HANDS-ON ARCHITECTURE

PART II

RECOMMENDATIONS FOR STANDARDS

PREPARED FOR:

U.S. Architectural and Transportation
Barriers Compliance Board
1331 F Street, NW
Suite 1000
Washington, DC 20004-1111

Prepared By:

Edward Steinfeld

Illustrations:

Tuna Saka
Danraj Vishwamath
Marcia Feuerstein
Edward Steinfeld

Adaptive Environments Laboratory
Department of Architecture
SUNY/Buffalo
Buffalo, New York 14214

12/17/1986

PREFACE

This technical assistance document is based on the results and findings of the Hand Anthropometrics Project (Contract No. 300-84-0247), created to develop an information base for designing products that are used in buildings and intended to be manipulated by hand. The study focused on the abilities of people with disabilities affecting hand strength and coordination, a group for which there is a lack of human factors design data.

The citations to volume, part and section in this document refer to the three-volume final report of the project, *Hands-On Architecture*. Volume One, the main research report, summarizes the literature review and presents the conceptual framework for organizing the research and findings. Volume Two presents a method and data for improving design of buildings consistent with hand and arm abilities of persons with disabilities. Volume Three, the basis for this technical assistance document, contains an Executive Summary of the project and a set of recommendations or guidelines that can improve building design.

The complete research report can be obtained from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22164; or call (703) 487-4650. Specify order number PB90170861/AS.

HANDS-ON ARCHITECTURE
RECOMMENDATIONS FOR STANDARDS

TABLE OF CONTENTS **PAGE NUMBER**

RECOMMENDATIONS

Concept

This report provides recommendations for enforceable accessible design standards for architectural products that are intended to be used by the hand. In keeping with the jurisdiction of the Architectural Barriers Act, (P.L. 90-480) the scope of the recommendations is limited to products built into buildings as permanent fixtures. The recommendations could also provide guidance for design or selection of office furniture and equipment, appliances, tools, and other manipulated objects that are found in buildings on a temporary basis.

The recommendations are based on two sources of information. First, general human factors design principles and specific data bases generated through human performance research with people with disabilities. The second source consists primarily of the results from laboratory and field research conducted as part of the Hand Anthropometrics Project.

There are two kinds of research data that are helpful in generating design standards: directly observed performance data such as the amount of force an individual can exert or his or her reaching abilities, and response data obtained from users of products.

In developing these recommendations, both types of data were used. First, data on observed performance were reviewed to identify the extent to which research subjects could accomplish various tasks related to the use of products. Tentative criteria were developed based on accommodating at least 90% of the sample in terms of performance in the laboratory. The cost impact of these criteria was estimated by assessing the number of products tested in the laboratory and field that did not "comply". About 20% of the field products and over 50% of the laboratory products did not "comply," yet most of these products had been proven usable. We then set new criteria based upon the 25th percentile level of performance for selected variables in the basic laboratory research. A user response rate of 40% in terms of negative user evaluation was the bottom line. In addition, recommendations were never relaxed to the point that products that had observed performance rates of less than 90% for the research samples would "comply." After relaxing the criteria levels as much as necessary to meet these objectives, a qualitative cost analysis of the products not meeting the criteria was performed to identify the cost impact of the proposals.

The format, organization and illustration of the recommended criteria were designed to allow the greatest ease in implementation. Rather than develop specific criteria for hundreds of different types of products, three sets of criteria were developed:

1. general criteria that apply to all devices;

2. additional criteria that apply to individual classes of devices with specific types of devices within each class;

3. identification of important equipment that typically includes several devices with cross-referencing to appropriate general and specific criteria.

This approach kept the criteria from being voluminous. Moreover, the inclusion of general and categorical approaches reduces the likelihood that specific products would not be covered through omission and insured application to new products not yet introduced.

Implementation

A draft of the recommended accessible design standards was discussed with two local code officials to identify enforcement problems. The following problems in implementation were identified by this review:

1. building design documents do not normally show dimensions or other attributes of building products;

2. architects and other designers do not have access to information on many specific dimensions and the force of activation for most products;

3. building code officials do not have the expertise nor the time to evaluate the hundreds of operable devices that may be found in a building either before or after construction;

4. many products are changed or replaced over the lifetime of a building; it would be extremely unwieldy to require approval for every minor replacement or change.

It is recommended, therefore, that, except for the requirements for use clearances and reach limits, the other criteria be implemented in a manner similar to product approval for other aspects of design such as life safety. A certification procedure should be developed through which individual products, having once been submitted and evaluated by a responsible authority, could receive certificates of compliance. Architects could then require such a certificate as part of their specifications and design review officials would require only a label as evidence of that certificate in order to approve any product.

A certification procedure could be implemented in many ways. Three possible models are:

1. certification by an independent laboratory

2. Federal approval through agencies such as the General Services Administration (GSA) or Veterans Affairs (VA)

3. listing of acceptable products in model codes or state building code supplements

In the first model, a voluntary standard could be developed through ANSI to accompany the ANSI A117.1 standard. It would include not only design requirements such as presented here, but also standardized procedures for evaluating products against those requirements. In the development of the standard, a network of certifying organizations such as Underwriters Laboratories, Pittsburgh Testing Laboratories, the National Bureau of Standards, or even professional firms or advocacy organizations could be recruited that

would be willing and able to undertake the certification program. After adoption of the standard, manufacturers would submit products for evaluation and pay the certifying organizations a fee to cover the cost of each review. Upon approval, a certificate would be granted. The manufacturers would then include information on certification in their product literature and a label on the product itself. This approach is now used for certifying fire safety characteristics, such as flame spread and smoke generation, of many products.

The second approach would utilize the procurement procedures of the Federal government. The Federal agencies could require a one-time review and certification of all products included in Federally funded new construction or significant renovation or rehabilitation. After obtaining initial approval from any one agency, each product could be added to a centralized list of certified products. Architects, interior designers or facility managers could then choose products off the list. Or, manufacturers could include information in their product literature indicating that approval had been obtained. An agency or architect could check a master list if necessary. The cost of such a program could be borne by the Federal government, by product manufacturers on a fee-for-service basis, or shared.

The third approach would utilize the same process currently in use by model building code groups and some state codes. Once a product is reviewed by a centralized code body, a certificate of acceptability would be granted. A label and product literature would then be used for local code review as in the first approach.

The ATBCB could, if it was within its statutory authority, play a central role in each of these approaches by serving as the coordinating body for establishing the process, maintaining records on certified products and providing quality control.

Priorities

As currently designed, some operable devices are more difficult to use than others. The user response data collected through the Hand Anthropometrics Project provided insight on the relative difficulty of many different devices. From these data, priorities for applying the recommended standards were developed (see Figure A). If, in the process of implementing the requirements, it becomes necessary to focus efforts on a narrower range of devices than presented here, the list of priorities should be used to insure that the most important issues are addressed.

PRIORITIES FOR APPLICATION

Priority:	Product Type:
First	shower heads and shower/bathtub controls; locks for doors and windows; window opening devices, e.g., cranks; door opening devices, e.g., knobs; vending machines
Second	thermostats; paper dispensers; soap dispensers; switches; grab bars
Third	faucet controls; cabinet/drawer pulls; water fountain controls; appliance controls; handrails

Figure A

1.0 GENERAL REQUIREMENTS

1.1 Scope

These requirements apply to all operable devices incorporated into buildings on a permanent basis, either as part of the initial design or in substantial rehabilitation or renovation, that are intended for use by the general public, residents or general employees with the exception of manufacturing equipment and devices intended to be operated solely by maintenance or service personnel (see Table 3.2). Manufacturing, maintenance and service related devices, however, may fall under the jurisdiction of laws related to equal opportunity in employment. In such cases, the requirements found here can be used as a guide but should be supplemented by other more specific requirements for scope of application.

1.2 Use clearances

The minimum clear floor or ground space required to approach an object is 30 inches (762 mm) by 48 inches (1220 mm) (see Figure 1.2a). (For a side approach, the 30 inch (762 mm) clearance should be set back from the device by 6 inches (152 mm). The use clearance must be located on center with the device. Knee clearance for wheelchair use may overlap the use clearance by 24 inches (610 mm) maximum (see Figure 1.2b) for the front approach. This overlap is preferred because it reduces reach distance. The height of

any obstruction shall be 36 inches (914 mm) maximum (see Figure 1.2d). Door swings shall not impede access to the required use clearance for any device located within their vicinity.

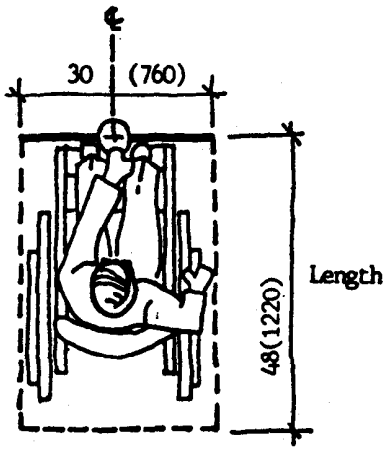
Rationale: Research findings showed that the 30 inch (762 mm) width will accommodate 90% of the study sample for front approaches. When using devices, ambulatory and non-ambulatory people generally position their shoulder to one side of the object to be used, left side for left-handed people and right side for right-handed people. Door swings could obstruct access as a door is opened. Requirements in the existing ATBCB Guidelines and the other accessibility standards cover actual clearances needed to open doors, including access to door openers themselves.

Cost Impact: The side displacement varies with the type of device used but does not exceed 15 inches (380 mm). For side approaches, 6 inches (152 mm) was needed by the 10th percentile group to have enough room for accurate use of the device. Most people would stand even further back but a larger value would put devices beyond the reach of some people. Research findings indicated that wheelchair users position themselves so that the shoulder of the hand being used is displaced to the side of the device when using a side approach. The actual displacement varies considerably but the 48 inch (1220 mm) width and the location of a device at the centerline is consistent with median values. Using the 10th and 90th percentile values would result in extremely large clearances because device locations would be off center with the clearance area. The 48 inch (1220 mm) clearance will accommodate 90% of the study sample for front approaches.

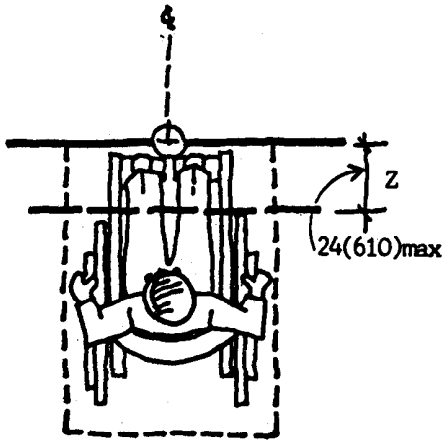
Figure 1.2

USE CLEARANCE:

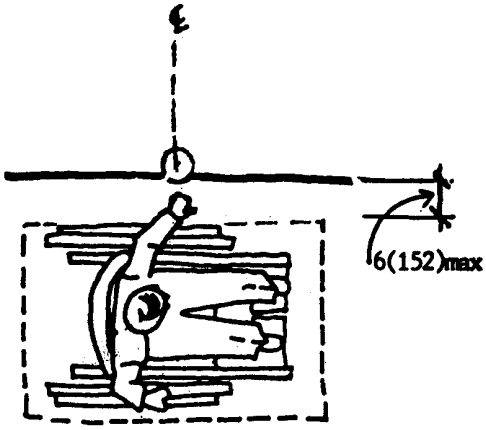
GENERAL REQUIREMENTS



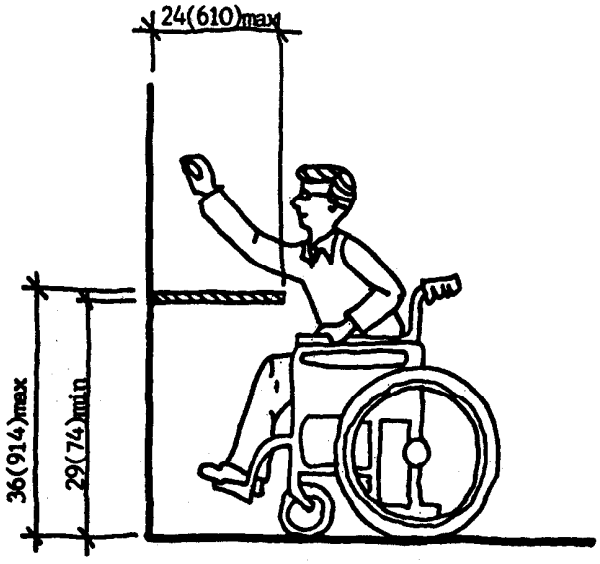
a. Min Clear Floor or Ground Space



b. Knee Clearance Overlap Front Approach



c. Side Approach Maximum Side Reach



d. Max Height and Depth of Obstruction

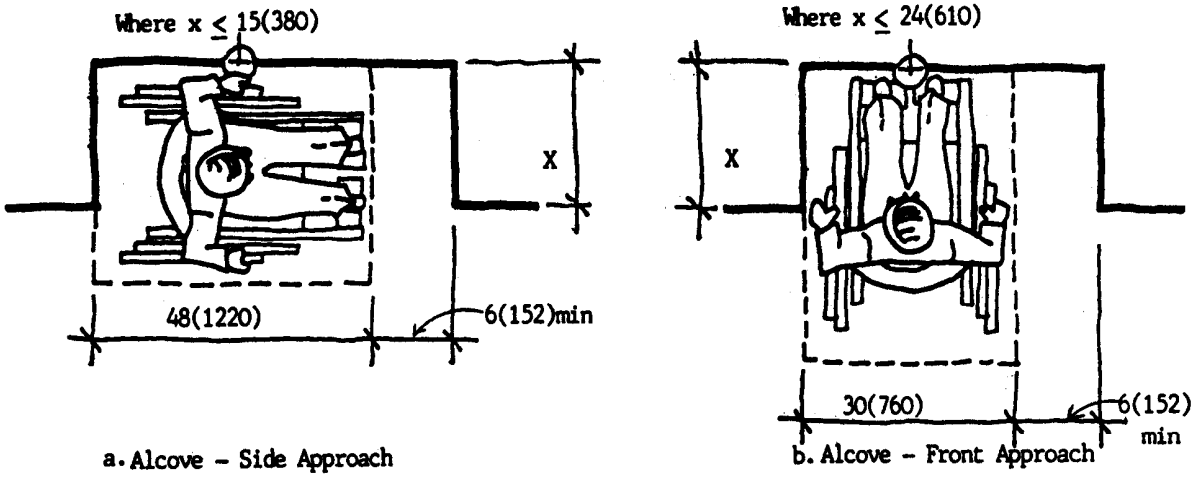
1.3 Access to Use Clearances

At least one full unobstructed side of the use clearance shall adjoin or overlap an accessible route or adjoin another use clearance. Any device located in an alcove or other space confined on three sides shall be increased in size as in Figure 1.3a and 1.3b. Dead-end spaces shall have a turn-around area. This area shall allow either a 180 degree U-turn or a backward T- or L-turn in a wheelchair when leaving the device (see Figure 1.3c and 1.3d).

Rationale: Not only must devices be accessible, but there must also be enough space to maneuver out of the immediate area in a wheelchair. The tolerances in Figures 1.3a and b are consistent with the ANSI A117.1-1980 Standard, ATBCB Guidelines and UFAS. The tolerances in Figure 1.3c are based on data from Steinfeld, et al., 1979.

Figure 1.3

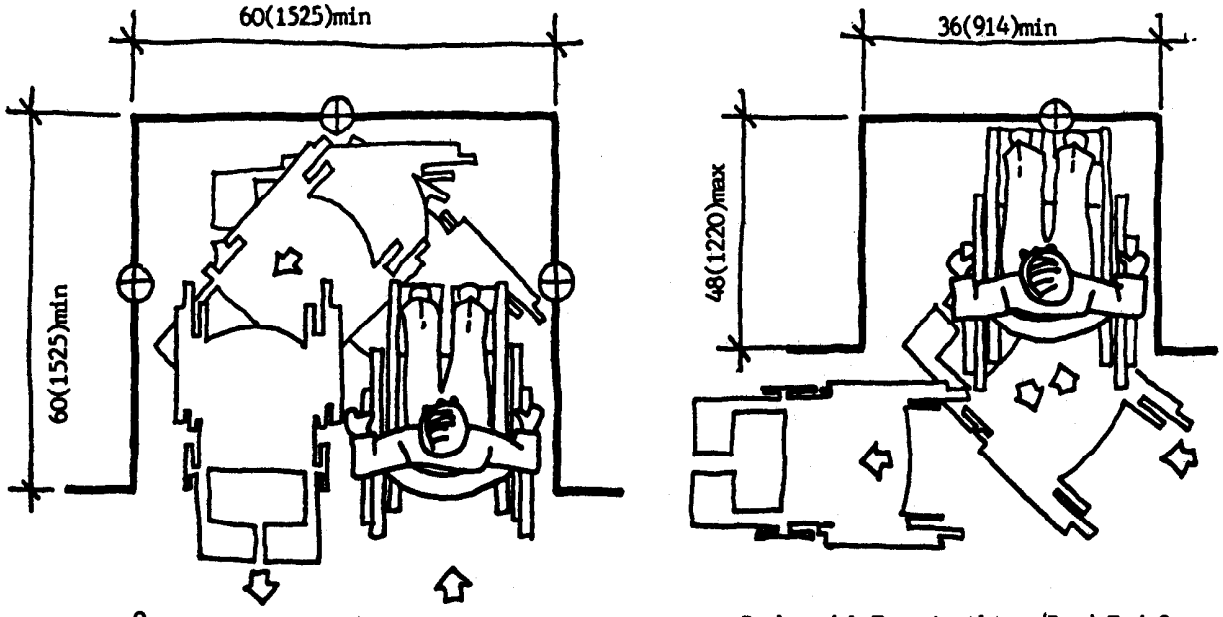
ACCESS TO USE CLEARANCES



a. Alcove - Side Approach

b. Alcove - Front Approach

Additional Maneuvering Clearance for Alcoves



c. 180° U-Turn in Alcove/Dead End Space

d. Backward L-Turn in Alcove/Dead End Space

Turning Clearances for Alcoves

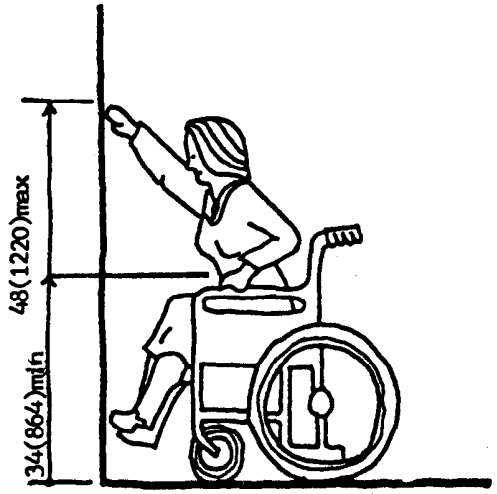
1.4 Reach Limits

The maximum height to an operable device shall be 48 inches (1220 mm) to center above the walking surface with one exception. For devices that can be operated with a flat hand push or finger push and that require 1.5 lb (0.7 kg-*f*) or less to operate, a 54 inch (1372 mm) maximum height is acceptable (see Figure 1.4a and 1.4b). The minimum height to an operable device shall be 34 inches (864 mm) on center (see Figure 1.4a and 1.4b). Within these ranges, the distance between an object and the adjacent edge of a use clearance may vary with the height of the operable device as shown in Figure 1.4c and 1.4d.

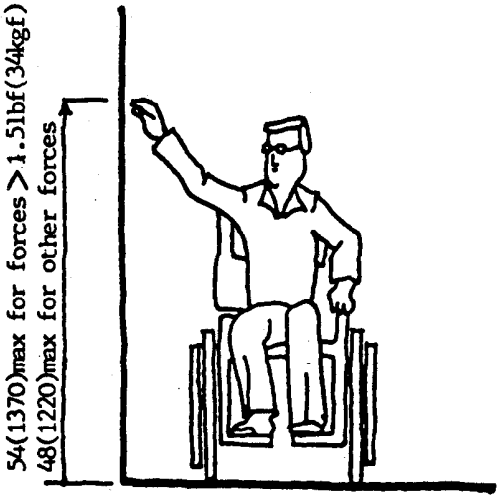
Rationale: Research findings demonstrated that these limits will accommodate 90% of the study sample, including 90% of the wheelchair users. Most wheelchair users have to bend at the waist to reach over their toes. Thus, forward reach lifts for wheelchair users are more difficult since bending lowers the shoulder and the feet obstruct access to the lower range. The research findings indicated that devices above 48 inches (1220 mm) were often impossible for more than 20% of the research sample to use with the exception of devices that required only small amounts of force and no opposing grip to operate. The distance between an obstruction or recessed area and the adjacent edge of a use clearance can vary with the height of a device since the horizontal component of reach increases as the vertical component is reduced.

Figure 1.4

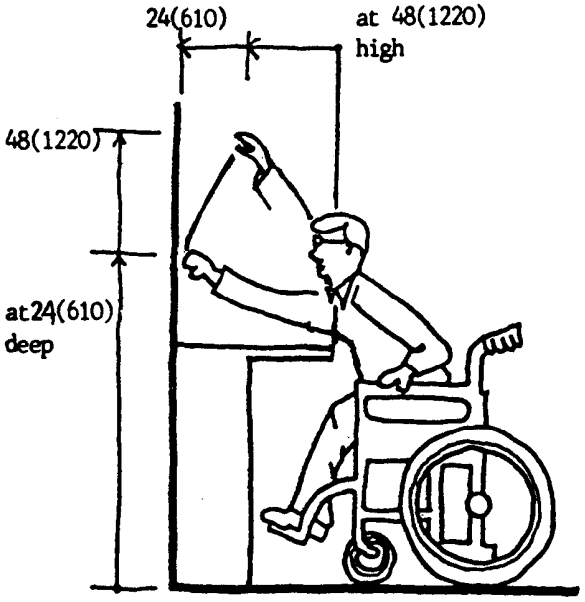
USE CLEARANCES VARIATIONS



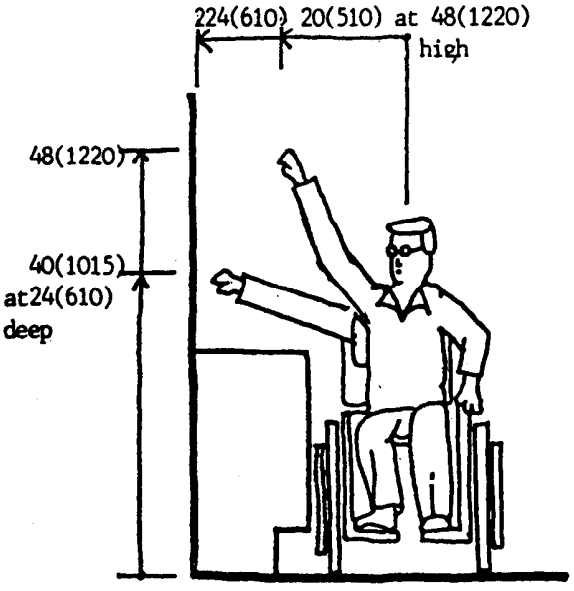
a. Forward Reach Heights



b. Side Reach Height



c. Front Reach Limit



b. Side Reach Limit

1.5 Grip Limits

All operable devices in accessible spaces shall comply with at least one of the grip limits shown in Table 1.5 although Sections 2.2 - 2.6 impose further limitations. Figure 1.5a illustrates the seven grips. Figure 1.5b illustrates how each dimensional requirement is determined. Operating forces shall be measured at the midpoint of the grip length (see Figure 1.5c). Grasp space is illustrated in Figure 1.5d. For those devices in which secondary objects are used in conjunction with a device, see Sections 2.3 and 2.4.

Rationale: The values in Table 1.5 will accommodate 90% of the research sample in the use of actual products. For many precision movements, pinch, span and disc grips are preferable if operating forces are low and wrist movement is restricted. Power grips are preferable for using assists. Many disabled people use alternate movements of the hand in place of one or more of the seven basic grips. These alternate movements include using the heel of the hand, back of the hand, knuckles, thumb, and two fists or flat hand. Hook, flat hand and finger push grips are preferred because they do not require opposing finger and thumb movements. Objects designed for these three grips are also much easier to use with the alternate hand movements.

TABLE 1.5: GRIP LIMITS

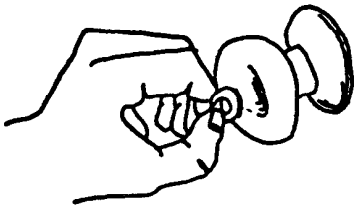
GRIP	MAXIMUM OPERATING FORCE lb (kg-f)	MINIMUM/MAXIMUM CROSS SECTION In (mm) CS	MINIMUM GRIP LENGTH In (mm) L	MINIMUM GRASP SPACE In (mm) a, b, c
POWER				
PULL/PUSH	7 (3.1)	0.5 (12) TO 1.7 (43)	5.3 (135)	a: 2.8 (70)
ROTATE (CRANKS)	2 (0.7)			b: 1.4 (36)
DISC	3 (1.5)	2.0 (50) TO 2.8 (72)	0.8 (20)[b]	a: 2.0 (50) b: 1.8 (46)
SPAN	3 (1.5)	2.1 (54) MAX	0.9 (23)[b]	a: 2.8 (72) b: 1.4 (36)
HOOK[a]	11 (5.2)	2.1 (54) MAX	3.5 (88)	a: 2.7 (69) b: 1.4 (36)
PINCH	4 (1.8)	0.1 (3) TO 1.2 (31)	1.0 (25)[b]	a: 6.2 (158) b: 2.5 (64)[d] c: 4.0 (101)[e]
FINGER PUSH[a]	3 (1.5)	NA	0.8 (20)[b]	0.7 (18)[b]
	0.2 (0.1)	NA	NONE	0.7 (18)[b]
FLAT HAND PUSH[a]	8 (3.6)	NA	a: 7.7 (196) b: 3.5 (88)	a: 7.7 (196)[g] b: 6.6 (167)[h]

NOTES: Original measurements taken in metric and converted to English units. Pounds were rounded to nearest whole number where possible.

[a]Preferred for all devices; required for handles. [b]Based on anthropometric data for population at large (see Diffrient, et al., Humanscale)
[c]a: grip clearance; b: finger clearance. [d]Clearance for thumb. [e]Width of fist. [f]If practically no force is required, an area can be very small with practically no impact on usability. [g]Vertical clearance. [h]Horizontal clearance.

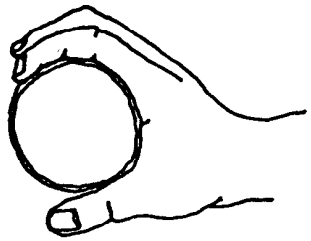
Figure 1.5a

PROJECT GRIP TYPOLOGY

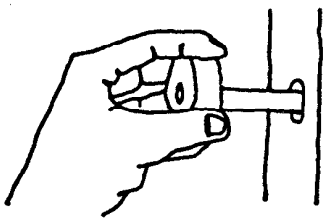


1. Pinch

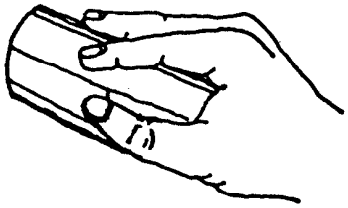
1. Pinch



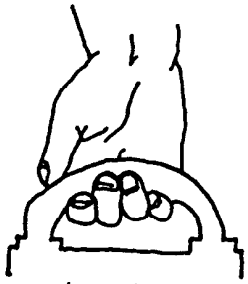
3. Span



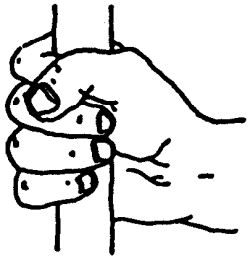
2. Disc



2. Disc

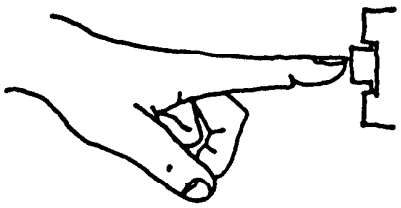


4. Hook



5. Power

6. Flat Hand Push



7. Finger Push

Figure 1.5b

GRIP SHAPES WITH SIZE PARAMETERS

KEY:

P: PERIMETER
CS: CROSS SECTION (diameter) (may be maximum and minimum cross section)
L: Length of Grip Area (may be more than one)

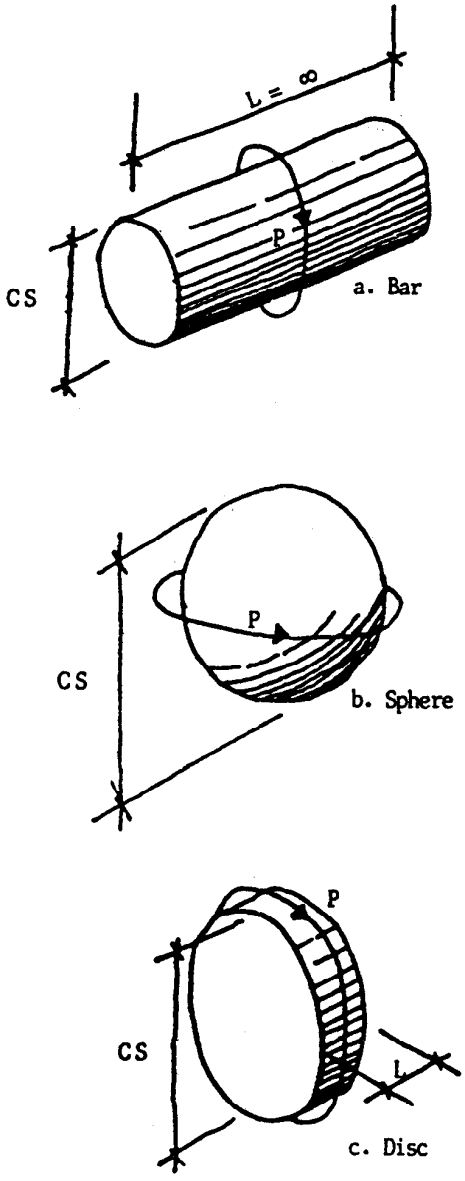
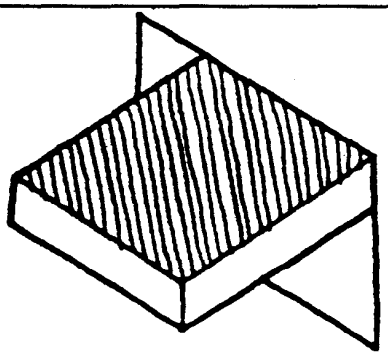


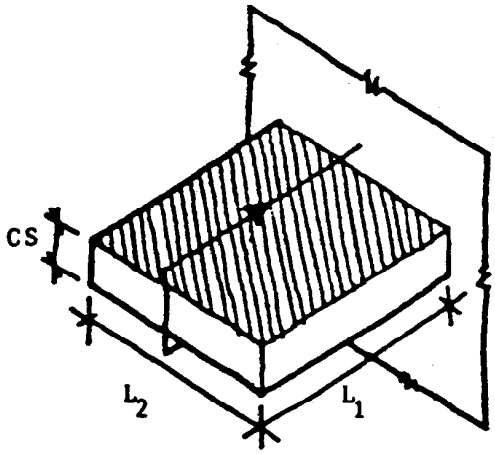
Figure 1.5b: Grip Shapes with Size Parameters, (continued)

KEY:

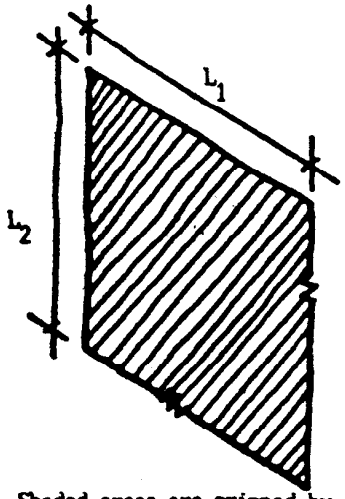
P: PERIMETER
CS: CROSS SECTION (diameter) (may be maximum and minimum cross section)
L: Length of Grip Area (may be more than one)



d. Plate



d. Plate

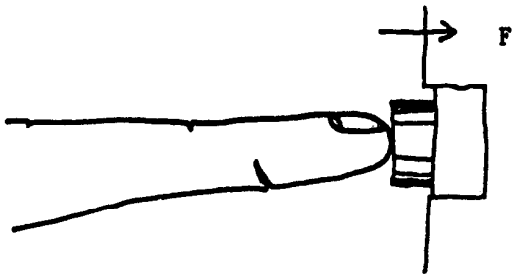


e. Area

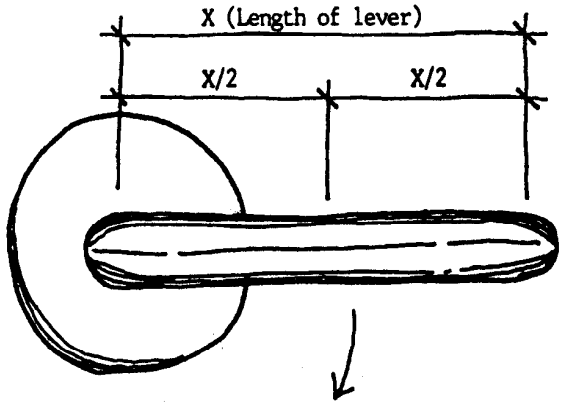
Shaded areas are gripped by the hand

Figure 1.5c

OPERATING FORCE MEASUREMENTS

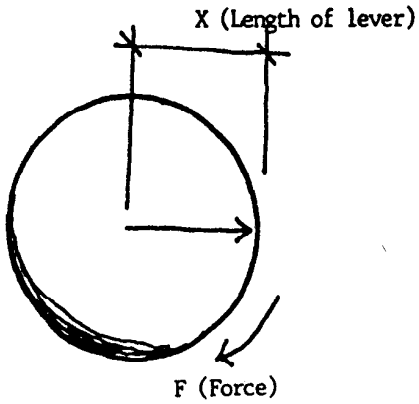


F = direct Force



Torque = $\frac{X}{2}$ (F)

F = $\frac{2(\text{Torque})}{X}$

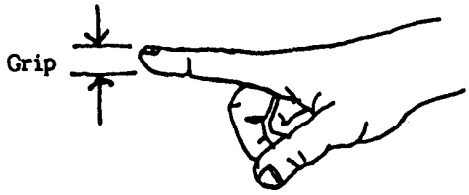


Torque = X(F)

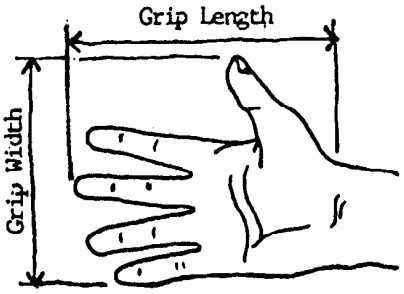
F = $\frac{\text{Torque}}{X}$

Figure 1.5d

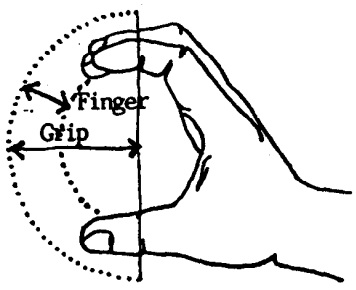
GRASP CLEARANCES



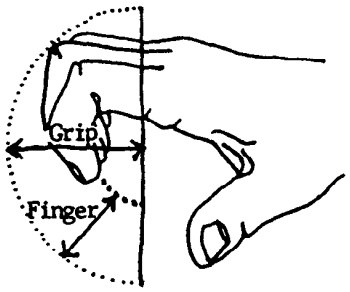
Finger Push



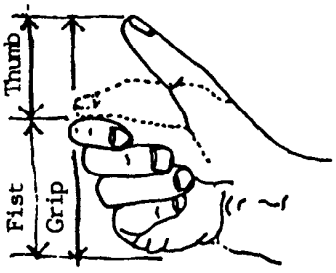
Flat Hand Push



Power, Span



Disc, Hook



Pinch

2.0 OPERABLE DEVICES

2.1 General

All devices falling under the scope of these requirements (see Section 1.1) and described in Sections 2.2 - 2.6 must be located within the reach limits described in Section 1.4 and comply with the requirements for Use Clearances in Section 1.2 and Access to Use Clearances in Section 1.3. Requirements in Sections 2.2 - 2.6 for specific devices are in addition to the General Requirements for grip limits in Section 1.5. Any device may be automatically operated. Controls for power operation shall comply with Sections 2.2 and 2.5 as applicable.

Rationale: Specific types of devices have requirements beyond those found in Section 1.4 Automatic operation is preferable, in most cases, to direct user manipulation. Power operation requires use of electronic controls, and often handles as well; thus, except where activation is controlled by sensors such as photo-electric cells or magnetic detectors, these controls and handles must also comply.

2.2 Additional Requirements For Electronic Controls

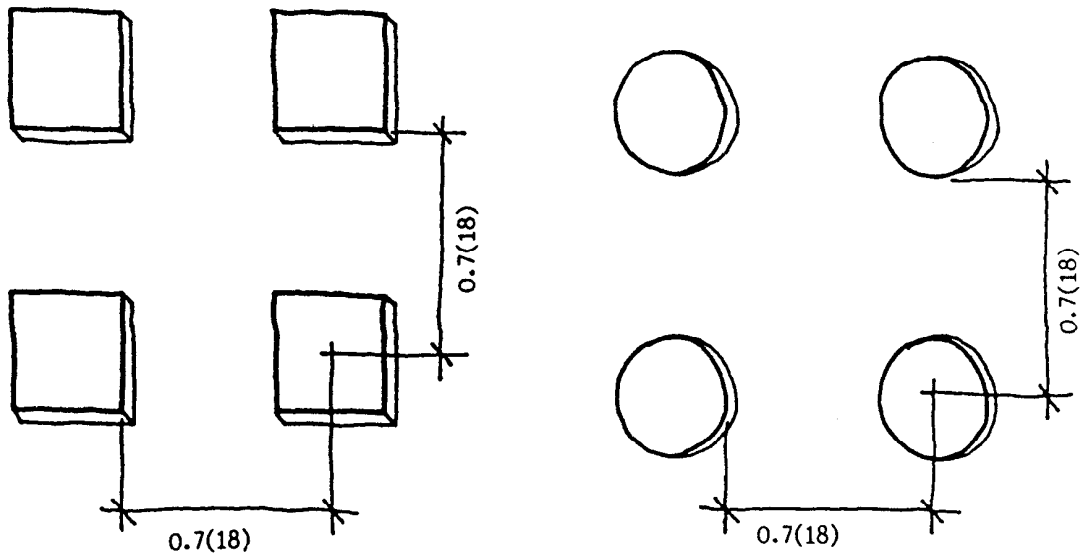
The minimum space between electronic controls shall comply with Table 2.2 and measured as in Figure 2.2. Where controls are clustered together, such as an elevator control panel or telephone button array, the height of the highest control shall be within the reach limits of Section 1.4. The minimum hand grasp space shown in Table 1.5 shall apply throughout the movement distance of an electronic control. Throughout its full movement distance, an electronic control shall not extend beyond the reach limits of Section 1.4.

Rationale: The minimum spacing requirements will accommodate 90% of the research sample. The spacing provides tolerance for inaccuracy and limited control due to deficits in psychomotor performance. However, such problems are relevant only for small controls (e.g., less than one finger width wide). Thus, the measurement of spacing is made from the center of the device. The spacing requirements also account for finger clearances required for moving the hand using disc or pinch grips. They accommodate 90% of the research sample. To use controls fully, they must be within reach and have sufficient hand clearance within movement range at all times.

TABLE 2.2: SPACING OF ELECTRONIC CONTROLS

DEVICE:	GRASP SPACE:
Buttons/Push Plate	0.7 inches (18mm), center to center
Knobs	1.8 inches (46 mm), outside to outside
Slides	2.0 inches (50 mm), center to center
Toggles	2.0 inches (50 mm), center to center

Figure 2.2: SPACING OF BUTTONS



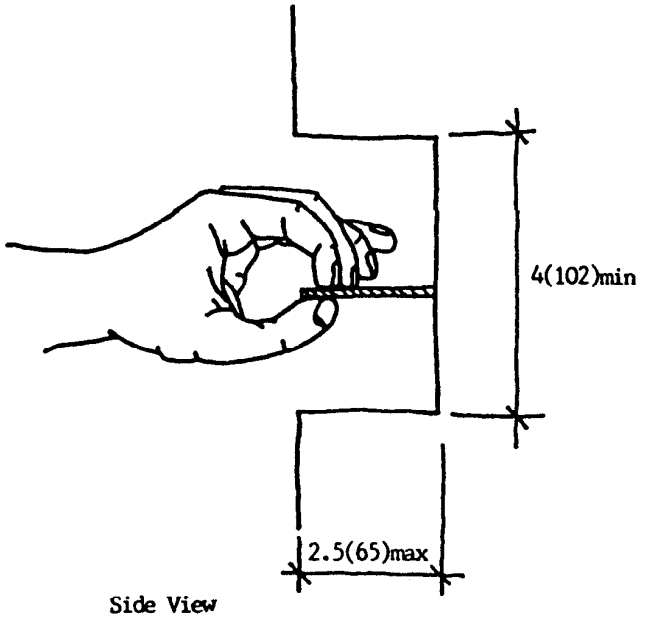
2.3 Additional Requirements for Dispensing Devices

At openings where objects are extracted from dispensers using pinch, power, span or disc grips, clearances shall be at least as large as those shown in Figure 2.3. For calculating reach limits, the depth of an opening shall be considered as an obstruction or recess (see Sections 1.2 and 1.4). Forces required for extracting objects from dispensers shall be no greater than 4 lb (1.8 kg-*f*).

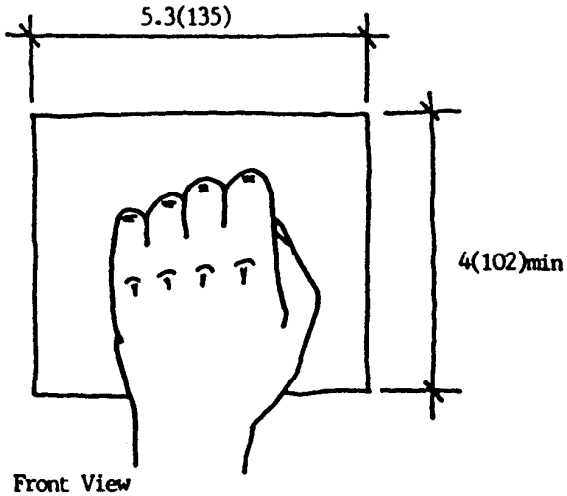
Rationale: These requirements accommodate the sizes of the above grips for 90% of the research sample.

Figure 2.3

CLEARANCES AT DISPENSER OPENINGS



Side View



Front View

2.4 Additional Requirements for Receptacles

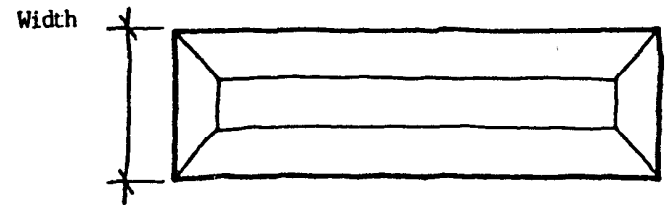
2.4.1 Card and Coin Slots

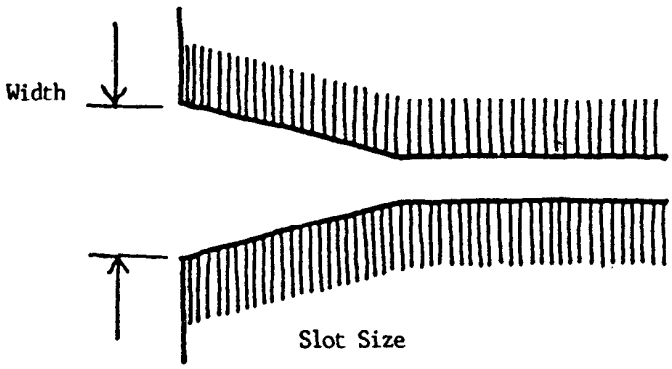
Coin slots shall be 0.12 inches (3 mm) wide, minimum at the outside surface of the slot (see Figure 2.4.1). Slots in a vertical surface shall be horizontal in orientation (see Figure 2.4.1). Slots in a horizontal surface shall be oriented with the slot length parallel to the user's (see Figure 2.4.1). Space clearances around slots shall comply with those shown in Figure 2.3. If cards are inserted only part way into a slot, at least 1 inch (25 mm) of the card shall remain exposed. The force required to insert a card into a slot shall be no greater than 4 lb (1.8 kg-*f*). The center of a slot shall be used to calculate compliance with reach limits in Section 1.4.

Rationale: These sizes would allow 90% of the research sample to use slots in times that are equivalent with those of able-bodied people. Increasing the slot width would not improve speeds to any great extent. The orientations specified reduce the need to flex, extend or laterally deviate the wrist, a major source of pain for hand-disabled people. The force limits will accommodate 90% of the research sample.

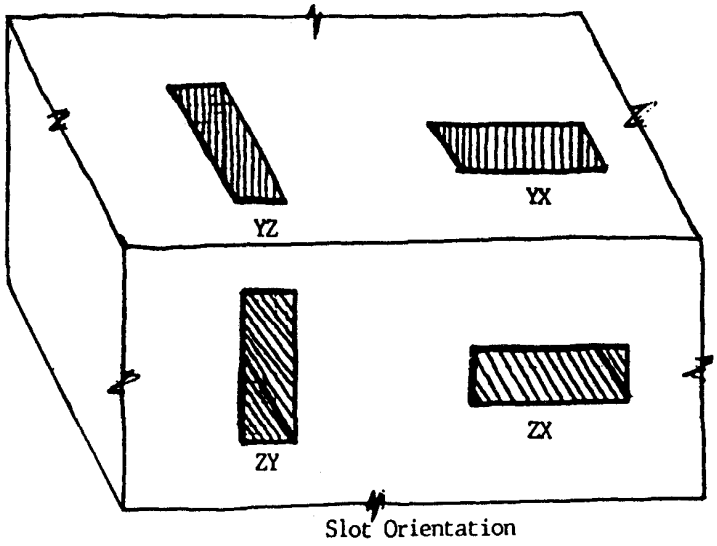
Figure 2.4.1

SLOT SIZE AND ORIENTATION





Coin Slots - Min: Card Slots - Min:



2.4.2 Keyed Locks

The force to turn a keyed lock shall be 4 lb (1.8 kg-*f*) maximum. Space clearances around the keyhole shall comply with those shown in Figure 2.3.

Rationale: Although keyed locks were difficult for 10% of our subjects to use, it is unlikely that they can be eliminated from buildings. Alternatives such as combination locks or magnetic card locks are preferred but are expensive at the present time. It is also unlikely that keyholes could be made wider. Standard key sizes now in use could not be changed without great cost. The use of guiding-type openings would result in the need for longer keys. The force limits accommodate 90% of the research sample.

2.4.3 Other Receptacles

The opening of any receptacle into which a hand must be inserted for use shall be as shown in Figure 2.3. The force required to open a door on a receptacle shall be 8 lb (3.6 kg-*f*) maximum for pushing and 11 lb (5.2 kg-*f*) maximum for pulling. All receptacle doors that must be pulled to open shall have handles complying with Section 2.6. The center of the opening at the point of maximum hand insertion shall be used to calculate compliance with reach limits in Section 1.4.

Rationale: These sizes and forces would accommodate 90% of the research sample.

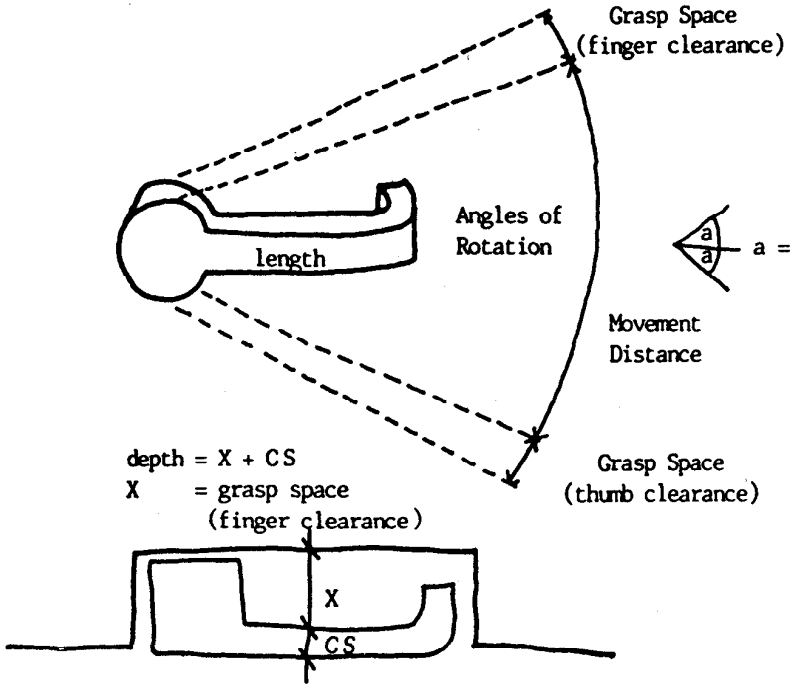
2.5 Additional Requirements for Handles

All handles in accessible spaces of public buildings and entries of accessible dwelling units shall be operable by at least one of the following grips: hook, flat hand or finger push. Design for use by other grips as well is allowable. The minimum hand grasp space shown in Table 1.5 shall apply throughout the movement distance of a handle (see Figure 2.5a, b and c for examples). Through its full movement distance, a handle shall not extend beyond the reach limits in Section 1.4. The minimum edge radius of any handle shall be 1/8 inch (3 mm). The maximum angle of rotation for any handle shall be as shown in figure 2.5a. All handle surfaces shall be free of abrasive textures and sharp elements.

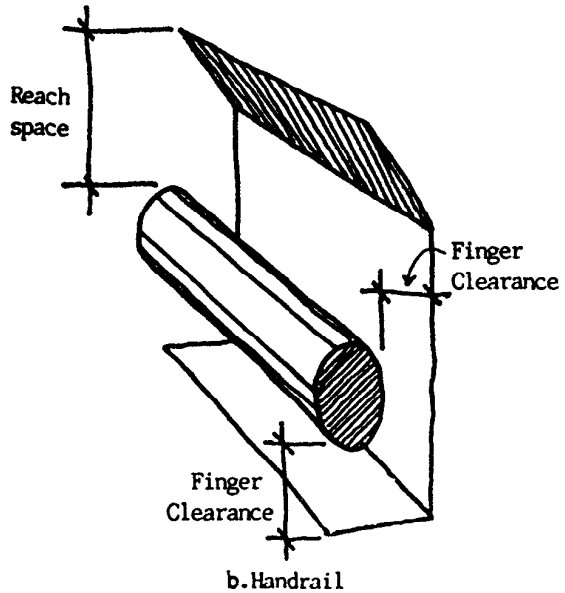
Rationale: To use a handle, it must remain within reach and have sufficient hand clearance throughout its movement range. Many people have difficulty rotating handles because they have limited wrist action or have pain when they flex, extend or laterally deviate their wrists. Cylindrical or bar-shaped handles can be moved with only slight wrist action but grasping and rotating discoids and spheres require considerably more involvement of the wrist even if they are only pushed or pulled. The angles of rotation in Figure 2.5a were comfortable for 90% of the research sample. The edge radius of a handle must not be too small or it will cause pain as it is grasped.

Figure 2.5

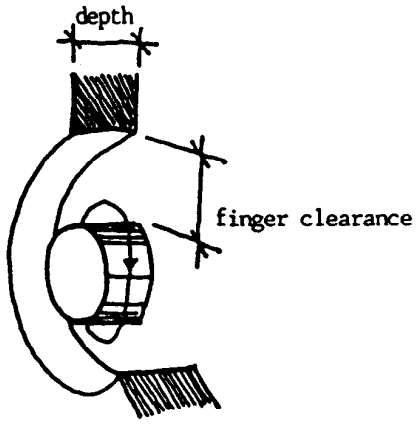
PROVIDING GRASP SPACE THROUGHOUT MOVEMENT DISTANCES



a. Recessed Lever Door handle



b.Handrail



c. Knob

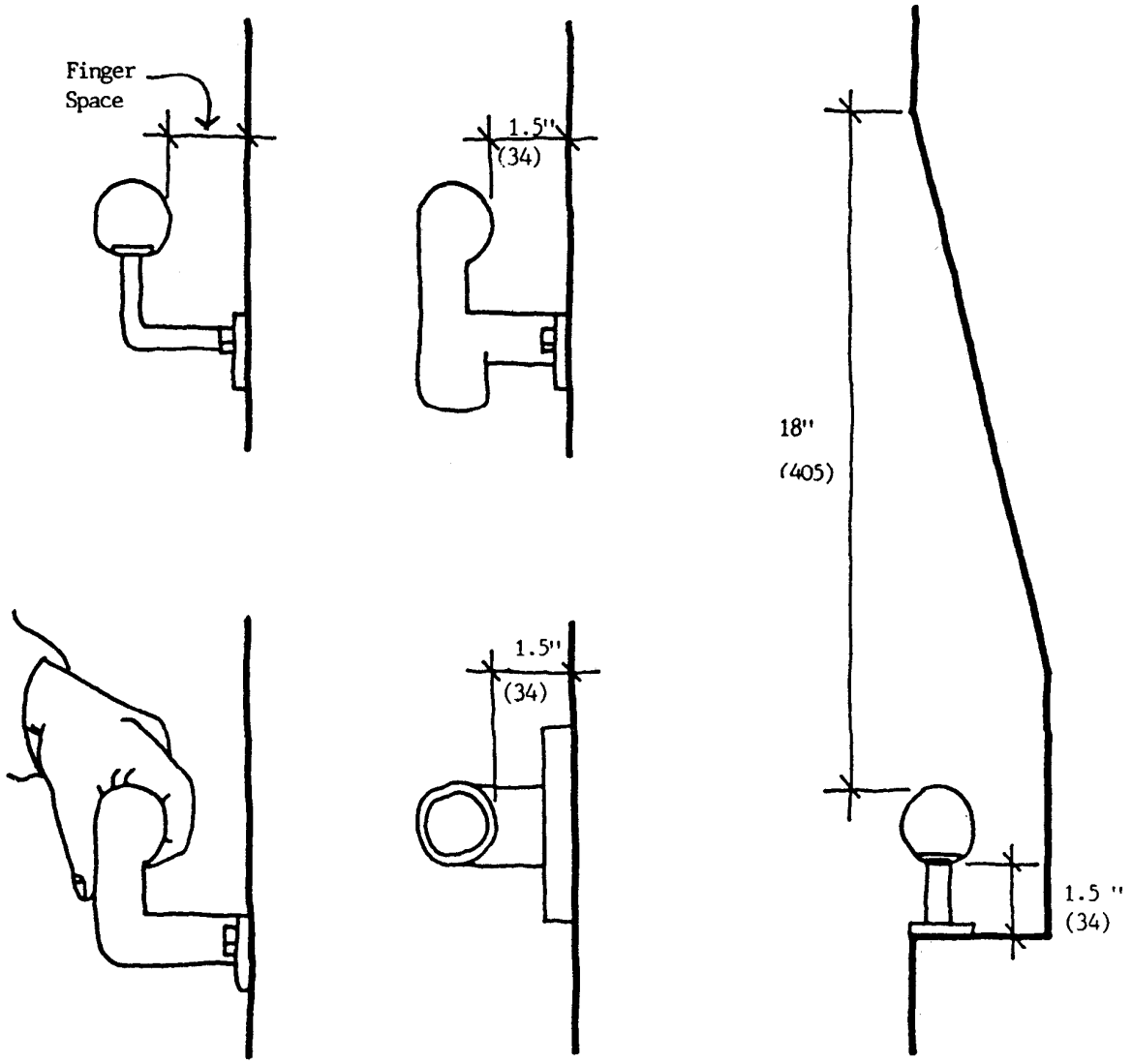
2.6 Additional Requirements for Assists

All assists shall comply with the requirements in Table 1.5 for power grips. The allowable range of cross sections shall be further limited to 1.3 inches (33 mm) minimum. The spacing of grab bars, hand rails and railings to adjacent mounting surfaces shall be as shown in Figure 2.6. All grab bar, handrail and railing sections and their fastening and mounting devices shall withstand a live load of 270 lb (121 kg-*f*) applied in any direction at any part of the object. Grab bars, handrails and railings shall not rotate or move laterally in their fittings. The minimum edge radius for any grab bar, handrail or railing shall be 1/8 inch (3 mm). All gripping surfaces shall be free of abrasive edges and sharp elements.

Rationale: The power grip allows the exertion of maximum strength which is of paramount importance in using assists. Although 90% of the research sample could form a grip around a 0.5 inch (12 mm) cross section, assists are used for support and, therefore, the minimum cross section should be larger than that of a handle. These space clearances are sufficient to accommodate 90% of the research sample using a power grip. Sharp edges on an assist can cause considerable discomfort. The maximum live load that a grab bar, handrail or railing would have to support with respect to building accessibility is the full falling weight of an individual in the 99th percentile range of the population which is 267 lb (120 kg-*f*). Other building regulatory concerns, structural safety requirements (e.g., a crowd leaning against a guardrail) supercede this requirement.

Figure 2.6

HANDRAIL, RAILING AND GRAB BAR CLEARANCES



3.0 EQUIPMENT

3.1 Applicability

All equipment in accessible spaces shall comply with Sections 1.2 - 2.6. Examples of equipment and devices that must comply are listed in Table 3.1. This table is not intended to be inclusive. It is presented as an aid for using the requirements.

3.2 Exceptions

All equipment listed in Table 3.2 need not comply with the requirements (see Section 1.1). This table provides examples only and is not intended to be inclusive. It is presented as an aid for using the requirements.

TABLE 3.1: APPLICABLE EQUIPMENT

EQUIPMENT	DEVICES	CROSS REFERENCES
ELEVATORS		1.2, 1.3, 1.4
	CAR CONTROLS	1.5, 2.2
	CALL CONTROLS	1.5, 2.2
	EMERGENCY COMMUNICATIONS	1.5, 2.2, 2.5
	HANDRAILS	1.5, 2.6
DOORS		1.3, 1.4
	OPENING HARDWARE	1.5, 2.4.1-2, 2.5
	POWER OPERATION CONTROLS	1.5, 2.2, 2.4.1-2
	LOCKS	1.5, 2.2, 2.4.1-2, 2.5
WINDOWS		1.2, 1.3, 1.4
	OPENING HARDWARE	1.5, 2.5
	POWER OPERATION CONTROLS	1.5, 2.2, 2.4.1, 2.5
	LOCKS	1.5, 2.4.1-2, 2.5
PLUMBING FIXTURES		1.2, 1.3, 1.4
	FAUCETS	1.5, 2.5
	FLUSH VALVES	1.5, 2.5
	SHOWER CONTROLS	1.5, 2.5
	SHOWER SPRAYS	1.5, 2.5
	STOPPER CONTROLS	1.5, 2.5
DRINKING FOUNTAINS AND WATER COOLERS	FLOW CONTROLS	1.2, 1.3, 1.4, 1.5, 2.5
APPLIANCES		1.2, 1.3, 1.4
	DOOR AND DRAWER HANDLES	1.5, 2.5
	SETTING CONTROLS	1.5, 2.2, 2.5
VENDING MACHINES, ATMS, FARE MACHINES, PUBLIC TELEPHONES		1.2, 1.3, 1.4
	COIN AND CARD SLOTS	1.5, 2.4.1
	CONTROLS	1.5, 2.2
	DISPENSER OPENINGS	1.5, 2.3
	DOOR AND DRAWER HANDLES	1.5, 2.5
CABINETRY AND STORAGE		1.2, 1.3, 1.4
	DOOR AND DRAWER HANDLES	1.5, 2.5
	LOCKS	1.5, 2.4.1-2
	SHELVES	1.5
	CLOTHES HANGING RODS	1.5
OFFICE FURNITURE		1.2, 1.3, 1.4
	DOOR AND DRAWER HANDLES	1.5, 2.5
	LOCKS	1.5, 2.4.1-2

TABLE 3.2: EXEMPTED EQUIPMENT

1. All equipment in locked mechanical and electrical rooms, closets and cabinets.
2. All equipment above suspended ceilings.
3. Locked thermostats.
4. Power tools and other manufacturing equipment.
5. Adjustment screws, knobs and other devices on appliances hidden by service panels or accessible only by moving equipment out of its intended operating position.
6. Switches in circuit breaker panels or fuse boxes.
7. Switches operable only with special tools in possession of maintenance personnel.
8. All keyed locks for which keys are distributed only to service or maintenance personnel.

4.0 DESIGN IMPLICATIONS

The recommendations for enforceable guidelines and requirements have significant implications for the design of several commonly used and specified products found in buildings. To illustrate these implications, the applicable design criteria for some specific products are summarized below (measurements were originally made in metric, converted into English units and rounded as necessary).

4.1 Card and Coin Slots

- minimum clear floor space for front approach: 30 inches (762 mm) by 48 inches (1220 mm).
- minimum clear floor spaces for side approach: 36 inches (914 mm) by 48 inches (1220 mm).
- located between 34 inches (864 mm) and 48 inches (1220 mm) from the floor.
- in a vertical surface, slots must be oriented in a vertical position.
- in a horizontal surface, slots must be oriented with their long dimension parallel to the user's shoulders.
- minimum dimension width: 0.12 inches (3 mm).

- maximum force required to push or pull object in the slot: 4 lb (1.8 kg-*f*).

- grasp clearance: 2.5 inches (64 mm) at the top side of horizontal slot in vertical surface; 4.0 inches (101 mm) at bottom of horizontal slot in vertical surface and at all other sides.

4.2 Window Hardware

- minimum clear floor space for front approach: 30 inches (762 mm) by 48 inches (1220 mm).

- minimum clear floor space of 36 inches (914 mm) by 48 inches (1220 mm) for a side approach.

- located between 34 inches (864 mm) and 48 inches (1220 mm) from the floor.

- handle must allow either a hook, flat hand, or finger push grip.

- using a small bar or plate (most likely shapes), maximum operable force of 2 lb (0.7 kg-*f*).

- minimum grasp space for a hook grip of 1.5 inches (38 mm).

- maximum angle of rotation: 90 degrees.

- cross section (diameter) of handle (hook grip): 2.7 inches (69 mm) maximum.

- minimum length of handle: 5.3 inches (135 mm).

- grasp clearance: 2.7 inches (69 mm).

4.3 Doors

- approach clearances would be established by existing accessibility standards and codes.

- height of opener 34 inches (864 mm) to 48 inches (1220 mm).

- grip shape must allow a hook, flat hand or finger push grip -- lever opener, door pull or push plate.

- force of opening door would be established by existing accessibility codes and standards (8.5 lb, 4 kg-*f*).

- operating force of handle would be 11 lb (5.2 kg-*f*) maximum if bar (lever opener).

- cross section (diameter) of handle (assuming power or hook grip): 0.5 inches (13 mm) to 1.7 inches (43 mm).

- minimum length of handle: 3.5 inches (88 mm).

- grasp clearance: 2.7 inches (69 mm) grip; 1.4 inches (36 mm) fingers.

4.4 Paper Dispensers

- minimum clear floor space for front approach: 30 inches (762 mm) by 48 inches (1220 mm).

- minimum clear floor space for a side approach: 36 inches (914 mm) by 48 inches (1220 mm).

- located between 34 inches (864 mm) and 48 inches (1220 mm).

- if paper projects out of the device so that it can be grasped directly, maximum force to pull out: 4 lb (1.8 kg-*f*).

- if a handle is used to control paper flow, it must be operable by a fist, a hook, flat hand, or finger push (e.g., button or large crank that a whole hand can move or a push plate): maximum force of 3 lb (1.5 kg-*f*) for a button.

- if a hand is inserted into an opening to pull out paper, then the opening must have at least 4 inches (102 mm) by 5.3 inches (135 mm) clearance.

- cross section (diameter) of handle: 2.1 inches (54 mm) maximum.

- minimum grip length of paper projection: 1 inch (25 mm).

- grasp clearance: 2.7 inches (69 mm) for handle; 6.2 inches (158 mm) for paper.

4.5 Lighting Controls

- minimum clear floor space for front approach: 30 inches (762 mm) by 48 inches (1220 mm).

- minimum clear floor space for a side approach: 36 inches (914 mm) by 48 inches (1220 mm).

- located between 34 inches (864 mm) by 48 inches (1220 mm) from the floor.

- button, push plate, knob, slide or toggle acceptable.

- minimum spacing to adjacent controls: 0.7 inches (18 mm).

- maximum force for operation: 3 lb (1.5 kg-*f*) for knob or plate; 2 lb (0.7 kg-*f*) if area is used, grip length can be very small.

- minimum cross section (diameter): 0.1 inch (3 mm) for plate; 2.0 inches (51 mm) to 2.8 inches (71 mm) for disc.

- grasp clearance: 6.2 inches (158 mm) for plate; 2.0 inches (51 mm) for knob.

4.6 Handrails and Grab Bars

- minimum clear floor space for front approach: 30 inches (762 mm) by 48 inches (1220 mm).

- minimum clear floor space for side approach: 36 inches (914 mm) by 48 inches (1220 mm).

- height and location required as currently established.

- shape must allow a power grip.

- cross section (diameter): 1.3 inches (33 mm) to 1.7 inches (43 mm).

- maximum perimeter of 5.2 inches (132 mm).

- minimum grip clearance: 1.5 inches (38 mm).

- minimum live load of 270 lb (121 kg-*f*).

- minimum edge radius of 1/8 inch (3 mm) with no abrasive edges or sharp elements.

- no rotation or lateral movement within fittings.

Cost Implications

After making final adjustments to the recommendations, their cost impact was evaluated by comparing the types of products that would meet the criteria to those that would not. Out of 39 products tested in the laboratory, 12, or 30%, did not meet the final recommendations. Eight of these were judged uncomfortable to use by 40% or more of the subjects. All of the twelve devices were designed to be used with a pinch, finger push or disc grip. Five of the devices were plumbing fixtures and controls. Three were locks and three were dispensers. The last was a window opener.

Out of nine door and window openers, only one did not meet the criteria. Thus there is no cost impact for such devices. There are many available on the market at various price ranges that will meet these recommendations.

The three locks that did not meet the recommendations all required a pinch grip to use. These devices were very common, including the "in the knob" type of twist lock. There are also inexpensive alternatives available for these devices, including the simple push type "in the knob" lock. The latter would be very easy for hand disabled people to use if, when in

the closed position, it can be unlocked by opening the latch or by another releasing push. The most uncomfortable device of all to use was the double hung window catch. This is a very common device for inexpensive windows. It is difficult to operate for all people.

Although five of the nine plumbing fixture controls did not meet the recommendations, four of these were similar devices -- all disc shapes that required considerable force to operate and/or required a disc grip to use. There are inexpensive alternatives to all of these devices.

For the dispensers, no problems were discovered for the paper dispensers which required practically no force to operate. The three soap dispensers which all operated on the same principle -- a push pump with a small circular shaped plate -- were all unsatisfactory. This type of dispenser has generally been replaced by the pre-packaged liquid soap dispensers. These require less force to operate and have large pull plates. Thus, there does not seem to be any cost impact for such dispensers.

All the electronic controls were satisfactory. There are many small keypads, however, that would not meet the spacing recommendations. The most serious problem here would be public telephones that have buttons spaced 0.2 inches (5 mm) closer together than the recommendations derived from the laboratory research. The subjects in the field study had no problems using a public telephone. Thus, a reduction in the spacing requirements might be in order.

The cabinet pulls all met the recommendations. Although two of them were difficult to use for about 30% of the subjects, both were unusual and not very sensibly designed. It is unlikely that such designs would be used often.

One aspect of the recommendations that would clearly have a significant cost impact is the clearance for dispenser openings. As found in the field study, the coin return on a public telephone was very difficult to use. This common device would not meet the recommendations.

Although no assists were studied in the laboratory or in the field, the recommendations would not be difficult to meet with a large variety of handrails and grab bars. The maximum cross section (diameter) recommendations would restrict the use of railings with diameters over 1.7 inches (43 mm). Railings of this size are relatively common. However, the recommendations are more flexible than the existing Federal and ANSI standards.

This project did not complete extensive testing of large pieces of equipment with several devices such as vending machines and automatic teller machines. It is conceivable that many vending machines would not comply with the recommendations, particularly those related to reach, coin returns and dispenser openings. The extent of the cost impact for such equipment is difficult to determine without considerably more investigation.

In summary, with a few important exceptions, there should be relatively little cost impact associated with implementation of the recommendations. There is also a good possibility that there are some product types not encountered in this research among which it would be difficult to find many devices that would comply completely. Before adopting these recommendations, it is suggested that considerable effort be invested in communications with industry to discover any unknown problems. Moreover, particular attention should be given to the problem of spacing for keypads and the space clearances of coin returns. These are clearly important issues that have to be addressed.

DEFINITIONS

ASSISTS: Devices such as handrails, grab bars and railings that are gripped in order to aid in movement or provide support while shifting posture.

AUTOMATIC OPERATION: A process not requiring direct human interaction to begin and control, such as activation by photo-electric cells, magnetic detection systems or floor-mounted pressure switches.

DISPENSER: A device from which users extract secondary objects for purposes of use or consumption, such as a paper towel dispenser slot, vending machine openings, or coin returns.

ELECTRONIC CONTROL: A device that activates or controls a process through electricity, such as a toggle switch, elevator push button or dimmer slide or knob.

EQUIPMENT: A product that incorporates more than one operable device that often must be manipulated in sequence, for example, a vending machine, door, elevator, or plumbing fixture.

GRASP SPACE: The space required to form a grip around a device and operate it; the grasp space includes at least two components -- overall grip clearance and finger clearance.

GRIP: A movement of the hand used to manipulate some object. There are several types, including power, hook, pinch, disc, span, finger push, and flat hand push.

HANDLE: A device that is gripped in order to move another object to which it is attached or to activate or control a process through mechanical means, such as a door opener, faucet, shower spray, window lock, or cabinet pull.

OPERABLE DEVICE: A device that can be manipulated by a hand movement for purposes of activating, adjusting or controlling a process related to the general use of buildings. Operable devices include devices in which a secondary object, including but not

	limited to coins, cards, keys, and paper products are used in conjunction with the device itself.
POWER OPERATION OR ASSIST:	A process utilizing electro-mechanical power that is activated directly and voluntarily by the building user through operable devices such as push buttons, levers or bars.
RECEPTACLES:	A device in which users insert a secondary object in order to activate or control a process, such as a mail slot, coin slot, magnetic card slot, key hole, or garbage can opening.
SAGITTAL:	In the direction or location from front to back in the median plane or in a plane parallel to the median.
TRANSVERSE:	Lying or being across or in a cross direction.

*U.S. Government Printing Office: 1995 — 392-125