SAE Aerospace
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AEROSPACE RECOMMENDED PRACTICE

SAE ARP767 REV. C

Issued 1967-10
Reaffirmed 1991-05
Revised 2000-03
Cancelled 2006-08

Superseding ARP767B

Impact Protective Design of Occupant Environment Transport Aircraft

RATIONALE

This document was made obsolete when the 14CFR 25.562 criteria was published in 1988. There was a series of documents cancelled at that time but this one was missed.

CANCELLATION NOTICE

This document has been declared "CANCELLED" as of August 2006. By this action, this document will remain listed in the Numerical Section of the Aerospace Standards Index.

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FOREWORD

Changes in this revision are format/editorial only.

INTRODUCTION

Injuries are sometimes sustained by occupants of transport aircraft during survivable crashes, turbulence, or unexpected flight conditions. In some instances, these injuries are caused, or made more severe, by equipment within the aircraft. Equipment design factors influencing injury, not generally familiar to the designer, include:

a. Relative velocity of the impacting equipment and the occupant.
b. Impact site on the occupant.
c. Area of impact on the occupant.
d. Mass of impacted or impacting equipment.
e. Geometry of the impactor (sharp edges, etc.)
f. Surface hardness or compliance of the equipment (ability to conform to the corresponding surface of the occupant's body).
g. Equipment surface roughness.
h. Energy absorption characteristics of the equipment.
i. Direction of impact (on the occupant).
j. Duration or time history of the impact.

These factors act concurrently and are interdependent in their effect. One other factor, not within the control of the designer, is the tolerance level of the occupant, which varies over a large range due to age, general health, physical size, and skeletal development.

Although the field of knowledge regarding impact injury protection is not yet fully defined, certain fundamental rules have become apparent:

a. Distribution of load over a large body area will tend to decrease injury.

b. Elimination or reduction of the flailing distance available for arms, legs, upper torso, or head generally decreases injury by reducing the relative velocity between the body and the impactor and allowing the body to "ride down" the impact with the aircraft. This is particularly true if the contact surface is sufficiently compliant to distribute the impact load over the body.

c. Distribution of impact loads over the body by use of lightweight structure or padding which plastically deforms, with minimum elastic rebound, will generally decrease injury. The use of systems that are largely elastic in their response to impact may increase injury since they store the energy of the impact for rebound into the body.

d. Deformation of material under impact loads should not expose structure which could cause injury.

Items within the passenger cabin which become loose; i.e., fittings, shields, ceiling panels, storage compartments, etc., can cause injury if they contact the occupants during the event. These should be located so as to reduce the likelihood of contact whenever possible, even if their retention system should fail. Deflections of the cabin and the interior contents during an impact should be considered when designing the retention system.

1. SCOPE:

This ARP provides design guidelines based on currently available information for the impact safety design of the cabin occupant environment.

2. REFERENCES:

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Schneider, L. W., et al.: Biomechanical Properties of the Human Neck in Lateral Flexion, SAE 751156, Proc. 19th Stapp Car Crash Conf., SAE P-62, November, 1975.

Snyder, R. G.: State-of-the-Art: Human Impact Tolerance, SAE 700398, August, 1970.

Stalnaker, R. L., et al.: Side Impact Tolerance to Blunt Trauma, SAE 730979, Proc. 17th Stapp Car Crash Conf., SAE, 1973.

Twigg, D. W., and R. N. Karnes; PROMETHEUS, A User-Oriented Program for Human Crash Dynamics, Report No. BCS 40038, Office of Naval Research, November, 1974.

3. DEFINITIONS:

3.1 Occupant Environment:

The structural area and components which comprise a transport aircraft cabin and which the passengers and cabin crew may impact during turbulent flight and emergency conditions, such as survivable crashes.

3.2 Structural Area:

The space adjacent to the occupants which any part of the occupants' bodies may impact during the conditions cited in paragraph 3.1.

4. TYPICAL DESIGN CONSIDERATIONS (PHYSIOLOGICAL):

4.1 Head and Neck:

The strength of facial bone under localized impact is relatively low because of the thinness of the facial bones. If the impact load can be distributed over the facial area, the face acts as a unit and its strength approaches that of the cranial vault. Areas to be contacted by the head should be designed for load distribution as well as energy absorption. The load distribution pad should allow the face to penetrate (at least 1.00 to 1.25 inches (2.5 to 3.2 cm)), insure full facial contact, and result in a total resisting load at the time of about 1,100 lb (4890 N). The understructure should plastically deform at between 1,100 and 1,200 lb (4890 - 5335 N) to absorb the energy of the impact. The effect of the cover material over the padding should be considered in the design, since some cover materials increase the resistance to load as much as 100 percent. The understructure should provide even support for the load distribution padding and should not present "hard spots" during deformation.

Angular acceleration of the head can cause loss of consciousness as well as injury. Although firm criteria are not available, localized contact with the head which could produce angularization of the head with respect to the torso should be avoided. Acceleration of the body, without head support, can produce equivalent results. This is of particular concern where "whiplash" reaction could occur due to hyperextension of the head over a backrest as a direct result of the accident or as a result of elastic rebound of the body after the accident. Voluntary head ranges of motion for healthy young subjects appear to be about 35° laterally right or left, 50° forward (flexion), 55° rearward (extension), and 68° right or left rotation. Elderly subjects can show a decrease of over 40% of voluntary range of motion relative to young subjects. The voluntary range of motion can be exceeded during impacts, with injury appearing at about 60° lateral head motion and 80° hyperextension. Localized impact to the neck can produce fracture of the laryngeal cartilage at loads between 90 and 100 lb (400 - 445 N).

4.2 Torso:

Chest impact tolerance varies widely with the impact conditions and the biological characteristics of the person involved. Elderly subjects generally have a lower injury threshold than do young subjects and, for the distributed loads, injury appears to be more closely associated with chest deflection than with the magnitude of the load. Chest deflections of less than 2 inches (5.1 cm) have been found to produce only minor injuries. Nevertheless, for design purposes, an impact load distributed over the sternum and producing a force of 400 lb (1780 N) can be considered to produce only moderate injury.

Fracture of ribs and sternum occur at higher loads, up to 1,000 to 1,500 lb (4450 - 6670 N). Internal injuries to the heart, great vessels, or lungs, are most serious and can occur at relatively low loads.