change for the specified test. If the magnitude of the acquired pulse is greater than the ideal pulse during entire interval from T_1 to T_3, this requirement is automatically met.

d. The result of integrating the acquired pulse during the interval from $t = T_1$ to $t = T_1 + 2.3(Treq)$ must equal or exceed the required test velocity change, V, of the test condition. If the acquired pulse returns to zero G's at $t = T_4 < (T_1 + 2.3(Treq))$, the end of the interval of integration is reduced to $t = T_4$.

e. If the magnitude of the acquired pulse is greater than the ideal pulse during the entire interval of $t = T_1$ to T_2, and the parameters of (a), (b), (c), and (d) above are satisfied, then the acquired pulse is acceptable.

If the magnitude of the acquired pulse is not greater than the ideal pulse during the entire interval $t = T_1$ to T_2, the difference between acquired pulse and the ideal must be no greater than 2.0 G's at those times when the acquired pulse is less than the ideal. Parameters of (a), (b), and (c) above must also be satisfied for the acquired pulse to be acceptable.

5.3.9.3 Head Injury Criterion (HIC): Data for determining the HIC need be collected during the tests discussed in this AS only if the ATD's head is exposed to impact in a particular aircraft installation. The HIC is calculated according to the following equation:

$$HIC = \left[(t_2 - t_1)\left[(1/(t_2 - t_1))\int_{t_1}^{t_2} a(t)\,dt\right]^{2.5}\right]_{MAX} \quad \text{(Eq. 1)}$$

where:

t_1, t_2 = Any two points in time during the head impact, in seconds
$a(t)$ = The resultant head acceleration during the head impact, in multiples of g's

The HIC is a method for defining an acceptable limit; i.e., the maximum value of the HIC shall not exceed 1000. The HIC is calculated by computer based data analysis systems. The discussion that follows outlines the basic method for computing the HIC, but manual attempts to use this method with real data are likely to be tedious. The HIC is based on data obtained from three mutually perpendicular accelerometers installed in the head of the ATD in accordance with the ATD specification.

5.3.9.3 (Continued):

For the tests discussed in this AS, only data taken during head impact with the aircraft interior need be considered. Head impact is often indicated in the data by a rapid change in the magnitude of the acceleration. Alternatively, film of the test may show head impact that can be correlated with the acceleration data by using the time base common to both electronic and photographic instrumentation to define the initial contact time.

The magnitude of the resultant acceleration vector obtained from the three accelerometers is plotted against time. Then, beginning at or just prior to the time of initial head contact (t_1), the average value of the resultant acceleration is found for each increasing increment of time (t_2-t_1) by integrating the curve between t_1 and t_2 and then dividing the integral value by the time (t_2-t_1). This calculation shall use all data points provided by the minimum 8000 samples per second digital sampling rate for the integration. However, the maximizing time intervals need be no more precise than 0.001 s. The average values are then raised to the 2.5 power and multiplied by the corresponding increment of time (t_2-t_1).

This procedure is then repeated, increasing t_1 by 0.001 s for each repetition. The maximum value of the set of computations that is obtained from this procedure is the HIC. The procedure may be simplified by noting that the maximum value will only occur in intervals where the resultant magnitude of acceleration at t_1 is equal to the resultant magnitude of acceleration at t_2, and when the average resultant acceleration in that interval is equal to 5/3 times the acceleration at t_1 or t_2. The HIC is usually reported as the maximum value, and the time interval during which the maximum value occurs is also given.

5.3.9.4 Total Velocity Change: Impact velocity can be obtained by measurement of a time interval and a corresponding sled displacement that occurs just before or after (if appropriate) the test impact and then dividing the displacement by the time interval. When making such a computation, the possible errors of the time and displacement measurements shall be used to calculate a possible velocity measurement error, and the test impact velocity should exceed the velocity shown in Figure 6 or 7 by at least the velocity measurement error. If the sled is not changing velocity during the immediate preimpact or postimpact interval, the impact velocity is the total velocity change. If the sled is changing velocity during the immediate preimpact or postimpact interval or if the facility produces significant rebound of the sled, the total velocity change can be determined by integrating the plot of sled acceleration versus time as described in Appendix A. If this method is used, the sled acceleration shall be measured in accordance with Channel Class 180 requirements.

5.3.9.5 Upper Torso Restraint System Load: The maximum load in the upper torso restraint system webbing can be obtained directly from a plot or listing of webbing load transducer output. If a three-axis load transducer, fixed to the test fixture, is used to obtain these data, the data from each axis shall be combined to provide the resultant vector magnitude. If necessary, corrections shall be made for the internal mass of the transducer and the fixture weight it supports. This correction will usually be necessary only when the inertial mass or fixture weight is high, or when the correction becomes critical to demonstrate that the measurements fall below the specified limits.

5.3.9.6 Compressive Load Between the Pelvis and Lumbar Column: The maximum compressive load between the pelvis and the lumbar column of the ATD can be obtained directly from a plot or listing of the output of the load transducer at that location. Since most load cells will indicate tension as well as compression, care should be taken that the polarity of the data has been correctly identified.

5.3.9.7 Retention of Upper Torso Restraint Straps: Retention of the upper torso restraint straps on the ATD's shoulders can be verified by observation of photometric or documentary camera coverage. The straps must remain on the ATD's shoulder until the ATD rebounds after the test impact and the upper torso restraint straps are no longer carrying any load. The straps must not bear on the neck or side of the head and must not slip to the upper rounded portion of the upper arm during that time period.

5.3.9.8 Retention of Pelvic Restraint: Retention of the pelvic restraint on the ATD's pelvis can be verified by observation of photometric or documentary camera coverage. The pelvic restraint shall remain on the ATD's pelvis, bearing on or below each prominence representing the anterior superior iliac spine, until the ATD rebounds after the test impact and the pelvic restraint becomes slack. If the pelvic restraint does not become slack throughout the test, the belt shall maintain the proper position throughout the test.

Movement of the pelvic restraint above the prominence is usually indicated by an abrupt displacement of the belt onto the ATD's soft abdominal insert which can be seen by careful observation of photo data from a camera located to provide a close view of the belt as it passes over the ATD's pelvis. This movement of the belt is sometimes indicated in measurements of pelvic restraint load (if such measurements are made) by a transient decrease or plateau in the belt force, as the belt slips over the prominence, followed by a gradual increase in belt force as the abdominal insert is loaded by the belt. Retention of the pelvic restraint can also be verified by submarining indicators located on the ATD's pelvis without changing its essential geometry (see 5.3.2.3).

5.3.9.9 Femur Load (Type A Seats): Data for measuring femur loads need to be collected in the tests discussed in this AS only if the ATD's legs contact seats or other structure. The maximum compressive load in the femur can be obtained directly from a plot or listing of each femur load transducer output.

If a seat/restraint system is installed in an aircraft in a manner that will expose the system to loads from an occupant seated behind the system as well as the occupant seated in the system, the tests discussed in this AS shall be conducted in a manner that will demonstrate that the system will perform properly under the combined loading. For example, Test 2 shall be conducted with at least two rows of seats in place, with femur loads measured in the legs of the ATDs in the second row as the seats in the first row carry the combined loads from the occupants in the first row and the second row.

5.3.9.10 Seat Attachment: Documentation that the seat and occupant restraint system has remained attached at all points of attachment shall be provided by documentary still photographs that show the load path exists between the attachment points and the ATD.

5.3.9.11 Seat Deformation: The permanent deformations affecting aircraft evacuation shall be evaluated and documented.

The floor deformation fixture may be returned to the flat floor condition for documenting seat deformation. This documentation can take the form of dimensioned scale drawings that show the seat in its deformed condition relative to a reference origin, such as a floor track fitting which can be related to the aircraft interior. If the seat deformation is not critical, still photographs of the seat (with dimensional targets or grids in place so that measurements can be made) will provide adequate documentation. Any actions necessary for proper seat functions, such as stowage of the seat when the ATD is removed, shall be observed and documented.

5.3.9.12 Seat Attachment Reactions: Data of maximum loads imposed on the tracks or fittings at all the critical seat attachment points shall be collected and recorded. These data can be obtained directly from the output of the load cell at each attachment location.

5.3.10 Test Documentation:

5.3.10.1 General: The tests discussed in this AS shall be completed and reported in a documentation package that includes the procedure and results. In addition to the specific contents described in 5.3.10.2 and 5.3.10.3, the documentation shall include the following:

5.3.10.1.1 Facility Data:

a. The name and address of the test facility performing the tests.

b. The name and telephone number of the individual at the test facility responsible for conducting the tests.

c. A brief description and/or photograph of each test fixture.

d. The date of the last instrumentation system calibration and the name and telephone number of the person responsible for instrumentation system calibration.

e. A statement confirming that the data collection was done in accordance with the recommendations of this AS, or a detailed description of the actual calibration procedure used and technical analysis showing equivalence to the recommendations of this AS (see 5.3.4.1).

f. Manufacturer, governing specification, serial number, and test weight of ATDs used in the tests, and a description of any modifications or repairs performed on the ATDs that could cause them to deviate from the specification.

g. A description of the photographic-instrumentation system used in the tests (see 5.3.4.2).

5.3.10.1.2 Seat/Restraint System Data:

a. Manufacturer's name and identifying model numbers of the seat/restraint system used in the tests, with a brief description of the system, including identification and a functional description of all major components and photographs or drawings as applicable.

b. For a system that is not symmetrical, an analysis supporting the selection of critical conditions used in the tests.

5.3.10.2 Test Description: The description of the test shall be documented in sufficient detail so that the test could be reproduced simply by following the guidance given in the report. The procedures outlined in this AS can be referenced in the report, and shall be supplemented by such details as are necessary to describe the unique conditions of the test. For example:

5.3.10.2.1 Pertinent dimensions and other details of the installation that are not included in the drawings of the test items shall be provided. This can include footrests, restraint system webbing guides, and restraint anchorages, interior surface simulations, bulkhead or sidewall attachments for seats or restraints, etc.

5.3.10.2.2 The floor deformation procedure, guided by goals of the most critical loading for the test articles, shall be documented.

5.3.10.2.3 Placement and characteristics of electronic and photographic instrumentation chosen for the test, beyond that information provided by the facility, shall be documented. This can include special targets, grids, or marking used for interpretation of photo documentation, and transducers and data-channel characteristics for restraint loads, floor reaction forces, or other measurements beyond those discussed in this AS.

5.3.10.2.4 Any unusual or unique activity or event pertinent to conducting the test shall be documented. This could include use of special break-away restraints or support for the ATDs, test articles or transducers; operational conditions or activities, such as delayed or aborted test procedures; and failures of test fixtures, instrumentation system components or ATDs.

5.3.10.3 Test Results: The documentation shall include copies of all test results, analysis and conclusions. The data shall include charts, listings, and/or tabulated results and copies of any photo/film/video instrumentation recordings used to support the results. As a minimum, the following shall be documented:

a. Impact pulse shape (see 5.3.9.2)

b. HIC results for all ATDs exposed to head impact with interior components of the aircraft (see 5.3.9.3) or head strike paths and velocities if head impact is likely but could not be evaluated by these tests (see 5.3.6.6)

c. Total velocity change (see 5.3.9.4)

d. Upper torso restraint system load, if applicable (see 5.3.9.5)

e. Compressive load between the pelvis and the lumbar column (see 5.3.9.6)

f. Retention of upper torso restraint straps, if applicable (see 5.3.9.7)

g. Retention of pelvic restraint (see 5.3.9.8)

h. Femur load, if applicable (see 5.3.9.9)

i. Seat attachment (see 5.3.9.10)

j. Seat deformation (see 5.3.9.11)

k. Seat system attachment reaction time histories (see 5.3.9.12)

5.4 Dynamic Impact Test Pass/Fail Criteria:

The dynamic impact tests shall demonstrate that:

5.4.1 The seat structure remains attached at all points of attachment and the load path remains between the attachment points and the ATD.

5.4.2 The occupant retention system is capable of carrying the dynamic loads.

5.4.3 The seat permanent deformations are within the quantitative limits of this AS and will not significantly impede an occupant from releasing his restraints, standing, and exiting the seat (see 3.5).

5.4.4 If the ATD's head is exposed to impact during the test, HIC of 1000 is not exceeded.

5.4.5 Where upper torso restraint straps are used, tension loads in individual straps do not exceed 7.78 kN (1750 lb). If dual straps are used for restraining the upper torso, the total strap tension load does not exceed 8.90 kN (2000 lb).

5.4.6 The maximum compressive load measured between the pelvis and the lumbar column of the ATD does not exceed 6.67 kN (1500 lb).

5.4.7 The upper torso restraint straps (where installed) remain on the ATD's shoulder during impact.

5.4.8 The pelvic restraint remains on the ATD's pelvis during impact.

5.4.9 Where leg contact with seats or other structure occurs, the axial compressive load in each femur does not exceed 10.0 kN (2250 lb). This requirement applies to Type A seats.

5.5 Markings:

Each seat shall be legibly and permanently marked with the following information:

a. Manufacturer's Name and Address
b. Seat Model Number or Name and Seat Part Number
c. Seat Facing Direction (e.g., forward, rearward, sideward, swivel)
d. Serial Number and/or Date of Manufacture
e. Aerospace Standard Number AS8049 (optional)
f. Maximum Static Load Factors (optional)

The marking shall be placed at a point on the structure which is easily inspectable and which will not be damaged by under-seat baggage or other expected usage.

APPENDIX A
PROCEDURE FOR EVALUATING PULSE SHAPES

A.1 This graphical procedure may be used to evaluate the impact pulse shape acquired from a test. While this procedure is based on graphical concepts, an accurate evaluation of the pulse parameters should be obtained using the digitized data and computer algorithms that provide the analysis illustrated in the following steps:

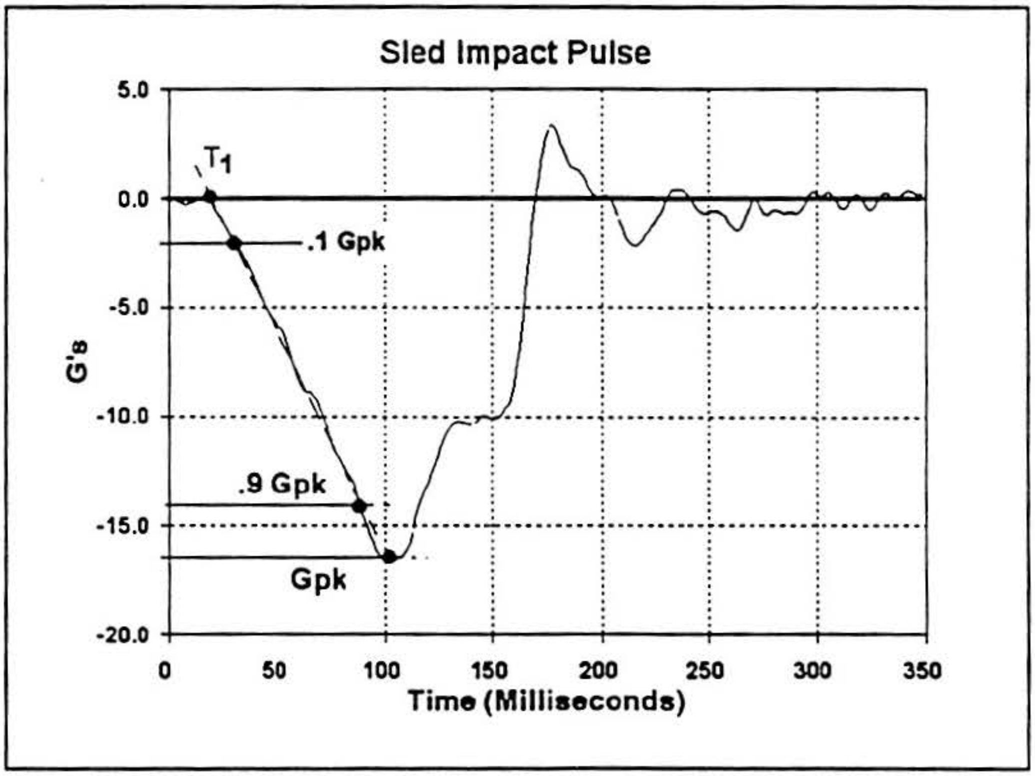


FIGURE A1

A.2 STEP 1:

On the plot of the acquired pulse, identify the peak deceleration point, Gpk, and points on the onset of the pulse equal to 0.1 Gpk and 0.9 Gpk. Construct an onset line through the points 0.1 Gpk and 0.9 Gpk. Extend the constructed onset line to the base line of the data plot, G = 0. Identify the intersection of the constructed onset line and baseline as the start of the acquired pulse, T_1. For the acquired pulse to be acceptable, the magnitude of Gpk must equal or exceed the minimum required pulse, Greq for the specified test condition.

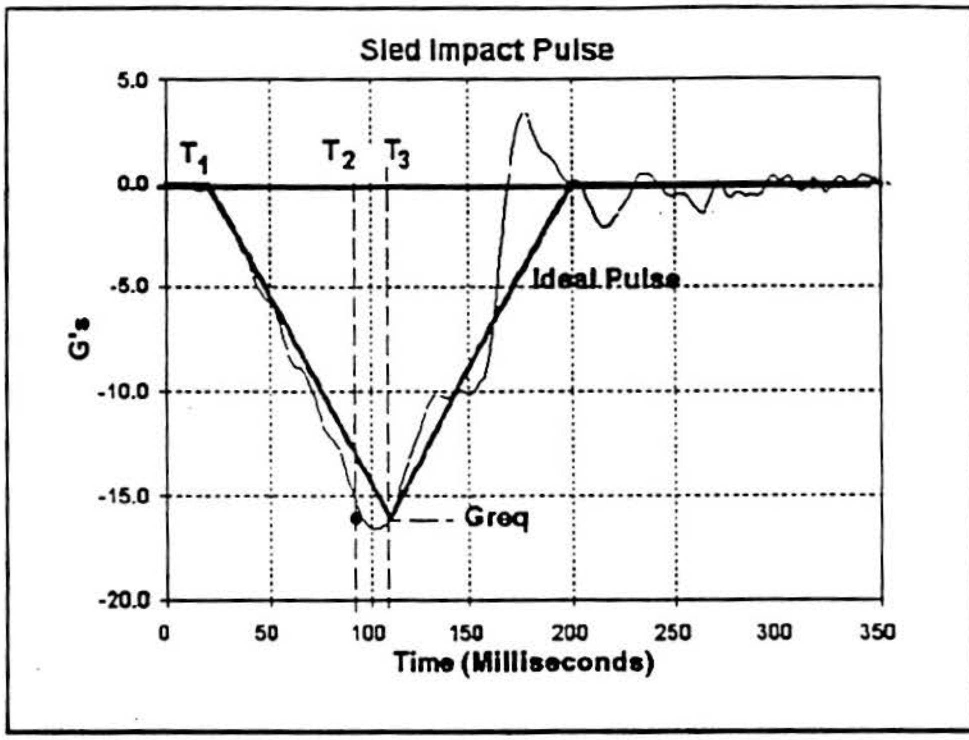


FIGURE A2

A.3 STEP 2:

Using T_1 as the start time, construct the ideal pulse required for the test condition. **Draw a vertical line and a horizontal line through the peak of** the ideal pulse, Greq. The vertical line through Greq will intersect the time axis at the maximum allowed rise time, T_3. Draw another vertical line at the first intersection of the horizontal line through Greq and the acquired pulse after T_1. This vertical line will intersect the time axis at T_2. The actual rise time, $Tr = T_2 - T_1$, must be less than or equal to Treq for the acquired pulse to be acceptable.

A.4 STEP 3:

Compute the velocity change, Vra, of the acquired pulse during the interval T_1 to T_3. Note that T_3 will usually occur after the peak, Gpk, of the acquired pulse. For the acquired pulse to be acceptable, Vra must be at least one-half the total velocity V, required for the specified test condition.

A.5 STEP 4:

If the total velocity change for the test is calculated from the acquired pulse, use the interval starting at T_1 and ending:

a. at the point T_4, where the acquired pulse first intersects the baseline, G = 0, after the time of Gpk or

b. at the time equal to: $T_1 + 2.3 \times Treq$

whichever occurs first.

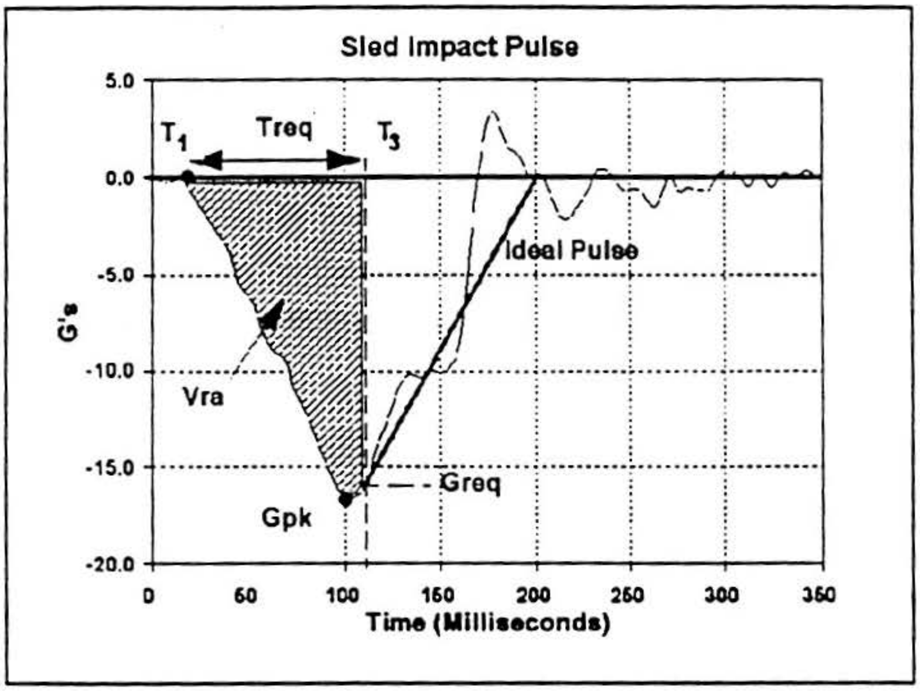


FIGURE A3

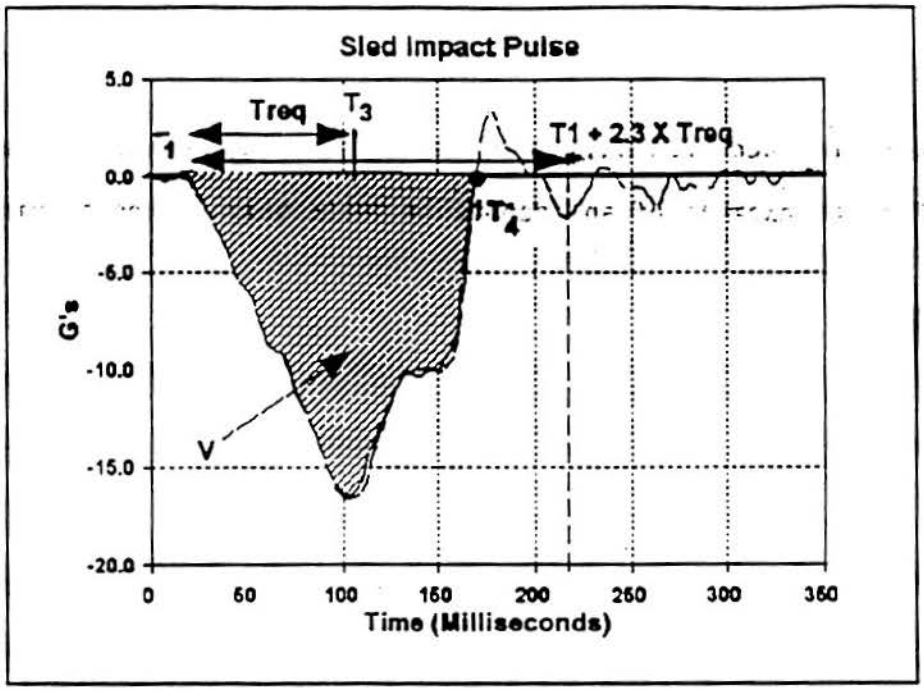


FIGURE A4

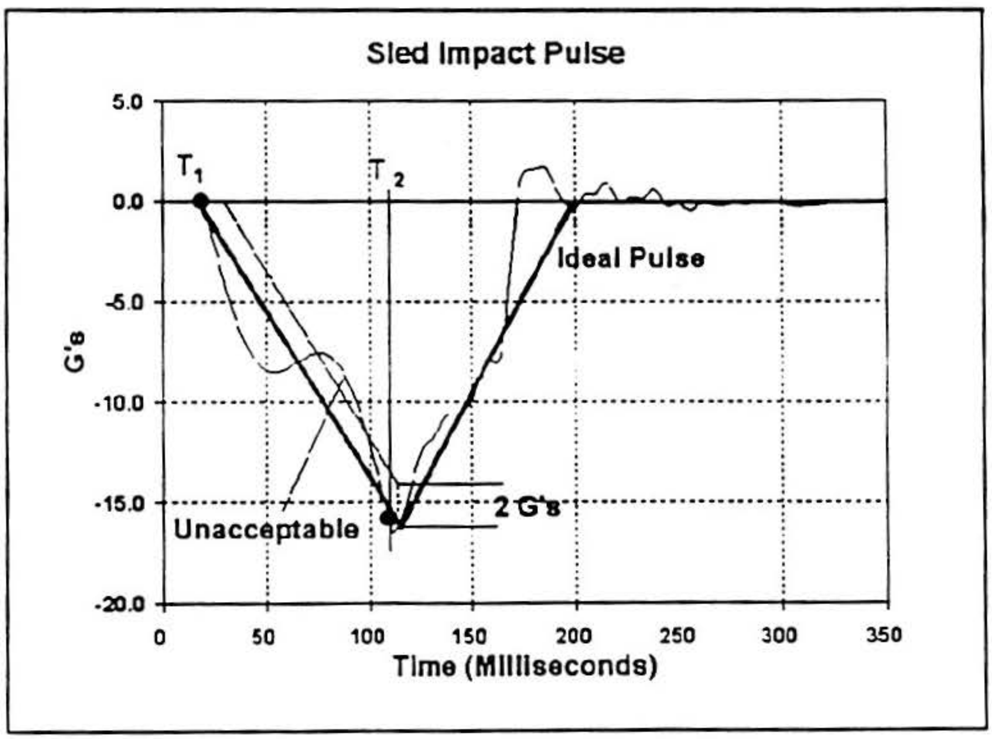


FIGURE A5

A.6 STEP 5:

Construct a line parallel to the ideal pulse and offset by 2 G's in magnitude less than the ideal during the time interval between T_1 and T_2. If the magnitude of the acquired pulse is 2 G's less than the ideal at any point during the interval between T_1 and T_2, the pulse is not acceptable. Figure A2 is an example of an acceptable pulse shape. The acquired pulse shown in Figure A5 is unacceptable.

FAA Action – Final rule FAA-2004-19629

Wednesday,

November 17, 2004

Part IV

Department of Transportation

Federal Aviation Administration

14 CFR Parts 25 and 121

Revision of Emergency Evacuation Demonstration Procedures To Improve Participant Safety; Final Rule

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Parts 25 and 121

[Docket No. FAA–2004–19629, Amendment Nos. 25–117 and 121–307]

RIN 2120–AF21

Revision of Emergency Evacuation Demonstration Procedures To Improve Participant Safety

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Final rule.

SUMMARY: These amendments revise the airworthiness standards for transport category airplanes and the operating requirements for domestic, flag, and supplemental operations, by allowing certain alternative procedures in conducting full-scale emergency evacuation demonstrations for transport category airplanes. The changes will make full-scale emergency evacuation demonstrations safer for participants and will codify existing practices.

DATES: December 17, 2004.

FOR FURTHER INFORMATION CONTACT: Jeff Gardlin, Airframe and Cabin Safety Branch, ANM–115, Transport Airplane Directorate, Aircraft Certification Service, FAA, 1601 Lind Avenue, SW., Renton, Washington 98055–4056; telephone (425) 227–2136.

SUPPLEMENTARY INFORMATION:

Availability of Rulemaking Documents

(**Note:** The FAA transitioned to the new Department of Transportation's Management System (DMS) during the course of this rulemaking. At earlier stages of the rulemaking, the docket number was ''28272.'' Under the new DMS, the docket number is FAA–2004–19629.)

You can get an electronic copy using the Internet by:

(1) Searching the DOTs electronic DMS Web page (*http://dms.dot.gov/search*);

(2) Visiting the Office of Rulemaking's Web page at *http://faa.gov/avr/arm/index.cmf;* or

(3) Assessing the Government Printing Office's Web page at *http://www.access.gpo.gov/su_docs/aces/aces140.html.*

You can also get a copy by submitting a request to the Federal Aviation Administration, Office of Rulemaking, ARM–1, 800 Independence Avenue, SW., Washington, DC 20591, or by calling (202) 267–9680. Make sure to identify the amendment number or docket number of this rulemaking.

Anyone is able to search the electronic form of all comments received into any of our dockets by the name of the individual submitting the comment (or signing the amendment, if submitted on behalf of an association, business, labor union, etc. You may review DOT's complete Privacy statement in the **Federal Register** publication on April 11, 2000 (volume 65, number 70, pages 19477–78) or you may visit *http://dms.dot.gov.*

Small Business Regulatory Enforcement Fairness Act

The Small Business Regulatory Enforcement Fairness Act (SBREFA) of 1996 requires FAA to comply with small entity requests for information or advice about compliance with statutes and regulations within its jurisdiction. Therefore, any small entity that has a question regarding this document may contact their local FAA official, or the person listed under **FOR FURTHER INFORMATION CONTACT**. You can find out more about SBREFA on the Internet at our site, *http://www.faa.gov/avr/arm/sbrefa.htm.* For more information on SBREFA, e-mail us at *9-AWA-SBREFA@faa.gov.*

Background

Notice of Proposed Rulemaking

These amendments are based on Notice of Proposed Rulemaking (NPRM), Notice No. 95–9, which was published in the **Federal Register** on July 18, 1995 (60 FR 36932). In that proposed rule, the FAA proposed to amend 14 Code of Federal Regulations (CFR) parts 25 and 121. Appendix J to part 25 would be changed to allow certain alternative procedures to be used during the conduct of full-scale emergency evacuation demonstrations. Section 121.291(b)(1) would be changed to require that even operators whose crews participate in a manufacturer's full-scale demonstration perform a partial evacuation demonstration upon entry of a new model into service.

Part 25 contains the airworthiness standards for transport category airplanes. Manufacturers of transport category airplanes must show that each airplane they produce complies with the relevant standards of part 25. These standards apply to airplanes manufactured within the U.S. and in other countries that import the airplanes under a bilateral airworthiness agreement. One of the standards that manufacturers must meet is that of demonstrating that passengers and crewmembers can be evacuated in a timely manner in an emergency. This standard is addressed by the requirements in § 25.803 and Appendix J to part 25. This standard is intended to demonstrate emergency evacuation capability under a consistent set of prescribed conditions but is not intended to demonstrate that all passengers can be evacuated under all conceivable emergency conditions.

Part 121 contains the requirements governing the operations of domestic, flag, and supplemental air carriers, and commercial operators of large airplanes. One of the requirements is that the certificate holder must demonstrate the effectiveness of the crewmember training and operating procedures for opening floor level and non-floor level exists and for deploying the evaluation slides, if installed, in a timely manner.

History of the Emergency Evacuation Regulations

Amendment 121–2, effective March 3, 1965, first introduced the requirements for an emergency evacuation demonstration in part 121. Operators operating under part 121 were required to conduct full-scale emergency evacuation demonstrations using 50 percent of the airplane's exits within 120 seconds. Half of the exits were rendered inoperative to simulate the type of emergency where fire, structural, or other adverse conditions would prevent those exits from being used. Operators were required to conduct a demonstration during the initial introduction of a type and model of airplane into passenger-carrying operations and when an airplane passenger seating capacity increased five percent or greater or when a major change was made to the interior arrangement that would affect emergency evacuation. The purposes of the demonstration were to demonstrate the ability of crewmembers to execute established emergency evacuation procedures, and to ensure realistic assignments of crewmember functions.

Amendment 25–15, effective October 24, 1967, introduced the emergency evacuation requirements into part 25. Newly created § 25.803 required airplane manufacturers to conduct an emergency evacuation demonstration for passenger-carrying airplanes with passenger seating capacity of 44 or more, within 90 seconds. The purpose of this demonstration was to establish the evacuation capability of the airplane. Section 25.803(d) listed conditions under which analysis could be used in lieu of a full-scale demonstration to demonstrate compliance with the regulation. The section stated that the full-scale demonstration did not have to be repeated for a change in the interior arrangement, or for an increase in passenger capacity of less than five percent, if it could be substantiated by analysis that all occupants could be evacuated in less than 90 seconds.

Amendment 121–30, effective October 24, 1967, reduced the demonstration time. This reduction was primarily attributable to significant gains made in the efficacy of devices, such as inflatable slides, to assist in the evacuation. The purpose of the part 121 demonstration is crew training and crew procedures so that demonstration conditions remained somewhat different between the two parts.

Amendment 25–46, effective December 1, 1978, revised § 25.803 to allow means other than actual demonstration to show the evacuation capability of the airplane. It also replaced the existing part 25 demonstration conditions with conditions that would satisfy both parts 25 and 121. One demonstration could be used to satisfy both requirements. In addition, § 25.803 was revised to allow analysis in combination with tests to be used to substantiate compliance for an increase in seating capacity of more than five percent. Amendment 121–149, effective December 1, 1978, revised part 121 to accept the results of demonstrations conducted in compliance with § 25.803 as of Amendment 25–46.

Amendment 25–72, effective August 20, 1990, placed the demonstration conditions previously listed in § 25.803(c) into a new Appendix J to part 25 and amended them for clarification and editorial consistency with part 121.

Amendment 25–79, effective September 27, 1993, revised the age/gender mix in Appendix J to part 25 to be used when running an emergency evacuation demonstration. The revision allowed the use of stands or ramps for descending from overwing exits only when the airplane is not equipped with an off-wing descent means, and prohibited the flightcrew from taking an active role in assisting in the passenger cabin.

Amendment 121–233, effective September 27, 1993, revised § 121.291 to allow demonstrations in compliance with § 25.803 in effect on or after December 1, 1978—not just in effect on December 1, 1978—to satisfy the requirements of § 121.291.

Injuries During Full Scale Emergency Evacuation Demonstrations

Hundreds of people jumping from an airplane in simulated dark of night conditions onto inflated slides, sliding as many as 25 feet to the ground, can result in some injuries. In a sampling of seven full-scale evacuation demonstrations conducted between 1972 and 1980, involving 2,571 passengers and crewmembers, 166 participants suffered injuries (''An FAA Analysis of Aircraft Emergency Evacuation Demonstrations,'' 1982, Society of Automotive Engineers Technical Paper Series #82148).

Additionally, a review of 19 full-scale evacuation demonstrations between 1972 and 1991, involving 5,797 participants, identified 269 injuries, or 4.5 percent of the passenger and crewmembers. In the seven demonstrations for which there was information on the types of injuries, of 216 people, 13 suffered fractures, 63 sprains or strains, 32 contusions, and 108 suffered lacerations or abrasions. In one of the demonstrations involving a McDonnell Douglas DC–11 for 410 passengers, a participant was seriously injured, resulting in paralysis. For its second attempt to certificate the MD–11 on December 11 and 12, 1992, McDonnell Douglas replaced the slides with level platforms or gently sloped ramps, and the exterior or the aircraft was lighted.

In addition, the U.S. Congressional Office of Technology Assessment reported that on average, 6 percent of full-scale emergency evacuation demonstration participants are injured during full-scale tests (''Aircraft Evacuation Testing. Research and Technology Issues'' September 1993, OTA–BP–SET–121, NTIS Order #107620).

The Aviation Rulemaking Advisory Committee

The FAA formally established the Aviation Rulemaking Advisory Committee (ARAC) on January 22, 1991, to provide advice and recommendations to the FAA concerning the full range of the FAA's safety-related rulemaking activity (56 FR 2190).

Members of ARAC interested in issues involving emergency evacuation met on May 24, 1991, and instituted the charter and membership for the Performance Standards Working Group (PSWG), for a working group that would report to ARAC. Members of the PSWG included United States and European representatives from airplane and parts manufacturers, pilot, flight attendant and machinist unions, airlines, airworthiness authorities, passenger associations, and other public interest groups. The PSWG charter instructed the working group to recommend to the ARAC whether new or revised emergency evacuation standards could and should be stated in terms of performance standards rather than design standards.

On October 26, 1991, two unsuccessful emergency evacuation demonstrations were conducted on an airplane for which increased seating capacity was sought. During one of them, a participant was seriously injured. Following the demonstrations, the FAA tasked the ARAC to draft recommendations for revising the emergency evacuation demonstration requirements and compliance methods to eliminate or minimize the potential for injury to demonstration participants. The ARAC accepted the task and decided to add this task to the charter of the PSWG.

In response to this additional task, the PSWG drafted a report for discussion. The draft report consisted primarily of two sets of recommendations—(1) Changes that could be made to the current demonstration that would improve participant safety, but would not alter the basic character of the demonstration; and (2) analysis that could be used in lieu of the full scale demonstration, plus an outlined step-by-step methodology for preparing such an analysis. The former recommendation would require a revision to Appendix J to part 25, while the latter recommendations would expand FAA guidance currently in Advisory Circular 25.803–1, Emergency Evacuation Demonstrations. The report was revised numerous times, over several PSWG meetings, based on comments from PSWG members. Nonetheless, after numerous attempts to develop a report that was acceptable, members of the working group were unable to reach consensus.

Representatives of three organizations on the PSWG wrote letters stating their objections to the report as finalized. These letters are included as Appendix 2 of the report. Comments were primarily aimed at the proposed revisions to the existing advisory circular and not to the revisions to Appendix J of part 25 contained in the NPRM. The objectors expressed concern that the committee did not systematically review the causes of injuries in emergency evacuation demonstrations, and thus could not make meaningful recommendations to reduce or eliminate those injuries. Instead, the objectors felt that the committee had concentrated on an approach which would effectively eliminate the full-scale demonstration.

The report was forwarded to the ARAC on January 28, 1993, and then forwarded on to the FAA. The ARAC then tasked the PSWG to draft the appropriate rulemaking document and revise the advisory material as recommended in the report. The PSWG completed the task and the recommendations were accepted by the FAA. These amendments cover the recommended revisions to part 25 covered in the report, ''Emergency Evacuation Requirements and Compliance Methods That Would Eliminate or Minimize the Potential for Injury to Full Scale Evacuation Demonstration Participants.'' A copy of the report has been placed in the docket. The FAA is developing a revised advisory circular based on the report submitted by ARAC.

Discussion of the Final Rule

This amendment changes Appendix J to part 25 to reduce the possibility of injury to participants in a full-scale emergency evacuation demonstration and to codify existing practice regarding airplanes equipped with overwing slides as recommended by the ARAC.

Exterior Lighting

Paragraph (a) of Appendix J is amended to allow exterior light levels of 0.3 foot-candles or less prior to the activation of the airplane emergency lighting system, in lieu of ''dark of night'' conditions. This light level is approximately the level that would be found in the passenger cabin when the emergency lighting system is the only source of illumination. Allowing this low level of lighting outside the airplane enhances the ability of the demonstration director to see and react more quickly to problems that may develop during the demonstration. While this does not prevent injuries incurred at the onset of the problems, it could result in reducing the number of injuries by halting the demonstration sooner than in the past. Specific tests were not run to ascertain whether or not such exterior ambient lighting would enhance or detract from evacuation performance, since it was considered that crew performance, escape system efficiency, and illumination provided by the airplane emergency lighting system have the predominant impact on evacuation performance. As discussed below, airplane exterior emergency lighting is being addressed separately.

Pre-Deployment of Escape Slides

Paragraph (p) of Appendix J is revised to allow exits with inflatable slides to have the slides deployed and available for use prior to the start of the demonstration. If this method were used, the exit preparation time, which would be established in separate component tests, would need to be accounted for in some manner. This change prevents a participant exiting the airplane before the slide is fully available for use, which has occurred in at least two instances. In both cases, the participant was not seriously injured; however, the potential for serious injury is great, particularly considering the sill heights of wide-body airplanes.

An additional benefit is that pre-deployed and inflated slides are not subject to damage from equipment that is placed near the airplane to facilitate conduct or documentation of the demonstration (for example, infrared lighting). The pre-deployment and inflation of slides also allows the proper placement and opportunity for inspection of safety mats around the slide prior to the start of the demonstration. Additionally, paragraph (p) is revised to require that the exits that are not to be used in the demonstration must be clearly indicated once the demonstration has started. The more general wording of this change accommodates the additional flexibility in exit configuration (slide stowed or pre-deployed and inflated).

Finally, the opening sentence in paragraph (p) is revised to more succinctly describe the exits that are to be used in the demonstration. The ''exit pairs'' in this regulation are as discussed in the passenger seating tables in § 25.807(g). This change responds to numerous prior requests to the FAA for clarification of the existing text. As in the past, exits which are not installed in pairs, typically tail cone or ventral exits, are not used in the demonstration.

Paragraph (f) of Appendix J is revised to remove the requirement that each external door and exit be in the takeoff configuration. This change is necessary to be consistent with the change to paragraph (p), noted above, which allows slides to be deployed and inflated prior to the start of the demonstration. If the option to pre-deploy the slide is selected by the applicant, the FAA must approve the specific procedures to prevent demonstration participants from determining which exits will be used, as well as the method of making the exits available, prior to the demonstration. The method of assessing the impact on the resulting evacuation times for each of the exits used must also be agreed in advance.

Paragraph (o) of Appendix J is revised to state more generally its intent rather than requiring specific actions. The intent is that participants inside the airplane should not be able to identify, prior to the start of the demonstration, which exits will be used during the demonstration. Although this may be made more difficult if an applicant elects to utilize pre-deployed escape slides in accordance with the change to paragraph (p), this change is in keeping with general regulatory practice. This change is not specifically related to reducing injuries.

Safety Briefing

Paragraph (n) of Appendix J is revised to allow passengers to be briefed on safety procedures that are in place for the particular demonstration, *e.g.,* procedures to abort the demonstration, or procedures that have to do with the demonstration site, *e.g.,* how to evacuate the building in which the demonstration is being conducted. The revision also notes when that briefing could take place. This briefing could help some participants from adding to an already potentially injurious situation in the event of problems, such as a collapsed evacuation slide. It could also provide information that would be helpful in case of a problem at the demonstration site, *e.g.,* a fire in the building. The briefing would have to be carefully constructed so as not to impart any information that would enable the participants to evacuate the airplane faster. Additionally, the appropriate time for the passenger briefing required by § 121.571 has been added.

Other Changes

The ARAC recommended that paragraph (c) of Appendix J be amended to allow the use of stands or ramps for overwing exits only if assist means are not required as part of the airplane type design. It was not proposed in Notice No. 95–9, however because that change has already been implemented by Amendment 25–79.

Another of the recommendations involved revising the age/gender mix to require using only the age/gender groups least susceptible to injury. It was not proposed in Notice No. 95–9, pending research to identify the groups and develop an appropriate mix. A group of participants based on the new mix would have to have the same evacuation capability as a group based on the existing mix. This possible future proposal would be in addition to the change to the mix adopted by Amendment 25–79.

This amendment also makes minor revisions to part 121, to be consistent with the changes being made to part 25. Section 121.291(a) requires that certificate holders must conduct an emergency evacuation demonstration in accordance with paragraph (a) of Appendix D to part 121, or in accordance with § 25.803 of part 25. Section 25.803 incorporates by reference Appendix J of part 25 which is amended by this final rule. Section 121.291(b)(1) is amended to require that even operators whose crews participate in a manufacturer's full-scale demonstration perform a partial evacuation demonstration upon entry of a new model into service. This change will account for aspects of the operator's evacuation procedure that might be lost if the manufacturer elects to conduct the full-scale demonstration with pre-deployed slides.

Discussion of Comments

Comments were received from 10 parties, representing foreign and domestic airplane manufacturers, labor associations, foreign and domestic operators, as well as foreign regulatory authorities and one individual. Each proposed change received comments. Two commenters support the proposals with minor editorial suggestions. Four commenters agree with specific aspects of the proposals, and did not comment on others. Four commenters disagree with at least parts of the proposals.

Exterior Lighting

Three commenters support and four commenters oppose the proposal to allow a specified ambient light level, exterior to the airplane, for the purposes of conducting the full-scale evacuation demonstration.

Commenters opposing the change cite the lack of specific research to support the proposed light level, and contend that such light levels would, in any case, speed the evacuation. One commenter suggests that night vision goggles could be provided to the test directors to enable them to survey the situation and thereby achieve the same objective as the proposal. One commenter cites a non-aviation research study where an increase in ambient light level increased the speed of evacuation for different age groups. This commenter also suggests that the proposed light level would be acceptable, if it were produced by the airplane's emergency lighting system.

While the FAA acknowledges that the proposed exterior light level is not based on dedicated research, this level is considered reasonable, based on several factors. First, the proposed light level is still quite dim, particularly in comparison with the typical emergency cabin lighting environment. Second, as is discussed below, the area surrounding the airplane is not a primary factor in the speed of evacuations as compared to the escape slide itself, and its conspicuity. Third, as discussed later, the FAA tasked the ARAC working group to develop qualification methods for escape slides that would determine their usability under strict dark of night conditions. The qualification of the escape slides in the absence of ambient illumination means that the ambient illumination level for the demonstration would not be critical.

The FAA agrees that the use of night vision goggles could improve some aspects of the test directors' ability to assess the situation during the full-scale evacuation. However, the results would not be equivalent since the goggles will not provide peripheral visual information, and will be distorted by the light that is produced by the airplane's emergency lighting system. Thus, while this amendment would not prohibit the use of night vision goggles, that approach is not considered a direct substitute for the proposal.

Numerous airplane evacuation studies have been conducted in daylight conditions, as well as ''dark of night'' conditions. Statistically, the evacuation rates seen in these diametrically opposed illumination conditions have been equivalent. The FAA also reviewed certification test data for tests conducted in daylight and dark of night conditions, where the other parameters are the same, and has seen no statistical difference in evacuation rates. However, to maintain the ''feel'' of a nighttime evacuation and address the safety of participants, the FAA has chosen a low light level that will still provide enhanced situational awareness to the demonstration director.

An important adjunct to the change in ambient illumination level is the change to the requirements for escape slide qualification relative to dark of night conditions. The FAA and the ARAC have developed new methods of escape slide qualification testing that would ensure that the escape system itself has adequate lighting capability to enable rapid evacuation in the absence of any other source(s) of light. The FAA has incorporated these methods into the Technical Standard Order (TSO) C69 for escape slides. The rule change adopted here pertains to the full-scale evacuation demonstration only. Qualification of the escape systems is an independent requirement and should be largely completed prior to the full-scale evacuation demonstration. In the past, qualification of the escape systems has not always been completed prior to the full-scale evacuation demonstrations. The FAA, however, considers that qualification of the system is an essential element of this amendment. Since the change adopted here applies to new type certificates, the FAA expects that the TSO revision will be adopted prior to a full-scale evacuation demonstration for type certification in accordance with this amendment. Should that prove not to be the case, the FAA will still require that the escape systems lighting performance be substantiated in an approved manner prior to the demonstration.

The FAA reviewed the research study cited by the commenter and concluded that the findings in the study do not directly relate to the full-scale evacuation requirement. The study is primarily an assessment of a test subject's ability to negotiate an unknown evacuation path in conditions of varied illumination. This proposal addresses lighting conditions, which only become evident upon leaving the airplane, after the evacuees have negotiated the evacuation path.

In addition, the reflectivity of the test environment in the study is much higher than would be allowed by this amendment, increasing the effective ambient illumination. Further, differences in egress performance are greatly reduced when luminous versus non-luminous signs were used for a given illumination level. This indicates that the test subjects performed poorly at effective ambient illumination levels above those allowed by this amendment, and that ambient illumination may not be the primary factor controlling performance in the conditions tested. In summary, the FAA has concluded that the study does not directly relate to this amendment and, as discussed above, issues related to escape slide performance have been addressed in TSO C69.

The FAA does not agree that increased ambient light level should be required to be generated by the airplane's emergency lighting system. The current standards for airplane emergency lighting systems have been shown to be adequate for evacuation. The purpose of allowing increased ambient lighting in this amendment is not to assist in the evacuation, but to assist in monitoring the evacuation to insure participant safety. As noted earlier, the qualification of the actual lighting will be a requirement for certification. The commenter's suggestion would essentially change the regulations for exterior emergency lighting, which is beyond the scope of the notice.

Pre-Deployment of Escape Slides

Two commenters support, while four commenters oppose the proposal to allow the demonstration to be conducted with escape slides pre-deployed.

Commenters supporting the proposal note the potential to prevent injuries resulting from persons leaving the airplane prior to the escape slide being ready for use, for whatever reason.

Commenters opposing the proposal cite various reasons for their opposition. Some commenters state that separating exit operation and evacuation would not demonstrate the efficacy of flight attendant training. Some commenters assert that not having a specific methodology for accounting for the pre-deployed slides will invalidate the demonstration. A commenter suggests that this option is purely a cost saving measure to avoid repeating tests that fail on account of equipment failure. One commenter suggests that the noise of deploying slides and opening doors is not accounted for as part of the demonstration, and will reduce the ''chaos and distraction'' aspects of the demonstration. Another commenter notes that the risk of persons leaving the airplane early can be accommodated by different designs that prevent the doors from opening prior to the escape slide being deployed.

The FAA has considered all the comments and believes that, while many of the issues raised require consideration, the proposal is sound and does not require changes.

In the case of the flight attendant training program and the crews' interaction with the escape systems, the change to § 121.291(b)(1) would necessitate that the operators conduct a partial evacuation demonstration before entering service, whether or not that operator's crew participated in the full-scale evacuation demonstration. Since typically only one operator's crew participates in the full-scale part 25 evacuation demonstration, the training benefits that might result from the demonstration are limited to that operator. This proposal would actually increase the number of operators required to conduct a partial evacuation demonstration in accordance with § 121.291(b)(1), over what was previously required.

In addition, regarding the comment that the proposal is intended to avoid repeat demonstrations due to equipment failure, qualification of equipment is not the purpose of the demonstration. Under § 25.810, the certificate holder would have to demonstrate the proper operation of the escape systems from a mechanical standpoint and it is not appropriate to rely on the full-scale evacuation demonstration to identify problems with equipment. The full-scale demonstration is intended to address the gross evacuation capability of the airplane and its crew, and not to address specific equipment qualification.

The FAA has not proposed a specific methodology to pre-deploy the escape slides since deployment will vary among the different exit designs. In addition, recommendations on methodology are more appropriately the function of advisory material. While there is no obvious need for advisory material at this time, if a need develops appropriate guidance will be prepared.

The FAA has determined that there are means of accounting for pre-deployed escape slides that will not compromise the evacuation demonstration. Issues that must be addressed include the time it takes for a flight attendant to operate and assess the availability of the exit; the inflation time of the slide; the queue of passengers that might form while the slide is inflating and the effect that the queue has on the initial evacuation rate. Many of these issues could be addressed by correctly timing the availability of the exits to be used in the demonstration.

As is currently the case, exits that will be used must not be distinguishable from exits that will not be used, prior to the demonstration. This approach may necessitate the use of special covers over all exits, for example. In those cases where it is not possible to develop a satisfactory methodology, the applicant will not be able to use the option of pre-deployed slides.

Predeployment of slides will reduce the potential for slide failure or damage to slides that can occur during a demonstration. This could avoid repeating a demonstration and the applicant costs associated with repeating. But the purpose of the evacuation demonstration is to determine if the aircraft, as designed, can be evacuated in a timely manner. The test limitation allowing use of only 50 percent of available slides accounts for the potential for unusable slides. The reliability of the slide system is required to be demonstrated separately under § 25.810. Although the potential for repeat demonstrations may be reduced, the reason for considering this change is to prevent injuries.

The noise that is produced by deploying escape slides is not generally accounted for, if the slides are pre-deployed. The FAA is unaware of what role, if any, the sound of deploying escape slides plays in an evacuation demonstration. Research tests conducted with pre-deployed escape slides result in evacuation rates consistent with those produced in full-scale demonstrations that do not pre-deploy slides. In addition, and as the basis for the proposal, in past full-scale evacuation demonstrations, passengers frequently reached the exit before the slide was fully deployed and, in some cases, have left the airplane before the slide is ready. It is doubtful that the absence of the sounds of deployment will cause them to reach the exit any sooner. Nonetheless, if there are data that indicate that the sounds are necessary, it would be a simple matter to include recorded sounds, as a part of the other procedures that will be needed to follow this option. At this time, however, the data do not suggest that this is necessary.

It is true that the escape system design could be such that the exits were prevented from opening until the escape slide was fully deployed. However, such a requirement could have the unintended effect of delaying an evacuation in an accident. Under actual emergency conditions it is less likely that persons would depart the airplane prior to the escape slide's deployment, since there is no defined ''start'' signal such as there is in a demonstration. Under actual conditions, the sooner the escape slide is available, the more likely the success of the evacuation. Since the escape slide is not available to passengers until the exit is open, requiring the exits to delay opening would not be in the interest of safety. It should be noted that there are specific designs that incorporate features to permit the exit opening to coincide with the slide deployment, that do not delay the overall exit system availability. Such designs would, of course, continue to be acceptable.

Safety Briefing

Three commenters support and three commenters oppose the proposal to allow a safety briefing for test participants. One commenter expresses concern regarding the use of test participants' to assist at the bottom of the escape slides, commenting that this is better left to test personnel.

Most commenters opposing the proposal were not specific as to their opposition, other than concern that the briefing could somehow enable the participants to evacuate faster. As stated in Notice No. 95–9, the purpose of this provision is to convey safety information about the logistics of the demonstration site and test sequence. The notice also states that such briefings would have to be carefully constructed in order not to disclose information about the demonstration itself. In actual practice, the manufacturers have conducted such briefings in the past, but with no real standardization. This amendment provides codification of that practice and gives information as to content and when such a briefing can take place.

With respect to persons who are assigned to assist at the bottom of the slide, the FAA agrees with the commenter who believes that test personnel would probably be the best choice. However, if an operator's procedures included assigning passengers to perform this duty, they should not be precluded from employing the same procedures in the demonstration. This provision would not override the safety procedures to be followed for demonstration purposes and, should problems develop, it might be necessary for test personnel to provide additional assistance. Were that to occur, the contribution of the test personnel would have to be assessed to determine whether the validity of the demonstration had been affected. The proposal is therefore adopted.

Other Comments

Other comments concerned editorial suggestions that have been adopted where appropriate, and some comments that were beyond the scope of the notice. One commenter suggests that the combination of exits likely to result in the slowest evacuation times should be required in paragraph (p) of Appendix J of part 25, and not one from each pair of exits, as proposed. The current standard contained in the first sentence of paragraph (p) only requires that not more than 50 percent of the exits are used in the demonstration. Currently, applicants are free to select any combination of exits. The proposed change to the first sentence of paragraph (p) was intended to reflect current practice of using one exit from each pair, not to establish a new standard. The commenter's suggestion would create a more stringent standard. Although the comments may be applicable to future rulemaking in this area, they were not considered applicable to this proposal.

One commenter recommends against combining the demonstration requirements for parts 25 and 121. The provision to demonstrate compliance with both parts 25 and part 121 actually occurred in Amendments 25–46 and 121–149, in 1978, and was not a part of NPRM 95–9.

Finally, commenters contend that the proposal is an indirect effort to do away with the full-scale demonstration entirely. Since the entire proposal focuses on procedures for conducting the demonstration, this contention is not accurate. The FAA will continue to require full-scale demonstrations when appropriate.

Paperwork Reduction Act

In accordance with the Paperwork Reduction Act of 1995 (44 U.S.C. 3507(d)), there are no current or new requirements for information collection associated with this amendment.

International Compatibility With ICAO Standards

In keeping with U.S. obligations under the Convention on International Civil Aviation, it is FAA policy to comply with International Civil Aviation Organization (ICAO) Standards and Recommended Practices to the maximum extent practical. The FAA has reviewed the corresponding ICAO Standards and Recommended Practices and the Joint Aviation Authorities regulations, where they exist, and has identified no differences in these amendments and the foreign regulations.

Economic Evaluation, Regulatory Flexibility Determination, International Trade Impart Assessment, and Unfunded Mandates Assessment

Changes to Federal regulations must undergo several economic analyses. First, Executive Order 12866 directs that each Federal agency shall propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs. Second, the Regulatory Flexibility Act of 1980 requires agencies to analyze the economic impact of regulatory changes on small entities. Third, the Trade Agreements Act (19 U.S.C. 2531–2533) prohibits agencies from setting standards that create unnecessary obstacles to the foreign commerce of the United States. In developing U.S. standards, this Trade Act requires agencies to consider international standards and, where appropriate, that they be the basis of U.S. standards. And fourth, the Unfunded Mandates Reform Act of 1995 requires agencies to prepare a written assessment of the costs, benefits and other effects of proposed or final rules that include a Federal mandate likely to result in the expenditure by State, local or tribal governments, in the aggregate, or by the private sector, of $100 million or more, in any one year (adjusted for inflation.)

For regulations with an expected minimal impact a complete regulatory evaluation is not required. The Department of Transportation Order DOT 2100.5 prescribes policies and procedures for simplification, analysis, and review of regulations. If it is determined that the expected impact is so minimal that the proposal does not warrant a full Evaluation, a statement to that effect and the basis for it is included in the final regulation. Since this final rule revises existing rules and codifies existing practices, the expected outcome is to have a minimal impact with positive net benefits. The justification for the minimal impact determination follows.

Regulatory Evaluation Summary

Exterior Lighting

In the original NPRM, the FAA estimated that it will take two engineers and two technicians ½ hour at burdened rates of $60 and $45 per hour, respectively, to prepare and adjust the exterior lighting level to 0.3 foot-candles or less, at a cost of $105.

Predeployment of Escape Slides

The final rule removes the requirement in paragraph (f) that the external doors and exits be in the takeoff configuration. No costs are associated with this change.

Safety Briefings

Paragraph (n) is amended to allow demonstration participants to be briefed only with respect to safety procedures in place for the demonstration or the demonstration site, such as demonstration abort procedures or procedures pertaining to the demonstration site. Flight attendants will be allowed to assign demonstration subjects to assist other participants from the bottom of the slide. The final rule will continue to prohibit passengers from being instructed on procedures to be followed in the demonstration. No costs are attributed to these changes.

Paragraph (o) requires that the airplane be configured so that available emergency exits are not disclosed to participants. This revision states more generally the intent of the requirement rather than specific actions. Associated costs are described in comments pertaining to paragraph (p) below.

Paragraph (p) allows exits with inflatable slides to be opened with the slides deployed prior to the start of the demonstration timing. The final rule retains the current requirement that all exits will have to be configured so that the usable exits are not disclosed to participants prior to the demonstration. Manufacturers currently cover all windows to prevent participants from determining which exits will be usable in the demonstration. The FAA estimates that, under the final rule, manufacturers will also cover exits with curtains, screens, or other means to prevent premature disclosure of active exits. These screening devices will cost approximately $1,000 for labor and materials. (Depending on future airplane designs, slides may be able to be deployed without opening the exits they serve. In those cases, there will be no costs for screening devices because it will not be necessary to cover the exit doors to prevent participants from determining which exits will be used.)

Costs

The final rule does not necessarily result in additional compliance costs, because it allows *alternative* procedures in conducting demonstrations, rather than mandating them. If manufacturers elect to use the final procedures, however, the FAA estimates that there will be incremental costs of approximately $1,105 per demonstration. These costs will be insignificant in comparison to the total cost of an evacuation demonstration, estimated to range between $1,000,000 and $2,000,000.

Benefits

The risk of injury to passengers during repetitive full-scale emergency demonstrations is appreciable.

The FAA reviewed seven full-scale evacuation demonstrations conducted between 1972 and 1980 (''An FAA Analysis of Aircraft Emergency Evacuation Demonstrations''). Of the 2,571 participants in the demonstrations, 166, or 6.5 percent were injured.

In addition, the Office of Technology Assessment states that on average, 6 percent of full-scale emergency evacuation demonstration participants are injured during full-scale tests (''Aircraft Evacuation Testing: Research and Technology Issues'', September 1993, OTA–BP–SET–121, NTIS order #PB94–107620).

The FAA reviewed 19 demonstrations conducted between 1972 and 1991. Of the 5,797 participants in the demonstrations, 269 were injured. In the seven demonstrations for which there was information on the types of injuries, 13 suffered fractures, 63 sprains or strains, 32 contusions, and 108 suffered lacerations or abrasions, a total of 216 people injured. This review revealed 4.5 percent of the passengers or crewmembers received injuries. In one of the emergency evacuation demonstrations reviewed by the FAA, a participant was seriously injured, which resulted in paralysis. The FAA believes a 4.5% injury rate during an emergency evacuation demonstration is not an acceptable safety practice.

Personnel participating in the demonstration should be protected from potential injury without compromising the test results (''Emergency Evacuation Demonstrations'', AC 20–118). The primary benefit of the rule will be reduced risks of injuries to demonstration participants.

The National Transportation Safety Board (NTSB) classifies fractures, strains, contusions, lacerations, and abrasions as ''minor'', ''moderate'', or ''Critical'' according to the abbreviated injury scale (AIS) used. The FAA estimates that the average cost of a ''minor injury'' is $5,400, the average cost of a ''moderate'' injury is $41,900, and the average cost of a ''Critical'' injury, resulting in paralysis, is $2,058,800 (''Economic Values for Evaluation of Federal Aviation Administration Investment and Regulatory Programs,'' (FAA–APO–98–8), Treatment of the Values of Life and Injury in Economic Analyses). Avoiding only one minor injury during an evacuation demonstration will result in cost savings exceeding the estimated $1,105 incremental costs of the alternative procedures.

The emergency evacuation demonstration must be conducted during the dark of night or with the dark of night simulated, so that the airplane's emergency lighting system provides the only illumination of exit paths and slides (''Aircraft Evacuation Testing: Research and Technology Issues,'' September 1993, OTA–BP–SET–121, NTIS order #PB94–107620). But allowing low-level light, outside the airplane, will enhance the ability of the demonstration director to react more quickly to problems, which could develop during the demonstration. The ability of the demonstrator to react more quickly to problems could reduce the risk of injuries to demonstration participants.

The FAA has determined since costs will be minor, and the benefits could be significantly higher than the costs, the rule will be cost-beneficial.

Regulatory Flexibility Determination

The Regulatory Flexibility Act of 1980 (RFA) was establishes ''as a principle of regulatory issuance that agencies shall endeavor, consistent with the objective of the rule and of applicable statutes, to fit regulatory and informational requirements to the scale of the business, organizations, and governmental jurisdictions subject to regulation.'' To achieve that principle, the Act requires agencies to solicit and consider flexible regulatory proposals and to explain the rationale for their actions. The Act covers a wide-range of small entities, including small businesses, not-for-profit organizations and small governmental jurisdictions.

Agencies must perform a review to determine whether a proposed or final rule will have a significant economic impact on a substantial number of small entities. If the determination is that it will, the agency must prepare a regulatory flexibility analysis as described in the Act.

However, if an agency determines that a proposed or final rule is not expected to have a significant economic impact on a substantial number of small entities, section 605(b) of the 1980 act provides that the head of the agency may so certify and a regulatory flexibility analysis is not required. The certification must include a statement providing the factual basis for this determination, and the reasoning should be clear.

This final rule will make full-scale emergency evacuation demonstrations safer for participants and will codify existing practices. Because there are no manufacturers of part 25 airplanes with 1,500 or fewer employees,[1] the FAA certifies that the final amendments will not have a significant economic impact on a substantial number of small entities.

International Trade Impact Analysis

The Trade Agreement Act of 1979 prohibits Federal agencies from engaging in any standards or related activities that create unnecessary obstacles to the foreign commerce of the United States. Legitimate domestic objectives, such as safety, are not considered unnecessary obstacles. The statute also requires consideration of international standards and where appropriate, that they be the basis for U.S. standards.

In accordance with the above statute and policy, the FAA has assessed the potential effect of this final rule to be minimal and therefore has determined that this final rule will not result in an impact on international trade by companies doing business in or with the United States.

Unfunded Mandates Reform Act

The Unfunded Mandates Reform Act of 1995 (the Act) is intended, among other things, to curb the practice of imposing unfunded Federal mandates on State, local, and tribal governments.

Section 202(a) (2 U.S.C. 1532) of Title II of the Act requires that each Federal agency, to the extent permitted by law, prepare a written statement assessing the effects of any Federal mandate in a proposed or final agency rule that may

[1] 13 CFR 121.201, Size Standards Used To Define Small Business Concerns, Sector 48–49 Transportation, Subsector 481 Air Transportation.

result in the expenditure by State, local, and tribal governments, in the aggregate, or by the private sector, of $100 million or more (adjusted annually for inflation) in any one year; such a mandate is deemed to be a ''significant regulatory action.'' The FAA currently uses an inflation-adjusted value of $120.7 million in lieu of $100 million. Section 203(a) of the Act (2 U.S.C. 1533) provides that before establishing any regulatory requirements that might significantly or uniquely affect small governments, an agency shall have developed a plan under which the agency shall: (1) Provide notice of the requirements to potentially affected small governments, if any; (2) enable officials of affected small governments to provide meaningful and timely input in the development of regulatory proposals containing significant Federal intergovernmental mandates; and, (3) inform, educate, and advise small governments on compliance with the requirements. With respect to (2), Section 204(a) of the Act (2 U.S.C. 1534) requires the Federal agency to develop an effective process to permit elected officers of State, local, and tribal governments (or their designees) to provide the input described.

This final rule does not contain a significant Federal intergovernmental/private sector mandate. Therefore, the requirements of Title II do not apply.

Executive Order 3132, Federalism

The FAA has analyzed this final rule under the principles and criteria of Executive Order 13132, Federalism. We determined that this action will not have a substantial direct effect on the State, or the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government. Therefore, we determined that this final rule does not have federalism implications.

Environmental Analysis

FAA Order 1050.1E identifies FAA actions that are categorically excluded from preparation of an environmental assessment or environmental impact statement under the National Environmental Policy Act in the absence of extraordinary circumstances. The FAA has determined this rulemaking action qualifies for the categorical exclusion identified in paragraph 312f and involves no extraordinary circumstances.

Regulations That Significantly Affect Energy Supply, Distribution, or Use

The FAA has analyzed this final rule under Executive Order 13211, Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use (May 18, 2001). We have determined that it is not a ''significant energy action'' under the executive order because it is not a ''significant regulatory action'' under Executive Order 12855, and it is not likely to have a significant adverse effect on the supply, distribution, or use of energy.

List of Subjects

14 CFR Part 25

Air transportation, Aircraft, Aviation safety, Safety.

14 CFR Part 121

Aviation safety, Safety, Air carrier, Air traffic control, Air transportation, Aircraft, Aircraft pilots, Airmen, Airplanes, Airports, Airspace, Cargo Chemicals, Children, Narcotics, Flammable materials, Handicapped, Hazardous materials, Common carriers.

The Amendment

■ In consideration of the foregoing, the Federal Aviation Administration amends parts 25 and 121 of Title 14 Code of Federal Regulations as follows:

PART 25—AIRWORTHINESS STANDARDS—TRANSPORT CATEGORY AIRPLANES

■ 1. The authority citation for part 25 continues to read as follows:

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

■ 2. Appendix J to part 25 is amended by revising paragraphs (a), (f), (n), (o), and (p) as follows:

Appendix J to Part 25—Emergency Evacuation

* * * * *

(a) The emergency evacuation must be conducted with exterior ambient light levels of no greater than 0.3 foot-candles prior to the activation of the airplane emergency lighting system. The source(s) of the initial exterior ambient light level may remain active or illuminated during the actual demonstration. There must, however, be no increase in the exterior ambient light level except for that due to activation of the airplane emergency lighting system.

* * * * *

(f) Each internal door or curtain must be in the takeoff configuration.

* * * * *

(n) Prior to entering the demonstration aircraft, the passengers may also be advised to follow directions of crewmembers but may not be instructed on the procedures to be followed in the demonstration, except with respect to safety procedures in place for the demonstration or which have to do with the demonstration site. Prior to the start of the demonstration, the pre-takeoff passenger briefing required by § 121.571 may be given. Flight attendants may assign demonstration subjects to assist persons from the bottom of a slide, consistent with their approved training program.

(o) The airplane must be configured to prevent disclosure of the active emergency exits to demonstration participants in the airplane until the start of the demonstration.

(p) Exits used in the demonstration must consist of one exit from each exit pair. The demonstration may be conducted with the escape slides, if provided, inflated and the exits open at the beginning of the demonstration. In this case, all exits must be configured such that the active exits are not disclosed to the occupants. If this method is used, the exit preparation time for each exit utilized must be accounted for, and exits that are not to be used in the demonstration must not be indicated before the demonstration has started. The exits to be used must be representative of all of the emergency exits on the airplane and must be designated by the applicant, subject to approval by the Administrator. At least one floor level exit must be used.

* * * * *

PART 121—OPERATING REQUIREMENTS: DOMESTIC, FLAG, AND SUPPLEMENTAL OPERATIONS

■ 3. The authority citation for part 121 continues to read as follows:

Authority: 49 U.S.C. 106(g), 40113, 40119, 41706, 44101, 44701–44702, 44705, 44709–44711, 44713, 44716–44717, 44722, 46105.

■ 4. Section 121.291 is amended by revising paragraph (b)(1) as follows:

§ 121.291 Demonstration of emergency evacuation procedures.

* * * * *

(b) * * *

(1) Initial introduction of a type and model of airplane into passenger-carrying operation;

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Issued in Washington, DC, on November 8, 2004.

Marion C. Blakey,

Administrator.

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