United States
A·T·B·C·B

GUIDELINES
FOR
AIRCRAFT BOARDING CHAIRS

U.S. Architectural and Transportation Barriers Compliance Board
1331 F Street, N.W. • Suite 1000 • Washington, D.C. 20004-1111

Guidelines
for
AIRCRAFT BOARDING CHAIRS

A Technical Paper on the Design of
Chairs Used Primarily for
Enplaning and Deplaning
Physically Handicapped Passengers

Prepared for:

ARCHITECTURAL AND TRANSPORTATION BARRIERS COMPLIANCE BOARD

1331 F Street, N.W.
Suite 1000
Washington, D.C. 20004-1111

Prepared by:
AMERICAN INSTITUTES FOR RESEARCH
45 North Road
Medford, MA 01730
(617) 275-0800

PREFACE

Aircraft boarding chairs, wheelchair-like devices used to transport disabled passengers onto airplanes, have been cited for safety and other problems. The Architectural and Transportation Barriers Compliance Board (ATBCB), in an effort to gain more information, distributed a survey on boarding chairs through the *Federal Register (49 Fed Reg 36210, September 14, 1984).* Passengers using aircraft boarding chairs responded by reporting complaints regarding safety, comfort, independent mobility, and personal dignity. In response to these problems and complaints, the ATBCB sponsored research to examine aircraft boarding chairs. The objective of the research was to develop non-binding guidelines aimed at improving aircraft boarding chair design and use.

The ATBCB retained the services of a human factors engineering consulting firm to perform the research and develop performance specifications. A human factors team, which included human factors engineers and a physician and physical therapist specializing in wheelchair design and prescription, analyzed existing aircraft boarding chairs in both their static state and during use. This approach permitted a comprehensive evaluation of the physical features of aircraft boarding chairs and the "human-machine" interactions. A draft advisory standard was reviewed by the ATBCB, industry experts, boarding chair designers, airline personnel, airport operators and aircraft boarding chair users prior to publication for public comment.

On May 15, 1986, the ATBCB published a proposed advisory standard in the *Federal Register (51 Fed Reg 17762),* for the purpose of eliciting public comment. Shortly after publication in the *Federal Register,* a copy of the proposal was sent to each of a group of reviewers (rehabilitation engineers, designers, air carriers, physical therapists, consumers, and governmental agencies) previously identified by the contractor and to members of the National Transportation Facilitation Committee (NTFC) subgroup on Air Travel Accessibility. Together these groups include a broad cross-section of air carriers, wheelchair designers and manufacturers, rehabilitation engineers, government officials, and disabled consumers. In addition, copies were sent to the committee developing wheelchair standards convened by the American National Standards Institute (ANSI) from the Rehabilitation Engineering Society of North America (RESNA), past participants in the Access to the Skies conferences, Air Transport Association (which represents major carriers), Regional Airline Association (which represents most of the small regional carriers), Airline Pilots Association, Airport Operators Council International, Association of Flight Attendants, National Air Carrier Association, Society for Advancement of Travel for the Handicapped, Paralyzed Veterans of America, National Council of Independent Living Centers, Transport Canada, and Rehabilitation International USA among others.

The ATBCB received a total of five substantive comments addressed to Docket Trans-1-86. An analysis of the public comments and associated changes to the May 15, 1986, published draft are provided in the sections which follow.

On March 9, 1987, the Board's Standards Committee reviewed the final report submitted by the contractor, including the incorporation of comments submitted by those who responded to the *Federal Register* publication. The Committee recommended that the product of this research be published as a technical paper. The contents should be viewed as the product of the contractor, distributed by the Board in the furtherance of its technical assistance mandate, not to be interpreted as a determination by the Board as to the suitability of specific provisions.

ANALYSIS OF PUBLIC COMMENTS

In the May 15, 1986, *Federal Register* publication of the proposed advisory standard, the ATBCB included an invitation for general comments on the technical provisions and specific comments on the following four issues:

1. Use of the 99th percentile male weight, as opposed to the 95th percentile male weight, in guidance associated with load bearing;
2. The cost impact of the proposed advisory standard in terms of new designs, existing boarding chair modifications and boarding chair replacement;
3. Whether the final advisory standard, when published and provided for public information, should also be included in the *Code of Federal Regulations* even though it will be a non-binding standard;
4. The size of the area on which the downward force is applied to the seat [see guideline 4.1(d)].

The limited number of comments was interpreted as a sign of concurrence with the proposed technical provisions given that a large number of comments typically signals disagreement and controversy over the published material. In fact, the majority of comments received supported the development of the document and concurred on technical details. The Eastern Paralyzed Veterans Association (EPVA) stated, "In general terms as this standard relates to the nature of our membership, we believe that it is an excellent document." EPVA cited eleven (11) specific items it considered strong points. One respondent who also is a physically handicapped traveler stated, "I was impressed with the comprehensive, competent effort evident in the draft."

It is worth noting that, although copies of the proposal were sent to major airlines, aircraft manufacturers, and especially aircraft boarding chair and wheelchair manufacturers, no comments were received from any of these organizations.

Specific comments (paraphrased) and associated analyses by the human factors engineering consultant are presented below. Comments received which affirmed the contents of the guidelines have not been addressed.

PUBLIC COMMENTS AND ATBCB RESPONSES

One respondent suggested that, instead of transferring the disabled person laterally, a transfer from a ninety degree angle would be less taxing and safer for aircraft personnel. This suggestion relates to transfer procedures versus boarding chair design. The suggested transfer method would require an area wider than the boarding chair in front of the passenger's seat and involves standards for seating access, an aircraft cabin design topic not addressed in the guidelines. No change was made to the technical provisions.

Another respondent recommended use of the 95th (as opposed to the 99th) percentile male weight in guidelines associated with load-bearing capacity. Since only one respondent among all reviewers recommended use of the 95th versus the 99th percentile value, the 99th percentile male weight value was retained in the load-bearing capacity guidelines.

A representative of the Minnesota State Council for the Handicapped recommended inclusion of the advisory standard in the *Code of Federal Regulations* even though it would be a non-binding standard. The ATBCB has determined that publication in the *Federal Register* and codification in the *Code of Federal Regulations* could be misinterpreted as giving the guidelines more weight than they are intended to have and has instead decided to publish a technical paper as a source of information only.

Another respondent suggested modifying Appendix draft test procedure (ISO/173 SCI/WIC-220) to include a note stating that domestic standards should be in effect within the year and will supersede the draft standards at that time. In concurrence, reference to the RESNA/ANSI wheelchair standards was added to Appendix A.

One respondent pointed out that several federal government organizations, e.g., IRS and Social Security, use the word "disabled" exclusively to mean unable to earn an income by reason of impairment. The respondent suggested that it may increase consistency in federal terminology to substitute the word "handicapped" instead. The term "disabled" had originally been selected because many individuals find the term "handicapped" demeaning. However, the reason cited for using the term "handicapped" was deemed justified and the change was made.

Another respondent felt that the topic of boarding chair comfort should be given additional emphasis in the design guidelines. While improvement in comfort is intrinsic to many of the guidelines, such as recommendations on seat padding and use of armrests, the purpose of the guidelines is to improve safety and accessibility. Therefore, no additional comfort performance guidelines were considered warranted or appropriate.

One respondent felt that folding backrests should be recommended. The document identifies the need for easy transfers and suggests folding features where needed to meet the performance criteria [see 4.3(i)]. The technical provisions have not been made more specific since they are limited to performance guidelines.

Concerning Section 4.7(b), another respondent felt that the wording indicated that four separate restraints should be used and believed that four separate restraints would not be cosmetically acceptable to many passengers. The respondent suggested stating that there do not necessarily have to be four separate belts. No change was made to the technical provisions since they specify restraint performance by virtue of support functions, not a belt design. It is preferred to allow designers to develop their own design solution which meets the four stated restraint functions.

One respondent believed that USDOT regulations have been in effect since 1979 which prohibit the carrying of disabled passengers up and down stairs for access to the aircraft. It was found that, while the regulation cited requires airport operators to provide certain boarding equipment, it does not prohibit carrying passengers up stairs. Therefore, no changes were made to guidelines which reference aircraft boarding via stairs.

Regarding the four specific issues identified by the ATBCB for comment, issues 1 & 3 were addressed above. A single comment which concurred with the document's contents regarding issue 4 was the only response to that question. No respondents addressed the cost impact issue; no boarding chair manufacturers commented on any portion of the proposal.

Technical assistance with respect to this and related subjects is available by writing to Office of Technical and Information Services, ATBCB, 1111 18th St. N.W., Washington, D.C. 20036-3894 or by calling (202) 653-7848.

CONTENTS

INTRODUCTION

TECHNICAL PROVISIONS

INTRODUCTION

I THE PURPOSE OF THE TECHNICAL PAPER

This technical paper is intended to promote improvements in the accessibility of facilities and services to disabled people. As described in Section II, this particular document is part of a larger effort by the ATBCB to provide technical assistance on eliminating architectural and transportation barriers encountered by disabled people. The ATBCB's mechanism for accomplishing this goal with respect to aircraft boarding chairs is the publication of guidelines on their design and use.

1. WHY BOARDING CHAIR DESIGN GUIDELINES WERE CREATED

The guidelines presented in this paper do not constitute a legally enforceable regulation. Neither are they necessarily exhaustive or definitive. Rather, since the ATBCB does not have legal jurisdiction over such devices, this technical paper was deemed the most effective and appropriate means to promote and facilitate improvements in aircraft boarding chair design and use. The need for some form of guidance arises from safety problems and complaints regarding these chairs. The technical provisions provide a range of guidance that is intended to help eliminate the most common problems encountered by disabled passengers and airline attendants.

The development of the guidelines is the result of several years work in the aircraft boarding chair area. Over several years, representatives of the government, airlines, airport operators, aircraft boarding chair manufacturers and wheelchair users have organized and worked together in an effort to identify problem areas and improve boarding chair design and use.

Many of the reported problems appear to be due to design while others appear to be due to improper use of the devices. The latter may be due to improper or inadequate training. Therefore, the technical paper addresses both of these areas.

2. APPLICATION OF THE GUIDELINES

Aircraft boarding chair designers and specifiers should find the comprehensive design guidance useful. It can be utilized as the basis for detailed design criteria or specifications to develop new designs, or enhance an existing one, or to develop product specifications and evaluation checklists. Aircraft boarding chair design is an optimization problem that requires tradeoff analysis so the guidance is performance-oriented rather than prescriptive to allow for creative, trade-off solutions. Data on desirable design features are based on user testing and preferences to which the designer or specifier may not otherwise have access.

The technical provisions identify performance requirements for boarding chairs that the purchaser should look for in devices on the market and identifies how a specific feature should operate or be designed to satisfy passenger and attendant needs. It can also be used to improve boarding chair maintenance and airline attendant training. The technical provisions may also help to evaluate boarding chairs currently in use and help determine whether they should be replaced with improved products. The guidelines may also be useful when designing training courses.

In addition, aircraft designers may find the technical provisions useful in designing seating layouts and interior configurations which facilitate boarding chair use.

3. SCOPE OF THE GUIDELINES

The technical provisions apply to aircraft boarding chairs. They are not intended to be applied directly to devices used for functions other than aircraft boarding, such as on-board chairs used for in-flight mobility or wheelchairs used for mobility within the airport terminal. However, some features desirable for boarding chairs may also be desirable for on-board chairs and, where an on-board chair is used for boarding and deplaning, the technical provisions are applicable.

The scope of the guidance provided in this technical paper is broad enough to accommodate the many types of aircraft boarding chairs currently in use. The broad scope also supports the objectives of sustaining or increasing the number of boarding chair manufacturers. The technical provisions are not intended to restrict design freedom. The performance-based guidelines are designed to eliminate safety hazards while permitting different and creative solutions to the engineering problems.

Not all of the guidance provided will or can be applied to a single type or design of aircraft boarding chair. This is due to the fact that such chairs have competing design requirements such as maximum adjustability and mechanical simplicity. It is the responsibility of the user to interpret the guidelines and determine where specific provisions apply. Technical assistance to supplement the technical paper and provide guidance for interpretation and implementation will be available through the ATBCB.

4. HOW THE TECHNICAL PAPER IS ORGANIZED

This document is divided into six parts. Sections I and II provide background information regarding the function of the guidelines and the topic of architectural barriers and aircraft boarding chairs. The technical provisions themselves are in four parts. Part 1 provides a list of key terms; Part 2 defines the physical characteristics of the users, both the passenger and attendant, and the environment in which the boarding chair is used. The remainder of the provisions, Parts 3 and 4, consist of detailed guidelines for boarding chair design. Appendix A provides the version of the International Standards Organization (ISO) test procedures which were used to define whether a specific performance criterion was met. Appendix B contains guidelines on personnel training and defines who should be trained, how often training should be conducted, and the extent of training needed.

Amendments, the Board is required to "insure [sic] that public conveyances, including rolling stock, are readily accessible to, and usable by physically handicapped persons" (29 U.S.C. at 792(b)(8)).

The Amendments also require the ATBCB, in cooperation and consultation with other concerned agencies, to "develop standards and provide appropriate technical assistance to any public or private activity, person or entity affected by regulations prescribed pursuant to this title [Title V of the Rehabilitation Act] with respect to overcoming . . . transportation . . . barriers" (id. at 792(d)(3)).

Since the ATBCB had received a number of reports of accidents or near-accidents involving the use of aircraft boarding chairs, the Board was concerned with the lack of standards that would ensure adequate safety features, equipment and procedures necessary to secure the safe enplaning and deplaning of physically disabled passengers by airport operators and airline carriers. This concern led to further research and the initiative to develop this technical paper.

3. HOW THIS TECHNICAL PAPER WAS DEVELOPED

The development of this document was based on human factors engineering research and analysis. The human factors engineering research conducted to develop the technical provisions included full consideration of the product users (disabled passengers and airline attendants). Research methods included a complete literature search, static evaluations of the current product designs, dynamic observations of the products in use in their intended environment (the airport skybridge and aircraft), an assessment of the user's physiological needs, and extensive interviews with wheelchair users, airline attendants and boarding chair designers.

A set of problems, complaints, and concerns regarding boarding chairs was derived from each of the techniques. For each of the problems, complaints, and concerns identified, as well as for potential problems not actually observed or reported, a performance guideline was written to help alleviate the problem. The guidelines were then classified by topic (aircraft boarding chair feature, documentation issue, or training concern) for inclusion in this technical paper.

Standards or standardized test procedures developed by industry consensus groups such as the International Organization for Standardization (ISO) or the American National Standards Institute (ANSI) have been incorporated where available and appropriate. Preliminary drafts were circulated for review and comment to the National Transportation Facilitation Committee (NTFC) subgroup on Air Travel Accessibility, members of the ATBCB, and over 60 reviewers selected for their expertise in the subject area.

4. THE NEEDS OF THE PASSENGERS AND AIRLINE PERSONNEL

The guidelines address the needs of both disabled passengers and airline attendants. For the passenger, the boarding chair must provide adequate body support and restraint. Typically, a passenger is seated in the boarding chair for approximately 5 minutes or less. However, under circumstances when flight changes must be made, delays occur, or a standard wheelchair is unavailable, the time spent seated in the boarding chair can extend to an hour or longer. In such cases, support, ease of body repositioning and passenger independent mobility are vital. Regardless of the length of time spent seated in the boarding chair, proper support can only be achieved if the boarding chair accommodates the size of the passenger.

The airlines are concerned not only with the safety and comfort of the passenger, but also with the safety and comfort of the airline attendant and the ease of use of the aircraft boarding chair. The attendant is susceptible to injury if the transfer is performed incorrectly. Often, the size of the attendant in relation to the size of the boarding chair and passenger makes a proper transfer difficult. If the airline attendant must assume an awkward position while boarding or deplaning a passenger, there is a potential risk of injury for both the attendant and passenger.

5. GOALS FOR BOARDING CHAIR DESIGNERS AND AIRLINES

It should be the goal of boarding chair designers and manufacturers to develop boarding chairs that minimize the potential for injury and increase overall comfort without sacrificing ease-of-use and low cost. The airline should select and purchase boarding chairs that best suit the needs of the passengers and attendants and provide adequate training for personnel. This technical paper provides guidelines to help fulfill these goals.

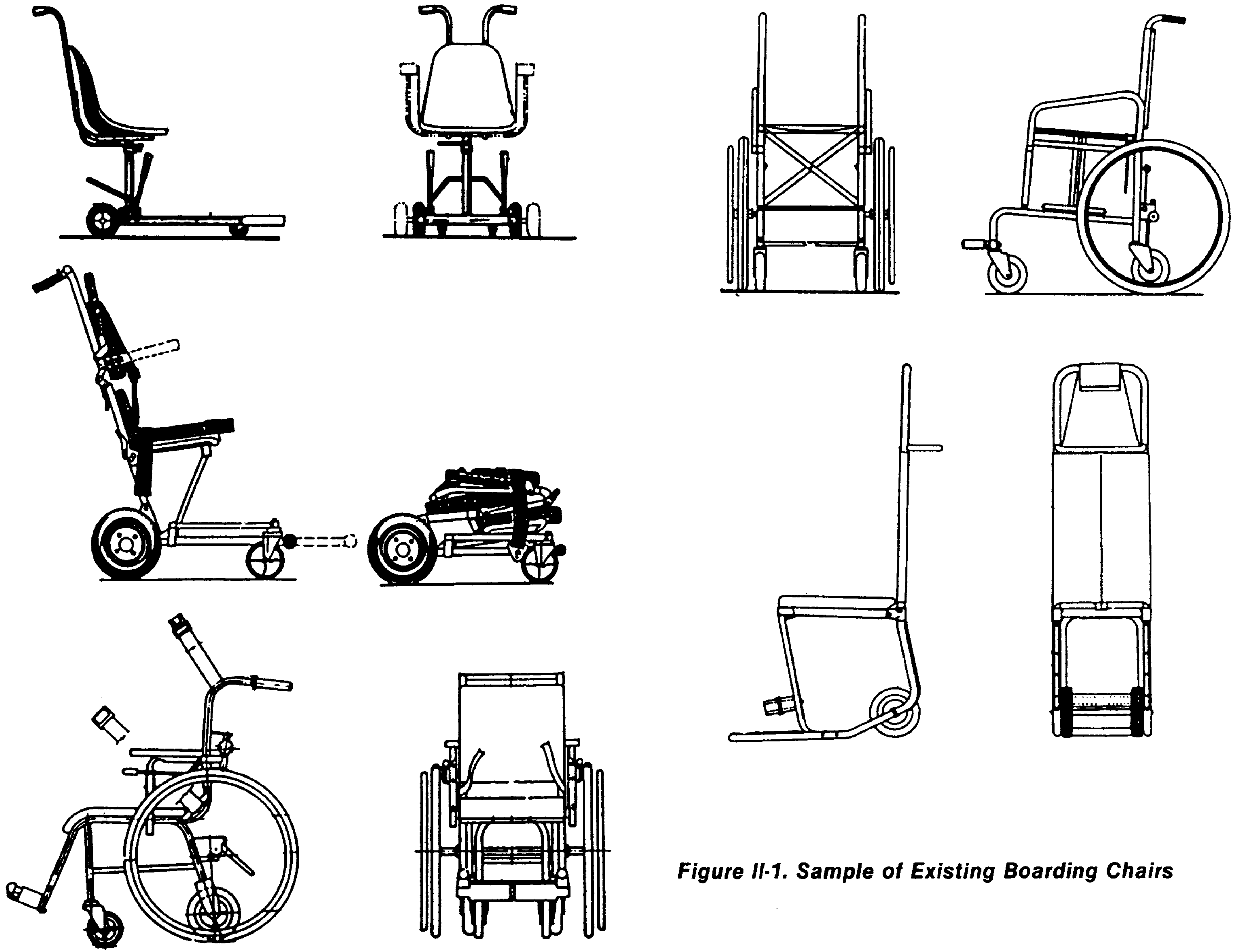


Figure II-1. Sample of Existing Boarding Chairs

TECHNICAL PROVISIONS

Part 1. Definition of Key Terms

Air Carrier Airport: Airport that serve airlines utilizing aircraft that seat fifty or more passengers or receive federal funds for terminal facilities. (REF: 49CFR Part 27, Section 27.5)

Aircraft Boarding Chair: Narrow, wheelchair-like device used to transport non-ambulatory passengers between the airport terminal gate, via a skybridge or aircraft steps, and the aircraft seat.

Anthropometrics: Measurement of various human physical traits such as size, mobility (range-of-motion) and strength.

Attendant: Any individual who participates in the task of transporting and transferring a passenger; can be an airline employee, a service contractor, or a passenger's private assistant.

Boarding: The process of moving a passenger from the terminal, via a skybridge or aircraft steps, to the aircraft seat. The boarding task incorporates both transporting and transferring tasks.

Boarding Chair: Same as aircraft boarding chair

Channeling: A groove used to direct or guide an attached mechanical part such as a strap in a specified direction.

Clarity of Function: Degree to which it is obvious how a boarding chair feature should be used.

Deplaning: The process of moving a passenger from the aircraft seat, via a skybridge or aircraft steps, to the airport terminal. The deplaning task incorporates both transporting and transferring.

Extended Periods (period of time) : A duration of 15 minutes or longer.

5th Percentile Female: An adult woman who is smaller than 95% of the female population for a given parameter.

Independent Mobility: The capability of moving without the help of another person while using a manual device.

ISO (Test) Dummy: A test apparatus, developed by the International Organization for Standardization (ISO), used as an equivalent human load for wheelchair testing. The dummy is equivalent to a male weighing 220 lbs with a standing height of 78 inches and is constructed according to Draft International Standard ISO-DIS 7176/11.

Lifting Device: Device used to elevate disabled passengers to the aircraft cabin entrance level, eliminating the need to use a stairway (REF: 49 CFR Part 27, Subpart D, Section 27.71(a)(2)(v))

95th Percentile Male: An adult man who is larger than 95% of the male population for a given parameter.

Quadriplegia: Paralysis involving the trunk and all limbs.

Repositioning: Shifting body position to redistribute weight.

Restrain: To restrict body movement or keep the body under control.

Skin Ulceration: Breakdown of skin tissue caused by prolonged external pressure on the skin.

Skybridge: Ramp that connects the airplane cabin door to the airport terminal gate entrance.

Standard Loading Mass: A regulation soccer ball (European football) filled with lead shot of approximately 3.0 mm to 4.0 in diameter to a specified weight (ISO definition).

Standard Loading Pad: A rigid circular object 100 mm in diameter whose face has a convex spherical curvature of 300 mm radius with a 12 mm front edge radius. Pad should be faced with a layer of hard polyether foam 2 mm thick (ISO definition).

Storage Location: A place within the terminal (not on the aircraft) where boarding chairs are kept when not in use.

3.0 Safety Factor: A 200% increase in load capacity to ensure safety. To calculate load capacity with a 3.0 safety factor, multiply the baseline load by 3.0. This safety factor is generally accepted by wheelchair manufacturers and the ISO.

Transfer: The process of lifting up and moving a passenger from one seated position to another.

Transfer Board: Accessory used to bridge the gap between the aircraft boarding chair and aircraft seat. Passenger slides over the board thus reducing the time the passenger is held by the attendants.

Transport: The process of moving a passenger in a boarding chair whether it be by pushing, pulling or lifting.

Part 2. Human and Environmental Factors

2.1 Physical Characteristics of Users

Designing aircraft boarding chairs requires close attention to the physical dimensions and biomechanical capabilities (together termed anthropometrics) of the people who will use the devices: the disabled passenger and the airline attendant. The aircraft boarding chair, the disabled passenger, and the airline attendant together form a system which has several physical interrelationships or interfaces. Designing the interfaces which meet the anthropometric requirements of the users will help assure that the "Boarding Chair" system is easy and safe to operate.

Body Dimensions

The boarding chair user population includes both adult males and females. Therefore, the physical characteristics of the aircraft boarding chair must accommodate a large range of human dimensions and physical capabilities which varies from small females to large males. It is normal in engineering and design to develop a product to meet the anthropometric requirements of 95% of the user population; meeting a larger range which approaches 100% is usually infeasible or unwarranted. The range of anthropometric data is normally defined in terms of percentiles. To match the anthropometrics of approximately 95% of the aircraft boarding chair user population, one needs to find minimum and maximum anthropometric values (for a given parameter) for the 5th percentile female and the 95th percentile male, respectively.

A percentile is determined as follows:

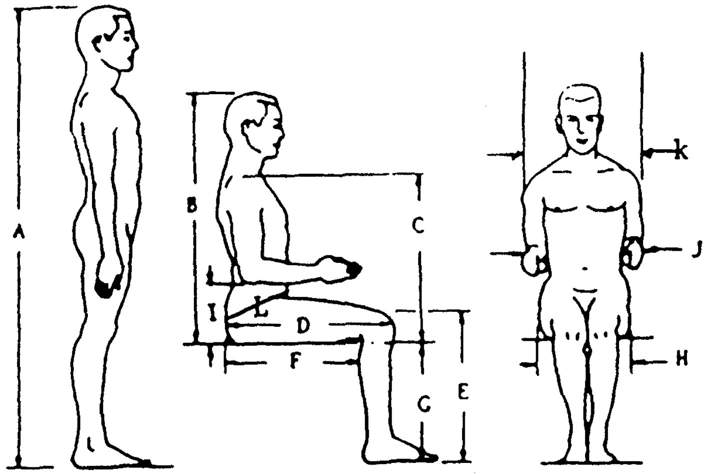
> For a 5th percentile female dimension, 5 out of 100 females would be smaller in that dimension.

The result of calculating parameter values for the 5th percentile female and 95th percentile male is a practical range of physical characteristics that can be used as a basis for design. This approach optimizes a design but may not meet as effectively the needs of 5% of the (small) females and 5% of the (large) males in the user population. It is not the intent to exclude any portion of the population. In practice a "5th - 95th" design usually accommodates more than 95% of the user population.

Anthropometric data is presented in Figures 2-1 and 2-2 for use in designing aircraft boarding chairs. Figure 2-1 provides overall dimensions for the 5th percentile female and the 95th percentile male. Figure 2-2 provides hand, arm, foot and head dimensions for the same anthropometric range. This data is referenced from the "Human Factors Design Handbook." Additional data that relates specifically to the aircraft boarding chair design problem is presented below. The data includes body weight and strength. Other anthropometric data can be found in NASA Reference Publication 1024, "Anthropometric Source Book, Volume I: Anthropometry for Designers."

Body Weight

Maximum body weight determines the maximum load or stress on the components and frame of the aircraft boarding chair: **A 99th percentile male weighs 241 lbs.** A weight of 241 lbs. should be used

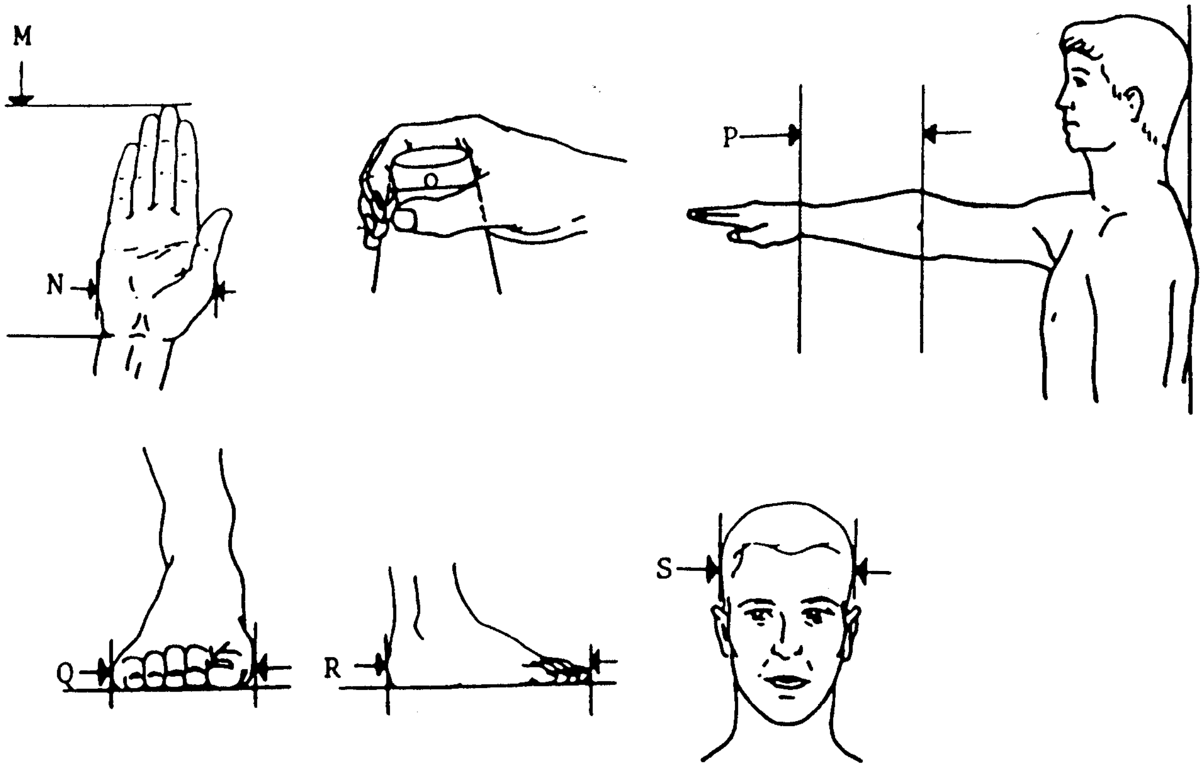


	DIMENSION	5% Female	95% Male
A	Standing Height	59.0"	72.8"
B	Sitting Height	30.9"	38.0"
C	Shoulder Height	18.0"	25.0"
D	Upper Leg Length	20.4"	25.2"
E	Knee Height	17.9"	23.4"
F	Seat Length	17.0"	21.6"
G	Seat Height	14.0"	19.3"
H	Seat Width	12.3"	15.9"
I	Elbow Height	7.1"	11.6"
J	Elbow Room	12.3"	19.9"
K	Shoulder Breadth	14.4"	19.6"
L	Hip Circumference	37.0"	44.5"

	5th Female	95th Male
Weight	104 lb	241 lb

Source: Woodson, Wesley E., Human Factors Design Handbook, 1981.

Figure 2-1. Overall Anthropometric Data



	DIMENSION	5% Female	95% Male
M	Hand Length	6.4"	8.2"
N	Hand Breadth	3.2"	4.4"
O	Grip Diameter*	1.64"	2.1"
P	Elbow to Wrist	9.6"	12.0"
Q	Foot Breadth	3.2"	4.3"
R	Foot Length	8.7"	11.2"
S	Head Breadth	5.4"	6.4"

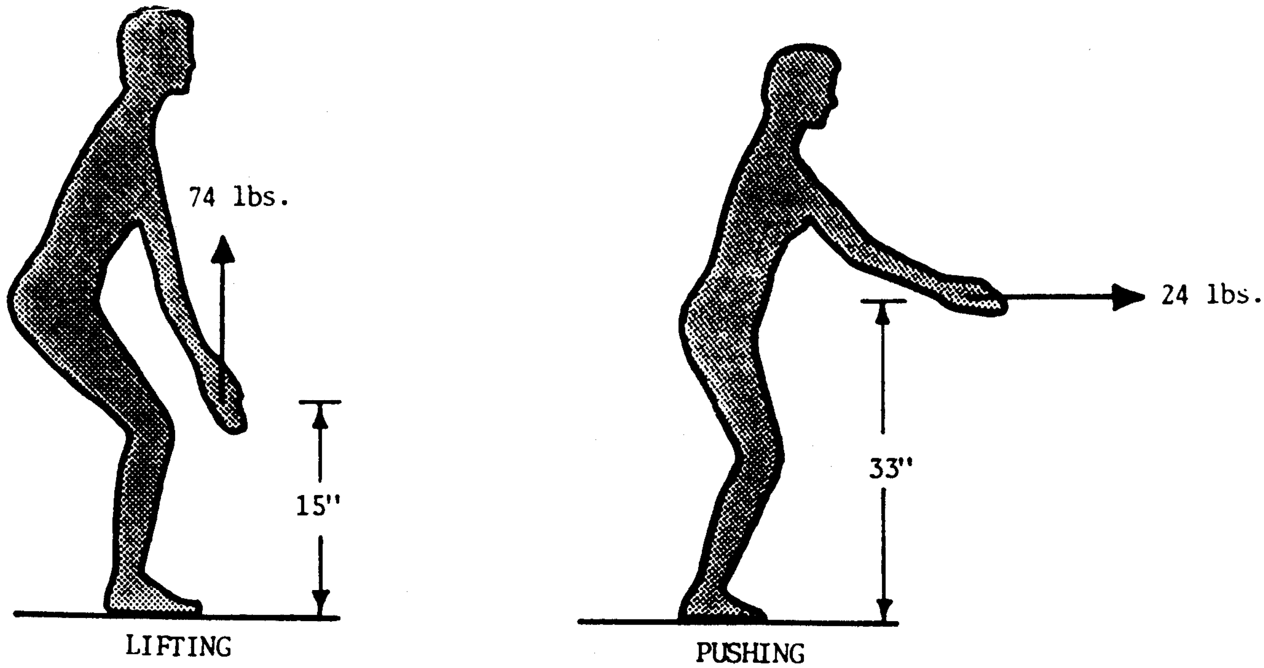
Sources: Woodson, Wesley E., Human Factors Design Handbook, 1981.
* NASA Reference Publication 1024.

Figure 2-2. Hand, Arm Foot, and Head Anthropometrics

as a design basis with appropriate consideration given to the use of safety factors in design, since there are still many people who weigh more than 241 lbs. Clearly, an aircraft boarding chair can not be designed to accommodate the heaviest person imaginable. Nonetheless, the designer is advised to maximize weight bearing capacity in aircraft boarding chair design. The 99th percentile weight has been used, as opposed to the 95th percentile (which is 224 pounds), since the potential for damage or collapse of the aircraft boarding chair is a significantly more serious safety hazard than the failure of other design features that affect comfort more than safety.

Physical Strength and Endurance

Figure 2-3 illustrates the lifting strength and pushing force capacity of the 5th percentile female. A 5th percentile female in a standing position is capable of lifting 74 pounds from a starting point 15 inches off the ground. The same individual can apply a horizontal force of 24 pounds to a handle device which is 33 inches off the ground. Strength declines continuously after initial application to the point that strength is reduced to 25% of the original maximum capacity after four minutes of force application. **This data suggests that many disabled passenger transfers will require two or more attendants or that only relatively strong attendants will be capable of performing all aspects of the boarding task which culminates with a transfer (involving a lift).** For this reason, strength and endurance requirements of the transporting task should be minimized in any given design. Attendant training should incorporate procedures for transporting heavy passengers.



Sources: Diffrient, Tilley and Harman. Humanscale 4/5/6
MIL-STD-1472C

Figure 2-3. 5th Percentile Female Lifting and Pushing Strength

Physical Disability

Aircraft boarding chairs should be designed for passengers with maximum disability. Therefore, a person with quadriplegia involving total loss of arm and leg control and weakened head control should be considered as the design basis. Designs should also consider the potential needs of individuals with missing limbs or deformities and/or involuntary movements.

2.2 The Aircraft Boarding Environment

Aircraft are not optimized for wheelchair access. Aircraft cabin interiors and aisles, in particular, are designed to be narrow so that the cabin can accommodate the maximum number of people. The narrow aisle is one of the major complicating factors in disabled passenger access. The other major factor is the continuing lack of skybridge connections to airplanes at many smaller airports and with many commuter airlines, requiring the use of a stairway to board an airplane. Stairways are still used at some airports to board even large, wide-body airplanes; especially during rush periods of the day when there are not always enough gates with skybridges available. The U.S. Department of Transportation requires that operators at federally assisted airports assure that adequate assistance is provided for enplaning and deplaning handicapped persons. Boarding by jetways and by passenger lounges are the preferred methods for movement of handicapped persons between terminal buildings and aircraft at air carrier airports; however, where this is not practicable, operators at air carrier airport terminals shall assure that there are lifts, ramps, or other suitable devices not normally used for movement of freight that are available for enplaning and deplaning wheelchair users [49 C.F.R. 27.71 (a) (2) (v)]. A lift eliminates the need to carry the passenger up a stairway. However, lifts are not consistently available and stairways are often used.

Since stairways will continue to be a common means of aircraft access for the indefinite future, aircraft boarding chairs must be designed so that they are safe to use on stairways.

Stairway operation is the most critical mode of aircraft boarding chair use. In stairway operations, the dropping or tipping hazard is greatest for the passenger, while the physical exertion requirement for attendants is also at its peak. Such operations also cause the disabled passenger the greatest discomfort and anxiety. Boarding chair design and boarding methods must be implemented which minimize the risk of injury.

Skybridges are the preferred boarding approach. There are two basic types of skybridges: stationary and movable. Stationary skybridges have a fixed floor inclination. Movable skybridges have vertical and horizontal adjustability and can result in a steeper overall floor incline of up to 7.5 degrees (13%). The slope angle of the connecting ramps between skybridge sections may be as high as 13 degrees (25%). The movable skybridge is also narrower to enhance its movability but satisfies the width requirement for wheelchair access.

Passengers who use wheelchairs normally travel down the skybridge in standard-sized wheelchairs. At the base of the skybridge they are transferred into an aircraft boarding chair and brought onto the airplane. When a skybridge is used for access, the only potential architectural barriers outside the aircraft are the inclination of the skybridge floor and the gap at the threshold between the aircraft cabin door and the skybridge. A steep skybridge floor inclination requires extra strength to control the wheelchair or boarding chair (in the case that the boarding chair is used from the terminal gate point). Brakes are required in case there is a need to stop and hold the boarding chair on the incline. The threshold gap may require backward tilting of the aircraft boarding chair to overcome it and has implications in wheel and caster design.

The aircraft, depending on make and cabin configuration, may present an access problem. This is particularly true for small commuter aircraft. Although the cabin doorway and entranceway are wide enough to permit easy entry into the aircraft with a boarding chair, the aisles between seats are narrow. The narrow aisle width increases the danger of a passenger's limbs getting wedged between the boarding chair and an aircraft seat. The narrowness of the aisle also presents a problem when the passenger must be moved from the boarding chair to the aircraft seat. The attendants are required to reach around the seated passenger to lift him or her into the aircraft seat. Space for the attendants' arms in the area between the aircraft seats and the boarding chair is tight. Therefore, in cases where the aircraft seat armrest does not pivot out of the way, transferring is further complicated. A fixed armrest necessitates that one attendant reach over the back of the aircraft seat and lift the passenger up over the armrest. This presents risk to the passenger and attendant. Reaching around the back of the seat does not permit the attendant to obtain secure grip of the passenger and the approach is generally less gentle and comfortable for the passenger. The attendant also risks back injury due to poor posture during lifting.

Part 3. Guidelines for Boarding Chair Use

3.1 Mobility

(a) Number of Attendants.

When boarding, a minimum of two airline attendants should be present to transport a passenger. If the passenger is particularly heavy or the attendant(s) is not physically strong, the transport task may require more than two attendants.

(b) Time.

Once the boarding chair is at the aircraft entrance, the time to prepare the boarding chair for passenger seating should be less than two minutes.

(c) Attendant Posture.

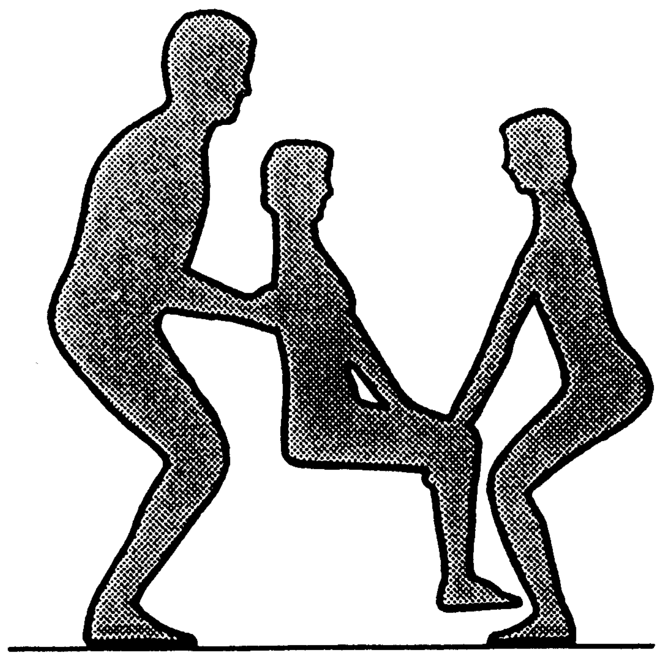
Transfers should not require the attendant to bend in awkward positions. Figure 3-1 illustrates the proper body posture that the boarding chair should permit.

(d) Passenger Posture.

The boarding chair design should ensure proper passenger posture. Figure 3-1 illustrates a proper body posture for passengers seated in a boarding chair.

(e) Boarding Chair Orientation.

The boarding chair should not require tilting for movement unless negotiating curbs, stairs, or similar barriers.



- BEND AT THE KNEES
- KEEP CENTER OF GRAVITY OVER THE KNEES
- USE A SYMMETRICAL POSTURE - DO NOT TWIST
- HOLD A FIRM, BALANCED STRAIGHT
- KEEP YOUR BACK STRAIGHT
- USE A SOLID GRIP - USE BOTH HANDS
- LIFT ABOVE THE OBJECT'S CENTER OF GRAVITY

Figure 3-1. Proper Posture for Transferring an Aircraft Boarding Chair Passenger

(f) Turning.

The occupied boarding chair should be able to turn within the confines of the boarding environment and the aircraft cabin layout shown in Figure 3-2. Turning should not require tilting or rocking the boarding chair.

(g) Ease of Movement.

The force required to push and turn (on a level surface) a boarding chair occupied by a 241 pound passenger (the 99th percentile male) should not exceed 24 pounds (the maximum force which can be exerted by a 5th percentile female).

(h) Ease of Transfer.

The boarding chair should be designed to facilitate the use of a transfer board.

(i) Vibration.

The boarding chair should be free of noticeable vibration when moving on a smooth surface such as a carpeted aircraft aisle.

(j) Alignment.

When the boarding chair is pushed in a straight line it should continue to track accurately along that path.

(k) Independent Mobility.

Boarding chairs **designed to be used in the airport terminal** should provide manual independent mobility for passengers who have manual independent mobility in their own wheelchairs.

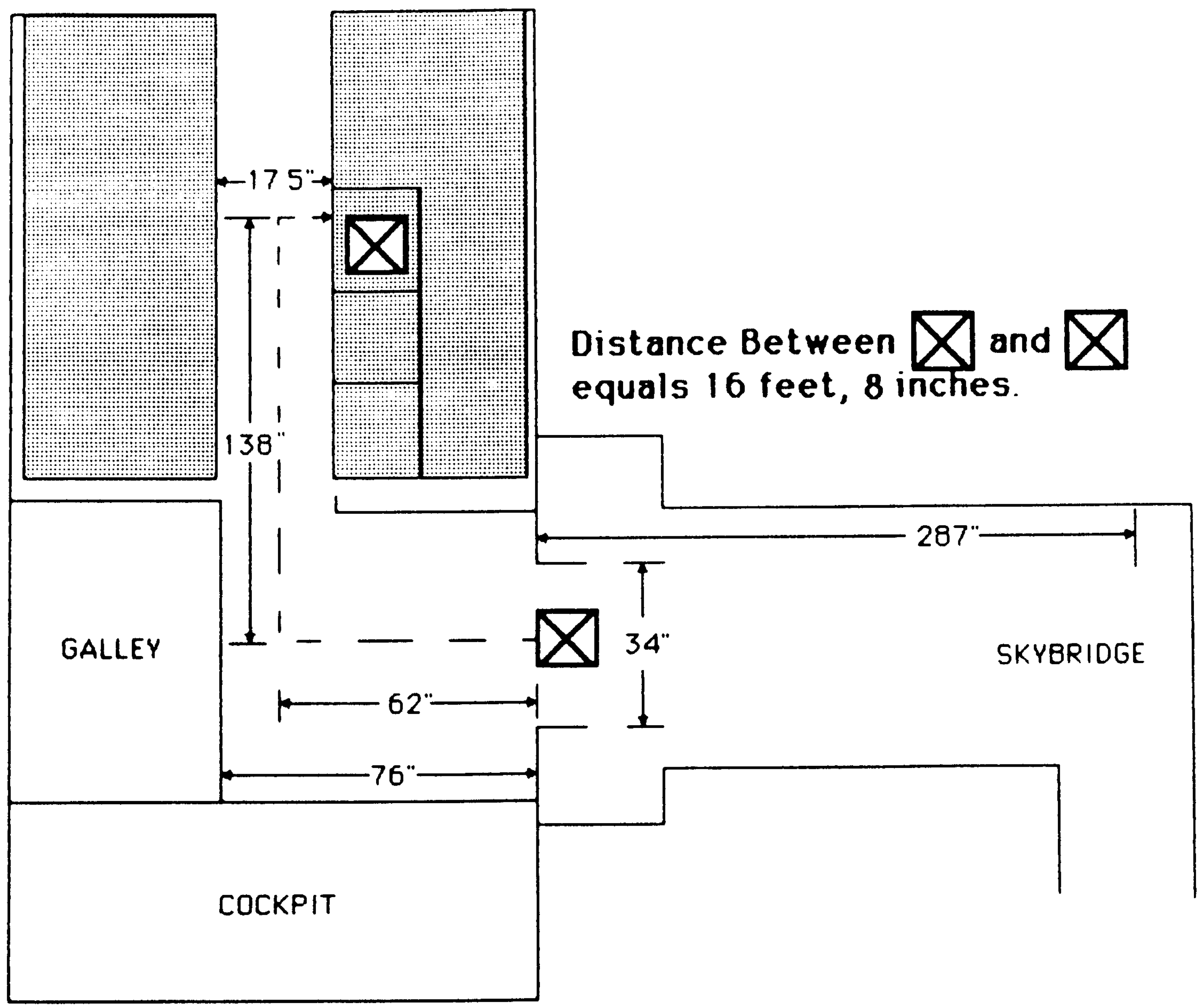


Figure 3-2. Typical Cabin Layout of a Jet Aircraft

(1) Locking Mechanism.

Wheel locks should be accessible to the passenger. To the extent possible, the force required to engage/disengage locks should not exceed that which a passenger with limited hand and/or upper extremity function can exert. Wheel locks should hold the boarding chair (occupied by the 100 kg ISO dummy) motionless when placed at a 13 degree angle (maximum skybridge ramp angle) and faced either uphill or downhill. Wheel locks should not cause tire damage or excessive wear.

3.2 Safety

(a) Posture.

The boarding chair should be designed so that the passenger and attendant maintain proper posture during the passenger transport and transfer. (see Figure 3-1).

(b) Support.

The boarding chair should provide adequate passenger body support for the full range of users, including quadriplegics and amputees. The passenger should not require supplementary seating or restraints outside those that are part of the boarding chair.

(c) Restraints.

The restraining system should prevent the passenger from falling out of the boarding chair under all circumstances.

(d) Hinges and Locking Mechanisms.

Hinges and locking mechanisms on movable and removable components should be located where they cannot pinch or damage the attendant's or passenger's skin or clothing.

(e) Releases.

Releases (for components such as locks and footrests) should be located where they cannot be accidentally activated (released). Where accidental activation is possible and a safety concern, a guarded release or two-step release procedure should be used.

(f) Rounded Edges.

The boarding chair design should incorporate rounded edges on all components to avoid injury to passenger, attendant, or passerby and to protect the physical environment (stairway, skybridge, airplane).

3.3 Maintenance

(a) Preventive Maintenance.

Preventive maintenance tasks, task frequency, and specific procedures should be specified by the manufacturer. Maintenance task descriptions should include inspecting, cleaning, and performing minor repairs. All parts requiring maintenance should be easily accessible.

(b) Cleaning.

Surfaces which come in contact with the passenger and attendant should be cleaned easily and cleaned as frequently as deemed appropriate by the airline. Boarding chair hardware components should be cleaned on a regular basis as deemed appropriate by the manufacturer. All surfaces and mechanisms requiring cleaning, as specified by the manufacturer, should be cleaned by airline personnel or the responsible contractor.

(d) Inspection.

Parts which are subject to wear should be easily accessed and inspected on a regular basis. Inspection procedures should not require special knowledge, skills, tools, or equipment and should be performed by airline personnel or the responsible contractor.

(e) Replacement of Parts.

Damaged or missing parts which are not part of the chair frame (main structure) should be available for purchase and replaceable according to paragraph 3.3(g).

(f) Tools.

Only common tools should be required to perform maintenance tasks. Specialized or one-of-a-kind tools should not be required for maintenance tasks performed by airline personnel.

(g) Spare Parts.

Components of the boarding chair which are easily replaced (such as fasteners and bearings) and not part of the chair frame (main structure) should be made readily available as spare parts stocked by the manufacturer and at least one other source. Available spare parts should be easily replaced.

3.4 Storage

(a) Damage Resistance.

Boarding chairs should be of durable construction to avoid damage during storage. Fabric on the chairs should be resistant to tears, stains, or fading which may occur during storage.

(b) Compactness.

When possible, boarding chair design should utilize adjustable features which maximize compactness during storage.

(c) Collapsibility.

Collapsible boarding chairs should lock in the collapsed position. Collapsible chairs should be easy to move when in the collapsed position. Reconfiguring the chair for use should be achieved easily and quickly.

(d) Removable Items.

To avoid loss or theft, removable components should be attached to the chair during storage, though not necessarily in their operational configuration. Configuring components for storage should be performed easily and quickly. Small parts (such as nuts and bolts) should remain fastened to the chair during storage.

(e) Loose Items.

Loose items (such as restraints) should have a clear method for storage so they do not get lost or damaged.

(f) Time Requirements.

Time required to prepare the boarding chair for storage should not exceed two minutes.

Part 4. Guidelines for Design Features

4.1 General Physical Characteristics

(a) Overall Dimensions.

The boarding chair should, to the extent possible, be sized to comfortably accommodate 95% of the passenger population (see section 2.1), but should not exceed the dimensional limitations of the aircraft on which it is to be used. The narrowest part of the aisle (17") is generally at the aircraft seat armrest height but wide ________________________.

(b) Overall Weight.

Overall weight should be minimized.

(c) Load Capacity.

The boarding chair should support 723 lbs (the 99th percentile male body weight with a 3.0 safety factor).

(d) Static Stability.

The boarding chair should not structurally deflect (bend), rock or tip from the placement of a 241 lb vertical, downward force at any point on the seat. The object should be a rigid circular object 4 inches in diameter (see ISO Definition for Standard Loading Pad). The boarding chair should also meet the requirements for static stability as defined in Draft International Standard ISO/DIS 7176/1 (See Appendix A).

(e) Static and Impact Strength.

For boarding chairs, the following sections of Draft

International Standard ISO/TC173/SCI N3, "Static and Impact Strength Test", should be applied:

(1) 1-5.7 (Background Test Information)

(2) 6.1.1 Armrest Downward Static Load Test

(3) 6.1.2 Push Handle(s) Downward Static Load Test

(4) 6.1.3 Footrest Downward Static Load Test

(5) 6.1.4 Tipping Levers Downward Static Load Test

(6) 6.1.5 Hand Grip Static Load Test

(7) 6.1.6 Armrest Upward Static Load Test

(8) 6.1.7 Footrest Supports Upward Static Load Test

(9) 6.1.8 Push Handle(s) Upward Static Load Test

(10) 7.0 Conditions for Acceptance After Static Strength Tests

(11) 8.1.1 Seat Impact Strength

(12) 8.1.2 Backrest Impact Strength

(13) 8.2.1 Drop Test Impact Strength

(14) 8.2.2 Rolling Test Wheels and/or Castors Impact Strength

For all above tests, the 220 lb ISO dummy should be used (See Appendix A for test procedures).

(f) Adjustable.

Where practical, adjustable features should be used to increase safety, support and comfort. The features should be easy to adjust and should not sacrifice chair and passenger stability.

(g) Removable Parts.

To avoid loss, the number of removable parts should be minimized, or, if possible, eliminated.

(h) Construction Materials.

Construction materials should be durable, damage resistant, fire retardant and low and high temperature resistant.

(i) Protective Features.

The boarding chair should have protective features (such as rounded edges and bumpers) to avoid damage to the aircraft boarding environment.

4.2 Seating

(a) Function.

Seating should accommodate 95% of the passenger population and should be designed to facilitate transfers by providing unobstructed access for lifting.

(b) Dimensions.

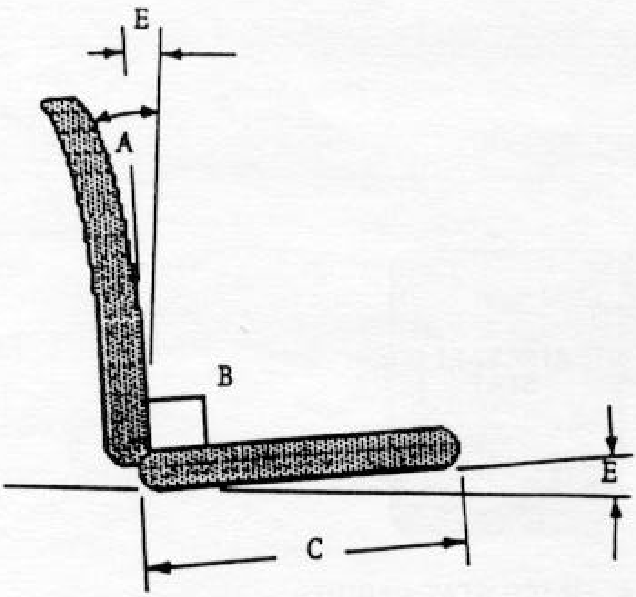
Seating should be sized according to the dimensions given in Figure 4-1.

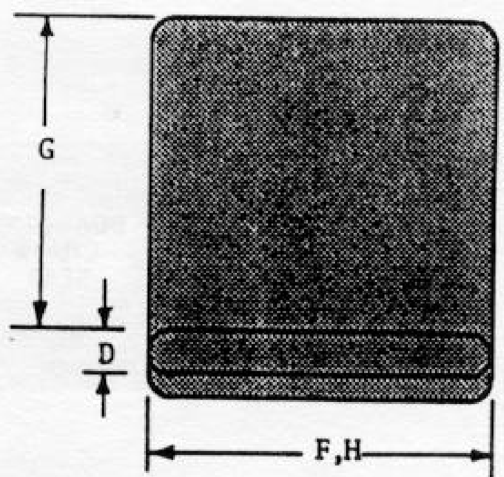
(c) Strength.

Seats should support a weight of at least 723 pounds (the weight of the 99th percentile male with a 3.0 safety factor) and should meet the requirements in guideline 4.1(e).

(d) Location.

Seat surface height (compressed) should be 17-19 inches to match the height of aircraft seats and should incline 5 degrees to increase body restraint (See Figures 4-2 and 4-3).





DIMENSION	VALUE
A Backrest, Optimum Angle (degrees)	8-10
B Backrest to Seat Angle (degrees)	90
C Seat depth (inches)	16
D Seat Thickness (inches)	2 (min)
E Seat Angle (degrees)	5
F Backrest width (inches)	15
G Backrest height (inches)	25
H Seat width (inches)	15

Figure 4-1. Seat and Backrest Dimensions and Angles

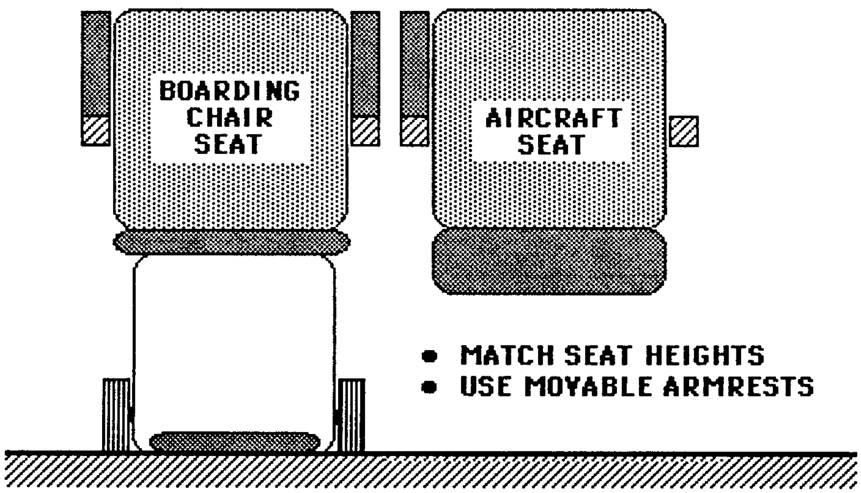


Figure 4-2. Seat Comparison

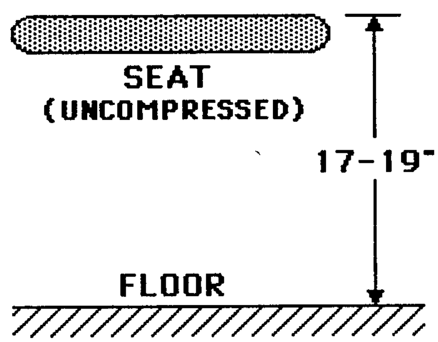


Figure 4-3. Seat Height

(e) Shape.

Seat shape should provide passenger body support and restraint and distribute body weight evenly to avoid the risk of skin ulceration. Seat shape should not hinder passenger transfers.

(f) Material.

Seat material should be water repellent, stain resistant, fire retardant, non-abrasive, durable, cleanable, and aesthetic. Based on ISO research, the cushion should be constructed of a good quality foam at least 2 inches thick with a indentation load deflection (ILD) of 70 as measured by ASTM Designation D 1564-71, "Standard Methods of Testing Slab Flexible Urethane Foam." The cushion cover should be stretchable or be fitted so that the top surface is 0.5 inches longer and wider than the foam pad. The cushion cover should be a color which is low in heat absorption so that the cover does not overheat (if left in the sun) and cause thermal trauma to passengers.

(g) Texture.

Seat material texture should not be so rough (high friction) that it hinders passenger body positioning.

(h) Cushioning.

Cushioned seating should be provided to distribute body weight evenly and to protect against skin ulceration. Seat cushions should not strike the back of the passenger's knee, thereby avoiding blood flow restriction and cause nerve damage (See Figure 4-4).

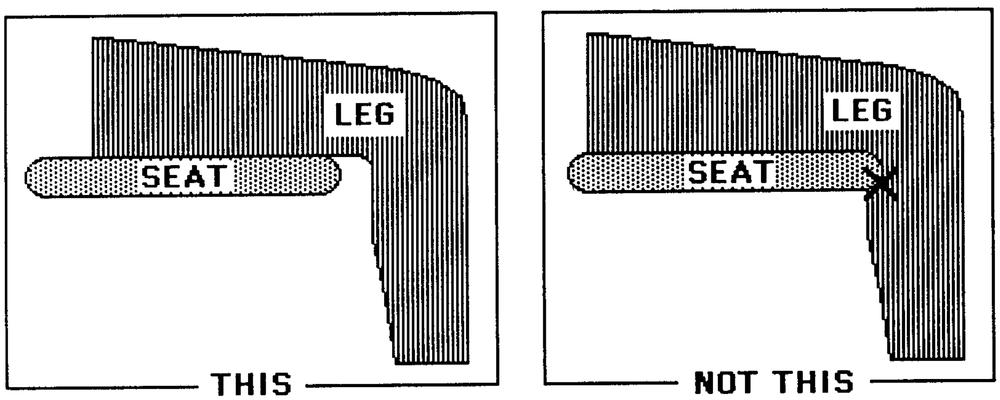


Figure 4-4. Seat Cushioning Placement

(i) Construction.

Seats should keep their shape, even after extended use.

4.3 Backrests

(a) Function.

Backrests should support the passenger and aid in restraining the passenger's torso and be comfortable.

(b) Dimensions.

Backrests should be sized according to dimensions given in Figure 4-1. Note: Where boarding chairs must be carried up stairways (i.e., at locations which are not air carrier airports) the backrest height should be a minimum of 38 inches. Refer to Section 4.4, Headrest.

(c) Orientation.

The angle between the base of the backrest and the seat should be 90 degrees. For comfort purposes, the middle to upper portion of the backrest may be gradually reclined as shown in Figure 4-1.

(d) Strength.

Backrests should meet the requirements in guideline 4.1(e).

(e) Shape.

Backrests should be constructed to provide support, aid in restraining a passenger, and avoid interference with passenger transfers.

(f) Material.

Backrest material should be water repellent, stain resistant, fire retardant, non-abrasive, durable, cleanable, and attractive. For aesthetic purposes, cover material used on the backrest should be coordinated with the material used on the seat.

(g) Texture.

Backrest cover material should not be so rough (high friction) that it hinders passenger body positioning.

(h) Cushion.

The backrest cushion should provide a firm surface. However, cushion firmness should not compromise skin protection.

(i) Folding.

Folding backrests should collapse in a manner which does not hinder transfers. Hinging mechanisms should automatically lock in place when the backrest is fully extended and folded.

(j) Adjustment Mechanisms.

The method of operation of backrest adjustment mechanisms should be readily apparent and easy to perform.

4.4 Headrests

(a) Function.

Headrests should be provided to support the head, preventing the head from falling back or to the sides.

(b) Dimensions.

Headrests should be dimensioned to accommodate 95% of the user population. (see Figure 2-2)

(c) Location.

Headrests should support the passenger's head at ear level.

(d) Strength.

Headrests should support a force of 30 lbs (the average weight of a male's head with a 3.0 safety factor) applied in the aft and both lateral directions and should meet the requirements in guideline 4.1(e).

(e) Material.

Headrest material should be water repellent, stain resistant, fire retardant, non-abrasive, durable and cleanable.

(f) Ease of Transfer.

The position of the headrest should be one which does not require an attendant to assume an awkward body position (with poor leverage) during a transfer. (e.g., the headrest could fold or retract out of the way).

4.5 Armrests

(a) Function.

Armrests should be provided to support the passenger's arms. Armrests should provide a firm gripping or resistance surface for passengers to push against when repositioning themselves and to assist in protecting the passenger from injury.

(b) Dimensions.

Armrests should be sized to accommodate 95% of the passenger population for the dimension of arm length. (see Figure 2-2).

(c) Location.

Armrests should be located at the seated elbow resting height optimized for 95% of the passenger population. The armrests should be adjustable over the range of 7.0-12.0 inches above the seat surface.

(d) Strength.

Each armrest should support 241 lbs (the weight of the 99th percentile male) and meet the requirements in guideline 4.1(e).

(e) Material.

Armrest material should be durable, non-slip, water repellent, stain resistant, fire retardant and cleanable.

(f) Orientation.

Armrests should be oriented to provide vertical and lateral arm support.

(h) Adjustability/Removability.

Armrests should be removable or fold away. Adjustable, folding, and/or removable armrests should have locking and quick release mechanisms that are accessible to the passenger.

4.6 Gripping Surfaces

(a) Function.

Clearly identified gripping surfaces should be provided for attendants to hold onto during the transport of a passenger.

(b) Number.

Gripping surfaces should be provided where needed for pushing, pulling, and lifting, as determined by defined operating procedures. As many gripping surfaces as possible should be provided to adapt to a variety of boarding chair-to-attendant orientations. As a minimum, the number of gripping surfaces should fulfill the requirements of paragraph 4.6(d).

(c) Dimensions.

Gripping surface size should accommodate the 95th percentile male hand for width and length and the 5th percentile female hand for diameter (see Figure 2-2). Physical clearance between the gripping surface and surrounding boarding chair parts should be provided for the 95th percentile male hand.

(d) Location.

As a minimum, gripping surfaces should be provided on the boarding chair frame near the shoulders and feet of the seated passenger. The pushing surface should be located at the attendants' standing elbow height, 40-42 inches optimized for the 50th percentile of the total user population. (see Figure 2-1).

(e) Material.

Gripping surface material should be textured, water repellent, stain resistant, temperature resistant, fire retardant and durable. Gripping surface materials should be firmly attached to avoid turning, slipping, or accidental removal.

(f) Strength.

Each gripping surface should be capable of supporting (for all possible load applications) the total weight of the boarding chair plus 723 lbs (the 99th percentile male weight with a 3.0 safety factor). Each gripping surface should meet the requirements in guideline 4.1(e).

(g) Body Posture.

The attendants should not be required to assume awkward positions (such as a twisted back or bent wrists) while pushing or lifting the chair.

(h) Skin Protection.

The attendant's hands should be protected from contact with surrounding surfaces such as aircraft walls, seats, doors, or stairways while holding onto the gripping surfaces.

(i) Clarity of Function.

Gripping surfaces should be readily apparent to the attendant.

(j) Chair Stability.

When the boarding chair, occupied by the 5th percentile female or 99th percentile male, is pushed, pulled or lifted in the direction of travel by the gripping surfaces, the boarding chair should not tip or fall to either side.

4.7 Restraints

(a) Function.

Restraints, such as safety belts, should be used to secure a passenger in the boarding chair and ensure the safety of the passenger during transportation.

(b) Placement.

Restraints should be designed to securely support:

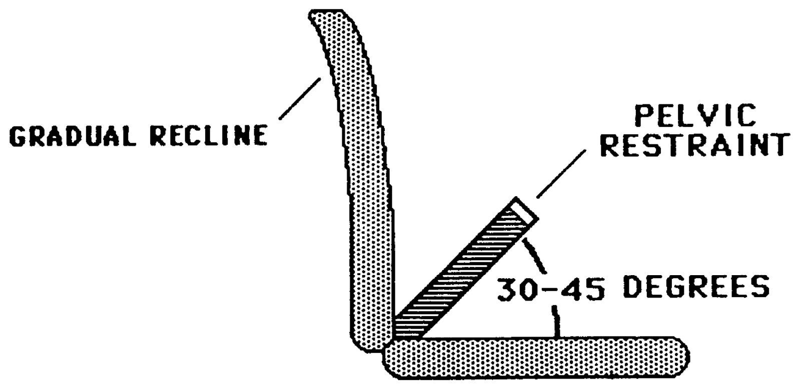
(1) Torso

(2) Pelvis

(3) Knees

(4) Feet.

Restraint placement should ensure that the passenger's body is centralized and stabilized in the boarding chair. Restraints should be attached rigidly to the boarding chair frame and held in their intended position of use by their method of attachment, channeling or some other means. Pelvic straps should be attached at a 30-45 degree angle from the seat connected at the seat and back joint to hold the pelvis against the back of the boarding chair (see Figure 4-5).



OTHER RESTRAINTS:

- UPPER TORSO
- KNEES
- LOWER LEG (FOOT)

Figure 4-5. Pelvic Restraint Placement

(c) Material.

Material should be stain resistant, non-abrasive, fire retardant, water resistant, durable, cleanable and attractive.

(d) Texture.

Material used should not cause skin irritation or promote skin ulceration at contact points.

(e) Fastening Mechanisms.

Restraint connect and release mechanisms should require as few steps as possible to be secured effectively (1-2 steps is optimum). Fastening mechanisms should connect and release quickly and be within the passenger's reach. Fastening mechanisms should be able to be released by individuals with impaired strength and reduced hand and arm dexterity.

(f) Adjustability.

Restraining devices should be easily adjustable in size to accommodate the body dimensions of passengers ranging from the 5th percentile female to the 95th percentile male (see Figure 2-1) Once a restraining device has been adjusted to fit a passenger, any excess poriton of a strap should not interfere with boarding chair operation and create a potential hazard for tripping or catching.

(g) Clarity of Function.

Restraining device method of use and connection should be obvious. Incorrect use should be impossible. The need for instructions on use should be minimized. Coding techniques, such as color or shape, should be used to simplify the identification of interacting parts (see Figure 4-6).

(h) Strength.

Restraining devices should withstand a force of 723 pounds (the weight of the 99th percentile male with a 3.0 safety factor) as shown in Figure 4-7.

(i) Storage.

When not in use, restraining devices should not interfere with chair movement. Restraining devices not in use for a particular passenger should not interfere with operation or cause discomfort to the passenger. The method of restraint storage should be obvious and efficient.

4.8 Footrests

(a) Function.

Footrests should be provided to support and stabilize the passenger's feet and legs during transport. The footrest should prevent the passenger's foot from slipping off the footrest when tilted back and should prevent the passenger's feet from sliding sideways or forward under all circumstances.

(b) Dimensions.

Footrests should be a minimum of 4.3 inches in width for each

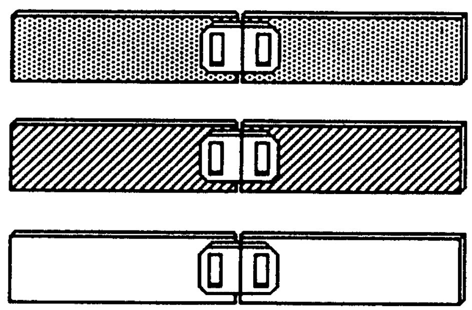


Figure 4-6. Visual Coding of Restraints

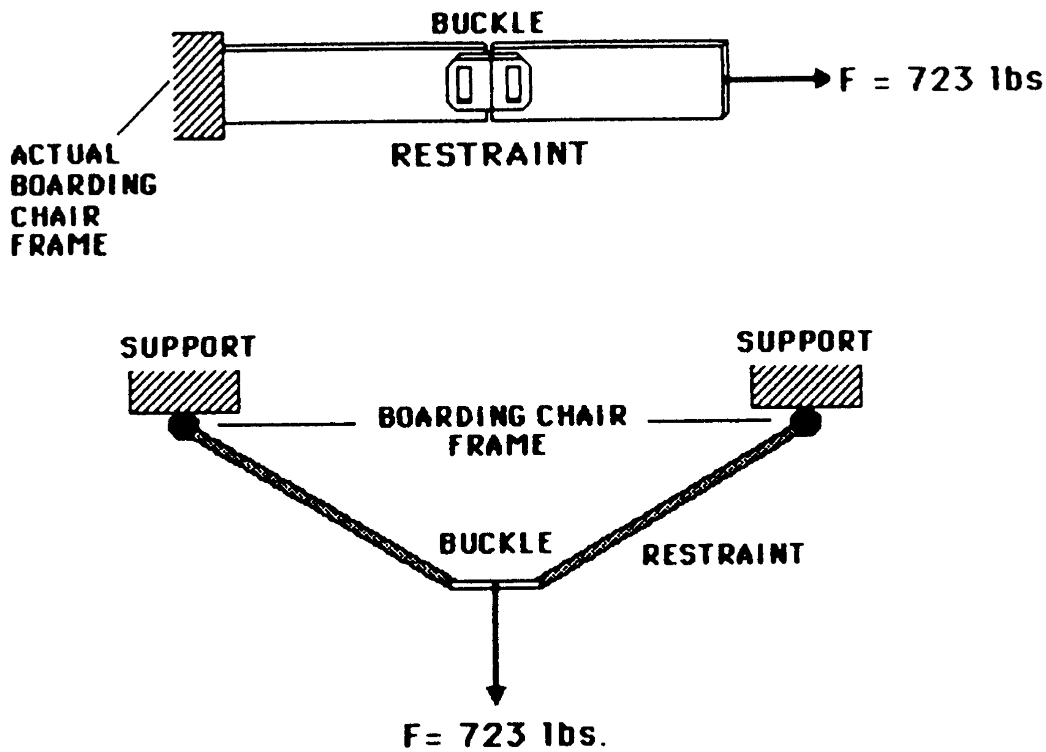


Figure 4-7. Static Testing of Restraints

foot. The depth of the footrest should maintain a secure and comfortable foot posture for extended periods. (See Figure 2-2).

(c) Location.

The contact point between the foot and footrest should be located at an adjustable distance over the range of 16.0 to 29.0 inches from the front of the seat as shown in Figure 4-8.

(d) Orientation.

Footrests should allow the passenger's foot and lower leg to rest in the position typical to that person (this may not be directly side by side).

(e) Adjustability.

Footrests should be easy to adjust.

(f) Strength.

During operation, a collision between the footrest and a surrounding object should not cause passenger injury, alteration of passenger leg position, or damage to the boarding chair. Footrests should meet the requirements in guideline 4.1(e).

(g) Support.

Footrests should provide complete support to the passenger's feet and lower legs. Foot supports should prevent the passenger's feet from slipping beneath the boarding chair under all operating conditions.

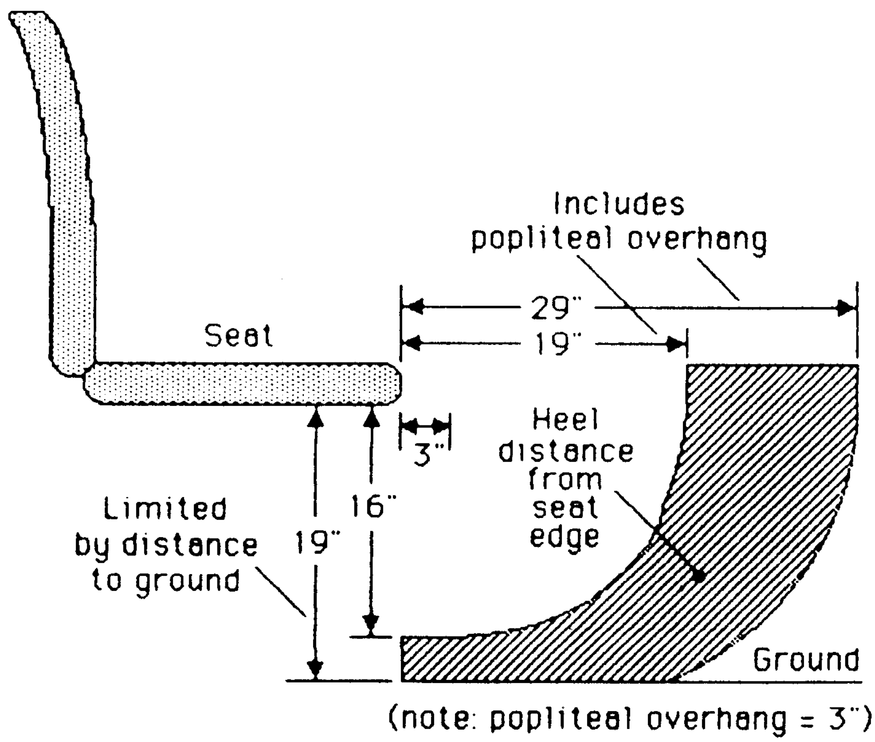


Figure 4-8. Footrest Location

(h) Material.

Footrest material should be durable, resistant to cracking, chipping, or splintering, temperature resistant and cleanable.

(i) Padding.

Footrests should not promote skin ulceration even after prolonged contact. Padding should be used, as necessary, to provide a comfortable contact surface; particularly in the area of the lower leg.

(j) Ease of transfer.

Transfer of passengers should not be impeded by footrest size or location. If necessary, footrests should be retractable or swing away to ensure attendant and passenger safety.

Appendix A: Adopted ISO Test Procedures

Note: Test procedures have been paraphrased and adapted for applicability to aircraft boarding chairs. Although several testing protocols were considered practicable, the ISO protocol has been designated to provide testing consistency and to facilitate product performance comparisons. For comparison with comprehensive wheelchair testing procedures, see the complete Draft ISO Test Procedure Document, ISO/173 SCI/WC1-220 and similar domestic version pending publications by RESNA/ANSI.

A1 Scope

This part of ISO 7176 specifies a method for determining the static, impact and fatigue strength of manual wheelchairs.

A2 References

ISO 6440 Wheelchairs - Nomenclature, Terms and Definitions ISO/DIS 7176/11 "Wheelchairs - Part II : Test Dummies

A3 Definitions

For the purpose of the part of ISO, 7176, the definitions of ISO 6440 apply.

A4 Test Principles

The Static Tests are intended to assess the static strength of the wheelchair and its component parts under the high levels of loading that occur only occasionally.

The evaluation of boarding chairs does not require destructive tests.

A5 <u>General Conditions</u>

The following conditions shall be established and recorded during the testing of boarding chairs in accordance with this evaluation protocol.

A5.1 The boarding chair shall be fully equipped for normal use.

A5.2 If the wheelchair has pneumatic tires, the air pressure in them shall be adjusted in accordance with the directions set forth by the manufacturer/supplier. If a pressure range is specified, the highest recommended pressure shall be selected.

A5.3 The seat unit, if adjustable, shall be set to correspond to a natural sitting posture. The leg support/footrest, if adjustable, should be positioned 50mm above the ground. Horizontally adjustable seat units shall be set at their mid position. If adjustable, the slope of the seat relative to the horizontal shall be as close as possible to 4 degrees, and the slope of the backrest relative to the vertical shall be as close as possible to 10 degrees. The angle between the seat and leg support shall be as close as possible to 90 degrees. Wheelchairs with fore/aft adjustment on the rear wheels shall be adjusted at their middle position.

A5.4 The wheelchair shall be inspected to insure that:

(1) All supporting wheels are contacting the ground

(2) All wheels meet the specified alignment tolerance limits

(3) The folding mechanism (if it exists) fully and readily deploys (a wheelchair with a folding X-frame should fold under the influence of gravity when laid horizontally)

(4) All detachable components detach and reassemble readily

(5) The tires are firmly seated in their rims

(6) There are no loose spokes (if existing)

A5.5 The dimensions shall be recorded before the commencement of the tests and again after all tests have been completed. Before any measurements are taken, any free play in the structure of the boarding chair which might affect the measurements should be taken up by loading the wheelchair with appropriate ISO dummy (Refer to ISO/DIS 7176/11). Measurements should be made from well-defined points on the structure to give maximum indication of any deformation that might occur as result of the tests.

A5.6 Immediately before commencing each test procedure the components for which the test was conducted shall be thoroughly inspected. Any visible defects shall be noted, and any defects considered sufficiently significant as to affect further testing shall, if possible, be rectified.

A5.7 References to an appropriate standard test dummy shall mean a test dummy of 220 lb constructed according to the details in ISO/DIS 7176/11 of this standard.

A6.1.1 Armrests Downward Static Load Test

A downward force of 1470N, at 45 degrees, shall be applied to the upper surface of both armrests simultaneously with a load fixture at the front of the horizontal surface of both armrests. For tests on chairs with removable armrests, check that armrests remove and reinstall correctly.

A6.1.2 Push handle(s) Downward Static Load Test

A vertical downward force of 1960N shall be applied to the push bar or both push handles simultaneously. If the wheelchair is equipped with a push bar, the force is applied to the center of the push bar. If there are separate push handles the force is applied simultaneously be placing a bar over the push handles and applying the force, using the standard loading pad, midway between the handles.

A6.1.3 Footrest Downward Static Load Test

A downward force of 1320N shall be applied once vertically downward, to the center of each footrest plate. If the footrest is of one-piece construction, the specified force shall be applied to its center, using the standard loading pad. If the wheelchair has adjustable knee angle leg rests they shall be adjusted as close as possible to 90 degrees between the seat and leg rest. Adjustable height footrests shall be extended to their lowest position of 50 mm above the ground, whichever is higher. If the footplate is adjustable, adjust to 90 degrees to the leg reference plane. During this test, slippage of adjustment shall not exceed 25 mm. The movable caster shall be placed in its normal trailing position.

A6.1.4 Tipping Levers Downward Static Load Test

A vertical downward force of 1470N shall be applied to each tipping lever in turn. The force shall be applied over a length of 50 mm at the end of each tipping lever. This applies to any rearward projection that might be used as a foot tipping lever.

A6.1.5 Hand Grip Static Load Test

A force of 1600N shall be applied once to each handgrip using a loading fixture. The force should be applied for 10 seconds without the handgrip pulling off.

A6.1.6 Armrests Upward Static Load Test

An upward force of 1600N shall be applied at 10 degrees to the vertical, outward to the side. Force shall be applied to the underside of each armrest simultaneously, in the middle of the armrest, using 50mm webbing or strap material. For test on chairs with removable armrests check that armrests remove and reinstall correctly. Note: Vertically pivoting or non-locking armrests should pivot or remove easily and will therefore pass the test with regard to safety considerations.

A6.1.7 Footrest Supports Upward Static Load Test

A vertical force of 430N shall be applied to both footrest support structures simultaneously (or most forward projecting part), using 50mm webbing or strapping material. If the footrest is constructed in one piece, the specified force shall be applied to its center. Note: Adjustable knee angle leg rests shall not be tested.

A6.1.8 Push Handle(s) Upward Static Load Test

A vertical upward force of 850N shall be applied to the push handle(s) simultaneously using 50mm webbing or strapping material. If a push bar is used, the load is applied to the center.

A7 Conditions for Acceptance after Static Strength Tests

The boarding chair shall be visually inspected after static strength tests are completed noting the following:

(1) Any fracture of any member, joint or component;

(2) Any fracture, cracking or discontinuity of the surface finish of the structure;

(3) Free play or loosening in the frame structure, folding mechanism, armrests, footrests, brakes, wheels or wheel bearings and any other component of the wheelchair, greater than that noted in the initial inspection;

(4) Any deformation or maladjustment of any part of the wheelchair, or its attachments, that will adversely affect its function;

(5) Wheel alignment shall be remeasured and recorded noting the tolerances given;

(6) The boarding chair dimensions shall be remeasured and recorded. These dimensions should be within 3mm of the pretest dimensions recorded;

A pass/fail disclosure shall be made based on the visual inspection and the alignment and dimensions noting the tolerances given.

A8.1.1 Seat Impact Strength

The seat shall be tested for impact with the Standard Loading Mass filled with a weight of 25 kg. During these tests the wheelchair shall be secured to the floor to prevent folding or movement. With the wheelchair in the normal open position, the weighted mass shall be dropped onto different areas of the seat from a height of 200mm. The specified impact tests are as follows:

(1) Drop mass onto center of the seat.

(2) Drop mass onto each front corner of seat as near to the corner as possible. If the wheelchair has removable armrests they shall be removed.

A8.1.2 Backrest Impact Strength

The backrest shall be tested for impact with the Standard Loading Mass with a weight of 25kg. The specified impact tests for the backrest are as follows:

(1) Suspend the standard loading mass as a pendulum such that it impacts the center top edge of the backrest from the front at a 45 degree angle. The standard loading mass shall be dropped from a height of 500mm.

(2) Suspend the standard loading mass as a pendulum such that it impacts each back frame member at the top, from the front at a 45 degree angle. The standard loading mass shall be dropped from a height of 500mm.
During this test the boarding chair shall be secured to the floor to prevent folding or movement.

A8.2.1 Drop Test Impact Strength

(1) With all folding mechanisms (if existing) deployed to the ready-to-use condition (open), lift the wheelchair loaded with the 220lb standard test dummy above a hard, flat surface at a height of 100mm. Using a quick release device drop the chair allowing it to fall freely under the influence of gravity to impact the flat surface. The wheelchair should be suspended from a single point so that it is tilted 10 degrees laterally (side-to-side) with an inclination 10 degrees aft so that a rear wheel will contact the floor first. The height of the chair should be measured from the floor to the lower surface of the wheel being tested.

(2) For folding chairs, repeat with an inclination fore 10 degrees so that a front wheel strikes the floor first.

A8.2.2 Rolling Test Wheels and/or Castors Impact Strength

With the chair unfolded and loaded with the 220 lb standard test dummy, the chair is rolled on a straight line path at the velocity of 1.1 m/sec towards a standardized obstacle, which is securely fastened to the floor. The velocity should be measured by use of a standardized procedure. The test dummy shall be securely fastened into the boarding chair. If there are removable/ adjustable footrests or other projections, they should be adjusted to the most upward position in order to clear obstacles. If the distance between the floor and non-removable structures or footrests is less than the height of the standardized obstacle, the maximum possible height object should be used and recorded.

Each front wheel or castor should contact the standardized obstacle independently. The impact angle should be 45 degrees to the long dimension of the standardized obstacle.

A9. Conditions for Acceptance after Impact Strength Tests

The boarding chair shall be visually inspected after impact strength tests are completed. A pass/fail disclosure shall be made based on the criteria to be determined by the ISO.

Appendix B: Guidelines for Training

B1 Training Course Responsibility.

Airlines or responsible contract personnel shall conduct training courses. The airline will ensure that contract personnel conduct adequate training and will be ultimately responsible for training content, frequency, and adequacy.

B2 Frequency of Training.

The airline or responsible contract personnel shall train all personnel who will perform disabled passenger transports with aircraft boarding chairs before they are allowed to perform the boarding task on the job. Refresher courses shall be taught when different equipment is acquired, new staff are hired, and routinely, according to an established schedule.

B3 Level of Training.

All attendants shall successfully perform a passenger transport and transfer using both a skybridge and stairway to gain access to the airplane.

B4 Training Course Content.

Training courses shall include the material covered in guidelines on passenger services, transfers and stairways.

Effectiveness of Passenger Services.

Training courses shall include the following topics to reduce the likelihood of passenger injury:

(a) Maintain proper attitude toward the passenger to avoid mistreatment.

(b) Consult with the passenger to identify the best method for transferring.

(c) Be aware of the risk of injury.

(d) Obtain the owner's chair during layovers if at all possible.

(e) Minimize the number of transfers per passenger.

(f) Restrain the passenger firmly, but not so tight as to cause injury.

(g) Take caution against legs and feet becoming dislodged from the support and getting caught on corners, seat braces or seats.

(h) Avoid pressure sores; allow the passengers to stay in their own wheelchairs (that is specifically padded for them) for as long as possible.

(i) Know where the movable armrests are located on the aircraft.

(j) Know where the boarding chair can be parked (greatest percent incline without danger of brakes not holding).

Passenger Transfers.

Training courses shall include the following information to reduce the likelihood of passenger or attendant injury:

(a) Consult with the passenger on the best way to accomplish to transport procedure.

(b) If possible, use a seat with a movable armrest.

(c) Do not lift a person who is too heavy for your strength.

(d) Stand with feet 12-18 inches apart, lift from the knees and not the back by keeping the back as straight as possible and stand as close to the passenger as possible.

(e) Engage brakes/locks on wheelchair and boarding chair whenever making a transfer.

(f) Allow the passenger to assist with the lift whenever possible.

Use of Stairways for Boarding.

Training courses shall include the following information to reduce the likelihood of injury:

(a) Whenever possible, avoid carrying a passenger up stairs.

(b) At air carrier airports, locate and know how to utilize the airport provided lifting device.

(c) Before starting, make certain that all restraints are securely fastened, especially about the lower extremities that could splay and injure the attendant or upset the balance of the boarding chair.

(d) Place the less experienced attendant at the foot of the passenger and the more experience attendant at the shoulders.

(e) Take a practice run if not fully familiar or comfortable with the layout. Practice with a heavy staff member.

(f) Keep the passenger informed at all times as to the progress.

(g) Make sure hands and gripping surfaces are not wet or slippery.

(h) Rest at each step to preserve stamina.

(i) Do not wear baggy clothing which could get caught. Wear non-slip footwear, such as rubber-soled shoes.

(j) Keep the boarding chair tilted back slightly but as horizontally straight as possible. Even the slightest sideways tilting can jeopardize control.