NOT MEASUREMENT SENSITIVE

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MILITARY STANDARD

HUMAN ENGINEERING DESIGN CRITERIA FOR MILITARY SYSTEMS, EQUIPMENT AND FACILITIES

AMSC N/A

AREA HFAC

Distribution Statement A. Approved for public release; distribution is unlimited.

FOREWORD

1. This Military Standard has been approved for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, US Army Missile Command, ATTN: AMSMI-RD-SE-TD-ST, Redstone Arsenal, AL 35898-5270, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

3. This standard establishes general human engineering criteria for design and development of Military systems, equipment and facilities. Its purpose is to present human engineering design criteria, principles and practices to be applied in the design of systems, equipment and facilities so as to:

a. Achieve required performance by operator, control and maintenance personnel.

b. Minimize skill and personnel requirements and training time.

c. Achieve required reliability of personnel-equipment combinations.

d. Foster design standardization within and among systems.

4. This standard does not alter requirements for system development participation of human engineering specialists to interpret and implement these practices and to provide solutions to human engineering problems which arise and which are not specifically covered herein.

5. The use of the words "shall," "should," "may," and "will" in this standard is in accordance with MIL-STD-962, wherein "shall" expresses a provision that is binding, "should" and "may" express nonmandatory provisions, and "will" expresses a declaration of purpose or simple futurity.

6. Requirements herein are expressed in the International System of units (SI). As a convenience, the metric units are accompanied by their approximate customary system equivalents (in parentheses). Angular measure is expressed in radians or milliradians, except for 45°, 90°, 180°, 360°, etc., which are shown as multiples or divisions of π radians.

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HUMAN ENGINEERING DESIGN CRITERIA FOR MILITARY SYSTEMS, EQUIPMENT AND FACILITIES

1. SCOPE

1.1 Scope. This standard establishes general human engineering design criteria for military systems, subsystems, equipment and facilities.

1.2 Purpose. The purpose of this standard is to present human engineering design criteria, principles, and practices to achieve mission success through integration of the human into the system, subsystem, equipment, and facility, and achieve effectiveness, simplicity, efficiency, reliability, and safety of system operation, training, and maintenance.

1.3 Application. This standard shall be applied to the design of all systems, subsystems, equipment and facilities. Nothing in this standard shall be construed as limiting the selection of hardware, materials, or processes to the specific items described herein. Unless otherwise stated in specific provisions, this standard is applicable to design of systems, subsystems, equipment and facilities for use by both men and women. This standard is not intended to be a criterion for limiting use of materiel already in the field in areas such as lift repetition or temperature exposure time. Where the procuring activity establishes use by male personnel exclusively, the following paragraphs are changed as noted below:

Paragraph	Line	From	To
3.1	9	female	(delete)
5.2.1.4.11	3	635 mm (25 in)	700 mm (28 in)
5.4.4.2	4&5	which...adjustment)	(delete)
5.4.4.3	5-7	The,...adjustment)	(delete)
5.6.1	4	female, male	(delete)
5.7.2.2	3	1.780 m (70 inches)	1.880 m (74 inches)
5.7.2.3	3&4	1.650 m (65 inches)	1.750 m (69 inches)
5.7.2.4	3	1.780 m (70 inches)	1.880 m (74 inches)
5.7.2.5	2&3	1.350 m (53 inches)	1.450 m (57 inches)
5.7.2.5	3&4	530 mm (21 inches)	560 mm (22 inches)
5.7.3.4.2	2	380 mm (15 inches)	400 mm (16 inches)
5.7.3.6	3	1.170 m (46 inches)	1.220 m (48 inches)
5.7.3.7	2&3	890 mm (35 inches)	940 mm (37 inches)
5.7.3.7	3	530 mm (21 inches)	560 mm (22 inches)
5.7.3.9	3	860 mm (34 inches)	890 mm (35 inches)
5.7.3.10	2	740 mm (29 inches)	760 mm (30 inches)
5.7.6.1.4	2&3	685 mm (27 inches)	750 mm (29.5 inches)

Table XX	A1	1.170 m (46.0 in)	1.210 m (47.5 in)
		1.335 m (52.5 in)	1.370 m (54.0 in)
		1.435 m (56.5 in)	1.470 m (58.0 in)
	A3&4	1.535 m (60.5 in)	1.570 m (62.0 in)
	B1	520 mm (20.5 in)	560 mm (22.0 in)
	B3&4	620 mm (24.5 in)	660 mm (26.0 in)
Figure 30	G	150 mm (6 in)	125 mm (5 in)
	H	190 mm (7.5 in)	165 mm (6.5 in)
Figure 36	B-Max	380 mm (15 inches)	410 mm (16 inches)
5.7.7.1.2	5	13 kg (29 lbs)	18 kg (40 lbs)
5.9.11.4.1	5-7	(Delete second and third sentences)	

1.4 Force limits. If it is known that an item is to be used by an already established military occupational specialty, for which physical qualification requirements for entry into that specialty are also established, any discrepancy between the force criteria of this standard and the physical qualification requirements shall be resolved in favor of the latter. In this event, the least stringent physical qualification requirement of all specialties which may operate, maintain, transport, supply, move, lift or otherwise manipulate the item, in the manner being considered, is selected as a maximum design force limit. If such physical qualification requirements for entry into a specialty do not cover the task addressed by the criteria herein, the criteria herein shall govern.

1.5 Manufacturing tolerances. When manufacturing tolerances are not perceptible to the user, this standard shall not be construed as preventing the use of components whose dimensions are within a normal manufacturing upper or lower limit tolerance of the dimensions specified herein.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solication (see 6.2).

SPECIFICATIONS

MILITARY

MIL-W-5044	Walkway Compound, Nonslip, and Walkway Matting, Nonslip
MIL-W-5050	Walkway Coating and Matting, Nonslip, Aircraft Application of
MIL-L-5667	Lighting Equipment, Aircraft Instrument Panel, General Specification for Installation of
MIL-P-7788	Panels, Information, Integrally Illuminated
MIL-A-8806	Acoustical Noise Level in Aircraft, General Specification for
MIL-S-008806	Sound Pressure Levels in Aircraft, General Specification for
MIL-S-9479	Seat System, Upward Ejection, Aircraft, General Specification for
MIL-M-18012	Markings for Aircrew Station Displays, Design and Configuration of
MIL-S-18471	System, Aircrew Automated Escape, Ejection Seat Type: General Specification for
MIL-A-23121	Aircraft Environmental, Escape and Survival Cockpit Capsule System, General Specification for
MIL-T-23991	Training Devices, Military, General Specification for
MIL-C-25050	Colors, Aeronautical Lights and Lighting Equipment, General Requirements for

MIL-L-25467 Lighting, Integral, Red, Aircraft Instrument, General Specification for

MIL-C-25969 Capsule, Emergency Escape System, General Specification for

STANDARDS

FEDERAL

FED-STD-515/17 Outside Rearview Mirror(s) for Automotive Vehicles

FED-STD-595 Colors

MILITARY

MIL-STD-12 Abbreviation for Use on Drawings, Specifications, Standards, and in Technical Documents

MIL-STD-129 Marking for Shipment and Storage

MIL-STD-130 Identification Markings of U.S. Military Property

MIL-STD-195 Marking of Connections for Electric Assemblies

MIL-STD-203 Aircrew Station Controls and Displays for Fixed Wing Aircraft

MIL-STD-250 Aircrew Station Controls and Displays for Rotary Wing Aircraft

MIL-STD-280 Definitions of Item Levels, Item Interchangeability, Models and other related Terms

MIL-STD-411 Aircrew Station Signals

MIL-STD-415 Test Provisions for Electronic Systems and Associated Equipment, Design Criteria for

MIL-STD-454 Standard General Requirements for Electronic Equipment

MIL-STD-490 Specification Practices

MIL-STD-681 Identification Coding and Application of Hookup and Lead Wire

MIL-STD-740-1 Airborne Sound Measurements and Acceptance Criteria of Shipboard Equipment

MIL-STD-783	Legends for Use in Aircrew Stations and on Airborne Equipment
MIL-STD-850	Aircrew Station Vision Requirements for Military Aircraft
MIL-STD-1179	Lamp, Reflectors and Associated Signalling Equipment for Military Vehicles
MIL-STD-1180	Safety Standards for Military Ground Vehicles
MIL-STD-1247	Markings, Functions and Hazard Designations of Hose, Pipe, and Tube lines for Aircraft, Missile and Space Systems
MIL-STD-1280	Keyboard Arrangements
MIL-STD-1294	Acoustical Noise Limits in Helicopters
MIL-STD-1333	Aircrew Station Geometry for Military Aircraft
MIL-STD-1348	Knobs, Control, Selection of
MIL-STD-1473	Standard General Requirements for Color and Marking of Army Materiel
MIL-STD-1474	Noise Limits for Army Materiel
MIL-STD-1787	Aircraft Display Symbology

HANDBOOKS

MILITARY

DOD-HDBK-743	Anthropometry of US Military Personnel
MIL-HDBK-759	Human Factors Engineering Design for Army Materiel

(Unless otherwise indicated, copies of federal and military specifications, standards and handbooks are available from the Naval Publications and Forms Center (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099.)

2.1.2 Other Government documents, drawings, and publications. The following other government documents, drawings and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

PUBLICATIONS

NAVY

OPNAVINST 5100.23B   Hearing Conservation Program

AIR FORCE

AFR 161-35   Hazardous Noise Exposure (Regulation)

FEDERAL REGULATION

29 CFR 1910   Occupational Safety and Health Standards

(Copies of other government documents, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Non-Government publications. The following document(s) form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

Human Engineering Guide to Equipment Design, 1972 Edition

(Application for copies should be addressed to the Superintendent of Documents, US Government Printing Office, Washington, DC 20402)

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS (ACGIH)

Threshold Limit Values

(Application for copies should be addressed to the ACGIH, 1014 Broadway, Cincinnati, OH 45202.)

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI S1.1 1960	Acoustical Terminology
ANSI S1.4	Sound Level Meters
ANSI S1.6 1967	Preferred Frequencies and Band Numbers for Acoustical Measurements
ANSI S3.2 1960	Monosyllabic Word Intelligibility, Method for Measurement of

ANSI S3.5 1969 — Articulation Index, Methods for the Calculation of

(Application for copies should be addressed to the American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM E 380-84 — Metric Practice, Standard for

ASTM F 1166-88 — Standard Practice for Human Engineering design Criteria for Marine systems equipment and facilities

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

INTERNATIONAL STANDARDIZATION ORGANIZATION (ISO)

ISO DIS 2631 — Guide to the Evaluation of Human Exposure to Whole Body Vibration

(Application for copies should be addressed to the American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

SAE J925 — Minimum Access Dimensions for Construction and Industrial Machinery

(Application for copies should be addressed to the Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096-0001.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

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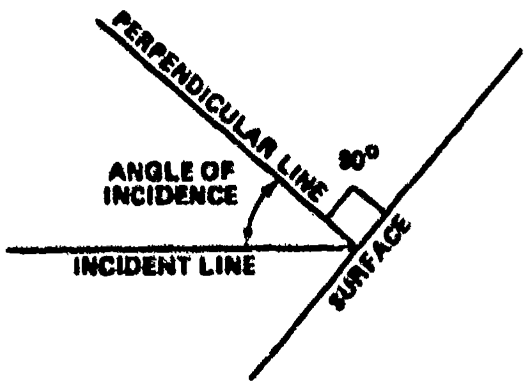
3. DEFINITIONS

3.1 Abort. A capability that cancels all user entries in a defined transaction sequence.

3.2 Accessible. Except where stated to the contrary herein or where specific design values are given, an item is considered accessible only where it can be operated, manipulated, removed or replaced by the suitably clothed and equipped user with applicable 5th and 95th percentile body dimensions. Applicable body dimensions are those dimensions which are design-critical to the operation, manipulation, removal or replacement task. (For example, an adjustment control behind an aperture should be located sufficiently close to the aperture to enable a suitably clothed and equipped user with a 5th percentile female depth of reach to grasp and manipulate the adjustment control, while the opening should be sufficently large to enable passage of similarly clothed and equipped 95th percentile male hand and arm dimensions. See 5.6.1.)

3.3 Advisory signal. A signal to indicate safe or normal configuration, condition of performance, operation of essential equipment, or to attract attention and impart information for routine action purposes.

3.4 Angle of incidence. The angle between the line of direction of anything (as a ray of light or line of sight) striking a surface and a line perpendicular to that surface drawn to the point of contact.



3.5 Backup. A capability that returns a user to the last previous display in a defined transaction sequence. Also refers to the practice of preserving a second copy of files for data protection purposes.

3.6 Cancel. A capability that regenerates or re-initializes the current display without processing or retaining any changes made by the user.

3.7 Caution signal. A signal which alerts the operator to an impending dangerous condition requiring attention, but not necessarily immediate action.

3.8 Command and control system equipment. The main mission element equipment and related ground equipment used in collecting, transmitting, processing, and displaying information for command and control.

3.9 Command language. A type of dialogue in which a user composes control entries with minimal prompting by the computer.

3.10 Common hand tools. Items of tools found in common usage or applicable to a variety of operations or to a single operation on a variety of material. Screwdrivers, hammers, and wrenches are examples of common hand tools.

3.11 Control entry. User input for sequence control, such as function key actuation, menu selection, command entry, etc.

3.12 Data. The raw materials from which a user extracts information. Data may include numbers, words, pictures, etc.

3.13 Data display. Output of data from a computer to its users. Generally, the phrase denotes visual output, but it may be qualified to indicate a different modality, such as an "auditory display."

3.14 Data entry. User input of data for computer processing and computer responses to such inputs.

3.15 Data field. An area of the display screen reserved for user entry of a data item.

3.16 Data item. A set of characters of fixed or variable length that forms a single unit of data. Examples of a data item might be a person's name or a ZIP code. Data items may be entered by a user or may be supplied by the computer.

3.17 Data protection. Functional capabilities that guard against unauthorized data access and tampering, user errors, and computer failure.

3.18 dB(A). The unit used to express sound level measured through the A-weighting network of a sound level meter.

3.19 Decibel (dB). See para 3.58.

3.20 De-emphasis. The inverse of pre-emphasis, employed for the purpose of restoring original vowel-consonant amplitude relationships in pre-emphasized speech; primarily useful in maintaining the "natural" sound quality. (See pre-emphasis.)

3.21 Default value. A predetermined, frequently used value for a data field or control entry, intended to reduce required user entry actions.

3.22 Dialogue. A structured series of interchanges between a user and a computer terminal. Dialogues can be computer initiated, e.g., question and answer, or user initiated, e.g., command languages.

3.23 Dichotic. The condition in which the sound stimulus presented at one ear differs from the sound stimulus presented at the other ear. The stimulus may differ in sound pressure, frequency, phase, time, duration, or bandwidth.

3.24 Display format. The organization of different types of data in a display, including information about the data such as labels, and other user guidance such as prompts, error messages, etc.

3.25 Effective temperature. An arbitrary index which combines into a single value the effect of temperature, humidity, and air movement on the sensation of warmth or cold felt by the human body. The numerical value is that of the temperature of still, saturated air which would induce an identical sensation.

3.26 Enter. An explicit user action that effects computer processing of user entries. For example, after typing a series of numbers, a user might press an ENTER key that will add them to a data base, subject to data validation.

3.27 Equipment. General term designating any item or group of items.

3.28 Equipment failure. An equipment failure is the cessation of the ability to meet the minimum performance requirements of the equipment specifications. Further, equipment failure shall imply that the minimum specified performance cannot be restored through permissible readjustment of operator controls.

3.29 Facilities. A physical plant, such as real estate and improvements thereto, including building and equipment, which provides the means for assisting or making easier the performance of a system function. The facilities to which this standard apply are those in which personnel perform system operational or maintenance duties.

3.30 Fail-safe design. Fail-safe design is one in which a failure will not adversely affect the safe operation of the system, equipment, or facility.

3.31 Field. See "Data Field."

3.32 File. A collection of data, treated as a single unit, that is stored in a computer.

3.33 Function key. A key whose actuation will effect a control entry.

3.34 Help. A capability that displays information upon user request for on-line guidance. HELP may inform a user generally about system capabilities, or may provide more specific guidance in information handling transactions.

3.35 Highlighting. Emphasizing displayed data or format features in some way, e.g., through the use of underlining, bolding, or inverse video.

3.36 Human engineering design criteria. The summation of available knowledge which defines the nature and limits of human capabilities as they relate to the checkout, operation, maintenance or control of systems or equipment, and which may be applied during engineering design to achieve optimum compatibility between equipment and human performance.

3.37 Information. Organized data that users need to successfully perform their tasks. Information serves as an answer to a user's questions about data. It is used here to refer to the effective assimilation of data by a user.

3.38 Interrupt. Stopping an ongoing transaction in order to redirect the course of the processing. Examples of interrupt options are ABORT, BACKUP, CANCEL, and RESTART.

3.39 Luminance contrast. The contrast between the background and a figure equals the difference between the higher luminance (L_1) and the lower luminance (L_2) divided by the lower luminance (L_2); i.e.,

$$C = \frac{L_1 - L_2}{L_2}$$

Conversions to the other contrast formulae are as follows:

L1 (brighter)	L2 (dimmer)	$\frac{L1-L2}{L2}$	$\frac{L1-L2}{L1}$	$\frac{L1-L2}{L1+L2}$	$\frac{L1}{L2}$
100	50	1.0	0.50 (50%)	0.33	2.0
100	25	3.0	0.75 (75%)	0.60	4.0
100	10	9.0	0.90 (90%)	0.82	10.0

3.40 Luminance ratio (LR). The ratio of luminance between the target or subject and the surrounding field or background. For projection systems, the luminance ratio is equal to the light output of a projector (measured with no film in the projector) reflected off the screen (image luminance) divided by all the light falling on the screen (measured from the greatest viewing angle) other than that actually forming the image (nonimage or background); i.e.,

$LR = \frac{L}{L_n}$, where: L = Image or subject luminance
L_n = Nonimage or background luminance

3.41 Macro. The capability to allow the user to assign a single name or function key to a defined series of commands for use with subsequent command entry. Sometimes called "smart key." Examples of use are storage of addresses or signature blocks that are frequently used.

3.42 Maintainability, design for. Design considerations directed toward achieving those combined characteristics of equipment and facilities which

3.43 Master caution (warning) signal. A signal which indicates that one or more caution (warning) lights has been actuated.

3.44 Menu selection. A type of dialogue in which the user selects one item out of a list of displayed alternatives, whether the selection is by pointing, by entry of an associated option code, or by actuation of an assigned function key.

3.45 Metric equivalents, abbreviations and prefixes. Table I has been used herein in accordance with paragraph 4 of the Foreword.

TABLE I METRIC EQUIVALENTS, ABBREVIATIONS AND PREFIXES

TO CONVERT FROM:	TO:	MULTIPLY BY:
DEGREE (ANGLE) (deg)	RADIAN (rad)	1.745 329 E-02
FOOT (ft)	METER (m)	3.048 000 E-01
FOOT^2 (ft^2)	METER^2 (m^2)	9.290 304 E-02
FOOT^3 (ft^3)	METER^3 (m^3)	2.831 685 E-02
FOOTCANDLE (ft-C)	LUX (lx)	1.076 391 E+01
FOOTLAMBERT (ft-L)	CANDELA PER METER^2 (cd/m^2)	3.426 259 E+00
INCH (in. OR ")	METER	2.540 000 E-02
INCH^2 (in.^{2})	METER^2 (m^2)	6.451 600 E-04
INCH^3 (in.^{3})	METER^3 (m^3)	1.638 706 E-05
MINUTE (ANGLE) (min)	RADIAN (rad)	2.908 882 E-04
OUNCE-FORCE (ozf)	NEWTON (N)	2.780 139 E-01
OUNCE-INCH (ozf · in.)	NEWTON METER (N · m)	7.061 552 E-03
POUND (lb) AVOIRDUPOIS	KILOGRAM (kg)	4.535 924 E-01
POUND-FORCE (lbf)	NEWTON (N)	4.448 222 E+00
POUND-INCH (lbf · in.)	NEWTON METER (N · m)	1.129 848 E-01
SECOND (ANGLE) (sec)	RADIAN (rad)	4.848 137 E-06

PREFIXES

NANO	n	10^{-9}	CENTI	c	10^{-2}
MICRO	μ	10^{-6}	KILO	k	10^{3}
MILLI	m	10^{-3}	MEGA	M	10^{6}

TEMPERATURE CONVERSION

$$°C = \frac{5}{9}(°F - 32)$$

$$°F = \frac{9}{5}°C + 32$$

NOTE: EACH CONVERSION FACTOR IS PRESENTED AS A NUMBER, BETWEEN ONE AND TEN, TO SIX DECIMAL PLACES. THE LETTER E (FOR EXPONENT), A PLUS OR MINUS SIGN AND TWO DIGITS FOLLOWING THE NUMBER, REPRESENT THE POWER OF 10 BY WHICH THE NUMBER IS TO BE MULTIPLIED.

FOR EXAMPLE: 3.048 000 E-01 = 3.048 000 x 10^{-1} = 0.3048000

OR: 1.076 391 E+01 = 1.076 391 x 10^{1} = 10.76391

EXAMPLES OF USE OF TABLE:

TO CONVERT 2 ft^3 TO m^3, MULTIPLY 2 BY 2.831 685 E-02

2 x 0.028 316 85 = 0.056 634 m^3

(TO CONVERT 2 m^3 TO ft^3, DIVIDE 2 BY 2.831 685 E-02)

(2/0.028 316 85 = 70.629 225 ft^3)

A MORE COMPLETE LISTING AND DISCUSSION MAY BE FOUND IN ASTM E 380-76

3.46 Noise-cancelling (microphone). A feature which reduces the masking effect of ambient noise upon speech impressed on a microphone, usually by providing equal access of the ambient noise to both surfaces of a diaphragm to achieve approximate equilibrium, effectively causing the noise to cancel itself out. Since the talker's own voice output impinges on only one side of the microphone diaphragm, the talker's signals are not subject to this cancellation, and so are transmitted more favorably than if both ambient noise and speech fell simultaneously upon one face of the diaphragm.

3.47 Nuclear, biological, chemical (NBC) survivability. NBC survivability includes both the instantaneous, cumulative and residual effects of NBC weapons upon a system including its personnel. NBC survivability describes the capability of a system to withstand the NBC environment, including decontamination, without losing the ability to accomplish its mission. For any system to be considered survivable in an NBC contaminated battlefield, it must have at least three essential characteristics: Decontaminability, hardness, and compatibility.

(1) Decontaminability is the ability of a system to be rapidly decontaminated to reduce the hazard to personnel operating, maintaining and resupplying it.

(2) Hardness is the ability of a system to withstand the materiel damaging effects of NBC contamination and any decontamination agents and procedures required to remove it.

(3) Compatibility is the ability of a system to be effectively operated, maintained, and resupplied by persons wearing the full NBC protective ensemble.

3.48 Page. The data appearing at one time on a single display screen.

3.49 Panel. The front face of an assembly, normally used for mounting controls and displays.

3.50 Panning. An orientation for display framing in which a user conceives of the display frame as moving over a fixed array of data. The opposite of scrolling.

3.51 Peak-clipping (of speech signals). A technique for controlling amplitude relationships in speech by limiting the instantaneous peak-amplitudes to improve intelligibility of speech, usually followed by amplification of the signal to increase the amplitude of the clipped peaks to their original level, with proportional increase of the weaker speech sounds.

3.52 Pre-emphasis. Systematic distortion of the speech spectrum to improve intelligibility of speech sound by attenuating the low-frequency components of vowels (relatively unimportant for intelligibility) and proportionately increasing the amplitude of high-frequency vowel components and consonants (highly important for intelligible speech transmission).

3.53 Prompt. An indicator provided by the computer that alerts the user that the computer is ready, data should be entered, etc.

3.54 Query language. A type of dialogue in which users compose control enteries for displaying specified data from a data base.

3.55 Question and answer. A type of dialogue in which the computer displays questions, one at a time, for a user to answer.

3.56 Scrolling. An orientation for display framing in which the user conceives of data as moving behind a fixed display frame. The opposite of panning.

3.57 Seat reference point (SRP). The point at which the center line of the seat back surface (depressed) and seat bottom surface (depressed) intersect. When the seat is positioned at the midpoint of the adjustment range(s), this intersection point is called the neutral seat reference point. (See MIL-STD-1333 for Army and Navy aircraft definition.)

3.58 Sound pressure level (SPL). The pressure of an acoustic wave; usually expressed in decibels (dB), equal to 20 times the logarithm to the base 10 of the ratio of the effective root-mean-square (rms) pressure of this sound to the reference pressure, i.e.,

$$SPL = 20 \log_{10} \frac{P}{20\mu Pa}$$

where P = the effective (rms) sound pressure in micropascals (μPa) or micronewtons per square meter ($\mu N/M^2$). ($20\mu Pa = 20\mu N/M^2 = 0.0002$ microbar = 0.0002 dynes/cm^2.)

3.59 Source documents. User's documents, which are a source of data eventually processed by the computer program, such as target lists, supply codes, parts lists, maintenance forms, bills of lading, etc.

3.60 Special tools. Tools not listed in the Federal Supply Catalog.

3.61 Speech intelligibility. A measure of the percent of words, phrases or sentences correctly understood over a given speech communication system in a given noise situation. It may be measured, when complying with this standard, by either the Phonetically Balanced (PB) Monosyllabic Word Intelligibility Test or the Modified Rhyme Test (MRT). The former consists of a list of 1,000 words in which each word is spoken from a source and written down by a listener at a destination. The latter consists of a list of 300 words in which a word is spoken from a source and the listener at a destination responds on a prepared multiple format selecting one of six words as the item heard. Speech intelligibility may also be predicted by the Articulation Index (AI) in which calculation is performed of the peak speech-to-root-mean-square noise ratio obtained in selected frequency bands from 200 to 7,000 Hertz (Hz), i.e., peak amplitude of speech in relation to the root-mean-square amplitude of the background noise.

3.62 Speech interference level (SIL). A measure of the effectiveness of noise in masking speech, defined as the arithmetic average of the same pressure levels of the interfering noise (in decibels re 20μPa) in the four octave bands centered on the frequencies 500, 1000, 2000, and 4000 Hz, respectively. The unit of speech-interference is the decibel.

3.63 Speech signal processing. The modification of the electrical signal representing speech to enhance the capability of a speech communications channel. Some examples are simple analog processing, automatic gain control (AGC), frequency shaping, peak clipping and syllabic compression.

3.64 Speech spectrum. A segment of the range of audible frequencies containing the sounds of speech; defined as approximately the range from 80 to 8000 Hz.

3.65 Speech-to-noise ratio (peak speech to rms noise). The ratio between the arithmetic mean of peak amplitudes of speech and the root-mean-square (rms) amplitude of background noise.

3.66 Standard tools. Standard tools (normally hand tools) used for the assembly, disassembly, inspection, servicing, repair and maintenance of equipment, and which are manufactured by two or more recognized tool manufacturing companies and listed in those companies' catalogs.

3.67 String. In the user's context, a word, phrase, or number (string of characters) in the test or file. Normally employed in the context of causing the computer to search for, find, or replace a desired "string."

3.68 Text entry. Initial entry and subsequent editing of textual material, typified by messages.

3.69 Transaction. An action by a user followed by a response from the computer. The term is used here to represent the smallest functional "molecule" of user-computer interaction.

3.70 Transillumination. Light passed through, rather than reflected off, an element to be viewed, e.g., illumination used on console panels or indicators utilizing edge and/or back lighting techniques on clear, translucent, flourescent, or sandwich type plastic materials.

3.71 Warning signal. A signal which alerts the operator to a dangerous condition requiring immediate action.

3.72 Wet bulb globe temperature (WBGT). A meterological measurement which can be used as an index to designate conditions of temperature and humidity at which on-set of heat stress can be expected at a particular energy expenditure level. It is calculated as follows:

$$WBGT = 0.7T_{WB_{np}} + 0.2T_g + 0.1T_A,$$

where $T_{WB_{np}}$ = non-psychrometric (np) wet-bulb (WB) temperature

T_g = temperature at interior center of a 15.2 cm (6 in) black globe

T_A = non-psychrometric, but shaded, dry bulb (air) temperature.

4. GENERAL REQUIREMENTS

4.1 Objectives. Military systems, equipment and facilities shall provide work environments which foster effective procedures, work patterns, and personnel safety and health, and which minimize factors which degrade human performance or increase error. Design shall be such that operator workload, accuracy, time constraint, mental processing and communication requirements do not exceed operator capabilities. Design shall also minimize personnel and training requirements within the limits of time, cost, and performance trade-offs.

4.2 Standardization. Controls, displays, marking, coding, labeling, and arrangement schemes (equipment and panel layout) shall be uniform for common functions of all equipment. Criterion for selecting off-the-shelf commercial or Government equipment shall be the degree to which the equipment conforms to this standard. Where off-the-shelf equipment requires modification in order to interface with other equipment, the modification shall be designed to comply with the criteria herein. Redesign of off-the-shelf equipment must have the approval of the procuring activity.

4.3 Function allocation. Design shall reflect allocation of functions to personnel, equipment and personnel-equipment combinations to achieve:

a. Required sensitivity, precision, time, and safety.

b. Required reliability of system performance.

c. Minimum number and level of skills of personnel required to operate and maintain the system.

d. Required performance in a cost-effective manner.

4.4 Human engineering design. The design of military systems, equipment and facilities shall reflect human engineering, life support, and biomedical factors that affect human performance, including, when applicable:

a. Satisfactory atmospheric conditions including composition, pressure, temperature and humidity, including safeguards against uncontrolled variability beyond acceptable limits.

b. Range of acoustic noise, vibration, acceleration, shock, blast, and impact forces and safeguards against uncontrolled variability beyond safe limits.

c. Protection from thermal, toxicological, radiological, mechanical, electrical, electromagnetic, pyrotechnic, visual, and other hazards.

d. Adequate space for personnel, their equipment, and free volume for the movements and activities they are required to perform during operation and maintenance tasks under both normal and emergency conditions.

e. Adequate physical, visual, auditory, and other communication links between personnel, and between personnel and their equipment, under both normal and emergency conditions.

f. Efficient arrangement of operation and maintenance workplaces, equipment, controls, and displays.

g. Provisions for insuring safe, efficient task performance under reduced and elevated gravitational forces with safe guards against injury, equipment damage and disorientation.

h. Adequate natural or artificial illumination for the performance of operation, control, training, and maintenance.

i. Safe and adequate passageways, hatches, ladders, stairways, platforms, inclines, and other provisions for ingress, egress, and passage under normal, adverse and emergency conditions.

j. Provision of acceptable personnel accommodations including body support and restraint, seating, rest, and sustenance, i.e., oxygen, food, water, and waste management.

k. Provision of non-restrictive personal life support and protective equipment.

l. Provisions for minimizing psychophysiological stress effects of mission duration and fatigue.

m. Design features to assure rapidity, safety, ease and economy of operation and maintenance in normal, adverse and emergency maintenance environments.

n. Satisfactory remote handling provisions and tools.

o. Adequate emergency systems for contingency management, escape, survival and rescue.

p. Compatibility of the design, location and layout of controls, displays, workspaces, maintenance accesses, stowage provisions and passenger compartments with the clothing and personal equipment (C/PE) to be worn by personnel operating, riding in, or maintaining military systems or equipment. Task allocation and control movements shall be compatible with restrictions imposed on human performance by C/PE.

4.5 Fail safe design. A fail safe design shall be provided in those areas where failure can cause catastrophe through damage to equipment, injury to personnel or inadvertent operation of critical equipment.

4.6 Simplicity of design. The equipment shall represent the simplest design consistent with functional requirements and expected service conditions. It shall be capable of being operated, maintained, and repaired in its operational environment by personnel with a minimum of training.

4.7 Interaction. The design of the system shall reflect the interaction requirements of crew served equipment.

4.8 Safety. Design shall reflect applicable system and personnel safety factors, including minimization of potential human error in the operation and maintenance of the system, particularly under the conditions of alert, battle stress, or other emergency or non-routine conditions.

4.9 Ruggedness. Systems and equipment shall be sufficiently rugged to withstand handling in the field during operation, maintenance, supply and transport within the environmental limits specified for those conditions in the applicable hardware or system specification.

4.10 Design for NBC survivability. As applicable, equipment design shall be compatible with NBC protection and shall permit performance of mission-essential operations, communications, maintenance, resupply and decontamination tasks by suitably clothed, trained and acclimatized personnel for the survival periods and NBC environments required by the system. Equipment design shall also facilitate NBC hardness surveillance and shall minimize susceptibility to reduction of inherent NBC hardness as a result of maintenance/operator-induced errors/damage: i.e.,

a) NBC hardness shall be easily verifiable by maintenance personnel before and after maintenance actions (hardness surveillance),

b) NBC hardness shall not be degraded when routine (scheduled) and corrective (unscheduled) maintenance are performed,

c) Maintenance of the equipment's inherent NBC hardness shall not be dependent on maintenance personnel expertise and critical alignments/maintenance actions.

4.11 Design for electromagnetic pulse (EMP) hardening. As applicable, equipment design shall be compatible with EMP hardening requirements, including personal accommodations such as EMP-hardened electrical power outlets and antenna lead-ins within EMP-hardened facilities or spaces. Access shall be provided to EMP-hardened facilities or spaces without the need to open doors or hatches which form part of an electromagnetic barrier protecting the space. Items such as surge arrestors, terminal protection devices, and filters, which form part of an electromagnetic barrier for protection against EMP effects, shall be accessible.

5. DETAILED REQUIREMENTS

5.1 Control/display integration.

5.1.1 General criteria.

5.1.1.1 Relationship. The relationships of a control to its associated display and the display to the control shall be immediately apparent and unambiguous to the operator. Controls should be located adjacent to (normally under or to the right of) their associated displays and positioned so that neither the control nor the hand normally used for setting the control will obscure the display.

5.1.1.2 Design. Control-display relationships shall be apparent through proximity, similarity of groupings, coding, framing, labeling, and similar techniques.

5.1.1.3 Complexity and precision. The complexity and precision required of control manipulation and display monitoring shall be consistent with the precision required of the system. Control/Display complexity and precision shall not exceed the capability of the operator (in terms of discrimination of display detail) or exceed the operator's manipulative capability under the dynamic conditions and environment (in terms of manual dexterity, coordination or reaction time) in which human performance is expected to occur.

5.1.1.4 Feedback. Feedback on control response adequacy shall be provided as rapidly as possible. Critical control functions, such as those entered by keyboard, shall provide adequate feedback to the operator prior to entry to ensure that the keyed entry is, in fact, errorless and the one that the operator desires to enter.

5.1.1.5 Illumination. Adjustable illumination shall be provided for visual displays, including display, control and panel labels and critical markings, that must be read at night or under darkened conditions.

5.1.1.6 Simultaneous access. If more than one crew member must have simultaneous access to a particular group of controls or displays in order to insure proper functioning of a system or subsystem, the operator assigned to control and monitor a particular function or group of related functions shall have physical and visual access to all controls, displays and communication capability necessary to adequately perform assigned tasks.

5.1.2 Position relationships.

5.1.2.1 Functional grouping. Functionally related controls and displays shall be located in proximity to one another--arranged in functional groups, e.g., power, status, test.

5.1.2.1.1 Functional group arrangement.

5.1.2.1.1.1 Sequence. Functional groups of controls and displays shall be located to provide for left-to-right (preferred) or top-to-bottom order of use, or both.

5.1.2.1.1.2 Access. Providing that the integrity of grouping by function and sequence is not compromised, the more frequently used groups and the most important groups should be located in areas of easiest access. Control-display groups required solely for maintenance purposes shall be located in positions providing a lesser degree of access relative to operating groups.

5.1.2.1.1.3 Functional group marking. Functional groups may be set apart by outlining with contrasting lines which completely encompass the groups. Where such coding is specified by the procuring activity, and where gray panels are used, noncritical functional groups (i.e., those not associated with emergency operations) shall be outlined with a 1.5 mm (1/16 in) black border (27038 of FED-STD-595), and those involving emergency or extremely critical operations shall be outlined with a 5 mm (3/16 in) red border (21136 of FED-STD-595). As an alternate method, contrasting color pads or patches may be used to designate both critical and noncritical functional areas, subject to prior approval by the procuring activity. When red compartment lighting is used, an orangeyellow (23538 of FED-STD-595) and black (27038 of FED-STD-595) striped border shall be used to outline functional groups involving emergency or extremely critical operations. Control-display areas in aircraft crew stations shall be delineated in accordance with MIL-M-18012.

5.1.2.1.1.4 Consistency. Location of recurring functional groups and individual items shall be similar from panel to panel. Mirror image arrangements shall not be used.

5.1.2.2 Location and arrangement. Whenever an operator must use a large number of controls and displays, their location and arrangement shall be designed to aid in determining which controls are used with which displays, which equipment component each control affects, and which equipment component each display describes.

5.1.2.3 Arrangement within groups. Controls and displays within functional groups shall be located according to operational sequence or function, or both.

5.1.2.3.1 Left-to-right arrangement. If controls must be arranged in fewer rows than displays, controls affecting the top row of displays shall be positioned at the far left; controls affecting the second row of displays shall be placed immediately to the right of these, etc.

5.1.2.3.2 Vertical and horizontal arrays. If a horizontal row of displays must be associated with a vertical column of controls or vice versa, the farthest left item in the horizontal array shall correspond to the top item in the vertical array, etc. However, this type of arrangement shall be avoided whenever possible.

5.1.2.3.3 Simultaneous use. A visual display that must be monitored concurrently with manipulation of a related control shall be located so that the operator is not required to observe the display from an extreme visual angle and thus introduce the possibility of parallax error.

5.1.2.3.4 Multiple displays. When the manipulation of one control requires the reading of several displays, the control shall be placed as near as possible to the related displays and preferably beneath the middle of the displays, but not so as to obscure displays when manipulating the control.

5.1.2.3.5 Combined control. When separate displays are affected by a combined control (e.g., concentrically ganged knobs), the display shall be arranged from left to right with the combined control underneath the center of the displays, but not so as to obscure displays when manipulating controls.

5.1.2.3.6 Separate panels. When related controls and displays must be located on separate panels and both panels are mounted at approximately the same angle relative to the operator, the control positions on one panel shall correspond to the associated display positions on the other panel. The two panels shall not be mounted facing each other.

5.1.2.3.7 Component groups. When a group of equipment components has the same function, the related control and display positions shall be oriented to correspond to those of the controlled and monitored components. (For example, the position of aircraft engine controls shall be oriented as if the operator faces the normal direction of vehicle movement.)

5.1.2.3.8 Emergency use. Emergency displays and controls shall be located where they can be seen and reached with minimum delay (e.g., warning lights within a 30-degree cone about the operator's normal line of sight; emergency control close to its related warning display or the nearest available hand in its nominal operating position).

5.1.3 Movement relationships.

5.1.3.1 Lack of ambiguity. Display indicators shall clearly and unambiguously direct and guide the appropriate control response. The response of a display to control movements shall be consistent, predictable, and compatible with the operator's expectations.

5.1.3.2 Time lag. The time lag between the response of a system to a control input and the display presentation of the response shall be minimized, consistent with safe and efficient system operation.

5.1.3.3 Moving pointer circular scales. Clockwise movement of a rotary control or movement of a linear control forward, up, or to the right shall produce a clockwise movement of circular scale pointers and an increase in the magnitude of the setting.

5.1.3.4 Moving pointer linear scales. Clockwise movement of a rotary control or movement of a linear control forward, up, or to the right shall produce a movement up or to the right for horizontal and vertical scale pointers and an increase in the magnitude of the reading.

5.1.3.5 Fixed pointer circular scale. Displays with moving scales and fixed pointers or cursors should be avoided. When circular fixed-pointer, moving-scale indicators are necessary, clockwise movement of a rotary control or movement of a linear control forward, up, or to the right shall normally produce a counterclockwise movement of the scale and an increase in the magnitude of the reading.

5.1.3.6 Fixed pointer linear scale. When use of vertical or horizontal fixed pointer, moving-scale indicators is necessary, clockwise movement of an associated rotary control or movement of a linear control forward, up, or to the right shall normally produce a movement of the scale down or to the left and an increase in the magnitude of the reading.

5.1.3.7 Direct linkage. When there is a direct linkage between control and display (e.g., radio frequency selector and station pointer), a rotary control shall be used if the indicator moves through an arc of more than πrad (180°). If the indicator moves through an arc of less than πrad (180°), a linear control may be used, provided the path of control movement parallels the average path of the indicator movement and the indicator and control move in the same relative direction.

5.1.3.8 Common plane. Controls shall be selected so that the direction of movement of the control will be consistent with the related movement of an associated display, equipment component, or vehicle.

5.1.3.9 Parallel movement. Direction-of-movement relationships shall be adhered to when control and display are parallel in line of movement.

5.1.3.10 Labeling. When control-display relationships specified herein cannot be adhered to, controls shall be clearly labeled (see para 5.5) to indicate the direction of control movement required.

5.1.3.11 Movement direction. When a rotary control and a linear display are in the same plane, the part of the control adjacent to the display shall move in the same direction as the moving part of the display.

5.1.4 Control display movement ratio.

5.1.4.1 Minimization of time. Control display ratios for continuous adjustment controls shall minimize the total time required to make the desired control movement (i.e., slewing time plus fine adjusting time), consistent with display size, tolerance requirements, viewing distance, and time delays.

5.1.4.2 Range of display movement. When a wide range of display element movement is required, small movement of the control shall yield a large movement of the display element. When a small range of display movement is required, a large movement of the control shall result in small movement of the display, consistent with final accuracy required.

5.1.4.3 Knob, coarse setting. When a knob is provided for making coarse display element settings on linear scales -- 0.4 to 2.5 mm (0.016 to 0.100 in) tolerance -- approximately 150 mm (6 in) display element movement shall be provided for one complete turn of the knob.

5.1.4.4 Knob, fine setting. For fine setting on linear scales--0.2 to 0.4 mm (0.008 to 0.016 in) tolerance--25 to 50 mm (1 to 2 in) of display element movement shall be provided for one complete turn of the knob.

5.1.4.5 Bracketing. When bracketing is used to locate a maximum or minimum rather than a specific value (e.g., as in tuning a transmitter), the control knob shall swing through an arc of not less than 175 mrad (10°) nor more than 525 mrad (30°) either side of the target value in order to make the peak or dip associated with that value clearly noticeable.

5.1.4.6 Lever, coarse setting. When a lever is provided for coarse settings--0.4 to 2.5 mm (0.016 to 0.100 in) tolerance--one unit of display element movement shall be used to three units of lever movement.

5.1.4.7 Lever, two-dimensional setting. When a lever is provided to make settings in two dimensions to coarse tolerances--2.5 mm (0.1 in)--one unit of display element movement shall be used to two and one-half units of lever movement.

5.1.4.8 Counters. When counters are provided, the control-display ratio shall be such that one revolution of the knob produces approximately 50 counts (i.e., the right hand drum rotates five times).

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5.2 Visual displays.

5.2.1 General. Visual displays should be utilized to provide the operator with a clear indication of equipment or system conditions for operation under any eventuality commensurate with the operational and maintenance philosophy of the system under design.

5.2.1.1 Alerting/warning. An alerting/warning display shall provide the operator with a greater probability of detecting the triggering condition than his normal observation would provide in the absence of the display.

5.2.1.2 Display illumination and light distribution.

5.2.1.2.1 Display illumination.

5.2.1.2.1.1 Normal. When maximum dark adaptation is not required, low brightness white light (preferably integral and adjustable as appropriate) shall be used; however, when complete dark adaptation is required, low luminance [0.07 - 0.35 cd/m^2 (0.02 - 0.10 fL)] red light (greater than 620 nm) shall be provided.

5.2.1.2.1.2 Night vision device compatibility. Where night vision device compatibility is required, display illumination color other than red may be used. The lighting shall be continuously variable to the full OFF position. In the OFF position, no current shall flow through the lamps.

5.2.1.2.1.3 Field use panel dimming. When control or annunciator panels will be viewed by personnel out of doors at night, maximum panel illumination shall be provided when a dimming rotary control is at its extreme clockwise rotation. Maximum illumination is that required by Tables XXI and XXII, as applicable. No current shall be provided to luminaires at extreme counter-clockwise rotation of a dimming control. Panel light levels shall be continuously variable from 0.1 cd/m^2 (0.03 fL) near OFF to 3.5 cd/m^2 (1 fL) at 50% of clockwise rotation.

5.2.1.2.2 Light distribution. Where multiple displays are grouped together, lighting shall be balanced across the instrument panel such that the mean indicator luminances of any two instruments shall not differ by more than 33% across the range of full ON to full OFF. Light distribution shall be sufficiently uniform within an integrally illuminated instrument such that the ratio of standard deviation of indicator element luminances to mean indicator luminance shall not be more than 0.25, using eight or more equally spaced test measurements.

5.2.1.2.3 Contrast. Sufficient contrast shall be provided between all displayed information and the display background to ensure that the required information can be perceived by the operator under all expected lighting conditions.

5.2.1.3 Information.

5.2.1.3.1 Content. The information displayed to an operator shall be sufficient to allow the operator to perform the intended mission, but shall be limited to that which is necessary to perform specific actions or to make decisions.

5.2.1.3.2 Precision. Information shall be displayed only within the limits and precision required for specific operator actions or decisions.

5.2.1.3.3 Format. Information shall be presented to the operator in a directly useable form. Requirements for transposing, computing, interpolating, or mentally translating into other units shall be avoided. Additional requirements for computer display formats are contained in 5.15.

5.2.1.3.4 Redundancy. Redundancy in the display of information to a single operator shall be avoided unless it is required to achieve specified reliability.

5.2.1.3.5 Combining operator/maintainer information. Operator and maintainer information shall not be combined in a single display unless the information content and format are well suited to, and time compatible for, both users.

5.2.1.3.6 Display failure clarity. Failure of a display or its circuit shall be immediately apparent to the operator.

5.2.1.3.7 Display circuit failure. Failure of the display circuit shall not cause a failure in the equipment associated with the display.

5.2.1.3.8 Unrelated markings. Trademarks and company names or other similar markings not related to the panel function shall not be displayed on the panel face.

5.2.1.3.9 Duration. Signals and display information shall have durations of sufficient length to be reliably detected under expected operator workload and operational environment.

5.2.1.3.10 Timeliness. Displays such as cathode ray tube displays, head-up displays, collimated displays and other displays requiring refreshed information shall be updated in a synchronous manner, where possible, and be refreshed to the degree of timeliness required by personnel in the normal operating or servicing mode.

5.2.1.3.11 Advisory and alerting. Displays such as multifunction displays, cathode ray tube displays, head-up displays, collimated displays and other visual display devices displaying simultaneous and integrated information shall advise or alert operating personnel to information that becomes critical within the display.

5.2.1.3.12 NBC contamination. As applicable, display characteristics (e.g., clarity, legibility) shall be compatible with viewing while wearing an NBC protective mask. Displays or indicators that show the presence of NBC agents shall also show when such agent concentrations decrease to safe levels.

5.2.1.3.13 Numeric digital displays. Numeric digital displays shall not be used as the only display of information when perception of the pattern of variation is important to proper perception. Numeric digital displays shall not be used when rapid or slow digital display rates inhibit proper perception.

5.2.1.4 Location and arrangement.

5.2.1.4.1 Location. Displays shall be located and designed so that they may be read to the degree of accuracy required by personnel in the normal operating or servicing positions without requiring the operator to assume an uncomfortable, awkward or unsafe position.

5.2.1.4.2 Access. Visual displays should be visually accessible without resorting to use of ladders, flashlights or other special equipment in order to read the display.

5.2.1.4.3 Orientation. Display faces shall be perpendicular to the operator's normal line of sight whenever feasible and shall not be less than $\pi/4$ rad (45°) from the normal line of sight (see Figure 1). Parallax shall be minimized.

5.2.1.4.4 Reflection. Displays shall be constructed, arranged, and mounted to prevent reduction of information transfer due to the reflection of the ambient illumination from the display cover. Reflection of instruments and consoles in windshields and other enclosures shall be avoided. If necessary, techniques (such as shields and filters) shall be employed to insure that system performance will not be degraded.

5.2.1.4.5 Vibration. Vibration of visual displays shall not degrade user performance below the level required for mission accomplishment (see 5.8.4.2).

5.2.1.4.6 Grouping. All displays necessary to support an operator activity or sequence of activities, shall be grouped together.

5.2.1.4.7 Function and sequence. Displays shall be arranged in relation to one another according to their sequence of use or the functional relations of the components they represent. They shall be arranged in sequence within functional groups, whenever possible, to provide a viewing flow from left to right or top to bottom.

5.2.1.4.8 Frequency of use. Displays used most frequently should be grouped together and placed in the optimum visual zone (see Figure 2).

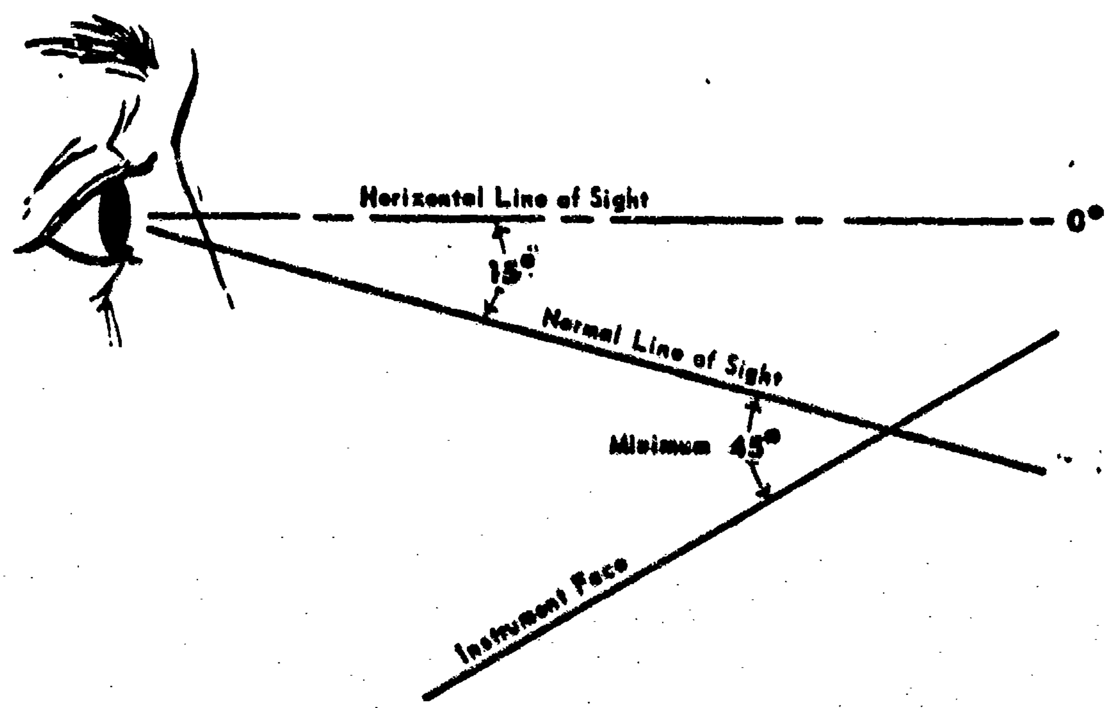


FIGURE 1. LINES OF SIGHT

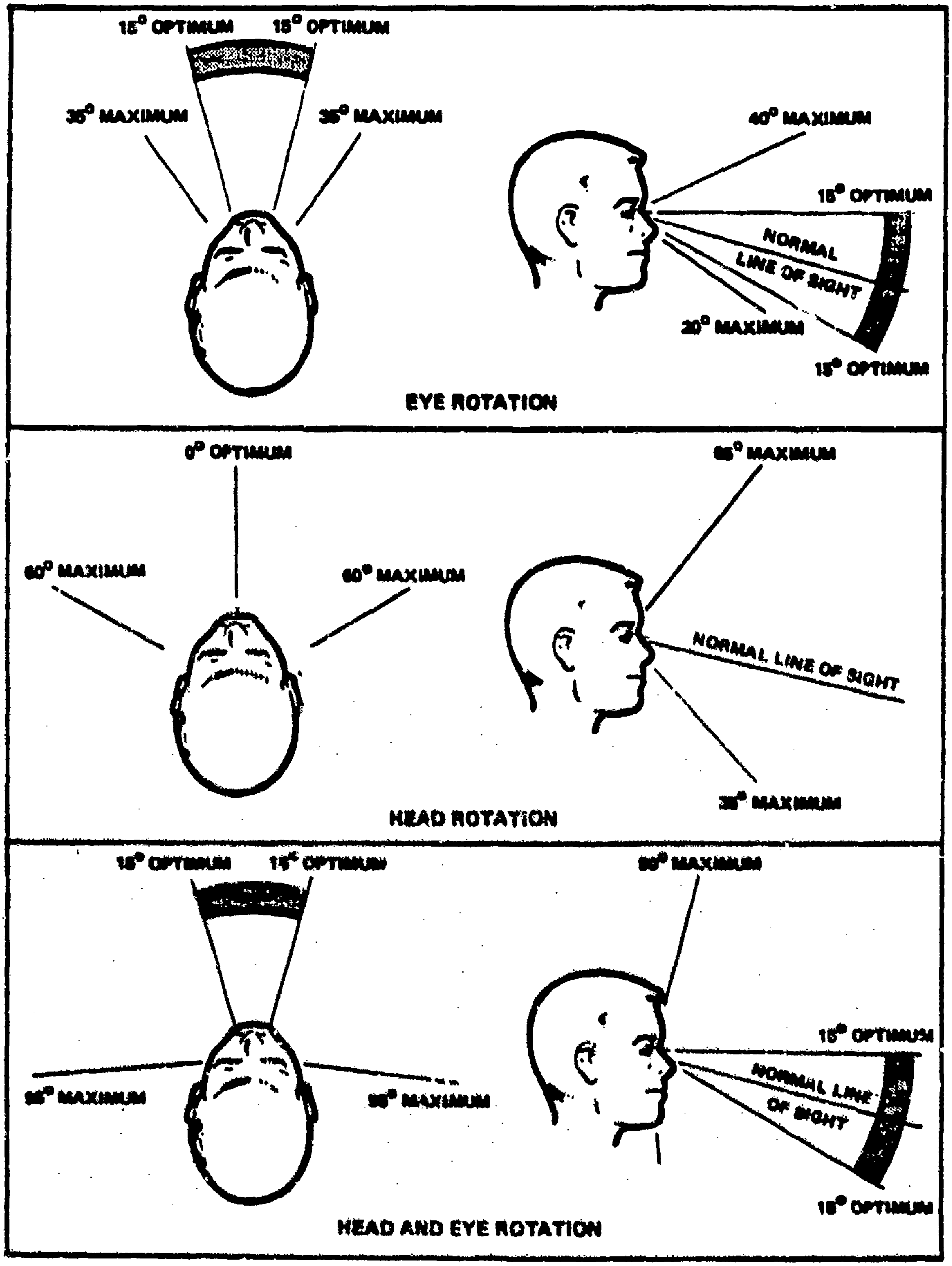


FIGURE 2. VERTICAL AND HORIZONTAL VISUAL FIELD

5.2.1.4.9 Importance. Important or critical displays shall be located in a privileged position in the optimum projected visual zone or otherwise highlighted.

5.2.1.4.10 Consistency. The arrangement of displays within a system shall be consistent in principle from application to application, within the limits specified herein.

5.2.1.4.11 Maximum viewing distance. The viewing distance from the eye reference point of the seated operator to displays located close to their associated controls shall not exceed 635 mm (25 in). Otherwise, there is no maximum limit other than that imposed by legibility limitations, which shall be compensated for by proper design. NOTE: A viewing distance of up to 760 mm (30 inches) may be used with ejection seats.

5.2.1.4.12 Minimum viewing distance. The effective viewing distance to displays, with the exception of cathode ray tube displays (see 5.2.4.2) and collimated displays, shall never be less than 330 mm (13 in) and preferably not less than 510 mm (20 in).

5.2.1.4.13 Aircrew station signals. Signals for aircrew stations shall be in accordance with MIL-STD-411. Human Engineering design for other members of the crew who occupy positions in the air vehicle other than on the flight deck (such as in multi-engined specialized aircraft) shall be in accordance with the criteria in this standard. (See 5.14.2.1)

5.2.1.5 Coding.

5.2.1.5.1 Objectives. Coding techniques shall be used to facilitate:

a. Discrimination between individual displays

b. Identification of functionally related displays

c. Indication of relationship between displays

d. Identification of critical information within a display

5.2.1.5.2 Techniques. Displays shall be coded by color, size, location, shape, or flash coding, as applicable.

5.2.1.5.3 Standardization. All coding within the system shall be uniform and shall be established by agreement with the procuring activity.

5.2.1.5.4 Symbology. Symbology for Aircrew displays shall be in accordance with MIL-STD-1787.

5.2.2 Transillu nated displays.

5.2.2.1 General. Three general types of transilluminated displays that may be used include:

a. Single- and multiple-legend lights, which present information in the form of meaningful words, numbers, symbols, and abbreviations.

b. Simple indicator lights.

c. Transilluminated panel assemblies, which present qualitative status or system readiness information.

5.2.2.1.1 Use. Transilluminated indicators should be used to display qualitative information to the operator requiring either an immediate reaction by the operator, or to draw attention to an important system status. Such indicators may also be used occasionally for maintenance and adjustment functions.

5.2.2.1.2 Equipment response. Lights, including those used in illuminated push buttons, shall display equipment response and not merely control position.

5.2.2.1.3 Information. Lights and related indicators shall be used sparingly and shall display only that information necessary for effective system operation.

5.2.2.1.4 Positive feedback. Changes in display status shall signify changes in functional status rather than results of control actuation alone. The absence or extinguishment of a signal or visual indication shall not be used to denote a "malfunction," "no go," or "out-of-tolerance" condition; however, the absence of a "power on" signal or visual indication shall be acceptable to indicate a "power off" condition for operational displays only--not for maintenance displays. The absence or extinguishment of a signal or visual indication shall not be used to indicate a "ready" or "in tolerance" condition, unless the status or caution light filament and its associated circuitry can be easily tested by the operator and operator perception of such events is not time critical.

5.2.2.1.5 Grouping. Master caution, master warning, master advisory and summation lights used to indicate the condition of an entire subsystem shall be set apart from the lights which show the status of the subsystem components, except as required under paragraph 5.2.2.1.8.

5.2.2.1.6 Location. When a transilluminated indicator is associated with a control, the indicator light shall be so located that it can be associated with the control without error and shall be visible to the operator during control operation.

5.2.2.1.7 Location, critical functions. For critical functions, indicators shall be located within 265 mrad (15°) of the operator's normal line of sight (see Figure 2). Warning lights shall be an integral part of, or located adjacent to, the lever, switch, or other control device by which the operator is to take action.

5.2.2.1.8 Maintenance displays. Indicator lights used solely for maintenance and adjustment shall be covered or non-visible during normal equipment operation, but shall be readily accessible when required.

5.2.2.1.9 Luminance. The luminance of transilluminated displays shall be compatible with the expected ambient illuminance level, and shall be at least 10% greater than the surrounding luminance. Where glare must be reduced, the luminance of transilluminated displays should not exceed 300% of the surrounding luminance.

5.2.2.1.10 Luminance control. When displays will be used under varied ambient illuminance, a dimming control shall be provided. The range of the control shall permit the displays to be legible under all expected ambient illuminance. The control shall be capable of providing multiple step or continuously variable illumination. Dimming to full OFF may be provided in non-critical operations, but shall not be used if inadvertent failure to turn on an indicator could lead to critical operator failures, i.e., failure to detect or perform a critical step in an operation.

5.2.2.1.11 False indication or obscuration. Provision shall be made to prevent direct or reflected light from making indicators appear illuminated when they are not, or to appear extinguished when they are illuminated. Self-reflection shall be minimized by proper orientation of the display with respect to the observer.

5.2.2.1.12 Contrast within the indicator. The luminance contrast (See 3.17) within the indicator shall be at least 0.1. This 0.1 luminance contrast requirement does not apply to special displays specifically designed for legibility in sunlight. For low ambient illumination applications (e.g., MIL-L-25467), this ratio should be at least 9.0 (See 3.17), with the background luminance less than the figure luminance.

5.2.2.1.13 Lamp redundancy. Incandescent display lamps shall incorporate filament redundancy or dual lamps. When one filament or bulb fails, the intensity of the light shall decrease sufficiently to indicate the need for lamp replacement, but not so much as to degrade operator performance.

5.2.2.1.14 Lamp testing. When indicator lights using incandescent bulbs are installed on a control panel, a master light test control shall be incorporated. When applicable, design shall allow testing of all control panels at one time. Panels containing three or fewer lights may be designed for individual press-to-test bulb testing. Circuitry should be designed to test the operation of the total indicator circuit. If dark adaptation is a factor, a means for reducing total indicator light brightness during test operation shall be provided.

5.2.2.1.15 Lamp removal, method. Where possible, lamps shall be removable and replaceable from the front of the display panel. The procedure for lamp removal and replacement shall not require the use of tools and shall be easily and rapidly accomplished.

5.2.2.1.16 Lamp removal, safety. Display circuit design shall permit lamp removal and replacement while power is applied without causing failure of indicator circuit components or imposing personnel safety hazards.

5.2.2.1.17 Indicator covers. If design of legend screen or indicator covers does not prevent inadvertent interchange, a means shall be provided for checking the covers after installation to insure they are properly installed.

5.2.2.1.18 Color coding. With the exception of aircrew station signals which shall conform to MIL-STD-411, and training equipment which shall conform to MIL-T-23991, transilluminated displays shall conform to the following color coding scheme, in accordance with Type I - Aviation colors of MIL-C-25050.

a. RED shall be used to alert an operator that the system or any portion of the system is inoperative, or that a successful mission is not possible until appropriate corrective or override action is taken. Examples of indicators which should be coded RED are those which display such information as "no-go", "error", "failure", "malfunction", etc.

b. FLASHING RED shall be used only to denote emergency conditions which require operator action to be taken without undue delay, or to avert impending personnel injury, equipment damage, or both.

c. YELLOW shall be used to advise an operator that a condition exists which is marginal. YELLOW shall also be used to alert the operator to situations where caution, recheck, or unexpected delay is necessary.

d. GREEN shall be used to indicate that the monitored equipment is in tolerance or a condition is satisfactory and that it is all right to proceed (e.g., "go-ahead", "in-tolerance", "ready", "function activated").

e. WHITE shall be used to indicate system conditions that do not have "right" or "wrong" implications, such as alternative functions "e.g., Missile No. 1 selected for launch, etc.) or transitory conditions (e.g., action or test in progress, function available), provided such indication does not imply success or failure of operations.

f. BLUE may be used for an advisory light, but preferential use of BLUE should be avoided.

5.2.2.1.19 Flashing lights. The use of flashing lights shall be minimized. Flashing lights should be used only when it is necessary to call the operator's attention to some condition requiring immediate action. The flash rate shall be within 3 to 5 flashes per second with approximately equal amounts of ON and OFF time. Flashing lights which could be simultaneously active should have synchronized flashes. If the indicator is energized and the flasher device fails, the light shall illuminate and burn steadily (see 5.3.2.4).

5.2.2.2 Legend lights.

5.2.2.2.1 Use. Legend lights shall be used in preference to simple indicator lights except where design considerations demand that simple indicators be used.

5.2.2.2.2 Color coding. Legend lights shall be color coded in conformance with 5.2.2.1.18. Legend lights required to denote personnel or equipment disaster (FLASHING RED), caution or impending danger (YELLOW), and master summation go (GREEN) or no-go (RED), shall be discriminably larger, and preferably brighter, than all other legend lights.

5.2.2.2.3 Positive vs negative legend. When the operator's dark adaptation must be maintained, or where legibility in high ambient illumination is critical, illuminated label/opaque background format shall be used and illuminated background/opaque label format shall be used only for critical alerting indicators (e.g., master warning lights). Where operator dark adaptation is not required, illuminated background/opaque label format should be used; contrast reversal may be employed under these conditions to designate displays which have physical appearance similar to legend switches on the same panel.

5.2.2.2.4 Lettering. The size and other characteristics of lettering shall conform to 5.5 herein, or as otherwise specified by the procuring activity.

5.2.2.2.5 Visibility and legibility. In other than aircrew stations, and with the exception of warning and caution indicators, the lettering on single-legend indicators shall be visible and legible whether or not the indicator is energized.

5.2.2.2.6 Multi-function legends. Indicators designed to provide alternately-presented legends shall present only one legend at a time, i.e., only the legend in use shall be visible. If the indicator device utilizes "stacked" legends, it shall be designed so that:

a. When the rear legend is energized, it shall not be obscured by the front legend.

b. Parallax is minimized.

c. Rear legends have approximately equal brightness to front legends, and the contrast between rear legends and background is equal to that of the front legend and its background.

5.2.2.3 Simple indicator lights.

5.2.2.3.1 Use. Simple indicator lights should be used when design considerations preclude the use of legend lights.

5.2.2.3.2 Spacing. The spacing between adjacent edges of simple round indicator light fixtures shall be sufficient to permit unambiguous labeling, signal interpretation, and convenient bulb removal.

5.2.2.3.3 Coding. Simple indicator lights shall be coded in conformance with Table II; however, the different sizes shown are intended only for the attention-getting value that larger lights of at least equal luminance provide in relation to indicator lights of lesser importance.

5.2.2.4 Transilluminated panel assemblies.

5.2.2.4.1 Use. Transilluminated (integrally lighted) panel assemblies may be used to:

a. Provide illuminated labels for a control panel.

b. Provide a light source for illuminating transilluminated control knobs.

c. Provide illuminated association markings on a control panel, e.g., connecting lines between controls, outlines around a functionally-related group of controls or displays or both.

d. Create a pictorialized representation of a system process, communication network, or other information/component organization.

5.2.2.4.2 Large, single pictorial graphic panels. Large, single pictorial graphic panels, used to display system processing, communications networks or similar applications, shall comply with requirements for visibility, legibility, color and illumination as specified herein.

5.2.2.4.3 Re-lamping. When replaceable incandescent lamps are used as the illuminant source for integral lighting of panel assemblies, lamps shall be readily accessible without disconnecting the panel(s). A sufficient number of lamps shall be provided so that failure of one lamp will not cause any part of the display to be unreadable.

5.2.2.4.4 Brightness. Brightness of illuminated markings and transilluminated controls shall be compatible with the ambient environment and operating conditions (e.g., dark adaptation requirements). Brightness control (dimming) by the operator shall be provided where applicable to maintain appropriate visibility and operator dark adaptation level.

5.2.3 Scale indicators.

5.2.3.1 General.

TABLE II. CODING OF SIMPLE INDICATOR LIGHTS

SIZE/TYPE	COLOR			
	RED	YELLOW	GREEN	WHITE
13 mm (1/2 in.) DIAMETER or SMALLER/STEADY	Malfunction; action stopped; failure; stop action.	Delay; check; recheck.	Go ahead; in tolerance; acceptable; ready.	Functional or physical position; action in progress.
25 mm (1 in.) DIAMETER or LARGER/STEADY	Master summation (system or subsystem)	Extreme caution (impending danger).	Master summation (system or subsystem).	
25 mm (1 in.) DIAMETER or LARGER/FLASHING (3 to 5/sec)	Emergency condition (impending personnel or equipment disaster).			

5.2.3.1.1 Types of scale indicators. The types of scale indicators that may be used include:

a. Moving-pointer, fixed-scale, circular, curved (arc), horizontal straight, and vertical straight.

b. Fixed-pointer, moving-scale, circular, curved (arc), horizontal straight, and vertical straight.

5.2.3.1.2 Use. The use of scale indicators should conform to the criteria in Table III as well as the specific criteria contained in this section. Moving-pointer, fixed-scale indicators are preferred to fixed-pointer, moving-scale indicators. The latter should be used only when necessitated by operational requirements or other conditions, and when approved by the procuring activity.

5.2.3.1.3 Type of information. Scale indicators should be used to display quantitative information in combination with qualitative information (such as trend and direction-of-motion) and where only quantitative information is to be displayed and there is no requirement (such as speed and accuracy of response) which demands the use of printers or counters.

5.2.3.1.4 Linear scales. Except where system requirements clearly dictate nonlinearity to satisfy operator information requirements, linear scales shall be used in preference to nonlinear scales.

5.2.3.1.5 Scale markings.

5.2.3.1.5.1 Graduations. Scale graduations shall progress by 1, 2, or 5 units or decimal multiples thereof.

5.2.3.1.5.2 Intermediate marks. The number of minor or intermediate marks between numbered scale pointers shall not exceed nine.

5.2.3.1.6 Numerals.

5.2.3.1.6.1 Major marks. Except for measurements that are normally expressed in decimals, whole numbers shall be used for major graduation marks.

5.2.3.1.6.2 Starting point. Display scale shall start at zero, except where this would be inappropriate for the function involved.

5.2.3.1.7 Pointers.

5.2.3.1.7.1 Length. The control or display pointer should extend to, but not overlap, the shortest scale graduation marks.

5.2.3.1.7.2 Tip configuration. The pointer tip should be tapered at a 350 mrad (20°) angle [(40°) included angle], terminating in a flat tip equal in width to the minor scale graduations.

TABLE III. APPLICATION OF VARIOUS TYPES OF MECHANICAL DISPLAYS

USE	SCALES		COUNTERS	PRINTERS	FLAGS
	Moving Pointer	Fixed Pointer			
QUANTITATIVE INFORMATION	FAIR May be difficult to read while pointer is in motion.	FAIR May be difficult to read while scale is in motion.	GOOD Minimum time and error for exact numerical value; however, cannot be read when changing rapidly	GOOD Minimum time and error for exact numerical value. Provides reference records.	N/A
QUALITATIVE INFORMATION	GOOD Location of pointer easy. Numbers and scale need not be read. Position change easily detected.	POOR Difficult to judge direction and magnitude of deviation without reading numbers and scale.	POOR Numbers must be read. Position changes not easily detected.	POOR Numbers must be read. Position changes not easily detected.	GOOD Easily detected. Economical of space.
SETTING	GOOD Simple and direct relation of motion of pointer to motion of setting knob. Position change aids monitoring.	FAIR Relation to motion of setting knob may be ambiguous. No pointer position change to aid monitoring. Not readable during rapid setting.	GOOD Most accurate monitoring of numerical setting. Relation to motion of setting knob less direct than for moving pointer. Not readable during rapid setting.	N/A	N/A
TRACKING	GOOD Pointer position readily controlled and monitored. Simplest relation to manual control motion.	FAIR No position changes to aid monitoring. Relation to control motion somewhat ambiguous.	POOR No gross position changes to aid monitoring	N/A	N/A
GENERAL	Requires largest exposed and illuminated area on panel. Scale length limited unless multiple pointers used.	Saves panel space. Only small section of scale need be exposed and illuminated. Use of tape allows long scale.	Most economical of space and illumination. Scale length limited only by number of counter drums.	Limited application.	Limited application

5.2.3.1.7.3 Mounting. The pointer shall be mounted as close as possible to the face of the dial to minimize parallax.

5.2.3.1.7.4 Color. Pointer color from the tip to the center of the dial shall be the same as the color of the marks. The tail of the pointer shall be the same color as the dial face, unless the tail is used as an indicator itself or unless the pointer is used for horizontal alignment.

5.2.3.1.8 Luminance contrast. Luminance contrast (see 3.17) of at least 3.0 shall be provided between the scale face and the markings and pointer.

5.2.3.1.9 Calibration information. Provision shall be made for placing calibration information on instruments without degrading dial legibility.

5.2.3.1.10 Coding.

5.2.3.1.10.1 Use. Coding on the face of scale indicators may be used to convey such information as desirable operating range, dangerous operating level, caution, undesirable, and inefficient.

5.2.3.1.10.2 Pattern- or color-coding. When certain operating conditions always fall within a given range on the scale, these areas shall be made readily identifiable by means of pattern- or color-coding applied to the face of the instrument.

5.2.3.1.10.3 Choice of colors. Red, yellow, and green may be applied, provided they conform to the meanings specified in 5.2.2.1.18 and are distinguishable under all expected lighting conditions.

5.2.3.1.10.4 Pattern coding. Zone scales may be shape coded when the indicator must be viewed in blackout stations or where the illuminant color will cause difficulty in color band discrimination.

5.2.3.2 Moving-pointer, fixed-scale indicators.

5.2.3.2.1 Numerical progression. The increase of numerical progression on fixed scales shall read clockwise, from left to right, or from the bottom up, depending on display design and orientation.

5.2.3.2.2 Orientation. Numbers on stationary scales shall be oriented in the upright position.

5.2.3.2.3 Circular scales.

5.2.3.2.3.1 Scale reading and pointer movement. The magnitude of the scale reading shall increase with clockwise movement of the pointer.

5.2.3.2.3.2 Zero position and direction of movement. When positive and negative values are displayed around a zero or a null position, the zero or null point shall be located at either the 12 or 9 o'clock position. The magnitude of positive values shall increase with clockwise movement of the pointer, and the magnitude of negative values shall increase with counterclockwise movement.

5.2.3.2.3.3 Scale break. There shall be an obvious break of at least 175 mrad (10°) of arc between the two ends of the scale, except on multirevolution instruments such as clocks.

5.2.3.2.3.4 Number of pointers. Whenever precise readings are required not more than two coaxial pointers shall be mounted on one indicator face.

5.2.3.2.3.5 Pointer alignment. When a stable value exists for given operating conditions in a group of circular-scale indicators, the indicators shall be arranged either in rows so that all pointers line up horizontally on the 9 o'clock position under normal operating conditions or in columns so that all pointers line up vertically in the 12 o'clock position under normal operating conditions. If a matrix of indicators is needed, preference shall be given to the 9 o'clock position.

5.2.3.2.3.6 Relative position of scale marks and numbers. When reading time and accuracy are critical, circular scale markings and location of associated numbers shall be arranged to prevent pointers from covering any portion of the scale marks or numerals, and scale marks shall be on or close to the plane of the pointer tip to avoid visual parallax (see Figure 3). If readout accuracy is not critical (i.e., gross relationship between the pointer and number is all that is required), an arrangement of numerals inside the scale annulus may be used. (See examples in Figure 3).

5.2.3.2.4 Curved (arc), horizontal straight, and vertical straight scales.

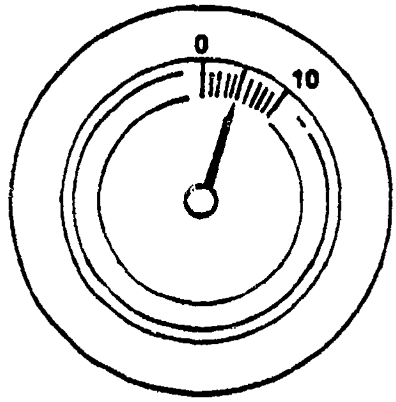
5.2.3.2.4.1 Scale reading and pointer movement. The magnitude of the scale reading shall increase with movement of the pointer up or to the right.

5.2.3.2.4.2 Zero position and direction of movements. When positive and negative values are displayed around a zero point, the magnitude of positive values shall increase with movement of the pointer up or to the right, and the magnitude of negative values shall increase with movement of the pointer down or to the left.

5.2.3.2.4.3 Placement of pointers. Pointers shall be located to the right of vertical scales and at the bottom of horizontal scales.

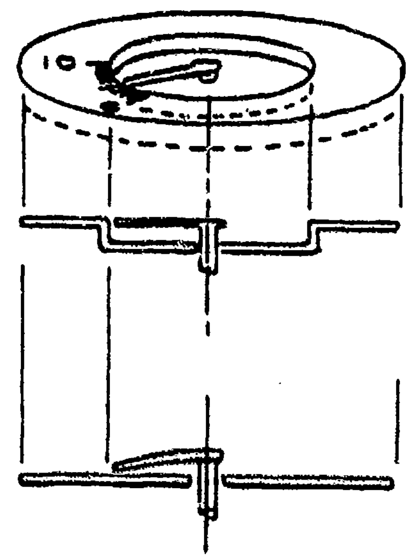
5.2.3.2.4.4 Placement of numerals. Numerals shall be placed on the side of the graduation marks away from the pointer to avoid having numbers covered by the pointer. If space is limited (for curved or arc scales) numerals may be placed inside of graduation marks to avoid undue constriction of the scale.

5.2.3.2.4.5 Pointer alignment. When a common stable value exists for given operating conditions in a group of indicators, they shall be arranged either

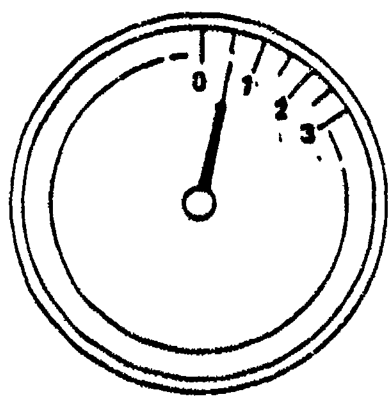


FOR MAXIMUM READING ACCURACY

(THE POINTER IS AN EQUAL DISTANCE – NOMINAL 0.8–1.6 mm (0.031–0.061 in.) – FROM ALL SCALE MARKS, NEVER OVERLAPPING ANY MARK OR NUMERAL.)



TO PREVENT OR MINIMIZE VISUAL PARALLAX



ALTERNATE FORMAT FOR GROSS READING OF NUMBERS

FIGURE 3. RELATIVE POSITION OF SCALE MARKS, NUMERALS, AND POINTERS ON CIRCULAR DIALS

in rows so that all pointers line up horizontally (for vertical scales) or in columns so that all pointers line up vertically (for horizontal scales).

5.2.3.3 Fixed-pointer, moving-scale indicators.

5.2.3.3.1 Numerical progression. On fixed-pointer, moving scale indicators, numbers shall progress in magnitude in clockwise direction around the faces of circular dials (counter-clockwise dial movement for numerical increase). On vertical or horizontal straight moving scales, numbers shall increase from bottom to top or from left to right.

5.2.3.3.2 Orientation. Numerals on moving scales shall be upright when in the reading position.

5.2.3.3.3 Alignment of pointer or fixed reference line. For circular scales, alignment of pointer or fixed reference line shall be in the 12 o'clock position for right-left directional information and in the 9 o'clock position for up-down information. For purely quantitative information, either position may be used.

5.2.3.3.4 Setting. If the display will be used for setting in a value (e.g., tuning in a desired wavelength), the unused portion of the dial face shall be covered, and the open window shall be large enough to permit at least one numbered graduation to appear at each side of any setting.

5.2.3.3.5 Tracking. If the display will be used for tracking, as in the case of a directional indicator, the whole face of the dial shall be exposed.

5.2.3.3.6 Moving tape displays. When the scale length required for acceptable readout accuracy exceeds the limits of the display package capacity (i.e., compaction of scale marking would make the display illegible or subject to readout error), moving tape scale format may be used.

5.2.3.3.7 Composite scalar/pictorial displays. Combinations of scales, pointers and pictorialized symbols may be used to combine functionally-related information into a single instrument or display (e.g., artificial horizon, command heading, true/relative bearing). Design of significant reference features (e.g., aircraft or ship symbols, horizon, altitude or pitch scales) shall conform to the general criteria herein for direction-of-motion, scale-pointer relationships, and legibility.

5.2.4 Cathode ray tube (CRT) displays.

5.2.4.1 Signal size. When a target of complex shape is to be distinguished from a nontarget shape that is also complex, the target signal should subtend not less than 6 mrad (20 minutes) of visual angle and should subtend not less than 10 lines or resolution elements. Image quality shall be consistent with the operator's needs.

5.2.4.2 Viewing distance. A 400 mm (16 in) viewing distance shall be provided whenever practicable. When periods of scope observation will be short, or when dim signals must be detected, the viewing distance may be reduced to 250 mm (10 in). Design should permit the observer to view the scope from as close as desired. Displays which must be placed at viewing distances greater than 400 mm (16 in) due to other considerations shall be appropriately modified in aspects such as display size, symbol size, brightness ranges, line-pair spacing and resolution.

5.2.4.3 Screen luminance. The ambient illuminance shall not contribute more than 25% of screen brightness through diffuse reflection and phosphor excitation. A control shall be provided to vary the CRT luminance from 10% of minimum ambient luminance to full CRT luminance. A control shall be provided to vary the luminous symbol/dark background or dark symbol/luminous background contrast ratio. Contrast adjustment shall not be included in flight deck displays because they are disallowed by FAA regulation.

5.2.4.4 Faint signals. When the detection of faint signals is required and when the ambient illuminance may be above 2.7 lux (0.25 ft-c), scopes shall be hooded, shielded, or recessed. (In some instances, a suitable filter system may be employed, subject to approval by the procuring activity.)

5.2.4.5 Luminance range of adjacent surfaces. The luminance range of surfaces immediately adjacent to scopes shall be between 10% and 100% of screen background luminance. With the exception of emergency indicators, no light source in the immediate surrounding area shall be of a greater luminance than the CRT signal.

5.2.4.6 Ambient illuminance. The ambient illuminance in the CRT area shall be appropriate for other visual functions (e.g., setting controls, reading instruments, maintenance) but shall not degrade the visibility of signals on the CRT display. When a CRT display is used in variable ambient illuminance, illuminance controls shall be provided to dim all light sources, including illuminated panels, indicators and switches in the immediate surround. Automatic adjustment of CRT brightness may be used if the CRT brightness is automatically adjusted as a function of ambient illuminance and the range of automatic adjustment is adequate for the full range of ambient illuminance.

5.2.4.7 Reflected glare. Reflected glare shall be minimized by proper placement of the scope relative to the light source, use of a hood or shield, or optical coatings on the CRT or filter control over the light source.

5.2.4.8 Adjacent surfaces. Surfaces adjacent to the scope shall have a dull matte finish.

5.2.4.9 Pictorial/graphic situation formats. Pictorial or situation data such as plan position indicator data, shall be presented as luminous symbols/dark background.

5.2.4.10 Font legibility. Where alpha-numeric characters appear on CRT-like displays, the font style shall allow discrimination of similar characters, such as letter l and number 1; letter Z and number 2.

5.2.5 Large-screen displays.

5.2.5.1 Use. Large-screen displays may be used when:

a. A group of operators frequently refer to the same information and are required to interact as a team, based on the same information.

b. One or more members of a team of operators must move about, yet require frequent referral to information required to make decisions, but which they cannot carry with them, or do not have displayed at their assigned position(s).

c. Space or other constraints preclude the use of individual displays for each team member to call up commonly-used information.

d. It may be desirable to have general information available to persons who should not interrupt on-going group operations by looking over the shoulder(s) of individual operator(s) to see their individual displays.

5.2.5.2 Avoidance. Large-screen displays shall be used only when the spatial and environmental conditions allow satisfactory observational geometry to insure that all critical operators have appropriate visual access in terms of viewing distance, angle and lack of interference from intervening objects, personnel or ambient lighting. If the display is optically projected, see 5.2.6.6.

5.2.5.3 Viewing distance. The display shall not be placed further from an observer than will provide appropriate resolution of critical detail presented on the display (see legibility requirements of 5.5). The display shall not be closer to any observer than 1/2 the display width or height, whichever is greater.

5.2.5.4 Physical interruption of view. Large screen displays shall not be located with respect to critical observers so that the view of the display is obscured regularly by persons moving about--by normal traffic patterns.

5.2.5.5 Control of displayed information. Control of large-screen group display systems shall ensure that critical information cannot be modified or deleted inadvertently or arbitrarily; and therefore:

a. Control of changes in the group display shall be under the control of designated operators who operate according to pre-established procedures, upon command of a person in charge, or both.

b. When an individual must make changes that are of interest only to him or her, a separate, remote display shall be provided.

5.2.5.6 Content of displayed information. The content of displayed information shall be evident to a trained observer without requiring reference to display control settings.

5.2.6 Other displays.

5.2.6.1 General.

5.2.6.1.1 Types. Where applicable, direct-reading counters, printers, plotters, flags, optical projection, LED, gas discharge, liquid crystal and electroluminescent displays may be used.

5.2.6.1.2 Applications. The selection of the above types of displays for various applications should be based on the following specific criteria as well as the criteria in Table III.

5.2.6.2 Counters.

5.2.6.2.1 Use. Counters should be used for presenting quantitative data when a continuous trend indication is not required and when a quick, precise indication is required.

5.2.6.2.2 Mounting. Counters shall be mounted as close as possible to the panel surface so as to minimize parallax and shadows and maximize the viewing angle.

5.2.6.2.3 Spacing between numerals. The horizontal separation between numerals shall be between one-quarter and one-half the numeral width. Commas shall not be used.

5.2.6.2.4 Movement.

a. Snap action. Numbers shall change by snap action in preference to continuous movement.

b. Rate. Numbers shall follow each other not faster than 2 per second when the observer is expected to read the numbers consecutively.

c. Direction. The rotation of the counter reset knob shall be clockwise to increase the counter indication or to reset the counter.

d. Reset. Counters used to indicate the sequencing of equipment shall be designed to be reset automatically upon completion of the sequence. Provision shall also be made for manual resetting. Where pushbuttons are used to manually reset mechanical counters, actuating force required shall not exceed 16.7 N (60 oz).

5.2.6.2.5 Illumination. Counters shall be self-illuminated when used in areas in which ambient illumination will provide display luminance below 3.5 cd/m^2 (1 ft-L).

5.2.6.2.6 Finish. The surface of the counter drums and surrounding areas shall have a dull finish to minimize glare.

5.2.6.2.7 Contrast. Color of the numerals and background shall provide high contrast (black on white or converse, as appropriate).

5.2.6.3 Printers.

5.2.6.3.1 Use. Printers should be used when a visual record of data is necessary or desirable. Use of printers should conform to Table III.

5.2.6.3.2 Visibility. The printed matter shall not be hidden, masked or obscured in a manner that impairs direct reading.

5.2.6.3.3 Contrast. A minimum of 3.0 luminance contrast shall be provided between the printed material and the background on which it is printed.

5.2.6.3.4 Illumination. The printer shall be provided with internal illumination if the printed matter is not legible in the planned operational ambient illumination.

5.2.6.3.5 Take-up provision. A take-up device for printed material shall be provided.

5.2.6.3.6 Annotation. Where applicable, printers should be mounted so that the printed matter (e.g., paper, metalized paper) may be easily annotated while still in the printer.

5.2.6.3.7 Legibility. The print output shall be free from character line misregistration, character tilt or smear.

5.2.6.3.8 Printed tapes. The information on the tapes shall be printed in such a manner that it can be read as it is received from the machine without requiring the cutting and pasting of tape sections.

5.2.6.3.9 Control, replenishment and service. Printers shall conform to the criteria of 5.2.6.4.8.

5.2.6.4 Plotters and recorders.

5.2.6.4.1 Use. Plotters and recorders may be used when a visual record of continuous graphic data is necessary or desirable.

5.2.6.4.2 Visibility. Critical graphics (those points, curves and grids that must be observed when the recording is being made) shall not be obscured by pen assembly, arm or other hardware elements.

5.2.6.4.3 Contrast. A minimum of 1.0 luminance contrast (see 3.17) shall be provided between the plotted function and the background on which it is drawn.

5.2.6.4.4 Take-up device. A take-up device for extruded plotting materials shall be provided when necessary or desirable.

5.2.6.4.5 Job aids. Graphic overlays should be provided where these may be critical to proper interpretation of graphic data as it is being generated. Such aids shall not obscure or distort the data.

5.2.6.4.6 Smudging/smearing. The plot should be resistant to smudging or smearing under operational use.

5.2.6.4.7 Annotation. Where applicable, plotters and recorders should be designed or mounted so that the operator can write on or mark the paper while it is still in the plotter/recorder.

5.2.6.4.8 Control, replenishment and service. Plotters and recorders shall conform to criteria herein with regard to:

a. Controls and displays used to start, stop or adjust the machine and critical operating elements.

b. Positive indication of the remaining supply of plotting materials (e.g., paper, ink, ribbon).

c. Insertion, adjustment for operation, and removal of paper, replenishment of ink supply, replacement of pen or other items determined to be operator tasks, without requiring disassembly, special equipment or tools.

d. Minor servicing on site by a technician, e.g., adjustment of drive system, cleaning, or replacement of operating items that ordinarily would not be available to an operator.

5.2.6.5 Flags.

5.2.6.5.1 Use. Flags should be used to display qualitative, non-emergency conditions. Use of flags should conform to Table III.

5.2.6.5.2 Mounting. Flags shall be mounted as close to the surface of the panel as possible without restricting their movement or obscuring necessary information.

5.2.6.5.3 Snap action. Flags shall operate by snap action.

5.2.6.5.4 Contrast. A minimum of 3.0 luminance contrast (see 3.17) shall be provided between flags and their backgrounds under all expected lighting conditions.

5.2.6.5.5 Malfunction indication. When flags are used to indicate the malfunction of a visual display, the malfunction position of the flag shall obscure part of the operator's view of the malfunctioning display and shall be readily apparent to the operator under all expected levels of illumination.

5.2.6.5.6 Legend. When a legend is provided on the flag, the lettering shall appear upright when the flag assumes the active or no-go position.

5.2.6.5.7 Test provision. A convenient means shall be provided for testing the operation of flags.

5.2.6.6 Large screen optical projection displays.

5.2.6.6.1 Use. Providing ambient light can be properly controlled, optical projection displays are suitable for applications requiring group presentation, pictorial and spatial information, past history vs real-time presentation, synthetically generated pictures, simulation of the external world and superposition of data from more than one source. Rear projection shall be used where physical obstructions to front projection result in poor visibility or where work areas require high ambient illumination for other activities.

5.2.6.6.2 Seating area. Viewing distance/image width relationship and off-center viewing of optical projection displays for group viewing should conform to the preferred limits of Table IV and shall not exceed the acceptable limits indicated. For individual viewing from a fixed location, off-centerline viewing shall not exceed 175 mrad (10°).

TABLE IV. GROUP VIEWING OF OPTICAL PROJECTION DISPLAYS

FACTOR	OPTIMUM	PREFERRED LIMITS	ACCEPTABLE LIMITS
Ratio of $\frac{\text{viewing distance}}{\text{screen diagonal}}$	4	3–6	2–8
Angle off centerline	0 mrad (0°)	350 mrad (20°)	525 mrad (30°)
*Image luminance (no film in operating projector)	35 cd/m² (10 ft–L)	27–48 cd/m² (8–14 ft–L)	17–70 cd/m² (5–20 ft–L)
Luminance variation across screen (ratio of maximum to minimum luminance)	1	1.5	3.0
Luminance variation as a function of viewing location (ratio of maximum to minimum luminance)	1	2.0	4.0
Ratio of $\frac{\text{ambient light}}{\text{brightest part of image}}$	0	0.002–0.01	0.1 max**

*For still projections higher values may be used
**For presentations not involving gray scale or color (e.g., line drawings, tables) 0.2 may be used.

5.2.6.6.3 Image luminance and light distribution. Image luminance and light distribution should conform to the preferred limits and shall not exceed the acceptable limits of Table IV. In any case, the luminance of the screen center at maximum viewing angle shall be at least half its maximum luminance.

5.2.6.6.4 Legibility of projected data.

5.2.6.6.4.1 Style. A simple style of numerals and letters shall be used. Capital letters shall be used, rather than lower case, except for extended copy or lengthy messages. Stroke width shall be 1/6 to 1/8 of numeral or letter height, but may be narrower for light markings on a dark background. Stroke width shall be the same for all letters and numerals of equal height. Letter and numeral widths, character spacing and word spacing shall conform to 5.5.5.5, 5.5.5.6, 5.5.5.10, and 5.5.5.11, respectively.

5.2.6.6.4.2 Size. The height of letters and numerals should be not less than 4.5 mrad (15 minutes) of visual angle and, in no instance, shall be less than 3 mrad (10 minutes) as measured from the longest anticipated viewing distance.

5.2.6.6.4.3 Contrast.

5.2.6.6.4.3.1 Luminance ratio. Under optimal ambient lighting conditions, the luminance ratio (see 3.18) for optically projected displays should be 500:1. The minimum luminance ratio for viewing charts, printed text and other linework via slides or opaque projectors shall be 5:1. For projections which are limited in shadows and detail, such as animation and photographs with limited luminance range, the minimum luminance ratio shall be 25:1. For images which show a full range of colors (or grays in black-and-white photographs), the minimum luminance ratio shall be 100:1.

5.2.6.6.4.3.2 Direction of contrast. Contrast may be either light on a dark background or vice-versa, except where superposition is used. For subtractive superposition (at the source), data shall be presented as dark markings on a transparent background. For additive superposition (at the screen), data shall be presented as light markings on an opaque background. Colored markings against colored backgrounds of comparable brightness shall be avoided.

5.2.6.6.4.4 Alignment. Misregistration of superimposed alphanumeric data or other symbols shall be minimized.

5.2.6.6.5 Keystone effects. Projector-screen arrangement shall minimize "keystone effect," e.g., distortion of projected data proportions due to non-perpendicularity between projector and screen.

5.2.6.7 Light emitting diodes (LEDs).

5.2.6.7.1 General. In general, the standard for LEDs shall be the same as the requirements for transilluminated displays, paragraph 5.2.2 of this standard, unless specified below.

5.2.6.7.2 Use. LEDs may be used for transilluminated displays, including legend and simple indicator lights, and for matrix (alphanumeric) displays, only if the display is bright enough to be readable in the environment of intended use (enclosure, bright sunlight, low temperature).

5.2.6.7.3 Intensity control. The dimming of LEDs should be compatible with the dimming of incandescent lamps.

5.2.6.7.4 Color coding. LED color coding shall conform to 5.2.2.1.18, herein, with the exception of red alpha-numeric displays; however, red LEDs should not be located in the proximity of red lights used as outlined in 5.2.2.1.18.

5.2.6.7.5 Lamp testing. LED indicator lights with 100,000 hours or longer MTBF (mean time between failure) shall not require the lamp test capability specified in 5.2.2.1.14.

5.2.6.8 Dot matrix/segmented displays.

5.2.6.8.1 General. The design criteria below shall be applied to those displays (LED, CRT, gas discharge, liquid crystal and incandescent) used for the presentation of alphanumeric and symbolic information.

5.2.6.8.2 Use. Dot matrix, fourteen segment and sixteen segment displays may be used for applications involving interactive computer systems, instruments, avionics, navigation and communication equipment, where the presentation of alphanumeric, vector-graphic, symbolic or real-time information is required. Seven segment displays shall only be used for applications requiring numeric information.

5.2.6.8.3 Symbol definition. The smallest definition for a dot matrix shall be 5 by 7 dots, with 7 by 9 preferred. If system requirements call for symbol rotation, a minimum of 8 by 11 is required, with 15 by 21 preferred.

5.2.6.8.4 Alphanumeric character and symbol sizes. Alphanumeric and symbolic characters shall not subtend less than 4.7 mrad (16 min) of visual angle. Flight display characters, which must be read under aircraft environmental conditions, shall subtend not less than 7 mrad (24 min) of visual angle.

5.2.6.8.5 Use of upper case. Alphanumeric characters shall be upper case.

5.2.6.8.6 Viewing angle. The optimum viewing angle is perpendicular to the display. Dot matrix or segmented displays should not be presented for viewing at an angle larger than 610 mrad (35°) off axis.

5.2.6.8.7 Emitter color. Monochromatic displays shall use the following colors in order of preference: green (555nm), Yellow (575nm), orange (585nm), and red (660nm). Blue emitters should be avoided.

5.2.6.8.8 Intensity control. Dimming controls shall be provided where applicable to maintain appropriate legibility and operator dark adaptation level.

5.2.6.8.9 Display testing. See 5.2.6.7.5.

5.2.6.8.10 Location of red alphnumeric LEDs/segmented displays. Red LEDs/segmented displays shall not be grouped with or located adjacent to red warning lights.

5.2.6.9 Electroluminescent displays.

5.2.6.9.1 Use. Electroluminescent displays may be used wherever system requirements dictate the use of transilluminated displays. In addition, they may replace existing mechanical instrumentation while offering advantages of lighter weight, conservation of panel space, lower power requirements, lack of heat production, uniform distribution of illumination, longer life, elimination of parallax and flexibility of display. Electroluminescent displays may also be used where sudden lamp failure could result in catastrophic consequences.

5.2.6.9.2 Alphanumeric character and symbol sizes. The height of alphanumeric characters and geometric and pictorial symbols shall not subtend less than 4.5 mrad (15 minutes) of visual angle. Alphanumerical characters shall be composed of upper case letters. Flight display alphanumerics shall not subtend less than 7 mrad (24 minutes) of visual angle to insure adequate legibility under aircraft environmental conditions.

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5.3 Audio displays.

5.3.1 General.

5.3.1.1 Use. Audio displays should be provided when:

a. The information to be processed is short, simple, and transitory, requiring immediate or time-based response.

b. The common mode of visual display is restricted by over-burdening; ambient light variability or limitation; operator mobility; degradation of vision by vibration, high g-forces, hypoxia, or other environmental considerations; or anticipated operator inattention.

c. The criticality of transmission response makes supplementary or redundant transmission desirable.

d. It is desirable to warn, alert, or cue the operator to subsequent additional response.

e. Custom or usage has created anticipation of an audio display.

f. Voice communication is necessary or desirable.

5.3.1.2 Signal type. When an audio presentation is required, the optimum type of signal should be presented in accordance with the Table V.

5.3.1.3 False alarms. The design of audio display devices and circuits shall preclude false alarms.

5.3.1.4 Failure. The audio display device and circuit shall be designed to preclude warning signal failure in the event of system or equipment failure and vice versa.

5.3.1.5 Circuit test. All audio displays shall be equipped with circuit test devices or other means of operability test.

5.3.1.6 Aircrew stations. Audio signals for air crew stations shall conform to MIL-STD-411, where applicable.

5.3.1.7 Use with several visual displays. One audio signal may be used in conjunction with several visual displays, provided that immediate discrimination is not critical to personnel safety or system performance.

5.3.2 Audio warnings.

5.3.2.1 Warning signals. Audio signals should be provided, as necessary, to warn personnel of impending danger, to alert an operator to a critical change in system or equipment status, and to remind the operator of a critical action or actions that must be taken. An alerting/warning system or signal

TABLE V. FUNCTIONAL EVALUATION OF AUDIO SIGNALS

FUNCTION	TYPE OF SIGNAL		
	TONES (Periodic)	COMPLEX SOUNDS (Non-Periodic)	SPEECH
QUANTITATIVE INDICATION	POOR Maximum of 5 to 6 tones absolutely recognizable.	POOR Interpolation between signals inaccurate.	GOOD Minimum time and error in obtaining exact value in terms compatible with response.
QUALITATIVE INDICATION	POOR-TO-FAIR Difficult to judge approximate value and direction of deviation from null setting unless presented in close temporal sequence.	POOR Difficult to judge approximate deviation from desired value.	GOOD Information concerning displacement, direction, and rate presented in form compatible with required response.
STATUS INDICATION	GOOD Start and stop timing. Continuous information where rate of change of input is low.	GOOD Especially suitable for irregularly occurring signals (e.g., alarm signals).	POOR Inefficient; more easily masked; problem of repeatability.
TRACKING	FAIR Null position easily monitored; problem of signal-response compatibility.	POOR Required qualitative indications difficult to provide.	GOOD Meaning intrinsic in signal.
GENERAL	Good for automatic communication of limited information. Meaning must be learned. Easily generated.	Some sounds available with common meaning (e.g., fire bell). Easily generated.	Most effective for rapid (but not automatic) communication of complex, multidimensional information. Meaning intrinsic in signal and context when standardized. Minimum of new learning required.

shall provide the operator with a greater probability of detecting the triggering condition than his normal observation would provide in the absence of the alerting/warning system or signal. NOTE: Certain audio signals have been standardized for aircraft use by joint service and international agreement. Stipulation of audio signals for future aircraft design should be in consonance with these agreements (see MIL-STD-411).

5.3.2.2 Nature of signals. Audio warning signals should normally consist of two elements: an alerting signal and an identifying or action signal.

5.3.2.2.1 Two element signals. when reaction time is critical and a two element signal is necessary, an alerting signal of 0.5 second duration shall be provided. All essential information shall be transmitted in the first 2.0 seconds of the identifying or action signals.

5.3.2.2.2 Single element signal. When reaction time is critical, signals shall be of short duration. If a single element signal is permissable, all essential information shall be transmitted in the first 0.5 second.

5.3.2.3 Caution signals. Caution signals shall be readily distinguishable from warning signals and shall be used to indicate conditions requiring awareness, but not necessarily immediate action.

5.3.2.4 Relation to visual displays. When used in conjunction with visual displays, audio warning devices shall be supplementary or supportive. The audio signal shall be used to alert and direct operator attention to the appropriate visual display.

5.3.3 Characteristics of audio warning signals.

5.3.3.1 Frequency.

5.3.3.1.1 Range. The frequency range shall be between 200 and 5,000 Hz and, if possible, between 500 and 3,000 Hz. When signals must travel over 300 m (985 ft), sounds with frequencies below 1,000 Hz should be used. Frequencies below 500 Hz should be used when signals must bend around obstacles or pass through partitions. The selected frequency band shall differ from the most intense background frequencies and shall be in accordance with other criteria in this section.

5.3.3.1.2 Spurious signals. The frequency of a warning tone shall be different from that of the electric power employed in the system, to preclude the possibility that a minor equipment failure may generate a spurious signal.

5.3.3.2 Intensity.

5.3.3.2.1 Compatibility with acoustical environment. The intensity, duration and source location of audio alarms and signals shall be compatible with the acoustical environment of the intended receiver as well as the requirements of other personnel in the signal areas.

5.3.3.2.2 Compatibility with clothing and equipment. As applicable, audio signals shall be loud enough to be heard and understood through equipment or garments (e.g., parka hood, NBC protective hood, hearing protective devices) covering the ears of the listener.

5.3.3.2.3 Discomfort. Audio warning signals should not be of such intensity as to cause discomfort or "ringing" in the ears as an after-effect.

5.3.4 Signal characteristics in relation to operational conditions and objectives.

5.3.4.1 Audibility. A signal-to-noise ratio of at least 20 dB shall be provided in at least one octave band between 200 and 5,000 Hz at the operating position of the intended receiver.

5.3.4.2 Alerting capability.

5.3.4.2.1 Attention. Signals with high alerting capacity should be provided when the system or equipment imposes a requirement on the operator for concentration of attention. Such signals shall not, however, be so startling as to preclude appropriate responses or interfere with other functions by holding attention away from other critical signals.

5.3.4.2.2 Onset and sound pressure level. The onset of critical alerting signals should be sudden, and a relatively high sound pressure level should be provided as specified 5.3.4.1.

5.3.4.2.3 Dichotic presentation. When earphones will be worn in the operational situation, a dichotic presentation should be used whenever feasible, alternating the signal from one ear to the other by means of a dual-channel headset.

5.3.4.2.4 Headset. When the operator is wearing earphones covering both ears during normal equipment operation, the audio warning signal shall be directed to the operator's headset as well as to the work area. Binaural headsets should not be used in any operational environment below 85 dB(A) when that environment may contain sounds that provide the operator with useful information when that information cannot be directed to the operator's headset. Such sounds may include voices, machine noise that indicates wear or malfunction and other auditory indications of system performance/mission status.

5.3.4.3 Discriminability.

5.3.4.3.1 Use of different characteristics. When several different audio signals are to be used to alert an operator to different types of conditions, discriminable difference in intensity, pitch, or use of beats and harmonics shall be provided. If absolute discrimination is required, the number of signals to be identified shall not exceed four.

5.3.4.3.2 Coding. Where discrimination of warning signals from each other will be critical to personnel safety or system performance, audio signals shall be appropriately coded. Alarms that are perceptibly different shall correlate with different conditions requiring critically different operator responses (e.g., maintenance, emergency conditions, and health hazards). Such signals shall be sufficiently different to minimize the operator's search of visual displays.

5.3.4.3.3 Critical signals. The first 0.5 second of an audio signal requiring fast reaction shall be discriminable from the first 0.5 second of any other signal that may occur. Familiar signals with established names or associations shall be selected. Speech should be used whenever feasible.

5.3.4.3.4 Action segment. The identifying or action segment of an audio warning signal shall specify the precise emergency or condition requiring action.

5.3.4.3.5 Differentiation from routine signals. Audio alarms intended to bring the operator's attention to a malfunction or failure shall be differentiated from routine signals, such as bells, buzzers, and normal operation noises.

5.3.4.3.6 Prohibited types of signals. The following types of signals shall not be used as warning devices where possible confusion might exist because of the operational environment:

a. Modulated or interrupted tones that resemble navigation signals or coded radio transmissions.

b. Steady signals that resemble hisses, static, or sporadic radio signals.

c. Trains of impulses that resemble electrical interference whether regularly or irregularly spaced in time.

d. Simple warbles which may be confused with the type made by two carriers when one is being shifted in frequency (beat-frequency-oscillator effect).

e. Scrambled speech effects that may be confused with cross modulation signals from adjacent channels.

f. Signals that resemble random noise, periodic pulses, steady or frequency modulated simple tones, or any other signals generated by standard countermeasure devices (e.g., "bagpipes").

g. Signals similar to random noise generated by air conditioning or any other equipment.

5.3.4.4 Compatibility.

5.3.4.4.1 Existing signals. The meaning of audio warning signals selected for a system should be consistent with warning signal meanings already established for that function.

5.3.4.4.2 Acoustic environment. Established signals shall be used, provided they are compatible with the acoustic environment and the requirements specified herein for the voice communication system. Standard signals shall not be used to convey new meanings.

5.3.4.5 Masking.

5.3.4.5.1 Other critical channels. Audio warning signals shall not interfere with any other critical functions or warning signals, or mask any other critical audio signals.

5.3.4.5.2 Separate channels. Where a warning signal delivered to a headset might mask another essential audio signal, separate channels may be provided to direct the warning signal to one ear and the other essential audio signal to the other ear. In such a situation and when required by operating conditions, this dichotic presentation may further provide for alternation of the two signals from ear to ear.

5.3.5 Verbal warning signals.

5.3.5.1 Nature of signals. Verbal warning signals shall consist of:

a. An initial alerting signal (nonspeech) to attract attention and to designate the general problem.

b. A brief standardization speech signal (verbal message) which identifies the specific condition and suggests appropriate action.

5.3.5.2 Intensity. Verbal alarms for critical functions shall be at least 20 dB above the speech interference level at the operating position of the intended receiver.

5.3.5.3 Vocal criteria.

5.3.5.3.1 Type of voice. The voice used in recording verbal warning signals shall be distinctive and mature.

5.3.5.3.2 Delivery style. Verbal warning signals shall be presented in a formal, impersonal manner.

5.3.5.4 Speech processing. Verbal warning signals shall be processed only when necessary to increase or preserve intelligibility, such as by increasing the strength of consonant sounds relative to vowel strength. Where a signal must be relatively intense because of high ambient noise, peak-clipping (see 3.24) maybe used to protect the listener against auditory overload.

5.3.5.5 Message content. In selecting words to be used in audio warning signals, priority shall be given to intelligibility, aptness, and conciseness in that order.

5.3.5.6 Message categories.

5.3.5.6.1 Critical warning signals. Critical warning signal shall be repeated with not more than a 3-second pause between messages until the condition is corrected or overridden by the crew.

5.3.5.6.2 Message priorities. A message priority system shall be established and more critical messages shall override the presentation of any message occuring below it on the priority list. If two or more incidents or malfunctions occur simultaneously, the message having the higher priority shall be given first. The remaining messages shall follow in order of priority. In the event of a complete subsystem failure, the system shall integrate previous messages via electronic gating and report the system rather than the component failure.

5.3.6 Controls for audio warning devices.

5.3.6.1 Automatic or manual shut-off. When an audio signal is designed to persist as long as it contributes useful information, a shut-off switch controllable by the operator, the sensing mechanism, or both, shall be provided, depending on the operational situation and personnel safety factors.

5.3.6.2 Automatic reset. Whether audio warning signal are designed to be terminated automatically, by manual control, or both, an automatic reset function shall be provided. The automatic reset function shall be controlled by the sensing mechanism which shall recycle the signal system to a specified condition as a function of time or the state of the signalling system so that the warning device can sound again if the condition repeats.

5.3.6.3 Redundant Visual Warning. All non-verbal aural annunciations shall be accompanied by a visual annunciation which defines the condition. In a cockpit, this may be an illuminated display. In the case of a warning horn on a backing vehicle, the vehicle's backward motion is adequate visual annunciation.

5.3.6.4 Volume control.

5.3.6.4.1 Automatic or manual. The volume (loudness) of an audio warning signal shall be designed to be controlled by the operator, the sensing mechanism, or both, depending on the operational situation and personnel safety factors. Control movements shall be restricted to prevent reducing the volume to an inaudible level.

5.3.6.4.2 Ganging to mode switches. Volume controls may be ganged to mode switches to provide maximum output during mission phases in which intense noise may occur and to provide reduced volume at other times. Ganging shall not be accomplished if there is a possibility that intense noise may occur in an emergency situation during a mission phase in which the volume would be decreased below an audible level.

5.3.6.4.3 Caution signal controls. Audio caution signals shall be provided with manual reset and volume controls.

5.3.6.5 Duration. Audio warning signal duration shall be at least 0.5 second, and may continue until the appropriate response is made. Completion of a corrective action by the operator or by other means shall automatically terminate the signal.

5.3.6.6 Duration limitations. In an emergency situation, signals that persist or increase progressively in level shall not be used if manual shut-off may interfere with the corrective action required.

5.3.7 Speech transmission equipment.

5.3.7.1 Frequency. Microphones and associated system-input devices shall be designed to respond optimally to that part of the speech spectrum most essential to intelligibility (i.e., 200 to 6,100 Hz). Where system engineering necessitates speech-transmission bandwidths narrower than 200 to 6,100 Hz, the minimum acceptable frequency range shall be 250 to 4,000 Hz.

5.3.7.2 Dynamic range. The dynamic range of a microphone used with a selected amplifier shall be great enough to admit variations in signal input of at least 50 dB.

5.3.7.3 Noise cancelling microphones. In very loud, low frequency noise environments (100 dB overall), noise cancelling microphones shall be used and shall be capable of effecting an improvement of not less than 10 dB peak-speech to root-mean-square-noise ratio as compared with non-noise-cancelling microphones of equivalent transmission characteristics.

5.3.7.4 Pre-emphasis. If necessary, speech system input devices should employ frequency pre-emphasis with a positive slope frequency characteristic no greater than 18 dB per octave from 140 to 1,500 to and no greater than 9 dB per octave over the frequency range 1,500 to 4,800 Hz, when no clipping is used.

5.3.7.5 Peak-clipping of speech signals. Where speech signals are to be transmitted over channels showing less than 15 dB peak speech to root-mean-square-noise ratios, peak clipping of 12 to 20 dB may be employed at system input and may be preceded by frequency pre-emphasis as specified in 5.3.7.4.

5.3.7.6 Noise shields. When the talker is in an intense noise field, the microphone should be put in a noise shield. Noise shields should be designed to meet the following requirements:

a. A volume of at least 250 cu cm (15.25 cu in) to permit a pressure gradient microphone to function normally.

b. A good seal against the face with the pressure of the hand or the tension of straps.

c. A hole or combination of holes covering a total area of 65 sq mm (0.1 sq in) in the shield to prevent pressure buildup.

d. Prevention of a standing wave pattern by shape, or by use of sound absorbing material.

e. No impediment to voice effort, mouth or jaw movement or breathing.

5.3.8 Speech reception equipment.

5.3.8.1 Frequency range. Headphones and loudspeakers shall be subject to the same frequency response restrictions as microphones and transmission equipment except that loudspeakers for use in multi-speaker installations and multiple channels fed into headphones (e.g., where several speech channels are to be monitored simultaneously) shall respond uniformly (±5 dB) over the range 100 to 4,800 Hz.

5.3.8.2 Loudspeakers for multi-channel monitoring.

5.3.8.2.1 Monitoring of speakers. When several channels are to be monitored simultaneously by means of loudspeakers, the speakers shall be mounted at least 175 mrad (10°) apart in the horizontal plane frontal quadrant, ranging radially from $\pi/4$ rad (45°) left to $\pi/4$ rad (45°) right of the operator's normal forward facing position.

5.3.8.2.2 Filtering. When additional channel differentiation is required, apparent lateral separation shall be enhanced by applying low-pass filtering (frequency cutoff, F_C = 1,800 Hz) to signals fed to loudspeakers on one side of the central operator position. If there are three channels involved, one channel shall be left unfiltered, a high pass filter with 1,000 Hz cutoff shall be provided in the second channel, and a low-pass filter with 2,500 Hz cutoff shall be provided in the third channel. A visual signal shall be provided to show which channel is in use.

5.3.8.3 Use of de-emphasis. When transmission equipment employs pre-emphasis and peak clipping is not used, reception equipment shall employ frequency de-emphasis of characteristics complementary to those of pre-emphasis only if it improves intelligibility, i.e., de-emphasis shall be a negative-slope frequency response not greater than 9 dB per octave over the frequency range 140 to 4,800 Hz.

5.3.8.4 Headsets. If listeners will be working in high ambient noise (85 dB(A) or above), binaural rather than monaural headsets shall be provided. Unless operational requirements dictate othrwise, binaural headsets shall be wired so that the sound reaches the two ears in opposing phases. Their attenuation qualities should be capable of reducing the ambient noise level to less than 85 dB(A). Provisions should be incorporated to furnish the same protection to those who wear glasses.

5.3.9 Operator comfort and convenience.

5.3.9.1 Comfort. Communication equipment to be worn by an operator (e.g., headphones and telephone headsets) shall be designed to preclude operator discomfort. Metal parts of the headset shall not come in contact with the user's skin.

5.3.9.2 Hands-free operation. Operator microphones, headphones, and telephone headsets shall be designed to permit hands-free operation under normal working conditions.

5.3.9.3 Accessibility of handsets. Where communication requirements necessitate the use of several telephone handsets, the accessibility of their standby locations shall be determined by operational priority, i.e., the most frequently or urgently needed handset shall be the most accessible. Color-coding may also be employed where operating personnel will have visual contact with headsets under the working conditions.

5.3.10 Operating controls for voice communication equipment.

5.3.10.1 Volume controls. Accessible volume or gain controls shall be provided for each communication receiving channel (e.g., loudspeakers or headphones) with sufficient electrical power to drive sound pressure level to at least 100 dB overall when using two earphones, and shall have pressure operated gain control switches to compensate for altitude in unpressurized compartments. The minimum setting of the volume control shall be limited to an audible level, i.e., it shall not be possible to inadvertently disable the system with the volume control. While separation of power (on-off) and volume control adjustment functions into separate controls is preferred, should conditions justify their combination, a noticeable detent position shall be provided between the OFF position and the lower end of the continuous range of volume adjustment. When combined power and volume controls are used, the OFF position shall be labeled.

5.3.10.2 Squelch control. Where communication channels are to be continuously monitored, each channel shall be provided with a signal-activated switching device (squelch control) to suppress channel noise during no-signal periods. A manually operated, on-off switch, to deactivate the squelch when receiving weak signals, shall be provided.

5.3.10.3 Foot-operated controls. When normal working conditions will permit the operator to remain seated at the working position and access to "talk-listen" or "send-receive" control switches are required for normal operation or if console operation requires the use of both hands, foot-operated controls shall be provided. Hand-operated controls for the same functions shall be provided for emergency use and for use when the operator may need to move from one position to another.

5.3.11 Speaker/side tone. The speaker's verbal input shall be in phase with its reproduction as heard on the headset. This side tone should not be filtered or modified before it is received in the headset.

5.3.12 Speech intelligibility.

5.3.12.1 General. When information concerning the speech intelligibility of a system is required, three recommended methods are available, with the appropriate selection being dependent upon the requirements of the test.

a. The ANSI standard method of measurement of phonetically balanced (PB) monosyllabic word intelligibility, S3.2-1960, should be used when a high degree of test sensitivity and accuracy is required.

b. The modified rhyme test (MRT) (see Human Engineering Guide to Equipment Design) should be used if the test requirements are not as stringent or if time and training do not permit the use of the ANSI method.

c. The articulation index (AI) calculations should be used for estimations, comparison and predictions of system intelligibility based upon ANSI S3.5-1969.

5.3.12.2 Criteria. The intelligibility criteria shown in Table VI shall be used for voice communication. The efficiency of communications needed and the type material to be transmitted shall determine which of the three communication requirements of Table VI is to be selected.

TABLE VI. INTELLIGIBILITY CRITERIA FOR VOICE COMMUNICATIONS SYSTEMS

COMMUNICATION REQUIREMENT	SCORE		
	PB	MRT	AI
Exceptionally high intelligibility; separate syllables understood	90%	97%	0.7
Normally acceptable intelligibility; about 98% of sentences correctly heard; single digits understood	75%	91%	0.5
Minimally acceptable intelligibility; limited standardized phrases understood; about 90% sentences correctly heard (not acceptable for operational equipment)	43%	75%	0.3

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5.4 Controls.

5.4.1 General criteria.

5.4.1.1 Selection.

5.4.1.1.1 Distribution of work load. Controls shall be selected and distributed so that none of the operator's limbs will be overburdened.

5.4.1.1.2 G-loading. Where applicable, control selection shall include consideration of operation under variable g-loading on the operator.

5.4.1.1.3 Multirotation controls. Multirotation controls shall be used when precision is required over a wide range of adjustment.

5.4.1.1.4 Detent controls. Detent controls shall be selected whenever the operational mode requires control operation in discrete steps.

5.4.1.1.5 Stops. Stops shall be provided at the beginning and end of the range of control positions if the control is not required to be operated beyond the indicated end positions or specified limits.

5.4.1.2 Direction of movement.

5.4.1.2.1 Consistency of movement. Direction of control movement shall be consistent with the related movement of an associated display, equipment component, or vehicle. In general, movement of a control forward, clockwise to the right, or up, or pressing a control, shall turn the equipment or component on, cause the quantity to increase, or cause the equipment or component to move forward, clockwise, to the right, or up. Valve controls are excepted (see 5.4.1.2.4).

5.4.1.2.2 Multidimensional operation. When the vehicle, the equipment, or the components are capable of motion in more than two dimensions, exception to 5.4.1.2.1 shall be made if necessary to ensure consistency or anticipated response (e.g., forward motion of a directional control causes some vehicles to dive or otherwise descend rather than to simply move forward). When several controls are combined in one control device, caution shall be exercised to avoid conflicts (e.g., control motion to the right is compatible with clockwise roll, right turn, and direct movement to the right).

5.4.1.2.3 Operator-control orientation. Controls shall be oriented with respect to the operator. Where the operator may use two or more vehicle operator stations, the controls shall cause movement oriented to the operator at the effecting station, unless remote visual reference is used.

5.4.1.2.4 Valve controls. Rotary valve controls should open the valve with a counterclockwise motion. Valve controls shall be provided with double-ended arrows showing the direction of operations and labeled at each end to indicate the functional result (e.g., open and close).

5.4.1.3 Arrangement and grouping.

5.4.1.3.1 Grouping. All controls which function in sequential operation necessary to a particular task, or which operate together, shall be grouped together along with their associated displays. When several steps of a sequence are selected by one control, the steps shall be arranged by order of occurrence to minimize control movements and prevent cycling through unnecessary steps. Cycling through the control's ON/OFF position shall be avoided.

5.4.1.3.2 Sequential operation. Where sequential operations follow a fixed pattern, controls shall be arranged to facilitate operation (e.g., in a pattern left-to-right and top-to-bottom, as a printed page).

5.4.1.3.3 Location of primary controls. The most important and frequently used controls shall have the most favorable position with respect to ease of reaching and grasping (particularly rotary controls and those requiring fine settings).

5.4.1.3.4 Consistency. The arrangement of functionally similar, or identical, primary controls shall be consistent from panel to panel throughout the system, equipment, or vehicle, e.g., a movement of a control to the right or left should result in a corresponding movement of a displayed element to the right or left.

5.4.1.3.5 Remote controls. Where controls are operated at a position remote from the display, equipment, or controlled vehicle, they shall be arranged to facilitate direction-of-movement consistency.

5.4.1.3.6 Maintenance and adjustment. In general, controls used solely for maintenance and adjustment shall be covered during normal equipment operation, but shall be readily accessible and visible to the maintenance technician when required.

5.4.1.3.7 Spacing. Minimum spacing between controls shall comply with Table VII. Spacing between a control and any adjacent obstruction shall be as shown by the figures referenced by Table VII. Minimum spacing shown shall be increased for operation with gloves, mittens, or NBC protective handwear, when such operation is a system requirement.

5.4.1.4 Coding.

5.4.1.4.1 Methods and requirements. The use of a coding mode (e.g., size and color) for a particular application shall be governed by the relative advantages and disadvantages of each type of coding. Where coding is used to differentiate among controls, application of the code shall be uniform throughout the system. (See Table VIII for advantages and disadvantages.)

TABLE VII. MINIMUM SEPARATION DISTANCES FOR CONTROLS

	TOGGLE SWITCHES	*PUSH-BUTTONS	CONTINUOUS ROTARY CONTROLS	ROTARY SELECTOR SWITCHES	DISCRETE THUMBWHEEL CONTROLS
TOGGLE SWITCHES	SEE FIG 13	13 mm (0.5 in.)	19 mm (0.75 in.)	19 mm (0.75 in.)	13 mm (0.5 in.)
*PUSHBUTTONS	13 mm (0.5 in.)	SEE FIG. 11	13 mm (0.5 in.)	13 mm (0.5 in.)	13 mm (0.5 in.)
CONTINUOUS ROTARY CONTROLS	19 mm (0.75 in.)	13 mm (0.5 in.)	SEE FIG 7	25 mm (1.0 in.)	19 mm (0.75 in.)
ROTARY SELECTOR SWITCHES	19 mm (0.75 in.)	13 mm (0.5 in.)	25 mm (1.0 in.)	SEE FIG 4	19 mm (0.75 in.)
DISCRETE THUMBWHEEL CONTROLS	13 mm (0.5 in.)	13 mm (0.5 in.)	19 mm (0.75 in.)	19 mm (0.75 in.)	SEE FIG 6

*For pushbuttons not separated by barriers

All values are for one hand operation. Distances are measured from edge to edge of each control.

TABLE VIII. ADVANTAGES AND DISADVANTAGES OF VARIOUS TYPES OF CODING

	TYPE OF CODING					
ADVANTAGES	LOCATION	SHAPE	SIZE	MODE OF OPERATION	LABELING	COLOR
Improves visual identification.	X	X	X		X	X
Improves nonvisual identification (tactual and kinesthetic).	X	X	X	X		
Helps standardization.	X	X	X	X	X	X
Aids identification under low levels of illumination and colored lighting.	X	X	X	X	(When trans-illuminated)	(When trans-illuminated)
May aid in identifying control position (settings).		X		X	X	
Requires little (if any) training; is not subject to forgetting.					X	
DISADVANTAGES						
May require extra space.	X	X	X	X	X	
Affects manipulation of the control (ease of use).	X	X	X	X		
Limited in number of available coding categories.	X	X	X	X		X
May be less effective if operator wears gloves.		X	X	X		
Controls must be viewed (i.e., must be within visual areas and with adequate illumination present).					X	X

5.4.1.4.2 Location-coding. Controls associated with similar functions should be in the same relative location from operator work station to work station and from panel to panel.

5.4.1.4.3 Size-coding. No more than three different size of controls shall be used in coding controls for discrimination by absolute size. Controls used for performing the same function on different items of equipment shall be the same size. When knob diameter is used as the coding parameter, differences between diameters shall not be less than 13 mm (0.5"). When knob thickness is the coding parameter, differences between thicknesses shall not be less than 10 mm (0.4").

5.4.1.4.4 Shape-coding. Primary use of shape coding for controls is for identification of control knobs or handles by "feel;" however, shapes shall be identifiable both visually and tactually. When shape coding is used:

a. The coded feature shall not interfere with ease of control manipulation.

b. Shapes shall be identifiable by the hand regardless of the position and orientation of the control knob or handle.

c. Shapes shall be tactually identifable when gloves are worn, where applicable.

d. A sufficient number of identifiable shapes shall be provided to cover the expected number of controls that require tactual identification.

e. Shape coded knobs and handles shall be positively and non-reversably attached to their shafts to preclude incorrect attachment when replacement is required.

f. Shapes should be associated with or resemble control function, and not alternate functions.

5.4.1.4.5 Color-coding.

5.4.1.4.5.1 Choice of colors. Controls shall be black (17038, 27038, or 37038) or gray (26231 or 36231). If color coding is required, only the following colors identified in FED-STD-595 shall be selected for control coding.

a. Red, 11105, 21105, 31105

b. Green, 14187

c. Orange-Yellow, 13538, 23538, 33538

d. White, 17875, 27875, 37875

e. Blue, 15123 shall be used if an additional color is absolutely necessary.

5.4.1.4.5.2 Immediate action controls. Color coding of immediate action controls for aircraft shall conform to MIL-M-18012.

5.4.1.4.5.3 Relation to display. When color-coding must be used to relate a control to its corresponding display, the same color shall be used for both the control and the display.

5.4.1.4.5.4 Control panel contrast. The color of the control shall provide contrast between the panel background and the control.

5.4.1.4.5.5 Ambient lighting and color-coding exclusion. Color coding shall be compatible with anticipated ambient lighting throughout the mission. Color-coding shall not be used as a primary identification medium if the spectral characteristics of ambient light during the mission, or the operator's adaptation to that light, varies as the result of such factors as solar glare, filtration of light, and variation from natural to artificial light. If red lighting is to be used during a portion of the mission, controls which would otherwise be coded red shall be coded by orange-yellow and black striping.

5.4.1.5 Labeling of controls. Control labeling shall conform to the criteria in paragraph 5.5.

5.4.1.6 Compatibility with handwear. Controls shall be compatible with handwear to be utilized in the anticipated environment. Unless otherwise specified, all dimensions cited herein are for bare hands and should be revised where necessary for use with gloves or mittens.

5.4.1.7 Blind operation. Where "blind" operation is necessary, hand controls shall be shape-coded, or separated from adjacent controls by at least 125 mm (5 in.).

5.4.1.8 Prevention of accidental actuation.

5.4.1.8.1 Location and design. Controls shall be designed and located so that they are not susceptible to being moved accidentally, particularly critical controls whose inadvertent operation might cause damage to equipment, injury to personnel or degredation of system functions.

5.4.1.8.2 Internal controls. Internal or hidden controls should be protected, because it is usually not obvious that such controls have been disturbed and it may be difficult and time consuming to locate and readjust them.

5.4.1.8.3 Rapid operation. Any method of protecting a control from inadvertent operation shall not preclude operation within the time required.

5.4.1.8.4 Methods. For situations in which controls must be protected from accidental actuation, one or more of the following methods, as applicable, shall be used:

a. Locate and orient the controls so that the operator is not likely to strike or move them accidentally in the normal sequence of control movements.

b. Recess, shield, or otherwise surround the controls by physical barriers. The control shall be entirely contained within the envelope described by the recess or barrier.

c. Cover or guard the controls. Safety or lock wire shall not be used.

d. Provide the controls with interlocks so that extra movement (e.g., a side movement out of a detent position or a pull-to-engage clutch) or the prior operation of a related or locking control is required.

e. Provide the controls with resistance (i.e., viscous or coulomb friction, spring-loading, or inertia) so that definite or sustained effort is required for actuation.

f. Provide the controls with a lock to prevent the control from passing through a position without delay when strict sequential activation is necessary (i.e., the control moved only to the next position, then delayed).

g. Design the controls for operation by rotary action.

5.4.1.8.5 Dead man controls. Dead man controls, which will result in system shut-down to a non-critical operating state when force is removed, shall be utilized wherever operator incapacity can produce a critical system condition.

5.4.1.8.6 Foot-operated controls.

5.4.1.8.6.1 Use. Foot-operated controls may be used under the following conditions:

a. Control operation requires either greater force than the upper body can provide or force close to an upper body fatigue threshold.

b. The operator's hands are generally occupied by other manual control tasks at the same moment that an additional control action is required.

c. Specific foot-operated controls have been so well established that the operator expects such operating functions to be performed using foot controls (e.g., aircraft rudder/brake pedals, automotive clutch, brake and accelerator pedals).

d. A safety "shut-down" control is required during an operation in which the operator's hands cannot be freed to reach a safety switch.

5.4.1.8.6.2 Avoidance. Foot operated controls should not be used the following conditions:

a. Where a standing operator is confronted with a sensitive balancing requirement (e.g., a moving platform where balancing on the non-operating foot may become difficult as the operating foot is moved from a support to actuating position).

b. Precise control operations are required.

c. Selection from among a great many separate controls is required.

5.4.1.8.6.3 Operation. Foot controls shall be located and designed so they can be operated in as natural a pattern as practicable. Specifically, the following should be avoided:

a. Frequent, maximum reaching.

b. Requirement to hold the leg or foot in awkward position for extended periods of time.

c. Requirement for the operator to operate a control frequently or for an extended period of time while sitting in a twisted position, i.e., pedals shall be laid out symmetrically with reference to the operator's principal operating orientation.

d. Maximum force application frequently or for extended duration.

e. Requirement that the operator search for a particular foot control in order to select the proper one.

f. Placement of a foot control where it might be stepped on and inadvertently actuated, or where typical shifting from one foot control to another creates conditions where the foot or clothing might be entrapped by an intervening control as the operator shifts the foot from one control to another.

5.4.1.8.6.4 Configuration and placement. Configuration and placement of foot operated controls shall accommodate the anthropometry of the operator's foot wearing operational shoes or boots. They shall be located so that the actuation of a control by one foot does not interfere with the actuation of a control by another foot, and so that the movements of feet and legs are natural and easily accomplished within the work station where foot controls are located.

5.4.2 Rotary controls.

5.4.2.1 Discrete rotary controls.

5.4.2.1.1 Rotary selector switches.

5.4.2.1.1.1 Use. Rotary selector switches should be used for discrete functions when three or more detented positions are required. Rotary selector switches should not be used for a two-position function unless prompt visual identification of control position is of primary importance and speed of control operation is not critical.

5.4.2.1.1.2 Moving pointer. Rotary selector switches should be designed with a moving pointer and a fixed scale.

5.4.2.1.1.3 Shape. Moving pointer knobs shall be bar shaped, with parallel sides, and the index end shall be tapered to a point. Exceptions may be justified when pointer knobs are shape-coded or when space is restricted and torque is light. Shape-coding shall be used when a group of rotary controls, used for different functions, is placed on the same panel and control confusion might otherwise result.

5.4.2.1.1.4 Positions. A rotary selector switch which is not visible to the operator during normal system operation shall have no more than 12 positions. A rotary switch that is constantly visible to the operator shall have not more than 24 positions. In addition, the following criteria shall apply:

a. Rotary switch positions shall not be placed opposite each other unless knob shape precludes confusion as to which end of the knob is the pointer.

b. The switch resistance shall be elastic, building up, then decreasing as each position is approached, so that the control snaps into position without stopping between adjacent positions.

5.4.2.1.1.5 Contrast. A reference line shall be provided on rotary switch controls. This line shall have at least 3.0 luminance contrast (see 3.17) with the control color under all lighting conditions.

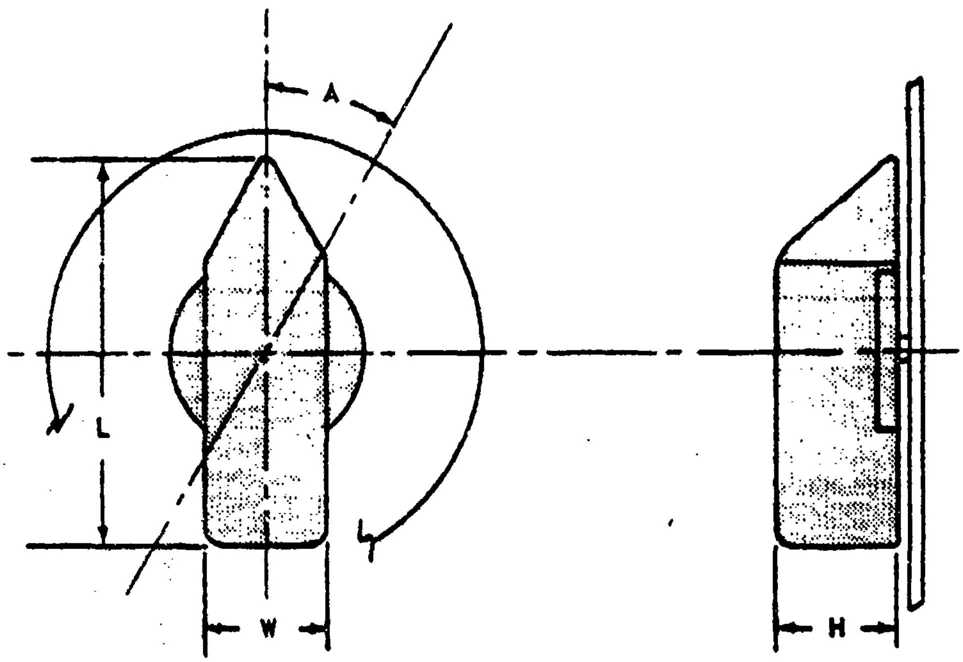
5.4.2.1.1.6 Parallax. The knob pointer shall be mounted sufficiently close to its scale to minimize parallax between the pointer and the scale markings. When viewed from the normal opertor's position, the parallax errors shall not exceed 25% of the distance between scale markings.

5.4.2.1.1.7 Dimensions, resistance, displacement, and separation. Control dimensions, resistance, displacement, and separation between adjacent edges of areas swept by rotary selector switches should conform to the criteria in Figure 4.

5.4.2.1.2 Key operated switches (KOS).

5.4.2.1.2.1 Use. KOS are used to prevent unauthorized operation. Ordinarily, they control system operation by go no-go.

5.4.2.1.2.2 Dimensions, displacement, and resistance. Dimensions, displacement, and resistance shall conform to the criteria in Figure 5.



	DIMENSIONS			RESISTANCE
	L Length	W Width	H Depth	
Minimum	25 mm (1 in.)		16 mm (5/8 in.)	115 mN · m (1 in.–lb)
Maximum	100 mm (4 in.)	25 mm (1 in.)	75 mm (3 in.)	680 mN · m (6 in.–lb)

	DISPLACEMENT A		SEPARATION	
	*	**	One-Hand Random	Two-Hand Operation
Minimum	262 mrad (15°)	525 mrad (30°)	25 mm (1 in.)	75 mm (3 in.)
Maximum	700 mrad (40°)	1570 mrad (90°)	-	-
Preferred	-	-	50 mm (2 in.)	125 mm (5 in.)

*For facilitating performance.

**When special engineering requirements demand large separation or when tactually ("blind") positioned controls are required.

FIGURE 4. ROTARY SELECTOR SWITCH

5.4.2.1.2.2 Dimensions, displacement, and resistance. Dimensions, displacement, and resistance shall conform to the criteria in Figure 5.

5.4.2.1.2.3 Color, shape and size coding. Color, shape, or size coding or a combination may be used as follows:

a. Color may be used to aid in identifying various keys by function or use location and when illumination is adequate to differentiate the colors. Red (# 11105 or 21105 of FED-STD-595) shall be reserved for emergency functions.

b. Shape coding may be used when it is desirable to identify a given key by feel. When shape coding is used, sharp corners shall be avoided.

c. Size coding, within the height limits of Figure 5, may also be used if no more than two sizes are employed.

5.4.2.1.2.4 Marking and labeling. Keylock switch applications shall include appropraite positional markings and labels (see 5.5).

5.4.2.1.2.5 Other requirements.

a. Keys with teeth on both edges, which fit the lock with either side up or forward, are preferred.

b. Keys with a single row of teeth should be inserted into the lock with the teeth pointing up or forward.

c. Locks should be oriented so the key's vertical position is the OFF position.

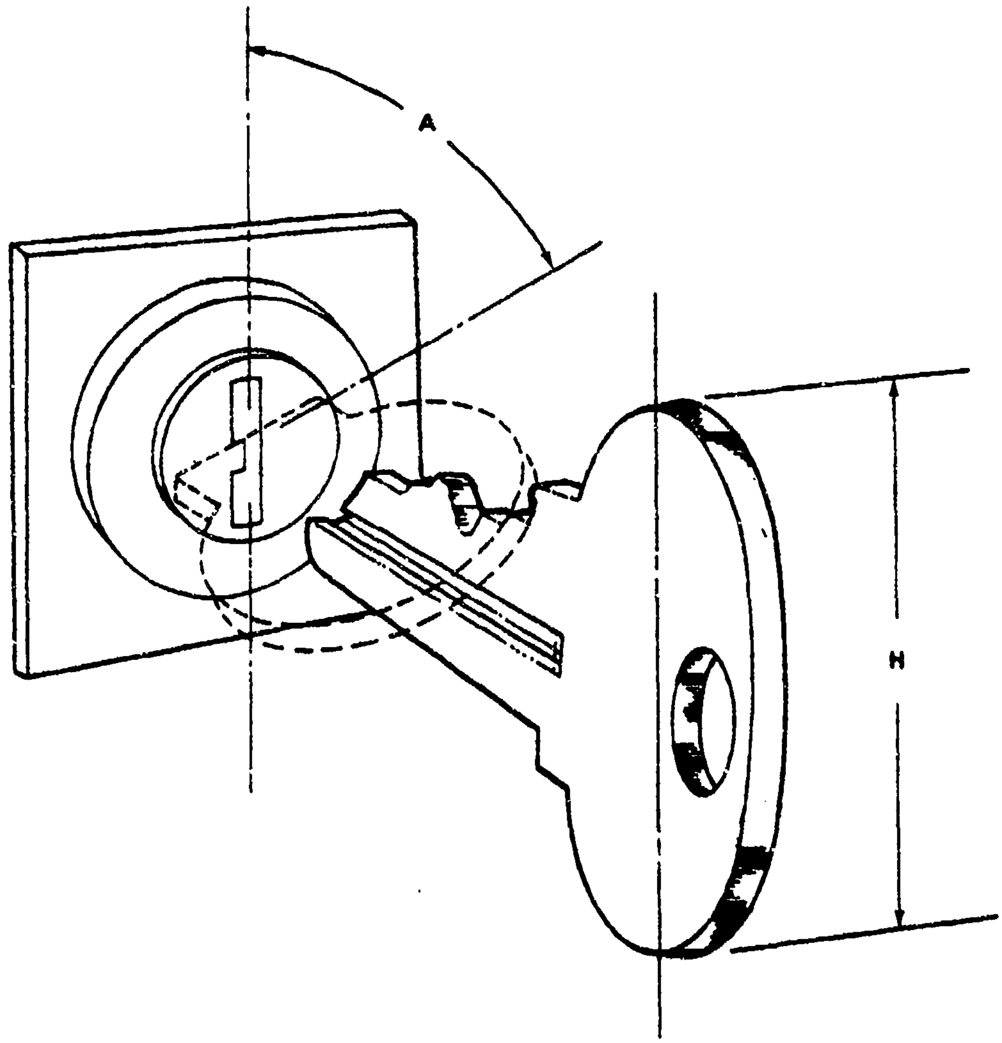
d. Operators should normally not be able to remove the key from the lock unless the switch is turned OFF.

e. Actuation of an item by a key operated switch should be accomplished by turning the key clockwise from the vertical OFF position.

5.4.2.1.3 Discrete thumbwheel controls.

5.4.2.1.3.1 Application. Thumbwheel controls may be used if the function requires a compact digital control-input device (for a series of numbers) and a readout of these manual inputs for verification. The use of thumbwheels for any other purposes is discouraged. Detent indexing units should provide 10 positions (0 - 9) in digital or binary (3 or 4 bits and complement) outputs.

5.4.2.1.3.2 Shape. Each position around the circumference of a discrete thumbwheel shall have a concave surface or shall be separated by a high-friction area which is raised from the periphery of the thumbwheel. The thumbwheels shall not preclude viewing the digits within $\pi/6$ rad (30°) viewing angle to the left and right of a perpendicular to the thumbwheel digits.



	DISPLACEMENT (A)	HEIGHT (H)	RESISTANCE
MINIMUM	525 mrad (30°)	13 mm (1/2 in.)	115 mN·m (1 in.—lb)
MAXIMUM	1570 mrad (90°)	75 mm (3 in.)	680 mN·m (6 in.—lb)

FIGURE 5. KEY-OPERATED SWITCH

thumbwheels shall not preclude viewing the digits within $\pi/6$ rad (30°) viewing angle to the left and right of a perpendicular to the thumbwheel digits.

5.4.2.1.3.3 Coding. Thumbwheel controls may be coded by location, labeling, and color (e.g., reversing the colors of the least significant digit wheel as on typical odometers). Where used as input devices, thumbwheel switch OFF or NORMAL positions should be color coded to permit a visual check that the digits have been reset to their normal position.

5.4.2.1.3.4 Direction of movement. Moving the thumbwheel edge forward, or upward, or to the right shall increase the setting.

5.4.2.1.3.5 Numerals.

5.4.2.1.3.5.1 Internal illuminance. For areas in which ambient illumination will provide display brightness below 3.5 cd/m^2 (1 ft-L), the thumbwheel shall be internally illuminated. Digits shall appear as illuminated characters on a black background, and their dimensions should approximate the following:

a. Height: 4.8 mm (3/16")

b. Height-to-Width Ratio: 3:2

c. Height-to-Stroke Width Ratio: 10:1

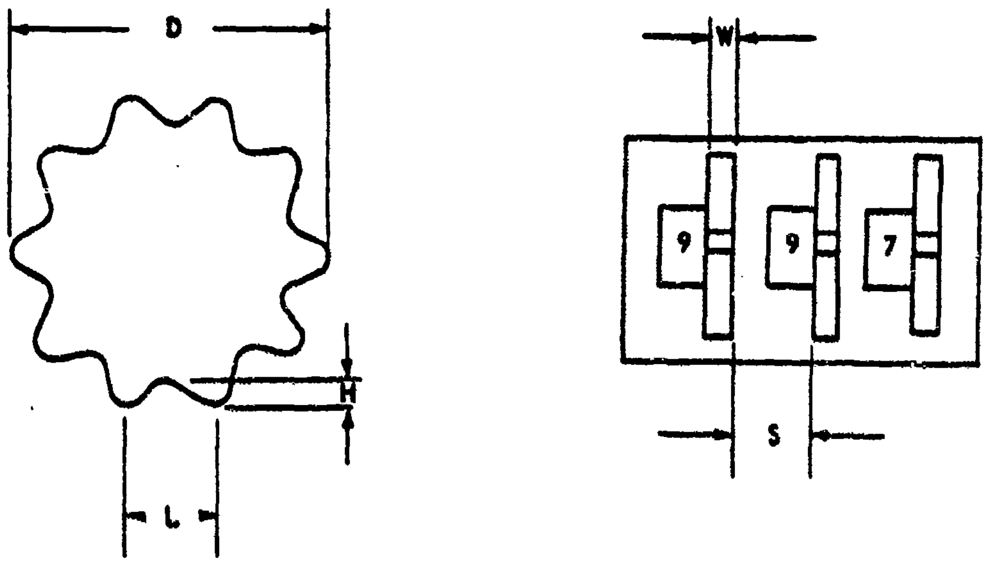
5.4.2.1.3.5.2 External illuminance. In areas where ambient illumination will provide a display luminance above 3.5 cd/m^2 (1 ft-L), internal illumination is not required. Digits should be bold, black numerals engraved on a light (or white) thumbwheel background. The dimensions should approximate those specified in 5.4.2.1.3.5.1, except that the height-to-stroke width ratio should be approximately 5:1.

5.4.2.1.3.6 Visibility. Thumbwheel design shall permit viewing of inline digital read-out from all operator positions.

5.4.2.1.3.7 Dimensions. Control dimensions shall conform to the criteria in Figure 6.

5.4.2.1.3.8 Resistance. Detents shall be provided for discrete position thumbwheels. Resistance shall be elastic, building up and then decreasing as each detent is approached so that the control snaps into position without stopping between adjacent detents. The resistance shall be within the limits indicated in Figure 6.

5.4.2.1.3.9 Separation. The separation between adjacent edges of thumbwheel controls shall conform to the criteria in Figure 6 and shall be sufficient to preclude accidental activation of adjacent controls during



	D DIAMETER	L TROUGH DISTANCE	W WIDTH	H DEPTH	S SEPARATION	RESISTANCE
MINIMUM	30 mm (1-1/8 in.)	11 mm (7/16 in.)	3 mm (1/8 in.)	3 mm (1/8 in.)	10 mm (13/32 in.)	1.7 N (6 oz)
MAXIMUM	75 mm (3 in.)	19 mm (3/4 in.)		13 mm (1/2 in.)		5.6 N (20 oz)

FIGURE 6. DISCRETE THUMBWHEEL CONTROL

5.4.2.2 Continuous adjustment rotary controls.

5.4.2.2.1 Knobs.

5.4.2.2.1.1 Use. Knobs should be used when low forces or precise adjustments of a continuous variable are required. A moving knob with fixed scale is preferred over a moving scale with fixed index for most tasks. If positions of single revolution controls must be distinguished, a pointer or marker should be available on the knob.

5.4.2.2.1.2 Dimensions, torque and separation. The dimensions of knobs shall be within the limits specified in Figure 7. Within these ranges, knob size is relatively unimportant, provided the resistance is low and the knob can be easily grasped and manipulated. When panel space is extremely limited, knobs should approximate the minimum values and should have resistance as low as possible without permitting the setting to be changed by vibration or merely touching the control. Resistance and separation between adjacent edges of knobs shall conform to Figure 7.

5.4.2.2.1.3 Knob style. Unless otherwise specified by the procuring activity, control knob style shall conform to MIL-STD-1348.

5.4.2.2.2 Ganged control knobs.

5.4.2.2.2.1 Application. Ganged knob assemblies may be used in limited applications when panel space is at a premium. Two-knob assemblies are preferred. Three-knob configurations should be avoided. Ganged knob configurations should not be used under the following conditions:

a. Extremely accurate or rapid operations are required.

b. Frequent changes are necessary.

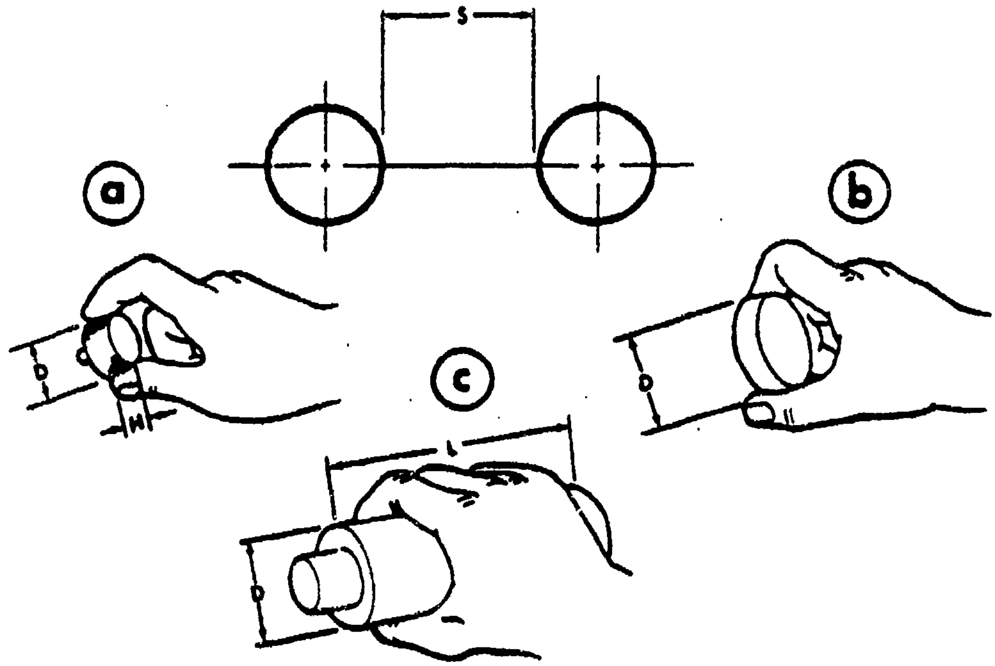
c. Heavy gloves must be worn by the operator.

d. Equipment is exposed to the weather or used under field conditions.

5.4.2.2.2.2 Dimensions and separation. Dimensions and separation should conform to Figure 8.

5.4.2.2.2.3 Resistance. Resistance shall conform to requirements in Figure 8. Knobs should be serrated. Fine serrations should be used on precise adjustment knobs; coarse serrations should be used on gross adjustment knobs.

5.4.2.2.2.4 Marking. An indexing mark or pointer shall be provided on each knob. Marks or pointers should differ sufficiently to make it apparent which knob indexing mark is being observed.

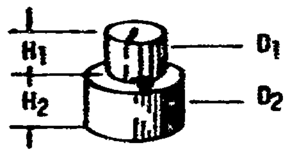


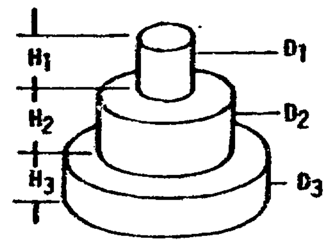
	DIMENSIONS				
	a Fingertip Grasp		b Thumb and Finger Encircled	c Palm Grasp	
	H Height	D Diameter	D Diameter	D Diameter	L Length
Minimum	13 mm (1/2 in.)	10 mm (3/8 in.)	25 mm (1 in.)	38 mm (1-1/2 in.)	75 mm (3 in.)
Maximum	25 mm (1 in.)	100 mm (4 in.)	75 mm (3 in.)	75 mm (3 in.)	-

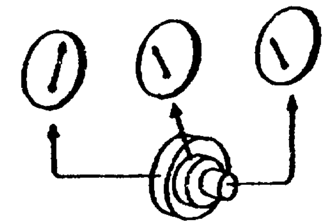
	TORQUE		SEPARATION	
			S	S
	*	**	One Hand Individually	Two Hands Simultaneously
Minimum	-		25 mm (1 in.)	50 mm (2 in.)
Optimum	-	-	50 mm (2 in.)	125 mm (5 in.)
Maximum	32 mN-m (4-1/2 in.-oz.)	42 mN-m (6 in.-oz.)	-	-

*To and including 25 mm (1.0 in.) diameter knobs
**Greater than 25 mm (1.0 in.) diameter knobs

FIGURE 7. KNOBS







GANGED KNOB/DISPLAY ASSOCIATION

	DIMENSIONS									
	TWO KNOB ASSEMBLY				THREE KNOB ASSEMBLY					
	H_1	H_2	D_1	D_2	H_1	H_2	H_3	D_1	D_2	D_3
MINIMUM	16 mm (5/8")	13 mm (1/2")	13 mm (1/2")	22 mm (7/8")	19 mm (3/4")	19 mm (3/4")	6 mm (1/4")	13 mm (1/2")	44 mm (1-3/4")	75 mm (3")
MAXIMUM				100 mm (4")						100 mm (4")

	TORQUE		SEPARATION			
	*	**	ONE HAND INDIVIDUALLY		TWO HANDS SIMULTANEOUSLY	
			BARE	GLOVED	BARE	GLOVED
MINIMUM			25 mm (1")	63 mm (2-1/2")	50 mm (2")	90 mm (3-1/2")
OPTIMUM			50 mm (2")	90 mm (3-1/2")	75 mm (3")	100 mm (4")
MAXIMUM	32 mN·m (4-1/2 in.-oz.)	42 mN·m (6 in.-oz.)				

*To and including 25 mm (1") diameter knobs.
**Greater than 25 mm (1") diameter knobs.

FIGURE 8. GANGED KNOBS

5.4.2.2.2.5 Knob/display relationship. When each knob of a ganged assembly must be related to an array of visual displays, the knob closest to the panel shall relate to the left-most display in a horizontal array, or the uppermost display in a vertical array (see Figure 8).

5.4.2.2.2.6 Inadvertent operation. When it is critical to prevent inadvertent activation of one knob as the other is being adjusted, a secondary knob control movement shall be required (e.g., pressing the top knob before it can be engaged with its control shaft). Where inadvertent movement is undesirable but not necessarily critical, knob diameter/depth relationships should be optimized as shown in Figure 8. Contrasting colors between knobs may also be used to improve individual knob identification.

5.4.2.2.3 Continuous adjustment thumbwheel controls.

5.4.2.2.3.1 Use. Continuously adjustable thumbwheel controls may be used as an alternative to rotary knobs when the application will benefit from the compactness of the thumbwheel device.

5.4.2.2.3.2 Orientation and movement. Thumbwheels shall be oriented and move in the directions specified in Figure 9. If a thumbwheel is used as a continuous control which affects vehicle motion, movement of the thumbwheel forward or up shall cause the vehicle to move down or forward.

5.4.2.2.3.3 Turning aids. The rim of the thumbwheel shall be serrated or provided with a high friction surface to aid the operator in manipulating the control.

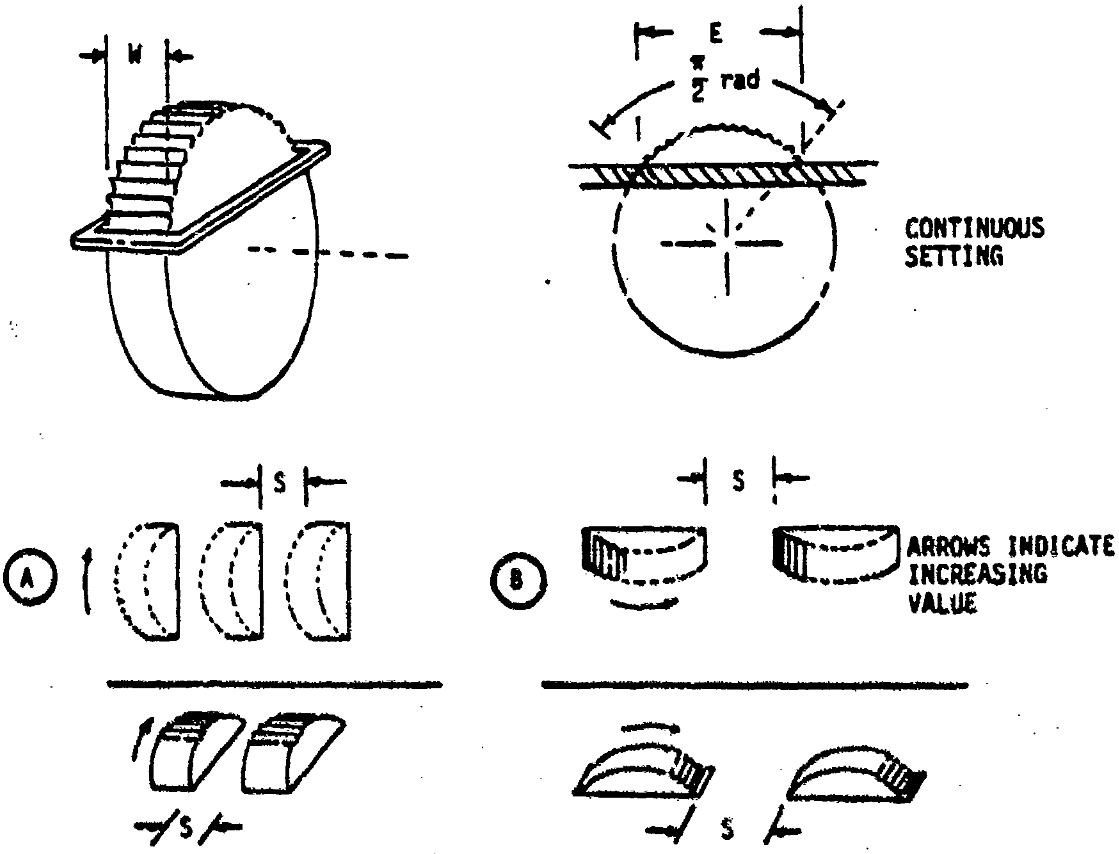
5.4.2.2.3.4 Dimensions, separation and resistance. Dimensions, separation and resistance shall conform to criteria in Figure 9.

5.4.2.2.3.5 Labeling and visibility. Marking and labeling shall conform to requirements herein, with respect to visibility of markings and legibility of label alphanumerics.

5.4.2.2.3.6 OFF position. A detent shall be provided for continuous thumbwheels having an OFF position.

5.4.2.2.4 Cranks.

5.4.2.2.4.1 Use. Cranks should be used for tasks requiring many rotations of a control, particularly where high rates or large forces are involved. For tasks involving large slewing movements, plus small, fine adjustments, a crank handle may be mounted on a knob or handwheel, the crank for slewing and the knob or handwheel for fine adjustments. Where cranks are used for tuning, or other processes involving numerical selection, each rotation should correspond to a multiple of 1, 10, 100, etc. Simultaneously operated handcranks should be used in preference to other two-axis controllers where extreme precision is required in setting crosshairs or reticles as in map readouts or optical sighting mechanisms (as opposed to tracking). This type of control may also



	E RIM EXPOSURE	W WIDTH	S (A)	S (B)	RESISTANCE
MINIMUM	25 mm * (1")	3 mm * (1/8")	25 mm (1") Add 13 mm (1/2") for gloves	50 mm (2") Add 25 mm (1") for gloves	TO MINIMIZE EFFECTS OF INADVERTENT INPUT IF OPERATOR SUBJECT TO MOTION
MAXIMUM	100 mm (4")	23 mm (7/8")	N/A	N/A	3.3 N (12 oz.)

*Preferred. Some miniature applications may require less.

FIGURE 9. THUMBWHEEL ADJUSTMENT

be used in other applications requiring x-y control provided there is no requirement for rapid or frequent operation. The gear ratio and dynamic characteristics of such cranks shall allow precise placement of the follower (e.g., crosshairs) without overshooting or undershooting and successive corrective movements.

5.4.2.2.4.2 Grip handle. The crank grip handle shall be designed so that it turns freely around its shaft.

5.4.2.2.4.3 Dimensions, resistance and separation. Dimensions, resistance and separation between adjacent swept circular areas of cranks shall conform to the criteria of Figure 10.

5.4.2.2.4.4 Folding handle. If a crank handle could become a hazard to persons passing by, or it is critical that the handle not be inadvertently displaced by being accidentally bumped, a folding handle type control should be used. Such a control shall be designed so that the handle is spring-loaded to keep it extended in the cranking position when in use and folded when not in use.

5.4.2.2.4.5 Crank balance. In applications where resistance is light, the crank shall be balanced to prevent the handle weight from turning the crank from its last setting.

5.4.2.2.5 Handwheels. (Two-hand operated)

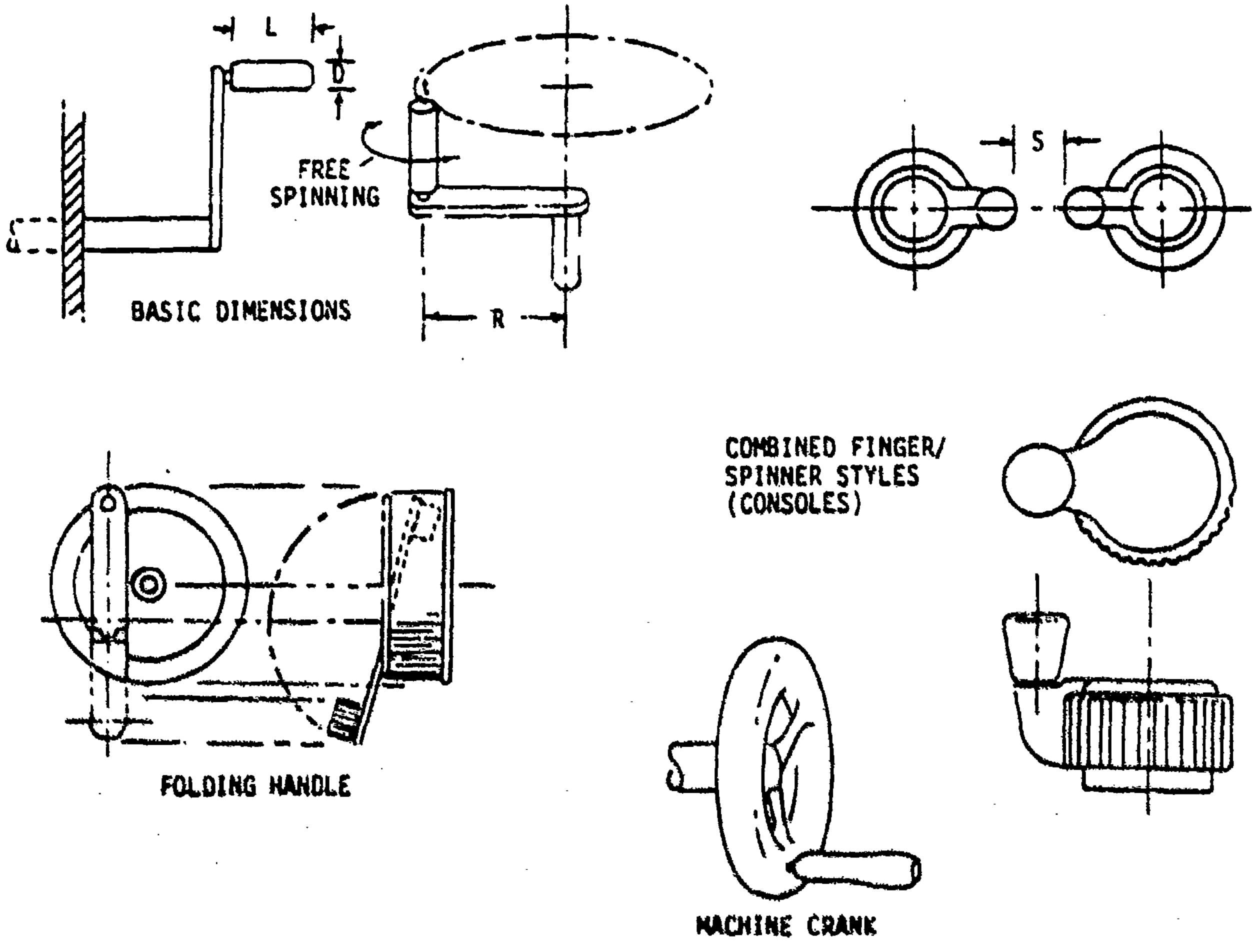
5.4.2.2.5.1 Use. Handwheels, designed for nominal two-hand operation, should be used when the breakout or rotational forces are too high to be easily overcome with a one-handed control, provided that two hands are available for this task. Typical applications are steering, latch securing, valve opening/closing and direct-linkage adjustment.

5.4.2.2.5.2 Turning aids. Knurling, indentation, high-friction covering, or a combination of these shall be built into the handwheel to facilitate operator grasp for applying maximum torque and to reduce the possibility of the wheel's being jerked from the operator's hands.

5.4.2.2.5.3 Spinner handles. For applications where the wheel may be rotated rapidly through several revolutions, a spinner handle may be added. Such handles shall not be used, however, if the projecting handle is vulnerable to inadvertent displacement of a critical wheel setting or if it creates a safety hazard.

5.4.2.2.5.4 Direction of movement. Except for valves (see 5.4.1.2.4), handwheels shall rotate clockwise for ON or INCREASE and counterclockwise for OFF or DECREASE. The direction of motion shall be indicated on the handwheel, or immediately adjacent thereto, by means of arrow and appropriate legends.

5.4.2.2.5.5 Dimensions, resistance, displacement and separation. Control dimensions, resistance, displacement and separation between edges of adjacent handwheels shall conform to the criteria in Table IX.



LOAD	SPECIFICATION	HANDLE				R, TURNING RADIUS			
		L, LENGTH		D, DIAMETER		RATE BELOW 100 RPM		RATE ABOVE 100 RPM	
		mm	in.	mm	in.	mm	in.	mm	in.
LIGHT LOADS: Less than 22 N (5 lb). (Wrist and finger movement)	MINIMUM	25	1	10	3/8	38	1½	13	1/2
	PREFERRED	38	1½	13	1/2	75	3	65	2½
	MAXIMUM	75	3	16	5/8	125	5	115	4½
HEAVY LOADS: More than 22 N (5 lb). (Arm movement)	MINIMUM	75	3	25	1	190	7½	125	5
	PREFERRED	95	3-3/4	25	1	--	--	--	--
	MAXIMUM	--	--	38	1½	510	20	230	9

S, Separation between adjacent controls: 75 mm (3") minimum.

FIGURE 10. CRANKS

5.4.2.2.5.6 Steering wheel shape. Except for established uses in submarines, armored combat vehicles, aircraft, and other applications where maximum wheel deflection does not exceed $\pm 2/3\ \pi$rad (120°), all steering wheels shall be round.

5.4.2.2.5.7 Power steering failure. Steering systems shall be designed with sufficient mechanical advantage to meet the force requirements of Table IX, even when the primary operating mode is powerassisted, i.e., the operator shall be able to steer the vehicle to a safe stop in the event of a power failure.

5.4.2.2.5.8 Steering ratio. Steering systems should be designed so that the maximum turning limits of the vehicle can be achieved with no more than 3½ turns if consistent with force limits of Table IX.

5.4.3 Linear controls.

5.4.3.1 Discrete linear controls.

5.4.3.1.1 Push buttons (finger or hand operated).

5.4.3.1.1.1 Use. Push buttons should be used when a control or an array of controls is needed for momentary contact or for activating a locking circuit, particularly in high-frequency-of-use situations.

5.4.3.1.1.2 Shape. The push button surface should normally be concave (indented) to fit the finger. When this is impractical, the surface shall provide a high degree of frictional resistance to prevent slipping.

5.4.3.1.1.3 Positive indication. A positive indication of control activation shall be provided (e.g., snap feel, audible click, or integral light).

5.4.3.1.1.4 Channel or cover guard. A channel or cover guard shall be provided when it is imperative to prevent accidental activation of the controls. When a cover guard is in the open position, it shall not interfere with operation of the protected device or adjacent controls.

5.4.3.1.1.5 Dimensions, resistance, displacement, and separation. Except for use of push buttons in keyboards, control dimensions, resistance, displacement, and separation between adjacent edges of finger or hand-operated pushbuttons shall conform to the criteria in Figure 11.

5.4.3.1.1.6 Interlocks or barriers. Mechanical interlocks or barriers may be used instead of the spacing required by Figure 11.

5.4.3.1.2 Foot operated switches.

5.4.3.1.2.1 Use. Foot-operated switches should be used only where the operator is likely to have both hands occupied when switch activation may be

TABLE IX. HANDWHEELS

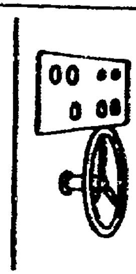
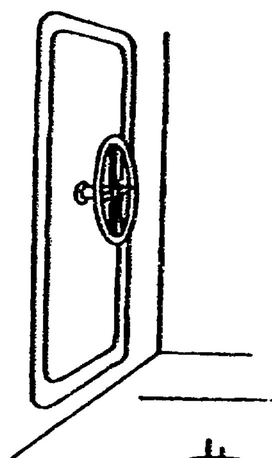
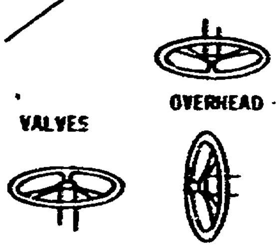
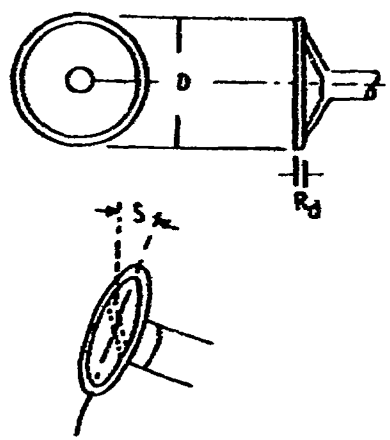
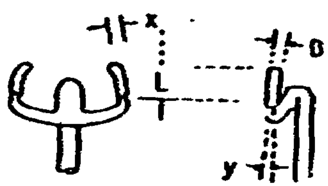
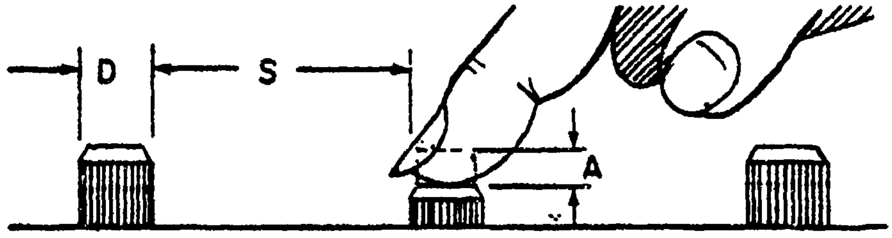
CONFIGURATION EXAMPLE	APPLICATION CRITERIA	DESIGN CRITERIA: DIMENSIONS: DIAMETER	DESIGN CRITERIA: DIMENSIONS: RIM DIAM	DESIGN CRITERIA: DIMENSIONS: MIN HAND CLEARANCE	DESIGN CRITERIA: DISPLACEMENT	DESIGN CRITERIA: SEPARATION
	CONTINUOUS ADJUSTMENT FOR ALTERNATE SLEWING/PRECISE POSITIONING, USING DISPLAY REFERENCE. RESISTANCE LOW (e.g., BELOW 110 N (25 lb)	200-510 mm (8-20")	19-32 mm (3/4 - 1-1/4")	75 mm (3") around rim	See control/ display ratios 5.1.4	710 mm (28") elbow-elbow clearance
	CONTINUOUS LOCK-UNLOCK OPERATION	200 mm (8") for 22 N (5 lb) to 510 mm (20") for 155 N (35 lb)	19-32 mm (3/4 - 1-1/4")	75 mm (3") around rim	N/A	710 mm (28") elbow-elbow clearance
	HIGH TORQUE VALVES	200-400 mm (8-16") for overhead; 200-510 mm (8-20") for other positions; 300-1520 mm (12-60") abv standing surface	19-32 mm (3/4 - 1-1/4")	75 mm (3") around rim	See 5.1.4 when applicable	710 mm (28") elbow-elbow clearance

TABLE IX. HANDWHEELS (CONCLUDED)

CONFIGURATION EXAMPLE	APPLICATION CRITERIA	DESIGN CRITERIA				
		DIMENSIONS			DISPLACEMENT	SEPARATION
		D, DIAMETER	R_d, RIM DIAM	S, SLOPE		
	VEHICLE STEERING (AUTOMOTIVE). MAX RESISTANCE POWER STEERING MAX NON-POWER = 220 N (50 lb)	355-400 mm (14-16") for pwr steering 400-510 mm (16-20") for non-pwr steering	19-32 mm (3/4 - 1-1/4")	525 mrad (30^0) for light vehicle (preferred) 785 mrad (45^0) for heavy vehicle (preferred)	Max of $\pm 2/3\,\pi$ rad (120^0) when both hands must remain on wheel	N/A
		D, GRIP DIAM	L, GRIP LGTH	X-Y GRIP TILT		
	AIRCRAFT STEERING (COMBINE WITH LEVER FOR PITCH, RUDDER PEDALS FOR ROLL/STEER)	32 mm (1-1/4") preferred	100 mm (4") minimum	X = 262 mrad (15^0) Y = 0-262 mrad (0-15^0) preferred	±525 mrad (30^0) max preferred	N/A



	DIMENSIONS: DIAMETER D		RESISTANCE		
	Fingertip	Thumb or Palm	Single Finger	Different Fingers	Thumb or Palm
Minimum	9.5 mm (3/8 in.)	19 mm (3/4 in.)	2.8 N (10 oz.)	1.4 N (5 oz.)	2.8 N (10 oz.)
Maximum	25 mm (1 in.)		11 N (40 oz.)	5.6 N (20 oz.)	23 N (80 oz.)

	DISPLACEMENT A	
	Fingertip	Thumb or Palm
Minimum	2 mm (5/64 in.)	3 mm (1/8 in.)
Maximum	6 mm (1/4 in.)	38 mm (1-1/2 in.)

	SEPARATION S			
	Single Finger	Single Finger Sequential	Different Fingers	Thumb or Palm
Minimum	13 mm (1/2 in.)	6 mm (1/4 in.)	6 mm (1/4 in.)	25 mm (1 in.)
Preferred	50 mm (2 in.)	13 mm (1/2 in.)	13 mm (1/2 in.)	150 mm (6 in.)

Note: Above data for barehand application. For gloved hand operation, minima should be suitably adjusted.

FIGURE 11. PUSHBUTTONS (FINGER OR HAND OPERATED)

required, or when load sharing among limbs is desirable. Because foot-operated switches are susceptible to accidental activation, their uses should be limited to non-critical or infrequent operations such as press-to-talk communication or vehicle headlight dimming.

5.4.3.1.2.2 Operation. Foot switches shall be positioned for operation by the toe and the ball of the foot rather than by the heel. They shall not be located so near an obstruction that the operator cannot center the ball of the foot on the switch button. A pedal may be used over the button to aid in location and operation of the switch. When the switch may become wet and slippery, the switchcap surface should possess a frictional surface to minimize the possibility of the foot slipping off the switch.

5.4.3.1.2.3 Dimensions, resistance and displacement. Dimensions, reistance and displacement of foot-operated switches shall conform to the criteria in Figure 12. Although not recommended (i.e., only one switch per foot is preferred), when one foot is required to operate more than one switch, such switches shall be at least 75 mm (3 in.) apart (horizontal); 200 mm (8 in.) apart (vertical).

5.4.3.1.2.4 Feedback. A positive indication of control activation shall be provided (e.g., snap feel, audible click, association visual or auditory display).

5.4.3.1.3 Keyboards.

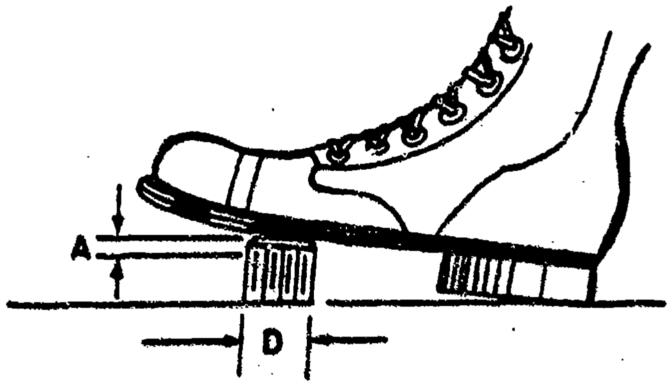
5.4.3.1.3.1 Use. Arrangements of push buttons in the form of keyboards should be used when alphabetic, numeric or special function information is to be entered into a system.

5.4.3.1.3.2 Layout and configuration. The key configuration and the number of keys are dependent upon the predominant type of information to be entered into the system. The major forms that keyboards can take, which aid in the entry of such information, are given below:

a. Numeric keyboard. The configuration of a keyboard used to enter solely numeric information should be a 3 x 3 + 1 matrix with the zero digit centered on the bottom row.

b. Alpha-numeric keyboard. Keyboard configurations for entry of alphabetic and some numeric information shall conform to MIL-STD-1280. For some applications the entry of data varies from primarily alphabetic to primarily numeric. For these applications two alternatives are preferred: Provide a keyboard of the type shown in Figure 2 of MIL-STD-1280 (where there is no separation between alphabetic and numeric characters) or provide a separation to emphasize the two separate functions, with the numeric keyboard located to the right of the standard keyboard.

5.4.3.1.3.3 Dimensions, resistance, displacement, and separation. The control dimensions, resistance, displacement and separation between adjacent



	DIAMETER	RESISTANCE		DISPLACEMENT			
	D			A			
		Foot Will Not Rest On Control	Foot Will Rest On Control	Normal Operation	Heavy Boot Operation	Ankle Flexion Only	Total Leg Movement
Minimum	13 mm (1/2 in.)	18 N (4 lb)	45 N (10 lb)	13 mm (1/2 in.)	25 mm (1 in.)	25 mm (1 in.)	25 mm (1 in.)
Maximum		90 N (20 lb)	90 N (20 lb)	65 mm (2-1/2 in.)	65 mm (2-1/2 in.)	65 mm (2-1/2 in.)	100 mm (4 in.)

FIGURE 12. FOOT-OPERATED SWITCHES

edges of the pushbuttons which form keyboards shall conform to the criteria in Table X. For a given keyboard these criteria shall be uniform for all individual keys. For those applications where operation while wearing (trigger finger) arctic mittens is required, the minimum key size shall be 19 mm (0.75 in). Other parameters are unchanged from those of bare-handed operation (see Table X).

5.4.3.1.3.4 Slope. The slope of nonportable keyboards should be 260-435 mrad (15-25°) from the horizontal. The preferred slope is 280-300 mrad (17-18°). The slope of a portable device can be varied according to the preference of the operator.

5.4.3.1.3.5 Multiple keyboards. Systems containing more than one keyboard shall maintain the same configuration for alphanumeric, numeric and special function keys throughout the system.

5.4.3.1.3.6 Feedback. Feedback shall be provided to inform the operator whether the key was pressed, the intended key was pressed, and the next operation may be initiated, where applicable.

5.4.3.1.4 Toggle switch controls.

5.4.3.1.4.1 Use. Toggle switches should be used for functions which require two discrete positions or where space limitations are severe. Toggle switches with three positions shall be used only where the use of a rotary control, legend switch control, etc., is not feasible or when the toggle switch is of the spring-loaded, center position-off type. Three position toggle switches which are spring-loaded to center-off from only one other position shall not be used if release from the spring-loaded position results in switch handle travel beyond the off position. (Toggle switches are considered herein to be discrete position controls. Small controls that are the same size and shape as toggle switches and used for making continuous adjustments are described herein as levers.)

5.4.3.1.4.2 Accidental actuation. When the prevention of accidental actuation is of primary importance (i.e., critical, dangerous, or hazardous conditions would result), channel guards, lift-to-unlock switches, or other equivalent prevention mechanisms shall be provided. Safety or lock wire shall not be used. Resistance of lift-to-unlock mechanisms shall not exceed 13 N (3 lb). If a cover guard is used, its location when open shall not interfere with the operation of the protected device or adjacent controls.

5.4.3.1.4.3 Dimensions, resistance, displacement, and separation. Dimensions, resistance, displacement, and separation between adjacent edges of toggle switches shall conform to the criteria in Figure 13. Resistance should gradually increase, then drop when the switch snaps into position. The switch shall not be capable of being stopped between positions.

5.4.3.1.4.4 Positive indication. An indication of control activation shall be provided (e.g., snap feel, audible click, associated or integral light).

TABLE X. KEYBOARDS

	Dimensions: Diameter D* Bare-handed	Dimensions: Diameter D* Arctic mittens**	Resistance: Numeric	Resistance: Alpha-numeric	Resistance: Dual Function
Minimum	10 mm	19 mm	1 N	250 mN	250 mN
Maximum	19 mm		4 N	1.5 N	1.5 N
Preferred	13 mm	19 mm			

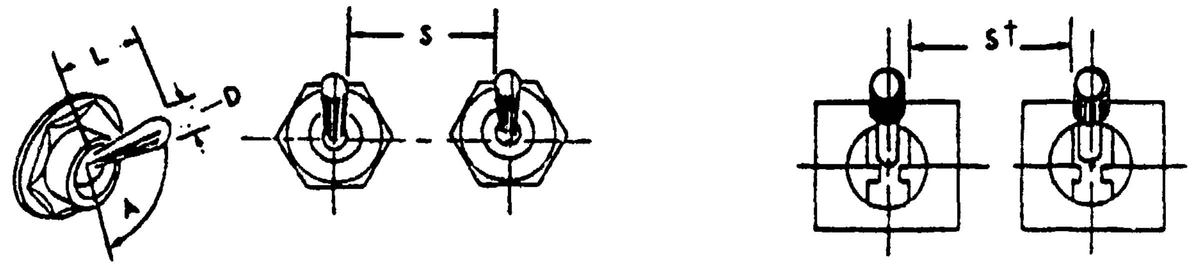
	Displacement: Numeric	Displacement: Alpha-numeric	Displacement: Dual Function	Separation (between adjacent key tops)
Minimum	0.8 mm	1.3 mm	0.8 mm	6.4 mm
Maximum	4.8 mm	6.3 mm	4.8 mm	
Preferred				6.4 mm

*See Figure 11
**Trigger finger type

	Dimensions: Diameter D* Bare-handed	Dimensions: Diameter D* Arctic mittens**	Resistance: Numeric	Resistance: Alpha-numeric	Resistance: Dual Function
Minimum	0.385 in.	0.75 in.	3.5 oz	0.9 oz	0.9 oz
Maximum	0.75 in.		14.0 oz	5.3 oz	5.3 oz
Preferred	0.5 in.	0.75 in.			

	Displacement: Numeric	Displacement: Alpha-numeric	Displacement: Dual Function	Separation (between adjacent key tops)
Minimum	0.03 in.	0.05 in.	0.03 in.	0.25 in.
Maximum	0.19 in.	0.25 in.	0.19 in.	
Preferred				0.25 in.

*See Figure 11
**Trigger finger type



	DIMENSIONS			RESISTANCE	
	L Arm Length *	L Arm Length **	D Control Tip	Small Switch	Large Switch
Minimum	13 mm (1/2 in.)	38 mm (1-1/2 in.)	3 mm (1/8 in.)	2.8 N (10 oz.)	2.8 N (10 oz.)
Maximum	50 mm (2 in.)	50 mm (2 in.)	25 mm (1 in.)	4.5 N (16 oz.)	11 N (40 oz.)

	DISPLACEMENT BETWEEN POSITIONS	
	A	
	2 Position	3 Position
Minimum	525 mrad (30°)	295 mrad (17°)
Maximum	1400 mrad (80°)	700 mrad (40°)
Desired	...	435 mrad (25°)

	SEPARATION			
	S			
	Single Finger Operation	Single Finger Operation †	Single Finger Sequential Operation	Simultaneous Operation by Different Fingers
Minimum	19 mm (3/4 in.)	25 mm (1 in.)	13 mm (1/2 in.)	16 mm (5/8 in.)
Optimum	50 mm (2 in.)	50 mm (2 in.)	25 mm (1 in.)	19 mm (3/4 in.)

*Use by bare finger **Use with heavy handwear †Using a lever lock toggle switch

FIGURE 13. TOGGLE SWITCHES

5.4.3.1.4.5 Orientation. Toggle switches should be vertically oriented with OFF in the down position. Horizontal orientation and actuation of toggle switches shall be employed only for compatibility with the controlled function or equipment location.

5.4.3.1.5 Legend switches.

5.4.3.1.5.1 Dimensions, resistance, displacement, and separation. Dimensions, resistance, displacement, and separation between adjacent edges of legend switches shall conform to the criteria in Figure 14, except that maximum switch separation does not apply to non-matrix applications.

5.4.3.1.5.2 Barrier height. Barrier height from panel surface shall conform to the criteria in Figure 14. Unless otherwise specified, barriers are required on critical switches and on switches likely to be inadvertently activated. Barriers, when used, shall not obscure visual access to controls, labels or displays, and shall have rounded edges.

5.4.3.1.5.3 Other requirements.

a. For positive indication of switch actuation, the legend switch shall be provided with a detent or click. When touch sensitive switches are used, a positive indication of actuation shall be provided, e.g., an integral light within or above the switch being actuated.

b. The legend shall be legible with or without internal illumination.

c. A lamp test or dual lamp/filament reliability shall be provided for switches if the mean time between failure (MTBF) is less than 100,000 hrs.

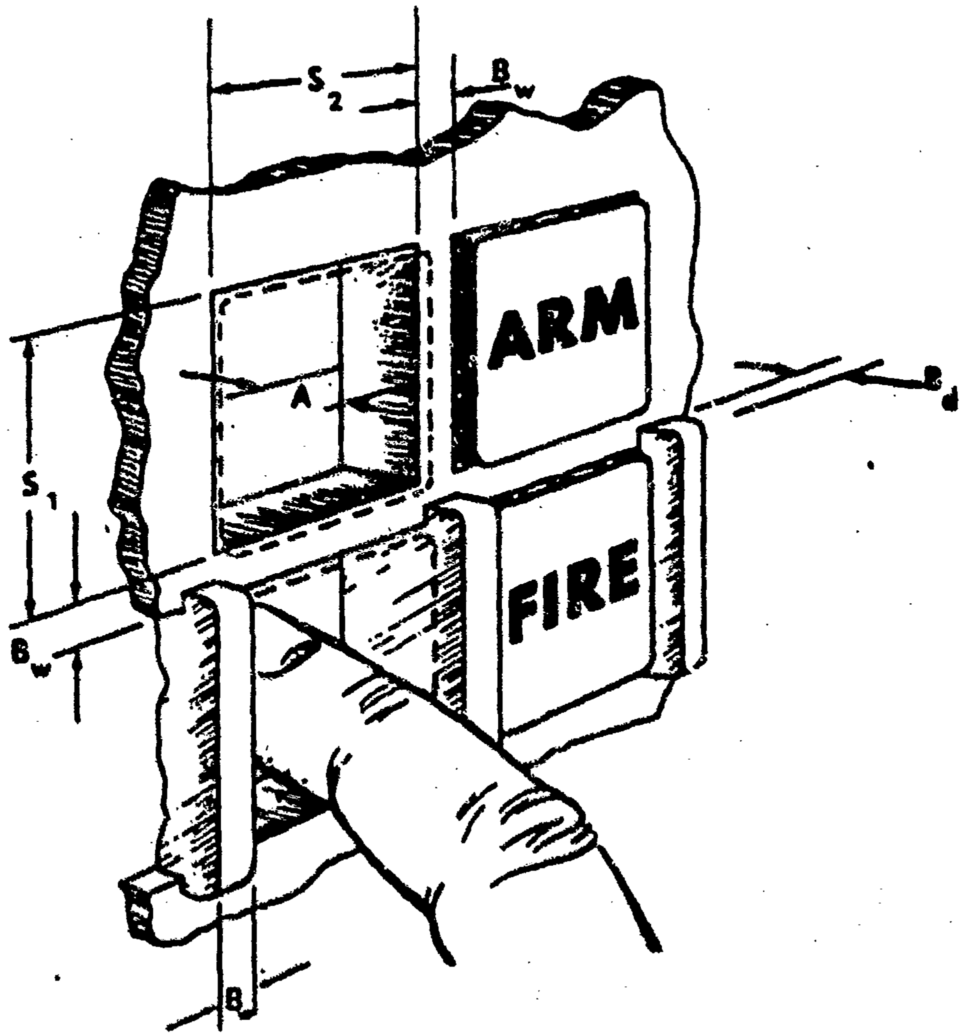
d. Lamps within the legend switch shall be replaceable from the front of the panel by hand and the legends or covers shall be keyed to prevent the possibility of interchanging the legend covers.

e. There shall be a maximum of three lines of lettering on the legend plate.

5.4.3.1.6 Rocker switches.

5.4.3.1.6.1 Use. Rocker switches may be used in lieu of toggle switches for functions which require two discrete positions. They may be used for applications where toggle switch handle protrusions might snag the operator's sleeve or phone cord, or where there is insufficient panel space for separate labeling of switch positions. Rocker switches with three positions shall be used only where the use of a rotary control, legend switch control, etc., is not feasible or when the rocker switch is of the spring-loaded center-off type.

5.4.3.1.6.2 Accidental actuation. When the prevention of accidental actuation is of primary importance (i.e., critical, dangerous or hazardous



	S_1, S_2 Size	A DISPLACEMENT	BARRIERS		RESISTANCE
			B_w	B_d	
Minimum	19 mm* (3/4 in.)	3 mm** (1/8 in.)	3 mm (1/8 in.)	5 mm (3/16 in.)	2.8 N*** (10 oz.)
Maximum	38 mm (1-1/2 in.)	6 mm (1/4 in.	6 mm (1/4 in.)	6 mm (1/4 in.)	16.7 N (60 oz.)

* 16mm (5/8 in.) where switch is not depressed below the panel.

**5 mm (3/16 in.) for positive position switches.

***5.6 N (20 oz.) for use in moving vehicles.

NOTE: B_w also refers to switch separation.

FIGURE 14. LEGEND SWITCH

conditions would result), channel guards or equivalent protective measures shall be provided.

5.4.3.1.6.3 Positive indication. An indication of control actuation shall be provided (e.g., snap feel, audible click, associated or integral light).

5.4.3.1.6.4 Dimensions, resistance, displacement and separation. Dimensions, resistance, displacement and separation between centers of rocker switches shall conform to the criteria in Figure 15. Resistance should gradually increase, then drop when the switch snaps into position. The switch shall not be capable of being stopped between positions.

5.4.3.1.6.6 Orientation. Where practicable, rocker switches shall be vertically oriented. Actuation of the upper wing shall turn the equipment or component on, cause the quantity to increase, or cause the equipment of component to move forward, clockwise, to the right or up. Horizontal orientation of rocker switches shall be employed only for compatibility with the controlled function or equipment location.

5.4.3.1.6.7 Color and illumination. Alternate colors may be used to denote the ON and OFF portions of a rocker switch. Alternate illumination of either the ON or OFF switch position may be used to facilitate positive recognition of current switch position. For other color coding considerations, see 5.2.2.1.18. For areas where ambient illumination will provide display luminance below 3.5 cd/m^2 (1 Ft-L), the rocker switch should be internally illuminated. Digits and letters shall appear as illuminated characters on an opaque background and their dimensions should approximate the following:

a. Height: 4.8 mm (3/16")

b. Height-to-Width Ratio: 3:2

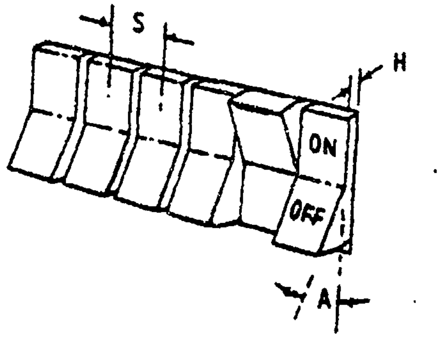
c. Height-to-Stroke-Width Ratio: 10:1

5.4.3.1.7 Slide switch controls.

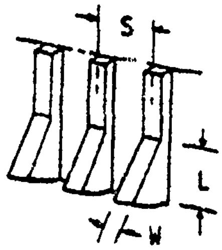
5.4.3.1.7.1 Use. Slide switch controls may be used for functions which require two discrete positions. Slide switch controls may also be used for functions which require a higher number of discrete positions in which the switches are arranged in a matrix to permit easy recognition of relative switch settings (e.g., audio settings across frequencies), but shall not be used where mispositioning is to be avoided.

5.4.3.1.7.2 Accidental actuation. When the prevention of accidental actuation is of primary importance (i.e., critical, dangerous, or hazardous conditions would result), channel guards or other equivalent means shall be provided.

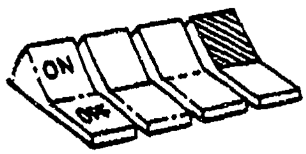
5.4.3.1.7.3 Dimensions, resistance, and separation. Dimensions, resistance and separation of slide switch handles shall conform to criteria in Figure 16. Detents shall be provided for each control setting. Resistance should



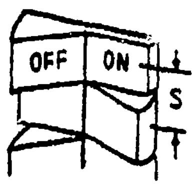
STANDARD ROCKER SWITCH: USE AS ALTERNATE TWO-POSN TOGGLE SWITCH TO PROVIDE LABELING SURFACE, EASE OF COLOR CODING, SWITCH ILLUMINATION.



NARROW WIDTH, ESPECIALLY DESIRABLE FOR TACTILE DEFINITION WITH GLOVES.



ALTERNATE (CONTRAST) COLOR FOR ON VERSUS OFF TO PROVIDE CONSPICUOUS CUE OF SWITCH POSITION. ILLUMINATED "ON" DESIRABLE AS SECOND FEEDBACK CUE.



	DIMENSIONS		RESISTANCE
	W, WIDTH	L, LENGTH	
MINIMUM	6 mm (1/4")	13 mm (1/2")	2.8 N (10 oz.)
MAXIMUM			11 N (40 oz.)

	DISPLACEMENT		SEPARATION (Center-to-Center)	
	H, HT, DEPRESSED	A, ANGLE	S (Bare Hand)	S (Gloved Hand)
MINIMUM	3 mm (1/8")	530 mrad (30°)	19 mm (3/4")	32 mm (1-1/4")

FIGURE 15. ROCKER SWITCHES

Detents shall be provided for each control setting. Resistance should gradually increase, then drop when the switch snaps into position. The switch shall not be capable of stopping between positions.

5.4.3.1.7.4 Orientation. Where practicable, slide switches shall be vertically oriented with movement of the slide up or away from the operator turning the equipment or component on, causing a quantity to increase, or causing the equipment or component to move forward, clockwise, to the right or up. Horizontal orientation or actuation slide switches shall be employed only for compatibility with the controlled function or equipment location.

5.4.3.1.7.5 Positive indication. Slide switch controls involving more than two positions shall be designed to provide positive indication of control setting, preferably a pointer located on the left side of the slide handle.

5.4.3.1.8 Discrete push-pull controls.

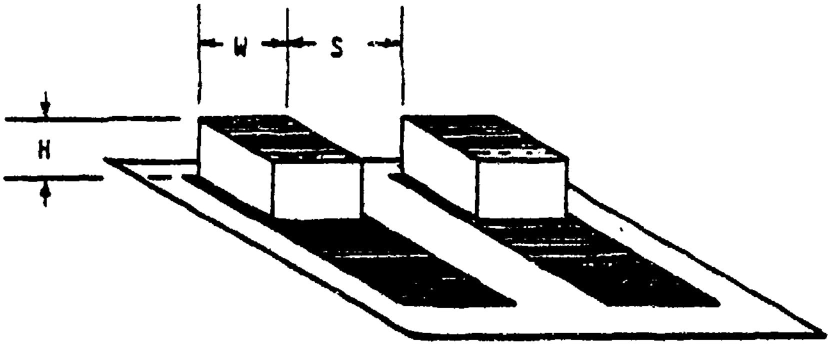
5.4.3.1.8.1 Applications. Push-Pull controls may be used when two discrete functions are to be selected. However such applications should be used sparingly and for applications in which such configurations are typically expected (e.g., vehicle headlight switch, choke, etc.). They may also be used in certain cases where limited panel space suggests a miniaturized knob that may be used to serve two related, but distinct functions (e.g., an ON-OFF/Volume switch for a T.V. monitor.) A three-position push-pull control is acceptable in isolated instances where the criticality of inadvertent selection of the wrong position has no serious consequences (e.g., the typical vehicle headlight switch configuration that provides three "pull" positions--OFF/Park/Headlight-plus a rotary panel light and dome light switch).

5.4.3.1.8.2 Handle dimensions, displacement and clearances. Push-Pull control handles shall conform to criteria in Table XI.

5.4.3.1.8.3 Rotation. Except for combination push-pull/rotate switch configurations, push-pull control handles shall be keyed to a non-rotating shaft, unless the control is to be used for a special application (e.g., the handle is rotated to disengage the brake setting). When the control system provides a combination push-pull/rotate functional operation, using a round style knob, the rim of the knob shall be serrated to denote (visually and tactually) that the knob can be rotated, and to facilitate a slip-free finger grip.

5.4.3.1.8.4 Detents. Mechanical detents shall be incorporated into push-pull controls to provide tactile indication of positions.

5.4.3.1.8.5 Snagging and inadvertent contact. Use, location and operating axis of push-pull type controls shall preclude the possibility of the operator's:



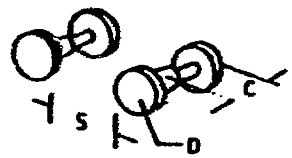
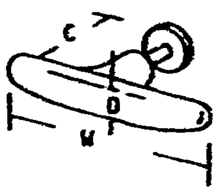
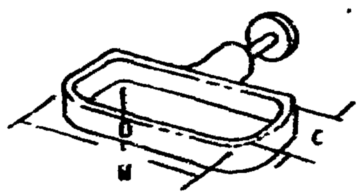
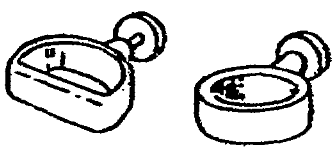
	DIMENSIONS			RESISTANCE	
	H ACTUATOR HEIGHT *	**	W ACTUATOR WIDTH	SMALL SWITCH	LARGE SWITCH
MINIMUM	6 mm (1/4")	13 mm (1/2")	6 mm (1/8")	2.8 N (10 oz.)	2.8 N (10 oz.)
MAXIMUM	--	--	25 mm (1")	4.5 N (16 oz.)	11 N (40 oz.)

	SEPARATION, S		
	SINGLE FINGER OPERATION	SINGLE FINGER SEQUENTIAL OPERATION	SIMULTANEOUS OPERATION BY DIFFERENT FINGERS
MINIMUM	19 mm (3/4")	13 mm (1/2")	16 mm (5/8")
OPTIMUM	50 mm (2")	25 mm (1")	19 mm (3/4")

*Use by bare finger.
**Use with heavy handwear.

FIGURE 16. SLIDE SWITCHES

TABLE XI. PUSH-PULL CONTROLS

CONFIGURATION EXAMPLE	APPLICATION CRITERIA	DESIGN CRITERIA				
		DIMENSIONS			DISPLACEMENT	SEPARATION
	PUSH-PULL CONTROL, LOW RESISTANCE, FOR TWO-POSITION, MECHANICAL AND/OR ELECTRICAL SYSTEMS. ALTERNATE THREE POSITION PLUS ROTARY FUNCTION ACCEPTABLE FOR APPLICATION SUCH AS VEHICLE HEADLIGHT PLUS PARKING LIGHTS, PANEL AND DOME LIGHTS PROVIDE SERRATED RIM.	D, MIN DIAM: 19 mm (3/4")	C, MIN CLEARANCE: 25 mm (1") Add 13 mm (1/2") for gloved hand		25 ±13 mm (1 ±1/2") MIN BETWEEN PULL POSNS: 13 mm (1/2")	S, MIN SPACE BETWEEN: 38 mm (1-1/2") Add 13 mm (1/2") for gloved hand
	ALTERNATE HANDLE; MINIATURE ELECTRICAL PANEL SWITCH ONLY. AVOID GLOVE USE APPLICATION.	D, MIN DIAM: 6 mm (1/4")	N/A	L, MIN LGTH: 19 mm (3/4")	MINIMUM: 13 mm (1/2")	S, MIN SPACE BETWEEN: 25 mm (1")
	HIGH-FORCE PUSH-PULL, FOR TWO-POSITION MECHANICAL SYSTEM ONLY.	W, MIN WIDTH: 100 mm (4")	D, DEPTH: 16-38 mm [5/8 - 1-1/2"]	C, MIN CLEARANCE: 38 mm (1-1/2") Add 6 mm (1/4") for gloved hand	MINIMUM: 25 mm (1") PREFERRED: 50 mm (2")	
 	SAME AS ABOVE. PREFERRED WHERE POSSIBLE GARMENT OR CABLE-SNAG POSSIBILITY EXISTS. NOTE: 1 & 2 FINGER PULLS ALSO ACCEPTABLE FOR LESS THAN 18 N (4 lb) APPLICATIONS.	W, MIN WIDTH: 100 mm (4") Add 25 mm (1") for gloves	D, DEPTH: 16-38 mm [5/8 - 1-1/2"]	C, MIN CLEARANCE: 32 mm (1-1/2")	MINIMUM: 25 mm (1") PREFERRED: 50 mm (2")	S, MIN SPACE BETWEEN: 13 mm (1/2")

a. Bumping a control while getting into or out of position (as in a vehicle).

b. Snagging clothing, communication cables, or other equipment items on the control.

c. Inadvertently deactuating the control setting while reaching for another control.

5.4.3.1.8.6 Direction of control motion. Control direction shall be as follows:

a. Pull towards the operator for ON or actuation; push away for OFF or deactuation.

b. Clockwise for actuation or increasing function of combination pull/rotary switches.

5.4.3.1.8.7 Resistance. Force for pulling a panel control with fingers should be not more than 18 N (4 lb), for pulling a T-bar with four fingers should be not more than 45 N (10 lb).

5.4.3.1.9 Printed circuit (PC) switch controls.

5.4.3.1.9.1 Use. PC switches may be used when manual programming functions are required in systems employing printed circuit boards.

5.4.3.1.9.2 Dimensions, resistance, displacement and separation. Dimensions, resistance, displacement and separation between adjacent PC switch actuators shall conform to the following:

a. Dimensions of actuators shall be sufficiently high to permit error-free manipulation by the operator when using some commonly available stylus (e.g., pencil or pen). The design of the actuators shall not require the use of a special tool for manipulation.

b. Actuator resistance shall be sufficiently high to avoid inadvertent actuation under expected use conditions. Resistance should gradually increase, then drop when the actuator snaps into position. The actuator shall not be capable of stopping between positions.

c. When actuators are slide-type, they shall have sufficient travel (displacement) to permit easy recognition of switch setting. At a minimum, the travel should be twice the length of the actuator. When actuators are rocker-type, the actuated wing shall be flush with the surface of the module.

d. Actuators shall have sufficient separation to permit error-free manipulation by the operator (i.e., the stylus cannot inadvertently contact adjacent actuators).

5.4.3.1.9.3 Shape. The surface of the actuator shall be indented to accept the point of the stylus. The indentation shall be sufficiently deep to avoid slippage of the stylus during manipulation.

5.4.3.2 Continuous adjustment linear controls.

5.4.3.2.1 Levers.

5.4.3.2.1.1 Use. Levers may be used when large amounts of force or displacement are involved or when multidimensional movements of controls are required.

5.4.3.2.1.2 Coding. When several levers are grouped in proximity to each other, the lever handles shall be coded.

5.4.3.2.1.3 Labeling. When practicable, all levers shall be labeled as to function and direction of motion.

5.4.3.2.1.4 Limb support. When levers are used to make fine or continuous adjustments, support shall be provided for the appropriate limb segment as follows:

a. For large hand movements: elbow

b. For small hand movements: forearm

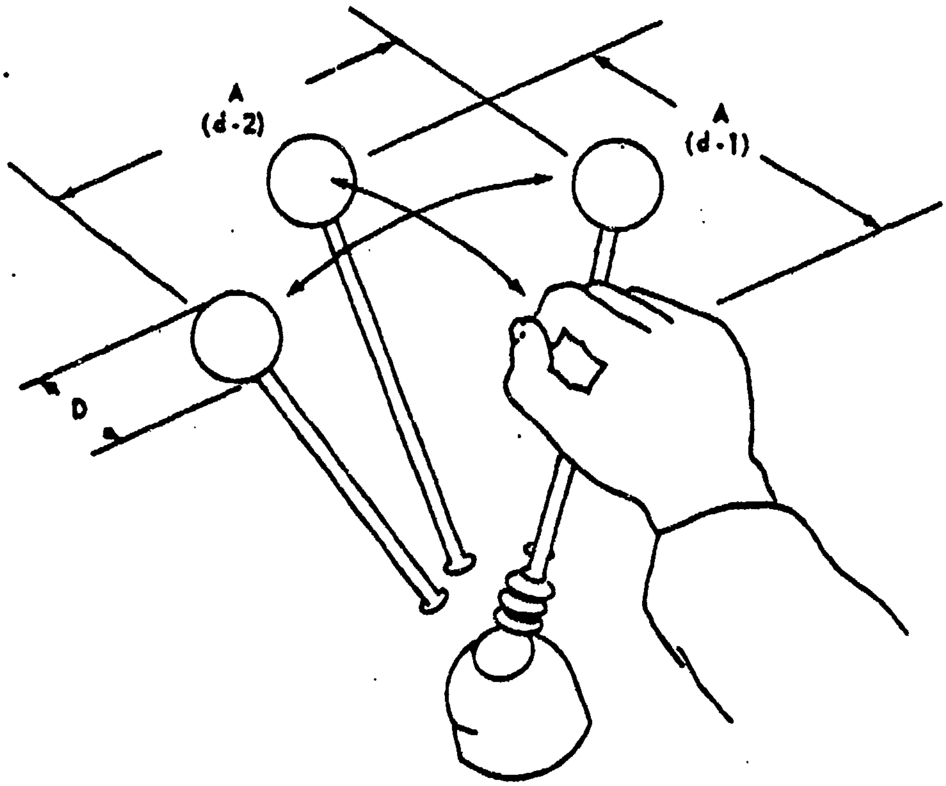
c. For finger movements: wrist.

5.4.3.2.1.5 Dimensions. The length of levers shall be determined by the mechanical advantage needed. When the lever or grip handle is spherical, its diameter shall conform to the criteria in Figure 17.

5.4.3.2.1.6 Resistance. The resistance incorporated in levers shall be within the limits indicated in Figure 17, measured as linear force applied to a point on the handle. (NOTE: The right hand can supply slightly more force than the left, but the difference is not significant. The same amount of push-pull force can be applied when the control is along the median plane of the body as when it is directly in front of the arm, 180 mm (7 in) from the median plane. When the control is placed in front of the opposite (unused) arm only 75 percent as much force can be applied. When the control is 250 to 480 mm (10 to 19 in) forward of the neutral seat reference point, twice as much push-pull force can be applied with two hands as with one-hand operation. Outside this range two-hand operation becomes less effective.)

5.4.3.2.1.7 Displacement and separation. Control displacement (for the seated operator) and separation shall conform to the criteria in Figure 17.

5.4.3.2.2 Displacement joysticks. (Also known as isotonic joysticks.) Displacement joysticks usually have a spring resistance to movement away from the center (null) position, although some have no spring. Joystick controls



	DIAMETER D		RESISTANCE			
			(d-1)		(d-2)	
	Finger Grasp	Hand Grasp	One Hand	Two Hands	One Hand	Two Hands
Minimum	13 mm (1/2 in.)	38mm (1-1/2 in.)	9 N (2 lb)	9 N (2 lb)	9 N (2 lb)	9 N (2 lb)
Maximum	38mm (1-1/2 in.)	75 mm (3 in.)	135 N (30 lb)	220 N (50 lb)	90 N (20 lb)	135 N (30 lb)

	DISPLACEMENT A		SEPARATION	
	Forward (d-1)	Lateral (d-2)	One Hand Random	Two Hands Simultaneously
Minimum	•	•	50 mm (2 in.)	75 mm (3 in.)
Preferred			100 mm (4 in.)	125 mm (5 in.)
Maximum	360 mm (14 in.)	970 mm (38 in.)		

FIGURE 17. LEVER

may be used when the task requires precise or continuous control in two or more related dimensions. (The term "joystick" is used here to refer primarily to controls used for cursor placement or precise adjustment.) When positioning accuracy is more critical than positioning speed, displacement joysticks should be selected over isometric joysticks. Displacement joysticks may also be used for various display functions such as data pickoff from a CRT and generation of free-drawn graphics. In rate control applications, which allow the follower (cursor or tracking symbol) to transit beyond the edge of the display, indicators shall be provided to aid the operator in bringing the follower back onto the display. Displacement joysticks which are used for rate control should be spring-loaded for return to center when the hand is removed. Displacement joysticks which have a deadband near the center or hysteresis shall not be used with automatic sequencing of a CRT follower (cursor or tracking symbol) unless they are instrumented for null return or zero-set to the instantaneous position of the stick at the time of sequencing. Upon termination of the automatic sequencing routine, joystick center shall again be registered to scope center. Displacement joysticks usually require less force than isometric joysticks and are less fatiguing for long operating periods.

5.4.3.2.2.1 Hand operated displacement joysticks

5.4.3.2.2.1.1 Specific Use. In addition to the general use, hand operated displacement joysticks may be used as vehicle controllers and aiming sensors. Hand operated displacement joysticks may be used as mounting platforms for secondary controls, such as thumb and finger operated switches. Operation of secondary controls has less induced error on the displacement hand grip than does isometric handgrips.

5.4.3.2.2.1.2 Dynamic characteristics. Movement shall not exceed 45 degrees from the center position. Movement shall be smooth in all directions, and positioning of a follower shall be attainable without noticeable backlash, cross-coupling or need for multiple corrective movements. Control ratios, friction and inertia shall meet the dual requirements of rapid gross positioning and precise fine positioning. When used for generation of free-drawn graphics, the refresher rate for the follower on the CRT shall be sufficiently high to give the appearance of a continuous track. Delay between control movement and the confirming display response shall be minimized and shall not exceed 0.1 second.

5.4.3.2.2.1.3 Dimensions, resistance, and clearance. The hand grip length should be in the range of 110 - 180 mm (4.3" - 7.1"). The grip diameter shall not exceed 50 mm (2"). Clearances of 100 mm (4") to the side and 50 mm (2") to the rear shall be provided to allow for hand movement. Joysticks shall be mounted to provide forearm support. Modular devices shall be mounted to allow actuation of the joystick without slippage, movement, or tilting of the mounting base.

5.4.3.2.2.2 Finger operated displacement joysticks

5.4.3.2.2.2.1 Specific use. In addition to the general uses, finger operated displacement joysticks are useful for free-drawn graphics. In this application, there is usually no spring return to center, and the resistance should be sufficient to maintain the handle position when the hand is removed.

5.4.3.2.2.2.2 Dynamic characteristics. Movement shall not exceed 45 degrees from the center position. Movement shall be smooth in all directions, and positioning of a follower shall be attainable without noticeable backlash, cross-coupling, or need for multiple corrective movements. Control ratios, friction and inertia shall meet the dual requirements of rapid gross positioning and precise fine positioning. Recessed mounting or pencil attachments may be utilized as indicated in Figure 18, to provide greater precision of control. When used for generation of free-drawn graphics, the refresher rate for the follower on the CRT shall be sufficiently high to give the appearance of a continuous track. Delay between control movement and the confirming display response shall be minimized and shall not exceed 0.1 second.

5.4.3.2.2.2.3 Dimensions, resistance, and clearance. The joystick should be mounted on a desk or shelf surface as shown in Figure 18. Joysticks shall be mounted to provide forearm or wrist support. Modular devices shall be mounted to allow actuation of the joystick without slippage, movement, or tilting of the mounting base.

5.4.3.2.2.3 Thumbtip/fingertip operated displacement joysticks.

5.4.3.2.2.3.1 Specific use. Thumbtip/fingertip operated joysticks may be mounted on a handgrip, which serves as a steady rest to damp vibrations and increase precision. If so mounted, the hand grip shall not simultaneously function as a joystick controller.

5.4.3.2.2.3.2 Dynamic characteristics. Movement shall not exceed 45 degrees from the center position.

5.4.3.2.2.3.3 Dimensions, resistance, and clearance. Joysticks shall be mounted to provide wrist or hand support. Console mounted devices shall be mounted as shown in Figure 18. Modular devices shall be mounted to allow actuation of the joystick without slippage, movement, or tilting of the mounting base.

5.4.3.2.3 Isometric joystick (two axis controllers). (Also known as stiff stick, force stick, or pressure stick. The control has no perceptible movement, but its output is a function of the force applied.) Joystick controls may be used when the task requires precise or continuous control in two or more related dimensions. Isometric joysticks are particularly appropriate for applications: (1) which require precise return to center after each use; (2) in which operator feedback is primarily visual rather than tactile feedback from the control itself; and (3) where there is minimal delay and tight coupling between control and input and system reaction. Isometric sticks should ordinarily not be used in applications where it would be necessary for the operator to maintain a constant force on the control for a long period of time or where there is no definitive feedback when maximum control inputs have been exceeded. Joystick controls may be used when the task requires precise or continuous control in two or more related dimensions. When positioning speed is more critical than positioning accuracy, isometric joysticks should be selected over displacement joysticks. Isometric joystick may also be used for various display functions such as data pickoff from a CRT. In rate control applications, which may allow the follower (cursor or tracking symbol) to transit beyond the edge of the display, indicators shall be provided in order to aid the operator in bringing the follower back onto the display.

5.4.3.2.3.1 Hand-operated.

5.4.3.2.3.1.1 Specific Use. In addition to the general use, hand-operated isometric joysticks may be used as vehicle controllers and aiming sensors. Hand operated isometric joysticks may be used as mounting platforms for secondary controls, such as thumb and finger operated switches. Operation of secondary controls has greater induced error on the isometric hand grip than does displacement handgrip joysticks.

5.4.3.2.3.1.2 Dynamic characteristics. Maxmimum force for full output shall not exceed 118 N (26.7 lb).

5.4.3.2.3.1.3 Dimensions, resistance, and clearance. The hand grip length should be in the range of 110 - 180 mm (4.3" - 7.1"). The grip diameter shall not exceed 50 mm (2"). Clearances of 100 mm (4") to the side and 50 mm (2") to the rear shall be provided to allow for hand movement. Joysticks shall be mounted to provide forearm support. Modular devices shall be mounted to allow actuation of the joystick without slippage, movement, or tilting of the mounting base.

5.4.3.2.3.2 Finger operated.

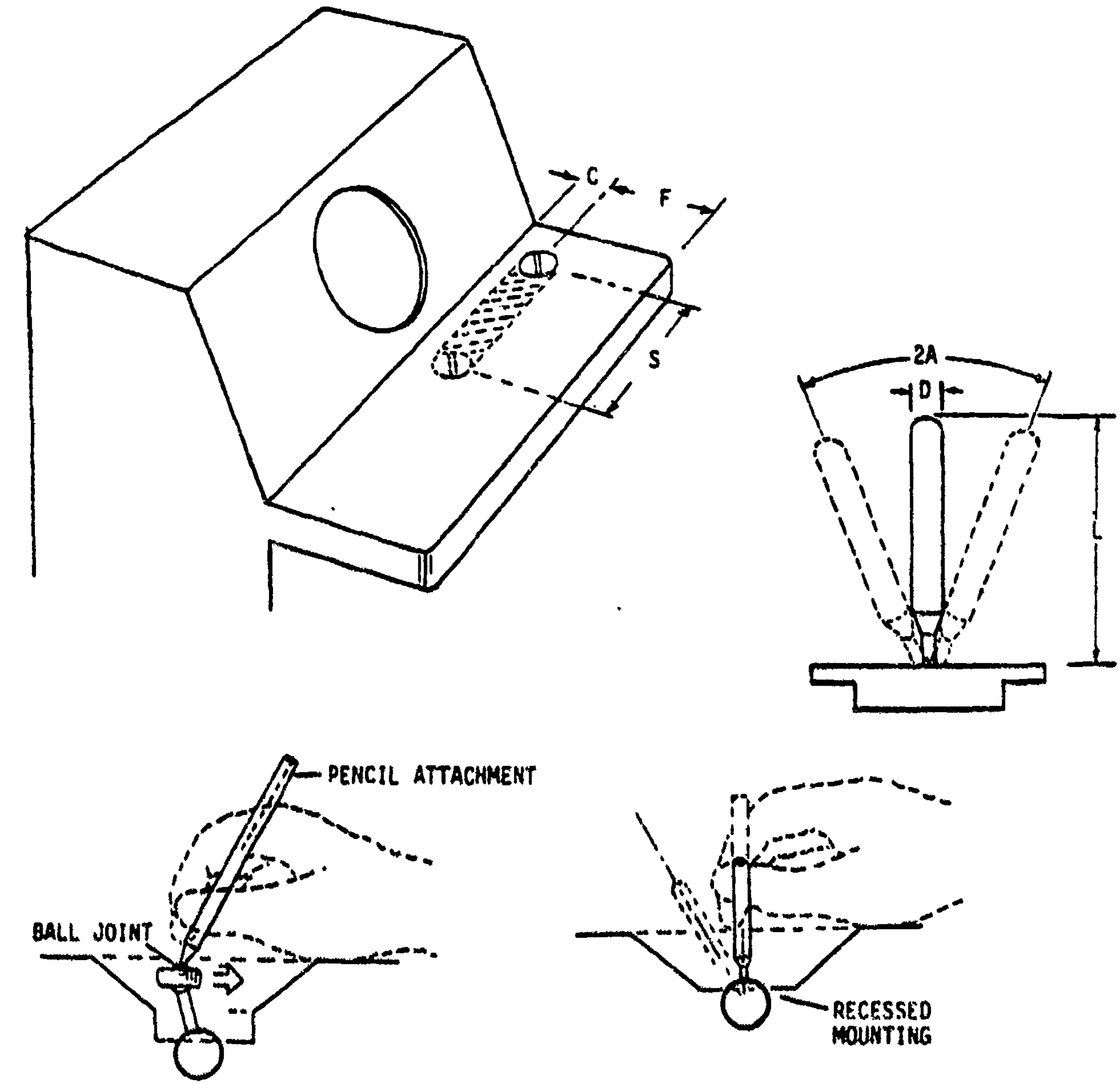
5.4.3.2.3.2.1 Specific use.

5.4.3.2.3.2.2 Dynamic characteristics.

5.4.3.2.3.2.3 Dimensions, resistance, and clearance. The joystick should be mounted on a desk or shelf surface as shown in Figure 18. Joysticks shall be mounted to provide forearm or wrist support. Modular devices shall be mounted to allow actuation of the joystick without slippage, movement, or tilting of the mounting base.

5.4.3.2.3.3 Thumbtip/fingertip operated.

5.4.3.2.3.3.1 Specific use. Thumbtip/fingertip operated joysticks may be mounted on a handgrip, which serves as a steady rest to damp vibrations or increase precision. If so mounted, the hand grip shall not simultaneously function as a joystick controller.



	DIMENSIONS		RESISTANCE	DISPLACEMENT	CLEARANCE		
	D DIAM	L LENGTH		A	S DISPLAY CL TO STICK CL	C AROUND STICK	F STICK CL TO SHELF FRONT
MINIMUM	6.5 mm (1/4")	75 mm (3")	3.3 N (12 oz.)		0	*	120 mm (4-3/4")
MAXIMUM	16 mm (5/8")	150 mm (6")	8.9 N (32 oz.)	$\frac{\pi}{4}$ rad (45^{0})	400 mm (15-3/4")		250 mm (9-7/8")

*Maximum stick excursion plus 100 mm (4").

FIGURE 18. ISOTONIC JOYSTICKS

5.4.3.2.3.3.2 Dynamic characteristics.

5.4.3.2.3.3.3 Dimensions, resistance and clearance. Joysticks shall be mounted to provide wrist or hand support. Console mounted devices shall be mounted as shown in Figure 18. Modular devices shall be mounted to allow actuation of the joystick without slippage, movement, or tilting of the mounting base.

5.4.3.2.4 Ball control (Also known as track ball, ball tracker, joyball and rolling ball.)

5.4.3.2.4.1 Use. A ball control suspended on low-friction bearings may be used for various control functions such as data pickoff on a display. The ball control cannot provide an automatic return to point of origin, hence if used in applications requiring automatic return to origin following an entry or readout, the interfacing system must provide this. Because the ball can be rotated without limit in any direction it is well suited for applications where there may be accumulative travel in a given direction. In any application which would allow the ball to drive the follower on the display off the edge of the display, indicators shall be provided to advise the operator how to bring the follower back onto the display. Ball controls should be used only as position controls (i.e., a given movement of a ball makes a proportional movement of the follower on the display).

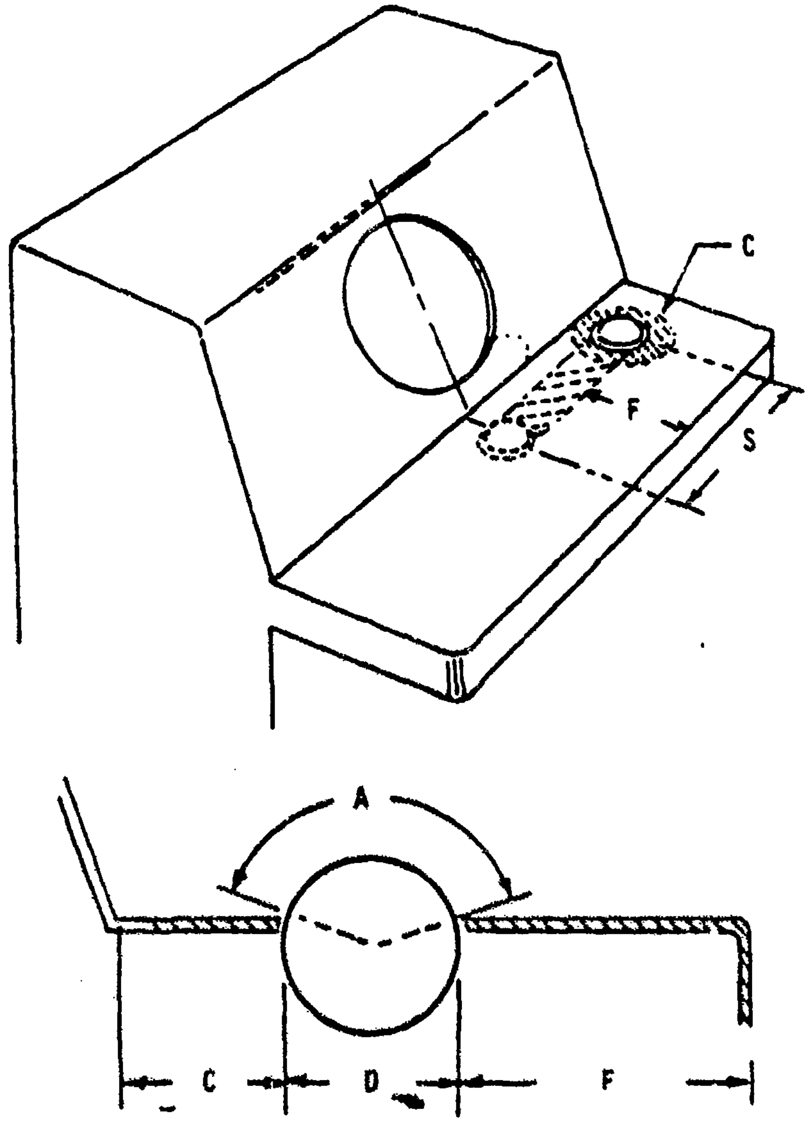
5.4.3.2.4.2 Dynamic characteristics. The ball control shall be capable of rotation in any direction so as to generate any combination of x and y output values. When moved in either the x or y directions alone there shall be no apparent cross-coupling (follower movement in the orthogonal direction). While manipulating the control, neither backlash nor cross-coupling shall be apparent to the operator. Control ratios and dynamic features shall meet the dual requirement of rapid gross positioning and smooth, precise fine positioning.

5.4.3.2.4.3 Limb support. When trackball controls are used to make precise or continuous adjustments, wrist support or arm support or both shall be provided. (See 5.4.3.2.1.4.)

5.4.3.2.4.4 Dimensions, resistance and clearance. Dimensions, resistance and clearances should conform to the criteria in Figure 19. The smaller diameter ball controls should be used only where space availability is very limited and when there is no need for precision. Preferred mounting is on a shelf or desk top (see Figure 19).

5.4.3.2.5 Grid-and-stylus devices. These provisions cover various techniques which utilize some means of establishing an x and y grid and a stylus for designating specific points on that grid for control purposes (e.g., time-shared x and y potential grids and a voltage-sensitive stylus).

5.4.3.2.5.1 Application. Grid and stylus devices may be used for data pickoff from a CRT, entry of points on a display, generation of free-drawn



	DIMENSIONS		RESISTANCE		CLEARANCE		
	D DIAM	A SURFACE EXPOSURE	PRECISION REQUIRED	VIBRATION OR ACCEL CONDITIONS	S DISPLAY CL TO BALL CL	C AROUND BALL	F BALL TO SHELF FRONT
MINIMUM	50 mm (2")	1745 mrad (100°)			0	50 mm (2")	120 mm (4-3/4")
MAXIMUM	150 mm (6")	2445 mrad (140°)	1.0 N (3.6 oz.)	1.7 N (6 oz.)	320 mm (12-5/8")		250 mm (9-3/4")
PREFERRED	100 mm (4")	2095 mrad (120°)	0.3 N (1.1 oz.)				

FIGURE 19. BALL CONTROLS

graphics and similar control applications. The grid may be on a transparent medium allowing stylus placement directly over corresponding points on the display or it may be displaced from the display in a convenient position for stylus manipulation. In either case a follower (bug, mark, hook, etc.) shall be presented on the display at the coordinate values selected by the stylus. Devices of this type should be used only for zero order control functions (i.e., displacement of the stylus from the reference position causes a proportional displacement of the follower).

5.4.3.2.5.2 Dynamic characteristics. Movement of the stylus in any direction on the grid surface shall result in smooth movement of the follower in the same direction. Discrete placement of the stylus at any point on the grid shall cause the follower to appear at the corresponding coordinates and to remain steady in position so long as the stylus is not moved. Refresh rate for the follower shall be sufficiently high to ensure the appearance of a continuous track whenever the stylus is used for generation of free-drawn graphics.

5.4.3.2.5.3 Dimensions and mounting. Transparent grids which are used as display overlays shall conform to the size of the display. Grids which are displaced from the display should approximate the display size and should be mounted below the display in an orientation to preserve directional relationships to the maximum extent (i.e., a vertical plane passing through the north/south axis on the grid shall pass through or be parallel to the north/south axis on the display).

5.4.3.2.6 Free-moving XY controller (Mouse)

5.4.3.2.6.1 Application. This type of controller may be used on any flat surface to generate x and y coordinate values which control the position of the follower on the associated display. It may be used for data pickoff or for entry of coordinate values. It should be used for zero order control only (i.e., generation of x and y outputs by the controller results in proportional displacement of the follower). It should not be used for generation of free-drawn graphics.

5.4.3.2.6.2 Dynamic characteristics. The design of the controller and placement of the maneuvering surface shall be such as to allow the operator to consistently orient the controller to within ±175 mrad (10°) of the correct orientation without visual reference to the controller. (That is, for example, when the operator grasps the controller in what seems to be the correct orientation and moves it rectilinearly along what is assumed to be straight up the y axis, then the direction of movement of the follower on the CRT shall be between 6110 and 175 mrad (350° and 10°). The controller shall be easily movable in any direction without a change of hand grasp and shall result in smooth movement of the follower in the same direction ±175 mrad (10°). The controller shall be operable with either the left or right hand. A complete excursion of the controller from side to side of the maneuvering area shall move the follower from side to side on the display regardless of scale setting or offset unless expanded movement is selected for an automatic sequencing mode of operation. In any application which would allow the controller to drive the follower off the edge of the display, indicators shall be provided to assist the operator in bringing the follower back onto the display.

5.4.3.2.6.3 Dimensions and shape. The free-moving xy controller shall have no sharp edges but shall be shaped roughly as a rectangular solid, with limiting dimensions as follows.

	Min.	Max.
Width (spanned by thumb to finger grasp)	40 mm (1.6 in.)	70 mm (2.8 in.)
Length	70 mm (2.8 in.)	120 mm (4.7 in.)
Thickness	25 mm (1.0 in.)	40 mm (1.6 in.)

5.4.3.2.7 Light pen

5.4.3.2.7.1 Use. A simple light pen may be used as a track-oriented readout device. That is, it may be positioned on the display screen to detect the presence of a computer-generated track by sensing its refresh pattern; the display system will then present a follower (hook) on the designed track. With suitable additional circuitry, a follower can be made to track the movement of the light pen across the surface, thus allowing it to function as a two-axis controller capable of serving the same purposes as the grid and stylus devices (paragraph 5.4.3.2.5.1).

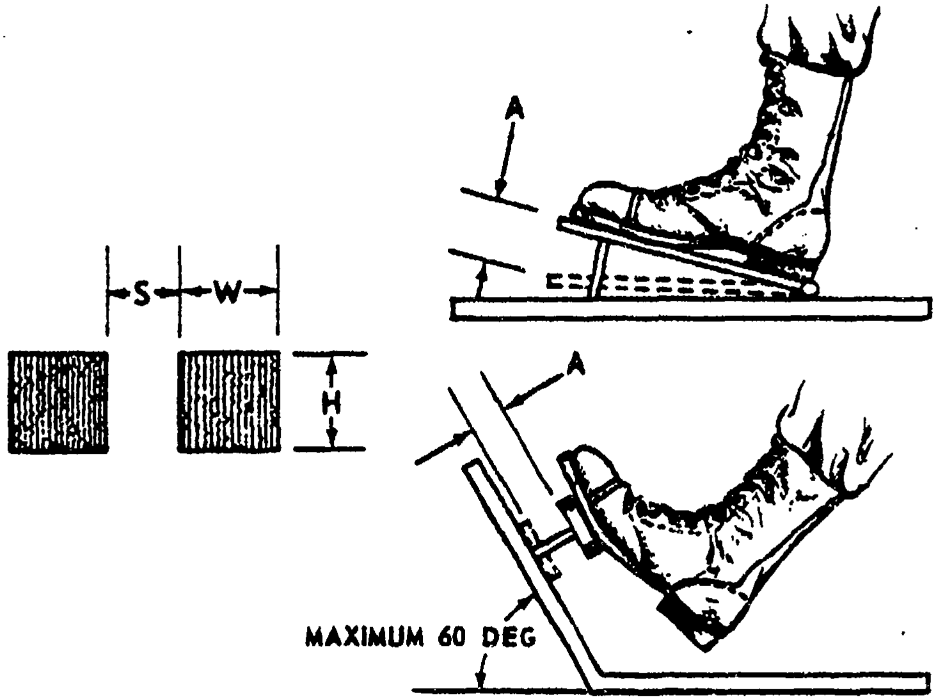
5.4.3.2.7.2 Dynamic characteristics. When used as a two-axis controller, light pen dynamic characteristics shall conform to paragraph 5.4.3.2.5.2.

5.4.3.2.7.3 Dimensions and mounting. The light pen shall be 120 - 180 mm (4.7 - 7.1") long with a diameter of 7 - 20 mm (0.3 - 0.8"). A convenient clip shall be provided at the lower right side of the CRT to hold the light pen when it is not in use.

5.4.3.2.8 Pedals.

5.4.3.2.8.1 Use. Pedal controls should be used only where the operator is likely to have both hands occupied when control operation is required, control system force is too high for manual force capability of the operator, or standardized use of pedals has created a sterotype expectancy (e.g., vehicle pedal control configurations such as clutch, brake, accelerator, rudder).

5.4.3.2.8.2 Location. Pedal controls shall be located so that the operator can reach them easily without extreme stretching or torso twisting and can reach the maximally-displaced pedals within anthropometric limits and force-capabilities (see Figure 20). Pedals that may be held or must be adjusted (accelerator, clutch, etc.) shall be located so the operator can



	DIMENSIONS		DISPLACEMENT			
	H	W	A			
	Height	Width	Normal Operation	Heavy Boots	Ankle Flexion	Total Leg Movement
Minimum	25 mm (1 in.)	75 mm (3 in.)	13 mm (1/2 in.)	25 mm (1 in.)	25 mm (1 in.)	25 mm (1 in.)
Maximum	-	-	65mm (2-1/2 in.)	90mm (3-1/2 in.)	65mm (2-1/2 in.)	180 mm (7 in.)

	RESISTANCE			
	Foot Not Resting on Pedal	Foot Resting on Pedal	Ankle Flexion Only	Total Leg Movement
Minimum	18 N (4 lb)	45 N (10 lb)	-	45 N (10 lb)
Maximum	90 N (20 lb)	90 N (20 lb)	45 N (10 lb)	800 N (180 lb)

	SEPARATION	
	S	
	One Foot Random	One Foot Sequential
Minimum	100 mm (4 in.)	50 mm (2 in.)
Preferred	150 mm (6 in.)	100 mm (4 in.)

FIGURE 20. PEDALS

"rest" and "steady" the foot, i.e., the pedal shall be an appropriate critical distance above the floor so the operator's heel can rest on the floor while articulating the ankle/foot. When this cannot be done (and the pedal angle is more than 350 mrad (20°) from the horizontal floor), a heel rest shall be provided.

5.4.3.2.8.3 Control return. Except for controls which generate a continuous output, (e.g., rudder controls) pedals shall return to the original null position without requiring assistance from the operator (e.g., brake pedal). For pedals in which the operator may normally rest the foot on the control between operations, sufficient resistance shall be provided to prevent the weight of the foot from inadvertently actuating the control (e.g., accelerator pedal).

5.4.3.2.8.4 Pedal travel path. The travel path shall be compatible with the natural articulation path of the operator's limbs (i.e., thigh, knee, ankle).

5.4.3.2.8.5 High force application aids. When high forces are required to fully actuate a pedal, appropriate aids shall be provided to assist the operator in applying maximum force including the following where applicable:

a. Seat backrest.

b. Optimized seat height-to-pedal and normal reach distance for maximum force, i.e., seat reference point (SRP) and pedal are at the same vertical height and reach distance is configured so the upper thigh and lower leg create an angle of approximately 2790 mrad (160°) (see Figure 22).

c. Double-width pedal so that both feet can be used.

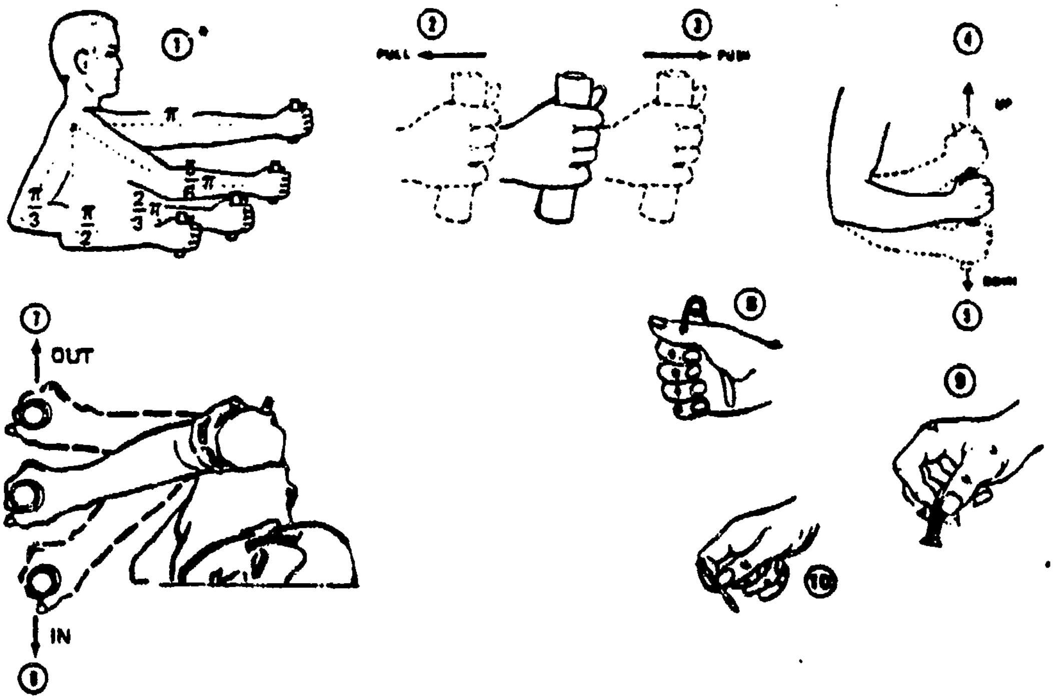
5.4.3.2.8.6 Non-slip pedal surface. Pedals used for high force applications shall be provided with a non-skid surface. Similar surfaces are desirable for all pedals.

5.4.3.2.8.7 Dimensions, resistance, displacement and separation. Dimensions, resistance, displacement and separation of pedals shall conform to the criteria in Figure 20.

5.4.4 High-force controls.

5.4.4.1 Use. In general, controls requiring operator forces exceeding the strength limits of the lowest segment of the expected user population shall not be used. In addition, high force controls shall not be used except when the operator's nominal working position provides proper body support or limb support or both, e.g., seat backrest, foot support. Sustained (i.e., durations longer than 3 seconds) high force requirements shall be avoided.

5.4.4.2 Arm, hand, and thumb-finger controls. Where arm, hand and thumb-finger controls requiring high control forces are to be used, the

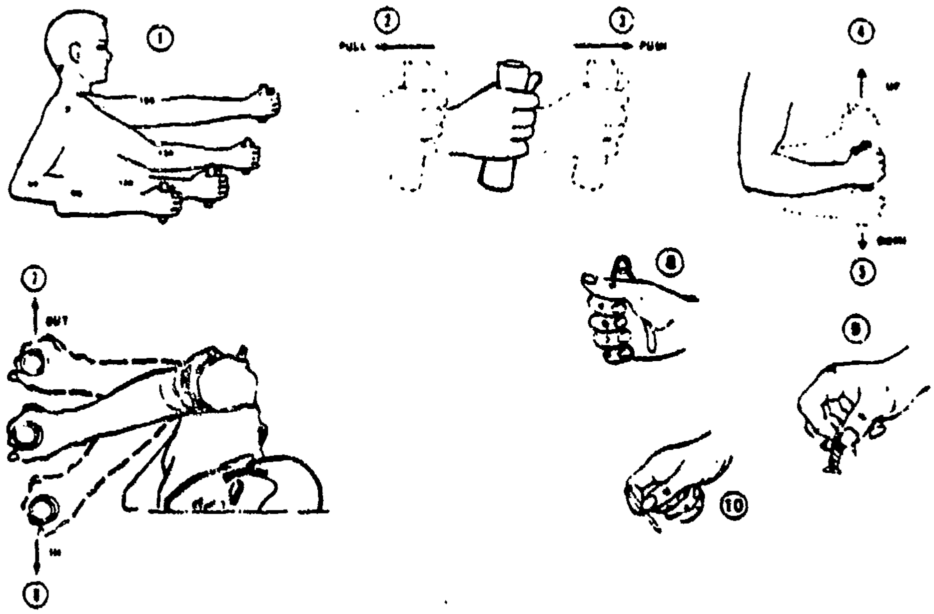


ARM STRENGTH (N)														
(1)	(2)		(3)		(4)		(5)		(6)		(7)	
DEGREE OF ELBOW FLEXION (rad)	PULL		PUSH		UP		DOWN		IN		OUT	
	L**	R**	L	R	L	R	L	R	L	R	L	R
π	222	231	187	222	40	62	58	76	58	89	36	62
$\frac{5}{6}\pi$	187	249	133	187	67	80	80	89	67	89	36	67
$\frac{2}{3}\pi$	151	187	116	160	76	107	93	116	89	98	45	67
$\frac{1}{2}\pi$	142	165	98	160	76	89	93	116	71	80	45	71
$\frac{1}{3}\pi$	116	107	96	151	67	89	80	89	76	89	53	76
HAND, AND THUMB-FINGER STRENGTH (N)												
	(8)		(9)				(10)					
	HAND GRIP		THUMB-FINGER GRIP (PALMER)				THUMB-FINGER GRIP (TIPS)					
	L	R										
MOMENTARY HOLD	250	260	60				60					
SUSTAINED HOLD	145	155	35				35					

*Elbow angle shown in radians.

**L = Left; R = Right.

FIGURE 21. ARM, HAND, AND THUMB-FINGER STRENGTH (5TH PERCENTILE MALE DATA)



ARM STRENGTH (Lb)												
(1)	(2)		(3)		(4)		(5)		(6)		(7)	
DEGREE OF ELBOW FLEXION (deg)	PULL		PUSH		UP		DOWN		IN		OUT	
	L	R*	L	R	L	R	L	R	L	R	L	R
180	50	52	42	50	9	14	13	17	13	20	8	14
150	42	56	30	42	15	18	18	20	15	20	8	16
120	34	42	26	36	17	24	21	26	20	22	10	15
90	32	37	22	36	17	20	21	26	16	18	10	16
60	26	24	22	34	15	20	18	20	17	20	12	17

HAND, AND THUMB-FINGER STRENGTH (Lb)				
	(8)		(9)	(10)
	HAND GRIP		THUMB-FINGER GRIP (PALMER)	THUMB-FINGER GRIPS (TIPS)
	L	R		
MOMENTARY HOLD	56	59	13	13
SUSTAINED HOLD	33	35	8	8

*L = LEFT; R = RIGHT

FIGURE 21. ARM, HAND, AND THUMB-FINGER STRENGTH (5TH PERCENTILE MALE DATA)(CONCLUDED)

5.4.6 Touch-screen controls for displays

5.4.6.1 Use. Touch-screen control may be used to provide an overlaying control function to a data display device such as CRTs, dot matrix/segmented displays, electroluminescent displays, programmable indicators, or other display devices where direct visual reference access and optimum direct control access are desired.

5.4.6.2 Luminance transmission. When used, touch-screen displays shall have sufficient luminance transmission to allow the display with touch-screen installed to be clearly readable in the intended environment and meet the display luminance requirements herein.

5.4.6.3 Positive indication. A positive indication of touch-screen actuation shall be provided to acknowledge the system response to the control action.

5.4.6.4 Dimensions and separation. The dimensions and separation of responsive areas of the touch-screen shall conform to S_1, S_2 and B_W of Figure 14.

5.4.6.5 Resistance. Force required to operate force-actuated touch-screens shall conform to the alphanumeric resistance limits of Table X.

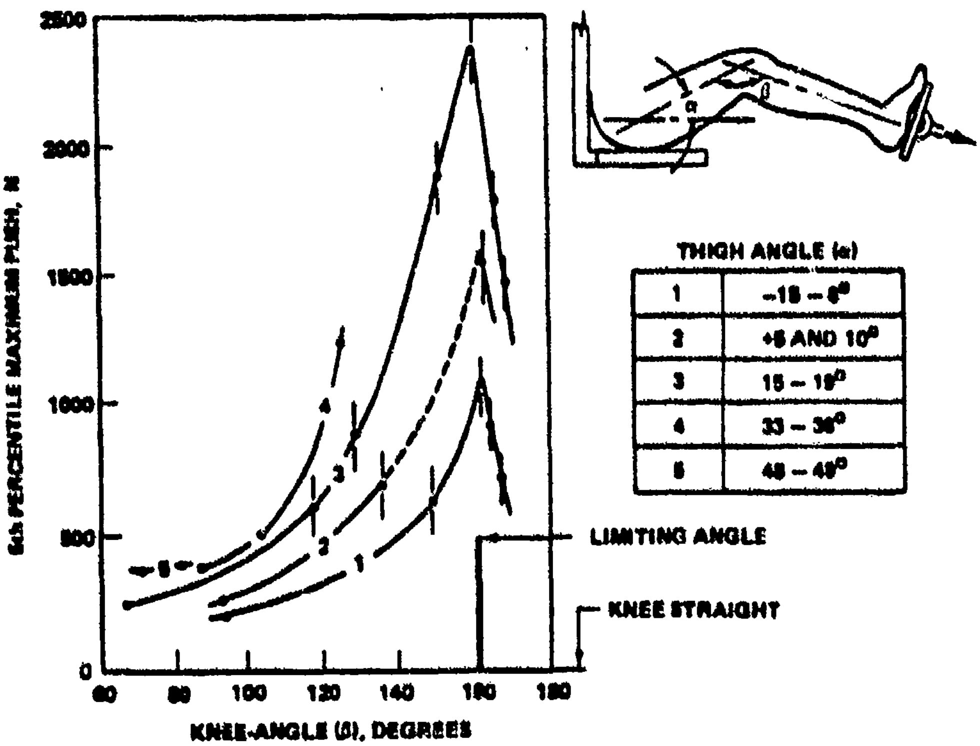


FIGURE 22. LEG STRENGTH AT VARIOUS KNEE AND THIGH ANGLES (5th PERCENTILE MALE DATA)

maximum force requirements shall not exceed those specified in Figure 21, which should be corrected, where applicable, for females. (Two-thirds of each value shown is considered to be a reasonable adjustment.)

5.4.4.3 Foot controls. Where foot controls requiring high control forces are to be used, the force push exerted by the leg depends on the thigh angle and the knee angle. Figure 22 specifies the mean maximum push at various knee and thigh angles. The maximum push is at about the 160 degree angle, referred to as the limiting angle. The values of Figure 22 apply to males only and should be corrected for females. (Two-thirds of each value is considered to be a reasonable adjustment.)

5.4.5 Miniature controls

5.4.5.1 Use. Miniature controls may be used only when severe space limitations exist. Miniature controls shall not be used when available space is adequate for standard-sized controls or when heavy gloves or mittens will be worn.

5.4.5.2 Dimensions, resistance, displacement and separation. When design constraints dictate the use of miniature controls, the dimensions and separation of the controls shall be the maximum permitted by the available space up to the maxima prescribed herein for standard-sized controls. Resistance and displacement of miniature controls should conform to the criteria specified for the standard size of that type of control.

5.4.5.3 Other requirements. Other design considerations (e.g., labeling, orientation) shall conform to the requirements specified for the standard size of the control.

5.4.6 Touch-screen controls for displays

5.4.6.1 Use. Touch-screen control may be used to provide an overlaying control function to a data display device such as CRTs, dot matrix/segmented displays, electroluminescent displays, programmable indicators, or other display devices where direct visual reference access and optimum direct control access are desired.

5.4.6.2 Luminance transmission. When used, touch-screen displays shall have sufficient luminance transmission to allow the display with touch-screen installed to be clearly readable in the intended environment and meet the display luminance requirements herein.

5.4.6.3 Positive indication. A positive indication of touch-screen actuation shall be provided to acknowledge the system response to the control action.

5.4.6.4 Dimensions and separation. The dimensions and separation of responsive areas of the touch-screen shall conform to S_1, S_2 and B_W of Figure 14.

5.4.6.5 Resistance. Force required to operate force-actuated touch-screens shall conform to the alphanumeric resistance limits of Table X.

5.5 Labeling

5.5.1 General

5.5.1.1 Application. Labels, legends, placards, signs or markings, or a combination of these shall be provided whenever it is necessary for personnel to identify, interpret, follow procedures or avoid hazards, except where it is obvious to the observer what an item is and what he or she is to do with it.

5.5.1.2 Label characteristics. Label characteristics shall be consistent with such factors as:

a. Accuracy of identification required.

b. Time available for recognition or other responses.

c. Distance at which the labels must be read.

d. Illuminant level and color.

e. Criticality of the function labeled.

f. Consistency of label design within and between systems.

5.5.1.3 Prototype and production equipment labels. Labels for both prototype and production equipment shall meet the criteria specified herein. Labels for production equipment shall meet the criteria specified for the duration of equipment use. Since frequent design changes may be anticipated in prototype equipment, labels for such equipment shall be simply and easily affixed, altered, and removed.

5.5.2 Orientation and location.

5.5.2.1 Orientation. Labels and information thereon should be oriented horizontally so that they may be read quickly and easily from left to right. Vertical orientation may be used only when labels are not critical for personnel safety or performance and where space is limited. When used, vertical labels shall read from top to bottom.

5.5.2.2 Location. Labels shall be placed on or very near the items which they identify, so as to eliminate confusion with other items and labels. Labels shall be located so as not to obscure any other information needed by the operator. Controls should not obscure labels.

5.5.2.3 Standardization. Labels shall be located in a consistent manner throughout the equipment and system.

5.5.3 Contents.

5.5.3.1 Equipment functions. Labels should primarily describe the functions of equipment items. Engineering characteristics or nomenclature may be described as a secondary consideration.

5.5.3.2 Abbreviations. Standard abbreviations shall conform to MIL-STD-12, MIL-STD-411, or MIL-STD-783. If a new abbreviation is required, its meaning shall be obvious to the intended reader. Capital letters shall be used. Periods shall be omitted except when needed to preclude misinterpretation. The same abbreviation shall be used for all tenses and for both singular and plural forms of a word.

5.5.3.3 Irrelevant information. Trade names and other irrelevant information shall not appear on labels or placards.

5.5.4 Qualities.

5.5.4.1 Brevity. Labels shall be as concise as possible without distorting the intended meaning or information and shall be unambiguous. Redundancy shall be minimized. Where the general function is obvious, only the specific function shall be identifed (e.g., frequency as opposed to frequency factor).

5.5.4.2 Familiarity. Words shall be chosen on the basis of operator familiarity whenever possible, provided the words express exactly what is intended. Brevity shall not be stressed if the results will be unfamiliar to operating personnel. For particular users (e.g., maintenance technicians), common technical terms may be used even though they may be unfamiliar to nonusers. Abstract symbols (e.g., squares and Greek letters) shall be used only when they have an accepted meaning to all intended readers. Common, meaningful symbols (e.g., % and +) may be used as necessary.

5.5.4.3 Visibility and legibility. Labels and placards shall be designed to be read easily and accurately at the anticipated operational reading distances, vibration/motion environment, and illumination.

5.5.4.4 Access. Labels shall not be covered or obscured by other units in the equipment assembly.

5.5.4.5 Label life. Labels shall be clear and distinct, have high contrast, be mounted so as to minimize wear or obscurement by grease, grime, or dirt, and shall remain legible for the overhaul interval of the equipment on which they are mounted.

5.5.4.6 Label background. Label color shall contrast with the equipment background specified in 5.7.9. No special background for the label shall be provided without approval by the procuring activity.

5.5.5 Design of label characters.

5.5.5.1 Black characters. Where the ambient illuminance will be above 10 lux (0.9 ft-c), black characters shall be provided on a light background.

5.5.5.2 Dark adaptation. Where dark adaptation is required, the displayed letters or numerals shall be visible without interfering with night vision requirements. Where possible, markings shall be white on a dark background.

5.5.5.3 Style. Style of label characters shall conform to MIL-M-18012, where consistent with 5.5.5.4, 5.5.5.5, 5.5.5.7, and 5.5.5.8, herein.

5.5.5.4 Capital vs lower case.

5.5.5.4.1 Labels. Labels shall be printed in all capitals; periods shall not be used after abbreviations.

5.5.5.4.2 Legends. Legends shall be printed in all capitals; periods or commas shall not be used.

5.5.5.4.3 Placards. Instructional material placards may employ capitals and lower case when the amount of material consists of several lines; however, for short, instructional material, all-capitals are preferred. All-capital material, consisting of larger caps for the initial letter in a paragraph, line of instruction or procedural step, may be used.

5.5.5.4.4 Signs. Signs shall consist of all-capitals, except when the sign is instructional and involves several lines of extended sentences, in which case capitals and lower case letters may be used.

5.5.5.5 Letter width. The width of letters should be 3/5 of the height, except for "H" and "W", which shall be 4/5 of the height, and "I", which shall be one stroke wide.

5.5.5.6 Numeral width. The width of numerals shall preferably be 3/5 of the height, except for the "4", which shall be one stroke width wider, and the "1" which shall be one stroke wide.

5.5.5.7 Wide characters. Where conditions indicate the use of wider characters, as on a curved surface, or where numerals must be aligned vertically in columns, the basic height-to-width ratio may be increased to as much as 1:1.

5.5.5.8 Stroke width normal. For black characters on a white (or light) background, the stroke width shall be 1/6 to 1/7 of the height.

5.5.5.9 Stroke width, dark adaptation. Where dark adaptation is required or legibility at night is a critical factor, and white characters are specified on a black background, the stroke width of the characters shall be from 1/7 to 1/8 of the height (i.e., narrower than specified for normal daytime vision). The stroke width shall be the same for all letters and numerals of equal height.

5.5.5.10 Stroke width, transilluminated characters. For transilluminated characters, the stroke width shall be 1/10 of the height.

5.5.5.11 Character spacing. The minimum space between characters shall be one stroke width.

5.5.5.12 Word spacing. The minimum space between words shall be the width of one character.

5.5.5.13 Line spacing. The minimum space between lines shall be one-half character height.

5.5.5.14 Label size vs luminance. The height of letters and numerals shall be determined by the required reading distance and luminance. With a 710 mm (28 in) viewing distance, the height of numerals and letters shall be within the range of values in Table XII for "low" and "high" control-display luminance conditions.

5.5.5.15 Character height and viewing distance. For general dial and panel design, with the luminance normally above 3.5 cd/m^2 (1 ft-L), character height should conform to the values given below for various distances:

Viewing distance	Minimum height
a. less than 500 mm (19.7 in)	2.3 mm (0.09 in)
b. 0.5 - 1.0 m (19.7 - 39.4 in)	4.7 mm (0.18 in)
c. 1.0 - 2.0 m (39.4 - 78.7 in)	9.4 mm (0.37 in)
d. 2.0 - 4.0 m (78.7 - 157.5 in)	19 mm (0.75 in)
e. 4.0 - 8.0 m (157.4 - 315.5 in)	38 mm (1.50 in)

5.5.6 Equipment labeling.

5.5.6.1 Units, assemblies, subassemblies and parts.

5.5.6.1.1. General requirements. Each unit, assembly, subassembly and part shall be labeled with a clearly visible, legible, and meaningful name, number, code, mark or symbol, as applicable.

5.5.6.1.2 Location. The gross identifying label on a unit, assembly or major subassembly shall be located:

a. Externally in such a position that it is not obscured by adjacent items.

b. On the flattest, most uncluttered surface available.

c. On a main chassis of the equipment.

TABLE XII. LABEL SIZE VERSUS LUMINANCE

MARKINGS	HEIGHT*	
	3.5 cd/m^2 (1 ft–L) OR BELOW	ABOVE 3.5 cd/m^2 (1 ft–L)
For critical markings, with position variable (e.g., numerals on counters and settable or moving scales):	5 – 8 mm (0.20–0.31 in.)	3 – 5 mm (0.12–0.20 in.)
For critical markings, with position fixed (e.g., numerals on fixed scales, controls, and switch markings, or emergency instructions):	4 – 8 mm (0.16–0.31 in.)	2.5 – 5 mm (0.10–0.20 in.)
For noncritical markings (e.g., identification labels, routine instructions, or markings required only for familiarization):	1.3 – 5 mm (0.05–0.20 in.)	1.3 – 5 mm (0.05–0.20 in.)

*Values assume a 710 mm (28 in.) viewing distance. For a distance, D, other than 710 mm (28 in.), multiply the above values by D/710 mm (D/28 in.).

d. In a way to minimize wear or obscurement by grease, grime, or dirt.

e. In a way to preclude accidental removal, obstruction, or handling damage.

5.5.6.1.3 Terms. Equipment shall be labeled with terms descriptive of the test or measurement applicable to their test points (e.g., demodulator rather than crystal detector and power amplifier rather than bootstrap amplifier).

5.5.6.1.4 Other criteria. In addition to the criteria herein, equipment labels and placards shall conform to MIL-STD-129, MIL-STD-130, MIL-STD-195, MIL-STD-411, MIL-STD-783, MIL-STD-1247, and Requirement 67 of MIL-STD-454, as applicable.

5.5.6.2 Controls and displays.

5.5.6.2.1 General requirements. Controls and displays shall be appropriately and clearly labeled with the basic information needed for proper identification, utilization, actuation, or manipulation of the element. Integrally illuminated panels shall comply with MIL-P-7788.

5.5.6.2.2 Simplicity. Control and display labels shall convey verbal meaning in the most direct manner, by using simple words and phrases. Abbreviations may be used when they are familiar to operators (e.g., psi, km).

5.5.6.2.3 Functional labeling. Each control and display shall be labeled according to function, and the following criteria shall apply:

a. Similar names for different controls and displays shall be avoided.

b. Instruments shall be labeled in terms of what is being measured or controlled, taking into account the user and purpose.

c. Control labeling shall indicate the functional result of control movement (e.g., increase, ON, OFF) and may include calibration data where applicable. Such information shall be visible during normal operation of the control.

d. When controls and displays must be used together (in certain adjustment tasks), appropriate labels shall indicate their functional relationship. The selection and use of terminology shall be consistent.

5.5.6.2.4 Location. The following criteria shall apply to the location of control and display labels.

a. Ease of control operation shall be given priority over visibility of control position labels.

b. Labels should normally be placed above the controls and displays they describe. When the panel is above eye level, labels may be located below if label visibility will be enhanced thereby.

c. The units of measurement (e.g., volts, psi, meters) shall be labeled on the panel.

d. Labels shall be used to identify functionally grouped controls and displays. The labels shall be located above the functional groups they identify. When a line is used to enclose a functional group and define its boundaries, the label shall be centered at the top of the group either in a break in the line or just below the line. When colored pads are used, the label shall be centered at the top within the pad area.

e. Label location throughout a system and within panel groupings shall be uniform.

5.5.6.2.5 Size graduation. To reduce confusion and operator search time, labels shall be graduated in size. The characters in group labels shall be larger than those used to identify individual controls and displays. The characters identifying controls and displays shall be larger than the characters identifying control positions. With the smallest characters determined by viewing conditions, the dimensions of each character shall be at least approximately 25 percent larger than those of the next smaller label.

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5.6 Anthropometry.

5.6.1 General. Design and sizing shall insure accommodation, compatibility, operability, and maintainability by the user population. Generally, design limits shall be based upon a range from the 5th percentile female to the 95th percentile male values for critical body dimensions, as appropriate, except for Naval aviator special populations (see 5.6.4). For any body dimension, the 5th percentile value indicates that five percent of the population will be equal to or smaller than that value, and 95 percent will be larger; conversely, the 95th percentile values indicates that 95 percent of the population will be equal to or smaller than that value and five percent will be larger. Therefore, use of a design range from the 5th to 95th percentile values will theoretically provide coverage for 90 percent of the user population for that dimension. Where two or more dimensions are used simultaneously as design parameters, appropriate multivariate data and techniques should be utilized. (See Appendix for representative references.) The limited anthropometric data presented in this section in Figures 23 through 28 and Tables XIII through XVIII are intended to provide general design guidance. DOD-HDBK-743 should be consulted for more extensive data. Use of these data shall take the following into consideration:

a. The nature, frequency, safety, and difficulty of the related tasks to be performed by the operator or wearer of the equipment.

b. The position of the body during performance of these tasks.

c. Mobility or flexibility requirements imposed by these tasks.

d. Increments in the design-critical dimensions imposed by the need to compensate for obstacles, projections, etc.

e. Increments in the design-critical dimensions imposed by protective clothing or equipment, packages, lines, padding, etc.

5.6.2 Anthropometric data. The anthropometric data presented in Tables XIII through XVIII are nude body measurements; data in centimeters are given in the upper half of each table, and data in inches are shown in the lower half of each table. (Note: The anthropometric data shown in these tables have been compiled and collated from several sources. The data on Ground Troops consist of measurements on a series of 6682 U.S. Army men and a series of 2008 U.S. Marines, both measured in 1966, as well as of 287 U.S. Army men measured in 1977. The data on Aviators represent 1482 U.S. Army aviation personnel, measured in 1970; 1549 U.S. Navy pilots, measured in 1964; and 2420 U.S. Air Force flying personnel, measured in 1967. The data on military women consist of measurements of 1300 U.S. Army WAC personnel and Army nurses, measured in 1977; and 1905 U.S. Air Force WAF personnel and Air Force nurses, measured in 1968.) Blanks in the tables indicate that data are not available for those dimensions. Technical reports (see appendix) should be consulted for definitions of specified measurements, methods of data collection and

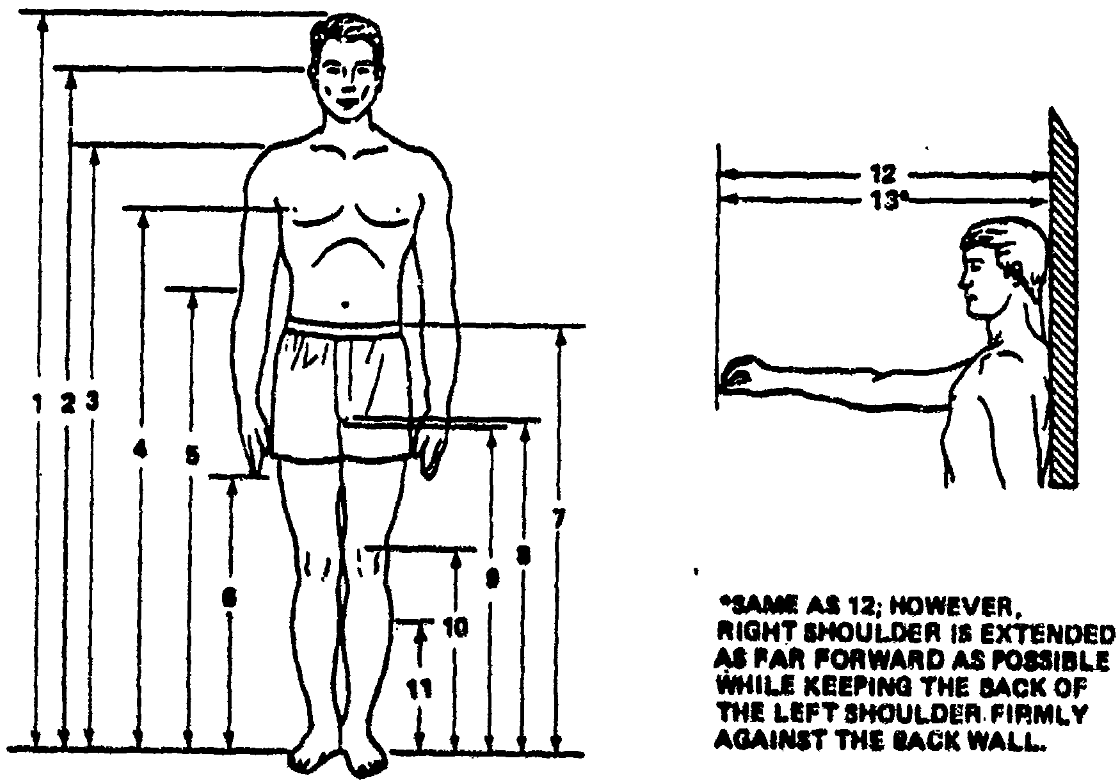

FIGURE 23. STANDING BODY DIMENSIONS

TABLE XIII. STANDING BODY DIMENSIONS

	PERCENTILE VALUES IN CENTIMETERS					
	5th PERCENTILE			95th PERCENTILE		
	GROUND TROOPS	AVIATORS	WOMEN	GROUND TROOPS	AVIATORS	WOMEN
WEIGHT (kg)	55.5	60.4	46.4	91.6	96.0	74.5
STANDING BODY DIMENSIONS						
1 STATURE	162.8	164.2	152.4	185.6	187.7	174.1
2 EYE HEIGHT (STANDING)	151.1	152.1	140.9	173.3	175.2	162.2
3 SHOULDER (ACROMIALE) HEIGHT	133.6	133.3	123.0	154.2	154.8	143.7
4 CHEST (NIPPLE) HEIGHT *	117.9	120.8	109.3	136.5	138.5	127.8
5 ELBOW (RADIALE) HEIGHT	101.0	104.8	94.9	117.8	120.0	110.7
6 FINGERTIP (DACTYLION) HEIGHT		61.5			73.2	
7 WAIST HEIGHT	96.6	97.6	93.1	115.2	115.1	110.3
8 CROTCH HEIGHT	76.3	74.7	68.1	91.8	92.0	83.9
9 GLUTEAL FURROW HEIGHT	73.3	74.6	66.4	87.7	88.1	81.0
10 KNEECAP HEIGHT	47.5	46.8	43.8	58.6	57.8	52.5
11 CALF HEIGHT	31.1	30.9	29.0	40.6	39.3	36.6
12 FUNCTIONAL REACH	72.6	73.1	64.0	90.9	87.0	80.4
13 FUNCTIONAL REACH, EXTENDED	84.2	82.3	73.5	101.2	97.3	92.7
	PERCENTILE VALUES IN INCHES					
WEIGHT (lb)	122.4	132.1	102.3	201.9	211.6	164.3
STANDING BODY DIMENSIONS						
1 STATURE	64.1	64.6	60.0	73.1	73.9	68.5
2 EYE HEIGHT (STANDING)	59.5	59.9	55.5	68.2	69.0	63.9
3 SHOULDER (ACROMIALE) HEIGHT	52.6	52.5	48.4	60.7	60.9	56.6
4 CHEST (NIPPLE) HEIGHT *	46.4	47.5	43.0	53.7	54.5	50.3
5 ELBOW (RADIALE) HEIGHT	39.8	41.3	37.4	46.4	47.2	43.6
6 FINGERTIP (DACTYLION) HEIGHT		24.2			28.8	
7 WAIST HEIGHT	38.0	38.4	36.6	45.3	45.3	43.4
8 CROTCH HEIGHT	30.0	29.4	26.8	36.1	36.2	33.0
9 GLUTEAL FURROW HEIGHT	28.8	29.4	26.2	34.5	34.7	31.9
10 KNEECAP HEIGHT	18.7	18.4	17.2	23.1	22.8	20.7
11 CALF HEIGHT	12.2	12.2	11.4	16.0	15.5	14.4
12 FUNCTIONAL REACH	28.6	28.8	25.2	35.8	34.3	31.7
13 FUNCTIONAL REACH, EXTENDED	33.2	32.4	28.9	39.8	38.3	36.5

*BUSTPOINT HEIGHT FOR WOMEN

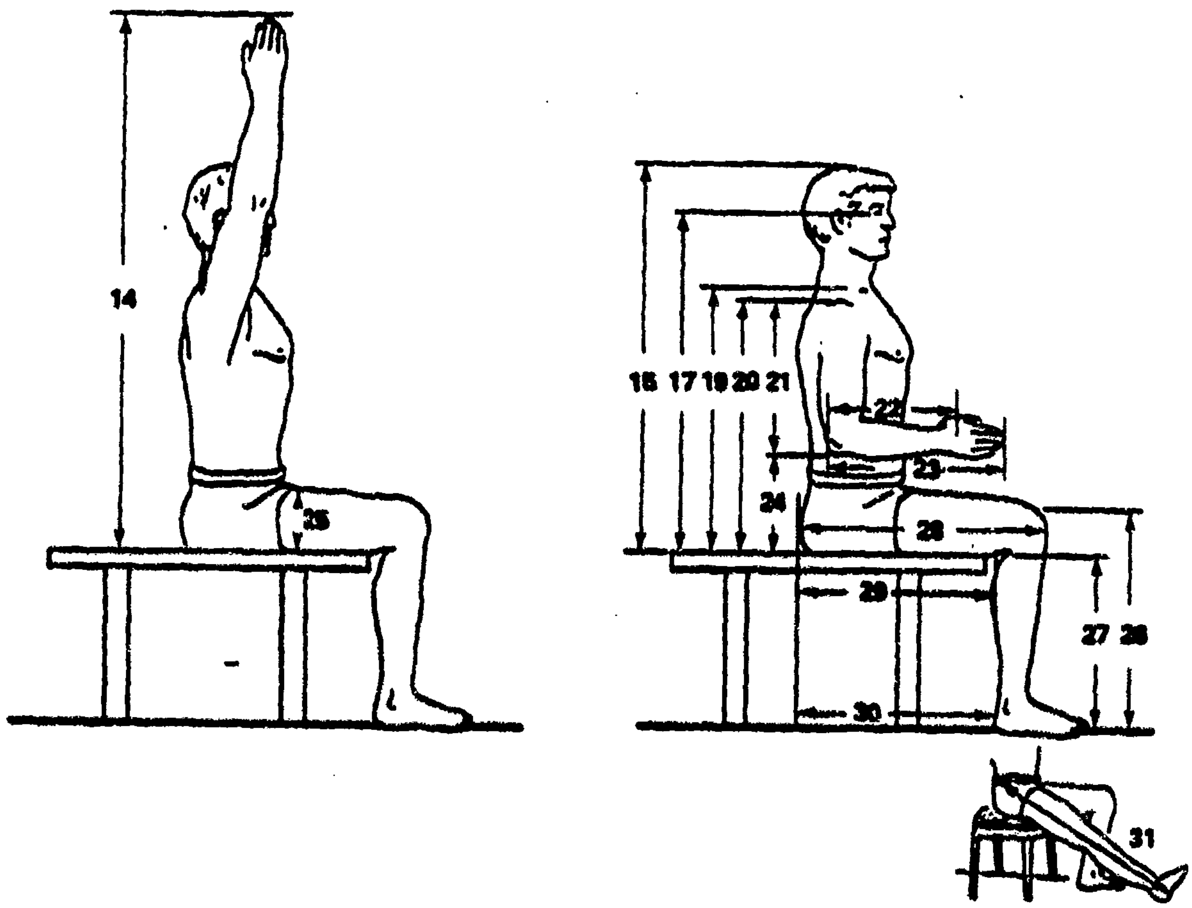

FIGURE 24. SEATED BODY DIMENSIONS

TABLE XIV. SEATED BODY DIMENSIONS

	PERCENTILE VALUES IN CENTIMETERS					
	5th PERCENTILE			95th PERCENTILE		
	GROUND TROOPS	AVIATORS	WOMEN	GROUND TROOPS	AVIATORS	WOMEN
SEATED BODY DIMENSIONS						
14 VERTICAL ARM REACH, SITTING	128.6	134.0	117.4	147.8	153.2	139.4
15 SITTING HEIGHT, ERECT	83.5	85.7	79.0	96.9	98.6	90.9
16 SITTING HEIGHT, RELAXED	81.5	83.6	77.5	94.8	96.5	89.7
17 EYE HEIGHT, SITTING ERECT	72.0	73.6	67.7	84.6	86.1	79.1
18 EYE HEIGHT, SITTING RELAXED	70.0	71.6	66.2	82.5	84.0	77.9
19 MID-SHOULDER HEIGHT	56.6	58.3	53.7	67.7	69.2	62.5
20 SHOULDER HEIGHT, SITTING	54.2	54.6	49.9	65.4	65.9	60.3
21 SHOULDER-ELBOW LENGTH	33.3	33.2	30.8	40.2	39.7	36.6
22 ELBOW-GRIP LENGTH	31.7	32.6	29.6	38.3	37.9	35.4
23 ELBOW-FINGERTIP LENGTH	43.8	44.7	40.0	52.0	51.7	47.5
24 ELBOW REST HEIGHT	17.5	18.7	16.1	28.0	29.5	26.9
25 THIGH CLEARANCE HEIGHT		12.4	10.4		18.8	17.5
26 KNEE HEIGHT, SITTING	49.7	48.9	46.9	60.2	59.9	55.5
27 POPLITEAL HEIGHT	39.7	38.4	38.0	50.0	47.7	45.7
28 BUTTOCK-KNEE LENGTH	54.9	55.9	53.1	65.8	65.5	63.2
29 BUTTOCK-POPLITEAL LENGTH	45.5	44.9	43.4	54.5	54.6	52.6
30 BUTTOCK-HEEL LENGTH		46.7			56.4	
31 FUNCTIONAL LEG LENGTH	110.6	103.9	99.6	127.7	120.4	118.6
	PERCENTILE VALUES IN INCHES					
SEATED BODY DIMENSIONS						
14 VERTICAL ARM REACH, SITTING	50.6	52.8	46.2	58.2	60.3	54.9
15 SITTING HEIGHT, ERECT	32.9	33.7	31.1	38.2	38.8	35.8
16 SITTING HEIGHT, RELAXED	32.1	32.9	30.5	37.3	38.0	35.3
17 EYE HEIGHT, SITTING ERECT	28.3	29.0	26.6	33.3	33.9	31.2
18 EYE HEIGHT, SITTING RELAXED	27.6	28.2	26.1	32.5	33.1	30.7
19 MID-SHOULDER HEIGHT	22.3	23.0	21.2	26.7	27.3	24.6
20 SHOULDER HEIGHT, SITTING	21.3	21.5	19.6	25.7	25.9	23.7
21 SHOULDER-ELBOW LENGTH	13.1	13.1	12.1	15.8	15.6	14.4
22 ELBOW-GRIP LENGTH	12.5	12.8	11.6	15.1	14.9	14.0
23 ELBOW-FINGERTIP LENGTH	17.3	17.6	15.7	20.5	20.4	18.7
24 ELBOW REST HEIGHT	6.9	7.4	6.4	11.0	11.6	10.6
25 THIGH CLEARANCE HEIGHT		4.9	4.1		7.4	6.9
26 KNEE HEIGHT, SITTING	19.6	19.3	18.5	23.7	23.6	21.8
27 POPLITEAL HEIGHT	15.6	15.1	15.0	19.7	18.8	18.0
28 BUTTOCK-KNEE LENGTH	21.6	22.0	20.9	25.9	25.8	24.9
29 BUTTOCK-POPLITEAL LENGTH	17.9	17.7	17.1	21.5	21.5	20.7
30 BUTTOCK-HEEL LENGTH		18.4			22.2	
31 FUNCTIONAL LEG LENGTH	43.5	40.9	39.2	50.3	~~47.4~~	46.7

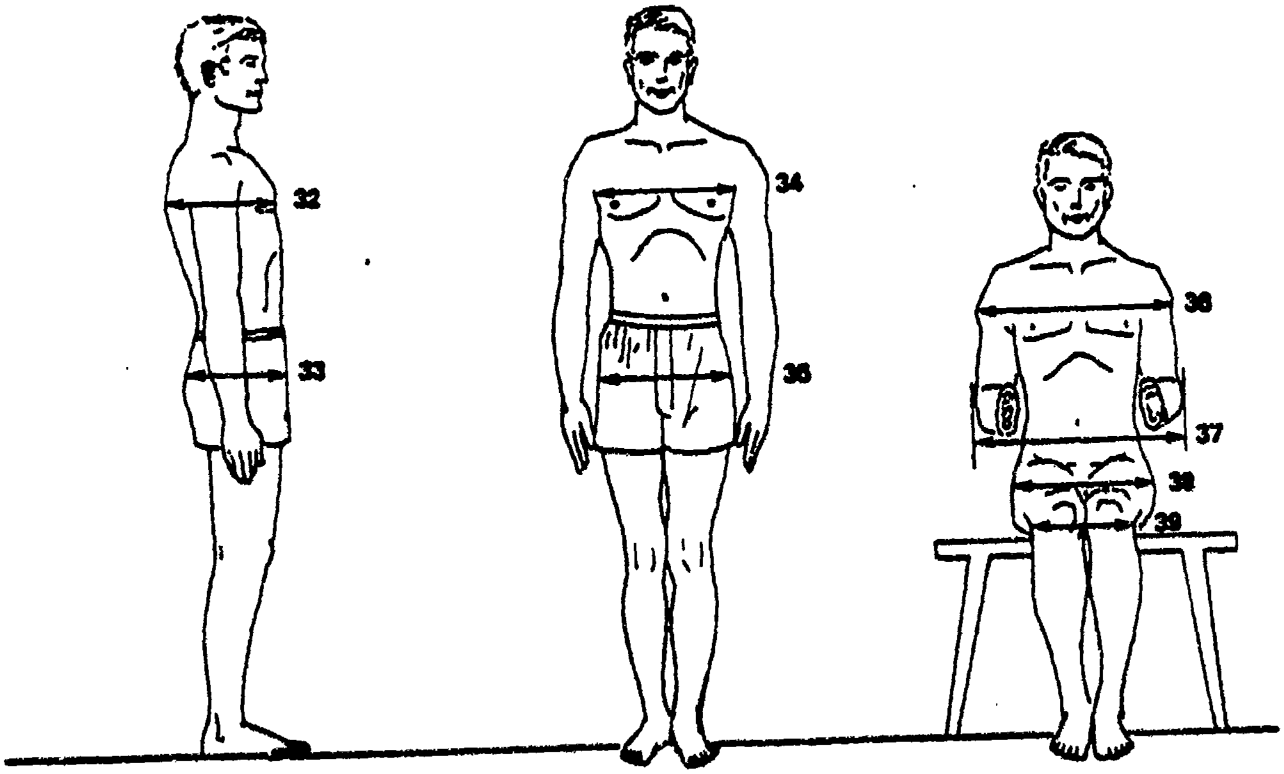

FIGURE 25. DEPTH AND BREADTH DIMENSIONS

TABLE XV. DEPTH AND BREADTH DIMENSIONS

	PERCENTILE VALUES IN CENTIMETERS					
	5th PERCENTILE			95th PERCENTILE		
DEPTH AND BREADTH DIMENSIONS	GROUND TROOPS	AVIATORS	WOMEN	GROUND TROOPS	AVIATORS	WOMEN
32 CHEST DEPTH*	18.9	20.4	19.6	26.7	27.8	27.2
33 BUTTOCK DEPTH		20.7	18.4		27.4	24.3
34 CHEST BREADTH	27.3	29.5	25.1	34.4	38.5	31.4
35 HIP BREADTH, STANDING	30.2	31.7	31.5	36.7	38.8	39.5
36 SHOULDER (BIDELTOID) BREADTH	41.5	43.2	38.2	49.8	52.6	45.8
37 FOREARM–FOREARM BREADTH	39.8	43.2	33.0	53.6	60.7	44.9
38 HIP BREADTH, SITTING	30.7	33.3	33.0	38.4	42.4	43.9
39 KNEE–TO–KNEE BREADTH		19.1			25.5	
	PERCENTILE VALUES IN INCHES					
DEPTH AND BREADTH DIMENSIONS						
32 CHEST DEPTH*	7.5	8.0	7.7	10.5	11.0	10.7
33 BUTTOCK DEPTH		8.2	7.2		10.8	9.6
34 CHEST BREADTH	10.8	11.6	9.9	13.5	15.1	12.4
35 HIP BREADTH, STANDING	11.9	12.5	12.4	14.5	15.3	15.6
36 SHOULDER (BIDELTOID) BREADTH	16.3	17.0	15.0	19.6	20.7	18.0
37 FOREARM–FOREARM BREADTH	15.7	17.0	13.0	21.1	23.9	17.7
38 HIP BREADTH, SITTING	12.1	13.1	13.0	15.1	16.7	17.3
39 KNEE–TO–KNEE BREADTH		7.5			10.0	

*BUST DEPTH FOR WOMEN

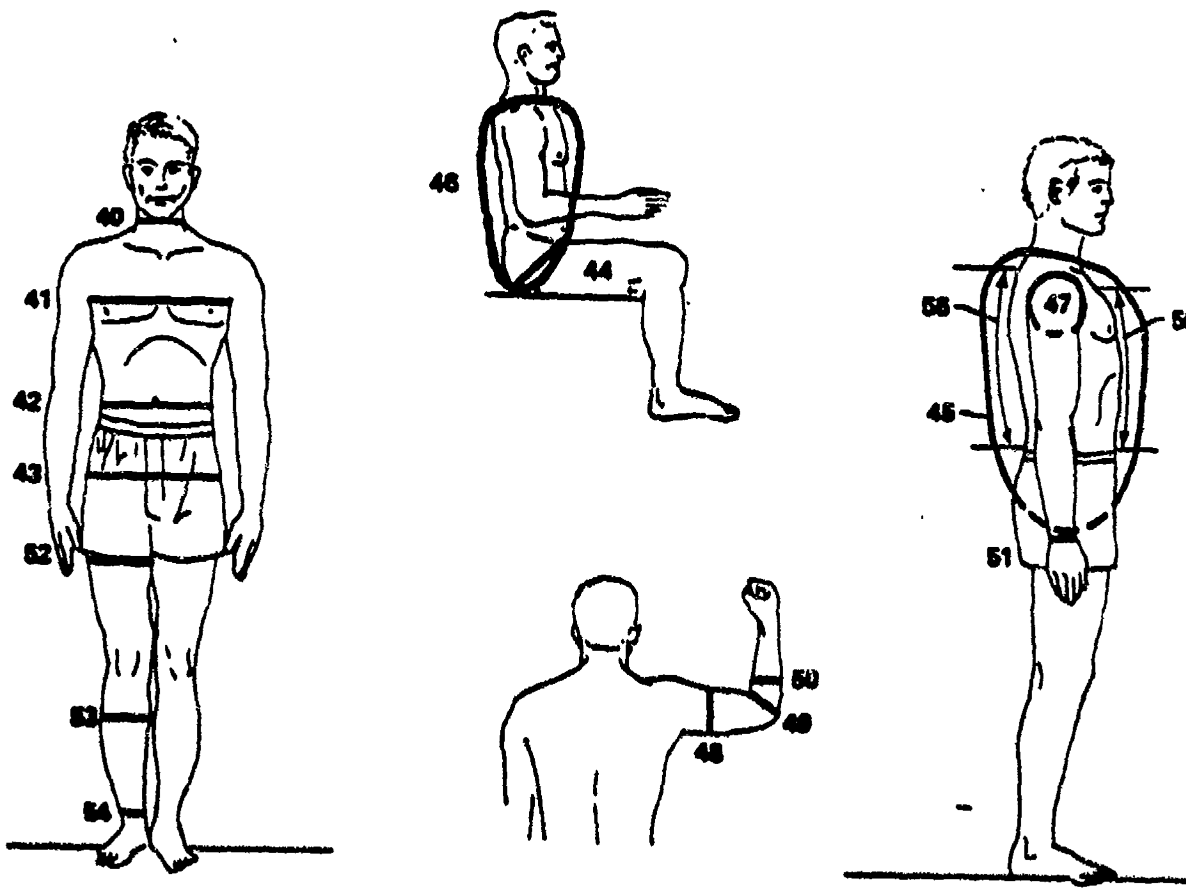

FIGURE 26. CIRCUMFERENCES AND SURFACE DIMENSIONS

TABLE XVI. CIRCUMFERENCES AND SURFACE DIMENSIONS

	PERCENTILE VALUES IN CENTIMETERS					
	5th PERCENTILE			95th PERCENTILE		
	GROUND TROOPS	AVIATORS	WOMEN	GROUND TROOPS	AVIATORS	WOMEN
CIRCUMFERENCES						
40 NECK CIRCUMFERENCE	34.2	34.6	29.9	41.0	41.6	36.7
41 CHEST CIRCUMFERENCE*	83.8	87.5	78.4	106.9	109.9	100.2
42 WAIST CIRCUMFERENCE	68.4	73.5	59.5	95.9	101.7	83.5
43 HIP CIRCUMFERENCE	85.1	87.1	85.5	106.9	108.4	106.1
44 HIP CIRCUMFERENCE, SITTING		97.0	87.7		119.3	110.8
45 VERTICAL TRUNK CIRCUMFERENCE, STANDING	150.6	156.3	142.2	178.6	181.9	166.3
46 VERTICAL TRUNK CIRCUMFERENCE, SITTING		150.4	134.8		175.0	161.0
47 ARM SCYE CIRCUMFERENCE	39.6	39.9	33.6	50.3	53.0	41.7
48 BICEPS CIRCUMFERENCE, FLEXED	27.0	27.8	23.2	37.0	36.9	30.8
49 ELBOW CIRCUMFERENCE, FLEXED		28.5	23.5		34.2	30.0
50 FOREARM CIRCUMFERENCE, FLEXED	26.1	26.3	22.2	33.1	33.1	27.5
51 WRIST CIRCUMFERENCE	15.7	15.3	13.6	18.6	19.2	16.2
52 UPPER THIGH CIRCUMFERENCE	48.1	49.6	48.7	63.9	66.9	64.5
53 CALF CIRCUMFERENCE	31.6	33.3	30.6	41.2	41.3	39.2
54 ANKLE CIRCUMFERENCE	19.3	20.0	18.7	25.2	24.8	23.3
55 WAIST BACK LENGTH	39.2	42.4	36.7	50.8	50.9	45.4
56 WAIST FRONT LENGTH	36.1	36.7	30.5	48.2	44.2	41.4
	PERCENTILE VALUES IN INCHES					
CIRCUMFERENCES						
40 NECK CIRCUMFERENCE	13.5	13.6	11.8	16.1	16.4	14.4
41 CHEST CIRCUMFERENCE*	33.0	34.4	30.8	41.7	43.3	39.5
42 WAIST CIRCUMFERENCE	26.9	28.9	23.4	37.8	40.0	32.9
43 HIP CIRCUMFERENCE	33.5	34.3	33.7	42.1	42.7	41.8
44 HIP CIRCUMFERENCE, SITTING		38.2	34.5		47.0	43.6
45 VERTICAL TRUNK CIRCUMFERENCE, STANDING	59.3	61.6	56.0	70.3	71.6	65.5
46 VERTICAL TRUNK CIRCUMFERENCE, SITTING		59.2	53.1		68.9	63.4
47 ARM SCYE CIRCUMFERENCE	15.6	15.7	13.2	19.8	20.9	16.4
48 BICEPS CIRCUMFERENCE, FLEXED	10.6	11.0	9.1	14.6	14.5	12.1
49 ELBOW CIRCUMFERENCE, FLEXED		11.2	9.2		13.5	11.8
50 FOREARM CIRCUMFERENCE, FLEXED	10.3	10.4	8.7	13.0	13.0	10.8
51 WRIST CIRCUMFERENCE	6.2	6.0	5.4	7.3	7.6	6.4
52 UPPER THIGH CIRCUMFERENCE	18.9	19.5	19.2	25.1	26.3	25.4
53 CALF CIRCUMFERENCE	12.4	13.1	12.0	16.2	16.3	15.4
54 ANKLE CIRCUMFERENCE	7.6	7.9	7.4	9.9	9.7	9.2
55 WAIST BACK LENGTH	15.4	16.7	14.4	20.0	20.0	17.9
56 WAIST FRONT LENGTH	14.2	14.1	12.0	18.2	17.4	16.3

*BUST CIRCUMFERENCE FOR WOMEN

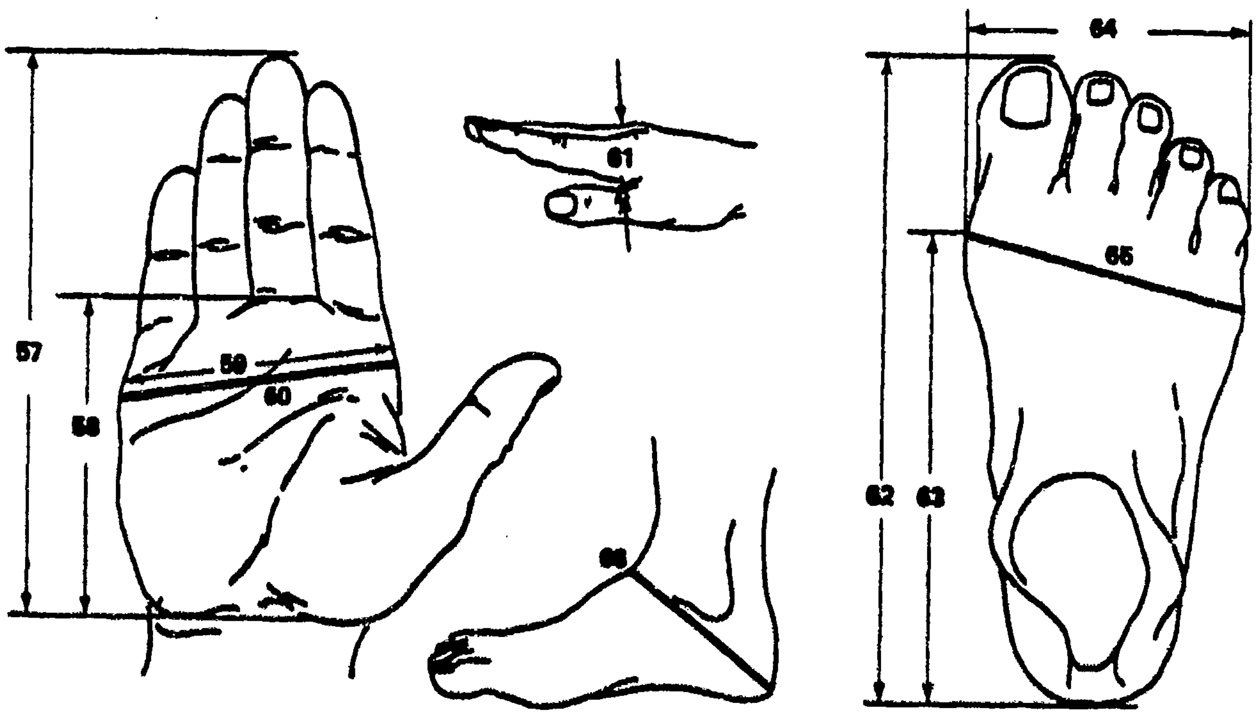

FIGURE 27. HAND AND FOOT DIMENSIONS

TABLE XVII. HAND AND FOOT DIMENSIONS

	PERCENTILE VALUES IN CENTIMETERS					
	5th PERCENTILE			95th PERCENTILE		
	GROUND TROOPS	AVIATORS	WOMEN	GROUND TROOPS	AVIATORS	WOMEN
HAND DIMENSIONS						
57 HAND LENGTH	17.4	17.7	16.1	20.7	20.7	20.0
58 PALM LENGTH	9.6	10.0	9.0	11.7	11.9	10.8
59 HAND BREADTH	8.1	8.2	6.9	9.7	9.7	8.5
60 HAND CIRCUMFERENCE	19.5	19.6	16.8	23.6	23.1	19.9
61 HAND THICKNESS		2.4			3.5	
FOOT DIMENSIONS						
62 FOOT LENGTH	24.5	24.4	22.2	29.0	29.0	26.5
63 INSTEP LENGTH	17.7	17.5	16.3	21.7	21.4	19.6
64 FOOT BREADTH	9.0	9.0	8.0	10.9	11.6	9.8
65 FOOT CIRCUMFERENCE	22.5	22.6	20.8	27.4	27.0	24.5
66 HEEL–ANKLE CIRCUMFERENCE	31.3	30.7	28.5	37.0	36.3	33.3
	PERCENTILE VALUES IN INCHES					
HAND DIMENSIONS						
57 HAND LENGTH	6.85	6.98	6.32	8.13	8.14	7.89
58 PALM LENGTH	3.77	3.92	3.56	4.61	4.69	4.24
59 HAND BREADTH	3.20	3.22	2.72	3.83	3.80	3.33
60 HAND CIRCUMFERENCE	7.68	7.71	6.62	9.28	9.11	7.82
61 HAND THICKNESS		0.96			1.37	
FOOT DIMENSIONS						
62 FOOT LENGTH	9.65	9.62	8.74	11.41	11.42	10.42
63 INSTEP LENGTH	6.97	6.88	6.41	8.54	8.42	7.70
64 FOOT BREADTH	3.53	3.54	3.16	4.29	4.58	3.84
65 FOOT CIRCUMFERENCE	8.86	8.91	8.17	10.79	10.62	9.65
66 HEEL–ANGLE CIRCUMFERENCE	12.32	12.08	11.21	14.57	14.30	13.11

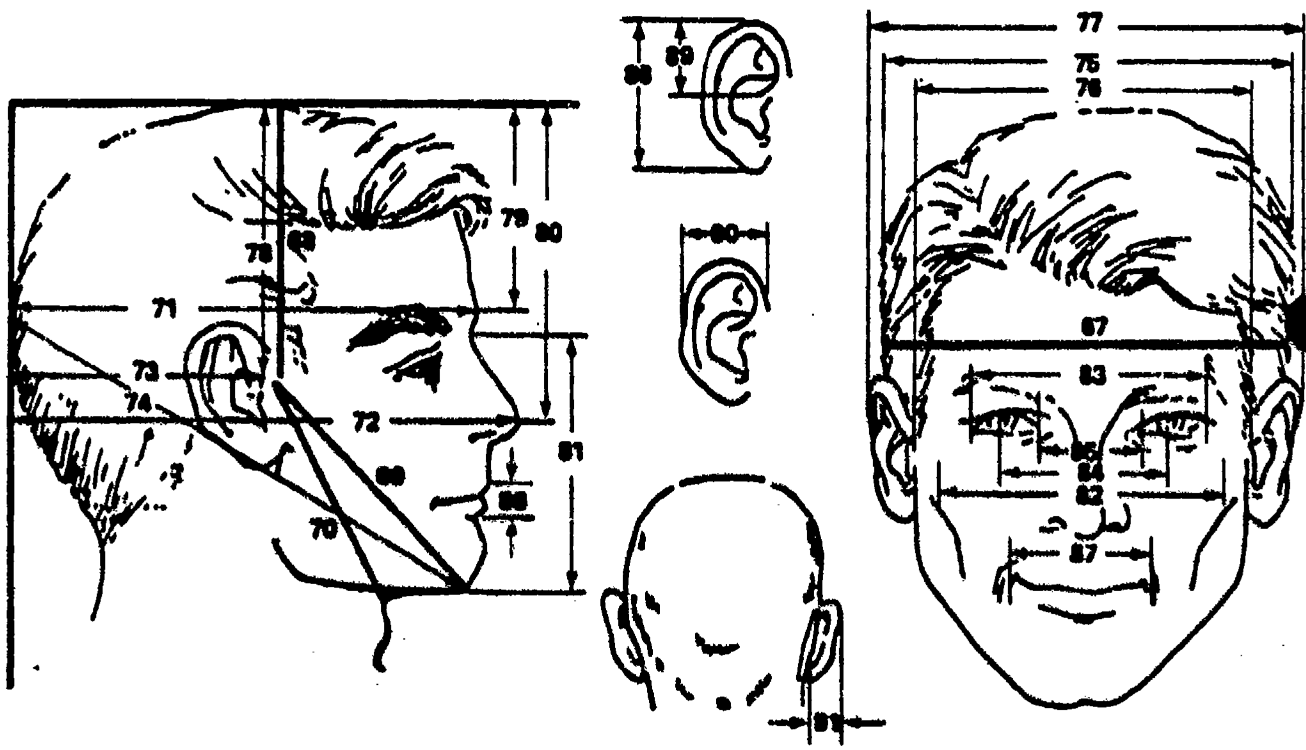

FIGURE 28. HEAD AND FACE DIMENSIONS

TABLE XVIII. HEAD AND FACE DIMENSIONS

	PERCENTILE VALUES IN CENTIMETERS					
	5th PERCENTILE			95th PERCENTILE		
	GROUND TROOPS	AVIATORS	WOMEN	GROUND TROOPS	AVIATORS	WOMEN
HEAD AND FACE DIMENSIONS						
67 HEAD CIRCUMFERENCE	53.2	53.8	52.2	58.8	59.9	57.7
68 BITRAGION-CORONAL CURVATURE	31.9	33.4	31.3	36.1	37.8	36.3
69 BITRAGION-MENTON CURVATURE	29.0	30.1	27.3	33.1	34.7	31.6
70 BITRAGION-SUBMANDIBULAR CURVATURE	26.7	28.4	24.5	30.7	33.6	28.9
71 HEAD LENGTH	18.2	18.6	17.3	20.7	21.0	19.8
72 PRONASALE TO WALL	20.8	21.4	19.7	23.5	24.1	23.2
73 TRAGION TO WALL	8.5	9.2	8.8	12.6	12.1	11.8
74 HEAD DIAGONAL (MENTON-OCCIPUT)		24.4			28.9	
75 HEAD BREADTH	14.2	14.4	13.5	16.3	16.5	15.6
76 BITRAGION BREADTH	12.5	13.1	12.1	14.5	15.2	13.8
77 BIAURICULAR BREADTH	16.5	17.5	14.2	19.4	20.2	17.4
78 HEAD HEIGHT (TRAG.-TOP OF HEAD)	11.9	12.0	11.6	14.5	14.4	14.3
79 GLABELLA TO TOP OF HEAD	8.5	7.2	7.1	9.4	10.9	9.9
80 PRONASALE TO TOP OF HEAD	11.4	13.0	11.9	15.1	16.6	16.8
81 FACE LENGTH (MENTON-SELLION)	10.6	10.2	9.6	13.1	13.0	11.8
82 FACE (BIZYGOMATIC) BREADTH	12.8	12.4	11.9	14.9	15.1	14.0
83 BIOCULAR BREADTH	8.3	8.4	8.8	10.9	10.1	10.5
84 INTERPUPILLARY BREADTH	5.1	5.3	5.1	6.8	7.0	6.5
85 INTEROCULAR BREADTH		2.7	2.7		3.8	3.7
86 LIP TO LIP LENGTH		1.1			2.3	
87 LIP-LENGTH (MOUTH BREADTH)		4.6	3.7		6.9	6.1
88 EAR LENGTH	5.5	5.9	4.5	6.9	7.3	6.0
89 EAR LENGTH ABOVE TRAGION		2.5			3.4	
90 EAR BREADTH	3.8	3.0	2.4	5.0	4.3	3.5
91 EAR PROTRUSION		1.6			2.8	

(Continued)

TABLE XVIII. HEAD AND FACE DIMENSIONS (CONCLUDED)

	PERCENTILE VALUES IN INCHES					
	5th PERCENTILE			95th PERCENTILE		
	GROUND TROOPS	AVIATORS	WOMEN	GROUND TROOPS	AVIATORS	WOMEN
HEAD AND FACE DIMENSIONS						
67 HEAD CIRCUMFERENCE	20.94	21.18	20.57	23.16	23.59	22.73
68 BITRAGION-CORONAL CURVATURE	12.56	13.14	12.31	14.21	14.80	14.29
69 BITRAGION-MENTON CURVATURE	11.42	11.86	10.74	13.03	13.66	12.45
70 BITRAGION-SUBMANDIBULAR CURVATURE	10.51	11.18	9.63	12.09	13.23	11.37
71 HEAD LENGTH	7.19	7.32	6.80	8.14	8.27	7.80
72 PRONASALE TO WALL	8.18	8.42	7.88	9.27	9.50	9.15
73 TRAGION TO WALL	3.33	3.62	3.47	4.95	4.77	4.64
74 HEAD DIAGONAL (MENTON-OCCIPUT)		9.60			10.59	
75 HEAD BREADTH	5.59	5.67	5.33	6.40	6.50	6.12
76 BITRAGION BREADTH	4.92	5.17	4.76	5.71	5.98	5.45
77 BIAURICULAR BREADTH	6.50	6.89	5.61	7.64	7.95	6.84
78 HEAD HEIGHT (TRAG.-TOP OF HEAD)	4.69	4.74	4.56	5.72	5.69	5.62
79 GLABELLA TO TOP OF HEAD	2.56	2.81	2.79	3.70	4.30	3.88
80 PRONASALE TO TOP OF HEAD	4.57	5.12	4.70	5.94	6.54	6.61
81 FACE LENGTH (MENTON-SELLION)	4.17	4.04	3.79	5.17	5.13	4.63
82 FACE (BIZYGOMATIC) BREADTH	5.04	4.87	4.69	5.88	5.94	5.53
83 BIOCULAR BREADTH	3.66	3.31	3.47	4.29	3.99	4.14
84 INTERPUPILLARY BREADTH	2.01	2.10	2.00	2.67	2.75	2.57
85 INTEROCULAR BREADTH		1.08	1.05		1.50	1.45
86 LIP TO LIP LENGTH		0.41			0.92	
87 LIP LENGTH (MOUTH BREADTH)		1.76	1.46		2.30	2.01
88 EAR LENGTH	2.17	2.31	1.77	2.72	2.88	2.34
89 EAR LENGTH ABOVE TRAGION		0.97			1.36	
90 EAR BREADTH	1.50	1.19	0.95	1.97	1.70	1.38
91 EAR PROTRUSION		0.65			1.09	

more detailed anthropometric data; definitive or more specific data should be obtained from the service agency responsible for anthropometry.

5.6.3 Use of data.

5.6.3.1 Data limitations. Because the anthropometric data presented here represent nude body measurements, suitable allowances shall be made for light or heavy clothing, flying suits, helmets, boots, body armor, load-carrying equipment, protective equipment, and other worn or carried items, when utilizing these data for design criteria.

5.6.3.2 Clearance dimensions. Clearance dimensions (e.g., for passageways and accesses), which must accommodate or allow passage of the body or parts of the body, shall be based upon the 95th percentile values for applicable body dimensions.

5.6.3.3 Limiting dimensions. Limiting dimensions (reaching distance, control movement, displays, test points, handrails, etc.) which restrict or are limited by extensions of the body shall be based upon the 5th percentile values for applicable body dimensions.

5.6.3.4 Adjustable dimensions. Seats, restraint systems, safety harnesses, belts, controls or any equipment that must be adjusted for the comfort or performance of the individual user shall be adjustable over the range of the 5th to 95th percentile values for the applicable body member(s).

5.6.3.5 Clothing and personal equipment. Clothing and personal equipment (including protective or specialized equipment worn or carried by the individual) shall be designed and sized to accommodate at least the 5th through the 95th percentile values of body dimensions. Pertinent dimensions of essential or critical equipment (e.g., aviators' helmets) shall be based on the 1st and 99th percentile values. Where two or more dimensions are used simultaneously as design parameters, appropriate multivariate data and techniques shall be utilized. (See appendix for representative references.)

5.6.4 Special populations. Where equipment will be used, inclusively or exclusively, by selected or specialized segments of the military population (e.g., Army tank crews, Navy divers, etc.) or population ranges other than the 5 -.95th percentiles (e.g., disproportionate anthropometric accommodation test cases), appropriate available anthropometric data on these specialized populations, contained in DOD-HDBK-743, shall be utilized for design and sizing criteria. Where equipment is intended for use by foreign military personnel, appropriate anthropometric data on such populations shall be utilized for design and sizing criteria. (See appendix for representative references.)

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5.7 Workspace design.

5.7.1 General. Unless otherwise noted, the following criteria apply to ground installations and, as practical, to airborne and shipboard installations.

5.7.1.1 Kick space. All cabinets, consoles, and work surfaces that require an operator to stand or sit close to their front surfaces shall contain a kick space at the base at least 100 mm (4 inches) deep and 100 mm (4 inches) high to allow for protective or specialized apparel.

5.7.1.2 Handles. Handles on cabinets and consoles shall be recessed whenever practicable, to eliminate projections on the surface. If handles cannot be recessed, they shall be designed such that they shall neither injure personnel nor entangle clothing or equipment.

5.7.1.3 Work space. Whenever feasible, free floor space of at least 1.220 m (4 feet) shall be provided in front of each console. For equipment racks that require maintenance, free floor space shall be provided in accordance with the following criteria.

5.7.1.3.1 Depth of work area. Clearance from the front of the rack to the nearest facing surface or obstacle shall not be less than 1.070 m (42 inches). The minimum space between rows of cabinets shall be 200 mm (8 inches) greater than the depth of the deepest drawer (equipment).

5.7.1.3.2 Lateral work space. The minimum lateral workspace for racks having drawers or removable equipment shall be as follows (measured from the drawers or equipment in the extended position):

a. For racks having drawers or removable items weighing less than 20 kg (44 pounds): 460 mm (18 inches) on one side and 100 mm (4 inches) on the other.

b. For racks having drawers or removable items weighing over 20 kg (44 pounds): 460 mm (18 inches) on each side.

5.7.1.3.3 Space between rows of cabinets. The minimum space between rows of cabinets shall be 200 mm (8 inches) greater than the depth of the deepest drawer or cabinet.

5.7.1.3.4 Storage space. Adequate and suitable space shall be provided on consoles or immediate work space for the storage of manuals, worksheets, and other materials that are required for use by the operational or maintenance personnel.

5.7.2 Standing operations

5.7.2.1 Work surface. Unless otherwise specified, work surfaces to support job instruction manuals, worksheets, etc., shall be 915 ±15 mm (36 ±0.6 inches) above the floor.

5.7.2.2 Display placement, normal. Visual displays mounted on vertical panels and used in normal equipment operation shall be placed between 1.040 m (41 inches) and 1.780 m (70 inches) above the standing surface.

5.7.2.3 Display placement, special. Displays requiring precise and frequent reading shall be placed between 1.270 m (50 inches) and 1.650 m (65 inches) above the standing surface.

5.7.2.4 Control placement, normal. All controls mounted on a vertical surface and used in normal equipment operation shall be located between 860 mm and 1.780 m (34 and 70 inches) above the standing surface.

5.7.2.5 Control placement, special. Controls requiring precise or frequent operation and emergency controls shall be mounted between 860 mm and 1.350 m (34 and 53 inches) above the standing surface and no farther than 530 mm (21 inches) laterally from the centerline.

5.7.3 Seated operations.

5.7.3.1 Work surface width and depth. A lateral workspace of at least 760 mm (30 inches) wide and 400 mm (16 inches) deep shall be provided whenever practicable.

5.7.3.2 Work surface height. Desk tops and writing tables shall be 740 to 790 mm (29 to 31 inches) above the floor, unless otherwise specified.

5.7.3.3 Writing surfaces. Where a writing surface is required on equipment consoles, it shall be at least 400 mm (16 inches) deep and should be 610 mm (24 inches) wide, when consistent with operator reach requirements.

5.7.3.4 Seating.

5.7.3.4.1 Compatibility. Work seating shall provide an adequate supporting framework for the body relative to the activities that must be carried out. Chairs to be used with sit-down consoles shall be designed to be operationally compatible with the console configuration.

5.7.3.4.2 Vertical adjustment. Provision shall be made for vertical seat adjustment from 380 to 535 mm (15 to 21 inches) in increments of no more than 25 mm (1 inch) each.

5.7.3.4.3 Backrest. A supporting backrest that reclines between 1745 and 2005 mrad (100 and 115 degrees) shall be provided. The backrest shall engage the lumbar and thoracic regions of the back, and shall support the torso in such a position that the operator's eyes can be brought to the "Eye Line" with no more than 75 mm (3 inches) of forward body movement.

5.7.3.4.4 Cushioning. Where applicable, both the backrest and seat shall be cushioned with at least 25 mm (1 inch) of compressible material and provided with a smooth surface.

5.7.3.4.5 Armrests. Unless otherwise specified, armrests shall be provided. Armrests that are integral with operators' chairs shall be at least 50 mm (2 inches) wide and 200 mm (8 inches) long. Modified or retractable armrests shall be provided when necessary to maintain compatibility with an associated console and shall be adjustable from 190 to 280 mm (7.5 to 11 inches) above the compressed sitting surface.

5.7.3.5 Knee room. Knee and foot room that equals or exceeds the following minimum dimensions shall be provided beneath work surfaces:

a. Height: 640 mm (25 inches). If a fixed footrest or a foot-operated control is provided, this dimension shall be increased accordingly.

b. Width: 510 mm (20 inches)

c. Depth: 460 mm (18 inches)

5.7.3.6 Display placement, normal. Visual displays mounted on vertical panels and used in normal equipment operation shall be placed in an area between 150 and 1170 mm (6 and 46 inches) above the sitting surface.

5.7.3.7 Display placement, special. Indicators that must be read precisely and frequently shall be placed in an area between 360 and 890 mm (14 and 35 inches) above the sitting surface, and no further than 530 mm (21 inches) laterally from the centerline.

5.7.3.8 Warning displays. For "sit" consoles requiring horizontal vision over the top, critical visual warning displays shall be mounted at least 570 mm (22.5 inches) above the sitting surface.

5.7.3.9 Control placement, normal. All controls mounted on a vertical surface and used in normal equipment operation shall be located between 200 and 860 mm (8 and 34 inches) above the sitting surface.

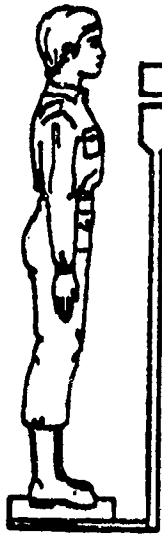
5.7.3.10 Control placement, special. Controls requiring precise or frequent operation shall be mounted between 200 and 740 mm (8 and 29 inches) above the sitting surface.

5.7.4 Common working positions. Anthropometric data for the design and sizing of workspaces involving standing, sitting, stooping, kneeling and supine positions are presented in Table XIX and illustrated in Figure 29. Fifth and 95th percentile values for men and women are given for various body dimensions in both centimeters and inches. (The data are based on measurements of 300 Army women and 106 Army men in 1977; therefore, differences in several measurements common to Table XIX and tables of para 5.6 should be resolved in favor of the latter tables. Information on other "Anthropometry of Common Working Positions" may be found in the reference so titled in the Appendix.) Suitable allowances should be made for heavy clothing or protective equipment when required. In no case shall clearance dimensions be less than the 95th percentile values for men or limiting dimensions be more than the 5th percentile values for women, shown in Table XIX.

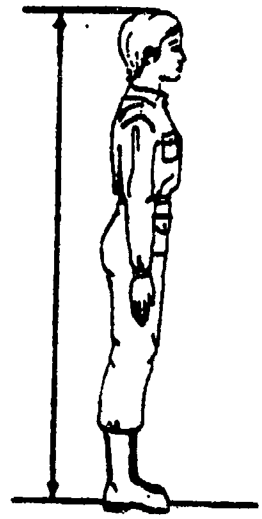
TABLE XIX. ANTHROPOMETRIC DATA FOR COMMON WORKING POSITIONS

*	PERCENTILE VALUES IN CENTIMETERS			
	5th PERCENTILE		95th PERCENTILE	
	MEN	WOMEN	MEN	WOMEN
1. WEIGHT – CLOTHED (KILOGRAMS)	58.6	48.8	90.2	74.6
2. STATURE – CLOTHED	168.5	156.8	189.0	178.7
3. FUNCTIONAL REACH	72.6	64.0	86.4	79.0
4. FUNCTIONAL REACH, EXTENDED	84.2	73.5	101.2	92.7
5. OVERHEAD REACH HEIGHT	200.4	185.3	230.5	215.1
6. OVERHEAD REACH BREADTH	35.2	31.5	41.9	37.9
7. BENT TORSO HEIGHT	125.6	112.7	149.8	138.6
8. BENT TORSO BREADTH	40.9	36.8	48.3	43.5
9. OVERHEAD REACH, SITTING	127.9	117.4	146.9	139.4
10. FUNCTIONAL LEG LENGTH	110.6	99.6	127.7	118.6
11. KNEELING HEIGHT	121.9	114.5	136.9	130.3
12. KNEELING LEG LENGTH	63.9	59.2	75.5	70.5
13. BENT KNEE HEIGHT, SUPINE	44.7	41.3	53.5	49.6
14. HORIZONTAL LENGTH, KNEES BENT	150.8	140.3	173.0	163.8
	PERCENTILE VALUES IN INCHES			
1. WEIGHT – CLOTHED (POUNDS)	129.1	107.6	198.8	164.5
2. STATURE – CLOTHED	66.4	61.8	74.4	70.3
3. FUNCTIONAL REACH	28.6	25.2	34.0	31.1
4. FUNCTIONAL REACH, EXTENDED	33.2	28.9	39.8	36.5
5. OVERHEAD REACH HEIGHT	78.9	73.0	90.8	84.7
6. OVERHEAD REACH BREADTH	13.9	12.4	16.5	14.9
7. BENT TORSO HEIGHT	49.4	44.4	59.0	54.6
8. BENT TORSO BREADTH	16.1	14.5	19.0	17.1
9. OVERHEAD REACH, SITTING	50.3	46.2	57.9	54.9
10. FUNCTIONAL LEG LENGTH	43.5	39.2	50.3	46.7
11. KNEELING HEIGHT	48.0	45.1	53.9	51.3
12. KNEELING LEG LENGTH	25.2	23.3	29.7	27.8
13. BENT KNEE HEIGHT, SUPINE	17.6	16.3	21.1	19.5
14. HORIZONTAL LENGTH, KNEES BENT	59.4	55.2	68.1	64.5

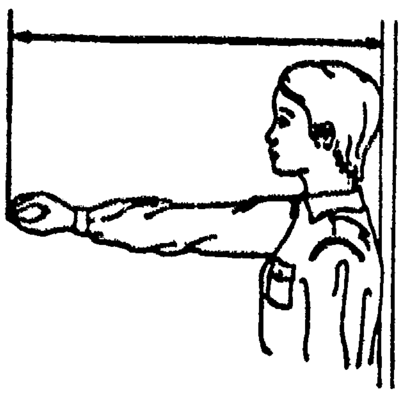
*See Figure 28 for illustration of each measurement.



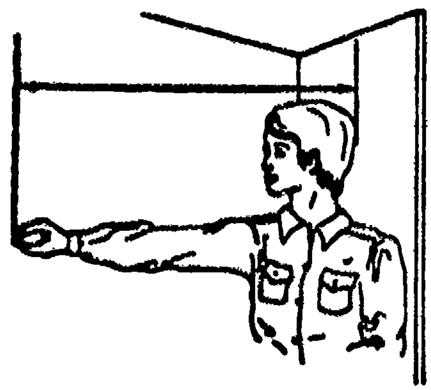
① WEIGHT (CLOTHED) WEARING FATIGUES & COMBAT BOOTS; STANDING IN CENTER OF SCALE



② STATURE (CLOTHED) STANDING ERECT; HEELS TOGETHER; WEIGHT DISTRIBUTED EQUALLY ON BOTH FEET. MEASURED FROM STANDING SURFACE TO TOP OF HEAD.

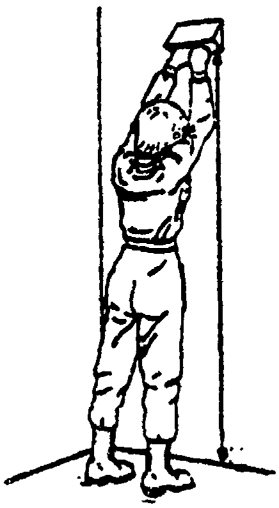


③ FUNCTIONAL REACH – STANDING ERECT; LOOKING STRAIGHT AHEAD; BOTH SHOULDERS AGAINST WALL; RIGHT ARM HORIZONTAL. MEASURED FROM WALL TO TIP OF INDEX FINGER

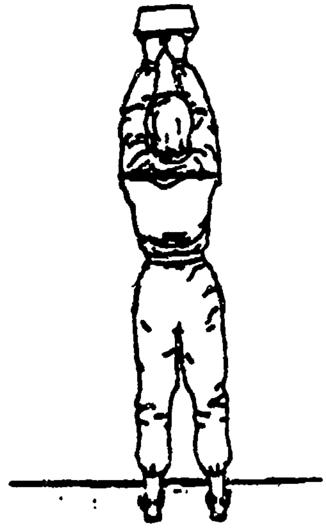


④ FUNCTIONAL REACH, EXTENDED– STANDING ERECT; LOOKING STRAIGHT AHEAD; RIGHT SHOULDER EXTENDED AS FAR FORWARD AS POSSIBLE WHILE BACK OF LEFT SHOULDER FIRMLY AGAINST WALL; ARM HORIZONTAL. MEASURED FROM WALL TO TIP OF INDEX FINGER.

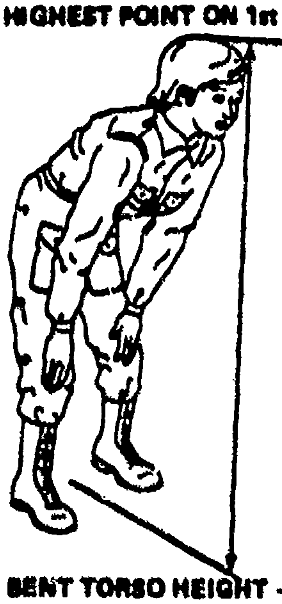
FIGURE 29. ANTHROPOMETRIC DATA FOR WORKSPACES



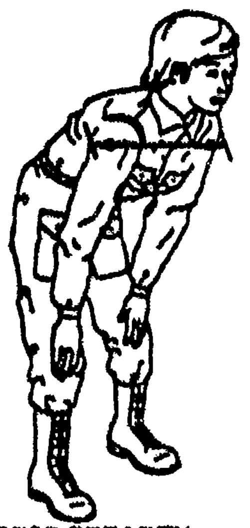
(5) OVERHEAD REACH HEIGHT – STANDING WITH HEELS 23 cm APART AND TOES 15 cm FROM WALL; ARMS EXTENDED OVERHEAD WITH FISTS TOUCHING AND AGAINST WALL; 1st PHALANGES HORIZONTAL. MEASURED FROM FLOOR TO HIGHEST POINT ON 1st PHALANGES



(6) OVERHEAD REACH BREADTH – STANDING WITH HEELS 23 cm APART AND TOES 15 cm FROM WALL; ARMS EXTENDED OVERHEAD WITH FISTS TOUCHING AND AGAINST WALL; 1st PHALANGES HORIZONTAL. MEASURED HORIZONTALLY ACROSS ARMS OR SHOULDERS, WHICHEVER IS WIDER.



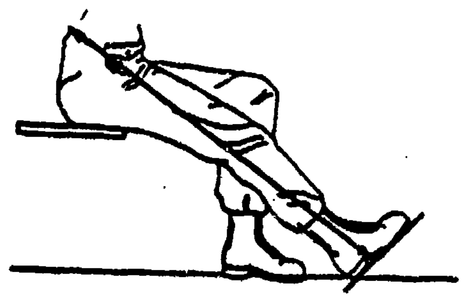
(7) BENT TORSO HEIGHT – STANDING WITH FEET 30 cm APART; BENDING OVER AND PLACING PALMS OF THE HANDS ON KNEECAPS; ELBOWS AND KNEES LOCKED; LOOKING FORWARD; HEAD TILTED AS FAR BACK AS POSSIBLE. MEASURED FROM FLOOR TO TOP OF HEAD.



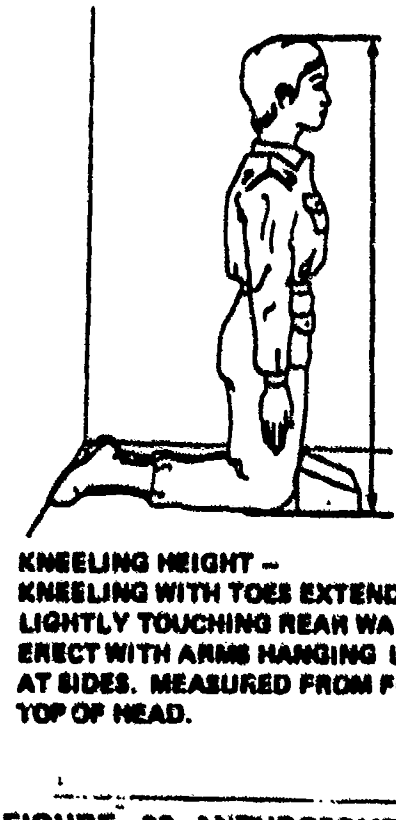
(8) BENT TORSO BREADTH – STANDING WITH FEET 30 cm APART; BENDING OVER AND PLACING THE PALMS OF THE HANDS ON KNEECAPS; ELBOWS AND KNEES LOCKED; LOOKING FORWARD; HEAD TILTED AS FAR BACK AS POSSIBLE. MEASURED AS MAXIMUM HORIZONTAL DISTANCE ACROSS SHOULDERS.

FIGURE 29. ANTHROPOMETRIC DATA FOR WORKSPACES (CONTINUED)

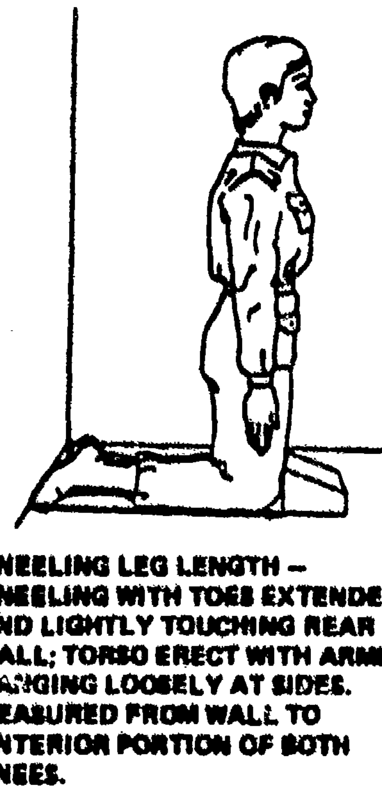
(9) OVERHEAD REACH, SITTING – SITTING ERECT; RIGHT SIDE AGAINST WALL; RIGHT ARM EXTENDED UPWARD WITH PALM FLAT AGAINST WALL AND FINGERS EXTENDED. MEASURED FROM SITTING SURFACE TO TIP OF MIDDLE FINGER.



(10) FUNCTIONAL LEG LENGTH – SITTING ERECT ON EDGE OF CHAIR; RIGHT LEG EXTENDED FORWARD WITH KNEE STRAIGHTENED. MEASURED FROM HEEL ALONG AXIS OF LEG TO POSTERIOR WAIST.

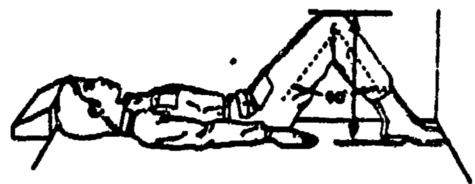


(11) KNEELING HEIGHT – KNEELING WITH TOES EXTENDED AND LIGHTLY TOUCHING REAR WALL; TORSO ERECT WITH ARMS HANGING LOOSELY AT SIDES. MEASURED FROM FLOOR TO TOP OF HEAD.

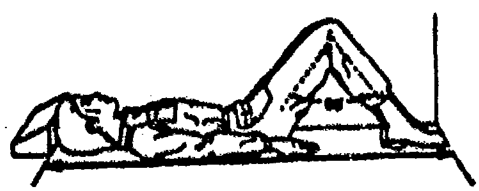


(12) KNEELING LEG LENGTH – KNEELING WITH TOES EXTENDED AND LIGHTLY TOUCHING REAR WALL; TORSO ERECT WITH ARMS HANGING LOOSELY AT SIDES. MEASURED FROM WALL TO ANTERIOR PORTION OF BOTH KNEES.

FIGURE 29. ANTHROPOMETRIC DATA FOR WORKSPACES (CONTINUED)



(13) BENT KNEE HEIGHT, SUPINE –
LYING SUPINE; KNEES RAISED UNTIL ANGLE BETWEEN UPPER AND LOWER LEGS APPROXIMATES 60°; TOES LIGHTLY TOUCHING WALL. MEASURED FROM FLOOR TO HIGHEST POINT ON KNEES.



(14) HORIZONTAL LENGTH, KNEES BENT –
LYING SUPINE; KNEES RAISED UNTIL ANGLE BETWEEN UPPER AND LOWER LEGS APPROXIMATES 60°; TOES LIGHTLY TOUCHING WALL. MEASURED FROM WALL TO TOP OF HEAD.

FIGURE 29. ANTHROPOMETRIC DATA FOR WORKSPACES (CONCLUDED)

5.7.5 Standard console design.

5.7.5.1 Dimensions. For purposes of standardization, consoles and the units and racks which constitute operator work stations should be designed to conform with the dimensions shown in Table XX and Figure 30.

5.7.5.2 Configurations. The configurations represented in Table XX and Figure 30 may not be applicable to all design situations. In some cases, however, operational requirements may necessitate unique design solutions. Because of the benefits and economies inherent in a standard console, design should conform with the standard configurations.

5.7.5.3 Variables. The selected console design should accommodate the following requirements, as applicable:

a. Visibility over the top of the console.

b. Operator mobility (e.g., "sit", "stand", or "sit-stand" requirements).

c. Panel space. (Note columns "B" and "E", Table XX)

d. Volume in the area below the writing surface.

5.7.5.4 Console selection. On the basis of the considerations in 5.7.5.3, the particular configuration that will best meet the requirements should be selected from among the five console types represented in Table XX.

5.7.6 Special-purpose console design.

5.7.6.1 Horizontal wrap-around. (Figure 31)

5.7.6.1.1 Panel width. When requirements for preferred panel space for a single seated operator exceed a panel width of 1.120 m (44 inches), a flat-surface, segmented, wrap-around console should be provided, so as to place all controls within the reach of the 5th percentile stationary operator.

5.7.6.1.2 Panel angle. The left and right segments should be placed at an angle, measured from the frontal plane of the central segment, such that they can be reached by the 5th percentile stationary operator.

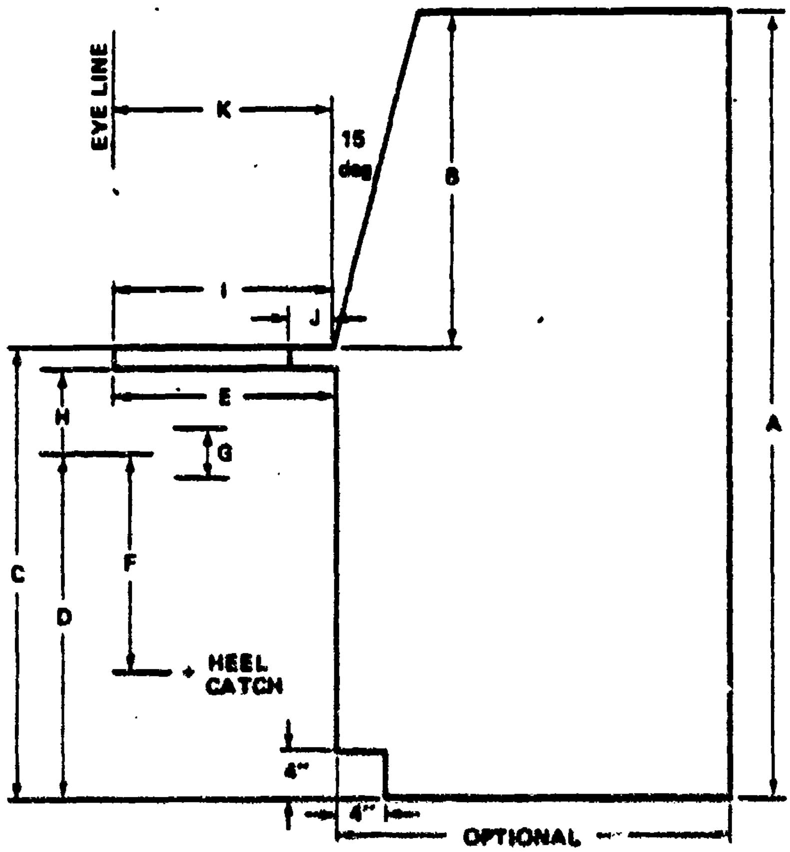
5.7.6.1.3 Dimensions (vision over top). Where vision over the top is required (thereby limiting vertical panel space), the width of the central segment shall not exceed 1.120 m (44 inches), and that of the left and right segments shall not exceed 610 mm (24 inches).

5.7.6.1.4 Dimensions. Where vision over the top is not required, i.e., the total console height may exceed the seat height by more than 685 mm (27 inches), the width of the central segment shall not exceed 860 mm (34 inches), and that of the left and right segments should not exceed 610 mm (24 inches).

TABLE XX. STANDARD CONSOLE DIMENSIONS

TYPE OF CONSOLE	MAXIMUM TOTAL CONSOLE HEIGHT FROM STANDING SURFACE	SUGGESTED VERTICAL DIMENSION OF PANEL (INCLUDING SILLS)	WRITING SURFACE: SHELF HEIGHT FROM STANDING SURFACE	SEAT HEIGHT FROM STANDING SURFACE AT MIDPOINT OF G	MAXIMUM CONSOLE WIDTH (NOT SHOWN)
	A	B	C	D	
1. SIT (W/VISION OVER TOP)*	1.170 m (46 in.)	520 mm (20.5 in.)	650 mm (25.5 in.)	435 mm (17 in.)	1.120 m (44 in.)
	1.335 m (52.5 in.)	520 mm (20.5 in.)	810 mm (32 in.)	595 mm (23.5 in.)	1.120 m (44 in.)
	1.435 m (56.5 in.)	520 mm (20.5 in.)	910 mm (36 in.)	695 mm (27.5 in.)	1.120 m (44 in.)
2. SIT (W/O VISION OVER TOP)	1.310 m (51.5 in.)	660 mm (26 in.)	650 mm (25.5 in.)	435 mm (17 in.)	910 mm (36 in.)
	1.470 m (58.0 in.)	660 mm (26 in.)	810 mm (32 in.)	595 mm (23.5 in.)	910 mm (36 in.)
	1.570 m (62.0 in.)	660 mm (26 in.)	910 mm (36 in.)	695 mm (27.5 in.)	910 mm (36 in.)
3. SIT-STAND (W/STANDING VISION OVER TOP)	1.535 m (60.5 in.)	620 mm (24.5 in.)	910 mm (36 in.)	695 mm (27.5 in.)	910 mm (36 in.)
4. STAND (W/VISION OVER TOP)	1.535 m (60.5 in.)	620 mm (24.5 in.)	910 mm (36 in.)	NA	1.120 m (44 in.)
5. STAND (W/O VISION OVER TOP)	1.830 m (72 in.)	910 mm (36 in.)	910 mm (36 in.)	NA	910 mm (36 in.)

*THE RANGE IN "A" IS PROVIDED TO ALLOW LATITUDE IN THE VOLUME OF THE LOWER PART OF THE CONSOLE; NOTE RELATIONSHIP TO "C" AND "D".



KEY	DIMENSIONS	mm	(in.)
A	MAXIMUM TOTAL CONSOLE HEIGHT FROM STANDING SURFACE	SEE TABLE XX	SEE TABLE XX
B	SUGGESTED VERTICAL DIMENSION OF PANEL, INCL SILLS	SEE TABLE XX	SEE TABLE XX
C	WRITING SURFACE: SHELF HEIGHT FROM STANDING SURFACE	SEE TABLE XX	SEE TABLE XX
D	SEAT HEIGHT FROM STANDING SURFACE AT MIDPOINT OF "G"	SEE TABLE XX	SEE TABLE XX
E*	MINIMUM KNEE CLEARANCE	(460)	18
F*	FOOT SUPPORT TO SITTING SURFACE **	(460)	18
G*	SEAT ADJUSTABILITY	(150)	6
H*	MINIMUM THIGH CLEARANCE AT MIDPOINT OF "G"	(190)	7.5
I	WRITING SURFACE DEPTH INCLUDING SHELF	(400)	16
J	MINIMUM SHELF DEPTH	(100)	4
K	EYE LINE-TO-CONSOLE FRONT DISTANCE	(400)	16

*NOT APPLICABLE TO CONSOLE TYPES 4 AND 5 OF TABLE XX.

**SINCE THIS DIMENSION MUST NOT BE EXCEEDED, A HEEL CATCH MUST BE ADDED TO THE CHAIR IF "D" EXCEEDS 460 mm (18 in.).

NOTE: A SHELF THICKNESS OF 25 mm (1 in.) IS ASSUMED. FOR OTHER SHELF THICKNESSES, SUITABLE ADJUSTMENTS SHOULD BE MADE.

FIGURE 30. STANDARD CONSOLE DIMENSIONS KEY

5.7.6.1.5 Viewing angle. The total required left-to-right viewing angle shall not exceed 190 degrees (see Figure 2). This angle should be reduced whenever possible through appropriate control-display layout.

5.7.6.2 Vertical/stacked segments. (See Figure 32 for example.)

5.7.6.2.1 Panel division. Where direct forward vision over the top of the console is not required by a seated operator, and when lateral space is limited, the panel shall be divided into three vertical/stacked segments whose surfaces should be perpendicular to the operator's line of sight with little or no head movement.

5.7.6.2.2 Height. The center of the central segment should be 800 mm (31.5 inches) above the seat reference point. The height of this segment shall not exceed 530 mm (21 inches).

5.7.6.3 Sit-stand consoles. Where personnel will work from standing or seated positions, console dimensions should conform to those of Table XX.

5.7.7 Stairs, stair-ladders, fixed ladders, and ramps.

5.7.7.1 General criteria.

5.7.7.1.1 Selection. The selection of stairs, stair-ladders, fixed ladders, or ramps for specific applications shall be based on the angle of ascent required and the criteria in Figure 33.

5.7.7.1.2 Provision for hand-carrying equipment. Ramps, elevators, or equivalent means should be provided when equipment must be hand carried. Ladders shall not be selected in such cases, since both hands should be free to grasp the ladder. Stairs and steps should not be used where hand-carrying bulky loads or loads in excess of 13 kg (29 lbs) is required.

5.7.7.1.3 Handrails and guardrails. Stairs, stair-ladders, fixed ladders, and ramps should be equipped with a handrail on each side. Where one or both sides are open, appropriate intermediate guardrails shall be provided to prevent personnel injury. Non-fixed vehicular-boarding ladders are neither stair ladders nor fixed ladders and are exempt from this requirement. Ladders shall not be selected in such cases, since both hands should be free to grasp the ladder. Stairs and steps should not be used where hand-carrying bulky loads or loads in excess of 13 kg (29 lbs) is required.

5.7.7.2 Stairs. Stair dimensions should conform with the recommended values and shall be within the minimum and maximum limits of Figure 34.

5.7.7.3 Stair ladders. Stair ladder dimensions should conform with the recommended values and shall be within the specified minimum and maximum limits of Figure 35. The tread rise shall be open at the rear. Landings should be provided every tenth or twelfth tread. The surface of treads on exterior stair ladders should be constructed of open grating material or should be treated with nonskid material conforming with specification

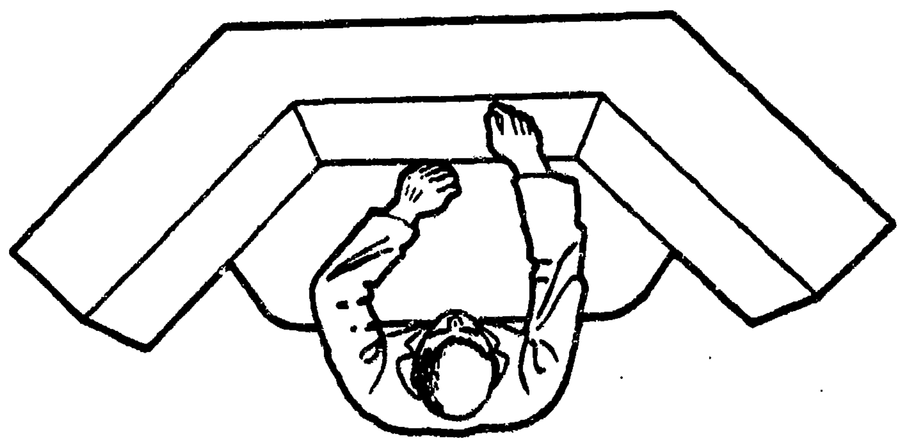


FIGURE 31. EXAMPLE OF HORIZONTAL WRAP-AROUND CONSOLE

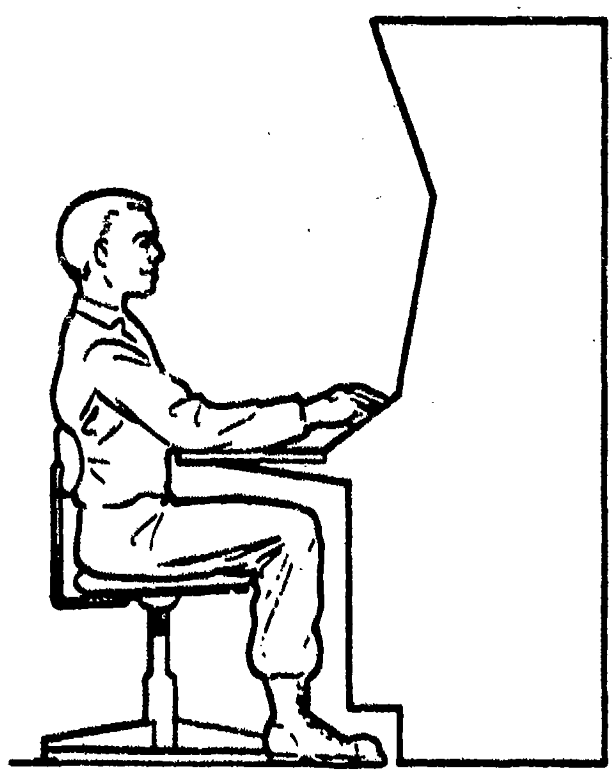


FIGURE 32. EXAMPLE OF VERTICAL/STACKED SEGMENTS

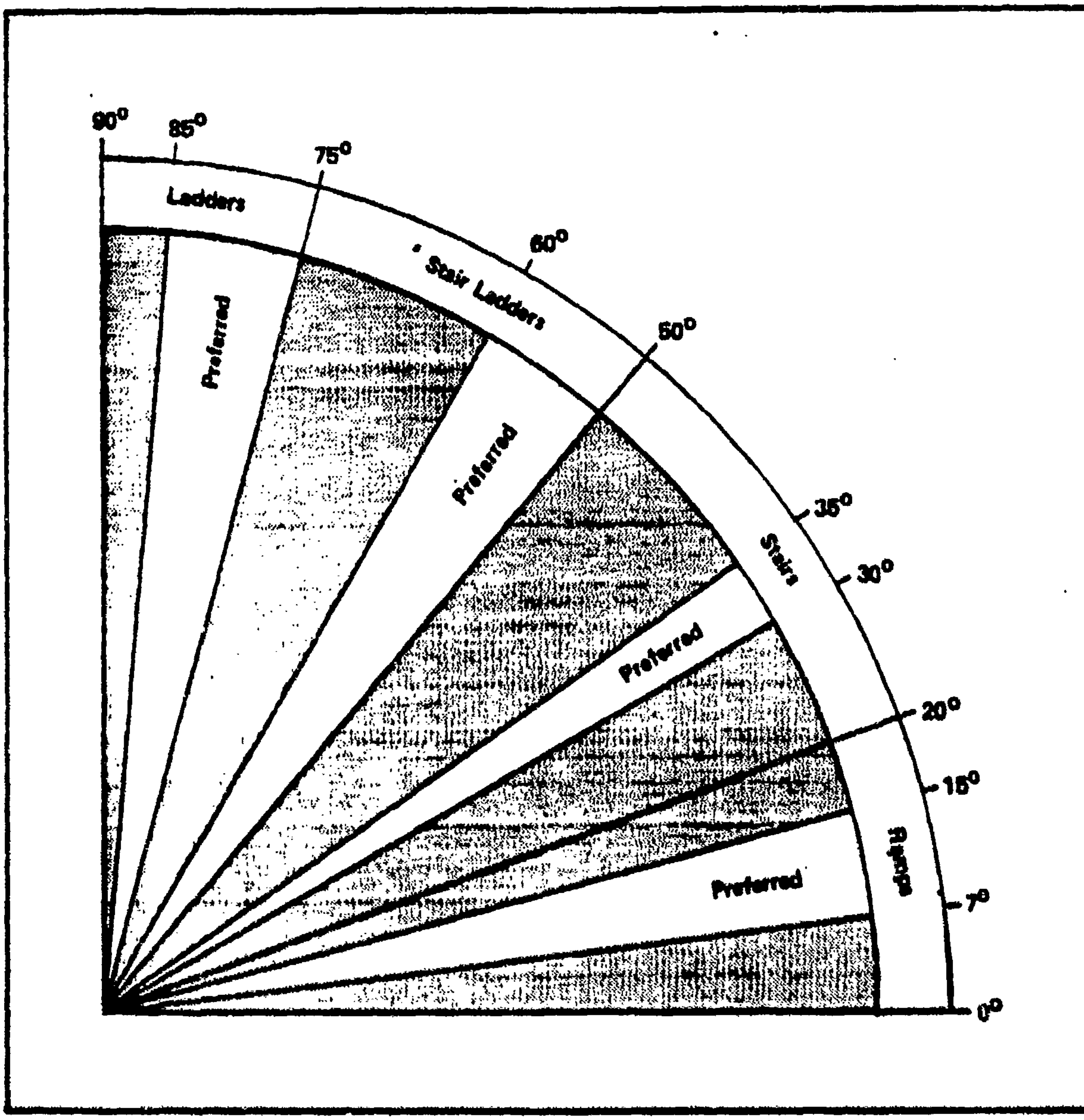


FIGURE 33. TYPE OF STRUCTURE IN RELATION TO ANGLE OF ASCENT

MIL-W-5044 applied in accordance with specification MIL-W-5050. Stair ladders shall be of metal construction. Handrails shall have nonslip surfaces.

5.7.7.4 Fixed ladders. Fixed ladder dimensions should conform with the recommended values and shall be within the specified minimum and maximum limits of Figure 36. Fixed ladders which are used to provide access to multiple levels should be offset at each successive level. Guardrails should be provided around the opening at the top of each fixed ladder. All fixed ladders more than 6 m (20 ft) high shall be equipped with, or include provision for, a safety device to provide positive protection from falls.

5.7.7.5 Ramps.

5.7.7.5.1 Cleating. Where special environmental conditions require cleating of pedestrian ramps, the cleats should be spaced 360 mm (14 in) apart and extend from handrail to handrail at right angles to the line of traffic.

5.7.7.5.2 Mixed traffic. When a ramp is required for both pedestrian and vehicle traffic, the vehicle bearing surface should be located in the center of the ramp, with the pedestrian surface next to the handrails. (A vehicle ramp with an adjacent pedestrian stairway is preferred for this situation.)

5.7.7.6 Personnel platforms and work areas. The surfaces of exterior personnel platforms and work areas shall be constructed of open metal grating. Exterior personnel platforms, for which utilization of open grating is impractical, and interior walkways shall be treated with nonskid material conforming to specification MIL-W-5044, applied in accordance with specification MIL-W-5050. All open sides of personnel platforms shall be equipped with guardrails (with intermediate rails), with a top rail height not less than 1.070 m (42 inches) and a toeboard or guard screen height not less than 75 mm (3 inches). Hand holds shall be furnished where needed. The distance between the platform edge and the centerline of the railing should not exceed 65 mm (2.5 inches).

5.7.7.7 Elevators, inclinators, and hydraulic-operated work platforms. Where these items are required, the following shall be provided:

a. Maximum load signs, located where they can be easily seen.

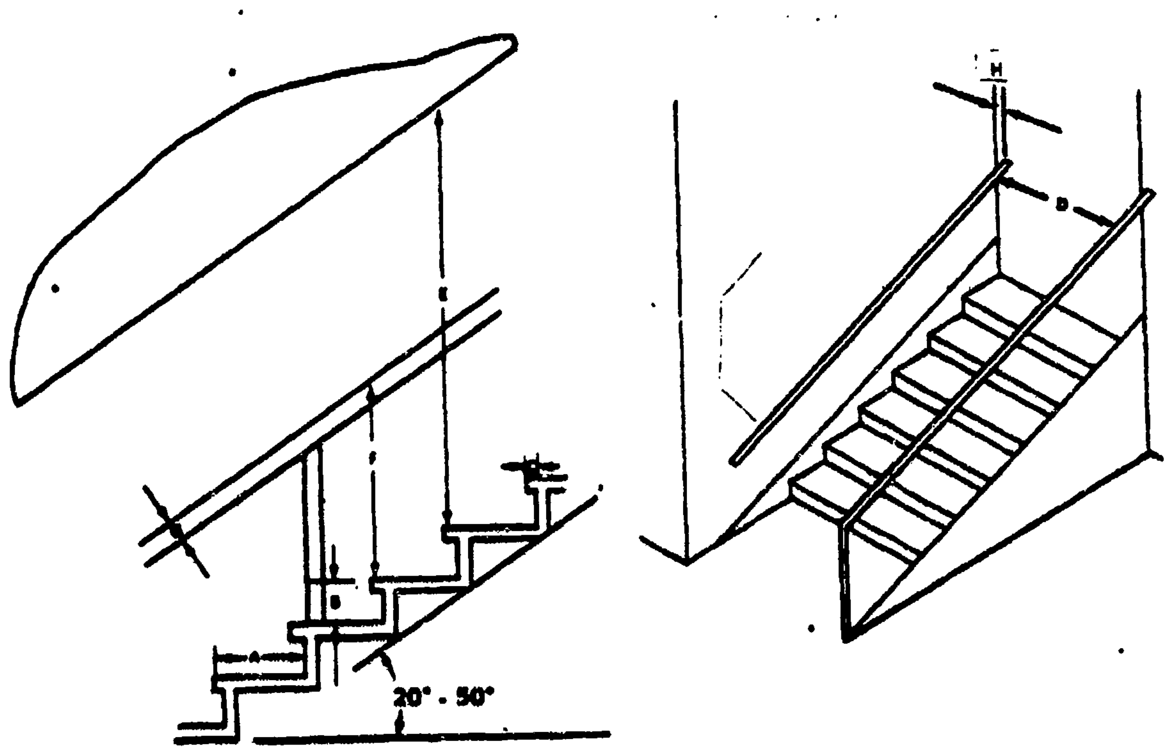
b. Guards, to prevent accidental operation of the lift.

c. Limit stops, to prevent injury to personnel and damage to equipment.

d. An automatic failsafe brake or other self-locking device in case of lift mechanism failure.

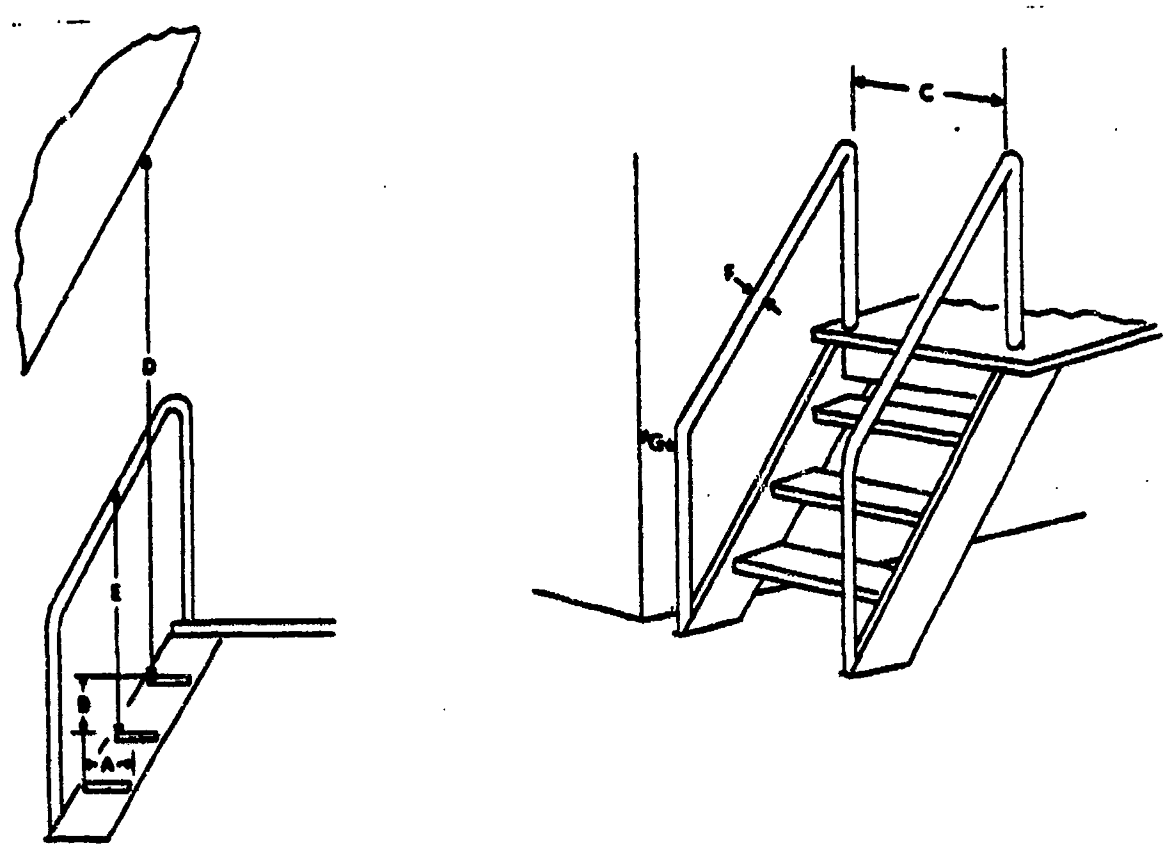
e. Provision for manually lowering the platform or elevator when feasible.

f. Surface construction or treatment of open platforms, in accordance with 5.7.7.6.



DIMENSION	MINIMUM	MAXIMUM	RECOMMENDED
A Tread depth (including nosing)	240 mm (9-1/2 in.)	300 mm (12 in.)	280–300 mm (11–12 in.)
B Riser height	125 mm (5 in.)	200 mm (8 in.)	165–180 mm (6-1/2 – 7 in.)
C Depth of nosing (where applicable)	19 mm (3/4 in.)	38 mm (1-1/2 in.)	25 mm (1 in.)
D Width (handrail to handrail):			
One-way stairs	760 mm (30 in.)	...	910 mm (36 in.)
Two-way stairs	1220 mm (48 in.)	...	1300 mm (51 in.)
E Overhead clearance	1930 mm (76 in.)	...	1980 mm (78 in.)
F Height of handrail (from leading edge of tread)	840 mm (33 in.)	940 mm (37 in.)	840 mm (33 in.)
G Handrail diameter	32 mm (1-1/4 in.)	75 mm (3 in.)	38 mm (1-1/2 in.)
H Rail clearance from wall	45 mm (1-3/4 in.)	...	75 mm (3 in.)

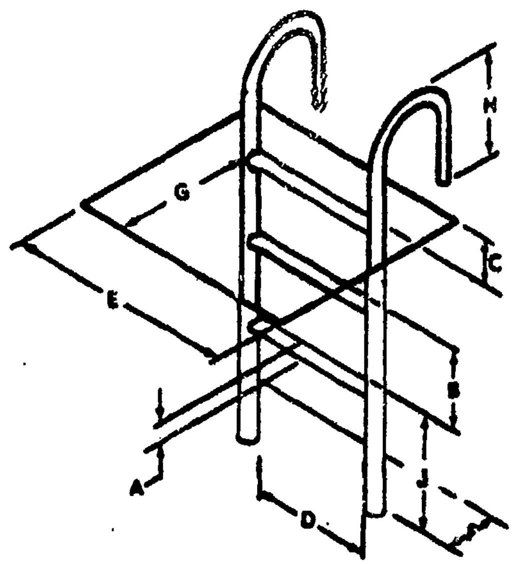
FIGURE 34. STAIR DIMENSIONS



DIMENSION	MINIMUM	MAXIMUM	RECOMMENDED
A Tread depth range:			
For 50° rise	150 mm (6 in.)	250 mm (10 in.)	215 mm (8-1/2 in.)
For 75° rise (open ladders only)	75 mm (3 in.)	140 mm (5-1/2 in.)	100 mm (4 in.)
B Riser height	180 mm (7 in.)	300 mm (12 in.)	230 mm (9 in.)
C Width (handrail to handrail)	530 mm (21 in.)	610 mm (24 in.)	560 mm (22 in.)
D Overhead clearance	1730 mm* (68 in.)	. . .	1930 mm (76 in.)
E Height of handrail (from leading edge of tread)	860 mm (34 in.)	940 mm (37 in.)	890 mm (35 in.)
F Handrail diameter	32 mm (1-1/4 in.)	75 mm (3 in.)	38 mm (1-1/2 in.)
G Rail clearance from wall	50 mm (2 in.)	. . .	75 mm (3 in.)

*Whenever the distance D is less than 1.880 m (74 in.), the overhead obstruction should be painted with yellow and black stripes.

FIGURE 35. STAIR-LADDER DIMENSIONS



DIMENSION	MINIMUM	MAXIMUM	RECOMMENDED
A Rung thickness:			
Wood	32 mm (1-1/8 in.)	38 mm (1-1/2 in.)	35 mm (1-3/8 in.)
Protected metal	19 mm (3/4 in.)	38 mm (1-1/2 in.)	35 mm (1-3/8 in.)
Corrosive metal	25 mm (1 in.)	38 mm (1-1/2 in.)	35 mm (1-3/8 in.)
B Rung spacing	230 mm (9 in.)	380 mm (15 in.)	300 mm (12 in.)
C Height, rung to landing	150 mm (6 in.)	380 mm (15 in.)	380 mm (15 in.)
D Width between stringers	300 mm (12 in.)	...	460–530 mm (18–21 in.)
E Climbing clearance width	610 mm (24 in.)	...	760 mm (30 in.)
Clearance depth:			
F In back of ladder	150 mm (6 in.)	...	200 mm (8 in.)
G On climbing side (range)	910 mm (36 in.) for 75° to 760 mm (30 in.) for 90°		
H Height of stringer above landing	840 mm (33 in.)	...	910 mm (36 in.)
J Height from lower elevation to bottom rung		380 mm (15 in.)	

FIGURE 36. FIXED-LADDER DIMENSIONS

5.7.8 Ingress and egress.

5.7.8.1 Doors. Sliding doors shall never be installed as the only personnel exit from a compartment. When a sliding door is used, a separate hinged door in the sliding door should be provided for personnel use. Fixed equipment shall be at least 75 mm (3 inches) from the swept area of hinged doors.

5.7.8.2 Hatches.

5.7.8.2.1 Configuration. Wall hatches shall be flush with the floor where structural considerations will permit this arrangement. Hatches shall open with a single motion of the hand or foot.

5.7.8.2.2 Force requirements. When a handle is used for unlocking a hatch, the unlocking force required shall not exceed 90 N (20 pounds). Hatches placed in the overhead position shall require no more than 220 N (50 lb) force for opening and closing and shall be operable by a suitably equipped and clothed user with 5th percentile arm and hand strength. The force of gravity should be used, where possible, for ease of opening. Additional requirements for hatch handwheels are given in 5.4.2.2.5 and Table IX.

5.7.8.2.3 Dimensions. Hatches shall accommodate suitably equipped and clothed user personnel in terms of limiting dimensions (see 5.6.3.3) for location and operability, and clearance dimensions (see 5.6.3.2) for size and passage factors. Where personnel must carry equipment through the hatch, allowance shall be made for clearance of suitably clothed 95th percentile hands and/or arms, as applicable. Where possible, hatch dimensions shall conform to the requirements of 5.7.8.3.

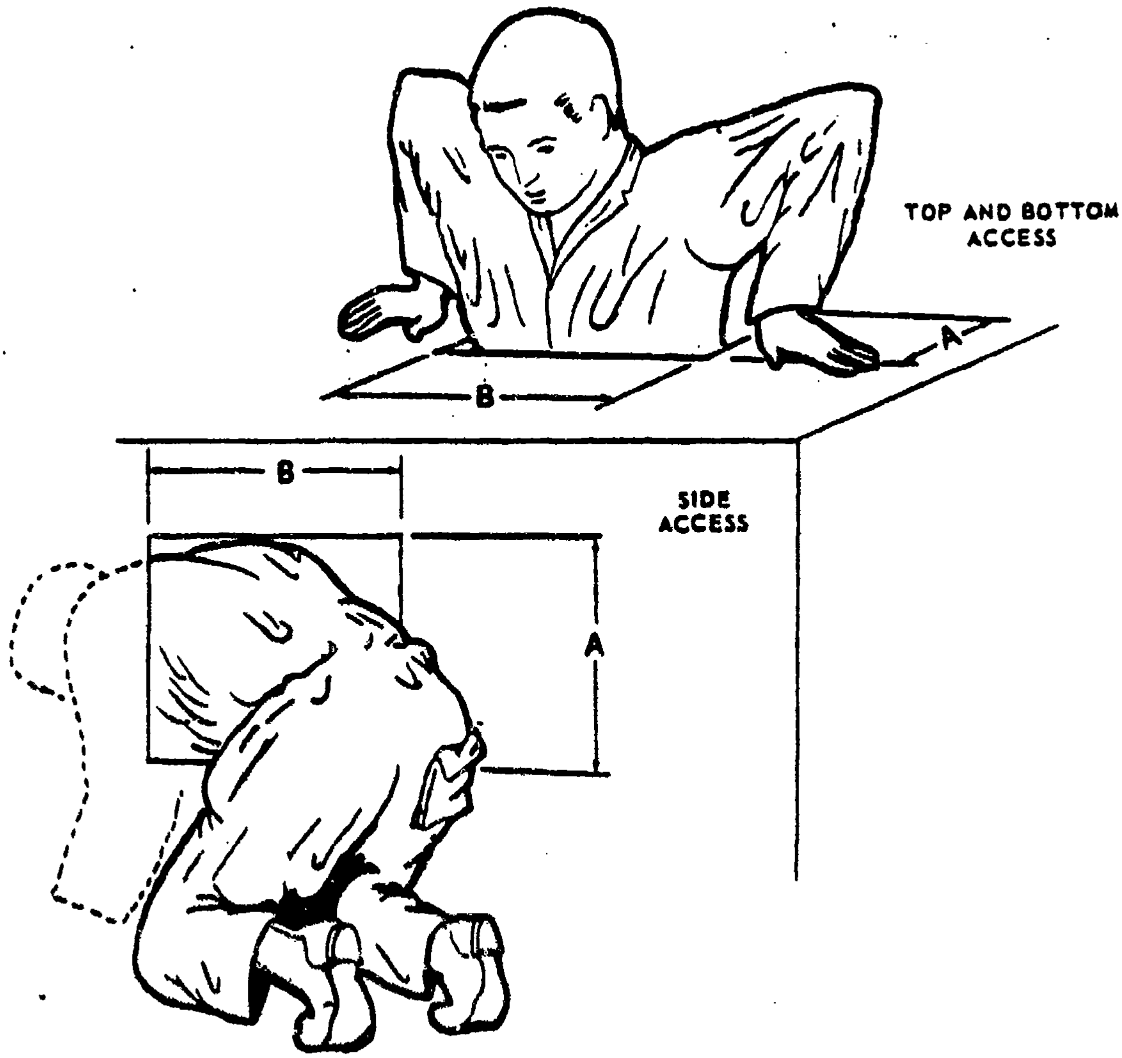
5.7.8.3 Whole-body access. Dimensions for rectangular access openings for body passage shall not be less than those dimensions shown in Figure 37. Minimum diameter for circular hatches shall be 760 mm (30 in). Diameters of oval hatches in armored vehicles shall not be less than 430 and 710 mm (17 and 28 inches). Where rescue of personnel may be required because of environmental hazards (e.g., toxic fumes) within the work place, larger access openings for two-person ingress and egress may be necessary. Where "step down" through a top access exceeds 690 mm (27 in), appropriate foot rests or steps shall be provided.

5.7.9 Surface colors

5.7.9.1 Army. Surface colors shall conform to MIL-STD-1473 unless specified by the procuring activity.

5.7.9.2 Navy. Surface colors shall be as specified by the procuring activity.

5.7.9.3 Air Force. Surface colors shall be selected from FED-STD-595 as follows:



DIMENSIONS	A. DEPTH		B. WIDTH	
CLOTHING	LIGHT	BULKY	LIGHT	BULKY
TOP AND BOTTOM ACCESS	330 mm (13 in.)	410 mm (16 in.)	580 mm (23 in.)	690 mm (27 in.)
SIDE ACCESS	660 mm (26 in.)	740 mm (29 in.)	760 mm (30 in.)	860 mm (34 in.)

NOTE: DIMENSIONS SHOWN BASED ON MALE DATA.

FIGURE 37. WHOLE BODY ACCESS OPENING

a.	Console, rack and cabinet exteriors	24300 Green
b.	Panels	26492 Gray
c.	Non-critical functional grouping pads	26622 Gray
d.	Emergency/critical grouping pads	21136 Red
e.	Interior walls, and ceilings	27875 White
f.	Interiors of uninhabited compartments where maintenance is performed	26622 Gray
g.	Standard commercial equipment (if, however, such equipment becomes an integral part of an assembly, the color must be identical to or compatible with that of the assembly)	Existing Color
h.	Anodized or conductive surface	Not Painted

i. Lettering colors:

Background Color	Lettering Color
24300 Green	17875 White
26492 Gray	17038 Black
27875 White	17038 Black
26231 Gray	17875 White
21136 Red	17875 White
Anodized or non-painted	17038 Black or 17875 White, whichever provides the best contrast
Commercial equipment	Contrasting Color

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5.8 Environment.

5.8.1 Heating, ventilating, and air conditioning.

5.8.1.1 Heating. Heating shall be provided within mobile personnel enclosures utilized for detail work or occupied during extended periods of time to maintain interior dry bulb temperature above 10°C (50°F). Within permanent and semi-permanent facilities, provisions shall be made to maintain an effective temperature (E.T.) or corrected effective temperature (C.E.T.) not less than 18°C (65°F) (see Figure 38), unless dictated otherwise by workload or extremely heavy clothing. (See 5.12.6.1 for vehicle heating provisions.) Heating systems shall be designed such that hot air discharge is not directed on personnel.

5.8.1.2 Ventilating. Adequate ventilation shall be assured by introducing fresh air into any personnel enclosure. If the enclosure volume is 4.25 m^3 (150 ft^3) or less per person, a minimum of 0.85 m^3 (30 ft^3) of ventilation air per minute shall be introduced into the enclosure; approximately two-thirds should be outdoor air. For larger enclosures, the air supply per person may be in accordance with the curves in Figure 39. Air shall be moved past personnel at a velocity not more than 60 m (200 ft) per minute. Where manuals or loose papers are used, airspeed past these items shall be not more than 30 m (100 ft) per minute--20 m (65 ft) per minute if possible, to preclude pages in manuals from being turned by the air or papers from being blown off work surfaces. Under NBC conditions, ventilation requirements shall be modified as required. Ventilation or other protective measures shall be provided to keep gases, vapors, dust, and fumes within the Permissible Exposure Limits specified by 29 CFR 1910 and the limits specified in the American Conference of Governmental Industrial Hygienists Threshold Limit Values. Intakes for ventilation systems shall be located to minimize the introduction of contaminated air from such sources as exhaust pipes. (See 5.12.6.2 for vehicle ventilation provisions.)

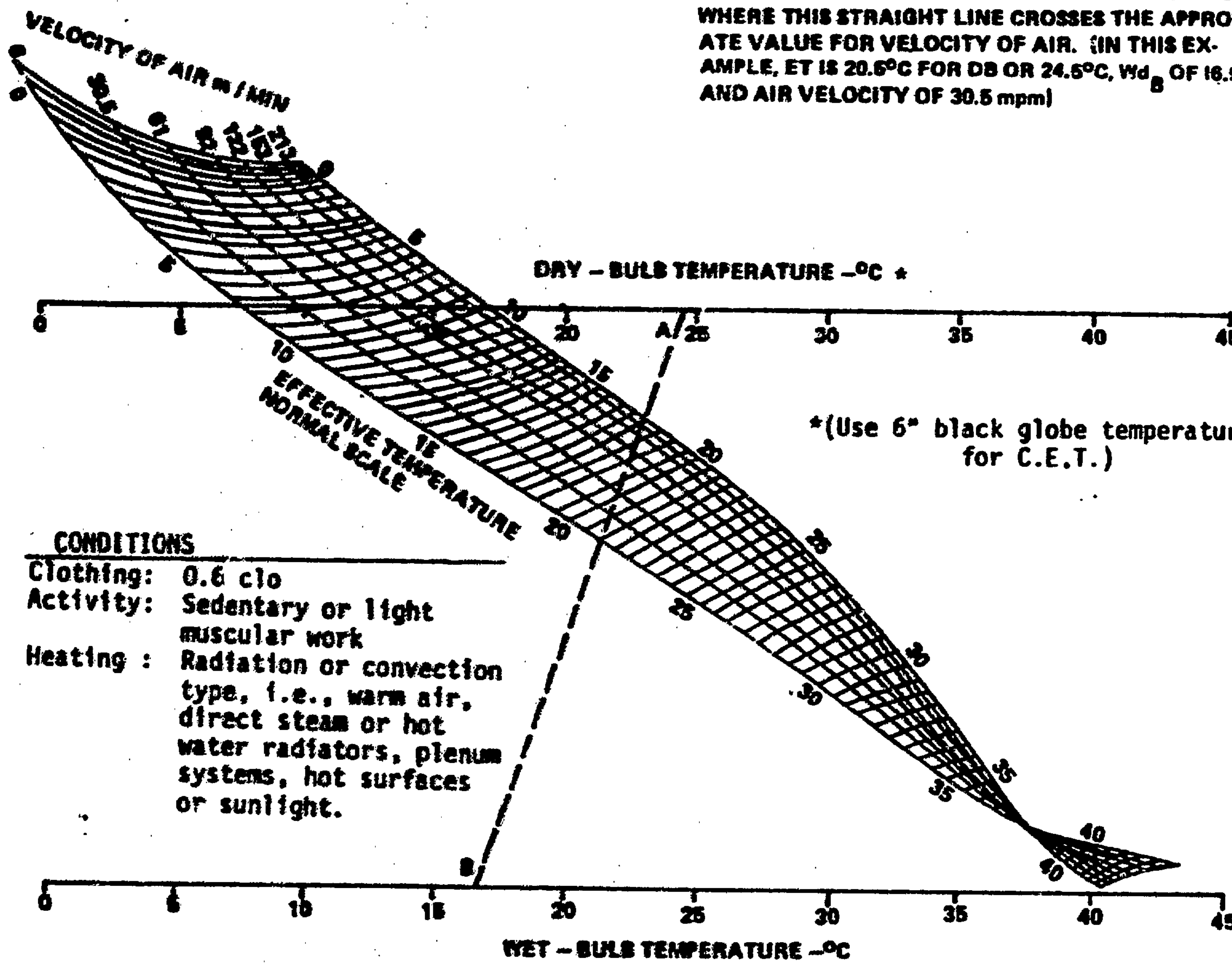
5.8.1.3 Air conditioning. The effective temperature or CET within personnel enclosures utilized for detail work during extended periods shall be maintained at or below 29.5°C (85°F) (see Figure 38). Air conditioning systems shall be designed such that cold-air discharge is not directed on personnel.

5.8.1.4 Humidity. Approximately 45% relative humidity should be provided at 21°C (70°F). This value should decrease with rising temperatures, but should remain above 15 percent to prevent irritation and drying of body tissues, e.g., eyes, skin, and respiratory tract (see Figure 40).

5.8.1.5 Temperature uniformity. The temperature of the air at floor level and at head level should not differ by more than 5.5°C (10°F).

5.8.1.6 Personal equipment thermal control. When special protective clothing or personal equipment, including full and partial pressure suits,

NOTE: TO USE NOMOGRAPH, DRAW STRAIGHT LINE BETWEEN DRY BULB TEMPERATURE (A) AND WET-BULB TEMPERATURE (B). EFFECTIVE TEMPERATURE IS INDICATED WHERE THIS STRAIGHT LINE CROSSES THE APPROPRIATE VALUE FOR VELOCITY OF AIR. (IN THIS EXAMPLE, ET IS 20.6°C FOR DB OR 24.5°C, Wd_B OF 16.5°C AND AIR VELOCITY OF 30.5 mpm)



*(Use 6" black globe temperature for C.E.T.)

CONDITIONS

Clothing: 0.6 clo
Activity: Sedentary or light muscular work
Heating : Radiation or convection type, i.e., warm air, direct steam or hot water radiators, plenum systems, hot surfaces or sunlight.

FIGURE 38. EFFECTIVE TEMPERATURE (E.T.) [illegible] CORRECTED EFFECTIVE TEMPERATURE (C.E.T)

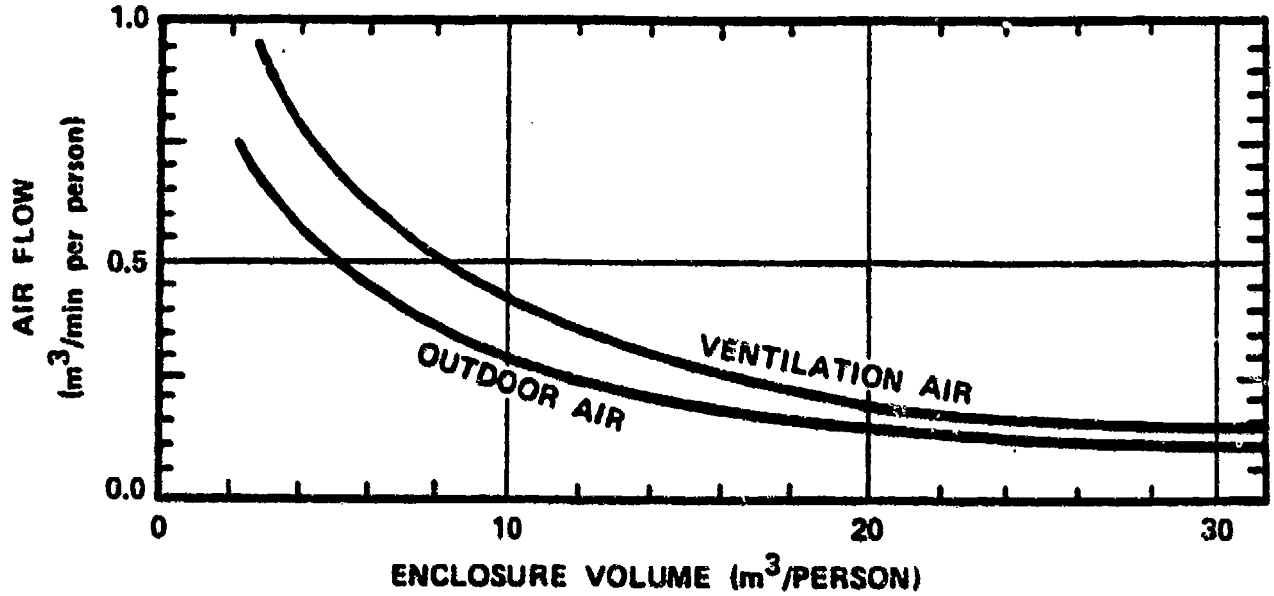


FIGURE 39. VENTILATION REQUIREMENTS

fuel handler suits, body armor, arctic clothing and temperature regulated clothing are required and worn, a comfort micro-climate between 20°C (68°F), 14 mm Hg ambient water vapor pressure and 35°C (95°F), 3 mm Hg ambient water vapor pressure is desirable and, where possible, shall be maintained by heat transfer systems.

5.8.1.7 Thermal tolerance and comfort zones. Temperature and humidity exposure should not exceed the effective temperature limits given in Figure 40 when corrected for air velocity (Figure 39).

5.8.1.8 Limited thermal tolerance zones. Where hard physical work is to be required for more than two hours, an environment not exceeding a WBGT or WD index of 25°C (77°F) shall be provided. Where the wearing of protective clothing systems (which reduce evaporation of sweat from the skin) is required, this index shall be decreased 5°C (10°F) for complete chemical protective uniforms, 4°C (7°F) for intermediate clothing systems, and 3°C (5°F) for body armor.

5.8.2 Illuminance. Where equipment is to be used in enclosures and is not subject to blackout or special low-level lighting requirements, illumination levels shall be as specified by Table XXI and shall be distributed so as to reduce glare and specular reflection. Capability for dimming shall be provided. Adequate illumination shall be provided for maintenance tasks. General and supplementary lighting shall be used as appropriate to insure that illumination is compatible with each task situation. Portable lights should be provided for personnel performing visual tasks in areas where fixed illumination is not provided. For display lighting, see Table XXII.

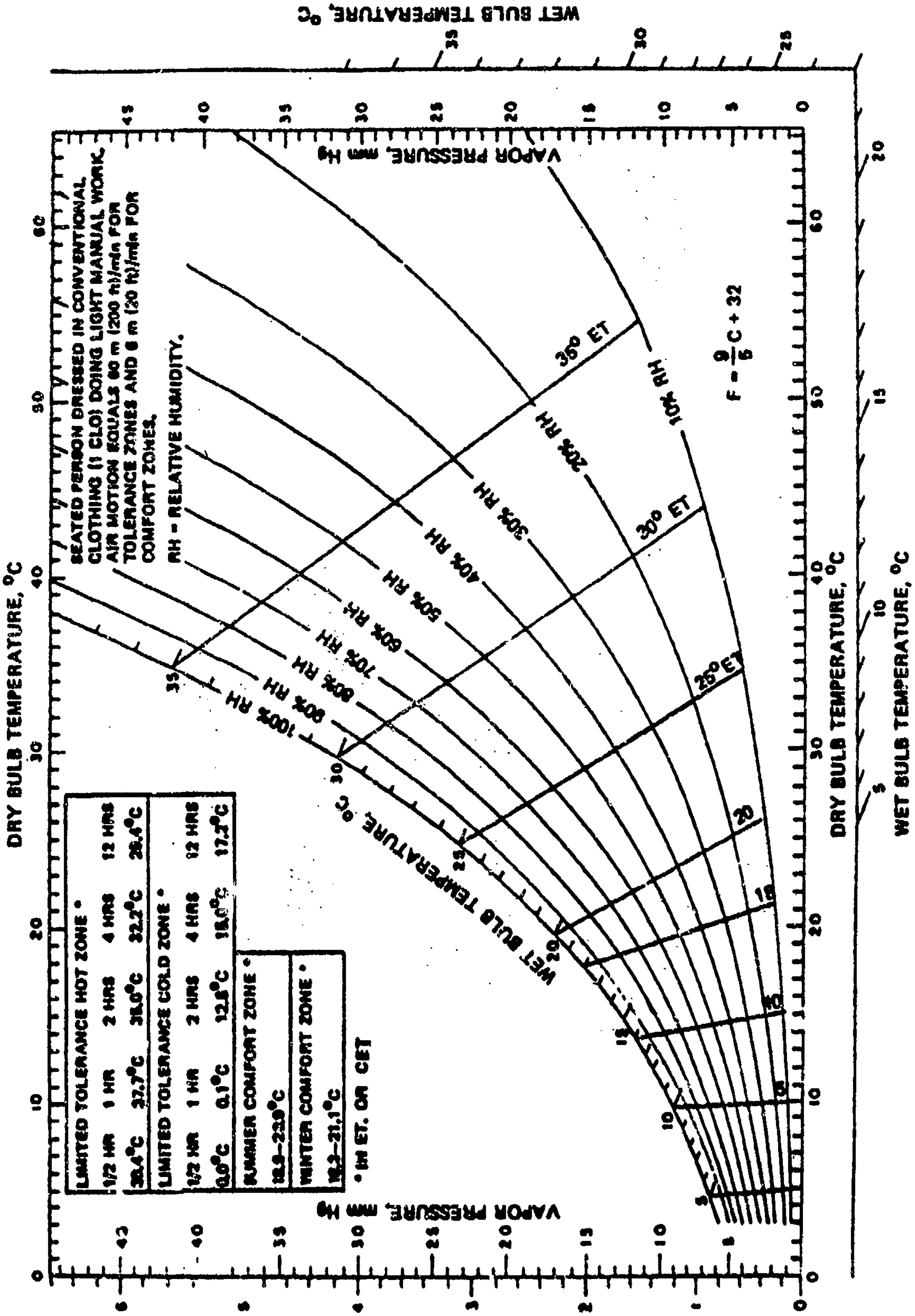


FIGURE 40. SUMMER AND WINTER COMFORT ZONES AND THERMAL TOLERANCE FOR INHABITED COMPARTMENTS

TABLE XXI. SPECIFIC TASK ILLUMINATION REQUIREMENTS

WORK AREA OR TYPE OF TASK	ILLUMINATION LEVELS LUX* (FT-C) RECOMMENDED	MINIMUM
Assembly, missile component	1075 (100)	540 (50)
Assembly, general		
coarse	540 (50)	325 (30)
medium	810 (75)	540 (50)
fine	1075 (100)	810 (75)
precise	3230 (300)	2155 (200)
Bench work		
rough	540 (50)	325 (30)
meduim	810 (75)	540 (50)
fine	1615 (150)	1075 (100)
extra fine	3230 (300)	2155 (200)
Bomb shelters and mobile shelters, when used for rest and relief	20 (2)	10 (1)
Business machine operation (calculator, digital, input, etc.)	1075 (100)	540 (50)
Console surface	540 (50)	325 (30)
Corridors	215 (20)	110 (10)
Circuit diagram	1075 (100)	540 (50)
Dials	540 (50)	325 (30)
Electrical equipment testing	540 (50)	325 (30)
Emergency lighting	NA	30 (3)
Gages	540 (50)	325 (30)
Hallways	215 (20)	110 (10)

*As measured at the task object or 760 mm (30 in.) above the floor.

(Continued)

TABLE XXI. SPECIFIC TASK ILLUMINATION REQUIREMENTS (CONTINUED)

WORK AREA OR TYPE OF TASK	ILLUMINATION LEVELS LUX* (FT-C) RECOMMENDED	MINIMUM
Inspection tasks, general		
rough	540 (50)	325 (30)
medium	1075 (100)	540 (50)
fine	2155 (200)	1075 (100)
extra fine	3230 (300)	2155 (200)
Machine operation, automatic	540 (50)	325 (30)
Meters	540 (50)	325 (30)
Missiles:		
repair and servicing	1075 (100)	540 (50)
storage areas	215 (20)	110 (10)
general inspection	540 (50)	325 (30)
Office work, general	755 (70)	540 (50)
Ordinary seeing tasks	540 (50)	325 (30)
Panels:		
front	540 (50)	325 (30)
rear	325 (30)	110 (10)
Passageways	215 (20)	110 (10)
Reading:		
large print	325 (30)	110 (10)
newsprint	540 (50)	325 (30)
handwritten reports, in pencil	755 (70)	540 (50)
small type	755 (70)	540 (50)
prolonged reading	755 (70)	540 (50)
Recording	755 (70)	540 (50)

*As measured at the task object or 760 mm (30 in.) above the floor.

(Continued)

TABLE XXI. SPECIFIC TASK ILLUMINATION REQUIREMENTS (CONCLUDED)

WORK AREA OR TYPE OF TASK	ILLUMINATION LEVELS LUX* (FT-C) RECOMMENDED	MINIMUM
Repair work:		
general	540 (50)	325 (30)
instrument	2155 (200)	1075 (100)
Scales	540 (50)	325 (30)
Screw fastening	540 (50)	325 (30)
Service areas, general	215 (20)	110 (10)
Stairways	215 (20)	110 (10)
Storage:		
inactive or dead	55 (5)	30 (3)
general warehouse	110 (10)	55 (5)
live, rough or bulk	110 (10)	55 (5)
live, medium	325 (30)	215 (20)
live, fine	540 (50)	325 (30)
Switchboards	540 (50)	325 (30)
Tanks, containers	215 (20)	110 (10)
Testing:		
rough	540 (50)	325 (30)
fine	1075 (100)	540 (50)
extra fine	2155 (200)	1075 (100)
Transcribing and tabulation	1075 (100)	540 (50)

Note: Some unusual inspection tasks may require up to 10,000 lux (1,000 ft-C)

Note: As a guide in determining illumination requirements the use of a steel scale with 1/64 inch divisions requires 1950 lux (180 ft-C) of light for optimum visibility.

*As measured at the task object or 760 mm (30 in.) above the floor.

TABLE XXII. RECOMMENDATIONS FOR DISPLAY LIGHTING

CONDITION OF USE	LIGHTING TECHNIQUE *	BRIGHTNESS OF MARKINGS cd/m^2 (Ft–L)	BRIGHTNESS ADJUSTMENT
Indicator reading, dark adaptation necessary	Red flood, indirect, or both, with operator choice	0.07–0.35 (0.02–0.1)	Continuous throughout range
Indicator reading, dark adaptation not necessary but desirable	Red or low-color-temperature white flood, indirect, or both, with operator choice	0.07–3.5 (0.02–1.0)	Continuous throughout range
Indicator reading, dark adaptation not necessary	White flood	3.5–70 (1–20)	Fixed or continuous
Panel monitoring, dark adaptation necessary	Red edge lighting, red or white flood, or both, with operator choice	0.07–3.5 (0.02–1.0)	Continuous throughout range
Panel monitoring, dark adaptation not necessary	White flood	35–70 (10–20)	Fixed or continuous
Possible exposure to bright flashes, restricted daylight	White flood	35–70 (10–20)	Fixed
Chart reading, dark adaptation necessary	Red or white flood with operator choice	0.35–3.50 (0.1–1.0)	Continuous throughout range
Chart reading, dark adaptation not necessary	White flood	17–70 (5–20)	Fixed or continuous

* Where detection of ground vehicles or other protected assets by image intensifier night vision devices must be minimized, blue-green light (incandescent filament through a filter which passes only wavelengths shorter than 600 mm) should be used in lieu of red light.

5.8.3 Acoustical noise

5.8.3.1 General. Personnel shall be provided an acoustical environment which will not cause personnel injury, interfere with voice or any other communications, cause fatigue, or in any other way degrade overall system effectiveness. The fact that a component which contributes to the overall noise may be government furnished equipment shall not eliminate the requirement that the total system conform to the criteria herein.

5.8.3.2 Hazardous noise. Equipment shall not generate noise in excess of maximum allowable levels prescribed by MIL-A-8806, MIL-S-008806, MIL-STD-740-1, MIL-STD-1294, MIL-STD-1474, Chapter 18 of OPNAVINST 5100.23B or AFR 161-35, as applicable.

5.8.3.3 Non-hazardous noise. Workspace noise shall be reduced to levels that permit necessary direct (person-to-person) and telephone communication and establish an acceptable acoustical work environment. Criteria for workspaces are defined by either the A-weighted sound level (dB(A)) or the speech interference level (SIL) and are given in 5.8.3.3.1 through 5.8.3.3.6. The A-weighted sound level is the desired requirement. Where it is not possible to meet the specified A-weighted sound level, the corresponding SIL requirement shall be met. Figure 41 provides guidance on the relationship between required vocal-effort, speaker-to-listener distance and noise level. Procedures for determining speech intelligibility are provided in 5.3.12.

5.8.3.3.1 General workspaces. Areas requiring occasional telephone use or occasional direct communication at distances up to 1.5 m (5 ft) shall not exceed 75 dB(A) SIL. (Examples: maintenance shops and shelters, garages, keypunch areas, shipboard engineering areas.)

5.8.3.3.2 Operational areas. Areas requiring frequent telephone use or occasional direct communication at distances up to 1.520 m (5 ft) shall not exceed 65 dB(A) SIL. (Examples: operation centers, mobile command and communication shelters, combat information centers, word processing centers.)

5.8.3.3.3 Large workspaces. Areas requiring no difficulty with telephone use or requiring occasional direct communication at distances up to 4.570 m (15 ft) shall not exceed 55 dB(A) SIL. (Examples: drafting rooms, shop offices, laboratories.)

5.8.3.3.4 Small office spaces/special areas. Areas requiring no difficulty with direct communication shall not exceed 45 dB(A) SIL. (Examples: conference rooms, libraries, offices, command and control centers.)

5.8.3.3.5 Extreme quiet areas. Areas requiring extreme quiet shall not exceed 35 dB(A) SIL. (Example: recording studios.)

5.8.3.3.6 Shipboard areas. Shipboard areas requiring a specified speech communication environment shall not exceed 5 dB above the levels of 5.8.3.3.1 to 5.8.3.3.5, as applicable. Levels for spaces and categories not covered in

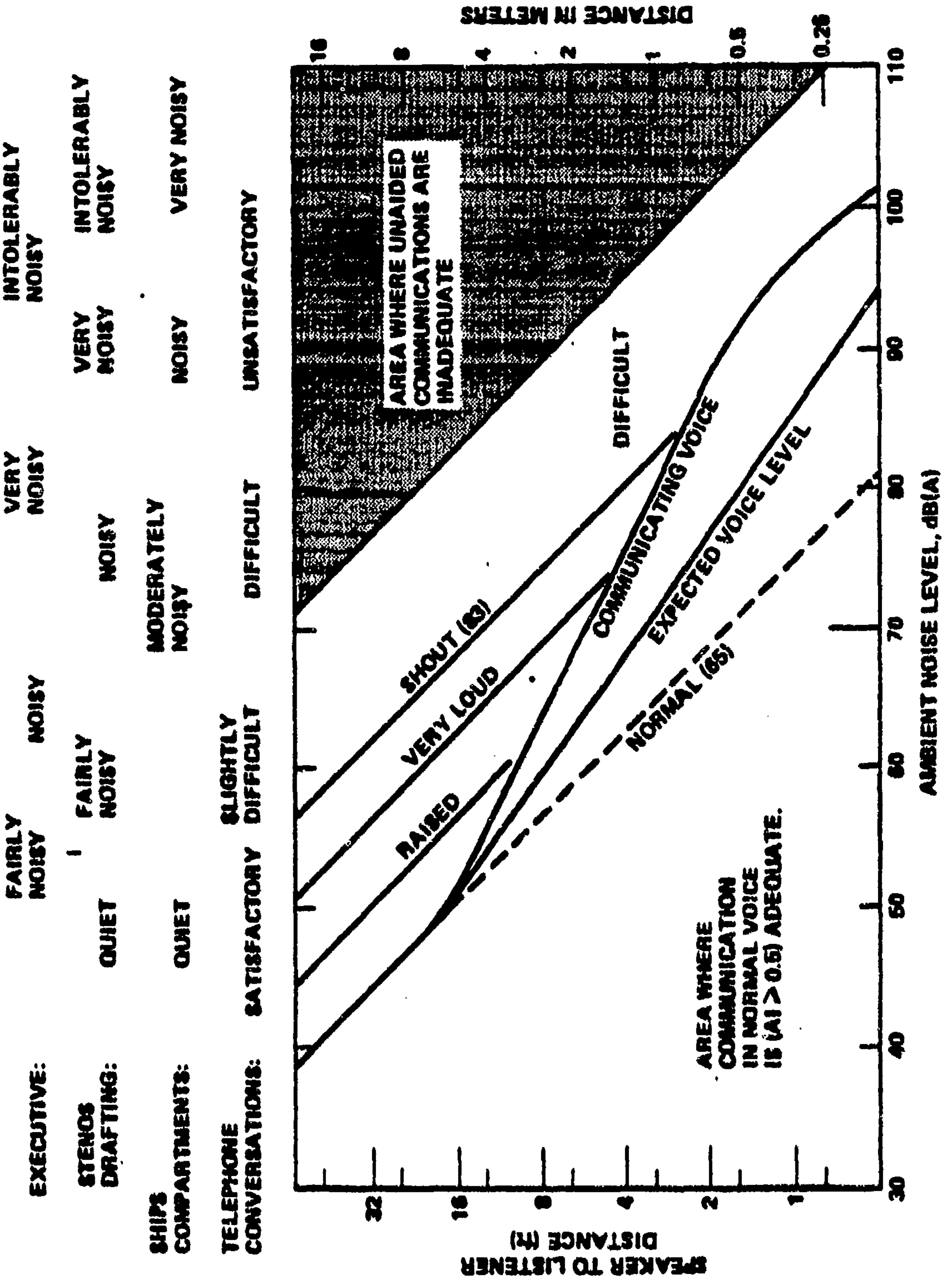


FIGURE 41. PERMISSIBLE DISTANCE BETWEEN A SPEAKER AND LISTENERS FOR SPECIFIED VOICE LEVELS AND AMBIENT NOISE LEVELS. (THE LEVELS IN PARENTHESES REFER TO VOICE LEVELS MEASURED ONE METER FROM THE MOUTH.)

these paragraphs shall be as given in the detailed shipbuilding specification. (Examples: sonar control rooms, ward rooms). Equipment noise acceptance criteria to achieve specified space levels shall conform to MIL-STD-740-1.

5.8.3.4 Facility design.

5.8.3.4.1 General provision. In the design of a workspace or facility, the ambient noise level shall be controlled to the extent feasible through effective sound reduction or attenuation to meet the criteria herein.

5.8.3.4.2 Attenuation by materials and layout. Acoustic materials with high sound-absorption coefficients should be provided as necessary in the construction of floors, walls, and ceiling to effect the required sound control. In the physical design and layout of rooms and work stations, excessive noise should be attenuated by such means as staggered construction of walls, staggering of doors in corridors or between rooms, and use of thick-paned or double-paned windows.

5.8.3.4.3 Reduction of reverberation time. Where speech communication is a consideration, the acoustical treatment of facilities should be sufficient to reduce reverberation time, as defined by ANSI S1.1, to the applicable limits of Figure 42.

5.8.4 Vibration.

5.8.4.1 Whole body vibration.

5.8.4.1.1 Vehicular vibration. Vehicles for use on land, sea, or air should be designed to control the transmission of whole body vibration to levels that will permit safe operation and maintenance as shown in Figure 43 (see ISO 2631). In the case of multidirectional vibration, each direction should be evaluated independently with respect to the limits presented.

5.8.4.1.1.1 Safety level. In order to protect human health, whole body vibration should not exceed twice the acceleration values shown on Figure 43 for the time and frequencies indicated.

5.8.4.1.1.2 Proficiency level. Where proficiency is required for operational and maintenance tasks, whole body vibration should not exceed the acceleration values shown on Figure 43 for the time and frequencies indicated.

5.8.4.1.1.3 Comfort level. Where comfort is to be maintained, the acceleration values shown on Figure 43 should be divided by 3.15.

5.8.4.1.1.4 Motion sickness. In order to prevent motion sickness, very low frequency vibration should not exceed the limits of Figure 44.

5.8.4.1.2 Building vibrations. Buildings intended for occupation by humans should be designed/located to control the transmission of whole body vibration levels that are acceptable to the occupants as specified by ISO 2631.

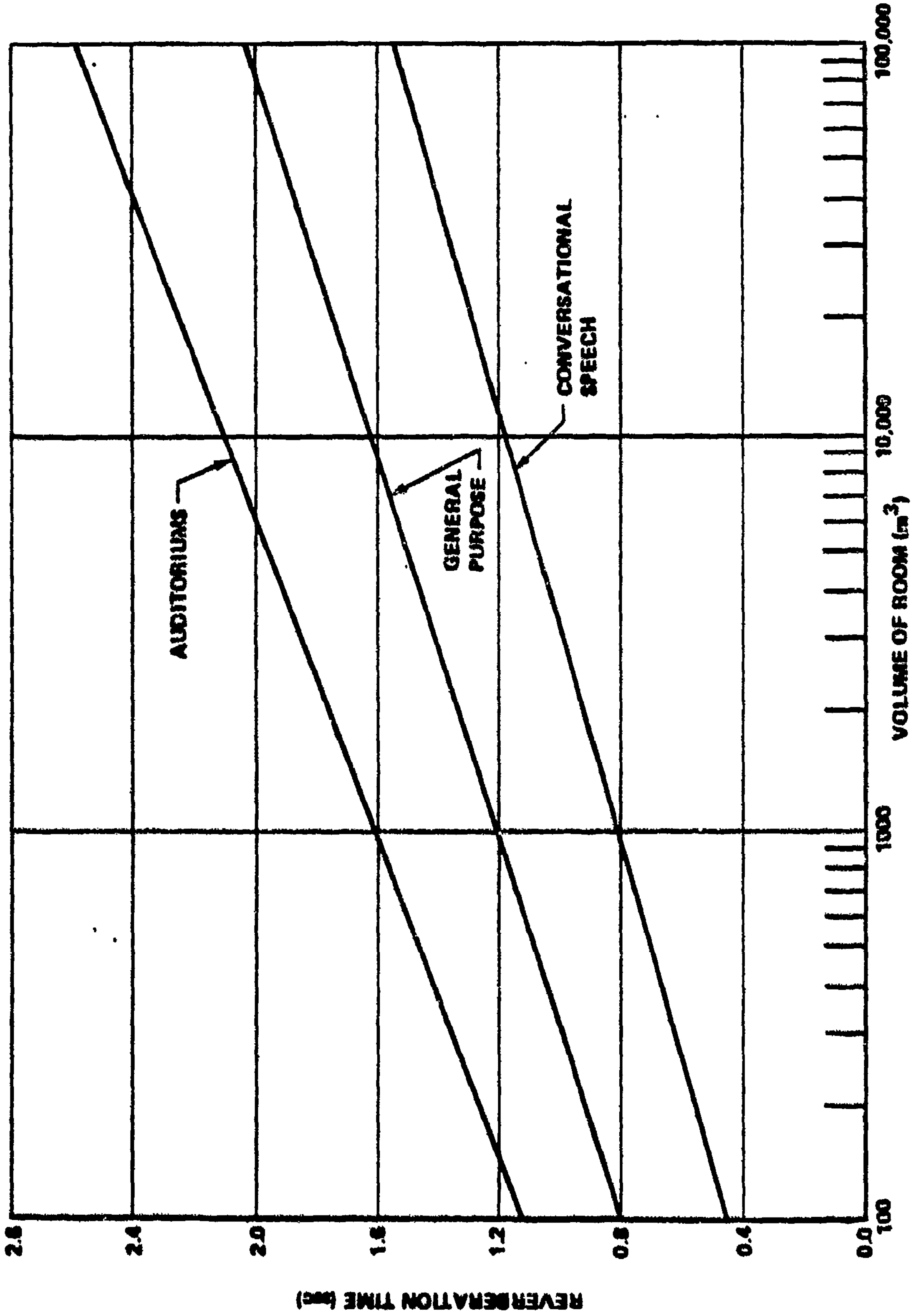
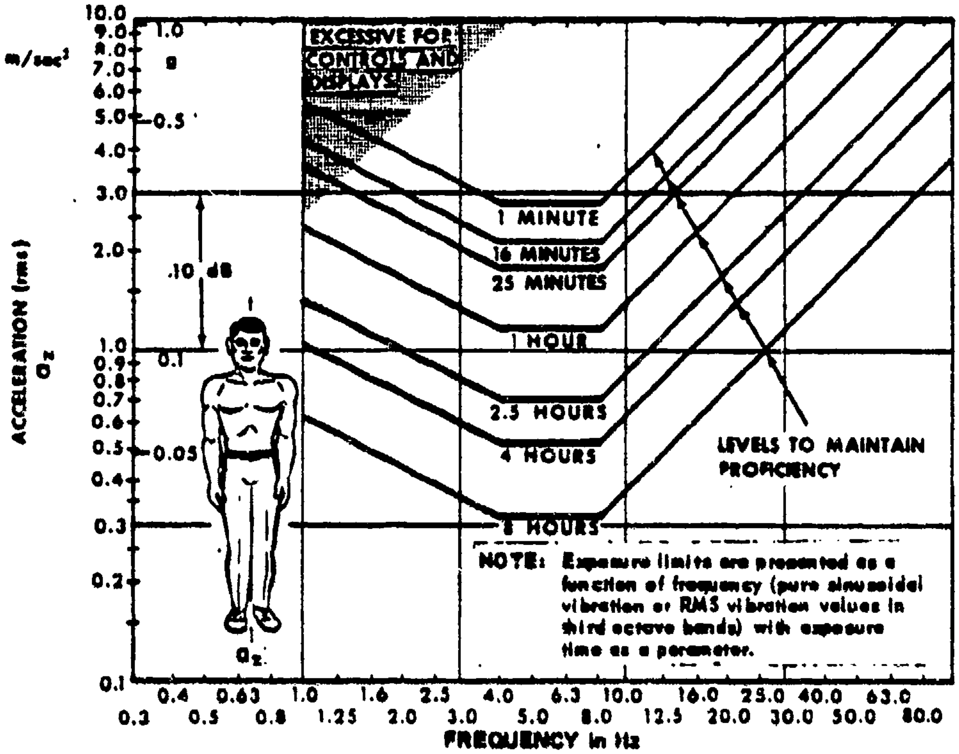


FIGURE 42. RANGE OF ACCEPTABLE REVERBERATION TIME



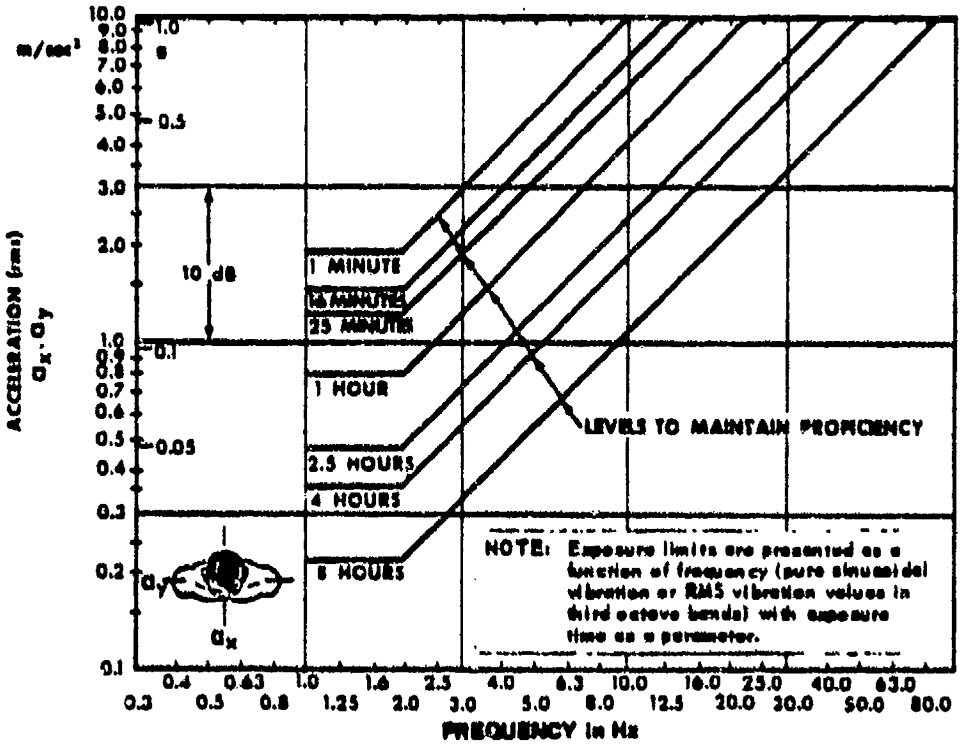


FIGURE 43. VIBRATION EXPOSURE CRITERIA FOR LONGITUDINAL (UPPER CURVE) AND TRANSVERSE (LOWER CURVE) DIRECTIONS WITH RESPECT TO BODY AXIS

5.8.4.2 Equipment vibration. Where whole body vibrations of the human operator or parts of the body are not a factor, equipment oscillations should not impair human performance with respect to control manipulations or the readability of numerals or letters. Equipment vibrations in the shaded area of the upper curve of Figure 43, should be avoided.

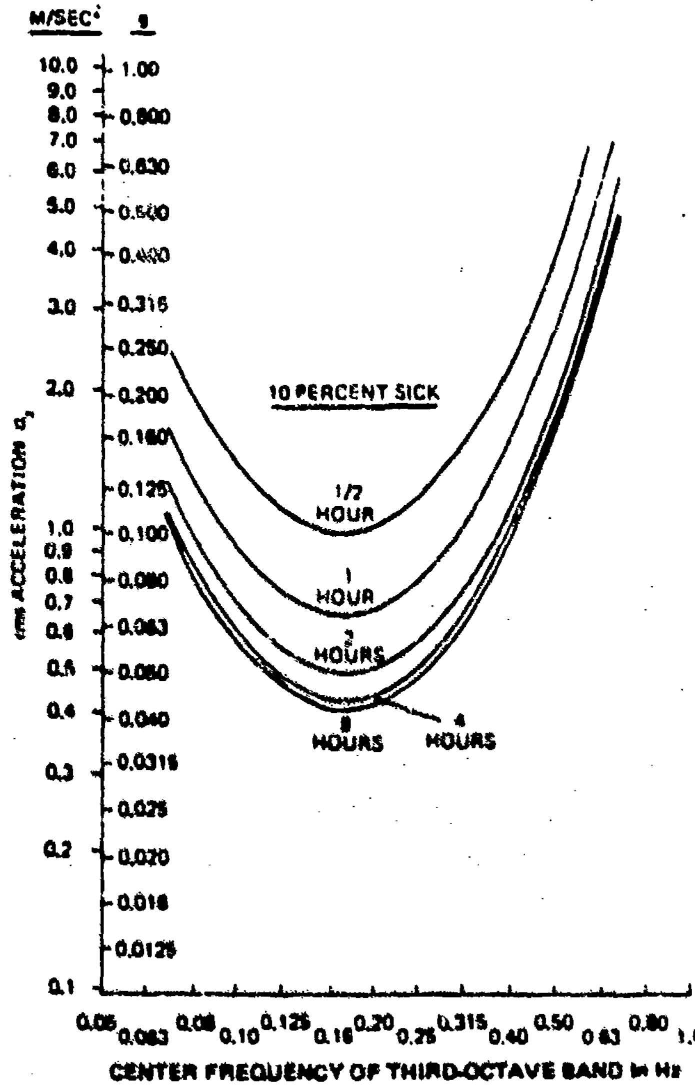


FIGURE 44. THE 90 PERCENT MOTION SICKNESS PROTECTION LIMITS FOR HUMAN EXPOSURE TO VERY LOW FREQUENCY VIBRATION

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5.9 Design for maintainer.

5.9.1 General.

5.9.1.1 Standardization. Standard parts shall be used whenever practicable and should meet the human engineering criteria herein.

5.9.1.2 Special tools. Special tools shall be used only when common hand tools cannot be utilized or when they provide significant advantage over common hand tools. Special tools required for operational adjustment maintenance should be securely mounted within the equipment in a readily accessible location.

5.9.1.3 Modular replacement. Equipment should be replaceable as modular packages and shall be configured for removal and replacement by one person where permitted by structural, functional, and weight limitations. (See 5.9.11.3.)

5.9.1.4 Separate adjustability. It shall be possible to check and adjust each item, or function of an item, individually.

5.9.1.5 Malfunction identification. Equipment design shall facilitate rapid and positive fault detection and isolation of defective items to permit their prompt removal and replacement.

5.9.1.6 Assembly and disassembly. Equipment shall be capable of being assembled and disassembled in its operational environment by a minimum number of trained personnel wearing clothing appropriate to the operating environment specified for the system maintenance concept.

5.9.1.7 Clothing constraints. Equipment shall be capable of being removed, replaced, and repaired by personnel wearing personal and special purpose clothing and equipment appropriate to the maintenance concept, including NBC protective clothing in an NBC contaminated environment.

5.9.1.8 Errorproof design. Provisions to preclude improper mounting and installation shall include:

a. Physical measures to preclude interchange of items of a same or similar form that are not in fact functionally interchangeable.

b. Physical measures to preclude improper mounting of units or components.

c. Measures (e.g., coding) to facilitate identification and interchange of interchangeable items.

d. Measures (e.g., alignment pins) to facilitate proper mounting of items.

e. Measures to insure that identification, orientation, and alignment provisions include cables and connectors.

5.9.2 Mounting of items within units.

5.9.2.1 Stacking avoidance. Parts should be mounted in an orderly array on a "two-dimensional" surface, rather than stacked one on another (i.e., a lower layer should not support an upper layer, so subassemblies do not have to be removed to access other subassemblies within the equipment.

5.9.2.2 Similar items. Similar items shall utilize a common mounting design and orientation within the unit. This mounting design shall preclude interchange of items which are not functionally interchangeable. Similar items which are not functionally interchangeable shall be made distinguishable by labeling, color coding, marking, etc., to prevent unwanted substitution.

5.9.2.3 Delicate items. Components susceptible to maintenance induced damage through rough handling, static electricity, abrasion, lack of cleanliness or other such factors shall be clearly identified and guarded from abuse both physically and by procedural requirements.

5.9.3 Adjustment controls. Controls required for maintenance purposes shall comply with basic control design requirements in 5.4 and labeling requirements in 5.5.

5.9.3.1 Knob adjustments. Knobs rather than screwdriver controls shall be used whenever adjustments occuring more often than once per month must be performed where access, weight, and related considerations permit their use. Knobs shall maintain setting following adjustment.

5.9.3.2 Blind screwdriver adjustments. Screwdriver adjustments made without visual access are permissable only if mechanical guides are provided to align the screwdriver. Screw travel shall be limited to prevent the screw from falling out of its intended position.

5.9.3.3 Reference scale for adjustment controls. A reference scale or other appropriate feedback shall be provided for all adjustment controls. The reference scale shall be readily visible to the person making the adjustment. Mirrors or flashlights should not be required for adjustments.

5.9.3.4 Control limits. Calibration or adjustment controls which are intended to have a limited degree of motion shall have mechanical stops with strength to prevent damage by a force or torque 100 times greater than the resistance to movement within the range of adjustment.

5.9.3.5 Critical controls. Critical and sensitive adjustment controls shall incorporate features to prevent inadvertent or accidental actuation. If a locking device is to be used to prevent inadvertent actuation, operation of the locking device shall not change the adjustment setting. Where the operator or maintainer is subjected to disturbing vibrations or acceleration during the adjustment operation, suitable hand or arm support shall be provided near the control location to facilitate making adjustment.

5.9.3.6 Hazardous locations. Adjustment controls should not be located close to dangerous voltages, moving machinery, or any other hazards. If such location cannot be avoided, the controls shall be appropriately shielded and labeled.

5.9.4 Accessibility.

5.9.4.1 Structural members. Structural members or permanently installed equipment shall not visually or physically obstruct adjustment, servicing, removal of replaceable equipment or other required maintenance tasks. Panels, cases, and covers removed to access equipment shall have the same access requirements as replaceable equipment. Mounting provisions shall be directly visually, and physically accessible by the maintainers. Unless required by security considerations, no special tools shall be required for removal or replacement.

5.9.4.2 Large items. Large items which are difficult to remove shall be so mounted that they will not prevent convenient access to other items.

5.9.4.3. Use of tools and test equipment. Check points, adjustment points, test points, cables, connectors, and labels shall be accessible and visible during maintenance. Sufficient space shall be provided for the use of test equipment and other required tools without difficulty or hazard.

5.9.4.4 Rear access. Sliding, rotating or hinged equipment to which rear access is required shall be free to open or rotate their full distance and remain in the open position without being supported by hand. Rear access shall also be provided to plug connectors for test points, soldering and pin removal where connectors require such operations. Aircraft installed equipment shall be configured for one-sided access.

5.9.4.5 Relative accessibility. Mission critical items which require rapid maintenance shall be most accessible. When relative criticality is not a factor, items requiring most frequent access shall be most accessible.

5.9.4.6 High-failure-rate items. High-failure-rate items should be accessible for replacement without moving non-failed items. Mechanical replacement items shall be removable with common hand tools and simple handling equipment.

5.9.4.7 Skills. Access to items maintained by one technician should not require removal of critical equipment maintained by another technician, particularly where highly specialized skills are involved.

5.9.5 Lubrication.

5.9.5.1 General. Configuration of equipment containing mechanical items requiring lubrication shall permit both lubrication and checking of lubricant levels without disassembly. Extended fittings shall be provided to lubricant ports that would not otherwise be readily accessible or visible. Permanently lubricated items for which lubricant lasts for the life of the items are excluded. A clear indication of completion of lube servicing shall be provided to ensure proper servicing level. Lube fittings shall be sized to prevent cross coupling with improper lube servicing devices.

5.9.5.2 Labeling. Where lubrication is required, the type of lubricant to be used and the frequency of lubrication shall be specified by a label mounted at or near the lube port or grease fitting. For non-airborne equipment, a lubrication chart of permanent construction shall be mounted at the operator station of the equipment; individual labels shall not be required when the equipment has only one type of fitting and uses only one type of lubricant.

5.9.6 Case and cover mounting. Cover or shield holes shall be large enough for mounting screw clearance without perfect case alignment.

5.9.7 Cases.

5.9.7.1 Orientation. The proper orientation of an item within its case shall be made obvious, either through design of the case or by means of appropriate labels.

5.9.7.2 Removal. Cases should lift from items rather than the converse. Equipment should be protected from damage when cases are removed or replaced. Cases shall not require manual support to remain in the open position during maintenance.

5.9.7.3 Size. Cases shall be sufficiently larger than the items they cover to facilitate installation and removal with little or no case manipulation.

5.9.7.4 Guides. Guides, tracks, and stops shall be provided as necessary to facilitate handling and to prevent damage to equipment or injury to personnel.

5.9.8 Covers.

5.9.8.1 Securing of covers. It shall be made obvious when a cover is not secured, even though it may be in place.

5.9.8.2 Instructions. If the method of opening a cover is not obvious from the construction of the cover itself, instructions shall be permanently displayed on the outside of the cover. Instructions shall consist of simple symbols such as arrows or simple words such as "push" or "push and turn."

5.9.8.3 Clearance. Bulkheads, brackets, and other equipment shall not obstruct visual or physical access for removal or opening of covers on equipment within which work must be performed in the installed condition. Covers, doors or panels which must be opened to perform on-site maintenance shall be visually and physically accessible to the maintainers.

5.9.9 Access openings and covers.

5.9.9.1 Application. An access shall be provided whenever frequent maintenance operations would otherwise require removing a case or covering, opening a fitting, or dismantling an item of equipment.

5.9.9.2 Self-supporting covers. Hinged access covers that are not completely removable shall be self-supporting in the open position. The cover in the open position shall not obstruct required visual or physical access to the equipment being maintained or to related equipment during maintenance. Self-supporting covers should be capable of being opened and closed with one hand. Covers shall be secured to withstand windgusts, vibrations, or other environmental effects as specified by system requirements.

5.9.9.3 Labeling. Each access should be labeled with nomenclature for items visible or accessible through it, nomenclature for auxiliary equipment to be used with it and recommended procedures for accomplishing operations. Accesses shall be labeled with warning signs, advising of any hazards existing beyond the access and stating necessary precaution. Opening or removing an access cover shall not remove or visually obstruct any hazard warning. If instructions applying to a covered item are lettered on a hinged door, the lettering shall be properly oriented to be read when the door is open. Warning notices shall be clear, direct, and attention-getting and have a 25 percent larger letter height than any detailed instructions which follow.

5.9.9.4 Rounding. Cover and access edges shall be rounded (See 5.13.5.4) to preclude hand injury or clothing damage.

5.9.9.5 Physical access.

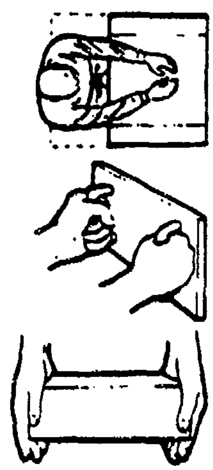
5.9.9.5.1 Arm and hand access. Access openings provided for adjusting and handling interior equipment shall be sized to permit the required operations and shall provide an adequate view of the item being manipulated. All blind arm and hand access shall require approval of procuring authority.

5.9.9.5.1.1 Opening covers. Access covers shall be equipped with grasp areas or other means for opening them. Where operations will require opening and closing the covers while wearing gloves or special clothing, opening provisions shall accommodate the gloves or special clothing.

5.9.9.5.1.2 Reach access dimensions. The dimensions of access openings for arms, hands, and fingers shall be no less than those shown in Figure 45. Allowance shall be made for the clearance of the operator's gloved or mittened hand, or special clothing as appropriate. Shape of access shall allow easy passage of equipment, body appendage or tools as appropriate. Access shape shall permit passage of all equipment that must be replaced through the opening allowing for protuberances, attachments and handles on the equipment.

5.9.9.5.1.3 Tool access dimensions. Access openings shall be large enough to operate tools required for maintenance of the equipment reached through the access.

MINIMAL TWO-HAND ACCESS OPENINGS WITHOUT VISUAL ACCESS



Reaching with both hands to depth of 150 to 490mm:

Light clothing:	Width:	200mm or the depth of reach*
	Height:	125mm
Arctic clothing:	Width:	150mm plus 3/4 the depth of reach
	Height:	180mm

Reaching full arm's length (to shoulders) with both arms:

Width:	500mm
Height:	125mm

Inserting box grasped by handles on the front:

13mm clearance around box, assuming adequate clearance around handles

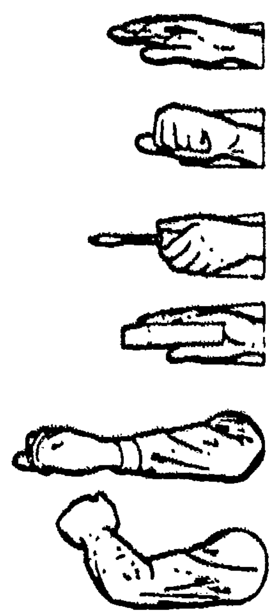
Inserting box with hands on the sides:

Light clothing:	Width	Box plus 115mm
	‡ Height:	125mm or 13mm around box*
Arctic clothing:	Width:	Box plus 180mm
	‡ Height:	215mm or 15mm around box*

*Whichever is larger.

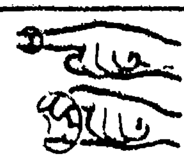
‡If hands curl around bottom, allow an extra 38mm for light clothing, 75mm for arctic clothing.

MINIMAL ONE-HAND ACCESS OPENINGS WITHOUT VISUAL ACCESS



	Height		Width		
Empty hand, to wrist:					
Bare hand, rolled:	95mm		sq or dia		
Bare hand, flat:	55mm	x	100mm	or	100mm dia
Glove or mitten:	100mm	x	150mm	or	150mm dia
Arctic mitten:	125mm	x	165mm	or	165mm dia
Clenched hand, to wrist:					
Bare hand:	95mm	x	125mm	or	125mm dia
Glove or mitten:	115mm	x	150mm	or	150mm dia
Arctic mitten:	180mm	x	215mm	or	215mm dia
Hand plus 1" dia object, to wrist:					
Bare hand:	95mm sq or dia				
Gloved hand:	150mm sq or dia				
Arctic mitten:	180mm sq or dia				
Hand plus object over 1" in dia, to wrist:					
Bare hand:	45mm clearance around object				
Glove or mitten:	65mm clearance around object				
Arctic mitten:	90mm clearance around object				
Arm to elbow:					
Light clothing:	100mm x 115mm				
Arctic clothing:	180mm sq or dia				
With object:	Clearances as above				
Arm to shoulder:					
Light clothing:	125mm sq or dia				
Arctic clothing:	215mm sq or dia				
With object:	Clearances as above				

MINIMAL FINGER ACCESS TO FIRST JOINT



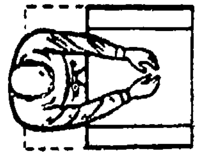
Push button access:	Bare hand:	32mm dia
	Gloved hand:	38mm dia
Two finger twist access:	Bare hand:	object plus 50mm
	Gloved hand:	object plus 65mm

FIGURE 45. ARM AND HAND ACCESS DIMENSIONS, IN mm

MINIMAL TWO-HAND ACCESS OPENINGS WITHOUT VISUAL ACCESS

Reaching with both hands to depth of 6 to 19.25 inches:

Light clothing:	Width:	8" or the depth of reach*
	Height:	5"
Arctic clothing:	Width:	6" plus 3/4 the depth of reach
	Height:	7"

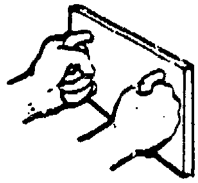


Reaching full arm's length (to shoulders) with both arms:

Width:	19.5"
Height:	5"

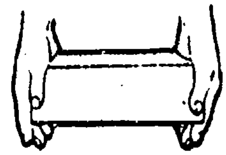
Inserting box grasped by handles on the front:

1/2" clearance around box, assuming adequate clearance around handles



Inserting box with hands on the sides:

Light clothing:	Width:	Box plus 4.5"
	‡ Height:	5" or 0.5" around box*
Arctic clothing:	Width:	Box plus 7"
	‡ Height:	8.5" or 0.5" around box*

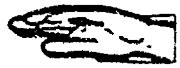


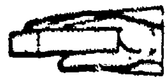
* Whichever is larger.

‡ If hands curl around bottom, allow an extra 1.5" for light clothing, 3" for arctic clothing.

MINIMAL ONE-HAND ACCESS OPENINGS WITHOUT VISUAL ACCESS

	Height		Width		
Empty hand, to wrist:					
Bare hand, rolled:	3.75"	sq or dia			
Bare hand, flat:	2.25"	x	4.0"	or	4.0" dia
Glove or mitten:	4.0"	x	6.0"	or	6.0" dia
Arctic mitten:	5.0"	x	6.5"	or	6.5" dia
Clenched hand, to wrist:					
Bare hand:	3.5"	x	5.0"	or	5.0" dia
Glove or mitten:	4.5"	x	6.0"	or	6.0" dia
Arctic mitten:	7.0"	x	8.5"	or	8.5" dia
Hand plus 1" dia object, to wrist:					
Bare hand:	3.75"	sq or dia			
Gloved hand:	6.0"	sq or dia			
Arctic mitten:	7.0"	sq or dia			
Hand plus object over 1" in dia, to wrist:					
Bare hand:	1.75" clearance around object				
Glove or mitten:	2.5" clearance around object				
Arctic mitten:	3.5" clearance around object				
Arm to elbow:					
Light clothing:	4.0"	x	4.5"	or	4.5" dia
Arctic clothing:	7.0"	sq or dia			
With object:	Clearances as above				
Arm to shoulder:					
Light clothing:	5.0"	sq or dia			
Arctic clothing:	8.5"	sq or dia			
With object:	Clearances as above				





MINIMAL FINGER ACCESS TO FIRST JOINT

Push button access:	Bare hand:	1.25" dia
	Gloved hand:	1.5" dia
Two finger twist access:	Bare hand:	object plus 2.0" dia
	Gloved hand:	object plus 2.5" dia

FIGURE 45. ARM AND HAND ACCESS DIMENSIONS, IN INCHES (CONCLUDED)

5.9.9.5.1.4 Remove and replace dimensions. Opening size for removal and replacement of equipment shall allow for handling clearance for bare hand or gloved hand as appropriate.

5.9.9.5.1.5 Guarding hazardous conditions. If a hazardous condition, such as exposed conducters energized with dangerous voltages or currents, exist behind the access, the physical barrier over the access shall be equiped with an interlock that will de-energize the hazardous equipment when the barrier is open or removed. Both the presence of the hazard and the fact that an interlock exists shall be noted on the equipment case or cover such that it remains visible when the access is open.

5.9.9.5.1.6 Type of opening. Where physical access is required, the following practices shall be followed in order of preference:

a. An opening with no cover unless this is likely to degrade system performance, safety, or NBC contamination survivability.

b. A hand operated (latched, sliding, or hinged) cap or door where dirt, moisture, or other foreign materials might otherwise create a problem.

c. A quick-opening cover plate using 1/4 turn captive fasteners if a cap will not meet stress requirements or space prevents a hinged cover.

d. When captive fasteners cannot be used because of stress, structure or pressurization, screw down cover. Use minimum number of interchangeable screws to fasten door.

5.9.9.6 Visual access. Where visual access is required, the opening shall provide a visual angle sufficient to view all required information at the normal operating or maintenance position. The maintainer should be provided unrestricted visual access from the work station without bending. Where bending is required, frequency and time in the bent position shall not cause fatigue. Where visual access only is required, the following practices shall be followed in order of precedence:

a. An opening with no cover except where this might degrade system performance or NBC survivability.

b. A transparent window if dirt, moisture, or other foreign materials might otherwise create a problem.

c. A break-resistant glass window if physical wear, heat, or contact with solvents would otherwise cause optical deterioration.

d. A quick-opening opaque cover if glass will not meet stress or other requirements.

5.9.9.7 Access cover attachment. Covers shall be attached with the fewest number of simplest-to-operate fasteners practicable. Fasteners shall be operable by hand or by common hand tools in that order of preference. Small, removable covers shall be attached to structure or otherwise retained to prevent loss.

5.9.10 Fasteners.

5.9.10.1 General. The number and diversity of fasteners used shall be minimized commensurate with stress, bonding, pressurization, shielding, thermal and safety requirements. When more than one size or type fastener is used on the same equipment or cover, the fasteners/equipment/cover interface shall permit the maintainer to readily distinguish the intended location of each fastener. Finger or hand-operated fasteners shall be used when consistent with these requirements, except where screws with heads flush with the case or fastening surface are required for NBC survivability. Fasteners requiring non-standard tools shall not be used.

5.9.10.2 Hinges and tongue-and-slot catches. Hinges, tongue-and-slot catches and mounting pins shall be used to minimize the number of fasteners required; however, where covers are subject to NBC survivability requirements, pin and hook arrangements, rather than hinges, should be used.

5.9.10.3 Captive fasteners. Captive fasteners shall be used where dropping or loss of such items could cause damage to equipment or create a difficult or hazardous removal problem. Captive fasteners shall also be provided for access covers requiring frequent removal.

5.9.10.4 Quantity. If a hinged access panel or quick-opening fasteners will not meet stress, pressurization, shielding, or safety requirements, the minimum number consistent with these requirements shall be used.

5.9.10.5 Fastener head type.

5.9.10.5.1 High torque fasteners. External hex or external double-hex wrenching elements shall be provided on all machine screws, bolts or other fasteners requiring more than 14 N·m (10ft-lb) of torque. When external wrenching fasteners cannot meet the mechanical function or personnel safety requirements, or in limited access situations, and where use is protected from accumulation of foreign material, internal wrenching fasteners may be used. Direct tool access shall be provided to allow for torquing without the use of irregular extensions.

5.9.10.5.2 Low torque fasteners. Hex type internal grip head, hex type external grip head or combination head (hex or straight-slot internal grip and hex type external-grip head) or Torq-set fasteners may be provided where less than 14 N·M (10 ft lb) torque is required; however, internal-grip head fasteners shall be provided only where a straight or convex smooth surface is required for mechanical function or for personnel safety and where use is protected from accumulation of foreign material (e.g., ice, snow). Straight-slot or cross-recess type internal grip fasteners shall not be provided, except as wood fasteners or where these type fasteners are provided on standard commercial items.

5.9.10.5.3 Common fasteners. Whenever possible, identical screw and bolt heads shall be provided to allow various panels and components to be removed with one tool. Combination bolt heads such as slotted hex head should be selected whenever feasible. Identical fasteners shall not be used where removal of wrong fastener can result in equipment damage or change to calibration settings.

5.9.10.6 Accessibility. The heads of mounting bolts and fasteners should be located on surfaces readily accessible to the maintainer. Both hand and tool access shall be provided to the unthreaded or loosened fastener.

5.9.10.7 Number of turns. Fasteners for mounting assemblies and subassemblies shall require a minimum number of turns, compatible with stress, alignment, positioning and load considerations. When machine screws or bolts are required, the number of turns and the amount of torque shall be no more than necessary to provide the required strength except when a common fastener is utilized. All items requiring removal for daily or more frequent scheduled inspections and servicing shall utilize quick release fasteners.

5.9.10.8 Torque labeling. When fastener torquing to meet EMI/RFI shielding, thermal conductance or other constraints is required for organizational or intermediate level maintenance actions, an instructional label or placard should be provided in reasonable proximity to fasteners. Such labels shall comply with requirements of 5.5 and specify required torque value and torquing sequence.

5.9.11 Unit design for efficient handling.

5.9.11.1 Rests and stands. When required to support operations or maintenance functions, rests or stands on which units can be placed, including space for test equipment, tools, technical orders and manuals, should be provided. When permitted by design requirements, such rests or stands shall be part of the basic unit, rack or console chassis.

5.9.11.2 Extensions. Extensions and connected appurtenances, accessories, utilities, cables, wave guides, hoses and similar items shall not interfere with removing, replacing, or carrying an item. If such extensions and connected appurtenances interfere with these tasks, they shall be easily removed or disconnected from the equipment before handling. Easy disconnect shall consist of hand operable quick disconnect or standard hand tool operable disconnects in that order of preference.

5.9.11.3 Weight.

5.9.11.3.1 Lifting limits. The weight limits in Table XXIII, conditions A and B, shall be used as maximum values in determining the design weight of items requiring one person lifting with two hands. Double the weight limits in Table XXIII shall be used as the maximum values in determining the design weight of items requiring two person lifting, provided the load is uniformly distributed between the two lifters. If the weight of the load is not uniformly distributed, the weight limit applies to the heavier lift point. Where three or more persons are lifting simultaneously, not more than 75 percent of the one-person value may be added for each additional lifter, provided that the object lifted is sufficiently large that the lifters do not interfere with one another while lifting. Where it is not possible to define the height to which an object will be lifted in operational use, the limit wherein the object is lifted to shoulder height shall be used rather than the more permissive bench height value. The values in Table XXIII are applicable to objects with or without handles.

TABLE XXIII. DESIGN WEIGHT LIMITS

HANDLING FUNCTION	Male and Female Population (kgs)	Male and Female Population (lbs)	Male Only Population (kgs)	Male Only Population (lbs)
A. Lift an object from the floor and place it on a surface not greater than 1.525 m (5 ft) above the floor.	16.8	37	25.4	56
B. Lift an object from the floor and place it on a surface not greater than 915 mm (36 in.) above the floor.	20.0	44	39.5	87
C. Carry an object 10 meters (33 feet) or less.	19.0	42	37.2	82

5.9.11.3.2 Lifting frequency. The equipment weight limits in Table XXIII are not for repetitive lifting as found, for example, in loading or unloading transport vehicles. If the frequency of lift exceeds one lift in 5 minutes or 20 lifts per 8 hours, the permissible weight limits shall be reduced by (8.33xLF) percent, where LF is the lift frequency in lifts per minute. For example, if the lift frequency is 6 lifts per minute, then the maximum permissible weight is reduced by 50 percent (8.33 x 6 = 50).

5.9.11.3.3 Load size. The maximum permissible weight lift limits in Table XXIV are applicable to an object with uniform mass distribution and a compact size not exceeding 460 mm (18 inches) high, 460 mm (18 inches) wide, and 300 mm (12 inches) deep (away from the lifter.) This places the hand holds at half the depth, or 150 mm (6 inches) away from the body. If the depth of the object exceeds 610 mm (24 inches) the permissible weight shall be reduced by 33 percent. If the depth of the object exceeds 910 mm (36 inches), the permissible weight shall be reduced by 50 percent. If the depth of the object exceeds 1.220 m (48 inches), the permissible weight shall be reduced by 66 percent.

5.9.11.3.4 Obstacles. The values in Table XXIII assume that there are no obstacles between the person lifting and the shelf, table, bench or other surface on which the object is to be placed. Where there is a lower protruding shelf or other obstacle limiting the lifter's approach to the desired surface, the weight limit of the object shall be reduced by 33 percent for an obstacle protruding 300 mm (12 inches), 50 percent for an obstacle protruding 460 mm (18 inches), and 66 percent for an obstacle protruding 610 mm (24 inches). If the allowable weight must be reduced by both oversize load considerations (paragraphs 5.9.11.3.3) and the obstacle considerations, only the more restrictive single value shall apply; two reductions shall not be applied.

5.9.11.3.5 Carrying limits. The weight limit in Table XXIII condition C shall be used as the maximum value in determining the design weight of items requiring one person carrying of objects a distance of up to 10 m (33 feet). The maximum permissible weight for carrying also applies to an object with a handle on top, such as a tool box, which usually is carried at the side with one hand. Double this weight carrying limit shall be used as the maximum value in determining the design weight of items requiring two-person carrying, provided the load is uniformly distributed between the two carriers. Where three or more persons are carrying a load together, not more than 75 percent of the one-person value may be added for each additional person and provided that the object is sufficiently large that the workers do not interfere with one another while carrying the load. In all cases involving carrying, it is assumed that the object is first lifted from the floor, carried a distance of 10 m (33 feet) or less, and placed on the floor or on another surface not higher than 915 mm (36 inches). If the final lift is to a higher height, the 1.525 m (5 foot) lift height applies as the more limiting case.

5.9.11.3.6 Carrying frequency. The reduction formula expressed in paragraph 5.9.11.3.2 shall be applied to repetitive carrying in the same manner as for repetitive lifting.

5.9.11.3.7 Object carry size. The reduction formula expressed in paragraph 5.9.11.3.3 shall be applied to size of objects to be carried in the same manner as for load size.

5.9.11.3.8 User population. Unless otherwise specified by the procuring activity, the values in Table XXIII for Male and Female Population shall apply to any object to be lifted or carried manually. Where the procuring activity specifies that the object is to be lifted or carried only in a combat environment, the Male Only Population will be applied.

5.9.11.3.9 Labeling. Items weighing more than the one-person lift or carry values for Male and Female Population of Table XXIII shall be prominently labeled with weight of the object and lift limitation, i.e., mechanical or two-person lift, three-person lift, etc. Where mechanical or power lift is required, hoist and lift points shall be provided and clearly labeled.

5.9.11.4 Push and pull forces.

5.9.11.4.1 Horizontal. Manual horizontal push and pull forces required, to be applied initially to an object to set it in motion or to be sustained over a short period of time, shall not exceed the values of Table XXIV, as applicable, or those given in Figure 21, if more appropriate to the force and movement characteristics of the task. The values shown in Table XXIV apply to males only and should be modified for females. (Two-thirds of each value shown is considered to be a reasonable adjustment.) Use of the maxima shown in Table XXIV is predicated upon a suitable surface for force exertion, i.e., vertical with rough surface and be approximately 400 mm (16 inches) wide between 0.510 and 1.270m (20 and 50 inches) above the floor to allow force application with the hands, the shoulder or the back (see Figure 46).

5.9.11.4.2 Vertical. Manual vertical push and pull forces required shall not exceed the applicable fifth percentile peak or mean force values of Table XXV, or those given in Figure 21, if more appropriate to the force and movement characteristics of the task.

TABLE XXIV. HORIZONTAL PUSH AND PULL FORCES EXERTABLE INTERMITTENTLY OR FOR SHORT PERIODS OF TIME (MALE PERSONNEL)

HORIZONTAL FORCE*; AT LEAST	APPLIED WITH **	CONDITION (μ: COEFFICIENT OF FRICTION)
100N (25 lb) push or pull	both hands or one shoulder or the back	with low traction $0.2 < \mu < 0.3$
200N (45 lb) push or pull	both hands or one shoulder or the back	with medium traction $\mu \sim 0.6$
250N (55 lb) push	one hand	if braced against a vertical wall 510–1525 mm (20–60 in.) from and parallel to the push panel
300N (70 lb) push or pull	both hands or one shoulder or the back	with high traction $\mu > 0.9$
500N (110 lb) push or pull	both hands or one shoulder or the back	if braced against a vertical wall 510–1780 mm (20–70 in.) from and parallel to the panel or if anchoring the feet on a perfectly nonslip ground (like a footrest)
750N (165 lb) push	the back	if braced against a vertical wall (600–1100 mm) (23–43 in.) from and parallel to the push panel or if anchoring the feet on a perfectly nonslip ground (like a footrest)

*May be doubled for two and tripled for three operators pushing simultaneously. For the fourth and each additional operator, not more than 75% of their push capability should be added.

**See Figure 46 for examples.

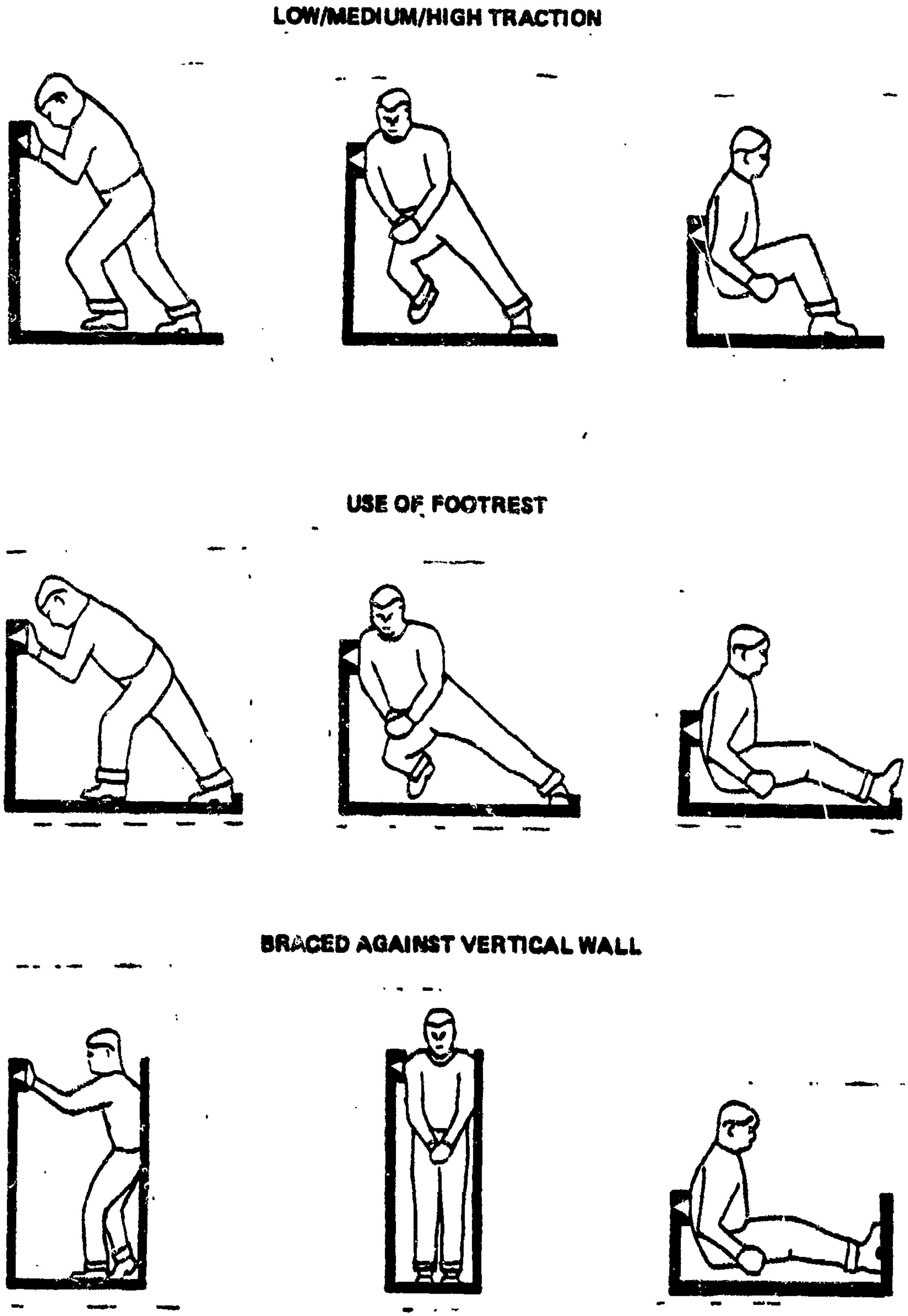


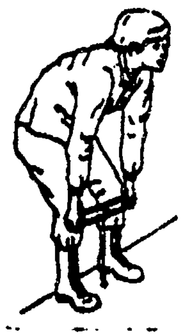
FIGURE 46. EXAMPLES OF PUSH FORCE CONDITIONS FOR TABLE XXIV

TABLE XXV. STATIC MUSCLE STRENGTH DATA

STRENGTH MEASUREMENTS (SEE FIGURE 47)	PERCENTILE VALUES IN NEWTONS			
	5th PERCENTILE		95th PERCENTILE	
	MEN	WOMEN	MEN	WOMEN
A STANDING TWO–HANDED PULL: 38 cm LEVEL				
MEAN FORCE	738	331	1354	818
PEAK FORCE	845	397	1437	888
B STANDING TWO–HANDED PULL: 50 cm LEVEL				
MEAN FORCE	768	326	1342	841
PEAK FORCE	831	374	1442	905
C STANDING TWO–HANDED PULL: 100 cm LEVEL				
MEAN FORCE	444	186	931	443
PEAK FORCE	504	218	988	493
D STANDING TWO–HANDED PUSH: 150 cm LEVEL				
MEAN FORCE	409	163	1017	380
PEAK FORCE	473	188	1094	430
E STANDING ONE–HANDED PULL 100 cm LEVEL				
MEAN FORCE	215	103	628	284
PEAK FORCE	259	132	724	322
F SEATED ONE–HANDED PULL: CENTERLINE, 45 cm LEVEL				
MEAN FORCE	227	106	678	392
PEAK FORCE	273	127	768	451
G SEATED ONE–HANDED PULL: SIDE, 45 cm LEVEL				
MEAN FORCE	240	109	604	337
PEAK FORCE	273	134	659	396
H SEATED TWO–HANDED PULL: CENTERLINE, 38 cm LEVEL				
MEAN FORCE	586	242	1221	770
PEAK FORCE	699	286	1324	842
I SEATED TWO–HANDED PULL: CENTERLINE, 50 cm LEVEL				
MEAN FORCE	525	204	1062	632
PEAK FORCE	598	237	1189	697

TABLE XXV STATIC MUSCLE STRENGTH DATA

STRENGTH MEASUREMENTS (SEE FIGURE 47)	PERCENTILE VALUES IN POUNDS			
	5th PERCENTILE		95th PERCENTILE	
	MEN	WOMEN	MEN	WOMEN
A STANDING TWO–HANDED PULL: 15 in. LEVEL				
MEAN FORCE	166	74	304	184
PEAK FORCE	190	89	323	200
B STANDING TWO–HANDED PULL: 20 in. LEVEL				
MEAN FORCE	170	73	302	189
PEAK FORCE	187	84	324	203
C STANDING TWO–HANDED PULL: 39 in. LEVEL				
MEAN FORCE	100	42	209	100
PEAK FORCE	113	49	222	111
D STANDING TWO–HANDED PUSH: 59 in. LEVEL				
MEAN FORCE	92	34	229	86
PEAK FORCE	106	42	246	97
E STANDING ONE–HANDED PULL: 39 in. LEVEL				
MEAN FORCE	48	23	141	64
PEAK FORCE	58	30	163	72
F SEATED ONE–HANDED PULL: CENTERLINE, 18 in. LEVEL				
MEAN FORCE	51	24	152	88
PEAK FORCE	61	29	170	101
G SEATED ONE–HANDED PULL: SIDE, 18 in. LEVEL				
MEAN FORCE	54	25	136	76
PEAK FORCE	61	30	148	89
H SEATED TWO–HANDED PULL: CENTERLINE, 15 in. LEVEL				
MEAN FORCE	134	54	274	173
PEAK FORCE	157	64	298	189
I SEATED TWO–HANDED PULL: CENTERLINE, 20 in. LEVEL				
MEAN FORCE	118	46	237	142
PEAK FORCE	134	53	267	157

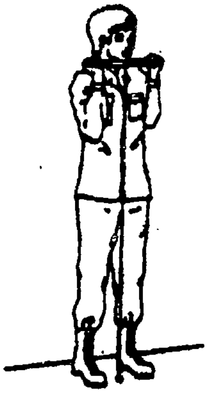


A. STANDING TWO–HANDED PULL: 38 cm (15") LEVEL
STANDING WITH FEET 45 cm (18") APART AND KNEES BENT. BENDING AT WAIST, GRASPING BOTH SIDES OF 45 cm (18") LONG HANDLE LOCATED DIRECTLY IN FRONT, 38 cm (15") ABOVE STANDING SURFACE, AND PULLING, USING PRIMARILY ARMS, SHOULDERS AND LEGS.

B. STANDING TWO–HANDED PULL: 50 cm (20") LEVEL
STANDING WITH FEET 45 cm (18") APART AND KNEES STRAIGHT. BENDING AT WAIST, GRASPING BOTH SIDES OF 45 cm (18") LONG HANDLE LOCATED DIRECTLY IN FRONT, 50 cm (20") ABOVE STANDING SURFACE, AND PULLING, USING PRIMARILY ARMS AND SHOULDERS.

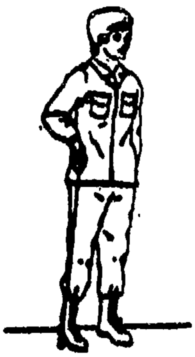
C. STANDING TWO–HANDED PULL: 100 cm (39") LEVEL
STANDING ERECT WITH FEET 45 cm (18") APART, GRASPING BOTH SIDES OF 45 cm (18") LONG HANDLE LOCATED DIRECTLY IN FRONT, 100 cm (39") ABOVE STANDING SURFACE, AND PULLING, USING THE ARMS.

FIGURE 47. STATIC MUSCLE STRENGTH DATA



D. STANDING TWO–HANDED PUSH: 150 cm (59") LEVEL

STANDING ERECT WITH FEET 45 cm (18") APART, GRASPING FROM BELOW, BOTH SIDES OF 45 cm (18") LONG HANDLE LOCATED DIRECTLY IN FRONT, 150 cm (59") ABOVE STANDING SURFACE. PUSHING UPWARD USING ARMS AND SHOULDERS.



E. STANDING ONE–HANDED PULL: 100 cm (39") LEVEL

STANDING ERECT WITH FEET 15 cm (6") APART, DOMINANT HAND GRASPING UNDERSIDE OF D–RING LOCATED DIRECTLY TO THE SIDE, 100 cm (39") ABOVE STANDING SURFACE. PULLING UPWARD WHILE KEEPING SHOULDER SQUARE AND OTHER ARM RELAXED AT SIDE.

F. SEATED ONE–HANDED PULL: SEAT CENTERLINE 45 cm (18") LEVEL

SITTING ERECT WITH FEET 55 cm (22") APART, DOMINANT HAND GRASPING UNDERSIDE OF D–RING LOCATED DIRECTLY TO THE FRONT, 45 cm (18") ABOVE THE FLOOR. PULLING UPWARD WHILE KEEPING SHOULDERS SQUARE AND OTHER ARM RESTING IN LAP.

FIGURE 47. STATIC MUSCLE STRENGTH DATA (CONTINUED)

G. SEATED ONE-HANDED PULL: SIDE OF SEAT, 46 cm (18") LEVEL

SITTING ERECT WITH FEET 55 cm (22") APART, DOMINANT HAND GRASPING UNDERSIDE OF D-RING LOCATED A SHORT DISTANCE TO SIDE, 45 cm (18") ABOVE THE FLOOR. PULLING UPWARD WHILE KEEPING SHOULDERS SQUARE AND OTHER ARM RESTING IN LAP.

H. SEATED TWO-HANDED PULL: CENTERLINE OF SEAT, 38 cm (15") LEVEL

SITTING ERECT WITH FEET 55 cm (22") APART. BENDING SLIGHTLY AT WAIST, GRASPING BOTH SIDES OF 15 cm (6") LONG HANDLE LOCATED DIRECTLY TO THE FRONT, 38 cm (15") ABOVE THE FLOOR. PULLING UPWARD, USING ARMS AND SHOULDERS, KEEPING ARMS OFF THIGHS.

I. SEATED TWO-HANDED PULL: CENTERLINE OF SEAT, 50 cm (20") LEVEL

SITTING ERECT WITH FEET 55 cm (22") APART. BENDING SLIGHTLY AT WAIST, GRASPING BOTH SIDES OF 15 cm (6") LONG HANDLE LOCATED DIRECTLY TO THE FRONT, 50 cm (20") ABOVE THE FLOOR. PULLING UPWARD, USING ARMS AND SHOULDERS, KEEPING ARMS OFF THIGHS.

FIGURE 47. STATIC MUSCLE STRENGTH DATA (CONCLUDED)

5.9.11.5 Handles and grasp areas.

5.9.11.5.1 General. All removable or carried units designed to be removed and replaced shall be provided with handles or other suitable means for grasping, handling, and carrying (where appropriate, by gloved or mittened hand). Items requiring handling should be provided with a minimum of two handles, or one handle and one grasp area. Items weighing less than 4.5 kg (10 lbs) whose form factor permits them to be handled easily shall be exempt from this requirement unless specifically directed by the procuring activity.

5.9.11.5.2 Location. Whenever possible, handles, grasp areas, or hoist points shall be located to preclude uncontrolled swinging or tilting when lifted. They shall be located to provide at least 50 mm (2 inches) of clearance from obstructions during handling. The location of handles shall not interfere with installing, removing, operating or maintaining the equipment.

5.9.11.5.3 Nonfixed handles. Nonfixed handles (e.g., hinged or fold-out) shall have a stop position for holding the handle perpendicular to the surface on which it is mounted and shall be capable of being placed into carrying position by one hand (where appropriate, by gloved or mittened hand).

5.9.11.5.4 Grasp surface. Where an item's installation requires that its bottom surface be used as a handhold during removal or installation, a nonslip grasp surface (e.g., grooved, knurled, or frictional) shall be provided.

5.9.11.5.5 Handle dimensions. Handles which are to be used with mittened, gloved, or ungloved hands shall equal or exceed the minimum applicable dimensions shown in Figure 48.

5.9.11.5.6 Handle and grasp area force requirements. Force requirements to operate handle and grasp areas other than controls covered by paragraph 5.4 shall not exceed the values in Figure 21.

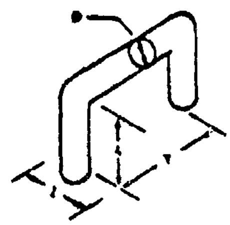
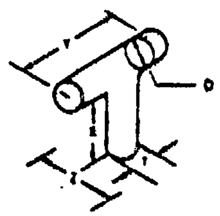
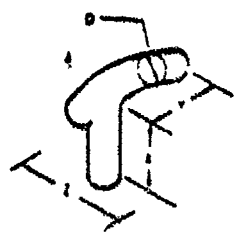
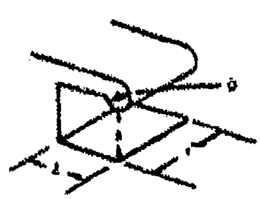
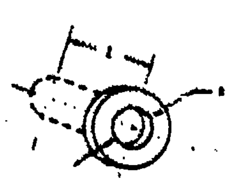
5.9.11.5.7 Handle material. Handles or grasp areas used with bare hands should have surfaces that are not thermally (see 5.13.4.6) or electrically conductive. The surface shall be sufficiently hard to prevent imbedding of grit and grime during normal use.

5.9.12 Mounting.

5.9.12.1 General. Equipment configuration shall preclude improper mounting.

5.9.12.2 Tools. Field removable items shall be replaceable by using only common hand tools.

5.9.12.3 Removal. Replaceable items should be removable along a straight or slightly curved line, rather than through an angle.

ILLUSTRATION	TYPE OF HANDLE	DIMENSIONS IN mm (in inches)								
		(Bare Hand)			(Gloved Hand)			(Mittened Hand)		
		X	Y	Z	X	Y	Z	X	Y	Z
	Two-finger bar	32 (1-1/4)	65 (2-1/2)	75 (3)	38 (1-1/2)	75 (3)	75 (3)	Not Applicable		
	One-hand bar	48 (1-7/8)	111 (4-3/8)	75 (3)	50 (2)	125 (5)	100 (4)	75 (3)	135 (5-1/4)	150 (6)
	Two-hand bar	48 (1-7/8)	215 (8-1/2)	75 (3)	50 (2)	270 (10-1/2)	100 (4)	75 (3)	280 (11)	150 (6)
	T-bar	38 (1-1/2)	100 (4)	75 (3)	50 (2)	115 (4-1/2)	100 (4)	Not Applicable		
	J-bar	50 (2)	100 (4)	75 (3)	50 (2)	115 (4-1/2)	100 (4)	75 (3)	125 (5)	150 (6)
	Two-finger recess	32 (1-1/4)	65 (2-1/2)	50 (2)	38 (1-1/2)	75 (3)	50 (2)	Not Applicable		
	One-hand recess	50 (2)	110 (4-1/4)	90 (3-1/2)	90 (3-1/2)	135 (5-1/4)	100 (4)	90 (3-1/2)	135 (5-1/4)	125 (5)
	Finger-tip recess	19 (3/4)	–	13 (1/2)	25 (1)	–	19 (3/4)	Not Applicable		
	One-finger recess	32 (1-1/4)	–	50 (2)	38 (1-1/2)	–	50 (2)	Not Applicable		

Curvature of Handle or Edge	Weight of Item	Minimum Diameter	
(DOES NOT PRECLUDE USE OF OVAL HANDLES)	Up to 6.8 kg (up to 15 lbs)	D - 6 mm (1/4 in)	Gripping efficiency is best if finger can curl around handle or edge to any angle of $\frac{2}{3}\pi$ rad (120°) or more.
	6.8 to 9.0 kg (15 to 20 lbs)	D - 13 mm (1/2 in)	
	9.0 to 18 kg (20 to 40 lbs)	D - 19 mm (3/4 in)	
	Over 18 kg (over 40 lbs)	D - 25 mm (1 in)	
	T-bar Post	T–13mm (1/2 in)	

FIGURE 48. MINIMUM HANDLE DIMENSIONS

5.9.12.4 Alignment. Items which must be precisely located or which incorporate rack and panel connectors shall utilize guide pins or their equivalent to assist in alignment during mounting.

5.9.12.5 Coding. Coding by such means as color or labels shall identify the correct item and its proper orientation or replacement. Where required to expedite field damage repair, wire bundles of more than five wires shall be label and color coded.

5.9.12.6 Rollout racks, slides or hinges. Items which must be frequently pulled out of their installed positions for inspection or maintenance shall be mounted on rollout racks, slides, or hinges. Rollout racks mounted in consoles should not shift the center of gravity to the extent that the entire rack or console falls. If this possibility exists, the console or rack shall be safely secured.

5.9.12.7 Limit stops. Limit stops shall be provided on racks and drawers which are required to be pulled out of their installed positions. Rollout racks and drawers shall be self-locking in the retracted and extended positions. The limit stop design shall permit convenient overriding of stops for rack or drawer removal. Unlocking of self-locking provisions should be accomplished by one hand.

5.9.12.8 Interlocks. Interlocks shall be provided to ensure disconnection of equipment that would otherwise be damaged by withdrawal of racks or drawers. Equipment design should obviate the need for interlocks.

5.9.12.9 Hinged mounting. Hinged items shall be provided with a brace or other means of support to hold equipment in the "out" position for maintenance if it is not free to rotate and remain in the "out" position without support.

5.9.12.10 Lay-out. Units shall be laid out so that a minimum of place-to-place movements will be required during checkout.

5.9.12.11 Covers or panels. Removal of any replaceable item shall require opening or removing a minimum number of covers or panels.

5.9.13 Conductors.

5.9.13.1 Coding. Cables containing individually insulated conductors with a common sheath shall be coded. The coding should be repeated every 300 mm (12 in.) along their entire length.

5.9.13.2 Cable clamps. Unless wiring ducts or conduits are used, mechanically (not adhesively) mounted cable clamps shall be provided to ensure correct routing of electrical cables within and between equipment items to ensure that cables do not hinder or obstruct equipment maintenance and to facilitate the mating of cables with their associated equipment items, and to prevent chaffing due to contact with adjacent structure.

5.9.13.3 Length. Cables shall be long enough so that required checking of any functioning item can be accomplished in a convenient place. Extension cables shall be provided where this is not feasible.

5.9.13.4 Cable routing. Cable routing shall not obstruct visual or physical access to equipment for operation or maintenance.

5.9.13.5 Access. Cables shall be routed so as to be accessible for inspection and maintenance.

5.9.13.6 Susceptability to abuse. Cables shall be routed or protected in such a way that they may not be pinched by doors, lids, etc., walked on, used for hand holds, or bent or twisted sharply or repeatedly.

5.9.13.7 Cable protection. When cables must pass over or through sharp edges, insulation shall be protected from fraying or other damage by grommets or equivalent means. Where required, cables shall be wrapped or sealed for NBC survivability.

5.9.13.8 Identification. Cables shall be labeled to indicate the equipment to which they belong and the connectors with which they mate. All replaceable wires and cables shall be uniquely identified with distinct color or number codes in accordance with MIL-STD-681.

5.9.14 Connectors.

5.9.14.1 Use of quick disconnect plugs. Plugs requiring no more than one turn, or other quick-disconnect plugs, shall be provided whenever feasible.

5.9.14.2 Keying. Plugs shall be so designed that it will be impossible to insert a wrong plug into a receptacle.

5.9.14.3 Identification. Marking of electrical connectors shall conform to Requirement 67 of MIL-STD-454. Electrical plugs and receptacles shall also be identified by color, shape, size, or equivalent means to facilitate identification when multiple, similar connectors are used in proximity to each other.

5.9.14.4 Alignment. Plugs and receptacles shall be provided with aligning pins, keyways, or equivalent devices to aid in alignment and to preclude inserting in other than the desired position.

5.9.14.5 Aligning pins and keyways. The configuration of aligning pins, keyways and other equivalent devices shall insure that alignment is obtained before the electrical pins engage and contact is made.

5.9.14.6 Orientation. Plugs and receptacles shall be arranged so that the aligning pins, keyways, or equivalent devices are oriented in the same relative position.

5.9.14.7 Coding. Plugs and receptacles shall have durable strips, arrows, or other indications to show the positions of aligning pins or equivalent devices for proper insertion.

5.9.14.8 Spacing. Connectors shall be spaced far enough apart so that they can be grasped firmly for connecting and disconnecting. Space between adjacent connectors, or between a connector and any adjacent obstructions, shall be compatible with the size and shape of the plugs, and the type of clothing worn by the maintainer (e.g., cold weather handwear, NBC gloves), but shall be not less than 25 mm (1 inch), except where connectors are to be sequentially removed and replaced and 25 mm (1") clearance is provided in a swept area of at least 1.5 μrad (270°) around each connector at the start of its removal/replacement sequence. Spacing shall be measured from the outermost portion of the connector, i.e., from the backshell, strain relief clamp, dust cover or EMI/RFI shield. Where high torque is required to tighten or loosen the connector, space shall be provided for use of a connector wrench.

5.9.14.9 Testing and servicing. The rear of plug connectors shall be accessible for testing and servicing, except where precluded by potting, sealing, or other requirements.

5.9.14.10 Drawer modules. Drawer modules designed for "remove and replace" maintenance shall be provided with connectors mounted on the back of the drawer and mated with connectors in the cabinet to accomplish electrical interconnection between the drawer, other equipment in the rack and external connectors, where feasible. Guide pins or equivalent devices shall be provided to aid in alignment.

5.9.14.11 Electronic modules. Replacement electronic items (e.g., modules and high-failure-rate components) should be provided with simple plug-in, rack-and-panel type connectors.

5.9.14.12 Disassembly and adapters. Disassembly of connectors to change pin connections should be performed without special tools. When adapters are required, they shall be capable of being hand-tightened.

5.9.14.13 Protective covers. If protective covers are required, captive types shall be used.

5.9.15 Test points.

5.9.15.1 Adjustment. Test points shall be located sufficiently close to the controls and displays used in the adjustment so that maintainer place-to-place movement is not required during the adjustment process. Test points for adjustment shall be physically and visually accessible in the installed condition by the maintainer without removing other items.

5.9.15.2 Trouble-shooting. Sufficient test points shall be provided so that it will not be necessary to remove subassemblies from assemblies to accomplish trouble-shooting.

5.9.15.3 Marking and color coding. Marking and color coding shall conform to MIL-STD-415.

5.9.16 Test equipment.

5.9.16.1 Storage. Adequate storage space shall be provided within portable test equipment, its handling case, or lid to contain leads, probes, spares, manuals, and special tools, as required for operation.

5.9.16.2 Instructions. Instructions for operating portable test equipment shall be provided on the face of the test equipment, in a lid, or in a special compartment. Instructions shall be directly readable while test equipment is being operated. Periodic calibration records including tolerance check values, shall be placarded on the equipment where appropriate. Where applicable, the instructions shall include a reminder to calibrate the equipment and calibration procedures.

5.9.17 Failure indications and fuse requirements.

5.9.17.1 Indication of equipment failure.

5.9.17.1.1 Power failure. An indication shall be provided to reveal when power failure occurs (see 5.2.2.1.4). All mission essential electronic computer and peripheral components which are part of a system shall incorporate an automatic self-check diagnostic of software and hardware at power up and at the request of the operator to assure they are functioning properly.

5.9.17.1.2 Out-of-tolerance. A display shall be provided to indicate when an equipment item has failed or is not operating within tolerance limits.

5.9.17.1.3 Critical malfunctions. If equipment is not regularly monitored, an audio alarm shall be provided to indicate malfunctions or conditions that would cause personnel injury or equipment damage. If auditory alarm would compromise covert operation of equipment, alert shall be a visual display.

5.9.17.2 Fuses and circuit breakers.

5.9.17.2.1 General. A positive indication shall be provided to reveal that a fuse or circuit breaker has opened a circuit.

5.9.17.2.2 Replacement and resetting. Fuses shall be readily accessible for removal and replacement. No other components shall require removal in order to gain access to fuses. No special tools shall be required for fuse replacement unless required by safety considerations. When resetting of circuit breakers is permissable, and is required for system operation during a mission, the breakers shall be located within reach of crew members in their normal operating posture.

5.9.17.2.3 Markings. Equipment served by the fuse or circuit breaker shall be identified in accordance with section 5.5. The current rating of fuses shall be permanently marked adjacent to the fuse holder. In addition, "SPARE" shall be marked adjacent to each spare fuse holder. Fuse ratings shall be indicated either in whole numbers, common fractions (such as 1/4 A), or whole numbers and common fractions (such as 2 1/4A). Labeling of fuses and circuit breakers shall be legible in the anticipated ambient illumination range for the operator's location.

5.9.17.2.4 Circuit breaker controls. Toggle bat and legend switch actuated circuit breakers may be used to control electrical power. Push-pull type breakers shall not be used as power switches.

5.9.17.2.5 Circuit breaker dimensions and separations. Dimensions and separation for toggle bat actuated breakers should comply with Figure 13. Legend switch actuated breakers should comply with the dimension and separation criteria shown in Figure 14. Push-pull actuated circuit breaker separation should comply with Table XI.

5.9.18 Printed circuit boards. Printed circuit boards shall be designed and mounted for ease of removal and replacement, considering such factors as finger access, gripping aids and resistance created by the mounting device. Appropriate feedback shall be provided to insure that the technician knows when the board is securely connected. Printed circuit boards shall be identified in accordance with MIL-STD-130 and reference designations for parts mounted on the printed circuit board shall be provided in accordance with MIL-STD-454, Requirement 67.

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5.10 Design of equipment for remote handling.

5.10.1 Characteristics of equipment to be handled remotely.

5.10.1.1 Alignment. Self-alignment devices shall be provided for components which must be joined remotely.

5.10.1.2 Disconnect. Quick-disconnect devices shall be provided to reduce remote-handling difficulties.

5.10.1.3 Fasteners. All fasteners shall be captive and readily replaceable by remote-handling techniques.

5.10.1.4. Lock and latching mechanisms. Each lock or latching mechanism shall be operable from a single point, have a positive catch, and provide a clear visual indication of the latch position.

5.10.2 Feedback. Provision shall be made for transmitting information from remote work areas to the operator of the remote-handling system. Visual information shall be regarded as most critical, followed, in order, by kinesthetic, tactual, and auditory feedback.

5.10.3 Manipulators.

5.10.3.1 Safety. Power manipulators shall be provided with positive stops to prevent accidents.

5.10.3.2 Characteristics. For tasks which require manipulative dexterity and load capacities of less than 10 kg (22 lb) manipulators with the following characteristics should be provided:

a. Position control (i.e., zero-order control in which the operator's control output directly determines the machine output).

b. Mutual force reflection between control and effector.

c. Seven degrees of freedom in motion and force control (i.e., three for translation, three for rotation, and one for gripping).

5.10.3.3 Power assist. For tasks involving gross positioning of loads heavier than 10 kg (22 lb), electrically or hydraulically powered manipulators with rate control should be provided (i.e., the operator's control output directly determines the rate of change of the machine output).

5.10.4 Viewing equipment.

5.10.4.1 General. A viewing system shall be provided which gives the operator of a remote manipulator adequate information with respect to the three spatial coordinates of the workspace (i.e., X, Y, and Z).

5.10.4.2 Direct viewing. When permitted by shielding requirements, provision shall be made for the operator to view the work directly through shielding windows.

5.10.4.3 Viewing angle. In order to avoid distortion, requirements shall be minimized for direct viewing of objects either near the viewing window or at line-of-sight angles at incidences greater than 60 degrees.

5.10.4.4 Indirect viewing. Applicable viewing systems, such as closed circuit television systems, periscopes, and microscopes, shall be provided to supplement direct viewing, where required by specific remote-handling situations.

5.10.4.5 Coding. Symbol-or pattern-coding should be used in preference to color-coding for television viewing.

5.10.4.6 Lettering. Letters, numbers, and important details which must be viewed by means of television shall be light against a dark background. Glazed or reflecting surfaces shall be avoided.

5.10.4.7 Stereo viewing. The two images produced by a stereoscopic periscope shall not differ more than 2% in magnification or 0.50 prism diopter in vertical imbalance. Horizontal imbalance shall be not greater than 0.50 prism diopter so as not to be fatiguing. Light transmittance of the two optical paths should be within 10% of each other.

5.10.5 Illumination.

5.10.5.1 Reflected light. Lighting provided in remote work areas shall be such that reflected light, as measured at the operator's work station (in direct viewing), will conform with the requirements of this standard, or as otherwise specified by the procuring activity.

5.10.5.2 Threshold viewing. Monochromatic lighting should be provided when viewing conditions are near threshold, when high magnification powers are required, or when the operator is required to view the work at high angles of incidence through refractive materials.

5.11 Small systems and equipment.

5.11.1 Portability and load carrying. Individual portions of equipment shall be designed so that, when carried, the weight of the load will be distributed through as many muscle groups as possible. Pressure should be avoided or minimized on sensitive areas, including large blood vessels, nerves and areas lacking muscular padding. Design of load-carrying systems shall consider the weight and distribution of individual items to be carried by the user. The weight of the items to be carried varies according to the climatic zone, mission to be performed, and occupational specialty. See Table XXVI for weights of representative individual items that an infantry rifleman carries in temperate hot weather areas. Load carrying systems shall be provided with a quick-release capability.

5.11.1.1 Portability.

5.11.1.1.1 Weight. Individual portions of equipment may weigh up to 16 kg (35 lb) if the load is balanced and is distributed over many muscle groups and it is not necessary for the individual carrying the load to maintain the pace of an infantry movement.

5.11.1.1.2 Lifting aids. When necessary, lifting aids shall be provided to permit a second person to assist the porter in placing the load on the body.

5.11.1.1.3 Configuration. The load should be designed to permit freedom of movement. The shape of the load should be free of sharp edges or projections that may be harmful to the porter or snag on undergrowth. The shape and weight of the load should not interfere with:

a. The length of step.

b. Movements of the head.

c. The ability to raise and lower the load when going over obstacles.

d. The ability to see where the feet are placed when walking.

e. The ability to squat.

f. Regulation of body temperature.

g. The maintenance of normal posture.

5.11.1.1.4 Carrying by two persons. Where the load is designed for carrying by two persons, a combination of stretcher type handles and shoulder support should be used, if feasible.

5.11.1.1.5 Standardization. Maximum use should be made of standard load carrying systems or components.

TABLE XXVI . TYPICAL FIGHTING AND EXISTENCE LOADS (TEMPERATE ZONE)

LOAD	APPROXIMATE WEIGHT	
	KILOGRAMS	POUNDS
FIGHTING LOAD		
CLOTHING:		
PASGT Helmet	1.36	3.00
Battle Dress Uniform	1.73	3.81
PASGT Vest	3.86	8.50
Underwear (Summer) and Socks	0.27	0.60
Belt; waist, web w/buckle	0.09	0.20
Boots, leather (DMS)	1.52	3.36
	8.83	19.47
EQUIPMENT:		
Rifle M16A1 w/30 rd magazine and sling	3.59	7.91
Ammunition pouches (2 ea) w/180 rounds in 6 magazines	3.21	7.07
Hand grenades 2 ea	0.91	2.00
LAW 2 ea or ILAW 1 ea	3.86	8.50
Canteen 1 qt filled w/cup and cover	1.63	3.60
Canteen 1 qt filled w/cover	1.36	3.00
Water purification tablets	0.03	0.06
Individual equipment belt, first aid packet w/case and suspenders	0.72	1.59
Intrenching tool w/carrier	1.14	2.52
Bayonet M7 w/scabard	0.59	1.30
Mask CB Protective w/hood	1.35	2.97
Poncho	0.77	1.70
	19.25	42.22
EXISTENCE LOAD:		
ALICE Pack medium w/straps	1.12	2.46
Chemical Protective overgarment w/gloves and boots	2.61	5.75
Cap, utility	0.10	0.22
Underwear and socks, 2 ea	0.54	1.20
Personal Hygiene Kit	1.20	2.64
Rations MCRE 3 ea	1.33	2.94
Bag, Sleeping, intermediate cold	3.40	7.50
Mattress, pneumatic insulated	1.59	3.50
Jacket Field, 1 ea w/gloves, leather w/wool insert 1 pr	1.94	4.28
Bag, waterproof 1 ea	0.34	0.75
	14.17	31.24

5.11.1.2 Transportability by personnel. Systems which include a requirement for transportability by personnel shall conform to the following provisions:

5.11.1.2.1 Weight. Individual portions of equipment should be designed to weigh as little as possible if the system is to be manually transported by an individual on foot while maintaining pace with an infantry movement.

5.11.1.2.2 Load carrying. The total load carried by an individual, including clothing, weapons and equipment for close combat operations should not exceed 30% of body weight and, for marching, 45% of body weight. Where personnel with 5th percentile body weight must be accommodated, the total load for close combat operations should not exceed 16.3 kg (36 lb) and, for marching, 24.5 kg (54 lb).

5.11.1.2.3 Lifting aids.

a. Units for which no back-packing aids are required shall be equipped with handles suitable for two-handed lifting and carrying.

b. The provisions of sections 5.9.11.5.1, 5.9.11.5.3, and 5.9.11.5.5 shall apply.

c. One-person back-packed loads over 20 kg (44 lbs) shall be designed, and, if necessary, provided with lifting aids to permit a second person to assist the porter in placing the load on the body.

5.11.1.2.4 Back-packing aids. Back-packing aids shall be designed to distribute the load over as many muscle groups as possible by means of buttock and hip supports in addition to padded shoulder straps. Backpacking aids shall be designed to bring the center of gravity of the load as close to the porter's spine at the waistline as possible, without any part of the load actually contacting the body. Load-carrying design shall minimize application of pressure or compression to the chest or armpits and eliminate local strain by transmitting weight to the ground through bone. Aids shall not produce laterally unbalanced loads, interfere with normal head movements, limit squatting, interfere with walking or climbing over low obstacles, interfere with movements of the shoulder girdle, produce strain on the shoulder muscle or interfere with regulation of body temperature.

5.11.1.2.5 Projections. Loads shall be designed with a minimum of projections to prevent injury to personnel or entanglement in undergrowth. Covers or cases may be provided to meet this requirement, as specified by the procuring activity.

5.11.1.2.6 Standardization. See 5.11.1.1.5.

5.11.2 Tracking.

5.11.2.1 Gunner environment. Obscuration, shock and vibration should be so minimized as to permit resumption of tracking rapidly after firing, where required.

5.11.2.2 Crank size. The size of tracking cranks, where used, shall be a function of rotation speed required. Within the parameters of Figure 10,

a. Maximum speed should be between 140 to 200 RPM.

b. Crank radius should be between 55 mm (2.2 in) and 115 mm (4.5 in):

(1) High RPM requirement: smaller crank radius.

(2) Low RPM requirement: larger crank radius.

5.11.2.3 Two-dimensional tracking. A single control should be used for two-dimensional tracking rather than separate controls for each dimension.

5.11.2.4 Supports. Where a joy stick is used for tracking, a hand, wrist, or forearm support (as appropriate) should be provided.

5.11.2.5 Compatibility. Movement of the tracking control shall be compatible with expected or conventional control movements.

5.11.3 Optical instruments and related equipment.

5.11.3.1 General. This section pertains only to direct-view, visual optical systems. The information is presented in order that human capabilities and limitations can be considered in the design, engineering, operation and maintenance of military optical equipment. Detailed instrument parameters, characteristics, etc., shall be a function of governing military applications and user requirements.

5.11.3.2 Visual accommodation. Any adjustment of the eyes beyond normal functional ability shall not be required.

5.11.3.3 Viewing angle. Optical instruments shall be oriented so that they are presented to the operator at an angle comfortable for viewing.

5.11.3.4 Magnification.

5.11.3.4.1 General. Instrument magnification shall be sufficiently high to permit performance of the required application, such as detection, recognition, identification, laying, etc.

5.11.3.4.2 Unstabilized, unsupported handheld sights. Because of hand tremors and body motion, magnification of unstabilized, unsupported handheld sights should not exceed the following:

a. Rifle and pistol telescopic sights: 4 power.

b. Monoculars or binoculars: 8 power.

5.11.3.4.3 Multiple magnification requirements. If more than one magnification is required, two or more discrete magnifications should be provided for optimum image quality and boresight integrity. Varifocal (zoom) systems should be considered for use only in systems where sighting accuracy is relatively unimportant and it results in overall simplification.

5.11.3.5 Field-of-view. Field of view shall be compatible with intended use and optical-mechanical design limitations.

5.11.3.6 Entrance pupil. The entrance pupil shall be equal to the product of the magnification and the exit pupil diameter and, therefore, defined by these parameters.

5.11.3.7 Exit pupil.

5.11.3.7.1 General. The diameter of the exit pupil should be consistent with intended use and size/weight limitations.

5.11.3.7.2 Daylight. For daylight application the exit pupil diameter should not be less than 3 mm (0.12 in).

5.11.3.7.3 Low light levels. For maximizing performance at twilight and lower light levels, the exit pupil should be not less than 7 mm (0.28 in).

5.11.3.8 Eye relief. A long eye relief e.g., 25 mm (1 in), is ordinarily desirable for vehicular mounted sights to provide the observer protection from gun recoil, to observe on the move, and to afford some field-of-view while wearing a protective mask. The required eye relief depends upon the particular application, but shall be at least 15 mm (0.6 in) to permit use by observers wearing glasses, when recoil is not encountered.

5.11.3.9 Eyepiece adjustments.

5.11.3.9.1 4-Power and less. Fixed focus eyepieces set between -0.50 and -1.00 diopter may be utilized for instruments 4-power and less.

5.11.3.9.2 Over 4-power. Eyepiece dioptric (focusing) adjustments (-4 to +2 diopters required, -6 to +2 diopters desired) shall be provided and marked in 0.5 diopter increments on all instruments over 4-power magnification.

5.11.3.10 Optical quality.

5.11.3.10.1 Axial resolution. Axial resolution shall be equal to or better than 300 μrad (1 min) divided by the magnification to provide an eye-limited instrument.

5.11.3.10.2 Luminous transmission. Luminous transmission should be as high as possible, preferably greater than 50%.

5.11.3.11 Reticles.

5.11.3.11.1 Line thickness. Reticle lines shall be thin enough so as not to obscure targets, but thick enough to be easily seen. Reticle lines should subtend a minimum of 600 μrad (2 min) at the eye.

5.11.3.11.2 Patterns. Reticle patterns should be as simple as possible and restricted to one main mission (e.g., major weapon ballistic scales) per reticle glass. Additional patterns should be on separate reticle glasses if added complexity is warranted for the particular application.

5.11.3.11.3 Format. Line reticles should be used in preference to reticles containing one, two, or three central spots. A small cross or very small circle should be used in preference to a dot.

5.11.3.11.4 Parallax. The reticle should be focused to the target range of primary interest to limit the parallax to an acceptable value throughout the usable range.

5.11.3.12 Illuminated sights and reticles.

5.11.3.12.1 Night operations. Illuminated reticles shall be provided for sights to be used during twilight or night operations.

5.11.3.12.2 Color. Blue shall not be used as the color of illumination for reticles or sights.

5.11.3.12.3 Dimming. It shall be possible to gradually lower the luminance of a sight until it is extinguished.

5.11.3.12.4 Illumination level. The illumination level of a sight (once an adjustment is made) shall remain fixed under all conditions of vibration.

5.11.3.12.5 Uniformity. Illuminated sights shall be evenly illuminated by means of an opal diffuser or similar device.

5.11.3.12.6 Reticle lines. Reticle lines for illuminated sights should be 150 μrad (0.5 min) visual angle or more in thickness. They shall be thin enough so as not to obscure targets, but thick enough to be easily seen. In any case, their thickness should not exceed 600 μrad (2 min).

5.11.3.13 Binoculars/biocular.

5.11.3.13.1 Biocular viewing. Where continuous use of a sight under low levels of illumination will exceed one minute, the single optical train shall be provided with two eyepieces, if this does not lead to unacceptable light losses.

5.11.3.13.2 Eyepiece separation. Binocular/biocular instruments should have an eyepiece separation scaled from 50 to 73 millimeters with one millimeter interval markings.

5.11.3.13.3 Magnification differences. Magnification differences of the two barrels should not exceed 2%.

5.11.3.13.4 Luminous transmission differences. Luminous transmission differences of the two barrels should not exceed 5%.

5.11.3.13.5 Matched oculars. To avoid size differences in the images supplied to the two eyes, hence eyestrain and headache or both, oculars shall be matched in focal length, i.e., shall be matched pairs.

5.11.3.13.6 Weight. Weight of handheld binoculars/biloculars should not exceed 1 kg (2.2 pounds) and shall not exceed 1.5 kg (3.3 pounds).

5.11.3.13.7 Size and configuration. Instrument size and configuration shall be compatible with anthropometric requirements of 5.6.

5.11.3.14 Eyecups and headrests. Any optical instrument requiring steady orientation of the eyes shall be provided with a headrest or eyecups, or both.

5.11.3.14.1 Eyecups. Eyecups shall be provided to maintain proper eye relief, eliminate stray light and, when required, to protect or cushion the eyes and orbital region against impact with the eyepieces. The radii of Figure 49 define a surface of revolution within which a satisfactory symmetrical eyepiece and cup must be designed if interferences with facial features are to be avoided. These should be applied to cushion forms when they are compressed to the maximum.

5.11.3.14.2 Headrests/browpads. A headrest or brow pad shall be used to absorb energy which would be injurious to the operator's head.

5.11.3.14.3 Compatibility with clothing and personal equipment. Eyecups and headrests shall be compatible with helmets, protective masks, and other clothing and personal equipment.

5.11.3.15 Accessories.

5.11.3.15.1 Filters.

5.11.3.15.1.1 General. Light filters, removable from the optical path, should be provided to reduce glare, light intensity, or protect the observer's eyes against hazardous light levels. Provisions should be made for filter stowage, where applicable.

5.11.3.15.1.2 Use. Use of color or neutral density filters will depend upon the application. For use in observing bright light sources, neutral filters should be considered for reducing overall brightness without affecting contrast. The use of polarizing filters should be considered where is it

A – SUPERCILIARY ARCH REQUIREMENT ———— 17 mm (11/16")
B – NASAL BONE REQUIREMENT ———— 22 mm (7/8")
C – GREATER ALAR CARTILAGE REQUIREMENT ———— 32 mm (1¼")
D SEPTAL CARTILAGE REQUIREMENT ———— 44 mm (1¾")

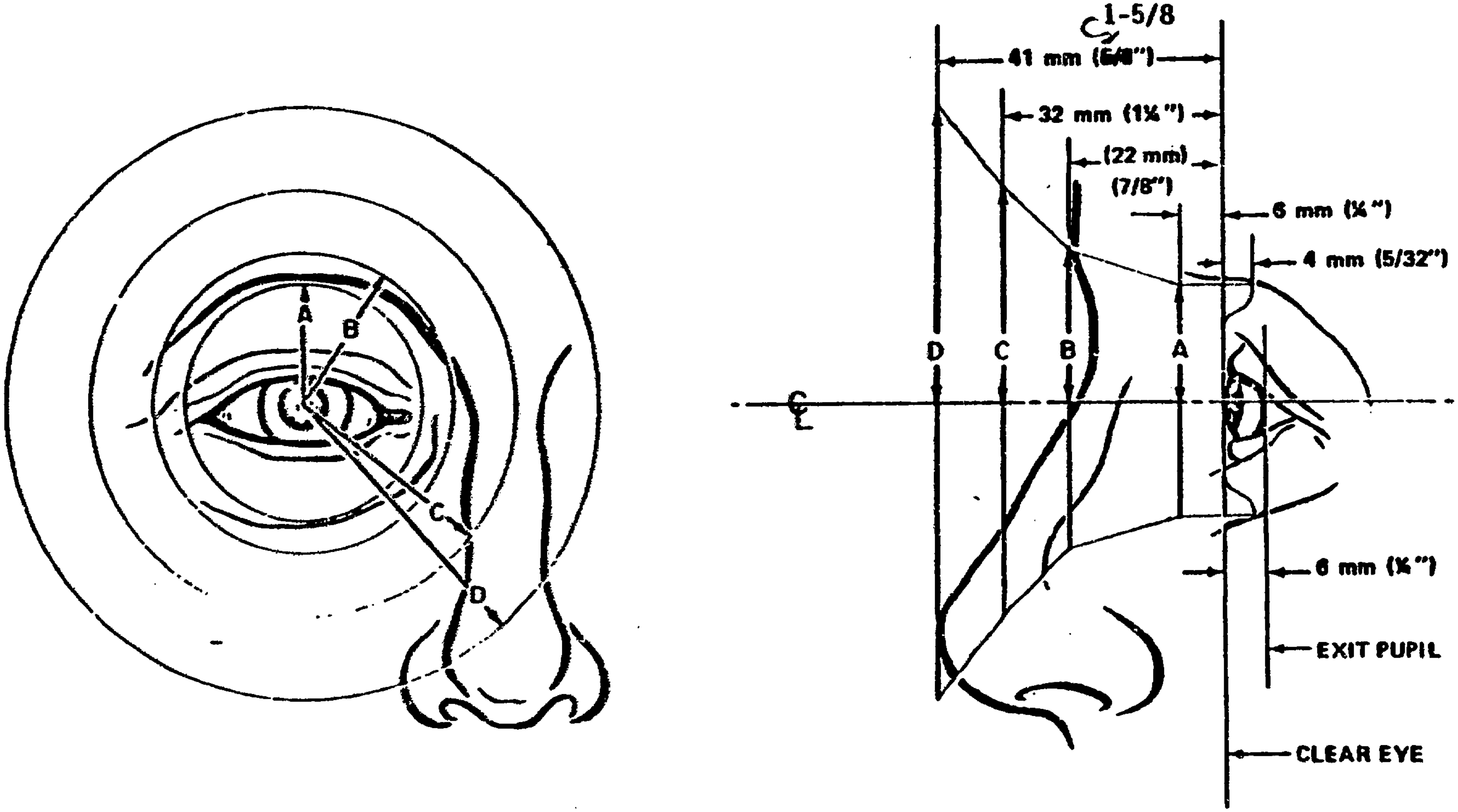

FIGURE 49. ANATOMICAL LIMITS ON AXIALLY SYMMETRICAL OCULAR METAL PARTS

necessary to reduce glare and increase apparent contrast from sun, snow, or water.

5.11.3.15.2 Shutters. Shutters having closure and reopening times appropriate for each application may be provided in lieu of fixed filters to protect the observer exposed to flashes from weapon systems, lasers or nuclear devices. Shutters for protection from the observer's own weapon system flash, which may be actuated just before the weapon is fired, shall not disturb the lay of the weapon before closing nor unnecessarily impede the observation of the projectile flight path or resultant impact.

5.11.3.15.3 Positioning aids. Level vials, scales, pointers and other devices required for positioning the instrument shall be readily visible and protected from damage of displacement.

5.11.3.16 Environmental conditions. Carrying/transport cases should be provided for instruments to be hand-carried or mounted/dismounted separately. Instruments to be utilized under severe environmental conditions should be designed to take into consideration the special clothing, headgear, protective masks or other ancillary equipment required by the operator, affecting controls, eyepieces, eyecups, headrests and other operator interfaces.

5.11.3.17 Lighting. Means shall be provided for illumination of internal and external scales, level vials, etc., under low light level conditions. Continuously variable control of illumination shall be provided as required by weapon system characteristics. Illumination under low light level conditions shall be designed to minimally affect the dark adaptation of the observer. Red illumination or red filters should be used to maintain dark adaptation.

5.11.3.18 Maintenance.

5.11.3.18.1 Modular design. When practical, optical equipment should be developed utilizing modular design to provide for interchangeability of optical subassemblies.

5.11.3.18.2 Positioning aids. Built-in aligning devices and other aids should be used wherever possible for ease of positioning optical assemblies within an instrument or optical modules that have multiple applications in equipment.

5.11.3.18.3 Quick release. Quick-release methods of removing optical instruments should be used wherever practical.

5.11.3.18.4 Collimation. Optical instruments should be provided with built-in collimation features to allow field adjustment.

5.11.3.18.5 Purging and charging. Where periodic purging and charging of optical instruments are required, an instruction plate, indicating time interval and pressure requirements shall be provided on the instrument. Purging and charging fittings shall be accessible for required maintenance.

5.11.3.18.6 Component replacement. Internal components such as light bulbs that require frequent replacement, checkout or maintenance should be easily accessible, removable without special tools, and replaceable without removal or disassembly or other components. Components that require frequent replacement and frequently used special tools and/or equipment shall be readily accessible. Provision should be made for storage of such components and tools in or on the specific equipment. This particularly applies to items such as light bulbs whose failure could make the instrument inoperable.

5.11.3.18.7 Boresighting.

5.11.3.18.7.1 Positive locks. Boresight knobs shall be provided with a positive lock. (The boresighting settings shall not be changed when locking.)

5.11.3.18.7.2 Lock-unlock resistance. Boresight knob locks shall not require more than 45 N (10 pounds) resistance to lock and unlock.

5.11.3.18.7.3 Adjustment operation. Boresight adjustment knobs should be capable of being locked, unlocked, and adjusted by suitably clothed and equipped users with hand dimensions varying between the 5th and 95th percentiles.

5.12 Operational and maintenance ground/shipboard vehicles.

5.12.1 General. Handles, levers, pedals, knobs, and workspace dimensions shall be designed to enhance effective vehicle operation by suitably clothed and equipped users with relevant body dimensions varying between 5th and 95th percentiles. (See 5.6.1.)

5.12.2 Seating.

5.12.2.1 Dimensions and clearances. Seating for vehicle operators should follow the dimensions and clearances recommended in Figures 50 and 51 and Table XXVII as applicable.

5.12.2.2 Vertical adjustment. If the seat's height above the floor is variable, requirements for leg room and footrest will also vary. When the seat is adjusted higher, there will be more leg room and larger footrest angles.

5.12.2.3 Horizontal adjustment. Seats shall adjust at least 150 mm (6 in) in the fore-aft direction.

5.12.2.4 Back-rest angle. Back-rest angle should be not more than 1920 mrad (110°) from horizontal. If only the lumbar area is supported, the backrest angle of tilt should be 1660 to 1745 mrad (95 to 100°) for operators in an alert position.

5.12.2.5 Seat pan. The seat pan shall be flat and made from a rigid material.

5.12.2.6 Seat padding. Seat padding should be kept to a minimum, but it should be resilient enough to keep the operator's body from contacting the seat bottom during severe vibration. Seat padding made of foam-type material should be adequately ventilated.

5.12.2.7 Seat belts. All administrative type vehicles shall have safety seat belts. Seat belts should be installed on other type vehicles except when they interfere with operational requirements.

5.12.3 Controls.

5.12.3.1 Design. Controls shall be designed so as not to be adversely affected by distortion, shock or vibration of the vehicle.

5.12.3.2 Steering. In case of power steering assist failure, the steering gear shall afford the operator sufficient mechanical advantage to guide the vehicle during an emergency stop or during low-speed operation (See Table IX for quantitative data.)

5.12.3.3 Pedals. Foot pedals shall be designed to accept the weight of the operator's foot without initiating control action.

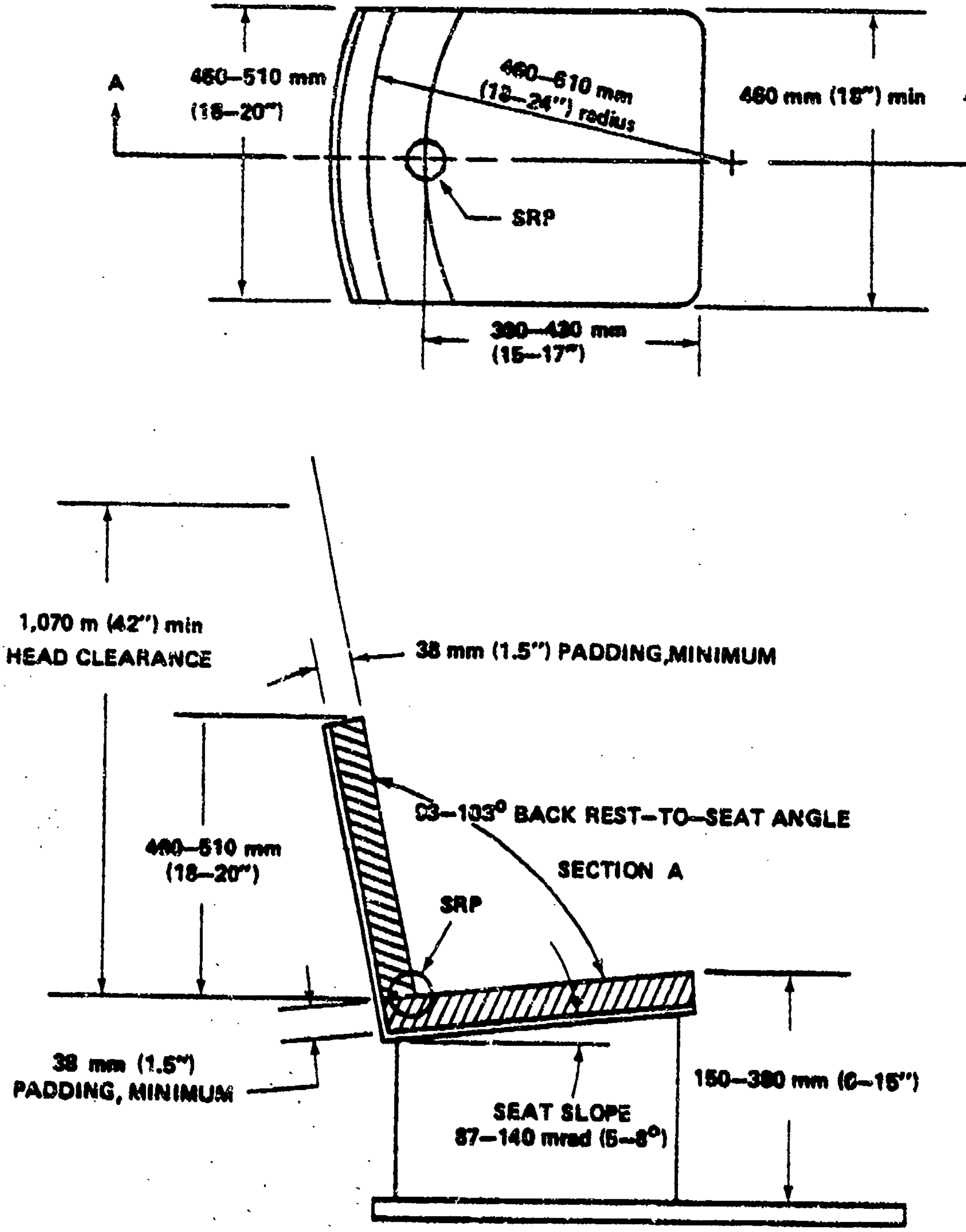

FIGURE 50. DIMENSIONS FOR VEHICLE OPERATOR'S SEAT

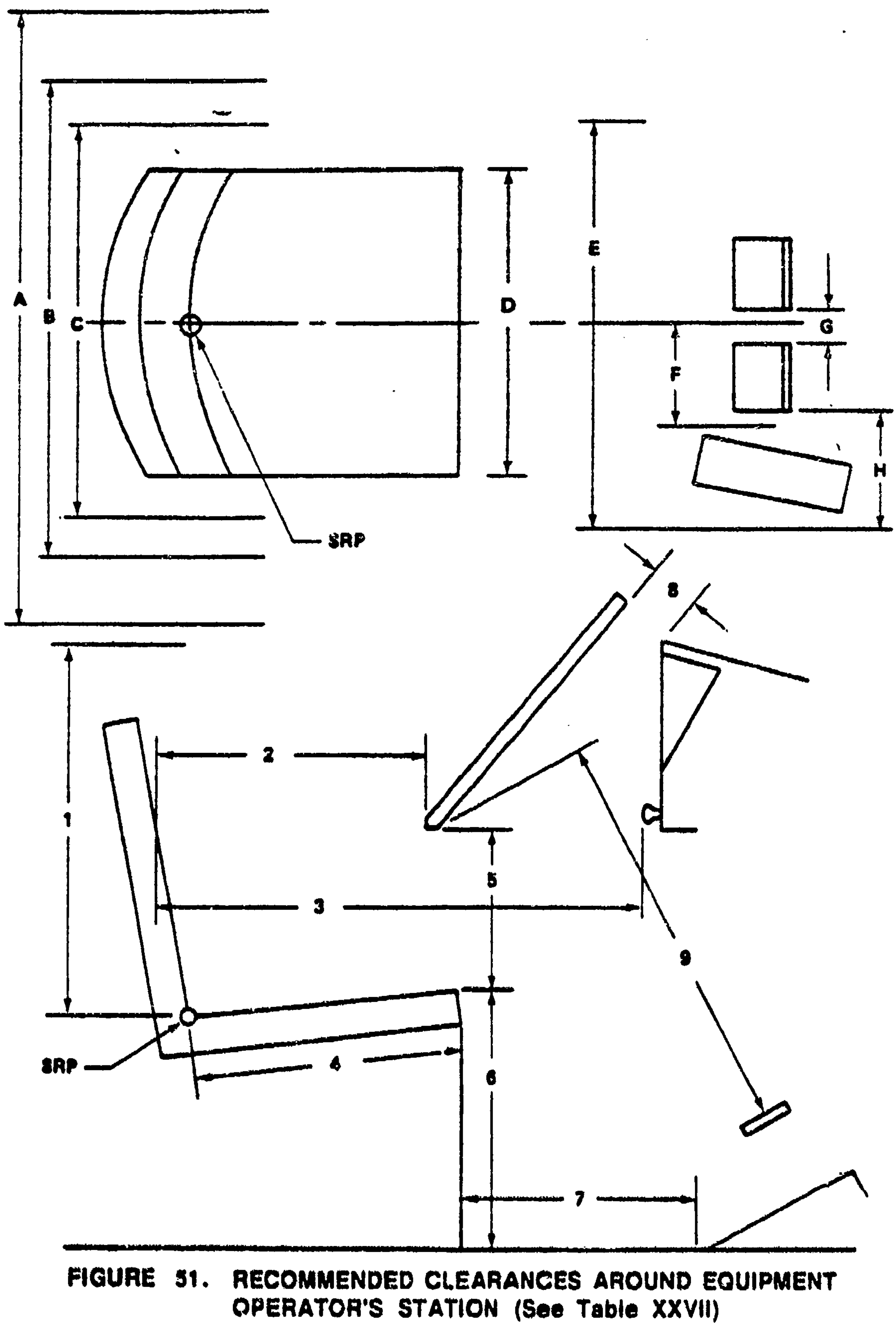

FIGURE 51. RECOMMENDED CLEARANCES AROUND EQUIPMENT OPERATOR'S STATION (See Table XXVII)

TABLE XXVII. RECOMMENDED CLEARANCES AROUND EQUIPMENT OPERATOR'S STATION TO ACCOMODATE THE 95th PERCENTILE SOLDIER DRESSED IN ARCTIC CLOTHING. OPERATOR SEAT IN REAR MOST POSITION (Figure 51)

A. ELBOW (DYNAMIC)	910 mm (36 in.)
B. ELBOW (STATIC)	710 mm (28 in.)
C. SHOULDER	580 mm (23 in.)
D. KNEE WIDTH (MINIMUM)	460 mm (18 in.)
E. KNEE WIDTH (OPTIMUM)	610 mm (24 in.)
F. BOOT – PROVIDE ADEQUATE CLEARANCE TO OPERATE BRAKE PEDAL WITHOUT INADVERTENT ACCELERATION OPERATION	150 mm (6 in.)
G. PEDALS (MINIMUM)	50 mm (2 in.)
H. BOOT – PROVIDE ADEQUATE CLEARANCE TO OPERATE ACCELERATOR WITHOUT INTERFERENCE BY BRAKE PEDAL	150 mm (6 in.)
1. HEAD (SRP TO ROOF LINE)	1070 mm (42 in.)
2. ABDOMINAL (SEAT BACK TO STEERING WHEEL)	410 mm (16 in.)
3. FRONT OF KNEE (SEAT BACK TO MANUALS/CONTROLS ON DASH)	740 mm (29 in.)
4. SEAT DEPTH (SEAT REFERENCE POINT TO FRONT EDGE OF SEAT PAN)	410 mm (16 in.)
5. THIGH – UNDER SIDE OF STEERING WHEEL TO SEAT PAN	240 mm (9.5 in.)
6. SEAT PAN HEIGHT	380 mm (15 in.)
7. BOOT (FRONT OF SEAT PAN TO HEEL POINT OF ACCELERATOR)	360 mm (14 in.)
8. MINIMUM MITTEN CLEARANCE AROUND STEERING WHEEL	75 mm (3 in.)
9. KNEE – LEG – THIGH (BRAKE – CLUTCH PEDAL) TO LOWER EDGE OF STEERING WHEEL	660 mm (26 in.)

5.12.3.4 Control of hazardous operations. The operation of switches or controls which initiate hazardous operations shall require the prior operation of a locking control.

5.12.4 Operating instructions.

5.12.4.1 Provision of operating instruction. Operating instructions shall be provided for all vehicles and vehicle equipment, except where the mode of operation will be obvious to all potential operators.

5.12.4.2 Format. Information shall be presented in the form of diagrams whenever possible.

5.12.4.3 Speed notice. Maximum permissible road speeds in each gear and range shall be indicated. On vehicles for which all road speeds are limited by engine speed, a red line on the tachometer (if so equipped), at maximum engine RPM, may be used in lieu of a speed placard.

5.12.4.4 Shift handle positions. Operating positions of shift handles, such as transmission, power take-off, winch-control, and transfer case mechanisms shall be illustrated.

5.12.4.5 Control movements. Control movements shall be shown in planes parallel to the movement of the actual controls.

5.12.4.6. General labeling criteria. Identification and instruction markings shall conform with the criteria for labeling contained in this standard.

5.12.5 Visibility.

5.12.5.1 Night operation. Indicators required by the vehicle operator during night operation shall be illuminated. The display luminance shall be adjustable from 0.1 to 3.5 cd/m^2 (0.03 to 1.0 ft-L). Blackout lighting systems, if required, shall be designed to preclude accidental operation of external lights and signals.

5.12.5.2 Visual field. The operator shall have forward visibility through a lateral visual field of at least πrad (180°) and preferably 3840 mrad (220°).

5.12.5.3 Ground view. Trucks should be designed to enable the operator, in the normal operating position, to view the ground at all distances beyond 3 m (10 feet) in front of the vehicle. When necessary, mirrors may be used to meet this requirement, if tactical requirements permit. Upward visibility shall extend to at least 260 mrad (15°) above the horizontal.

5.12.5.4 Rear view (vehicle). Side and rear enclosures should be designed to permit the operator to view the rear of the vehicle in order to observe the load and to facilitate trailer attachment and backing maneuvers. If mirrors are used to meet this requirement, they shall conform to Requirement 111 of MIL-STD-1180.

5.12.5.5 Rear view (road). A glare-proof, west coast type and spotter rearview mirror shall be provided on each side of the cab, located in such a manner as to afford the operator rearward vision from the normal operating position. Outside rear view mirrors for automotive vehicles should conform to Requirement 111 of MIL-STD-1180.

5.12.5.6 Glare. Appropriate use shall be made of visors or other means to preclude performance degradation due to glare from external sources such as sunlight or headlights except that windshields or other transparent areas through which high acuity vision is required shall not be tinted or colored.

5.12.5.7 Windshields and windows. Transparent materials selected for windshields and windows shall be shatter-proof and shall neither distort nor obscure vision.

5.12.5.8 Windshield wipers and washers. Windshield wipers and washers shall be provided. Blades shall return to the stored position when turned OFF. Provision shall be made for manual operation in event of power failure.

5.12.5.9 Fork lifts. The configuration of fork lift mechanisms and fork lift truck cabs shall permit the operator to have direct view of the tips of the forks in all typical modes of material loading and in all likely operator positions.

5.12.6 Heating and ventilation.

5.12.6.1 Heating. The crew compartment shall be provided with a heating system capable of maintaining temperatures above 20°C (68°F) during occupancy when personnel are not wearing Arctic clothing and exposure is for extended duration (i.e., more than 3 hours). When arctic clothing is worn, cab heaters shall be capable of maintaining a reference temperature of not less than 5°C (41°F) at the minimum ambient design temperature with the vehicle moving at two-thirds maximum speed and the defrosters operating at maximum capacity. The reference temperature is measured 610 mm (24") above the seat reference point of each operator/passenger position. Air temperatures around any part of the operator/passenger's body shall not vary more than ±5°C (±9°F). The heater shall achieve these requirements within one hour after it is turned on.

5.12.6.2 Ventilation. Outside fresh air shall be supplied at minimum rate of 0.57 m^3 (20 ft^3)/min./person. Air flow rates for hot-climate operation (temperatures above 32°C (90°F) shall be maintained between 4.2 and 5.7 m^3 (150 and 200 ft^3)/min./person, unless air conditioning or individual (microclimate) cooling is provided. Air velocity at each person's head location shall be adjustable either continuously or with not less than three settings (OFF, LOW and HIGH) from near zero to at least 120 m (400 ft)/minute.

5.12.6.3 Visibility. The heating-ventilating system shall be designed to minimize degradation of visibility due to frosting or misting of the windshield.

5.12.7 Trailers, vans, and intervehicular connections.

5.12.7.1 Trailers.

5.12.7.1.1 Brake controls. Trailer brake controls shall be located so that an operator can reach them while restraining or positioning the trailer manually. The controls shall not be located on the side of the trailer exposed to road traffic.

5.12.7.1.2 Positioning controls. Component trailers should be designed with precise positioning controls when the trailer will be used to mate parts.

5.12.7.1.3 Tie downs. Munitions tie-down facilities on stores trailers shall be designed to be easily installed and removed.

5.12.7.1.4 Landing gear lock. Landing gear lock and release shall be capable of being hand or foot-operated.

5.12.7.2 Vans. The criteria herein shall apply to trailer vans and transportable enclosures which serve as shelters for personnel or equipment, and which require occupancy by personnel for operational or maintenance tasks in excess of one hour, on a recurring basis where mission requirements permit:

a. The ceiling height--the distance from the floor to the bottom of any light, cable run or other protuberance over the aisle or standing work-space--shall not be less than 1.980 m (78") for vans and shelters, except as follows: When the occupants seldom stand to perform normal operations, the ceiling height can be reduced to 1.890 m (74.5") unless otherwise directed by the procuring activity.

b. The minimum opening for personnel access shall be 1.930 m (76") high and 760 mm (30") wide. Accesses for equipment shall be appropriate and convenient for the specific equipment to be transported.

c. Steps, stairs, or ladders shall be provided when van floors are more than 460 mm (18") above ground level.

d. Access doors of vans shall have provisions for locking doors in open positions as well as closed positions. Access doors shall have inner quick-opening releases for all doors.

e. On work spaces such as large personnel-occupied vans or shelters, intended for use as mobile work spaces, inclinometers shall be provided to permit readout of front-rear and side-side tilt within ± 2 degrees.

5.12.8 Cranes, materials handling and contruction.

5.12.8.1 General. Positioning of equipment and loads shall be facilitated through use of center-of-gravity identification, matching guidelines, identification of attaching points, detachable probes, etc. Latches on control levers shall not cause delay in operation.

5.12.8.2 Control labels. All controls used with lifting equipment shall be labeled as to function and direction of movement.

5.12.8.3 Control placement. The placement of controls shall be within easy reach of the operator and shall afford optimum visibility of the load at all times.

5.12.8.4 Foot-operated controls. Foot-operated controls shall not be selected for precise adjustments or movements. Foot operated brake pedals that require locking shall lock by foot action alone. For ease of operation, the pedals shall rise from the depressed position in a backward as well as vertical movement.

5.12.8.5 Load capacity. The load capacity shall be indicated on the equipment, and audible warning devices shall be provided where necesary to indicate that the allowable load is being exceeded.

5.12.8.6 Visibility. Maximum, unobstructed view of the work, including the point sheaves of the basic boom of a revolving crane at a 3 m (10 ft) radius shall be visible to suitably clothed and equipped users with relevant body dimensions varying between 5th and 95th percentiles.

5.12.8.7 Access. Where not otherwise specified herein, access dimensions for construction machinery shall conform to SAE J925, as applicable.

5.12.8.8 Handholds and footholds. Suitable handholds and footholds shall be provided to facilitate personnel access and movement.

5.12.9 Automotive subsystems.

5.12.9.1 General.

5.12.9.1.1 Drain valves. Vehicles shall be designed to require a minimum number of drain valves and drain sizes. Drain valves shall be readily accessible and hand-operable by the full range of user personnel wearing either arctic or NBC garments. Drain valve handles shall be in line with the corresponding pipe when ON and perpendicular to the pipe when OFF.

5.12.9.1.2 Filters. Fuel and oil filters shall be located in accessible positions for inspection and replacement and shall not require the removal of other parts.

5.12.9.1.3 Adjustment and access. Components requiring adjustment or replacement, such as distributors, fuel injectors, and fan belts, shall be as accessible as possible. Timing marks and other adjustment indicators shall be designed to minimize parallax and shall be readily accessible for visual inspection. Drive belt tensioning devices shall permit access for tensioning without removal of other components and, if needed, furnished with pry points.

5.12.9.1.4 Battery terminals - Positive and negative battery terminals shall be of different sizes to prevent incorrect cable attachment. Terminals shall be appropriately labeled "+" or "-".

5.12.9.2 Tires.

5.12.9.2.1 Dual tires. Design of dual wheel arrangement shall allow both the inner and outer tires to be inflated and checked for air. The location of valves shall permit tires to be inflated and checked when the tires are interchanged.

5.12.9.2.2 Spare tires. The spare tire shall be capable of being inflated and checked when mounted in the stowed position.

5.12.9.3 Turn signal and emergency flasher system. All wheeled vehicles designed for use on public highways shall be equipped with turn signals and emergency flasher systems in accordance with MIL-STD-1179.

5.12.9.4 Winches.

5.12.9.4.1 Instruction plates. Instruction plates covering winch operation shall be mounted in a conspicuous location for operator use.

5.12.9.4.2 Operation. Winch and vehicle power trains shall be capable of being operated simultaneously; the vehicle forward speed due to straight winch-line or snatch-block operation should match one of the vehicle power train speeds to facilitate simultaneous operation.

5.12.9.4.3 Cable unwinding. Winch cables shall be capable of being easily payed out by one crew member.

5.12.9.4.4 Control location. Winches shall be capable of being operated from both cab and winch locations and being observed by the operator during operation.

5.12.9.4.5 Clothing compatibility. Winch controls at the winch shall be capable of being operated by personnel wearing Arctic mittens.

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5.13 Hazards and safety.

5.13.1 General. As a part of system equipment design, safety factors shall be given major consideration, including, as a minimum, the effective application of the human engineering criteria in other sections of this standard, together with the representative safety criteria herein.

5.13.2 Safety labels and placards.

5.13.2.1 Warning placards. Conspicuous placards shall be mounted adjacent to any equipment which presents a hazard to personnel (e.g., from high voltage, heat, toxic vapors, explosion, radiation).

5.13.2.2 Center-of-gravity and weight. Where applicable, the center of gravity and the weight of equipment shall be distinctly marked.

5.13.2.3 Weight capacity. The weight capacity shall be indicated on stands, hoists, lifts, jacks, and similar weight-bearing equipment, so as to prevent overloading.

5.13.2.4 Identification of protective items. Areas of operation or maintenance where special protective clothing, tools, or equipment are necessary (e.g., insulated shoes, gloves, suits, etc.) shall be specifically identified.

5.13.2.5 "NO-STEP" markings. "NO-STEP" markings shall be provided when necessary to prevent injury to personnel or damage to equipment.

5.13.2.6 Electrical labels. All receptacles shall be marked with their voltage, phase, and frequency characteristics, as appropriate. For other electrical labeling and warning requirements, see MIL-STD-454.

5.13.2.7 Hand grasp areas. Hand grasp areas shall be conspicuously and unambiguously identified on the equipment.

5.13.3 Pipe, hose and tube line identification. Pipe, hose, and tube lines for liquids, gas, steam, etc., shall be clearly and unambiguously labeled or coded as to contents, pressure, heat, cold, or other specific hazardous properties in accordance with MIL-STD-1247.

5.13.4 General workspace hazards.

5.13.4.1 Alerting device. A hazard alerting device shall be provided to warn personnel of impending danger or existing hazards (e.g., fire, the presence of combustible or asphyxiating gas, radiation, etc.).

5.13.4.2 Emergency doors and exits. Emergency doors and exits shall be constructed so that they:

a. are simple to operate,

b. are readily accessible,

c. are unobstructed,

d. are simple to locate and operate in the dark,

e. are quick opening in three seconds or less,

f. require 44 to 133 N (10 to 30 lb) of operating force to open.

g. do not themselves, or in operation, constitute a safety hazard.

h. permit one person egress in 5 seconds or less.

5.13.4.3 Stairs. Stairs, including incline, step risers, and treads, shall conform with standard safe design practice. Skid-proof flooring, stair, and step treads shall be provided. Where conditions warrant special precaution, surfaces shall conform with the nonslip coating requirements of MIL-W-5044 and MIL-W-5050.

5.13.4.4 Obstructions. Workspace around areas where maintenance is performed shall be free of obstructions which could cause injury to personnel, either through accidental contact with the obstruction or because the obstruction requires an awkward or dangerous body position.

5.13.4.5 Illumination. Adequate illumination shall be provided in all areas. Warning placards, stairways, and all hazardous areas shall be illuminated, in accordance with the recommended levels of Table XXI.

5.13.4.6 Thermal contact hazards. Equipment which, in normal operation, exposes personnel to surface temperatures greater or less than those shown below, shall be appropriately guarded. Surface temperatures induced by climatic environment are exempt from this requirement. Cryogenic systems shall also be appropriately guarded.

Temperature limits

Exposure	Metal	Glass	Plastic or wood
Momentary contact	60 degrees C (140 degrees F)	68 degrees C (154 degrees F)	85 degrees C (185 degrees F)
Prolonged contact or handling	49 degrees C (120 degrees F)	59 degrees C (138 degrees F)	69 degrees C (156 degrees F)
Momentary contact	0 degrees C (32 degrees F)	0 degrees C (32 degrees F)	0 degrees C (32 degrees F)
Prolonged contact or handling	0 degrees C (32 degrees F)	0 degrees C (32 degrees F)	0 degrees C (32 degrees F)

5.13.5 General equipment-related hazards.

5.13.5.1 Interlocks and alarms. The operation of switches or controls which initiate hazardous operations (e.g., ignition, movement of a crane, etc.) shall require the prior operation of a related or locking control. Where practicable, the critical position of such a control shall activate a visual and auditory warning device in the affected work area.

5.13.5.2 Access. Units shall be so located and mounted that access to them can be achieved without danger to personnel from electrical charge, heat, moving parts, chemical contamination, radiation, or other hazards.

5.13.5.3 Hazardous access. Where access areas must be located over dangerous mechanical or electrical components, the access door or cover shall be designed to actuate an internal light when opened, and a highly visible warning label shall be provided on the outside of the door or cover.

5.13.5.4 Edge rounding. Where applicable, all exposed edges and corners shall be rounded to a minimum of .75 mm (.03 in) radius. Sharp edges and corners that present a personal safety hazard or potential damage to equipment during usage shall be suitably protected or rounded to a minimum radius of 13 mm (1/2 in).

5.13.5.5 Safety pins and streamers. Safety pins and streamers shall be clearly visible and accessible during ground maintenance.

5.13.6 Platforms.

5.13.6.1 Locks. Self-locking or other fail-safe devices shall be incorporated on elevating stands, work platforms and "draw bridges" to prevent accidental or inadvertent collapsing or falling.

5.13.6.2 Handrails, safety bars and chains. Handrails, safety bars, or chains shall be installed around platforms and across stair or step openings in platforms, ledges, catwalks, etc. Such guards shall be placed 1.070 m (42 inches) above the standing surface. An intermediate guard rail shall be provided. Chains shall only be used where it is not feasible to install handrails or safety bars. Kickboards, 150 mm (6 in) high, shall be installed.

5.13.6.3 Safety mesh. Screen or safety mesh shall be installed on the underside of open gratings, platforms, or flooring surfaces where there is a possibility that small tools, parts or debris may fall through the grating on workers or equipment beneath the platform.

5.13.7 Electrical, mechanical, fluid, toxic and radiation hazards.

5.13.7.1 Electrical hazards.

5.13.7.1.1 Insulation of tools. Tools and test leads to be used near high voltages shall be adequately insulated.

5.13.7.1.2 Plugs and receptacles. Plugs and receptacles shall be designed so that a plug of one voltage rating cannot be inserted into a receptacle of another rating.

5.13.7.1.3 Voltage exposure. Equipment shall be designed so that all hot contacts will be socket contacts.

5.13.7.1.4 Dangerous voltage or current. Guards, grounding, interlocks, and warning placards shall be provided to minimize the possibility of exposing personnel to dangerous voltages or currents.

5.13.7.1.5 Ground potential. Equipment shall be designed so that all external parts, with the exception of antenna and transmission line terminals, will be at ground potential in accordance with Requirement 1 of MIL-STD-454.

5.13.7.1.6 Electrically-operated hand tools. Electrically operated hand-held power tools shall be designed with three-wire power cords with one wire at ground potential and shall have exposed surfaces which are either non-conducting or are electrically connected to the ground wire. "Exposed surfaces" include cases, grips, handles, switches, triggers, chucks, and other surfaces which are capable of being contacted during operation. Portable tools, protected by an approved system of double insulation or its equivalent, may be used without a ground wire when approved by the procuring activity.

5.13.7.1.7 Electronic equipment. Electronic equipment safety provisions shall be in accordance with Requirement 1 of MIL-STD-454.

5.13.7.1.8 Vehicle batteries. All batteries which have a rating greater than 25 amp hours shall have terminal guarding to prevent inadvertent short-circuit. Such guarding shall also prevent short-circuiting of the battery in spite of clearly improper but possible acts by personnel, such as placing of tools across terminals, resting a heavy object on the battery cover, and standing on a battery cover.

5.13.7.2 Mechanical hazards.

5.13.7.2.1 Guards. A guard shall be provided on all moving parts of machinery and transmission equipment, including pulleys, belts, gears, blades, etc., on which personnel may become injured or entangled.

5.13.7.2.2 Telescoping ladders. Adequate finger clearance shall be provided between rungs of telescoping ladders.

5.13.7.3 Fluid hazards.

5.13.7.3.1 Connectors. Each connector utilized in the handling or control of hazardous fluids, including propellants, solvents, toxics, hypergolics, asphyxiants, etc., shall be incompatible with other connectors within the access area of that connector.

5.13.7.3.2 Fluid and fuel servicing equipment. Automatic shutoff devices shall be provided on fluid and fuel service equipment to prevent overflow and spillage.

5.13.7.4 Toxic hazards.

5.13.7.4.1 General. Personnel shall not be exposed to the concentrations of toxic substances in excess of the limits specified in either the Department of Defense (DoD) Occupational Safety and Health (OSH) standards or specialized standards applicable to military unique equipment, systems or operations.

5.13.7.4.2 Carbon monoxide. Carbon monoxide in personnel areas shall be reduced to the lowest level feasible. Personnel shall not be exposed to concentrations of carbon monoxide (CO) in excess of values which will result in carboxyhemoglobin (COHb) levels in their blood greater than the following percentages: 5% COHb (all system design objectives and aviation system performance limits); 10% COHb (all other system performance limits). It is acceptable to estimate COHb blood levels in personnel by solving the empirical equation given in paragraph 3.7.5 of MILHDBK-759A. When using the equations to estimate the percent COHb blood levels for combat vehicle occupants, the following work stress levels (defined by MIL-HDBK-759A) shall be applied as appropriate: activities involving weapons fire - level 4; all other mission activities - level 3. An initial value of $COHb_0$=1.0% shall be assumed for all estimates.

5.13.7.5 Radiation. Radiation emitting systems and equipment require special consideration to minimize hazards to operators and maintenance personnel. Ionizing radiation exposure rates produced by any device shall not exceed 0.5 milliroentgens/hr at a distance of 50 mm (2") from any point on the external surface. Microwave, radio frequency, X and laser radiation limits shall conform to those specified in Requirement 1, MIL-STD-454. Definitive and specific data should be obtained from the service agency responsible for control of personnel exposure to radiation.

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5.14 Aerospace vehicle compartments.

5.14.1 General. Aerospace vehicle compartments shall be designed to optimize human efficiency, safety, and comfort within the constraints imposed by system requirements.

5.14.1.1 Windows, canopies, and windshields.

5.14.1.1.1 Visual performance. Transparent areas shall be designed to be free from color, distortion, or any other factors that would degrade visual performance below the level required for mission accomplishment.

5.14.1.1.2 Multilayered windows. Visual performance shall not be degraded below the level required for mission accomplishment by loss of light transmission or by multireflections resulting from multilayered windows.

5.14.1.1.3 Angle of incidence. When undistorted external vision is required, the angle of incidence (see 3.3) shall not exceed $\pi/3$ rad (60°).

5.14.1.1.4 Unobstructed vision. Windows and canopies shall be designed for optimum unobstructed vision. Width of structural members in the line of vision should not exceed 56 mm (2.2 inches). Aircrew vision requirements are contained in MIL-STD-850.

5.14.1.1.5 Head-up displays.

5.14.1.1.5.1 General. Head-up displays shall be compatible with the capabilities and limitations of the human visual system. Information presented on head-up displays shall be limited to critical data which the operator is required to monitor while simultaneously performing some primary visual task.

5.14.1.1.5.2 Symbol brightness. Symbols shall be bright enough to be legible under all expected ambient lighting conditions. Symbol brightness shall not be less than 5000 cd/m^2 (1500 Ft-L) when legibility in direct sunlight or background luminance of 34,000 cd/m^2 (10,000 Ft-L) is required. For most high ambient light applications, symbol brightness should be 6,900 - 10,300 cd/m^2 (2,000 - 3,000 Ft-L).

5.14.1.1.5.3 Legibility. Sufficient contrast shall be provided to ensure symbol legibility under all expected viewing conditions.

5.14.1.1.5.4 Field of view. Head-up displays should have a minimum field of view of 350 mrad (20°) in the vertical plane and 490 mrad (28°) in the horizontal plane.

5.14.1.1.5.5 Exit pupil. Head-up displays shall have a minimum exit pupil (that area within a collimated beam in which the entire image formed by an objective lens is capable of being seen) of 72 mm (2.8").

5.14.1.1.5.6 Symbol line width. Symbols used in head-up displays shall have a minimum line width of 0.5 mrad (1.7 minutes). For most applications, symbol line width should be 1.0 ±0.2 mrad (3.4 ±0.7 minutes).

5.14.1.2 Instrument location. Instruments shall be located so that, with glare shields and bezels in place, they can be easily read by appropriate crew members.

5.14.2 Crew stations and passenger compartments (all aerospace vehicles).

5.14.2.1 Aircrew stations (aeronautical). Specific design requirements for pilot and copilot stations are contained in MIL-STD-203, MIL-STD-250, MIL-STD-411, MIL-STD-783, MIL-STD-850, MIL-STD-1333, MIL-STD-1776, MIL-STD-1787, MIL-STD-1800, MIL-STD-1801, MIL-L-5667, MIL-L-85762, MIL-L-87240, MIL-M-18012, MIL-P-7788, and AFGS-87213A. Human Engineering design of pilot and copilot stations not covered in the above documents or other contractual documents shall be in accordance with the criteria in this standard. Human engineering design of aircrew stations and passenger compartments other than pilot and co-pilot stations shall be in accordance with the criteria of 5.7.

5.14.2.2 Layout for shared work space.

5.14.2.2.1 General. Where applicable, design of compartments shall allow personnel to share equipment, reduce communication requirements, conduct required face-to-face communications, and minimize mutual interference when operating equipment which requires more than one operator.

5.14.2.2.2 Location and arrangement of groups. Groups should be located and arranged to share material, information, and equipment; to simplify supervision; and to simplify coordination.

5.14.2.2.3 Effects of crew size. Compartment design shall accommodate requirements for interaction and multiple use as crew size grows, including adequate provisions for communications; physical access; illumination; acoustics; air conditioning; traffic flow and free volume; oxygen regulators and portable units; first aid equipment; emergency egress; personal equipment storage; oxygen supplies and environmental control; food, water, and waste management; and rest areas.

5.14.2.2.4 Standing operations. Standing operations shall be limited to those necessitated by mission requirements.

5.14.2.2.5 Effects of variable gravity. When aerospace vehicle missions require the performance of crew operation, maintenance, and control tasks in a variable gravity flight regime, design shall include provisions for body positioning and restraint devices, locomotion aids, and safeguards against inadvertent displacement of controls and damage to vehicle and to personnel equipment.

5.14.2.3 Work space dimensions. The following dimensions and those presented in Figures 23 through 29 and Tables XIII through XIX shall be used in the design of work places so as to provide adequate clearance. If environmental conditions require personal protection encumbrances that necessitate larger clearances, allowances shall be made.

	Light Clothing cm (in)	Bulky Clothing cm (in)
Minimum height allowance for standing	193 (76)	198 (78)
Minimum height allowance for crawling	79 (31)	86 (34)
Maximum depth of objects which must be reached into	58 (23)	53 (21)
Minimum width allowance for passing body	58 (23)	69 (27)
Minimum thickness allowance for passing body	33 (13)	41 (16)
Minimum height allowance for bending or kneeling	122 (48)	127 (50)

5.14.2.4 Seating and restraint.

5.14.2.4.1 General. Seats, contours, positions, and restrains should be adjustable to individual anthropometric dimensions of shirtsleeve and pressure suit environments, survival equipment, armor, and to fore-seeable conditions and levels of g-loading. Seating or restrains shall provide an adequate supporting framework for the body relative to the activities that must be performed. Seats shall be designed for maximum protection under g-loading and for comfort, ease of adjustments, and minimum weight.

5.14.2.4.2 Vertical and horizontal (fore and aft) adjustments. Seats shall have vertical and horizontal adjustments sufficient to accommodate suitably clothed and equipped users with relavant body dimensions varying between 5th and 95th percentile (see 5.6), without degrading their performance capability.

5.14.2.4.3 Swivel adjustments. Seats capable of being rotated shall contain at least eight locking positions equally spaced through 2 urad (360°). The seat shall be capable of being swiveled freely, when unlocked, while supporting a load of 113 kg (250 lb).

5.14.2.4.4 Height. The sitting surface shall be designed to provide a minimum of 230 mm (9 in) between the sitting surface and the bottom of the work surface or shelf. (See figure 24)

5.14.2.4.5 Access to foot controls. When seated, the operator shall have free access to, and actuation of, foot-operated controls.

5.14.2.4.6 Backrest. Backrest angle shall vary between 85 and 260 mrad (5° and 15°) aft of the vertical for the work position and to a maximum of 875 mrad (50°) for the rest position. The rest angle shall not exceed an included angle between seat and backrest of 2375 mrad (136°).

5.14.2.4.7 Armrests. Armrests that are integral with operator's seats shall be at least 50 mm (2 in) wide and 200 mm (8 in) long and be 190 to 250 mm (7.5 to 10 in) above the seat surface. Modified or retractable armrests shall maintain compatibility with an associated console. The armrest shall not interfere with work requirements or emergency procedures.

5.14.2.4.8 Leg room. Knee and foot room shall be provided beneath work surfaces. Clearances shall equal or exceed the following dimensions:

a. Height: 640 mm (25 inches). (If a foot rest is provided, this dimension shall be increased accordingly.)

b. Width: 510 mm (20 inches).

c. Depth: 460 mm (18 inches).

5.14.2.4.9 Passenger seats. Where feasible, passenger seats should face the rear of the vehicle and should include a 400 mm (16 inches) walkway space between the seat pan edge and the back of the adjacent seat.

5.14.3 Personnel ingress and egress.

5.14.3.1 Hatches for normal exit and entrance. The minimum diameter of a circular hatch shall be 760 mm (30 inches). The minimum dimensions of a rectangular hatch or passageway shall be 660 mm (26 inches) wide and 760 mm (30 inches) high.

5.14.3.1.1 Exit markings. Exits shall be clearly identified under reduced lighting conditions. Exit instructions shall be legible, brief, and clearly worded.

5.14.3.2 Handholds and footholds. Suitable handholds and footholds shall be supplied where necessary.

5.14.3.3 Tunnels.

5.14.3.3.1 Diameter. The minimum diameter of tunnels shall be 760 mm (30 in).

5.14.3.3.2 Personal equipment space. Tunnels shall be designed to permit passage of an operator with personal equipment and clothing.

5.14.3.4 Doors.

5.14.3.4.1 Jamming. Doors shall be designed to minimize the possibility of jamming.

5.14.3.4.2 Latches. Latch handles should be used in preference to knobs. The latch handles shall be uniform in size, placement, and operation for similar applications throughout the vehicle. Correct movement of the latch handle shall be labeled in accordance with Section 5.5.

5.14.3.5 Inclines and stairs and ladders.

5.14.3.5.1 Angle of incline. The type of structure in relation to angle of ascent shall be as specified in Figure 33.

5.14.3.5.2 Hand and foot surface. Hand rails or gripping surfaces and nonslip foot surfaces shall be provided for ladders. Nonslip treads shall be provided on all stairs. Safety bars or chains shall be installed across stair or step openings. Handrails or hand holds should be provided when it is necessary for crew members to move between different locations while the vehicle is in motion. The handrails or hand hold shall be 915 mm (36 inches) above the walking surface.

5.14.3.6 Floors. Passage floors shall be provided with nonslip tread or other high friction surface.

5.14.4 Emergency evacuation.

5.14.4.1 General criteria.

5.14.4.1.1 Simplicity. The simplest possible escape mode, consistent with safety and effectiveness, shall be provided.

5.14.4.1.2 Evacuation time. Emergency evacuation (after crash landing) of the crew members shall be possible within 30 seconds, using only one-half of the exits. Emergency evacuation (after crash landing) of all passengers and crew members shall be possible within 60 seconds, using only one-half of the exits. Emergency doors and exits shall be readily accessible, unobstructed, and quick opening from both sides in three seconds or less.

5.14.4.1.3 Cutaway areas. Areas of the vehicle structure which can be chopped through with axes in emergencies shall be clearly marked. Axes shall be provided and adequately labeled.

5.14.4.1.4 Movable articles. Provision shall be made for securing movable articles within the vehicle.

5.14.4.1.5 Exterior protrusions. The design of the escape system shall preclude personnel contact with exterior vehicle protrusions during emergency evacuation.

5.14.4.1.6 Evacuation aids. Where hatches or door sills are more than 1.830 m (72 inches) above the ground, evacuation aids such as inflatable slides, slide poles, ladders, or ropes shall be provided. Ropes, where employed, shall be attached to the top of openings and stand off from the structure to permit use by more than one person at a time.

5.14.4.1.7 Handholds. Handholds shall be provided to assist personnel escape after crash landing or ditching. Handholds shall be designed to accommodate personnel wearing either lightweight and medium weight gloves or cold weather gloves and mittens.

5.14.4.2 Escape exits.

5.14.4.2.1 Emergency lighting. Emergency lighting with self-contained power shall be provided at or near each emergency or normal exit. Lighting shall be automatically energized when the vehicle is subject to conditions requiring such light. The fixture shall be turned on or off from a switch accessible to the vehicle commander. The fixture shall be removable for use outside the vehicle during emergencies.

5.14.4.2.2 Escape openings. Escape openings shall be smooth-edged and free of obstructions and shall permit the passage of personnel with necessary survival equipment.

5.14.4.2.3 Ease of operation. Doors and hatches shall be quick-opening, easily operated, and have a standard mode of latch-handle operation throughout the vehicle.

5.14.4.2.4 Latch-handle actuation. Release latch handles on emergency exits shall require no more than 110 N (25 lb) of force in lateral direction or 200 N (45 lb) pull. This operation should be possible using either hand and shall require no more than two distinct and different motions.

5.14.4.2.5 Control protection. Handles and controls for escape exits shall be protected from inadvertent contacts or contacts that are not escape oriented. Such controls shall not be secured by means of lockwire.

5.14.4.3 Ejection systems. Where ejection systems are specified, the following criteria, and those contained in MIL-S-9479 for USAF, or MIL-S-18471 for USN, shall apply.

5.14.4.3.1 Clearance. The vehicle shall be designed to provide adequate clearance for egress of either the ejection seat and occupant or the escape capsule, as applicable.

5.14.4.3.2 Safety harnesses. Personnel safety harnesses shall be easily adjusted and removed and shall be designed to preclude interference with safe ejection.

5.14.4.3.3 Ejection controls. Ejection controls shall be readily accessible and activation shall be possible with either hand.

5.14.4.3.4 Control protection. Provision shall be made to guard against accidental activation of ejection controls.

5.14.4.3.5 Safety pins and streamers. Safety pins and warning streamers for ejection seats and canopies shall be clearly visible and accessible during ground maintenance.

5.14.4.3.6 Automatic sequencing. The system shall be automatically sequenced and shall require no further action by the occupant once the escape control has been activated.

5.14.4.3.7 Survival requirements. The system shall deliver the crew-member with necessary survival equipment to the ground or water in adequate physical condition for performance of the actions required for survival and rescue.

5.14.4.3.8 Escape capsule. Where escape capsules are specified, the following additional criteria, and those contained in MIL-C-25969 for USAF, or MIL-A-23121 for USN, shall apply.

5.14.4.3.8.1 Capsule provision. The escape capsule shall provide for adequate vision for normal operational duties, limb and head restraint during the escape sequence, and stowage for survival equipment.

5.14.4.3.8.2 Pressurization. The escape system shall provide for pressurization and ventilation of the capsule. The escape system actuators, ballistics, pyrotechnics, or any other devices, shall not permit introduction of noxious or toxic products into the pressurized crew compartment upon activation.

5.14.4.3.8.3 Alighting impact. The system shall provide shock attenuation for landing on terrain or water without injury to occupants.

5.14.4.3.8.4 Flotation. The system shall ensure flotation of the capsule for water survival.

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5.15 User-computer interface.

5.15.1 General. Computer programs and equipment interfaces shall provide a functional interface between the system for which they are designed and users (operators/maintainers) of that system. This interface shall optimize compatibility with personnel and shall minimize conditions which can degrade human performance or contribute to human error.

5.15.1.1 Standard procedures. Users shall be provided standard procedures for similar, logically related transactions.

5.15.1.2 Computer response. Every input by a user shall consistently produce some perceptible response output from the computer.

5.15.1.3 On-line guidance. Users shall be provided on-line data and command indices, and dictionaries, to guide selection and composition for data and command entries. Definitions of allowable options, system capabilities, procedures, and ranges of values shall be displayable at the user's request.

5.15.1.4 System status. Users shall be provided information at all times on system status regarding operational modes, availability, and loads, either automatically or by request.

5.15.1.5 Log-on procedures. In applications where users must log-on to the system, log-on shall be a separate procedure that must be completed before a user is required to select among any operational options.

5.15.1.5.1 Automatic log-on display. Appropriate prompts for log-on should be automatically displayed on the user's terminal with no special action required other than turning on the terminal.

5.15.1.5.2 Log-on-feedback. Users shall be provided feedback relevant to the log-on procedure that indicates the status of the inputs.

5.15.1.5.3 Log-on delay. If a user cannot log-on to a system, a prompt should be provided to explain the reason for this inability. Log-on processes should require minimum input from the user consistent with the requirements prohibiting illegal entry.

5.15.1.6 Log-off procedures. When a user signals for log-off, the system should check pending transactions to determine if data loss seems probable. If so, the computer should prompt for confirmation before the log-off command is executed.

5.15.1.7 Computer failure. In the event of partial hardware/software failure, the program should allow for orderly shutdown and establishment of a check-point so restoration can be accomplished without loss of computing performed to date.

5.15.1.8 Interaction. Where two or more users must have simultaneous read access to the computer program or data processing results from multiple personnel-equipment interfaces, the operation by one person shall not interfere with the operations of another person unless mission survival may be contingent upon the pre-emption. Provisions shall be made so that the pre-empted user can resume operations at the point of interference without information loss.

5.15.2 Data entry.

5.15.2.1 General. Data entry functions shall be designed to establish consistency of data entry transactions, minimize input actions and memory load on the user, ensure compatibility of data entry with data display, and provide flexibility of user control of data entry.

5.15.2.1.1 User pacing-manual. Data entry shall be paced by the user, rather than by the system.

5.15.2.1.2 Positive feedback. The system shall provide a positive feedback to the user of the acceptance or rejection of a data entry. Feedback response times shall conform to 5.15.8.

5.15.2.1.3 Processing delay. Where system overload or other system conditions will result in a processing delay, the system shall acknowledge the data entry and provide an indication of the delay to the user. If possible, the system shall advise the user of the time remaining for the process or of the fraction of the process completed.

5.15.2.1.4 Explicit action. Data entry shall require an explicit completion action, such as the depression of an ENTER key.

5.15.2.1.5 Validation. Data entries should be validated by the system for correct format, legal value, or range of values. Where repetitive entry of data sets is required, data validation for each set should be completed before another transaction can begin. See also 5.15.8.11.

5.15.2.1.6 Software-available data. The user should not be required to enter data already available to the software.

5.15.2.1.7 Input units. Data should be entered in units which are familiar to the user.

5.15.2.1.8 Cursors.

5.15.2.1.8.1 Control. Systems employing cursors shall provide cursor control capability. The user should be able to adjust the sensitivity of the cursor movement to be compatible with the required task and user skills.

5.15.2.1.8.2 Display. A movable cursor within the display shall have a distinctive visual attribute that does not obscure other displayed entities. When fine positioning accuracy is required, as in some forms of graphic and image processing applications, the displayed cursor shall include an appropriate point designation feature (such as crosshairs). The cursor shall not move beyond the display boundaries and disappear from sight. If the cursor is moved by depressing a key, releasing the key shall cause the cursor to stop moving.

5.15.2.1.8.3 Home position. The home position for the cursor should be consistent across similar types of displays.

5.15.2.1.8.4 Explicit actuation. A separate, explicit action, distinct from cursor position, shall be required for the actual entry (e.g., enabling, actuation) of a designated position.

5.15.2.1.8.5 Consistent positioning. Where cursor positioning is incremental by discrete steps, the step size of cursor movement shall be consistent horizontally (i.e., in both right and left directions), and vertically (in both up and down directions).

5.15.2.1.8.6 Keyboard cursor control. When position designation is required in a task emphasizing keyed data entry, cursor control should be by some device integral to the keyboard. If cursor movement is accomplished by depressing keys, the keys shall be located on the main keyboard.

5.15.2.1.8.7 Movement relationships. The response of a cursor to control movements shall be consistent, predictable, and compatible with the user's expectations. For cursor control by key action a key labeled with a left-pointing arrow should move the cursor leftward on the display; for cursor control by joystick, leftward movement of the control should result in leftward movement of the cursor.

5.15.2.1.9 Abbreviations, mnemonics, and codes. When abbreviations, mnemonics, or codes are used to shorten data entry, they shall be distinctive and have a relationship or association to normal language or specific job-related terminology. Abbreviations should be the same length, the shortest possible that will ensure unique abbreviations.

5.15.2.1.10 Explicit delete action. Data deletion or cancellation shall require an explicit action, such as the depression of a DELETE key.

5.15.2.1.11 Change of data. Where a user requests change (or deletion) of a data item that is not currently being displayed, the option of displaying the old value before confirming the change should be presented.

5.15.2.1.12 Single method of data entry. Data entry methods and data displays should not require the user to shift between entry methods.

5.15.2.1.13 Data entry display. Where data entry on an electronic display is permitted only in prescribed areas, a clear visual definition of the entry fields shall be provided.

5.15.2.2 Keyboard.

5.15.2.2.1 Use. A keyboard should be used to enter alphabetic, numeric and other special characters into the system.

5.15.2.2.2 Configuration. Keyboards shall conform to MIL-STD-1280, unless otherwise specified or approved by the procuring activity.

5.15.2.2.3 Timely display. Keyed inputs, except security items such as passwords, shall be shown on the display in accordance with the values in Table XXVIII.

5.15.2.2.4 Length. Except for extended text, the length of individual data items shall be minimized.

5.15.2.2.5 Justification. When entering tabular data, the user shall not be required to right- or left-justify tabular data entries. The system shall automatically justify columnar data with respect to decimal systems point, left margin or right item margin, depending on the type of data.

5.15.2.2.6 Numeric keypads. Keyboards used in systems requiring substantial numeric input shall be equipped with a numeric keypad.

5.15.2.2.7 Minimization of keying. The amount of keying required should be minimized.

5.15.2.2.8 Minimization of shift keying. The use of key shifting functions should be minimized during data entry transactions.

5.15.2.2.9 Data change. In keyed data entry, means shall be provided to allow users to change previous entries, if necessary, by DELETE and INSERT actions.

5.15.2.3 Fixed function (dedicated) keys.

5.15.2.3.1 Use. Fixed function keys (for example, ENTER) should be used for time-critical, error-critical, or frequently used control inputs.

5.15.2.3.2 Standardization. Fixed function keys should be common throughout the system.

5.15.2.3.3 Functional consistency. Once a key has been assigned a given function, it should not be reassigned to a different function for a given user.

5.15.2.3.4 Availability. Fixed function keys should be selected to control functions that are continuously available; i.e., lockout of fixed function keys shall be minimized. At any step in a transaction sequence, however, function keys which are not used for current inputs should be temporarily disabled under computer control. Mechanical overlays should not be used for this purpose.

5.15.2.3.5 Non-active keys. Non-active fixed function keys should be replaced by a blank key on the keyboard.

5.15.2.3.6 Grouping. Fixed function keys shall be logically grouped and shall be placed in distinctive locations on the keyboard.

5.15.2.3.7 Actuation. Except when used to toggle between two opposing states, a fixed function key should require only a single actuation to accomplish its function.

5.15.2.3.8 Feedback. When fixed function key activation does not result in an immediately observable natural response, the user shall be given an indication of system acknowledgement.

5.15.2.3.9 Function labels. Key assignments shall be displayed at all times, preferably through direct marking. Where abbreviations are necessary, standardized DoD abbreviations (e.g., MIL-STD-12, MIL-STD-411, MIL-STD-783) should be used.

5.15.2.4 Variable function keys.

5.15.2.4.1 Use. Variable function keys may be used for programmable menu selection and entry of control functions.

5.15.2.4.2 Status display. When the effect of a function key varies, the status of the key shall be displayed.

5.15.2.4.3 Reprogrammable or inactive default functions. When keys with labeled default functions are reprogrammed or turned off, a visual warning shall alert the user that the standard function is not currently accessible via that key.

5.15.2.4.4 Relabeling. Provision shall be made for easily relabeling variable function keys. Labels for variable function keys, located along the perimeter of a display, may be generated on the display face.

5.15.2.4.5 Shifted characters. Shift keys should not be required to operate variable function keys.

5.15.2.4.6 Easy return to base-level functions. Where the functions assigned to a set of function keys change as a result of user selection, the user should be given an easy means to return to the initial, base-level functions. For example, in cockpit design, where multifunction keys may be used for various purposes such as navigation or weapons control, the aircrew should be able to take a single action to restore those keys quickly to their basic flight control functions.

5.15.2.5 Lightpen.

5.15.2.5.1 Use. A lightpen may be used when non-critical, imprecise input functions are required. Such direct-pointing controls should be used when item selection is the primary type of data entry.

5.15.2.5.2 Dimensions and mounting. See 5.4.3.2.7.3.

5.15.2.5.3 Actuation. Lightpens shall be equipped with a discrete actuating/deactuating mechanism. For most applications, a push-tip switch, requiring 0.5N - 1.4N (2-5 oz) of force to actuate, is preferred.

5.15.2.5.4 Feedback. Two forms of feedback shall be provided to the user when using a lightpen:

a. Feedback concerning the position of the lightpen, preferably in the form of displayed cursor (such as circle or crosshair) or highlighting which also informs the user that the system is recognizing the presence of the lightpen. The feedback shall be large enough to be seen under the point of the lightpen.

b. Feedback that the lightpen has actuated and the input has been received by the system.

5.15.2.6 Directional controllers.

5.15.2.6.1 Use. A joystick, trackball or similar device may be used when precise input functions are required. Joystick, trackballs, grid-and-stylus devices and x-y controllers shall conform to 5.4.3.2.2, 5.4.3.2.3, 5.4.3.2.4, 5.4.3.2.5, and 5.4.3.2.6.

5.15.2.6.2 Actuation/deactuation. A discrete mechanism shall be provided to allow the user to actuate/deactuate the device.

5.15.2.7 Touch screen. See paragraph 5.4.6 for information on touch screens.

5.15.3 Data display.

5.15.3.1 Display format.

5.15.3.1.1 Consistency. Display formats should be consistent within a system.

a. When appropriate for users, the same format should be used for input and output.

b. Data entry formats should match the source document formats.

c. Essential data, text, and formats should be under computer, not user, control.

5.15.3.1.2 Criticality. Only data essential to the user's needs shall be displayed.

5.15.3.1.3 Readily usable form. Data presented to the user shall be in a readily usable and readable form such that the user does not have to transpose, compute, interpolate or mentally translate into other units, number bases or languages.

5.15.3.1.4 Order and sequences. When data fields have a naturally occurring order (e.g., chronological or sequential), such order shall be reflected in the format organization of the fields.

5.15.3.1.4.1 Data grouped by importance. Where some displayed data items are of significant importance or require immediate user response, those items should be grouped at the top of the display.

5.15.3.1.4.2 Data grouped by function. Where sets of data are associated with particular questions or related to particular functions, each set may be grouped together to help illustrate those functional relationships.

5.15.3.1.4.3 Data grouped by frequency. Where some data items are used more frequently than others, those items may be grouped at the top of the display.

5.15.3.1.5 Data separation. Separation of groups of information should be accomplished by blanks, spacing, lines, color coding, or other means consistent with the application.

5.15.3.1.6 Recurring data fields. Recurring data fields within a system shall have consistent names and should have consistent relative position within displays.

5.15.3.1.7 Extended alphanumerics. When five or more alphanumeric characters without natural organization are displayed, the characters shall be grouped in blocks of three to five characters within each group separated by a minimum of one blank space or other separating character such as a hyphen or slash.

5.15.3.1.8 Comparative data fields. Data fields to be compared on a character-by-character basis shall be positioned one above the other with alignment of characters to be compared.

5.15.3.1.9 Labels and titles. Each display shall be labeled with a title or label that is unique within the system. To make the display as meaningful as possible and to reduce user memory requirements, every field or column heading should be labeled.

5.15.3.1.9.1 Display title. Every display should begin with a title or header at the top, describing briefly the contents or purpose of the display. There shall be at least one blank line between the title and the body of the display.

5.15.3.1.9.2 Command entry, prompts, messages at bottom. The last several lines at the bottom of every display should be reserved for status and error messages, prompts, and command entry.

5.15.3.1.10 Data group labels. Each individual data group or message shall contain a descriptive title, phrase, word or similar device to designate the content of the group or message. Labels shall:

a. Be located in a consistent fashion adjacent to (and preferably above or to the left of) the data group or message they describe.

b. Be unambiguously related to the group, field, or message they describe.

c. Be highlighted or otherwise accentuated to facilitate operator scanning and recognition. The technique used to accentuate labels shall be different from, and easily distinguished from, that used to highlight or code emergency or critical messages.

d. Be unique and meaningful to distinguish them from data, error messages, or other alphanumerics.

e. Be displayed in upper case only, while text may be displayed in upper and lower case.

f. Reflect the question or decision being posed to the user, when presenting a list of user options.

5.15.3.1.11 Scrolling. Items continued on the next page (scrolled) should be numbered relative to the last item on the previous page.

5.15.3.1.12 Page numbering. Each page of a multiple page display shall be labeled to identify the currently displayed page and the total number of pages, e.g., Page 2 of 5.

5.15.3.1.13 Frame identification. Every display frame shall have a unique identification to provide a reference for use in requesting the display of that frame. The frame identification should be an alphanumeric code or an abbreviation which is prominently displayed in a consistent location. It should be short enough (3-7 characters) and/or meaningful enough to be learned and remembered easily.

5.15.3.2 Display content.

5.15.3.2.1 Standardization. The content of displays within a system shall be presented in a consistent, standardized manner.

5.15.3.2.2 Information density. Information density shall be held to a minimum in displays used for critical task sequences. A minimum of one character space shall be left blank vertically above and below critical information with a minimum of two character spaces left blank horizontally before and after (see 5.15.3.1.5 and 5.15.3.3.1).

5.15.3.2.2.1 Crowded displays. When a display contains too much data for presentation in a single frame, the data shall be partitioned into separately displayable pages.

5.15.3.2.2.2 Related data on same page. When partitioning displays into multiple pages, functionally related data items shall be displayed together on one page.

5.15.3.2.2.3 Page labeling. In a multipage display, each page shall be labeled to show its relation to the others.

5.15.3.2.3 Abbreviations and acronyms. Information shall be displayed in plain concise text wherever possible. Abbreviations and acronyms shall conform to MIL-STD-12, MIL-STD-411, or MIL-STD-783. New acronyms, if required, shall be developed using the rules of abbreviation in MIL-STD-12. Abbreviations should be distinctive to avoid confusion. Words should have only one consistent abbreviation. No punctuation should be used in abbreviations. Definitions of all abbreviations, mnemonics and codes should be provided at the user's request.

5.15.3.2.4 Data entry and display consistency. Data display word choice, format, and style should be consistent with the requirements for data entry and control.

5.15.3.2.5 Context for displayed data. The user should not have to rely on memory to interpret new data; each data display should provide needed context, including recapitulating prior data from prior displays as necessary.

5.15.3.3 Display coding.

5.15.3.3.1 Use. Coding shall be employed to differentiate between items of information and to call the user's attention to changes in the state of the system. Coding should be used for critical information, unusual values, changed items, items to be changed, high priority messages, special areas of the display, errors in entry, criticality of command entry, and targets. Consistent, meaningful codes shall be used. Coding shall not reduce legibility or increase transmission time.

5.15.3.3.2 Flash. Flash coding shall be employed to call the user's attention to mission critical events only. No more than 2 flash rates shall be used. Where one rate is used, the rate shall be between 3 and 5 flashes per second. Where two rates are used, the second rate shall be less than 2 per second.

5.15.3.3.3 Brightness. Brightness intensity coding shall be employed only to differentiate between an item of information and adjacent information. No more than two levels of brightness shall be used. Each level shall be separated from the nearest by at least a 2:1 ratio.

5.15.3.3.4 Pattern and location. Pattern and location coding shall be employed to reduce user search time by restricting the area to be searched to prescribed segments.

5.15.3.3.5 Underlining. Underlining may be employed to indicate unusual values, errors in entry, changed items or items to be changed.

5.15.3.3.6 Symbol and size. Symbol coding may be employed to enhance information assimilation from data displays. Symbols shall be analogs of the event or system element they represent or be in general use and well known to the expected users. Where size difference between symbols is employed, the major dimensions of the larger shall be at least 150 percent of the major dimension of the smaller with a maximum of three size levels permitted.

5.15.3.3.6.1 Special symbols. When special symbols are used to signal critical conditions, they shall be used for only that purpose.

5.15.3.3.6.2 Markers close to words marked. When a special symbol is used to mark a word, the symbol shall be separated from the beginning of the word by one space.

5.15.3.3.7 Color. Color coding may be employed to differentiate between classes of information in complex, dense, or critical displays. The colors selected shall not conflict with the color associations specified in Table II. Information shall not be coded solely by color if the data must be accessed from monochromatic as well as color terminals or printed in hardcopy versions.

5.15.3.3.8 Shape. Shape coding may be used for search and identification tasks. When shape coding is used, the codes selected shall be based on established standards or conventional meanings.

5.15.3.3.9 Brightness inversion. When a capability for brightness inversion is available (so-called "reverse video", where dark characters on a bright background can be changed under computer control to bright on dark, or vice versa), it may be used for highlighting critical items that require user attention. When used for alerting purposes, brightness inversion shall be reserved consistently for that purpose, and not be used for general highlighting.

5.15.3.4 Dynamic displays.

5.15.3.4.1 Changing values. Changing alphanumeric values which the operator must reliably read shall not be updated more often than once per second. Changing values which the viewer uses to identify rate of change or to read gross values shall not be updated faster than 5 times per second, nor slower than 2 per second, when the display is to be considered as real-time.

5.15.3.4.2 Update rate. The rate of update should be controllable by the user and shall be determined by the use to be made of the information.

5.15.3.4.3 Display freeze. A display freeze mode shall be provided to allow close scrutiny of any selected frame that is updated or advanced automatically by the system. For frozen display frames, an option shall be provided to allow resumption at the point of stoppage or at the current real-time point.

5.15.3.4.4 Freeze feedback. An appropriate label shall be provided to remind the operator when the display is in the freeze mode.

5.15.3.5 Tabular data.

5.15.3.5.1 Use. Tabular data displays shall be used to present row-column data to aid detailed comparison of ordered sets of data.

5.15.3.5.2 Standard formats. Location of recurring data shall be similar among all tabular data displayed and common throughout the system.

5.15.3.5.3 Arrangement. Tabular data shall be displayed in rows and columns. If the data in the rows has order, the order shall be increasing from left to right. If the data in the columns has order, the order shall be increasing from top to bottom of the display.

5.15.3.5.4 Titles. When tabular data are divided into classifications, the classification titles shall be displayed and subclassification shall be identified. When tabular data extend over more than one page vertically, the columns shall be titled identically on each page.

5.15.3.5.5 Horizontal extension. Tabular displays should not extend over more than one page horizontally.

5.15.3.5.6 Lists. Items in lists shall be arranged in a recognizable order, such as chronological, alphabetical, sequential, functional, or importance.

5.15.3.5.6.1 List lines. Each item in a list shall start on a new line.

5.15.3.5.6.2 Vertical extension. Where lists extend over more than one display page, the last line of one page shall be the first line on the succeeding page.

5.15.3.5.6.3 Marking multiline items in a list. Where a single item in a list continues for more than one line, such items shall be marked in some way (e.g., blank line, indentation) so that the continuation of the item is obvious.

5.15.3.5.6.4 Arabic numerals. When listed items will be numbered, Arabic numerals should be used rather than Roman.

5.15.3.5.6.5 Vertical ordering in multiple columns. Where items in a list are displayed in multiple columns, items shall be ordered vertically within each column.

5.15.3.5.6.6 Hierarchic structure for long lists. Where lists are long and must extend beyond more than one displayed page, a hierarchic structure shall be used to permit the logical partitioning into related shorter lists.

5.15.3.5.7 Numeric punctuation. Long numeric fields should be punctuated with spaces, commas, or slashes. Conventional punctuation schemes should be used if in common usage. Where none exist a space should be used after every third or fourth digit. Leading zeros shall not be used in numerical data except where needed for clarity.

5.15.3.5.8 Alphanumeric grouping. Strings of alphanumerics should be grouped into sets of three to five characters or grouped at natural breaks. When a code consists of both letters and digits, common character types should be grouped by common character type for ease of location.

5.15.3.5.9 Distinctive and informative labels. Rows and columns shall be labeled distinctively to guide data entry.

5.15.3.5.10 Justification of numeric entry. Users shall be allowed to make numeric entries in tables without concern for justification; the computer shall right-justify integers, or else justify with respect to a decimal point if present.

5.15.3.5.11 Labeling units of measurement. In tabular displays, the units of displayed data shall be consistently included in the column labels.

5.15.3.5.12 Consistent column spacing. Column spacing within a table and from one table to another should be uniform and consistent.

5.15.3.5.13 Column scanning cues. A column separation of at least three spaces shall be maintained.

5.15.3.5.14 Row scanning cues. In dense tables with many rows, a blank line shall be inserted after a group of rows at regular intervals. No more than five lines should be displayed without a blank line being inserted.

5.15.3.6 Graphic displays.

5.15.3.6.1 Use. Graphic data displays may be used to present assessment of trend information, spatially structured data, time critical information or relatively imprecise information.

5.15.3.6.2 Recurring data. See 5.15.3.1.5.

5.15.3.6.3 Refresh rates. Graphic displays which require user visual integration of changing patterns shall be updated at the maximum refresh rate of the display device consistent with the user's information handling rates.

5.15.3.6.4 Graph axes. The axes of graphs shall be labeled and should be graduated in accordance with 5.2.3.1.4, 5.2.3.1.5, and 5.2.3.1.6.

5.15.3.6.5 Trend lines. When trend lines are to be compared, multiple lines should be used on a single graph.

5.15.3.6.6 Pointing. Where graphic data entry involves frequent pointing on a display surface, the user interface shall provide display control and sequence control by pointing, in order to minimize shifts from one entry device to another. For example, in drawing a flow chart, a user should be able to link elements or points directly by pointing at them or drawing lines between rather than by separately keyed entries.

5.15.3.6.7 Distinctive cursor. The current cursor position on graphic displays shall be indicated by displaying some distinctive cursor symbol at that point, e.g., a plus-sign, representing abbreviated cross-hairs whose intersection can mark a position with reasonable precision.

5.15.3.6.8 Precise positioning. Where data entry requires exact placement of graphic elements, users shall be provided the capability for expansion of the critical display area (e.g., zooming and panning) to make the positioning task easier and more precise.

5.15.3.6.9 Confirming cursor position. For most graphics data entry, pointing should be a dual action, with the first action positioning the cursor at a desired position and the second action confirming that position to the computer. An exception may be a design allowing "free-hand" drawing of continuous lines where the computer must store and display a series of cursor positions as they are entered by the user.

5.15.3.6.10 Selecting graphic elements. Users shall be provided some means for designating and selecting displayed graphic elements for manipulation. Normally this function is performed by pointing where a pointing device is provided for line drawing purposes.

5.15.3.6.11 Selecting from displayed attributes. During graphic data entry, users should be allowed to specify attributes for displayed elements (e.g., text font, plotting symbol, line type) by selecting from displayed samples illustrating the available options.

5.15.3.6.12 Displaying current attributes. During graphic data entry/editing, the selected attributes that will affect current actions shall be displayed for ready reference as a reminder of current selections in effect.

5.15.3.6.13 Easy storage and retrieval. An easy and convenient means shall be provided for saving and retrieving graphic displays for their possible re-use. The user should be allowed to designate filenames of his or her choice for the stored graphic data.

5.15.3.6.14 Automatic data registration. The computer should provide automatic registration or alignment of computer-generated graphic data, so that variable data are shown properly with respect to fixed background or data map at any display scale.

5.15.3.6.15 Predefined graphic formats. Where graphic data must be plotted in predefined standard formats (e.g., target areas on maps, flight plans), templates or skeletal displays shall be provided for those formats to aid data entry.

5.15.3.6.16 Computer derivation of graphic data. When graphic data can be derived from data already available in the computer, machine aids for that purpose shall be provided.

5.15.3.6.17 Drawing lines. When line drawing is required, users shall be provided with aids for drawing straight line segments. When line segments must join or intersect, computer aids shall be provided to aid in such connection.

5.15.3.6.18 Drawing figures. When a user must draw figures, computer aids shall be provided for that purpose (e.g., templates, tracing techniques, stored forms).

5.15.3.6.19 Changing size. When editing graphic data, users shall be provided with the capability to change the size (scale) of any selected element on the display, rather than delete and recreate the element in a different size.

5.15.3.6.20 Highlighting critical data. When a user's attention must be directed to a portion of a graphic display showing critical or abnormal data, that feature should be highlighted with some distinctive means of data coding.

5.15.3.6.21 Reference index. When a user must compare graphic data to some significant level or critical value, a reference index or baseline shall be included in the display.

5.15.3.6.22 Data annotation. When precise reading of a graphic display may be required, the capability should be provided to supplement the graphic representation with the actual numeric values.

5.15.3.6.23 Normal orientation for labels. The labels on dynamic graphic displays shall remain with the top of the label up when the displayed image rotates.

5.15.3.6.24 Pictorial symbols. Pictorial symbols (e.g., icons, pictograms) should look like the objects, features, or processes they represent.

5.15.3.6.25 Display of scale. When a map or other graphic display has been expanded from its normal presentation, an indicator of the scale expansion shall be provided.

5.15.3.6.26 Consistent scaling. When users must compare graphic data across a series of charts, the same scale should be used for each chart.

5.15.3.6.27 Single scale only. Where graphs are presented, only a single scale shall be shown in each axis, rather than including different scales for different curves in the graph. If interpolation must be made or where accuracy of reading graphic data is required, computer aids should be provided the user.

5.15.3.6.28 Unobtrusive grids. When grid lines are displayed, they should be unobtrusive and shall not obscure data elements. Grid lines should be displayed or suppressed at the option of the user.

5.15.3.6.29 Direct display of differences. Where users must evaluate the difference between two sets of data, that difference should be plotted directly as a curve in its own right, rather than requiring users to compare visually the curves that represent the original data sets.

5.15.3.6.30 Bar graphs. Bar graphs should be used for comparing a single measure across a set of several entities or for a variable sampled at discrete intervals.

5.15.3.6.30.1 Bar spacing. Adjacent bars should be spaced closely enough, normally not more than one bar width, so that a direct visual comparison can be made without eye movement.

5.15.3.6.30.2 Histograms (step charts). Histograms (bar graphs without spaces between the bars) should be used where bar graphs are required and where a great many intervals must be plotted.

5.15.3.7 Text/program editing.

5.15.3.7.1 Buffer. When inserting characters, words or phrases (e.g., editing), items to be inserted should be collected in a buffer area and displayed in the prescribed insert area of the screen for subsequent insertion by user command.

5.15.3.7.2 Presentation mode. Display mode rather than line mode should be used for text editing.

5.15.3.7.3 Display window. ROLL and SCROLL commands should refer to the display window, not the text/data; that is, the display window should appear to the user to be an aperture moving over stationary text.

5.15.3.7.4 Editing commands. Editing commands, such as MOVE, COPY, and DELETE, for adding, inserting, or deleting text/program segments shall be provided.

5.15.3.7.4.1 Text edit commands. In text editing, editing commands should be based on character, word, sentence, paragraph, and higher-order segments.

5.15.3.7.4.2 Program edit commands. In program editing, the special commands shall be based on lines or subprograms. Program lines shall reflect a numbering scheme for ease in editing and error correction. When available, line-by-line syntax checking shall be under user control.

5.15.3.7.4.3 Tab controls. For editing programs or tabular data, cursor tab controls or other provisions for establishing and moving readily from field to field shall be provided.

5.15.3.7.5 Editing commands. Where editing commands are made by keying onto the display, the editing commands shall be readily distinguishable from the displayed textual material.

5.15.3.7.6 Highlighted text. Where text has been specified to become the subject of control entries (e.g., for underlining, bolding, moving, copying, or deleting), the affected segment of text shall be highlighted to indicate its boundaries.

5.15.3.7.7 String search. The capability shall be provided to allow the user to specify a string of text (words, phrases, or numbers) and request the computer to advance (or back up) the cursor automatically to the next occurrence of that string.

5.15.3.7.8 Automatic line break. An automatic line break (carriage return) shall be provided when the text reaches the right margin for entry/editing of unformatted text. User override shall be provided.

5.15.3.7.9 Format control. An easy means shall be provided for users to specify required format control features during text entry/editing, e.g., to specify margins, tab settings, line spacing, etc.

5.15.3.7.10 Predefined formats. When text formats must follow predefined standards, the required format shall be provided automatically. Where text formats are a user option, a convenient means should be provided to allow the user to specify and store for future use the formats that have been generated for particular applications.

5.15.3.7.11 Frequently used text. The capability shall be provided to label and store frequently used text segments (e.g., signature blocks, organizational names, call signs, coordinates), and later to recall (copy into current text) stored segments identified by their assigned labels.

5.15.3.7.12 Text displayed as printed. Users should have the option of displaying text as it will be printed, including underlining, boldface, subscript, superscript, special characters, special symbols, and different styles and sizes of type. Where display of all possible features (e.g., special fonts) is impractical, format codes should be highlighted and displayed within the text in order to mark the text that will be affected by the code.

5.15.3.7.13 Control annotations. Where special formatting features are indicated in the text by use of special codes or annotation, the insertion of the special annotation should not disturb the spacing of the displayed text and shall not disturb formatting of graphs and tables or alignment of rows and columns.

5.15.3.7.14 Flexible printing options. In printing text, users shall be allowed to select among available output formats (e.g., line spacing, character size, margin size, heading, and footing) and to specify the pages of a document to be printed.

5.15.3.7.15 Head- and foot-of file. The means shall be provided to readily move the cursor to the head or the foot (end) of the file.

5.15.3.8 Audio displays.

5.15.3.8.1 Uses. Audio displays (signals), used as part of the user-computer interface, have application where:

a. The common mode of visual display is restricted by overburdening or user mobility needs and it is desirable to cue, alert or warn the user, or

b. The user should be provided feedback after control actuation, data entry, or completion of timing cycles and sequences.

5.15.3.8.2 Other requirements. Other audio design criteria apply: see 5.3.1, 5.3.2.1, and 5.3.2.3.

5.15.3.8.3 Supportive function - audio. Audio signals used in conjunction with visual displays shall be supplementary to the visual signals and shall be used to alert and direct the user's attention to the appropriate visual display.

5.15.3.8.4 Signal characteristics. Signals may be one time or intermittent. Intermittent signals shall be automatically terminated when no longer applicable, and by operator control.

5.15.3.8.5 Frequency. See 5.3.3.1.1.

5.15.3.8.6 Audibility. See 5.3.4.1

5.15.3.8.7 Alarm settings. When alarm signals are established on the basis of user-defined logic, users shall be permitted to obtain status information concerning current alarm settings, in terms of dimensions (variables) covered and values (categories) established as critical. Alarm status information is particularly necessary in monitoring situations where responsibility may be shifted from one user to another as in changes of shift.

5.15.4 Interactive control.

5.15.4.1 General. General design objectives include consistency of control action, minimized need for control actions, and minimized memory load on the user, with flexibility of interactive control to adapt to different user needs. As a general principle, it is the user who should decide what needs doing and when to do it. The selection of dialogue types should be based on anticipated task requirements and user skills. Different types of dialogue imply differences in system response time for effective cooperation. Estimated relative requirements for user training and for system response time are given in Table XXVIII.

5.15.4.1.1 Response time. System response times shall be consistent with operational requirements. Required user response times shall be compatible with required system response time. Required user response times shall be within the limits imposed by total user tasking expected in the operational environment. (See 5.15.8)

5.15.4.1.1.1 Response time induced keyboard lockout. If computer processing time requires delay of concurrent user inputs and no keyboard buffer is available, keyboard lockout shall occur until the computer can accept the next transaction. An alert shall be displayed to indicate to the user that lockout has occurred.

5.15.4.1.1.2 Keyboard restoration. When the computer is ready to continue, following response time-induced keyboard lockout, a signal to so indicate shall be presented, e.g., cursor changes back to normal shape.

TABLE XXVIII. DIALOGUE TYPE VERSUS USER TRAINING AND SYSTEM RESPONSE

Dialogue Type	Required User Training	Tolerable Speed of System Response
Question and Answer	None	Moderate (.5 to less than 2 secs)
Menu Selection	None	Very Fast (less than .2 secs)
Form Filling	Moderate	Slow (greater than 2 secs)
Function Keys	Moderate	Very Fast (less than .2 secs)
Command Language	High	Moderate/Slow (.5 to greater than 2 secs)
Natural/Query Language	Moderate	Fast (.2 to less than .5 sec)
Graphic Interaction	High	Very Fast (less than .2 sec)

5.15.4.1.1.3 Interrupt to end keyboard lockout. When keyboard lockout has occurred, the user should be provided with a capability to abort a transaction that has resulted in an extended lockout. Such capability should act like an UNDO command that stops ongoing processing and does not RESET the computer thereby losing prior processing.

5.15.4.1.2 Simplicity. Control/display relationships shall be straightforward and explicit. Control actions shall be simple and direct, whereas potentially destructive control actions shall require extended user attention such they are not easily acted on.

5.15.4.1.3 Accidental actuation. Provision shall be made to prevent accidental actuation of potentially destructive control actions, including the possibility of accidental erasure or memory dump.

5.15.4.1.4 Compatibility with user skill. Controls shall be compatible with the lowest anticipated user skill levels. Experienced users should have options which shortcut intervening steps necessary for inexperienced users.

5.15.4.1.5 Availability of information. Information necessary to select or enter a specific control action shall be available to the user when selection of that control action is appropriate.

5.15.4.1.6 Concurrent display. Control actions to be selected from a discrete set of alternatives shall have those alternatives displayed prior to the time of selection. The current value of any parameter or variable with which the user is interacting shall be displayed. User control inputs shall result in a positive feedback response displayed to indicate performance of requested actions.

5.15.4.1.7 Hierarchical process. When hierarchical levels are used to control a process or sequence, the number of levels shall be minimized. Display and input formats shall be similar within levels and the system shall indicate the current positions within the sequence at all times.

5.15.4.1.8 User memorization. The requirement to learn mnemonics, codes, special or long sequences, or special instructions shall be minimized.

5.15.4.1.9 Dialogue type. The choice of dialogue type (e.g., form filling, menus, command language) for interactive control shall be compatible with user characteristics and task requirements.

5.15.4.1.10 Number system. When numeric data is displayed or required for control input, such data shall be in the decimal, rather than binary, octal, hexadecimal or other number system.

5.15.4.1.11 Data manipulation. The user should be able to manipulate data without concern for internal storage and retrieval mechanisms of the system.

5.15.4.1.12 Computer processing constraints. The sequence of transaction selection should generally be dictated by user choices and not by internal computer processing constraints.

5.15.4.1.13 Feedback for correct input. Control feedback responses to correct user input shall consist of changes in state or value of those elements of the displays which are being controlled in an expected and logically natural form. An acknowledgement message shall be employed only in those cases where the more conventional mechanism is not appropriate or where feedback response time must exceed one second.

5.15.4.1.14 Feedback for erroneous input. Where control input errors are detected by the system (see 5.15.7.2), error messages shall be available as provided in 5.15.7.5, and error recovery procedures shall be as provided in 5.15.7.8.

5.15.4.1.15 Control input data display. The presence and location of control input data entered by the user shall be clearly and appropriately indicated. Data displayed should not mislead the user with regard to nomenclature, units of measure, sequence of task steps, or time phasing.

5.15.4.1.16 Originator identification. Except for broadcast communication systems, the transmitter of each message in inter-user communications should be identified--automatically, if possible.

5.15.4.2 Menu selection.

5.15.4.2.1 Use. Menu selection interactive control should be used for tasks that involve little or no entry of arbitrary data and where users may have relatively little training. It should also be used when a command set is so large that users are not likely to be able to commit all of the commands to memory.

5.15.4.2.2 Selection.

5.15.4.2.2.1 Devices. Lightpens or other pointing devices (including touch technology) should be used for menu selection. (See also Section 5.4.6 Touch Screen Controls for Displays). Where design constraints do not permit pointing devices, a standard window should be provided for the user to key the selected option code. If menu selection is accomplished by pointing, dual actions should be provided. The first action should designate the selected option. This should be followed by a separate action to enter the selection into the computer program.

5.15.4.2.2.2 Titles. Each page of options (menu) should have a title that clarifies the purpose of that menu.

5.15.4.2.2.3 Series entry. Users should be provided the capability to stack menu selections, i.e., to make several menu selections without having each menu displayed.

5.15.4.2.2.4 Sequences. A menu shall not consist of a long list of multi-page options, but shall be logically segmented to allow several sequential selections among a few alternatives.

5.15.4.2.3 Active option presentation. The system shall present only menu selections for actions which are currently available.

5.15.4.2.4 Format consistency. Menus shall be presented in a consistent format throughout the system and should be readily available at all times.

5.15.4.2.5 Option sequence. Menu selections shall be listed in a logical order, or, if no logical order exists, in the order of frequency of use.

5.15.4.2.6 Simple menus. When the number of selections can fit on one page in no more than two columns, a simple menu shall be used. If the selection options exceed two columns, hierarchical menus may be used.

5.15.4.2.7 Option presentation. Selection codes and associated descriptors shall be presented on single lines.

5.15.4.2.8 Direct function call. If several levels of hierarchical menus are provided, a direct function call capability shall be provided such that the experienced user does not have to step through multiple menu levels.

5.15.4.2.9 Consistency with command language. When menu selection is employed to train in the use of a command language, the wording and order shall be consistent with the command language.

5.15.4.2.10 Option coding. When selections are indicated by coded entry, the code associated with each option shall be included on the display in some consistent manner.

5.15.4.2.11 Keyed codes. If menu selections must be made by keyed codes, the options shall be coded by the first several letters of their displayed labels rather than by more arbitrary numeric codes. In defining the codes, however, they should not duplicate any other user function codes.

5.15.4.2.12 Position in structure. When menu traversal can be accomplished by clearly defined hierarchical paths, the user should be given some indication of the displayed menu's current position in the overall or relevant structure, such as by having an optional display of "path" information. A menu tree showing the menu hierarchy should be included in the user manual.

5.15.4.2.13 Back menu When using hierarchical menus, the user shall be able to return to the next higher level by using single key action until the initial, top-level menu or display is reached.

5.15.4.2.14 Return to top level. A function shall be provided to directly recall the initial, top-level menu or display without stepping through the menu or display hierarchy.

5.15.4.3 Form filling.

5.15.4.3.1 Use. Form filling interactive control may be used where some flexibility in data to be entered is needed and where the users will have moderate training. A form-filling dialogue should not be used when the computer must handle multiple types of forms and the computer response is slow.

5.15.4.3.2 Grouping. Displayed forms shall be arranged such that related items are grouped together.

5.15.4.3.3 Format and content consistency. The format and content of displayed forms shall be perceptually related to that of paper forms if paper forms are used to guide data entry. A standard input form should be used.

5.15.4.3.4 Distinctiveness of fields. Fields or groups of fields shall be separated by spaces, lines, or other delineation cues. Required fields shall be distinguished from optional fields.

5.15.4.3.5 Field labels. Field labels shall be distinctively presented such that they can be distinguished from data entry. Labels for data entry fields shall incorporate additional cueing of data format where the entry is made up of multiple inputs, e.g., DATE (M/D/Y): ______/______/______.

5.15.4.3.6 Cursor. A displayed cursor shall be positioned by the system at the first data entry field when the form is displayed. The cursor shall be advanced by a tab key to the next data entry field when the user has completed entry of the current field.

5.15.4.3.7 Entry length indication. The maximum acceptable length for variable length fields shall be indicated.

5.15.4.3.8 Overwriting. Data entry by overwriting a set of characters in a field (such as a default) should not be used.

5.15.4.3.9 Unused underscores. When an item length is variable, the user shall not have to remove unused underscores.

5.15.4.3.10 Dimensional units. When a consistent dimensional unit is used in a given entry field, the dimensional unit shall be provided by the computer. When the dimensional unit varies for a given field, it should be provided, or selected, by the user.

5.15.4.3.11 User omissions. When required data entries have not been input, the omission shall be indicated to the user and either immediate or delayed input of the missing items should be allowed. For delayed entry, the user should be required to enter a special symbol in the field to indicate that the missing item is delayed, not overlooked.

5.15.4.3.12 Non-entry areas. Non-entry (protected) areas of the display shall be designated and made inaccessible to the user via the cursor.

5.15.4.3.13 Flexible data entry. When multiple data items are entered as a single transaction, the user shall be allowed to re-enter, change, or cancel any item before taking a final ENTER action.

5.15.4.3.14 Informative labels. Descriptive wording shall be employed when labeling data fields; use of arbitrary codes shall be avoided.

5.15.4.3.15 Logical order. Where no source document or external information is involved, forms should be designed so that data items are ordered in a logical sequence for input.

5.15.4.3.16 Form filling for control entry. Form filling should be considered as an aid for composing complex control entries. For example, for a print request, a displayed form might help a user invoke the various format controls that are available.

5.15.4.4 Fixed function keys. Fixed function key interactive control may be used for tasks requiring only a limited number of control inputs or in conjunction with other dialogue types. (See 5.15.2.3)

5.15.4.5 Command language.

5.15.4.5.1 Use. Command language interactive control may be used for tasks involving a wide range of user inputs and where user familiarity with the system can take advantage of the flexibility and speed of the control technique.

5.15.4.5.2 User viewpoint. A command language shall reflect the user's point of view such that the commands are logically related to the user's conception of what is being done.

5.15.4.5.3 Distinctiveness. Command names shall be distinctive from one another.

5.15.4.5.4 Punctuation. The command language shall contain a minimum of punctuation or other special characters.

5.15.4.5.5 Abbreviations. The user shall be permitted to enter the full command name or an abbreviation for any command of more than 5 characters.

5.15.4.5.6 Standardization. All commands and their abbreviations, if any, shall be standardized and consistent with MIL-STD-12, MIL-STD-411 or MIL-STD-783.

5.15.4.5.7 Displayed location. Commands shall be entered and displayed in a standard location on the display.

5.15.4.5.8 Command prompts. The user shall be able to request prompts, as necessary, to determine required parameters or available options for an appropriate next command entry.

5.15.4.5.9 Complexity. The command language should be programmed in layers of complexity such that the basic layer will allow the inexperienced user to control a transaction. As this person's skill increases, the command language should allow skipping from basic to more advanced layers to meet the user's current needs.

5.15.4.5.10 User definition of macro commands. The programming shall not accept a user designated macro name that is the same as an existing command name.

5.15.4.5.11 Standard techniques for command editing. Users shall be allowed to edit erroneous command entries with the same techniques that are employed to edit data entries since consistent editing techniques will speed learning and reduce errors.

5.15.4.5.12 Destructive commands. Where a command entry may have disruptive consequences, the user shall be required to review and confirm a displayed interpretation of the command before it is executed.

5.15.4.6 Question and answer.

5.15.4.6.1 Use. Question-and-answer dialogues should be considered for routine data entry tasks, where data items are known and their ordering can be constrained, where users will have little or no training, and where the computer is expected to have medium response speed.

5.15.4.6.2 Questions displayed separately. Each question should be displayed separately in question-and-answer dialogues; users should not be required to answer several questions at once.

5.15.4.6.3 Recapitulating prior answers. When a series of computer-posed questions are interrelated, answers to previous questions should be displayed when those will provide context to help a user answer the current question.

5.15.4.6.4 Source document capability. When questions prompt entry of data from a source document, the question sequence shall match the data sequence in the source document.

5.15.4.7 Query language.

5.15.4.7.1 Use. Query language dialogue should be used for tasks emphasizing unpredictable information retrieval (as in many analysis and planning tasks), with moderately trained users.

5.15.4.7.2 Natural organization of data. Query languages should reflect a data structure or organization perceived by users to be natural. For example, if a user supposes that all data about a particular topic are stored in one place, then the query language should permit such data to be retrieved by a single query, even though actual computer storage might carry the various data in different files.

5.15.4.7.3 Coherent representation of data organization. A single representation of the data organization for use in query formulation should be established, e.g., if different queries will access different data bases over different routes, the user should not necessarily need to know this.

5.15.4.7.4 Task-oriented wording. The wording of a query should simply specify what data are requested; a user should not have to tell the computer how to find the data.

5.15.4.7.5 Logic to link queries. The query language should be designed to include logic elements that permit users to link (e.g., "and," "or") sequential queries as a single entry.

5.15.4.7.6 Confirming large-scale retrieval. If a query will result in a large-scale data retrieval, the user shall be required to confirm the transaction or else take further action to narrow the query before processing.

5.15.4.8 Graphic interaction.

5.15.4.8.1 Use. Graphic interaction as a dialogue may be considered for use by casual users to provide graphic aids as a supplement to other types of interactive control.

5.15.4.8.2 Iconic menus. When system users have different linguistic backgrounds, graphic menus may be used which display icons to represent the control options.

5.15.4.8.3 Supplementary verbal labels. Where icons are used to represent control actions in menus, verbal labels shall be displayed with each icon to help assure that its intended meaning will be understood.

5.15.5 Feedback.

5.15.5.1 Use. Feedback shall be provided which presents status information, confirmation, and verification throughout the interaction.

5.15.5.2 Stand-by. When system functioning requires the user to stand-by, WORKING, BUSY, or WAIT messages should be displayed until user interaction is again possible. Where the delay is likely to exceed 15 seconds, the user should be informed. For delays exceeding 60 seconds, a count-down display should show delay time remaining (see also 5.15.8).

5.15.5.3 Process outcome. When a control process or sequence is completed or aborted by the system, positive indication shall be presented to the user concerning the outcome of the process and the requirements for subsequent user action.

5.15.5.4 Input confirmation. Confirmation shall not cause displayed data removal.

5.15.5.5 Current modes. When multiple modes of operation exist, a means should be provided to remind the user of the current mode.

5.15.5.6 Highlighted option selection. When a displayed message or datum is selected as an option or input to the system, the subject item shall be highlighted to indicate acknowledgment by the system.

5.15.5.7 User input rejection. If the system rejects a user input, feedback shall be provided to indicate the reason for rejection and the required corrective action. Feedback should be self explanatory.

5.15.5.8 Feedback message content. Users shall not be required to translate feedback messages by use of reference system or code sheets. Abbreviations shall not be used unless necessary.

5.15.5.9 Time-consuming processes. The system shall give warning information when a command is invoked which will be time consuming or expensive to process.

5.15.6 Prompts.

5.15.6.1 Use. Prompts and help instructions shall be used to explain commands, error messages, system capabilities, display formats, procedures, and sequences and to provide data. Prompting should conform to the following:

a. When operating in special modes the system should display the mode designation and file(s) being processed.

b. Before processing any user requests which would result in extensive or final changes to existing data, the system should require user confirmation.

c. When missing data are detected, the system shall prompt the user.

d. When data entries or changes will be nullified by an abort action, the user should be requested to confirm the abort.

e. Neither humor nor admonishment should be used in structuring messages; the dialog should be strictly factual and informative for the user.

f. Error messages should appear as close as possible to the user entry that caused the message.

g. If a user repeats an entry error, the second error message should be revised to include a noticeable change so that the user may be certain that the computer has processed the attempted correction.

5.15.6.2 Standard display. Prompting messages shall be displayed in a standardized area of the displays.

5.15.6.3 Explicit prompts. Prompts and help instructions for systemcontrolled dialogue shall be explicit and the user shall not be required to memorize lengthy sequences or refer to secondary written procedural references.

5.15.6.4 Prompt clarity. Prompts shall be clear and understandable. They shall not require reference to coding schemes or conventions which may be unfamiliar to occasional users.

5.15.6.5 Definitions. A dictionary of abbreviations and codes shall be available on-line. Definitions of allowable options and ranges of values should be displayable at the user's request.

5.15.6.6 Consistent terminology. On-line documentation, off-line documentation, and help instructions shall use consistent terminology.

5.15.6.7 User confirmation. User acceptance of stored data or defaults shall be possible by a single confirming keystroke.

5.15.7 Default.

5.15.7.1 Workload reduction. Default values shall be used to reduce user workload. Currently defined default values should be displayed automatically in their appropriate data fields with the initiation of a data entry transaction and the user shall indicate acceptance of the default.

5.15.7.2 User selection. The user should have the option of generating default values based on operational experience if the systems designer cannot predefine appropriate values.

5.15.7.3 Default substitution. The user shall be able to replace any default value during a given transaction without changing the default definition.

5.15.7.4 Defaults for sequential entries. Where a series of default values have been defined for a data entry sequence, the user shall be allowed to default all entries or to default until the next required entry. The experienced user may not wish to accept each default value for each data field individually.

5.15.8 Error management/data protection.

5.15.8.1 Error correction. Where users are required to make entries into a system, an easy means shall be provided for correcting erroneous entries. The system shall permit correction of individual errors without requiring re-entry of correctly entered commands or data elements.

5.15.8.2 Early detection. A capability should be provided to facilitate detection and correction of errors after keying in, but before entering into the system. While it is desirable that errors be detected early, error checking should occur at logical data entry breaks, e.g., at the end of data fields rather than character-by-character, in order to avoid disrupting the user.

5.15.8.3 Internal software checks. User errors shall be minimized by use of internal software checks of user entries for validity of item, sequence of entry, completeness of entry, and range of value.

5.15.8.4 Critical entries. The system shall require the user to acknowledge critical entries prior to their being implemented by the system. An explicitly labeled CONFIRM function key, different from the ENTER key, should be provided for user confirmation of control and data entries that have been questioned by the computer.

5.15.8.5 Error message content. Error messages shall be constructive and neutral in tone, avoiding phrases that suggest a judgment of the user's behavior. The error messages shall reflect the user's view, not that of the programmer. Error messages should be appropriate to the user's level of training, be as specific as possible to the user's particular application, and describe a way to remedy, recover, or escape from the error situation.

5.15.8.6 Error recovery and process change. The user shall be able to stop the control process at any point in a sequence as a result of indicated error or as an option. The user shall be able to return easily to previous levels in multi-step processes in order to nullify an error or to effect a desired change.

5.15.8.7 Diagnostic information. Error messages shall explicitly provide as much diagnostic information and remedial direction as can be inferred reliably from the error condition. Where clear inference is not possible, probable helpful inference(s) may be offered.

5.15.8.8 Correction entry and confirmation. When the user enters correction of an error, such corrections shall be implemented by an explicit action by the user (e.g., actuation of an ENTER key.) All error corrections by the user shall be acknowledged by the systems either by indicating a correct entry has been made or by another error message.

5.15.8.9 Spelling errors. Spelling and other common errors shall not produce valid system commands or initiate transactions different from those intended. When possible, the system shall recognize common misspellings of commands and execute the commands as if spelling had been correct. Computer-corrected commands, values, and spellings shall be displayed and highlighted for user confirmation.

5.15.8.10 Errors in stacked commands. To prompt for corrections of an error in stacked commands, the system shall display the stacked sequence with the error highlighted. Where possible, a procedure shall be provided to correct the error and salvage the stack.

5.15.8.11 Display of erroneous entries. A computer-detected error, as well as the error message, shall be continuously displayed until the error is corrected.

5.15.8.12 Help. In addition to explicit error management aids, (labels, prompts, advisory messages) and implicit aids (cueing), users should be able to obtain further on-line guidance by requesting HELP. Following the output of a simple error message, users should be permitted to request a more detailed discussion at levels of increasing detail.

5.15.8.12.1 Standard action to request HELP. A simple, standard action that is always available should be provided to request HELP.

5.15.8.12.2 Multilevel HELP. When an initial HELP display provides only summary information, more detailed explanations should be provided in response to repeated user requests for HELP.

5.15.8.12.3 Browsing Help. Users should be permitted to browse through on-line HELP displays, just as they would through a printed manual, to gain familiarity with system functions and operating procedures.

5.15.8.13 Data security. Data shall be protected from unauthorized use, potential loss from equipment failure, and user errors.

5.15.8.13.1 Automated security measures. Automated measures shall be provided to minimize data loss from intruders in a system or from errors by legitimate users.

5.15.8.13.2 Warning of threats to security. Computer logic shall be provided that will generate messages and/or alarm signals in order to warn users of attempted intrusion by unauthorized users.

5.15.8.13.3 Segregating real from simulated data. When simulated data and system functions are provided (perhaps for user training), real data shall be protected and real system use shall be clearly distinguished from all simulated operations.

5.15.8.13.4 Display of simulated data. In applications where either real or simulated data can be displayed, a clear indication of simulated data shall be included as part of the classification label.

5.15.8.13.5 Displayed security classification. When displayed data are classified for security purposes, a prominent indication of security classification level shall be labeled in each display.

5.15.8.13.6 User identification. User identification procedures shall be as simple as possible, consistent with adequate data protection. For protection of the password, the password shall not be echoed on the display. See 5.15.1.2. Audio feedback, rather than visual, shall be provided when inputing secure passwords during log-on.

5.15.8.13.7 Choice of passwords. When passwords are required, users shall be allowed to choose their own passwords since a password chosen by a user will generally be easier for that individual to remember. Guidelines for password selection shall be given so that users will not choose easily guessable ones.

5.15.8.13.8 Changing passwords. Users should be allowed to change passwords whenever they choose; all passwords should be changed at periodic intervals.

5.15.9 System response time. Maximum system response times for real-time systems (e.g., fire control systems, command and control systems) shall not exceed the values of Table XXIX. Non-real-time systems may permit relaxed response times. If computer response time will exceed 15 seconds, the user should be given a message indicating that the system is responding.

5.15.10 Other requirements.

Table XXIX. System Response Times

System Interpretation	Response Time Definition	Maximum Acceptable Response Time (Secs)
Key Response	Key depression until positive response; for example, "click"	0.1
Key Print	Key depression until appearance of character	0.2
Page Turn	End of request until first few lines are visible	1.0
Page Scan	End of request until text begins to scroll	0.5
XY Entry	From selection of field until visual verification	0.2
Function	From selection of command until response	2.0
Pointing	From input of point to display point	0.2
Sketching	From input of point to display of line	0.2
Local Update	Change to image using local data base; for example, new menu list from display buffer	0.5
Host Update	Change where data is at host in readily accessible form; for example, a scale change of existing image	2.0
File Update	Image update requires an access to a host file	10.0
Inquiry (Simple)	From command until display of a commonly used message	2.0
Inquiry (Complex)	Response message requires seldom used calculations in graphic form	10.0
Error Feedback	From entry of input until error message appears	2.0

5.15.10.1 Overlays. Mechanical overlays, such as coverings over the keyboard or transparent sheets placed on the display, shall be avoided.

5.15.10.2 Hard copy. The user shall have the capability to obtain a paper copy of the exact contents of the alphanumeric or digital graphic display in those systems where:

a) Mass storage is restricted.

b) Mass stored data can be lost by power interruption, or

c) Record keeping is required.

5.15.10.2.1 Display print. The user shall be able to print a display by simple request, (e.g., PRINT-SCREEN) without having to take a series of other actions first, such as calling for the display to be filed, specifying a filename, then calling for a print of that named file.

5.15.10.2.2 Print page. The user shall have the capability to request printing of a single page, or sequence of pages, by specifying the page numbers.

5.15.11 Data and message transmission. See 5.15.8.13.1 and 5.15.8.13.2.

5.15.11.1 Functional integration. Data transmission functions shall be integrated with other information handling functions within a system. A user should be able to transmit data using the same computer system and procedures used for general entry, display and other processing of data.

5.15.11.2 Consistent procedures. Procedures for preparing, sending and receiving data and messages shall be consistent from one transaction to another, and consistent with procedures for other information handling tasks.

5.15.11.3 Minimal memory load on users. The data transmission procedures should minimize memory load on the users by providing computer aids for automatic insertion of standard information, such as headers and distribution lists.

5.15.11.4 Interrupt. Users should be allowed to interrupt message preparation, review, or disposition and then resume any of those tasks from the point of interruption.

5.15.11.5 Stored message forms. Where message formats conform to a defined standard or are predictable in other ways, prestored forms shall be provided to aid users in message preparation.

5.15.11.6 Incorporate existing files. Users should be allowed to incorporate an existing data file in a message, or to combine several files into a single message for transmission and to combine stored data with new data when preparing messages for transmission. It should not be necessary to re-enter any data already entered for other purposes.

5.15.11.7 Addresses.

5.15.11.7.1 Prompting address entry. When users must specify the address for messages, prompting should be provided to guide the user in the process.

5.15.11.7.2 Address directory. Users should be provided with an on-line directory showing all acceptable forms of message addressing for each destination in the system, and for links to external systems.

5.15.11.7.3 Aids for directory search. Computer aids should be provided so that a user can search an address directory by specifying a complete or partial name. It should also be possible to extract selected addresses from a directory for direct insertion into a header in order to specify the destination(s) for a message.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. This standard is intended for use as design criteria for military systems, equipment, and facilities, cited contractually in system specifications and elsewhere, and for use as a basis for structuring that part of human factors testing where design characteristics are assessed for purposes of acceptance. It is not intended for use to express binding requirements in conceptual and other early acquisition phases. The standard may be applied to traditional, as well as non-developmental item (NDI) acquisitions.

6.2 Issue of DODISS. When this standard is used in acquisition, the applicable issue of the DODISS must be cited in the solicitation (see 2.1.1 and 2.2).

6.3 Subject term (key word) listing.

Aerospace Vehicles
Anthropometry
Controls
Control/display integration
Design
Displays
Environment
Ergonomics
Hazards
Human engineering
Human factors
Labeling
Maintainer
Safety
Remote handling
User-computer interface
Vehicles
Workspace

6.4 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

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APPENDIX

GUIDANCE DOCUMENTS

10 SCOPE

The documents listed in this appendix provide supplementary information, criteria, and guidance that may be used, as applicable, to assist the designer in complying with the requirements of this standard. Their application is not to be regarded as mandatory, unless so specified by the procuring activity.

20 TRI-SERVICE PUBLICATIONS

DOD-HDBK-763	Human Engineering Procedures Guide
MIL-H-46855	Human Engineering Requirements for Military Systems, Equipment and Facilities
MIL-HDBK-141	Optical Design
TB MED 81 NAVMED P-5052-29 AFP 161-11	Cold Injury
TB MED 507 NAVMED P-5052-5 AFP 161-1	Prevention, Treatment and Control of Heat Injury
CSC-STD-002-85	Department of Defense Password Management Guide (Fort George G. Meade, MD: Department of Defense Security Center.)

30 ARMY PUBLICATIONS

30.1 Regulations

AR 40-10	Health Hazard Assessment Program in Support of the Army Materiel Acquisition Decision Process
AR 40-14	Control and Recording Procedures, Occupational Exposure to Ionizing Radiation
AR 385-16	Safety for Systems, Associated Subsystems and Equipment
AR 700-52	Licensing and Control of Sources of Ionizing Radiation

30.2 Pamphlets & Bulletins

AMCP 706-134	Maintainability Guide for Design (AD 823 539)
TB MED 62	Diagnostic X-Ray, Therapeutic X-Ray, and Gamma Beam Protection for Energies up to 10 Million Electron Volts
TB MED 501	Hearing Conservation
TB MED 270	Control of Hazards to Health from Microwave Radiation
TB MED 279	Control of Hazards to Health from Laser Radiation
TB MED 288	Medical Problems of Man at High Terrestrial Elevations

30.3 Design Criteria Handbook

MIL-HDBK-759	Human Factors Engineering Design for Army Materiel
DOD-HDBK-761	Human Engineering Guide for Management Information Systems

30.4 Reports

Aviation Sys Command AVSCOM Rept 75-47	Study to Determine the Impact of Aircrew Anthropometry on Airframe Configuration
Natick Laboratories TR EPT-2	Reference Anthropometry of the Arctic Equipped Soldier (AD 449 4831)
Natick Laboratories TR 73-51-CE	The Carrying of Loads within an Infantry Company (AD 762 559)
USAAMRDL TR 71-22	Crash Survival Design Guide (Revised 1971)
USAHEL TM 4-77	A Human Factors Evaluation of a Vertical Scale Instrument Display System for the OV-1D Aircraft (AD A03 6050)

40 NAVY PUBLICATIONS

40.1 Manual

NAVAIR 00-807-99	U.S. Naval Aerospace Physiologist's Manual, 1972

40.2 Reports

NATC Rept TM 77-1 SY	Analysis of Flight Clothing Effects on Aircrew Station Geometry (AD A046260)
NAMRL Report 1164	Empirical Reduction in Potential User Population as the Result of Imposed Multivariate Anthropometric Limits (AD 752 032)
NAVMISCEN Report TP-74-6	Reduction in Potential User Population as the Result of Imposed Anthropometric Limits: Monte Carlo Estimation (AD 919 319L)
NAVSHIPS 94323	Human Engineering Guidelines for Maintainability
NEL Report 688	Listening to Differentially Filtered Competing Voice Messages
NRL Report 155	Premodulation Speech Clipping and Filtering: Their Effects on the Intelligibility of Speech
PACMISTESTCEN Report TM-75-46	The Accommodated Proportion of a Potential User Population: Compilation and Comparisons of Methods for Estimation
PACMISTESTCEN Report TP-75-49	Computerized Accommodated Percentage (CAPE) Model for Cockpit Analysis and other Exclusion Studies (AD B008 948L)
PACMISTESTCEN Report TP-76-1	Improved Seat, Console and Workplace Design (AD A040 479)
PACMISTESTCEN Report TP-76-36	Recommended Human Exposure Limits for Very-Low-Frequency Vibration
PACMISTESTCEN Report TP-76-46	Computerized Accommodated Percentage Evaluation: Review and Prospectus (AD A035 205)

40.2 Notes

NAVMEDNOTE 6260	Hazardous Noise Areas, Equipment, Machine and Tools; Identification of

50 AIR FORCE PUBLICATIONS

50.1 Manuals

AFM 127-201	Missile Safety Handbook
AFP 160-6-7	Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radio-Nuclides in Air and Water for Occupational Exposure

50.2 Reports

AFSWC TR 59-11	Human Factors Handbook for Design of Transporting, Positioning, and Lifting Ground Support Equipment (AD 227 311)
AFSWC TR 59-12	Human Factors Handbook for Design of Testing and Monitoring Ground Support Equipment (AD 227 312)
AFSWC TR 59-13	Human Factors Handbook for Design of Protective and Storage Ground Support Equipment (AD 227 313)
AMRL TDR 64-59	Reach Capability of the USAF Population (AD 608 269)
AMRL TR 65-73	Anthropometry of Common Working Positions (AD 632 241)
AMRL TR 66-27	Aperture Sizes and Depths of Reach for One and Two-Handed Tasks (AD 646 716)
AMRL TR 68-24	Clearance and Performance Values for the Bare-Handed and the Pressure-Gloved (AD 681 457)
AMRL TR 69-6	Anthropometric Dimensions of Air Force Pressure-Suited Personnel for Workspace and Design Criteria (AD 697 022)
AMRL TR 70-114	Horizontal Static Forces Exerted by Men Standing in Common Working Positions on Surfaces of Various Tractions (AD 720 252)
ASD TR 61-381	Guide to the Design of Mechanical Equipment for Maintainability (AD 271 477)
ASD TR 61-424	Guide to Integrated System Design for Maintainability (AD 271 477)
ESD TR 62-4	A Test of the 20 Band and Octave Band Methods of Computing the Articulation Index (AD 271 606)
ESD TR 63-403	Psychoacoustic Speech Test: A Modified Rhyme Test
ESD TR 86-278	Guidelines for Designing User Interface Software (AD-A 177 198)
FDL TDR 64-86	Investigation of Aerospace Vehicle Crew Station Criteria (AD 452 187)
RADC TDR-63-315	Criteria for Group Display Chains for The 1962-1965 Time Period (AD 283 390)

WADC TR 52-204	Handbook of Acoustic Noise Control (AD 18 260)
WADC TR 54-520	The Anthropometry of Work Positions (AD 110 573)
WADC TR 55-159	Space Requirements of the Seated Operator (AD 87 892)
WADC TR 56-218	Guide to the Design of Electronic Equipment for Maintainability (AD 101 729)
WADC TN 57-248	Acoustical Criteria for Work Spaces, Living Quarters, and Other Areas on Air Bases (AD 130 839)
WADD TR 58-474	The Effect of Team Size and Intermember Communication on decision-Making Performance (AD 215 621)
WADD TR 60-814	Audio Warning Signals for Air Force Weapon Systems (AD 258 477)

50.3 Air Force Systems Command Design Handbooks

Copies of Air Force Systems Command design criteria handbooks may be obtained by nongovernmental organizations when compliance therewith is required by a Government contract, or when possession of the handbook will otherwise benefit the Government. Requests for the following handbooks should be directed to 4950/TZHM, Wright-Patterson AFB, OH 45433:

AFSC DH 1-1	General Index and Reference
AFSC DH 1-3	Human Factors Engineering
AFSC DH 1-6	System Safety
AFSC DH 2-1	Airframe
AFSC DH 2-2	Crew Stations and Passenger Accommodations
AFSC DH 2-3	Propulsion and Power
AFSC DH 2-6	Ground Equipment and Facilities

60 NATIONAL AERONAUTICS AND SPACE ADMINISTRATION PUBLICATIONS

60.1 Standards

(Copies of the following documents can be obtained by qualified requesters from MSIS Custodian/SP34, NASA-Johnson Space Center, Houston, TX 77058)

NASA-STD-3000, Volume I Man-Systems Integration Standards

NASA-STD-3000, Volume II Man-Systems Integration Standards-Appendices

60.2 Book

Copies of the following documents can be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402

Bioastronautics Data Book, Second Edition, J.F. Parker and V. R. West, eds., NASA SP-3006.

70 VOLUNTARY STANDARDS AND GUIDES

70.1 American National Standards Institute (ANSI)

Copies of the following standards can be obtained at a nominal cost from the ANSI, 1440 Broadway, New York, New York 10018.

A9.1	Building Exits Code (NFPA 101)
A11.1	Practice for Industrial Lighting
A12	Safety Code for Floor and Wall Openings, Railings and Toe Boards
A14.3	Safety Code for Fixed Ladders
C1	National Electrical Code (NFPA 70)
C2	National Electrical Safety Code (NBS H30)
S1.11-1966	Octave, Half-Octave and Third-Octave Band Filter Sets
Z35.1	Specifications for Industrial Accident Prevention Signs
Z136.1	The Safe Use of Lasers

70.2 American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), Copies of the following documents can be obtained at a nominal cost from the ASHRAE, 1791 Tullie Avenue, NE, Atlanta, GA 30329.

Standard 55-81	Thermal Environmental Conditions for Human Occupancy
Standard 62-81	Ventilation for Acceptable Indoor Air Quality Guide and Data Book (latest edition)

70.3 National Fire Protection Association (NFPA). Copies of the following document may be obtained from the NFPA, 60 Batterymarch Street, Boston, MA 02110

NFPA 101 (1985)	Code for Safety to Life from Fire in Buildings and Structures

80 BOOKS

The documents listed below are normally available in general and technical libraries:

a. A Collation of Anthropometry, J. W. Garett and K. W. Kennedy. Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio. 1971. (2 Volumes) (AD 723 629; Library of Congress Catalog Card No. 74-607818)

b. Directions in Human/Computer Interaction. A. Badre and B. Schneiderman, Eds, Ablex Publishing, Norwood, NJ, 1982

c. Fundamentals of Interactive Computer Graphics, J. D. Foley and A. Van Dam, Addison-Wesley, Reading, MA, 1982

d. General Safety Requirements - U.S. Army Engineer Manual 385-1-1.

e. Guide to Human Engineering Design for Visual Displays, D. Meister and D. J. Sullivan, The Bunker-Ramo Corp., Contract No. N0001468-C-027E, Work Unit No. NR196-080 (AD 693 237), Office of Naval Research, 30 August 1969.

f. Human Engineering Guide to Equipment Design - H. P. Van Cott, and R. G. Kinkade, eds, Wiley 605 Third Ave., New York, NY 10158, 1972 (Library of Congress Catalog Card No. 72600054).

g. Industrial Ventilation, Manual of Recommended Practice - Latest Edition, American Conference of Governmental Industrial Hygienists, Committee on Industrial Ventilation, P.O. Box 453, Lansing, Michigan.

h. Lighting Handbook, Illuminating Engineering Society (IES), latest edition.

i. Software Psychology: Human Factors in Computer and Information Systems. B. Schneiderman, Winthrop Publishers, Cambridge, MA, 1980.

j. Symbol Source Book, H. Dreyfuss, 1972, McGraw-Hill Book Company Library of Congress Card No. 71-172261.

k. The Human Body in Equipment Design, A. Damon, H. W. Stoudt, and R. A. McFarland, Harvard University Press, Cambridge, Mass, 1966. (Library of Congress Catalog Card No. 65-22067).

1. Engineering Anthropometry Methods. J. A. Roebuck, K. H. E. Kroemer and W. G. Thomson, John Wiley and Sons, New York, NY 1975 (Library of Congress) Catalog No. 74-34272.)

Copies of specification, standards, and other publications required by contractors in connection with specific procurement functions should be obtained from the procuring agency or as directed by the contracting officer.

Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal Agencies.

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Preparing Activity:
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(Project HFAC-0038)

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Review Activities:
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Navy - EC, MC, MS, OS, PE, SH, TD
Air Force - 13, 14, 19, 26

User Activities:
Army - AL, YD

Civilian Agencies
NASA - MSFC
DOT - RDS

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(See Instructions – Reverse Side)

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b. Recommended Wording:

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METRIC

NOTICE OF CHANGE

MIL-STD-1472D
NOTICE 1
20 March 1991

MILITARY STANDARD

HUMAN ENGINEERING DESIGN CRITERIA FOR MILITARY
SYSTEMS, EQUIPMENT, AND FACILITIES

TO ALL HOLDERS OF MIL-STD-1472D:

1. THE FOLLOWING PAGES OF MIL-STD-1472D HAVE BEEN REVISED AND SUPERSEDE THE PAGES LISTED:

NEW PAGE	DATE	SUPERSEDED PAGE	DATE
Cover	14 March 1989	Cover	14 March 1989
ii	14 March 1989	ii	REPRINTED WITHOUT CHANGE
7	20 March 1991	7	14 March 1989
8	14 March 1989	8	REPRINTED WITHOUT CHANGE
16 A	20 March 1991	NEW PAGE	
16 B	20 March 1991	NEW PAGE	
43	14 March 1989		REPRINTED WITHOUT CHANGE
44	20 March 1991	44	14 March 1989
91	14 March 1989		REPRINTED WITHOUT CHANGE
92	20 March 1991	92	14 March 1989
145	20 March 1991	120	14 March 1989
146	14 March 1989		REPRINTED WITHOUT CHANGE
169	20 March 1991	169	14 March 1989
170	14 March 1989		REPRINTED WITHOUT CHANGE
249	20 March 1991	249	14 March 1989
250	14 March 1989		REPRINTED WITHOUT CHANGE
278 A	20 March 1991	NEW PAGE	
278 B	20 March 1991	NEW PAGE	
281	20 March 1991	281	14 March 1989
282	20 March 1991	282	14 March 1989
285	14 March 89	285	REPRINTED WITHOUT CHANGE
286	20 March 1991	286	14 March 1989

2. MAKE THE FOLLOWING PEN AND INK CHANGES

a. Page 13, para 3.45, second line: Change "4" to "6."

b. Page 23, para 5.1.2.3.8, third line: After "sight," add "(see Fig 1)."

c. Page 25. Add: "5.1.4.9 Visual Display Terminals (VDTs). See 5.16."

d. Page 34, para 5.2.2.1.12, second and fifth lines: Change "3.17" to "3.39."

e. Page 41, para 5.2.3.1.8, first line: Change "3.17" to "3.39."

f. Page 48, para 5.2.6.4.3, first line: Change "3.17" to "3.39."

AMSC N/A AREA HFAC

Distribution Statement A. Approved for public release; distribution is unlimited.

g. Page 49, para 5.2.6.5.4, first line: Change "3.17" to "3.39."

h. Page 51, para 5.2.6.6.4.3.1, second line: Change "3.18" to "3.40."

i. Page 75, para 5.4.2.1.1.5, second line: Change "3.17" to "3.39."

j. Page 75: para 5.4.2.1.1.6, third line: Change "opertor's" to "operator's."

k. Page 123, para 5.5.5.8, title: Change to "Stroke width, normal."

l. Page 240, para 5.14.2.1, fifth line: Delete "MIL-L-87240."

m Page 287, para 70.3, sixth line: Delete "(1985)."

n. Page 388, Review Activities, first line: Delete "MR."

o. Page 388, Review Activities, second line: Delete "MS."

p. Page 388, Review Activities, third line: Delete "26."

q. Page 388, Civilian Agencies, Change "RDS" to "FAA."

3. RETAIN THIS NOTICE AND INSERT BEFORE TABLE OF CONTENTS.

4. Holders of MIL-STD-1472D will verify that page changes and additions indicated above have been entered. The notice pages will be retained as a check sheet. This issuance, together with appended pages, is a separate publication. Each notice is to be retained by stocking points until the Military Standard is completely revised or cancelled.

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Army - MI

(Project HFAC-0050)

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Navy - EC, MD, OS, PE, SH, TD
Air Force - 13, 14, 19

User activities:
Army - AL
Navy - YD

Civilian agencies:
NASA - MSFC
DOT - FAA

MIL-STD-1472D
NOTICE 1

METRIC

MIL-STD-1472D
14 MARCH 1989
SUPERSEDING
MIL-STD-1472C
2 May 1981

MILITARY STANDARD

HUMAN ENGINEERING DESIGN CRITERIA FOR MILITARY

SYSTEMS, EQUIPMENT, AND FACILITIES

AMSC N/A AREA HFAC

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Supersedes cover of 14 March 1989

FOREWORD

1. This Military Standard has been approved for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, US Army Missile Command, ATTN: AMSMI-RD-SE-TD-ST, Redstone Arsenal, AL 35898-5270, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

3. This standard establishes general human engineering criteria for design and development of Military systems, equipment and facilities. Its purpose is to present human engineering design criteria, principles and practices to be applied in the design of systems, equipment and facilities so as to:

a. Achieve required performance by operator, control and maintenance personnel.

b. Minimize skill and personnel requirements and training time.

c. Achieve required reliability of personnel-equipment combinations.

d. Foster design standardization within and among systems.

4. This standard does not alter requirements for system development participation of human engineering specialists to interpret and implement these practices and to provide solutions to human engineering problems which arise and which are not specifically covered herein.

5. The use of the words "shall," "should," "may," and "will" in this standard is in accordance with MIL-STD-962, wherein "shall" expresses a provision that is binding, "should" and "may" express nonmandatory provisions, and "will" expresses a declaration of purpose or simple futurity.

6. Requirements herein are expressed in the International System of units (SI). As a convenience, the metric units are accompanied by their approximate customary system equivalents (in parentheses). Angular measure is expressed in radians or milliradians, except for 45°, 90°, 180°, 360°, etc., which are shown as multiples or divisions of π radians.

ANSI S3.5	Articulation Index, Methods for the Calculation of

(Application for copies should be addressed to the American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM E 380	Metric Practice, Standard for

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

HUMAN FACTORS SOCIETY (HFS)

ANSI/HFS 100	American National Standard for Human Factors Engineering of Visual Display Terminal Workstations

(Applications for copies should be addressed to the Human Factors Society, Inc., P.O. Box 1369, Santa Monica, CA 90406

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO DIS 2631	Guide to the Evaluation of Human Exposure to Whole Body Vibration

(Application for copies should be addressed to the American National Standards Institute, Inc.,1430 Broadway, New York, NY 10018.)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

SAE J925	Minimum Access Dimensions for Construction and Industrial Machinery

(Application for copies should be addressed to the Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096-0001.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

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In the absence of a radiant heat source (e.g., solar, engine, furnace), a modified Wet-Dry (WD_{85}) index should be used where:

$$WD_{85} = 0.85T_{WB_{np}} + 0.15T_A$$

NOTE: Unless otherwise indicated, terms of equipment divisions are defined in accordance with MIL-STD-280.

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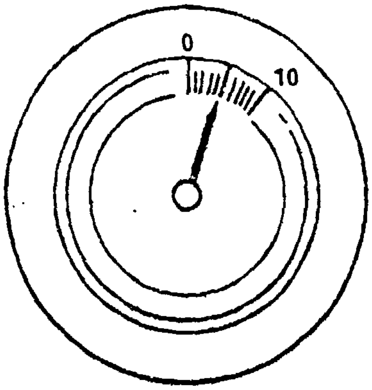
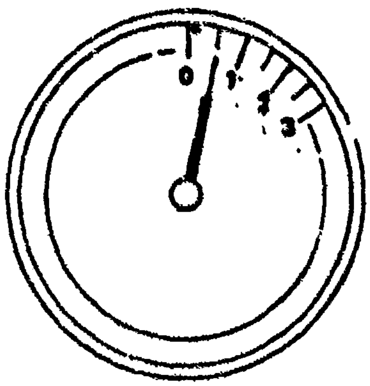
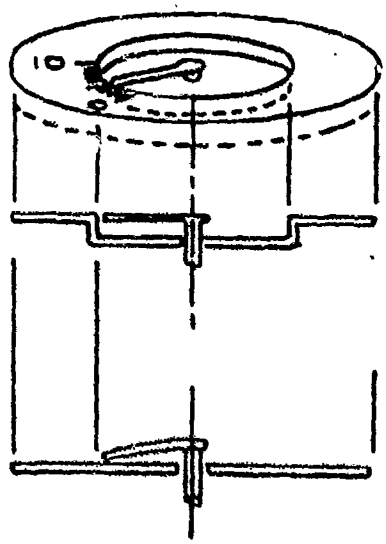


FOR MAXIMUM READING ACCURACY

(THE POINTER IS AN EQUAL DISTANCE – NOMINAL 0.8–1.6 mm (0.031–0.061 in.) – FROM ALL SCALE MARKS, NEVER OVERLAPPING ANY MARK OR NUMERAL.)



ALTERNATE FORMAT FOR GROSS READING OF NUMBERS



TO PREVENT OR MINIMIZE VISUAL PARALLAX

FIGURE 3. RELATIVE POSITION OF SCALE MARKS, NUMERALS, AND POINTERS ON CIRCULAR DIALS

in rows so that all pointers line up horizontally (for vertical scales) or in columns so that all pointers line up vertically (for horizontal scales).

5.2.3.3 Fixed-pointer, moving-scale indicators.

5.2.3.3.1 Numerical progression. On fixed-pointer, moving scale indicators, numbers shall progress in magnitude in clockwise direction around the faces of circular dials (counter-clockwise dial movement for numerical increase). On vertical or horizontal straight moving scales, numbers shall increase from bottom-to-top or from left-to-right.

5.2.3.3.2 Orientation. Numerals on moving scales shall be upright when in the reading position.

5.2.3.3.3 Alignment of pointer or fixed reference line. For circular scales, alignment of the pointer or fixed reference line shall be in the 12 o'clock position for right-left directional information and in the 9 o'clock position for up-down information. For purely quantitative information, either position may be used.

5.2.3.3.4 Setting. If the display will be used for setting in a value (e.g., tuning in a desired wavelength), the unused portion of the dial face shall be covered, and the open window shall be large enough to permit at least one numbered graduation to appear at each side of any setting.

5.2.3.3.5 Tracking. If the display will be used for tracking, as in the case of a directional indicator, the whole face of the dial shall be exposed.

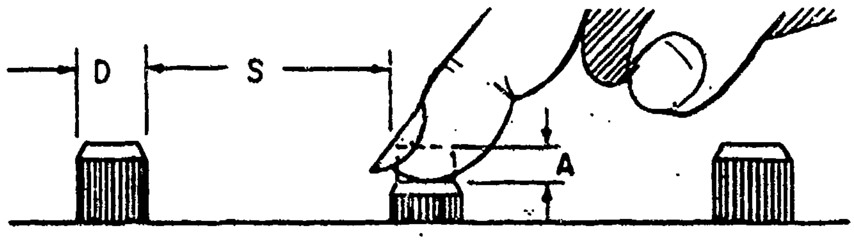
5.2.3.3.6 Moving tape displays. When the scale length required for acceptable readout accuracy exceeds the limits of the display package capacity (i.e., compaction of scale marking would make the display illegible or subject to readout error), moving tape scale format may be used.

5.2.3.3.7 Composite scalar/pictorial displays. Combinations of scales, pointers, and pictorial symbols may be used to combine functionally-related information into a single instrument or display (e.g., artificial horizon, command heading, true/relative bearing). Design of significant reference features (e.g., aircraft or ship symbols, horizon, altitude or pitch scales) shall conform to the general criteria herein for direction-of-motion, scale-pointer relationships, and legibility.

5.2.4 Cathode ray tube (CRT) displays. CRTs shall conform to the provisions below; however, where a CRT is part of a visual display terminal used for text processing, data entry, or data inquiry applications in an office environment or equivalent, see 5.16.

5.2.4.1 Signal size. When a target of complex shape is to be distinguished from a non-target shape that is also complex, the target signal should subtend not less than 6 mrad (20 minutes) of visual angle and should subtend not less than 10 lines or resolution elements. Image quality shall be consistent with the operator's needs.

Supersedes page 44 of 14 March 1989



	DIMENSIONS		RESISTANCE		
	DIAMETER D				
	Fingertip	Thumb or Palm	Single Finger	Different Fingers	Thumb or Palm
Minimum	9.5 mm (3/8 in.)	19 mm (3/4 in.)	2.8 N (10 oz.)	1.4 N (5 oz.)	2.8 N (10 oz.)
Maximum	25 mm (1 in.)		11 N (40 oz.)	5.6 N (20 oz.)	23 N (80 oz.)

	DISPLACEMENT A	
	Fingertip	Thumb or Palm
Minimum	2 mm (5/64 in.)	3 mm (1/8 in.)
Maximum	6 mm (1/4 in.)	38 mm (1-1/2 in.)

	SEPARATION S			
	Single Finger	Single Finger Sequential	Different Fingers	Thumb or Palm
Minimum	13 mm (1/2 in.)	6 mm (1/4 in.)	6 mm (1/4 in.)	25 mm (1 in.)
Preferred	50 mm (2 in.)	13 mm (1/2 in.)	13 mm (1/2 in.)	150 mm (6 in.)

Note: Above data for barehand application. For gloved hand operation, minima should be suitably adjusted.

FIGURE 11. PUSHBUTTONS (FINGER OR HAND OPERATED)

required, or when load sharing among limbs is desirable. Because foot-operated switches are susceptible to accidental actuation, their uses should be limited to non-critical or infrequent operations such as press-to-talk communication or vehicle headlight dimming.

5.4.3.1.2.2 Operation. Foot switches shall be positioned for operation by the toe and the ball of the foot rather than by the heel. They shall not be located so near an obstruction that the operator cannot center the ball of the foot on the switch button. A pedal may be used over the button to aid in locating and operating the switch. When the switch may become wet and slippery, the switch cap surface should possess a frictional surface to minimize the possibility of the foot slipping off the switch.

5.4.3.1.2.3 Dimensions, resistance, and displacement. Dimensions, resistance, and displacement of foot-operated switches shall conform to the criteria in Figure 12. Although not recommended (i.e., only one switch per foot is preferred), when one foot is required to operate more than one switch, such switches shall be at least 75 mm (3 in.) apart (horizontal); 200 mm (8 in.) apart (vertical).

5.4.3.1.2.4 Feedback. A positive indication of control actuation shall be provided (e.g., snap feel, audible click, associated visual or audio display change).

5.4.3.1.3 Keyboards. Keyboards shall conform to the provisions below; however, where a keyboard is part of a visual display terminal used for text processing, data entry, or data inquiry applications in an office environment or equivalent, see 5.16.

5.4.3.1.3.1 Use. Arrangements of push buttons in the form of keyboards should be used when alphabetic, numeric, or special function information is to be entered into a system.

5.4.3.1.3.2 Layout and configuration. The key configuration and the number of keys are dependent upon the predominant type of information to be entered into the system. The major forms that keyboards can take, which aid in the entry of such information, are given below:

a. Numeric keyboard. The configuration of a keyboard used to enter solely numeric information should be a 3 X 3 + 1 matrix with the zero digit centered on the bottom row.

b. Alpha-numeric keyboard. Keyboard configurations for entry of alphabetic and some numeric information shall conform to MIL-STD-1280. For some applications the entry of data varies from primarily alphabetic to primarily numeric. For these applications, two alternatives are preferred: Provide a keyboard of the type shown in Figure 2 of MIL-STD-1280 (where there is no separation between alphabetic and numeric characters) or provide a separation to emphasize the two separate functions, with the numeric keyboard located to the right of the standard keyboard.

5.4.3.1.3.3 Dimensions, resistance, displacement, and separation. The control dimensions, resistance, displacement, and separation between adjacent

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5.7 Workspace design.

5.7.1 General. Unless otherwise noted, the following criteria apply to ground installations and, as practical, to airborne and shipboard installations; however, where a visual display terminal is used for text processing, data entry, or data inquiry applications in an office environment or equivalent, see 5.16.

5.7.1.1 Kick space. All cabinets, consoles, and work surfaces that require an operator to stand or sit close to their front surfaces shall contain a kick space at the base at least 100 mm (4 inches) deep and 100 mm (4 inches) high to allow for protective or specialized apparel.

5.7.1.2 Handles. Handles on cabinets and consoles shall be recessed whenever practicable, to eliminate projections on the surface. If handles cannot be recessed, they shall be designed such that they shall neither injure personnel nor entangle clothing or equipment.

5.7.1.3 Work space. Whenever feasible, free floor space of at least 1.220 m (4 feet) shall be provided in front of each console. For equipment racks that require maintenance, free floor space shall be provided in accordance with the following criteria.

5.7.1.3.1 Depth of work area. Clearance from the front of the rack to the nearest facing surface or obstacle shall be not less than 1.070 m (42 inches). The minimum space between rows of cabinets shall be 200 mm (8 inches) greater than the depth of the deepest drawer (equipment).

5.7.1.3.2 Lateral work space. The minimum lateral workspace for racks having drawers or removable equipment shall be as follows (measured from the drawers or equipment in the extended position):

a. for racks having drawers or removable items weighing less than 20 kg (44 pounds): 460 mm (18 inches) on one side and 100 mm (4 inches) on the other,

b. for racks having drawers or removable items weighing over 20 kg (44 pounds): 460 mm (18 inches) on each side.

5.7.1.3.3 Space between rows of cabinets. The minimum space between rows of cabinets shall be 200 mm (8 inches) greater than the depth of the deepest drawer or cabinet.

5.7.1.3.4 Storage space. Adequate and suitable space shall be provided on consoles or immediate work space for the storage of manuals, worksheets, and other materials that area required for use by the operational or maintenance personnel.

5.7.2 Standing operations

5.7.2.1 Work surface. Unless otherwise specified, work surfaces to support documents such as job instruction manuals or worksheets shall be 915 ±15 mm (36 ±0.6 inches) above the floor.

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5.7.2.2 Display placement, normal. Visual displays mounted on vertical panels and used in normal equipment operation shall be placed between 1.040 m (41 inches) and 1.780 m (70 inches) above the standing surface.

5.7.2.3 Display placement, special. Displays requiring precise and frequent reading shall be placed between 1.270 m (50 inches) and 1.650 m (65 inches) above the standing surface.

5.7.2.4 Control placement, normal. All controls mounted on a vertical surface and used in normal equipment operation shall be located between 860 mm and 1.780 m (34 and 70 inches) above the standing surface.

5.7.2.5 Control placement, special. Controls requiring precise or frequent operation and emergency controls shall be mounted between 860 mm and 1.350 m (34 and 53 inches) above the standing surface and no farther than 530 mm (21 inches) laterally from the centerline.

5.7.3 Seated operations.

5.7.3.1 Work surface width and depth. A lateral workspace of at least 760 mm (30 inches) wide and 400 mm (16 inches) deep shall be provided whenever practicable.

5.7.3.2 Work surface height. Desk tops and writing tables shall be 740 to 790 mm (29 to 31 inches) above the floor, unless otherwise specified.

5.7.3.3 Writing surfaces. Where a writing surface is required on equipment consoles, it shall be at least 400 mm (16 inches) deep and should be 610 mm (24 inches) wide, when consistent with operator reach requirements.

5.7.3.4 Seating.

5.7.3.4.1 Compatibility. Work seating shall provide an adequate supporting framework for the body relative to the activities that must be carried out. Chairs to be used with sit-down consoles shall be designed to be operationally compatible with the console configuration.

5.7.3.4.2 Vertical adjustment. Provision shall be made for vertical seat adjustment from 380 to 535 mm (15 to 21 inches) in increments of no more than 25 mm (1 inch) each.

5.7.3.4.3 Backrest. A supporting backrest that reclines between 1745 and 2005 mrad (100 and 115 degrees) shall be provided. The backrest shall engage the lumbar and thoracic regions of the back, and shall support the torso in such a position that the operator's eyes can be brought to the "Eye Line" with no more than 75 mm (3 inches) of forward body movement.

5.7.3.4.4 Cushioning. Where applicable, both the backrest and seat shall be cushioned with at least 25 mm (1 inch) of compressible material and provided with a smooth surface.

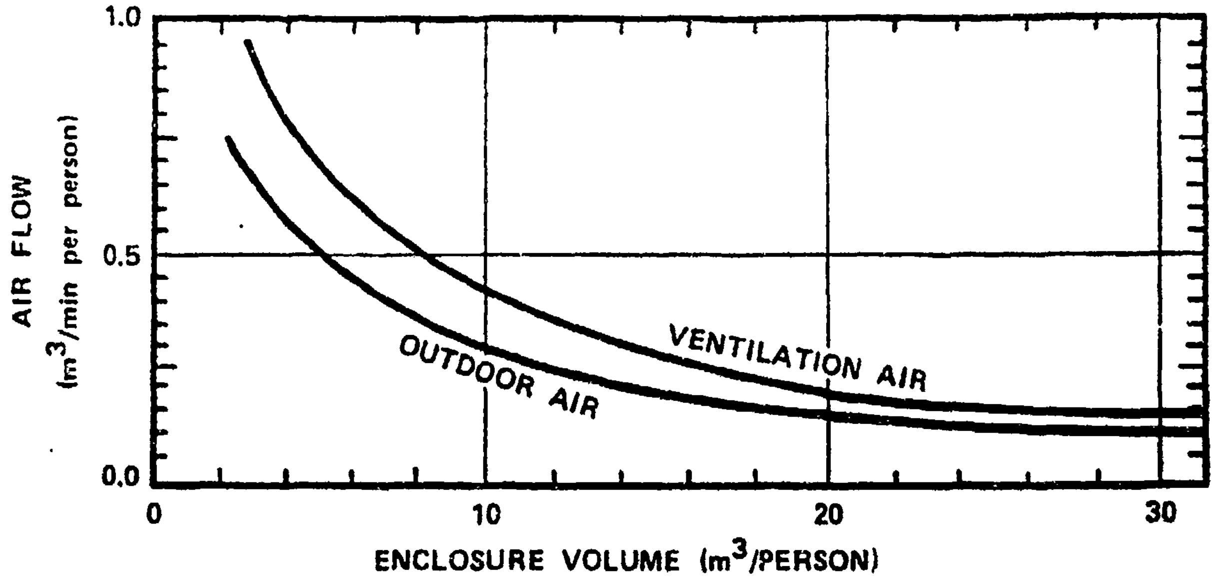

FIGURE 39. VENTILATION REQUIREMENTS

fuel handler suits, body armor, arctic clothing, and temperature regulated clothing are required and worn, a comfort micro-climate between 20°C (68°F), 14 mm Hg ambient water vapor pressure and 35°C (95°F), 3 mm Hg ambient water vapor pressure is desirable and, where possible, shall be maintained by heat transfer systems.

5.8.1.7 Thermal tolerance and comfort zones. Temperature and humidity exposure should not exceed the effective temperature limits given in Figure 40 when corrected for air velocity (Figure 39).

5.8.1.8 Limited thermal tolerance zones. Where hard physical work is to be required for more than two hours, an environment not exceeding WBGT or WD index of 25° C (77°F) shall be provided. Where the wearing of protective clothing systems (which reduce evaporation of sweat from the skin) is required, this index shall be decreased 5°C (10°F) for complete protective uniforms, 4°C (7°F) for intermediate clothing systems, and 3°C (5°F) for body armor.

5.8.2 Illuminance. Where equipment is to be used in enclosures and is not subject to blackout or special low-level lighting requirements, illumination levels shall be as specified by table XXI and shall be distributed so as to reduce glare and specular reflection. Capability for dimming shall be provided. Adequate illumination shall be provided for maintenance tasks. General and supplementary lighting shall be used as appropriate to ensure that illumination is compatible with each task situation. Portable lights should be provided for personnel performing visual tasks in areas where fixed illumination is not provided. For display lighting, see Table XXII. For illumination characteristics (illuminance, glare, balance, and specular reflectance) of VDTs, see 5.16.

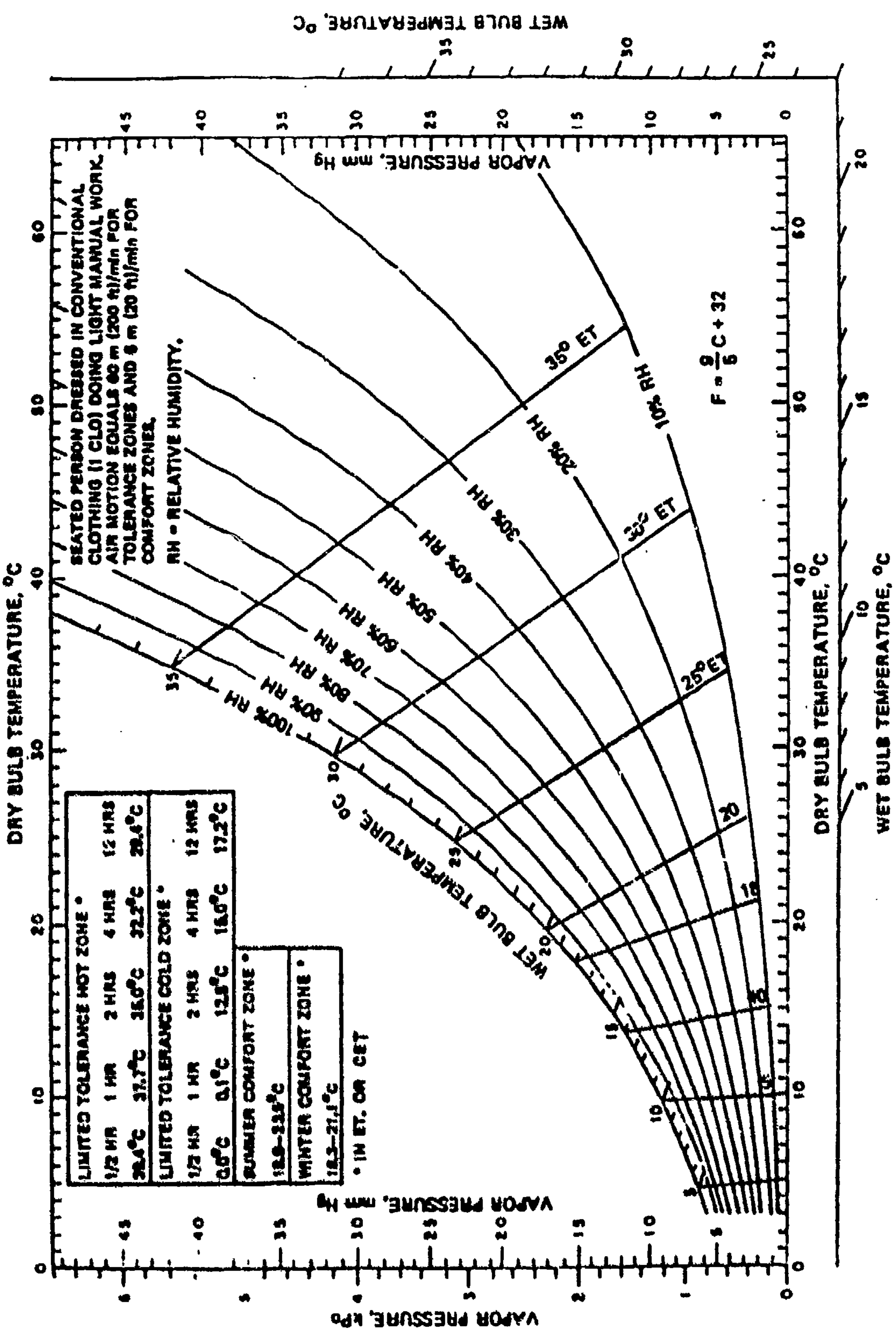

FIGURE 40. SUMMER AND WINTER COMFORT ZONES AND THERMAL TOLERANCE FOR INHABITED COMPARTMENTS

not move beyond the display boundaries and disappear from sight. If the cursor is moved by depressing a key, releasing the key shall cause the cursor to stop moving.

5.15.2.1.8.3 Home position. The home position for the cursor should be consistent across similar types of displays.

5.15.2.1.8.4 Explicit actuation. A separate, explicit action, distinct from cursor position, shall be required for the actual entry (e.g., enabling, actuation) of a designation position.

5.15.2.1.8.5 Consistent positioning. Where cursor positioning is incremental by discrete steps, the step size of cursor movement shall be consistent horizontally (i.e. in both right and left directions), and vertically (in both up and down directions).

5.15.2.1.8.6 Keyboard cursor control. When position designation is required in a task emphasizing keyed data entry, cursor control should be by some device integral to the keyboard. If cursor movement is accomplished by depressing keys, the keys shall be located on the main keyboard.

5.15.2.1.8.7 Movement relationships. The response of a cursor to control movements shall be consistent; predictable, and compatible with the user's expectation. For cursor control by key action a key labeled with a left-pointing arrow should move the cursor leftward on the display; for cursor control by joystick, leftward movement of the control should result in leftward movement of the cursor.

5.15.2.1.9 Abbreviations, mnemonics, and codes. When abbreviations, mnemonics, or codes are used to shorten data entry, they shall be distinctive and have a relationship or association to normal language or specific job-related terminology. Abbreviations should be the same length, the shortest possible that will ensure unique abbreviations.

5.15.2.1.10 Explicit delete action. Data deletion or cancellation shall require an explicit action, such as the depression of a DELETE key.

5.15.2.1.11 Change of data. Where a user requests change (or deletion) of a data item that is not currently being displayed, the option of displaying the old value before confirming the change should be presented.

5.15.2.1.12 Single method of data entry. Data entry methods and data displays should not require the user to shift between entry methods.

5.15.2.1.13 Data entry display. Where data entry on an electronic display is permitted only in prescribed areas, a clear visual definition of the entry fields shall be provided.

5.15.2.2 Keyboard. Keyboards shall conform to the provisions below; however, where a keyboard is part of a visual display terminal used for text processing, data entry, or data inquiry applications in an office environment or equivalent, see 5.16.

5.15.2.2.1 Use. A keyboard should be used to enter alphabetic, numeric and other special characters into the system.

5.15.2.2.2 Configuration. Keyboards shall conform to MIL-STD-1280, unless otherwise specified or approved by the procuring activity.

5.15.2.2.3 Timely display. Keyed inputs, except security items such as passwords, shall be shown on the display in accordance with the values in Table XXVIII.

5.15.2.2.4 Length. Except for extended text, the length of individual data items shall be minimized.

5.15.2.2.5 Justification. When entering tabular data, the user shall not be required to right- or left-justify tabular data entries. The system shall automatically justify columnar data with respect to decimal systems point, left margin or right item margin, depending on the type of data.

5.15.2.2.6 Numeric keypads. Keyboards used in systems requiring substantial numeric input shall be equipped with a numeric keypad.

5.15.2.2.7 Minimization of keying. The amount of keying required should be minimized.

5.15.2.2.8 Minimization of shift keying. The use of key shifting functions should be minimized during data entry transactions.

5.15.2.2.9 Data change. In keyed data entry, means shall be provided to allow users to change previous entries, if necessary, by DELETE and INSERT actions.

5.15.2.3 Fixed function (dedicated) keys.

5.15.2.3.1 Use. Fixed function keys (for example, ENTER) should be used for time-critical, error-critical, or frequently used control inputs.

5.15.2.3.2 Standardization. Fixed function keys should be common throughout the system.

5.15.2.3.3 Functional consistency. Once a key has been assigned a given function, it should not be reassigned to a different function for a given user.

5.15.2.3.4 Availability. Fixed function keys should be selected to control functions that are continuously available; i.e., lockout of fixed function keys shall be minimized. At any step in a transaction sequence, however, function keys which are not used for current inputs should be temporarily disabled under computer control. Mechanical overlays should not be used for this purpose.

5.15.2.3.5 Non-active keys. Non-active fixed function keys should be replaced by a blank key on the keyboard.

5.16 Visual Display Terminals (VDTs). Where a VDT is used only for text processing, data entry, and data inquiry applications in an office environment or equivalent, the VDT, associated furniture, and environments in which the VDT is placed shall conform to ANSI/HFS 100; however, where such criteria are not specified by ANSI/HFS 100, the VDT, associated furniture, and environments shall conform to applicable provisions herein.

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10 SCOPE

The documents listed in this appendix provide supplementary information, criteria, and guidance that may be used, as applicable, to assist the designer in complying with the requirements of this standard. Their application is not to be regarded as mandatory, unless so specified by the procuring activity.

20 TRI-SERVICE PUBLICATIONS

MIL-HDBK-761	Human Engineering Guidelines for Management Information Systems
DOD-HDBK-763	Human Engineering Procedures Guide
MIL-H-46855	Human Engineering Requirements for Military Systems, Equipment, and Facilities
MIL-HDBK-141	Optical Design
TB MED 81 NAVMED P-5052-29 AFR 161-11	Cold Injury
CSC-STD-002-85	Department of Defense Password Management Guide (Fort George G. Meade, MD: Department of Defense Security Center.)

30 ARMY PUBLICATIONS

30.1 Regulations

AR 40-10	Health Hazard Assessment Program in Support of the Army Materiel Acquisition Decision Process.
AR 40-14	Control and Recording Procedures, Occupational Exposure to Ionizing Radiation
AR 385-16	Safety for Systems, Associated Subsystems and Equipment
AR 700-52	Licensing and Control of Sources of Ionizing Radiation

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30.2 Pamphlets & Bulletins

AMCP 706-134	Maintainability Guide for Design (AD 823 539)
DA PAM 40-501	Hearing Conservation
TB MED 521	Diagnostic X-Ray, Therapeutic X-Ray, and Gamma Beam Protection for Energies up to 10 Million Electron Volts
TB MED 270	Control of Hazards to Health from Microwave Radiation
TB MED 279	Control of Hazards to Health from Laser Radiation
TB MED 288	Medical Problems of Man at High Terrestrial Elevations
TB MED 508	Cold Injury

30.3 Design Criteria Handbook

MIL-HDBK-759	Human Factors Engineering Design for Army Materiel

30.4 Reports

AVSCOM Report 75-47	Study to Determine the Impact of Aircrew Anthropometry on Airframe Configuration.
Natick Laboratories TR EPT-2	Reference Anthropometry of the Arctic Equipped Soldier (AD 449 4831)
Natick Laboratories TR 73-51-CE	The Carrying of Loads Within an Infantry Company (AD 762 559)
Natick RDEC TR 89/027	Anthropometric Survey of U.S. Army Personnel
USAAMRDL TR 71-22	Crash Survival Design Guide (Revised 1971)
USAHEL TM 4-77	A Human Factors Evaluation of a Vertical Scale Instrument Display System for the OV-1D Aircraft (AD A03 6050)

40 NAVY PUBLICATIONS

40.1 Manual

NAVAIR 00-807-99	U.S. Naval Aerospace Physiologist's Manual, 1972.

WADC TR 52-204	Handbook of Acoustic Noise Control (AD 18 260)
WADC TR 54-520	The Anthropometry of Work Positions (AD 110 573)
WADC TR 55-159	Space Requirements of the Seated Operator (AD 87 892)
WADC TR 56-218	Guide to the Design of Electronic Equipment for Maintainability (AD 101 729)
WADC TN 57-248	Acoustical Criteria for Work Spaces, Living Quarters, and Other Areas on Air Bases (AD 130 839)
WADD TR 58-474	The Effect of Team Size and Intermember Communication on decision-Making Performance (AD 215 621)
WADD TR 60-814	Audio Warning Signals for Air Force Weapon Systems (AD 258 477)

50.3 Air Force Systems Command Design Handbooks

Copies of Air Force Systems Command design criteria handbooks may be obtained by nongovernmental organizations when compliance therewith is required by a Government contract, or when possession of the handbook will otherwise benefit the Government. Requests for the following handbooks should be directed to 4950/TZHM, Wright-Patterson AFB, OH 45433:

AFSC DH 1-1	General Index and Reference
AFSC DH 1-3	Human Factors Engineering
AFSC DH 1-6	System Safety
AFSC DH 2-1	Airframe
AFSC DH 2-2	Crew Stations and Passenger Accommodations
AFSC DH 2-3	Propulsion and Power
AFSC DH 2-6	Ground Equipment and Facilities

60 NATIONAL AERONAUTICS AND SPACE ADMINISTRATION PUBLICATIONS

60.1 Standards

(Copies of the following documents can be obtained by qualified requesters from MSIS Custodian/SP34, NASA-Johnson Space Center, Houston, TX 77058)

NASA-STD-3000, Volume I	Man-Systems Integration Standards
NASA -STD-3000, Volume II	Man-Systems Integration Standards-Appendices

60.2 Book

Copies of the following document can be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402

NASA SP-3006	Bioastronautics Data Book, Second Edition, J.F. Parker and V. R. West, eds.

70 VOLUNTARY STANDARDS AND GUIDES

70.1 American National Standards Institute (ANSI)

Copies of the following standards can be obtained at a nominal cost from the ANSI, 1430 Broadway, New York, NY 10018

ANSI A12.1	Floor and Wall Openings, Railings, and Toeboards, Safety Requirements for
ANSI A14.3	Ladders-Fixed-Safety Requirements
ANSI C2	National Electrical Safety Code (NBS H30)
ANSI S1.11	Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters (ASA 65)
ANSI Z136.1	Safe Use of Lasers

70.2 American Society for Testing and Materials. Copies of the following document can be obtained at a nominal cost from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM F 1166-88	Standard Practice for Human Engineering Design Criteria for Marine Systems, Equipment, and Facilities

70.3 American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Copies of the following documents can be obtained at a nominal cost from the ASHRAE, 1791 Tullie Circle, NE, Atlanta, GA 30329

ASHRAE 55-81	Thermal Environmental Conditions for Human Occupancy
ASHRAE 61-81	Ventilation for Acceptable Indoor Air Quality Guide and Data Book (latest edition)

70.4 Illuminating Engineering Society (IES) of North America. Copies of the following document can be obtained at a nominal cost from the IES, 345 East 47th Street, New York, NY 10017

IES Lighting HDBK	SEC 9 Application-87, Industrial Lighting

METRIC

NOTICE OF CHANGE

MIL-STD-1472D
NOTICE 2
30 June 1992

MILITARY STANDARD

HUMAN ENGINEERING DESIGN CRITERIA FOR MILITARY SYSTEMS, EQUIPMENT AND FACILITIES

TO ALL HOLDERS OF MIL-STD-1472D:

1. THE FOLLOWING PAGES OF MIL-STD-1472D HAVE BEEN REVISED OR CREATED AND SUPERSEDE THE PAGES LISTED:

NEW PAGE	DATE	SUPERSEDED PAGE	DATE
v	14 March 1989	v	REPRINTED WITHOUT CHANGE
vi	30 June 1992	vi	14 March 1989
87	14 March 1989	87	REPRINTED WITHOUT CHANGE
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119	30 June 1992	119	14 March 1989
120	30 June 1992	120	14 March 1989
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131a	30 June 1992	NEW PAGE	N/A
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138	14 March 1989	138	REPRINTED WITHOUT CHANGE
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237	30 June 1992	237	14 March 1989
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281	30 June 1992	281	20 March 1991
282	30 June 1992	282	20 March 1991
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NEW PAGE	DATE	SUPERSEDED PAGE	DATE
284	30 June 1992	284	14 March 1989
285	30 June 1992	285	14 March 1989
286	20 March 1991	286	REPRINTED WITHOUT CHANGE

2. MAKE THE FOLLOWING PEN AND INK CHANGES:

a. Page iv, para 5.4.6, change "119" to "120."

b. Page 16, para 3.67, 2nd line, change "test" to "text."

c. Page 44, para 5.2.3.3.3, 4th line, add space before "bat."

d. Page 44, para 5.2.3.3.7, 5th line, change "allitude" to "attitude."

e. Page 44, para 5.2.4, 3rd line, change "5.16" to "5.15."

f. Page 60, para 5.3.5.4, 5th line, change "maybe" to "may be."

g. Page 60, para 5.3.5.4, 5th line, change "3.24" to "3.51."

h. Page 159, para 5.7.7.6, 9th line, change "75mm (3 inches)" to "150 mm (6 inches)."

i. Page 171, Table XXIII, delete comma after "digital."

j. Page 175, para 5.8.3.2, 2nd line, change "MIL-S-008806" to "MIL-STD-1789."

k. Page 195, para 5.9.11.4.1, 3rd line, change "adjustment" to "value for females."

l. Page 215, para 5.11.1.2.2, 5th line, change "16.3 kg (36 lb)" to "18.5 kg (41 lb)."

m. Page 215, para 5.11.1.2.2, 6th line, change "24.5 kg (54 lb)" to "27.7 kg (61 lb)"

n. Page 241, para 5.14.2.4.1, 1st and 4th sentences, change "restrains" to "restraints."

o. Page 241, para 5.14.2.4.3, 2nd line, change "2∏rad" to "2π rad."

p. Page 241, para 5.14.2.4.5, 2nd line, change "actuation" to "ability to actuate."

q. Page 263, para 5.15.3.8.2, add "5.3.2.4."

r. Page 263, para 5.15.3.8.5, change "5.3.3.1.1" to "5.3.3.1"

s Page 264, para 5.15.4.1.1, change "5.15.8" to "5.15.9"

t. Page 275, para 5.15.8.13.8, 3rd line, add "(not to exceed six months)."

u. Page 307, add "Covert operations- - - - -5.13.9 237"

v. Page 372, add "Stealth operations - - -.-5.13.9 237"

w. Page 377, add "Trainers - - - - - - - - - - - -5.13.8 237"

3. RETAIN THIS NOTICE AND INSERT BEFORE TABLE OF CONTENTS.

4. Holders of MIL-STD-1472D will verify that page changes and additions indicated above have been entered. This notice page will be retained as a check sheet. This issuance, together with appended pages, is a separate publication. Each notice is to be retained by stocking points until the military standard is completely revised or cancelled.

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Army - MI
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Preparing activity:
Army - MI

(Project HFAC-0048)

Review activities:
Army -AR, AT, AV, CR, ER, GL, ME, MD, MR, TE, TM, EA
Navy- EC, MC, MS, OS, PE, SH, TD
Air Force13, 14, 19, 26

User activities:
Army-AL
Navy-YD

Civilian agencies:
NASA-MSFC
DOT-RDS

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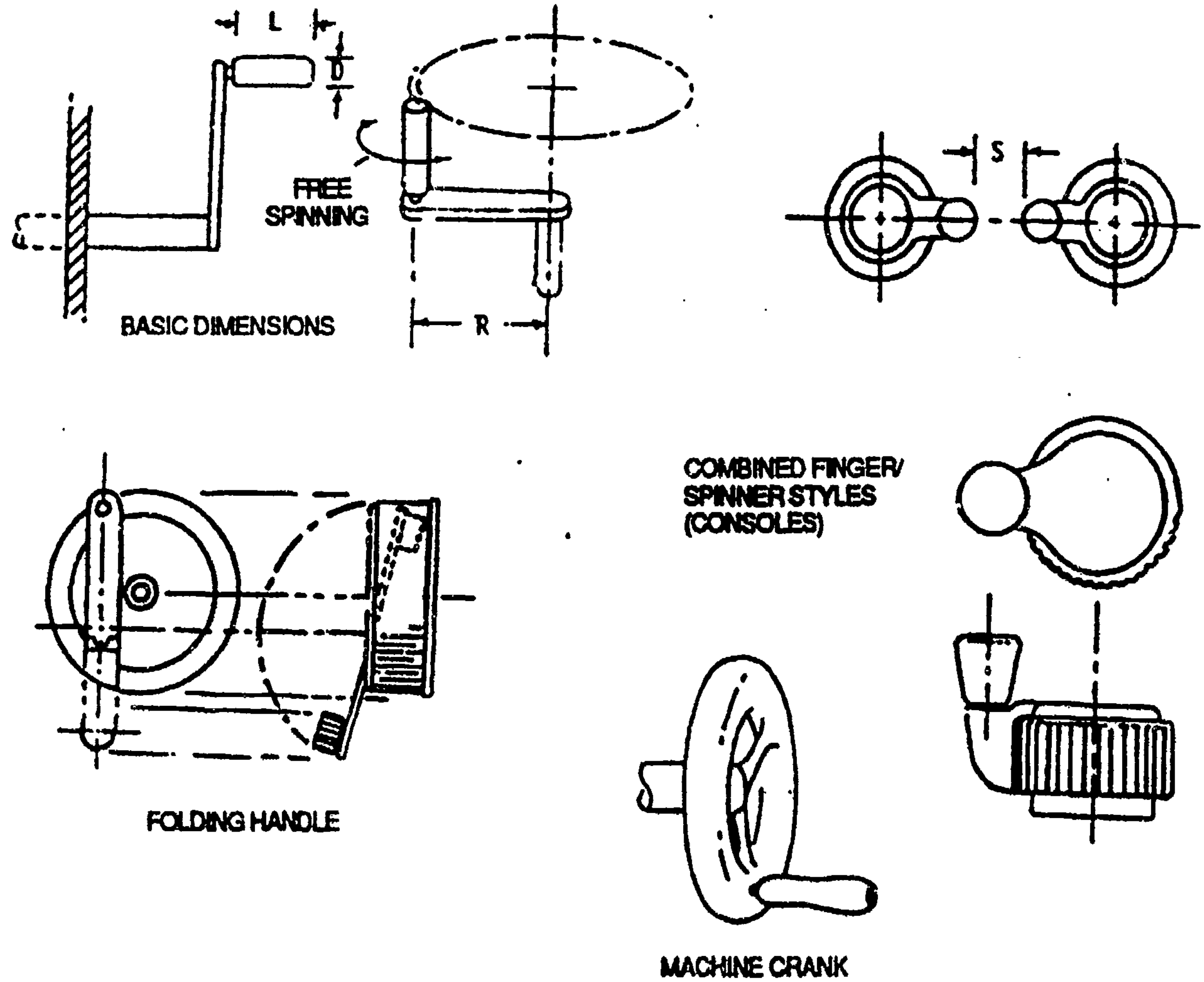
CONTENTS



LOAD	SPECIFICATION	HANDLE				R, TURNING RADIUS			
		L, LENGTH		D, DIAMETER		RATE BELOW 100 RPM		RATE ABOVE 100 RPM	
		mm	in.	mm	in.	mm	in.	mm	in.
LIGHT LOADS Less than 22 N: (5 lb). (Wrist and finger movement)	MINIMUM	25	1	10	3/8	38	$1\frac{1}{2}$	13	1/2
	PREFERRED	38	$1\frac{1}{2}$	13	1/2	75	3	65	$2\frac{1}{2}$
	MAXIMUM	75	3	16	5/8	125	5	115	$4\frac{1}{2}$
HEAVY LOADS: More than 22 N (5 lb). (Arm movement)	MINIMUM	75	3	25	1	190	$7\frac{1}{2}$	125	5
	PREFERRED	95	3-3/4	25	1	–	–	–	–
	MAXIMUM	–	–	38	1	510	20	230	9

S, Separation between adjacent controls: 75 mm (3") minimum.

FIGURE 10. CRANKS

5.4.2.2.5.6 Steering wheel shape. Except for established uses in submarines, armored combat vehicles, aircraft, and other applications where maximum wheel deflection does not exceed ±2/3 πrad (120°), all steering wheels shall be round.

5.4.2.2.5.7 Power steering failure. Steering systems shall be designed with sufficient mechanical advantage to meet the force requirements of Table IX, even when the primary operating mode is power assisted, i.e., the operator shall be able to steer the vehicle to a safe stop in the event of a power failure.

5.4.2.2.5.8 Steering ratio. Steering systems should be designed so that the maximum turning limits of the vehicle can be achieved with no more than $3\frac{1}{2}$ turns if consistent with force limits of Table IX.

5.4.3 Linear controls.

5.4.3.1 Discrete linear controls.

5.4.3.1.1 Push buttons (finger or hand operated).

5.4.3.1.1.1 Use. Push buttons should be used when a control or an array of controls is needed for momentary contact or for actuating a locking circuit, particularly in high-frequency-of-use situations. Push buttons should not be used for discrete control where the functions status is determined exclusively by position of the switch. (i.e., An on-off push buton that is pressed in and retained to turn a circuit on and pressed again to releast the push button and turn the circuit off.)

5.4.3.1.1.2 Shape. The push button surface should normally be concave (indented) to fit the finger. When this is impractical, the surface shall provide a high degree of frictional resistance to prevent slipping.

5.4.3.1.1.3 Positive indication. A positive indication of control actuation shall be provided (e.g., snap feel, audible click, or integral light).

5.4.3.1.1.4 Channel or cover guard. A channel or cover guard shall be provided when it is imperative to prevent accidental actuation of the controls. When a cover guard is in the open position, it shall not interfere with operation of the protected device or adjacent controls.

5.4.3.1.1.5 Dimensions, resistance, displacement, and separation. Except for use of push buttons in keyboards, control dimensions, resistance, displacement, and separation between adjacent edges of finger or hand-operated push buttons shall conform to the criteria in Figure 11.

5.4.3.1.1.6 Interlocks or barriers. Mechanical interlocks or barriers may be used instead of the spacing required by Figure 11.

5.4.3.1.2 Foot operated switches.

5.4.3.1.2.1 Use. Foot-operated switches should be used only where the operator is likely to have both hands occupied when switch actuation may be maximum force requirements shall not exceed those specified in Figure 21, and should be corrected, where applicable, for females. (Two-thirds of each value shown is considered to be a reasonable adjustment.)

5.4.4.3 Foot controls. Where foot controls requiring high control forces are to be used, the push force push exerted by the leg depends on the thigh angle and the knee angle. Figure 22 specifies the mean maximum push at various knee and thigh angles. The maximum push is at about the 160 degree angle, referred to as the limiting angle. The values of Figure 22 apply to males only and should be corrected for females. (Two-thirds of each value is considered to be a reasonable value for females.)

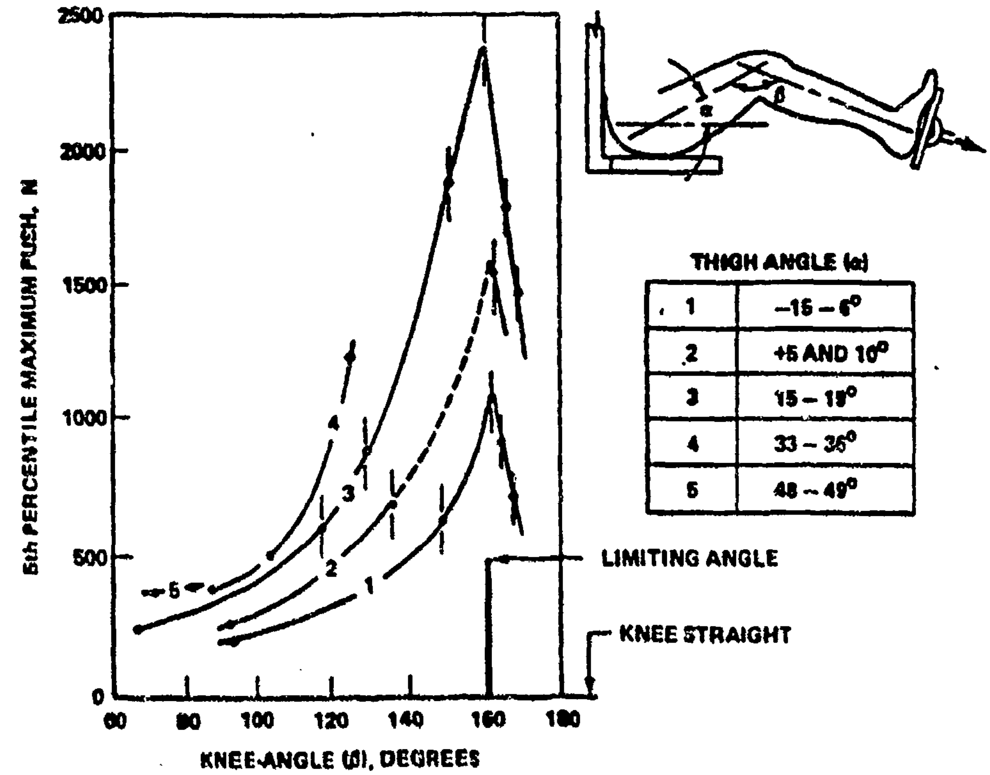


FIGURE 22. LEG STRENGTH AT VARIOUS KNEE AND THIGH ANGLES
(5th PERCENTILE MALE)

5.4.5 Miniature controls

5.4.5.1 Use. Miniature controls may be used only when severe space limitations exist. Miniature controls shall not be used when available space is adequate for standard-sized controls or when heavy gloves or mittens will be worn.

5.4.5.2 Dimensions, resistance, displacement and separation. When design constraints dictate the use of miniature controls, the dimensions and separation of the controls shall be the maximum permitted by the available space up to the maxima prescribed herein for standard-sized controls. Resistance and displacement of miniature controls should conform to the criteria specified for the standard size of that type of control.

5.4.5.3 Other requirements. Other design considerations (e.g., labeling, orientation) shall conform to the requirements specified for the standard size of the control.

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5.4.6 Touch-screen controls for displays

5.4.6.1 Use. Touch-screen control may be used to provide an overlaying control function to data display devices such as CRTs, dot matrix/segmented displays, electroluminescent displays, programmable indicators, or other display devices where direct visual reference access and optimum direct control access are desired.

5.4.6.2 Luminance transmission. When used, touch-screen displays shall have sufficient luminance transmission to allow the display with touch-screen installed to be clearly readable in the intended environment and meet the display luminance requirements herein.

5.4.6.3 Positive indication. A positive indication of touch-screen actuation shall be provided to acknowledge the system response to the control action. Visual feedback should be provided for touch-screen actuation.

5.4.6.4 Dimensions and separation. The dimensions and separation of responsive areas of the touch-screen shall conform to S1, S2 and Bw of Figure 14 for a seated operator in a benign environment. (An adverse environment may warrant larger sizes and separations.)

5.4.6.5 Resistance. Force required to operate force-actuated touch-screens shall conform to the alphanumeric resistance limits of Table X.

5.4.6.6 System Display Response Time. System display response time shall be not more than 0.25 seconds.

5.6 Anthropometry.

5.6.1 General. Design and sizing shall ensure accommodation, compatibility, operability, and maintainability by the user population. Generally, design limits shall be based upon a range from the 5th percentile female to the 95th percentile male values for critical body dimensions, as appropriate, except for special populations (see 5.6.4). For any body dimension, the 5th percentile value means that five percent of the population will be equal to or smaller than that value, and 95 percent will be larger; conversely, the 95th percentile value indicates that 95 percent of the population will be equal to or smaller than that value and five percent will be larger. Therefore, use of a design range from the 5th to 95th percentile values will theoretically provide coverage for 90 percent of the user population for that dimension. Where two or more dimensions are used simltaneously as design parameters, appropriate multivariate data and techniques should be utilized. (See Appendix for representative references.) The limited anthropometric data presented in this section in Figures 23 through 28 and Tables XIII through XVIII are intended to provide general design guidance only. DOD-HDBK-743 should be consulted for more extensive data. Use of these data shall take the following into consideration:

a. The nature, frequency, and difficulty of the related tasks to be performed by the operator or wearer of the equipment.

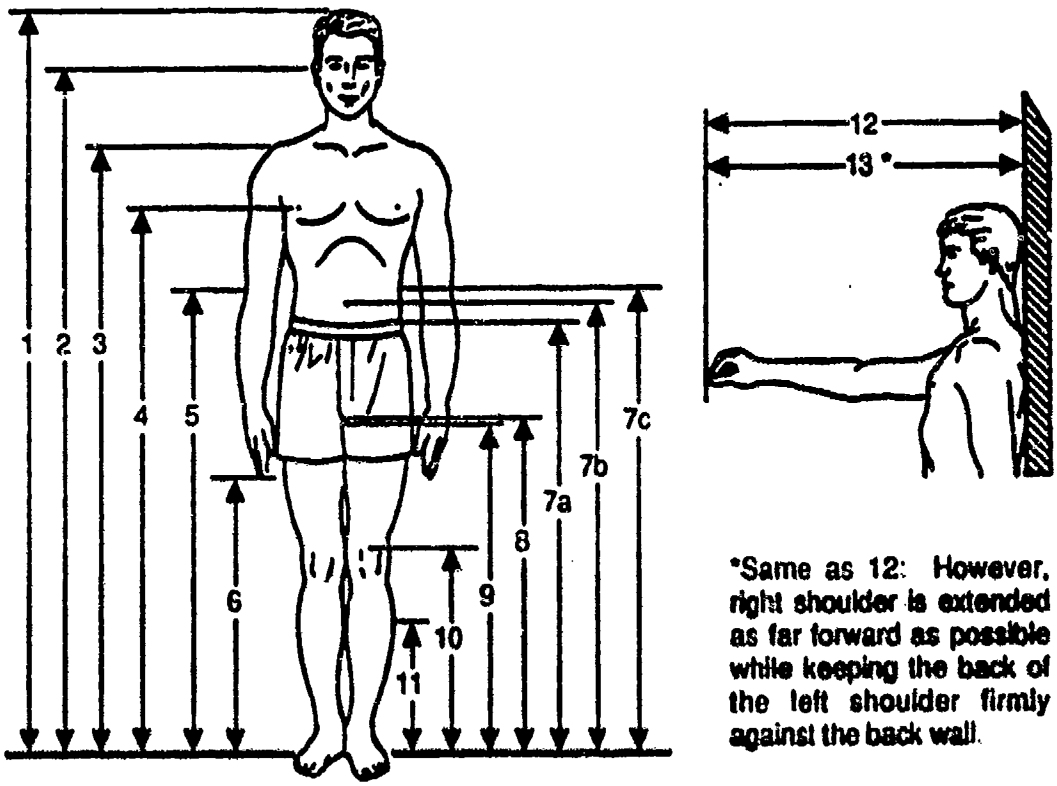
b. The position of the body during performance of these tasks.

c. Mobility or flexibility requirements imposed by these tasks.

d. Increments in the design-critical dimensions imposed by the need to compensate for obstacles, projections, etc.

e. Increments in the design-critical dimensions imposed by protective clothing or equipment, packages, lines, padding, etc.

5.6.2 Anthropometric Data. The anthropometric data presented in Tables XIII through XVIII are nude body dimensions; data are given in centimeters, with equivalent values in inches beneath in parentheses. The anthropometric data shown in these tables were compiled and collated from several sources. The data on "General Forces - Male" were compiled from the 1988 Anthropometric Survey of U.S. Army Personnel (ANSUR), the 1966 Anthropometric Survey of U.S. Marines and the 1965 Anthropometric Survey of U.S. Air Force male officers and enlisted personnel. The data on "General Forces - Female" were compiled from the ANSUR and the 1968 Anthropometric Survey of U.S. Air Force female officers and enlisted personnel. The data on "Army Pilots - Male" were compiled from a subset of pilots from the ANSUR data pool. The data on "Army Pilots - Female" were compiled from a subset of women, adjusted to match the demographic distribution of current female Army pilots, from the ANSUR data pool who met the body size requirements for entry into pilot training. The data on "Air Force Pilots - Male" were compiled from the 1967 Survey of USAF male rated officers. The data on "Air Force Pilots - Female" were compiled from a subset of the 1968 Survey of USAF female officers and enlisted personnel who met the body size requirements for entry into USAF Undergraduate Pilot Training. Data voids and omitted line numbers within these tables represent measurements which were not taken or for data not available.



*Same as 12: However, right shoulder is extended as far forward as possible while keeping the back of the left shoulder firmly against the back wall.

FIGURE 23. Standing Body Dimensions

TABLE XIII. STANDING BODY DIMENSIONS

A. GENERAL FORCES

Percentile Values in Centimeters (Inch Equivalents in Parentheses)				
	5th Percentile		95th Percentile	
	Male	Female	Male	Female
WEIGHT, kgs (lbs)	61.6 (135.8)	46.4 (102.3)	98.1 (216.3)	77.0 (169.8)
1 STATURE	164.5 (64.8)	152.4 (60.0)	187.1 (73.7)	173.7 (68.4)
2 EYE HEIGHT (STANDING)	152.8 (60.2)	141.5 (55.7)	174.3 (68.6)	162.1 (63.8)
3 SHOULDER (ACROMIALE) HEIGHT	134.2 (52.8)	123.0 (48.4)	154.6 (60.9)	143.2 (56.4)
4 CHEST (NIPPLE) HEIGHT*	118.6 (46.7)	108.9 (42.9)	137.3 (54.1)	127.3 (50.1)
5 ELBOW (RADIALE) HEIGHT	102.3 (40.3)	96.1 (37.8)	119.9 (47.2)	111.0 (43.7)
6 FINGERTIP (DACTYLION) HEIGHT	59.1 (23.3)	55.1 (21.7)	72.4 (28.5)	67.0 (26.4)
7a WAIST (ILIOCRISTALE) HEIGHT	95.3 (37.5)	91.1 (35.9)	115.9 (45.6)	107.1 (42.2)
7b WAIST (OMPHALION) HEIGHT	97.7 (38.5)	90.3 (35.6)	114.3 (45.0)	106.5 (41.9)
7c WAIST (NATURAL INDENTATION) HEIGHT	104.3 (41.1)	97.3 (38.3)	121.3 (47.8)	114.3 (45.0)
8 CROTCH HEIGHT	75.3 (29.6)	68.1 (26.8)	91.8 (36.1)	84.6 (33.3)
9 GLUTEAL FURROW HEIGHT	73.6 (29.0)	66.4 (26.1)	89.2 (35.1)	81.7 (32.2)
10 KNEE (MID-PATELLA) HEIGHT	46.1 (18.1)	41.7 (16.4)	55.2 (21.7)	50.3 (19.8)
11 CALF HEIGHT	31.6 (12.4)	27.8 (10.9)	40.6 (16.0)	35.7 (14.1)
12 FUNCTIONAL (THUMBTIP) REACH	71.7 (28.2)	67.7 (26.7)	88.6 (34.9)	80.5 (31.7)
13 FUNCTIONAL REACH, EXTENDED	80.5 (31.7)	73.5 (28.9)	94.2 (37.1)	92.3 (36.3)

*Bustpoint height for women

TABLE XIII. STANDING BODY DIMENSIONS (continued)

B. ARMY PILOTS

Percentile Values in Centimeters (Inch Equivalents in Parentheses)	5th Percentile		95th Percentile	
	Male	Female	Male	Female
WEIGHT, kgs (lbs)	64.5 (142.2)	51.2 (112.9)	97.3 (214.5)	81.1 (178.8)
1 STATURE	165.9 (65.3)	160.9 (63.3)	188.4 (74.2)	175.7 (69.2)
2 EYE HEIGHT (STANDING)	153.7 (60.5)	149.9 (59.0)	176.2 (69.4)	164.1 (64.6)
3 SHOULDER (ACROMIALE) HEIGHT	135.7 (53.4)	131.3 (51.7)	155.7 (61.3)	144.4 (56.9)
4 CHEST (NIPPLE) HEIGHT*	119.3 (47.0)	115.1 (45.3)	137.2 (54.0)	128.2 (50.5)
5 ELBOW (RADIALE) HEIGHT	104.8 (41.3)	101.0 (39.8)	120.4 (47.4)	112.7 (44.4)
6 FINGERTIP (DACTYLION) HEIGHT	60.2 (23.7)	58.3 (23.0)	72.0 (28.3)	68.7 (27.0)
7a WAIST (ILIOCRISTALE) HEIGHT	100.0 (39.4)	97.5 (38.4)	116.3 (45.8)	107.7 (42.4)
7b WAIST (OMPHALION) HEIGHT	98.6 (38.8)	96.3 (37.9)	114.9 (45.2)	107.2 (42.2)
7c WAIST (NATURAL INDENTATION) HEIGHT	105.3 (41.5)	102.8 (40.5)	121.4 (47.8)	115.5 (45.5)
8 CROTCH HEIGHT	77.4 (30.5)	75.5 (29.7)	92.1 (36.3)	83.9 (33.0)
9 GLUTEAL FURROW HEIGHT	74.6 (29.4)	72.5 (28.5)	88.7 (34.9)	81.2 (32.0)
10 KNEE (MID-PATELLA) HEIGHT	46.5 (18.3)	44.8 (17.6)	54.8 (21.6)	50.3 (19.8)
11 CALF HEIGHT	31.9 (12.6)	29.3 (11.5)	38.5 (15.2)	35.1 (13.8)
12 FUNCTIONAL (THUMBTIP) REACH	74.0 (29.1)	71.1 (28.0)	86.3 (34.0)	79.7 (31.4)
13 FUNCTIONAL REACH, EXTENDED	80.2 (31.6)	77.4 (30.5)	92.8 (36.6)	86.0 (33.9)

*Bustpoint height for women

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TABLE XIII. STANDING BODY DIMENSIONS (concluded)

C. AIR FORCE PILOTS

Percentile Values in Centimeters (Inch Equivalents in Parentheses)				
	5th Percentile		95th Percentile	
	Male	Female	Male	Female
WEIGHT, kgs (lbs)	63.6 (140.2)	51.0 (112.4)	95.6 (210.8)	67.1 (147.9)
1 STATURE	167.2 (65.8)	163.3 (64.3)	187.7 (73.9)	175.8 (69.2)
3 SHOULDER (ACROMIALE) HEIGHT	135.7 (53.4)	131.6 (51.8)	154.8 (60.9)	143.9 (56.7)
4 CHEST (NIPPLE) HEIGHT *	120.8 (47.6)	117.5 (46.3)	138.1 (54.4)	130.4 (51.3)
5 ELBOW (RADIALE) HEIGHT	104.8 (41.3)		120.0 (47.2)	
6 FINGERTIP (DACTYLION) HEIGHT	61.5 (24.2)		73.2 (28.8)	
7a WAIST (ILIOCRISTALE) HEIGHT	101.3 (39.9)		117.2 (46.1)	
7b WAIST (OMPHALION) HEIGHT	98.7 (38.9)		114.3 (45.0)	
7c WAIST (NATURAL INDENTATION) HEIGHT		99.3 (39.1)		110.5 (43.5)
8 CROTCH HEIGHT	78.3 (30.8)	72.6 (28.6)	92.0 (36.2)	83.4 (32.8)
9 GLUTEAL FURROW HEIGHT	74.6 (29.4)	70.4 (27.7)	87.9 (34.6)	81.5 (32.1)
10 KNEE (MID-PATELLA) HEIGHT	45.7 (18.0)		53.9 (21.2)	
11 CALF HEIGHT	32.0 (12.6)		39.3 (15.5)	
12 FUNCTIONAL (THUMBTIP) REACH	73.9 (29.1)	71.1 (28.0)	87.0 (34.3)	81.9 (32.2)
13 FUNCTIONAL REACH, EXTENDED	82.3 (32.4)	79.8 (31.4)	97.3 (38.3)	94.0 (37.0)

*Bustpoint height for women

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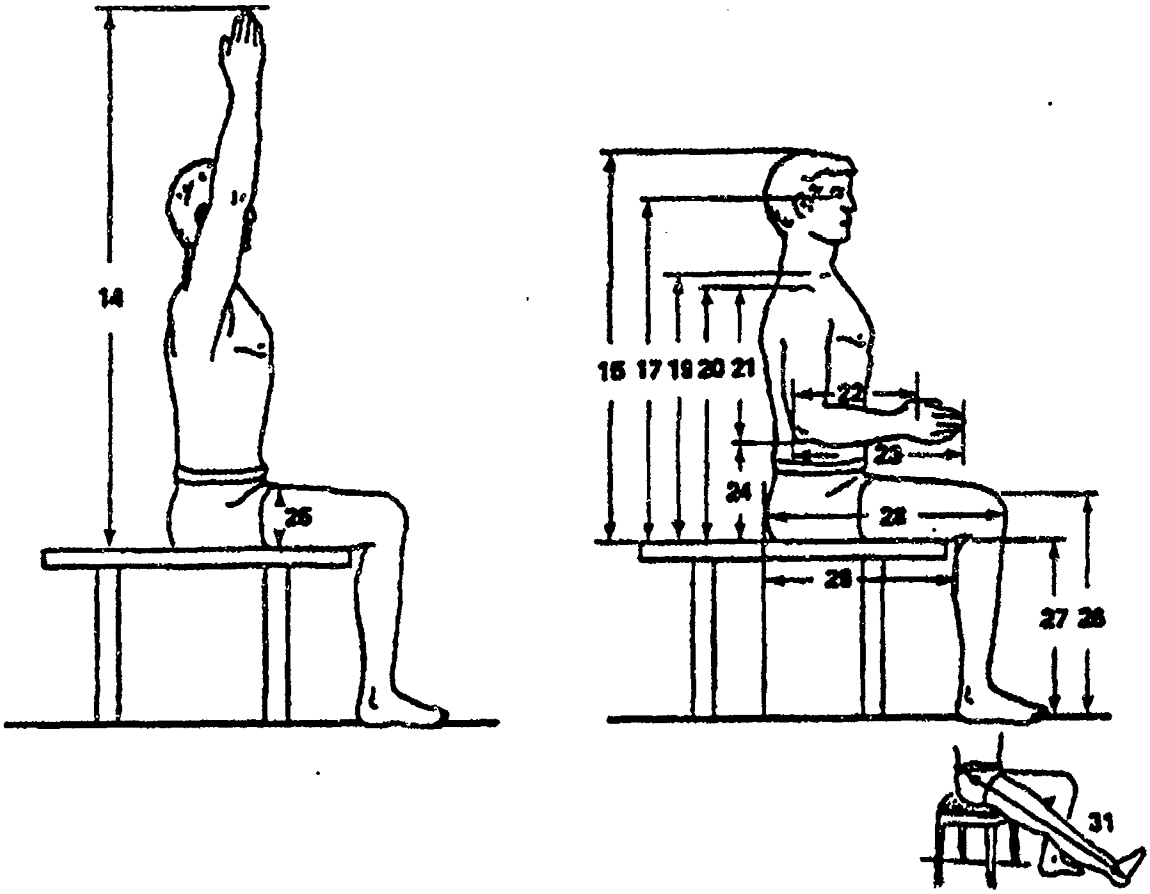

Dimension 16 — Sitting eye height (relaxed) is not shown on figure.

Dimension 30 — not used.

FIGURE 24. Seated Body Dimensions

TABLE XIV. SEATED BODY DIMENSIONS

A. GENERAL FORCES

Percentile Values in Centimeters (Inch Equivalents in Parentheses)				
	5th Percentile		95th Percentile	
	Male	Female	Male	Female
14 VERTICAL ARM REACH, SITTING	128.6 (50.6)	123.3 (48.5)	153.2 (60.3)	141.8 (55.8)
15 SITTING HEIGHT, ERECT	85.2 (33.5)	79.5 (31.3)	97.2 (38.3)	91.0 (35.8)
16 SITTING HEIGHT, RELAXED		78.9 (31.1)		89.7 (35.3)
17 EYE HEIGHT SITTING, ERECT	72.9 (28.7)	68.5 (27.0)	85.2 (33.5)	79.4 (31.3)
19 MID-SHOULDER HEIGHT	57.2 (22.5)	53.9 (21.2)	68.6 (27.0)	63.1 (24.8)
20 SHOULDER HEIGHT, SITTING	54.9 (21.6)	50.9 (20.0)	64.6 (25.4)	60.4 (23.8)
21 SHOULDER-ELBOW LENGTH	34.0 (13.4)	28.3 (11.1)	40.2 (15.8)	36.6 (14.4)
22 ELBOW-GRIP LENGTH	33.2 (13.1)	30.0 (11.8)	39.1 (15.4)	35.8 (14.1)
23 ELBOW-FINGERTIP LENGTH	44.4 (17.5)	40.6 (16.0)	52.4 (20.6)	48.3 (19.0)
24 ELBOW REST HEIGHT	18.4 (7.2)	17.6 (6.9)	28.6 (11.3)	26.9 (10.6)
25 THIGH CLEARANCE HEIGHT	13.7 (5.4)	10.4 (4.1)	19.0 (7.5)	18.0 (7.1)
26 KNEE HEIGHT, SITTING	50.0 (19.7)	47.4 (18.7)	60.6 (23.9)	56.0 (22.0)
27 POPLITEAL HEIGHT	39.5 (15.6)	35.1 (13.8)	50.0 (19.7)	44.1 (17.4)
28 BUTTOCK-KNEE LENGTH	55.2 (21.7)	53.2 (20.9)	66.7 (26.3)	64.0 (25.2)
29 BUTTOCK-POPLITEAL LENGTH	45.8 (18.0)	43.5 (17.1)	54.6 (21.5)	52.8 (20.8)
31 FUNCTIONAL LEG LENGTH	100.2 (39.4)	93.3 (36.7)	116.9 (46.0)	109.4 (43.1)

TABLE XIV. SEATED BODY DIMENSIONS (continued)

B. ARMY PILOTS

Percentile Values in Centimeters (Inch Equivalents in Parentheses)				
	5th Percentile		95th Percentile	
	Male	Female	Male	Female
14 VERTICAL ARM REACH, SITTING	135.0 (53.1)	129.7 (51.1)	153.8 (60.6)	143.3 (56.4)
15 SITTING HEIGHT, ERECT	87.1 (34.3)	83.7 (33.0)	98.1 (38.6)	92.7 (36.5)
17 EYE HEIGHT SITTING, ERECT	75.3 (29.6)	72.2 (28.4)	86.1 (33.9)	81.2 (32.0)
19 MID-SHOULDER HEIGHT	59.7 (23.5)	57.0 (22.4)	68.5 (27.0)	64.5 (25.4)
20 SHOULDER HEIGHT, SITTING	56.4 (22.2)	54.1 (21.3)	65.6 (25.8)	61.9 (24.4)
21 SHOULDER-ELBOW LENGTH	34.3 (13.5)	33.0 (13.0)	40.0 (15.7)	36.8 (14.5)
22 ELBOW-GRIP LENGTH	33.3 (13.1)	31.6 (12.4)	38.5 (15.2)	35.5 (14.0)
23 ELBOW-FINGERTIP LENGTH	45.1 (17.8)	43.1 (17.0)	51.8 (20.4)	47.6 (18.7)
24 ELBOW REST HEIGHT	19.9 (7.8)	19.7 (7.8)	28.4 (11.2)	26.6 (10.5)
25 THIGH CLEARANCE HEIGHT	14.9 (5.9)	14.1 (5.6)	18.7 (7.4)	18.1 (7.1)
26 KNEE HEIGHT, SITTING	51.9 (20.4)	50.3 (19.8)	60.6 (23.9)	56.0 (22.0)
27 POPLITEAL HEIGHT	39.6 (15.6)	37.7 (14.8)	47.5 (18.7)	42.8 (16.9)
28 BUTTOCK-KNEE LENGTH	57.7 (22.7)	56.8 (22.4)	66.5 (26.2)	63.6 (25.0)
29 BUTTOCK-POPLITEAL LENGTH	46.3 (18.2)	46.3 (18.2)	55.0 (21.7)	52.3 (20.6)
31 FUNCTIONAL LEG LENGTH	100.9 (39.7)	99.1 (39.0)	117.1 (46.1)	109.8 (43.2)

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TABLE XIV. SEATED BODY DIMENSIONS (concluded)

C. AIR FORCE PILOTS

Percentile Values in Centimeters (Inch Equivalents in Parentheses)				
	5th Percentile		95th Percentile	
	Male	Female	Male	Female
15 SITTING HEIGHT, ERECT	88.1 (34.7)	86.6 (34.1)	98.6 (38.8)	90.9 (35.8)
16 SITTING HEIGHT, RELAXED		84.9 (33.4)		89.7 (35.9)
17 EYE HEIGHT SITTING, ERECT	76.2 (30.0)	73.5 (28.9)	86.1 (33.9)	80.2 (31.6)
19 MID-SHOULDER HEIGHT	60.2 (23.7)	57.5 (22.6)	69.2 (27.2)	63.7 (25.1)
20 SHOULDER HEIGHT, SITTING	56.5 (22.2)		65.9 (25.9)	
21 SHOULDER-ELBOW LENGTH	33.2 (13.1)		38.8 (15.3)	
22 ELBOW-GRIP LENGTH	32.6 (12.8)		37.9 (14.9)	
24 ELBOW REST HEIGHT	20.9 (8.2)	20.3 (8.0)	29.5 (11.6)	27.8 (10.9)
25 THIGH CLEARANCE HEIGHT	14.3 (5.6)	10.7 (4.2)	18.8 (7.4)	14.5 (5.7)
26 KNEE HEIGHT, SITTING	51.7 (20.4)		59.9 (23.6)	
27 POPLITEAL HEIGHT	40.1 (15.8)	39.9 (15.7)	47.5 (18.7)	45.2 (17.8)
28 BUTTOCK-KNEE LENGTH	56.1 (22.1)	55.7 (21.9)	65.0 (25.6)	62.5 (24.6)
29 BUTTOCK-POPLITEAL LENGTH	46.1 (18.1)	45.2 (17.8)	54.6 (21.5)	53.2 (20.9)

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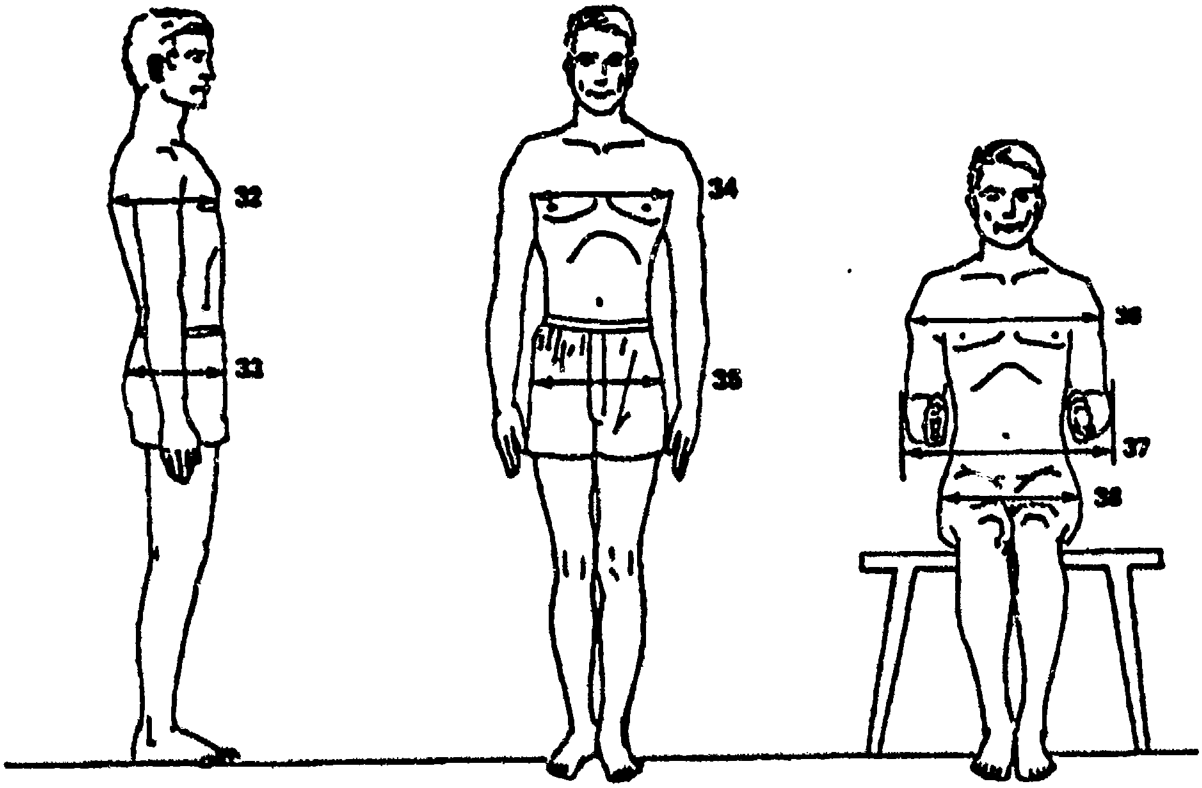

Dimension 39 — not used

FIGURE 25. Depth and Breadth Dimensions

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TABLE XV. DEPTH AND BREADTH DIMENSIONS

A. GENERAL FORCES

Percentile Values in Centimeters (Inch Equivalents in Parentheses)				
	5th Percentile		95th Percentile	
	Male	Female	Male	Female
32 CHEST DEPTH*	20.4 (8.0)	20.9 (8.2)	28.0 (11.0)	27.8 (10.9)
33 BUTTOCK DEPTH	21.2 (8.3)	18.4 (7.2)	28.6 (11.3)	26.5 (10.4)
34 CHEST BREADTH	27.8 (10.9)	25.0 (9.8)	36.7 (14.4)	31.5 (12.4)
35 HIP BREADTH, STANDING	30.5 (12.0)	30.8 (12.1)	38.3 (15.1)	38.8 (15.3)
36 SHOULDER (BIDELTOID) BREADTH	41.8 (16.5)	38.2 (15.0)	53.5 (21.1)	47.2 (18.6)
37 FOREARM-FOREARM BREADTH	47.7 (18.8)	41.5 (16.3)	62.1 (24.4)	52.8 (20.8)
38 HIP BREADTH, SITTING	31.1 (12.2)	33.8 (13.3)	41.3 (16.3)	43.3 (17.0)

B. ARMY PILOTS

Percentile Values in Centimeters (Inch Equivalents in Parentheses)				
	5th Percentile		95th Percentile	
	Male	Female	Male	Female
32 CHEST DEPTH*	21.7 (8.5)	20.7 (8.1)	28.4 (11.2)	28.2 (11.1)
33 BUTTOCK DEPTH	21.6 (8.5)	19.5 (7.7)	27.7 (10.9)	27.5 (10.8)
34 CHEST BREADTH	29.7 (11.7)	25.7 (10.1)	36.8 (14.5)	32.2 (12.7)
35 HIP BREADTH, STANDING	32.2 (12.7)	31.9 (12.6)	38.0 (15.0)	39.2 (15.4)
36 SHOULDER (BIDELTOID) BREADTH	46.0 (18.1)	40.3 (15.9)	53.4 (21.0)	47.8 (18.7)
37 FOREARM-FOREARM BREADTH	49.2 (19.4)	42.4 (16.7)	62.3 (24.5)	54.2 (21.3)
38 HIP BREADTH, SITTING	33.8 (13.3)	35.5 (14.0)	41.0 (16.1)	44.6 (17.6)

* Bust depth for women

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TABLE XV. DEPTH AND BREADTH DIMENSIONS (concluded)

C. AIR FORCE PILOTS

Percentile Values in Centimeters (Inch Equivalents in Parentheses)				
	5th Percentile		95th Percentile	
	Male	Female	Male	Female
32 CHEST DEPTH	21.3 (8.4)	20.9 (8.2)	27.7 (10.9)	26.1 (10.3)
33 BUTTOCK DEPTH	20.7 (8.1)	18.8 (7.4)	27.5 (10.8)	23.3 (9.2)
34 CHEST BREADTH	29.5 (11.6)	25.6 (10.1)	36.5 (14.4)	30.7 (12.1)
35 HIP BREADTH, STANDING	32.3 (12.7)	32.5 (12.8)	38.5 (15.2)	38.2 (15.0)
36 SHOULDER (BIDELTOID) BREADTH	44.1 (17.4)	38.8 (15.3)	52.6 (20.7)	45.0 (17.7)
37 FOREARM-FOREARM BREADTH	48.2 (19.0)		60.7 (23.9)	
38 HIP BREADTH, SITTING	34.2 (13.5)	34.5 (13.6)	41.8 (16.5)	41.9 (16.5)

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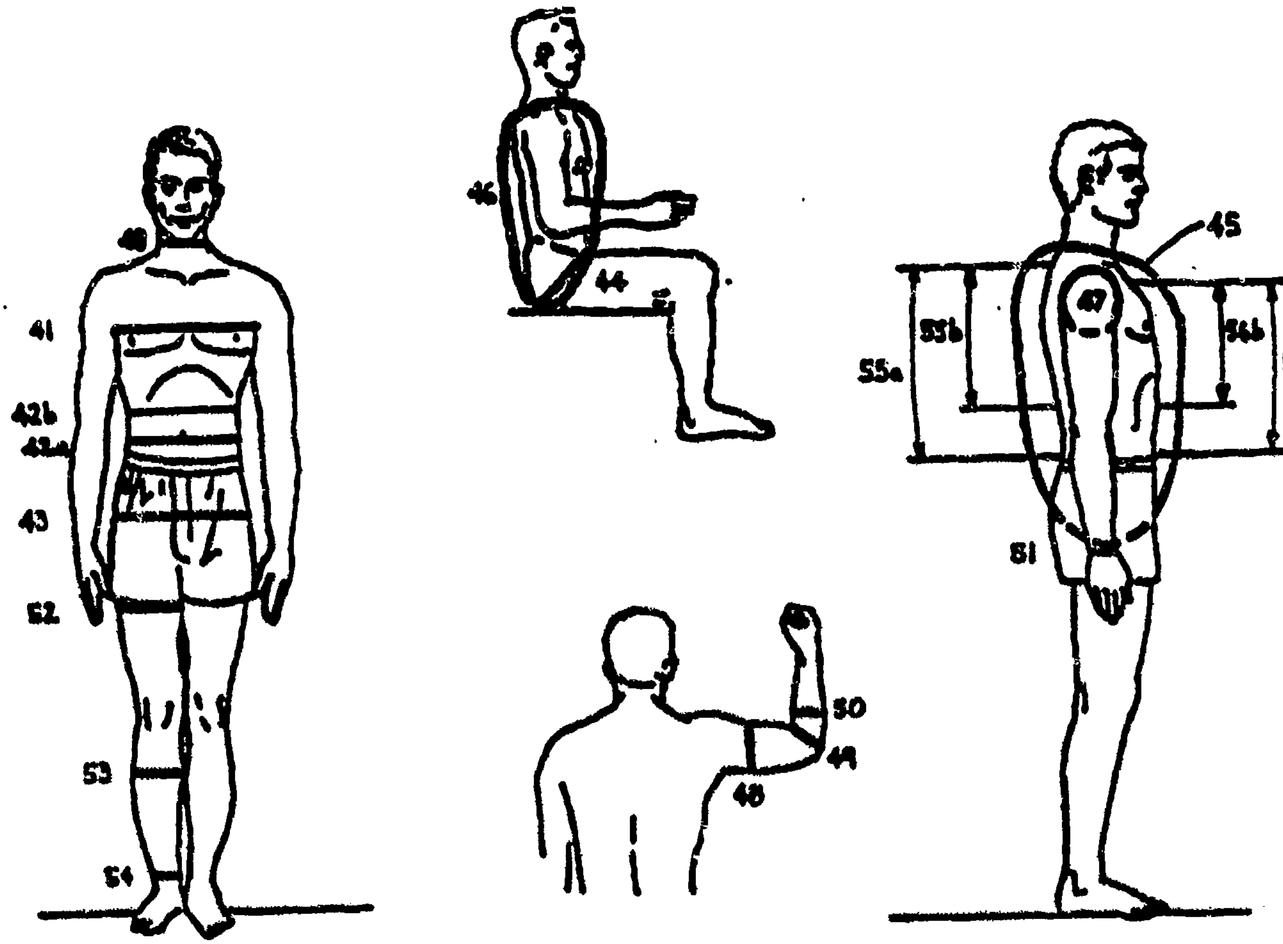

FIGURE 26. Circumferences and Surface Dimensions

TABLE XVI. CIRCUMFERENCES AND SURFACE DIMENSIONS

A. GENERAL FORCES

Percentile Values in Centimeters (Inch Equivalents in Parentheses)	5th Percentile		95th Percentile	
	Male	Female	Male	Female
40 NECK CIRCUMFERENCE	34.7 (13.7)	29.2 (11.5)	41.6 (16.4)	36.7 (14.4)
41 CHEST CIRCUMFERENCE*	85.5 (33.7)	81.4 (32.0)	111.3 (43.8)	102.2 (40.2)
42a WAIST CIRCUMFERENCE (OMPHALION)	70.2 (27.6)	67.6 (26.6)	101.6 (40.0)	94.6 (37.2)
42b WAIST CIRCUMFERENCE (NATURAL INDENTATION)	71.9 (28.3)	59.5 (23.4)	98.4 (38.7)	84.3 (33.2)
43 HIP (BUTTOCK) CIRCUMFERENCE, STANDING	86.7 (34.1)	85.8 (33.8)	109.0 (42.9)	107.0 (42.1)
45 VERTICAL TRUNK CIRCUMFERENCE, STANDING	150.6 (59.3)	142.0 (55.9)	180.7 (71.1)	166.3 (65.5)
47 ARM SCYE CIRCUMFERENCE	39.9 (15.7)	33.6 (13.2)	49.8 (19.6)	41.2 (16.2)
48 BICEPS CIRCUMFERENCE, FLEXED	27.7 (10.9)	23.3 (9.2)	38.6 (15.2)	32.1 (12.6)
49 ELBOW CIRCUMFERENCE, FLEXED	25.3 (10.0)	21.8 (8.6)	35.0 (13.8)	30.0 (11.8)
50 FOREARM CIRCUMFERENCE, FLEXED	26.5 (10.4)	23.0 (9.1)	33.6 (13.2)	27.9 (11.0)
51 WRIST CIRCUMFERENCE	15.7 (6.2)	13.8 (5.4)	18.8 (7.4)	16.3 (6.4)
52 UPPER THIGH CIRCUMFERENCE	49.1 (19.3)	48.7 (19.2)	67.9 (26.7)	65.7 (25.9)
53 CALF CIRCUMFERENCE	32.7 (12.9)	31.5 (12.4)	42.1 (16.6)	39.1 (15.4)
54 ANKLE CIRCUMFERENCE	20.0 (7.9)	18.6 (7.3)	25.0 (9.8)	23.3 (9.2)
55a WAIST (OMPHALION) - BACK LENGTH	43.5 (17.1)	40.4 (15.9)	52.3 (20.6)	48.6 (19.1)
55b WAIST (NATURAL INDENTATION) - BACK LENGTH	37.4 (14.7)	32.7 (12.9)	45.1 (17.8)	44.3 (17.4)
56a WAIST (OMPHALION) - FRONT LENGTH	35.9 (14.1)	35.5 (14.0)	45.7 (18.0)	42.8 (16.9)
56b WAIST (NATURAL INDENTATION) - FRONT LENGTH	31.0 (12.2)	27.5 (10.8)	38.1 (15.0)	36.9 (14.5)

*Bust circumference for women

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TABLE XVI. CIRCUMFERENCES AND SURFACE DIMENSIONS (continued)

B. ARMY PILOTS

Percentile Values in Centimeters (Inch Equivalents in Parentheses)				
	5th Percentile		95th Percentile	
	Male	Female	Male	Female
40 NECK CIRCUMFERENCE	35.2 (13.9)	29.3 (11.5)	41.2 (16.2)	34.5 (13.6)
41 CHEST CIRCUMFERENCE*	91.6 (36.1)	82.3 (32.4)	111.0 (43.7)	103.5 (40.7)
42a WAIST CIRCUMFERENCE (OMPHALION)	76.7 (30.2)	68.7 (27.0)	101.7 (40.0)	97.9 (38.5)
42b WAIST CIRCUMFERENCE (NATURAL INDENTATION)	75.3 (29.6)	64.7 (25.5)	96.7 (38.1)	87.6 (34.5)
43 HIP (BUTTOCK) CIRCUMFERENCE, STANDING	90.5 (35.6)	88.7 (34.9)	109.4 (43.1)	109.4 (43.1)
45 VERTICAL TRUNK CIRCUMFERENCE, STANDING	154.5 (60.8)	147.8 (58.2)	177.2 (69.8)	168.5 (66.3)
47 ARM SCYE CIRCUMFERENCE	40.8 (16.1)	34.5 (13.6)	48.5 (19.1)	42.2 (16.6)
48 BICEPS CIRCUMFERENCE, FLEXED	29.9 (11.8)	24.7 (9.7)	37.5 (14.8)	32.7 (12.9)
49 ELBOW CIRCUMFERENCE, FLEXED	25.4 (10.0)	22.3 (8.8)	30.1 (11.9)	26.5 (10.4)
50 FOREARM CIRCUMFERENCE, FLEXED	27.3 (10.7)	23.1 (9.1)	32.9 (13.0)	28.0 (11.0)
51 WRIST CIRCUMFERENCE	16.2 (6.4)	14.4 (5.7)	18.6 (7.3)	16.3 (6.4)
52 UPPER THIGH CIRCUMFERENCE	52.5 (20.7)	51.4 (20.2)	66.7 (26.3)	67.5 (26.6)
53 CALF CIRCUMFERENCE	34.2 (13.5)	32.0 (12.6)	41.6 (16.4)	39.6 (15.6)
54 ANKLE CIRCUMFERENCE	20.2 (8.0)	19.1 (7.5)	24.3 (9.6)	22.8 (9.0)
55a WAIST (OMPHALION) - BACK LENGTH	44.7 (17.6)	42.5 (16.7)	52.8 (20.8)	49.7 (19.6)
55b WAIST (NATURAL INDENTATION) - BACK LENGTH	38.7 (15.2)	34.8 (13.7)	45.7 (18.0)	42.2 (16.6)
56a WAIST (OMPHALION) - FRONT LENGTH	38.4 (15.1)	37.0 (14.6)	45.6 (18.0)	44.4 (17.5)
56b WAIST (NATURAL INDENTATION) - FRONT LENGTH	32.0 (12.6)	29.1 (11.5)	38.5 (15.2)	36.6 (14.4)

*Bust circumference for women

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TABLE XVI. CIRCUMFERENCES AND SURFACE DIMENSIONS (concluded)

C. AIR FORCE PILOTS

Percentile Values in Centimeters (Inch Equivalents in Parentheses)	5th Percentile		95th Percentile	
	Male	Female	Male	Female
40 NECK CIRCUMFERENCE	34.9 (13.7)	31.6 (12.4)	41.6 (16.4)	36.5 (14.4)
41 CHEST CIRCUMFERENCE*	88.6 (34.9)	82.7 (32.6)	109.4 (43.1)	96.1 (37.8)
42a WAIST CIRCUMFERENCE (OMPHALION)	75.7 (29.8)		100.1 (39.4)	
42b WAIST CIRCUMFERENCE (NATURAL INDENTATION)		60.8 (23.9)		73.0 (28.7)
43 HIP (BUTTOCK) CIRCUMFERENCE, STANDING	89.7 (35.3)	88.7 (34.9)	107.9 (42.5)	102.7 (40.4)
44 HIP (BUTTOCK) CIRCUMFERENCE, SITTING	97.1 (38.2)	93.9 (37.0)	119.3 (47.0)	107.4 (42.3)
45 VERTICAL TRUNK CIRCUMFERENCE, STANDING	156.7 (61.7)	150.6 (59.3)	180.2 (70.9)	166.0 (65.4)
46 VERTICAL TRUNK CIRCUMFERENCE, SITTING	150.4 (59.2)	147.6 (58.1)	173.2 (68.2)	161.8 (63.7)
47 ARM SCYE CIRCUMFERENCE	43.8 (17.2)	34.3 (13.5)	53.0 (20.9)	40.4 (15.9)
48 BICEPS CIRCUMFERENCE, FLEXED	29.1 (11.5)	23.6 (9.3)	36.6 (14.4)	29.1 (11.5)
49 ELBOW CIRCUMFERENCE, FLEXED	28.5 (11.2)	25.0 (9.8)	34.2 (13.5)	30.1 (11.9)
50 FOREARM CIRCUMFERENCE, FLEXED	27.2 (10.7)	23.0 (9.1)	32.4 (12.8)	27.1 (10.7)
51 WRIST CIRCUMFERENCE	16.2 (6.4)	14.2 (5.6)	19.2 (7.6)	16.3 (6.4)
52 UPPER THIGH CIRCUMFERENCE	51.5 (20.3)	49.5 (19.5)	66.2 (26.1)	60.8 (23.9)
53 CALF CIRCUMFERENCE	33.5 (13.2)	31.2 (12.3)	41.0 (16.1)	37.4 (14.7)
54 ANKLE CIRCUMFERENCE	20.4 (8.0)	19.7 (7.8)	24.6 (9.7)	23.5 (9.3)
55a WAIST (OMPHALION) - BACK LENGTH	43.1 (17.0)	39.3 (15.5)	50.9 (20.0)	45.4 (17.9)
56a WAIST (OMPHALION) - FRONT LENGTH	36.9 (14.5)	31.6 (12.4)	44.2 (17.4)	37.7 (14.8)

*Bust circumference for women

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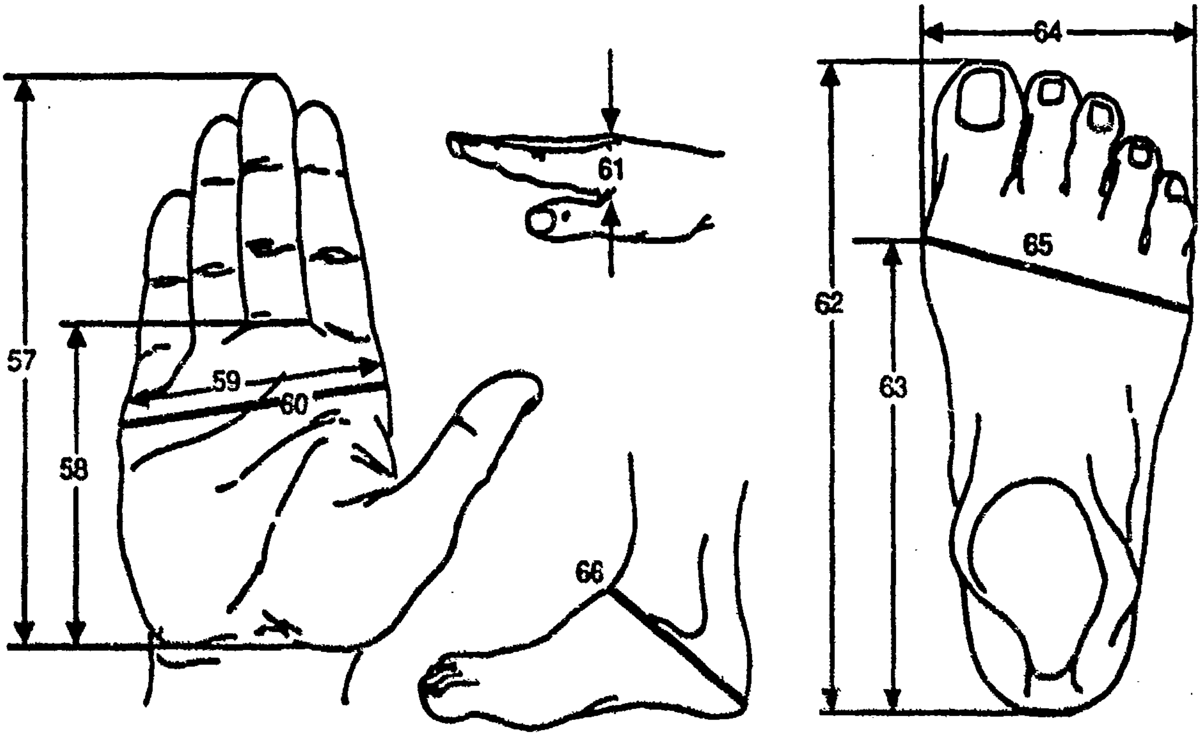

FIGURE 27. Hand and Foot Dimensions

TABLE XVII. HAND AND FOOT DIMENSIONS

A. GENERAL FORCES

Percentile Values in Centimeters (Inch Equivalents in Parentheses)	5th Percentile		95th Percentile	
	Male	Female	Male	Female
57 HAND LENGTH	17.5 (6.9)	16.5 (6.5)	21.1 (8.3)	20.1 (7.9)
58 PALM LENGTH*	9.6 (3.8)	9.0 (3.5)	11.7 (4.6)	10.8 (4.3)
59 HAND BREADTH	8.2 (3.2)	6.9 (2.7)	9.8 (3.9)	8.6 (3.4)
60 HAND CIRCUMFERENCE	19.9 (7.8)	16.8 (6.6)	23.5 (9.3)	20.0 (7.9)
62 FOOT LENGTH	24.6 (9.7)	22.2 (8.7)	29.2 (11.5)	26.5 (10.4)
63 INSTEP LENGTH	17.9 (7.0)	16.4 (6.5)	21.4 (8.4)	19.5 (7.7)
64 FOOT BREADTH	9.0 (3.5)	8.0 (3.1)	11.0 (4.3)	9.8 (3.9)
65 FOOT CIRCUMFERENCE	22.9 (9.0)	20.5 (8.1)	27.3 (10.7)	24.2 (9.5)
66 HEEL-ANKLE CIRCUMFERENCE	31.3 (12.3)	28.1 (11.1)	36.9 (14.5)	33.0 (13.0)

* Data for males were compiled from the 1966 survey of U.S. Army Men, the 1966 survey of U.S. Marines, and the 1965 survey of U.S. Air Force Men. Data for females were compiled from the 1977 survey of U.S. Army Women and the 1968 survey of U.S. Air Force Women.

B. ARMY PILOTS

Percentile Values in Centimeters (Inch Equivalents in Parentheses)	5th Percentile		95th Percentile	
	Male	Female	Male	Female
57 HAND LENGTH	18.1 (7.1)	17.2 (6.8)	20.9 (8.2)	19.5 (7.7)
59 HAND BREADTH	8.4 (3.3)	7.5 (3.0)	9.7 (3.8)	8.6 (3.4)
60 HAND CIRCUMFERENCE	19.9 (7.8)	17.6 (6.9)	22.8 (9.0)	20.1 (7.9)
62 FOOT LENGTH	25.0 (9.8)	23.2 (9.1)	28.9 (11.4)	26.5 (10.4)
63 INSTEP LENGTH	18.2 (7.2)	17.0 (6.7)	21.4 (8.4)	19.6 (7.7)
64 FOOT BREADTH	9.2 (3.6)	8.4 (3.3)	10.8 (4.3)	9.8 (3.9)
65 FOOT CIRCUMFERENCE	23.1 (9.1)	21.0 (8.3)	26.9 (10.6)	24.4 (9.6)
66 HEEL-ANKLE CIRCUMFERENCE	31.3 (12.3)	28.9 (11.4)	36.4 (14.3)	32.7 (12.9)

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TABLE XVII. HAND AND FOOT DIMENSIONS (concluded)

C. AIR FORCE PILOTS

	Percentile Values in Centimeters (Inch Equivalents in Parentheses)			
	5th Percentile		95th Percentile	
	Male	Female	Male	Female
57 HAND LENGTH	17.8 (7.0)	17.6 (6.9)	20.5 (8.1)	20.4 (8.0)
58 PALM LENGTH	10.0 (3.9)		11.8 (4.6)	
59 HAND BREADTH	8.2 (3.2)	7.1 (2.8)	9.6 (3.8)	8.3 (3.3)
60 HAND CIRCUMFERENCE	20.0 (7.9)	17.2 (6.8)	23.1 (9.1)	19.9 (7.8)
61 HAND THICKNESS	2.4 (0.9)		3.1 (1.2)	
62 FOOT LENGTH	25.1 (9.9)	23.2 (9.1)	29.0 (11.4)	26.3 (10.4)
63 INSTEP LENGTH	18.3 (7.2)		21.4 (8.4)	
64 FOOT BREADTH	9.0 (3.5)	8.2 (3.2)	10.6 (4.2)	9.9 (3.9)
65 FOOT CIRCUMFERENCE	22.9 (9.0)		27.0 (10.6)	
66 HEEL-ANKLE CIRCUMFERENCE	31.7 (12.5)		36.3 (14.3)	

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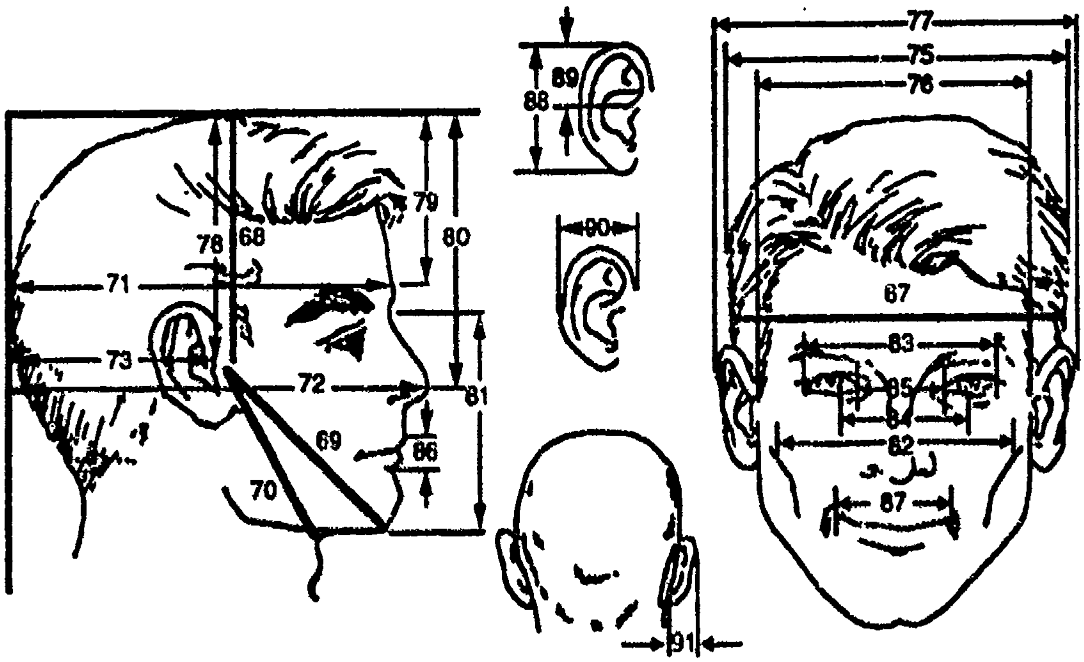

FIGURE 28. Head and face dimensions

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TABLE XVIII. HEAD AND FACE DIMENSIONS

A. GENERAL FORCES

Percentile Values in Centimeters (Inch Equivalents in Parentheses)				
	5th Percentile		95th Percentile	
	Male	Female	Male	Female
67 HEAD CIRCUMFERENCE	53.6 (21.1)	52.3 (20.6)	59.7 (23.5)	57.6 (22.7)
68 BITRAGION-CORONAL CURVATURE	33.2 (13.1)	31.6 (12.4)	38.0 (15.0)	36.3 (14.3)
69 BITRAGION-MENTON CURVATURE	30.4 (12.0)	28.2 (11.1)	34.8 (13.7)	32.6 (12.8)
70 BITRAGION-SUBMANDIBULAR CURVATURE	27.8 (10.9)	25.6 (10.1)	33.0 (13.0)	29.7 (11.7)
71 HEAD LENGTH	18.3 (7.2)	17.3 (6.8)	21.0 (8.3)	19.8 (7.8)
72 PRONASALE TO WALL	20.5 (8.1)	19.7 (7.8)	23.6 (9.3)	22.9 (9.0)
73 TRAGION TO WALL	8.6 (3.4)	8.6 (3.4)	12.6 (5.0)	11.8 (4.6)
75 HEAD BREADTH	14.3 (5.6)	13.5 (5.3)	16.5 (6.5)	15.5 (6.1)
76 BITRAGION BREADTH	12.6 (5.0)	12.1 (4.8)	15.5 (6.1)	14.5 (5.7)
77 BIAURICULAR BREADTH	17.4 (6.9)	14.2 (5.6)	21.0 (8.3)	19.5 (7.7)
78 HEAD HEIGHT (TRAGION TO TOP OF HEAD)	12.1 (4.8)	11.3 (4.4)	14.5 (5.7)	14.1 (5.6)
79 GLABELLA TO TOP OF HEAD	7.6 (3.3)	7.7 (3.0)	10.8 (4.3)	10.0 (3.9)
80 PRONASALE TO TOP OF HEAD	13.8 (5.4)	12.8 (5.0)	16.6 (6.5)	16.8 (6.6)
81 FACE LENGTH (MENTON-SELLION)	10.7 (4.2)	9.6 (3.8)	13.3 (5.2)	12.4 (4.9)
82 FACE (BIZYGOMATIC) BREADTH	13.1 (5.2)	11.9 (4.7)	15.0 (5.9)	14.0 (5.5)
83 BIOCULAR BREADTH	11.3 (4.4)	11.1 (4.4)	13.1 (5.2)	12.9 (5.1)
84 INTERPUPILLARY BREADTH	5.4 (2.1)	5.1 (2.0)	7.1 (2.8)	6.9 (2.7)
87 LIP LENGTH (MOUTH BREADTH)	4.4 (1.7)	3.7 (1.5)	6.3 (2.5)	6.2 (2.4)
89 EAR LENGTH ABOVE TRAGION	2.5 (1.0)	2.5 (1.0)	3.6 (1.4)	3.3 (1.3)
90 EAR BREADTH	3.2 (1.3)	2.4 (0.9)	4.2 (1.7)	3.9 (1.5)
91 EAR PROTRUSION	1.7 (0.7)	1.7 (0.7)	3.0 (1.2)	2.7 (1.1)

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TABLE XVIII. HEAD AND FACE DIMENSIONS (continued)

B. ARMY PILOTS

Percentile Values in Centimeters (Inch Equivalents in Parentheses)				
	5th Percentile		95th Percentile	
	Male	Female	Male	Female
67 HEAD CIRCUMFERENCE	54.8 (21.6)	52.6 (20.7)	59.2 (23.3)	56.8 (22.4)
68 BITRAGION-CORONAL CURVATURE	33.3 (13.1)	31.7 (12.5)	37.3 (14.7)	35.8 (14.1)
69 BITRAGION-MENTON CURVATURE	31.0 (12.2)	28.3 (11.1)	34.9 (13.7)	32.0 (12.6)
70 BITRAGION-SUBMANDIBULAR CURVATURE	28.8 (11.3)	25.8 (10.2)	33.1 (13.0)	29.9 (11.8)
71 HEAD LENGTH	18.8 (7.4)	17.6 (6.9)	20.9 (8.2)	19.8 (7.8)
72 PRONASALE TO WALL	20.9 (8.2)	19.9 (7.8)	23.2 (9.1)	22.3 (8.8)
73 TRAGION TO WALL	9.1 (3.6)	8.8 (3.5)	10.8 (4.3)	10.6 (4.2)
75 HEAD BREADTH	14.5 (5.7)	13.8 (5.4)	16.3 (6.4)	15.3 (6.0)
76 BITRAGION BREADTH	13.5 (5.3)	12.8 (5.0)	15.4 (6.1)	14.5 (5.7)
77 BIAURICULAR BREADTH	17.9 (7.0)	16.7 (6.6)	21.1 (8.3)	19.7 (7.8)
78 HEAD HEIGHT (TRAGION TO TOP OF HEAD)	12.1 (4.8)	11.6 (4.6)	13.9 (5.5)	13.5 (5.3)
79 GLABELLA TO TOP OF HEAD	8.6 (3.4)	7.8 (3.1)	10.9 (4.3)	10.1 (4.0)
80 PRONASALE TO TOP OF HEAD	14.0 (5.5)	13.1 (5.2)	16.5 (6.5)	15.8 (6.2)
81 FACE LENGTH (MENTON-SELLION)	11.2 (4.4)	10.5 (4.1)	13.2 (5.2)	12.5 (4.9)
82 FACE (BIZYGOMATIC) BREADTH	13.3 (5.2)	12.3 (4.8)	15.1 (5.9)	14.0 (5.5)
83 BIOCULAR BREADTH	11.4 (4.5)	11.0 (4.3)	13.0 (5.1)	12.7 (5.0)
84 INTERPUPILLARY BREADTH	5.9 (2.3)	5.6 (2.2)	7.0 (2.8)	6.6 (2.6)
87 LIP LENGTH (MOUTH BREADTH)	5.1 (2.0)	4.8 (1.9)	6.3 (2.5)	6.0 (2.4)
89 EAR LENGTH ABOVE TRAGION	2.8 (1.1)	2.6 (1.0)	3.6 (1.4)	3.3 (1.3)
90 EAR BREADTH	3.4 (1.3)	3.1 (1.2)	4.2 (1.7)	3.9 (1.5)
91 EAR PROTRUSION	2.0 (0.8)	1.7 (0.7)	3.0 (1.2)	2.8 (1.1)

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TABLE XVIII. HEAD AND FACE DIMENSIONS (concluded)

C. AIR FORCE PILOTS

Percentile Values in Centimeters (Inch Equivalents in Parentheses)				
	5th Percentile		95th Percentile	
	Male	Female	Male	Female
67 HEAD CIRCUMFERENCE	55.2 (21.7)	52.9 (20.8)	59.9 (23.6)	57.9 (22.8)
68 BITRAGION-CORONAL CURVATURE	33.7 (13.3)	32.0 (12.6)	37.9 (14.9)	36.7 (14.4)
69 BITRAGION-MENTON CURVATURE	30.6 (12.0)		34.7 (13.7)	
70 BITRAGION-SUBMANDIBULAR CURVATURE	28.4 (11.2)		33.6 (13.2)	
71 HEAD LENGTH	18.8 (7.4)	17.5 (6.9)	21.0 (8.3)	19.7 (7.8)
72 PRONASALE TO WALL	21.4 (8.4)	20.0 (7.9)	23.9 (9.4)	23.0 (9.1)
73 TRAGION TO WALL	9.3 (3.7)	9.0 (3.5)	11.4 (4.5)	11.9 (4.7)
75 HEAD BREADTH	14.7 (5.8)	13.8 (5.4)	16.5 (6.5)	15.5 (6.1)
76 BITRAGION BREADTH	13.4 (5.3)	12.2 (4.8)	15.2 (6.0)	13.8 (5.4)
77 BIAURICULAR BREADTH	17.5 (6.9)	14.4 (5.7)	20.2 (8.0)	17.5 (6.9)
78 HEAD HEIGHT (TRAGION TO TOP OF HEAD)	12.4 (4.9)	11.7 (4.6)	14.5 (5.7)	14.2 (5.6)
79 GLABELLA TO TOP OF HEAD	7.7 (3.0)		10.9 (4.3)	
80 PRONASALE TO TOP OF HEAD	13.0 (5.1)	13.3 (5.2)	16.6 (6.5)	17.1 (6.7)
81 FACE LENGTH (MENTON-SELLION)	11.0 (4.3)	9.8 (3.9)	13.0 (5.1)	11.8 (4.6)
82 FACE (BIZYGOMATIC) BREADTH	13.4 (5.3)	12.0 (4.7)	15.1 (5.9)	13.8 (5.4)
83 BIOCULAR BREADTH	8.4 (3.3)	9.0 (3.5)	10.0 (3.9)	10.6 (4.2)
84 INTERPUPILLARY BREADTH	5.7 (2.2)		6.9 (2.7)	
85 INTEROCULAR BREADTH	2.9 (1.1)		3.3 (1.3)	
86 LIP TO LIP LENGTH	1.1 (0.4)		2.3 (0.9)	
87 LIP LENGTH (MOUTH BREADTH)	4.6 (1.8)	3.7 (1.5)	5.8 (2.3)	5.1 (2.0)
88 EAR LENGTH	5.9 (2.3)	4.5 (1.8)	7.3 (2.9)	5.9 (2.3)
89 EAR LENGTH ABOVE TRAGION	2.6 (1.0)		3.5 (1.4)	
90 EAR BREADTH	3.3 (1.3)	2.4 (0.9)	4.3 (1.7)	3.5 (1.4)
91 EAR PROTRUSION	1.7 (0.7)		2.8 (1.1)	

Supersedes page 143 of 14 March 1989

5.6.3 Use of Data.

5.6.3.1 Data limitations. Because the anthropometric data presented here represent nude body measurements, suitable allowances shall be made for light or heavy clothing, flying suits, helmets, boots, body armor, load-carrying equipment, protective equipment, and other worn or carried items, when utilizing these data for design criteria.

5.6.3.2 Clearance dimensions. Clearance dimensions (e.g., for passageways and accesses), which must accommodate or allow passage of the body or parts of the body, shall be based upon the 95th percentile values for applicable body dimensions.

5.6.3.3 Limiting dimensions. Limiting dimensions (reaching distance, control movement, displays, test points, handrails, etc.) which restrict or are limited by extensions of the body shall be based upon the 5th percentile values for applicable body dimensions.

5.6.3.4 Adjustable dimensions. Seats, restraint systems, safety harnesses, belts, controls or any equipment that must be adjusted for the comfort or performance of the individual user shall be adjustable over the range of the 5th to 95th percentile values for the applicable body member(s).

5.6.3.5 Clothing and personal equipment. Clothing and personal equipment (including protective or specialized equipment worn or carried by the individual) shall be designed and sized to accommodate at least the 5th through the 95th percentile values of body dimensions. Pertinent dimensions of essential or critical equipment (e.g., aviators' helmets) shall be based on the lst and 99th percentile values. Where two or more dimensions are used simultaneously as design parameters, appropriate multivariate data and techniques shall be utilized. (See appendix for representative references.)

5.6.4 Special populations. Where equipment will be used, inclusively or exclusively, by selected or specialized segments of the military population (e.g., Army tank crews, Navy divers, etc.) or population ranges other than the 5 - 95th percentiles (e.g., disproportionate anthropometric accommodation test cases), appropriate available anthropometric data on these specialized populations, contained in DOD-HDBK-743, shall be utilized for design and sizing criteria. Where equipment is intended for use by foreign military personnel, appropriate anthropometric data on such populations shall be utilized for design and sizing criteria. (See appendix for representative references.)

5.11 Small systems and equipment.

5.11.1 Portability and load carrying. Individual portions of equipment shall be designed so that, when carried, the weight of the load will be distributed through as many muscle groups as possible. Pressure should be avoided or minimized on sensitive areas, including large blood vessels, nerves and areas lacking muscular padding. Design of load-carrying systems shall consider the weight and distribution of individual items to be carried by the user. The weight of the items to be carried varies according to the climatic zone, mission to be performed, and occupational specialty. See Table XXVI for weights of representative individual items that an infantry rifleman carries in temperate hot weather areas. Load carrying systems shall be provided with a quick-release capability. In general, portable refers to an item that is carried a distance of no more than 2 km (1.24 miles). For items to be carried up to 10 meters (33 ft.), see paragraphs 5.9.11.3.5, 5.9.11.3.6, and 5.9.11.3.7.

5.11.1.1 Portability.

5.11.1.1.1 Weight. Individual portions of equipment may weigh up to 16 kg (35 lb) if the load is balanced and is distributed over many muscle groups and it is not necessary for the individual carrying the load to maintain the pace of an infantry movement.

5.11.1.1.2 Lifting aids. When necessary, lifting aids shall be provided to permit a second person to assist the porter in placing the load on the body.

5.11.1.1.3 Configuration. The load should be designed to permit freedom of movement. The shape of the load should be free of sharp edges or projections that may be harmful to the porter or snag on undergrowth. The shape and weight of the load should not interfere with:

a. The length of step.

b. Movements of the head.

c. The ability to raise and lower the load when going over obstacles.

d. The ability to see where the feet are placed when walking.

e. The ability to squat.

f. Regulation of body temperature.

g. The maintenance of normal posture.

5.11.1.1.4 Carrying by two persons. Where the load is designed for carrying by two persons, a combination of stretcher type handles and shoulder support should be used, if feasible.

5.11.1.1.5 Standardization. Maximum use should be made of standard load carrying systems or components.

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TABLE XXVIII. TYPICAL FIGHTING AND EXISTENCE LOADS (TEMPERATE ZONE)

LOAD	APPROXIMATE WEIGHT KILOGRAMS	POUNDS
FIGHTING LOAD		
CLOTHING:		
PASGT Helmet	1.36	3.00
Battle Dress Uniform	1.73	3.81
PASGT Vest	3.86	8.50
Underwear (Summer) and Socks	0.27	0.60
Belt; waist, web w/buckle	0.09	0.20
Boots, leather (DMS)	1.52	3.36
	8.83	19.47
EQUIPMENT:		
Rifle M16A1 w/30 rd magazine and sling	3.59	7.91
Ammunition pouches (2 ea) w/180 rounds in 6 magazines	3.21	7.07
Hand grenades 2 ea	0.91	2.00
LAW 2 ea or ILAW 1 ea	3.86	8.50
Canteen 1 qt. filled w/cup and cover	1.63	3.60
Water purification tablets	0.03	0.06
Individual equipment belt, first aid packet w/case and suspenders	0.72	1.59
Intrenching tool w/carrier	1.14	2.52
Bayonet M7 w/scabard	0.59	1.30
Mask CB Protective w/hood	1.35	2.97
Poncho	0.77	1.70
	17.80	39.22
EXISTENCE LOAD:		
ALICE Pack medium w/straps	1.12	2.46
Chemical Protective overgarment w/gloves and boots	2.61	5.75
Cap, utility	0.10	0.22
Underwear and socks, 2 ea	0.54	1.20
Personal Hygiene Kit	1.20	2.64
Rations MRE 3 ea	1.33	2.94
Bag, Sleeping, intermediate cold	3.40	7.50
Mattress, pneumatic insulated	1.59	3.50
Jacket Field, 1 ea w/gloves, leather w/wool insert 1 pr	1.94	4.28
Bag, waterproof 1 ea	0.34	0.75
	14.17	31.24

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5.13.7.3.2 Fluid and fuel servicing equipment. Automatic shutoff devices shall be provided on fluid and fuel service equipment to prevent overflow and spillage.

5.13.7.4 Toxic hazards.

5.13.7.4.1 General. Personnel shall not be exposed to the concentrations of toxic substances in excess of the limits specified in either the Department of Defense (DoD) Occupational Safety and Health (OSH) standards or specialized standards applicable to military unique equipment, systems or operations.

5.13.7.4.2 Carbon monoxide. Carbon monoxide in personnel areas shall be reduced to the lowest level feasible. Personnel shall not be exposed to concentrations of carbon monoxide (CO) in excess of values which will result in carboxyhemoglobin (COHb) levels in their blood greater than the following percentages: 5% COHb (all system design objectives and aviation system performance limits); 10% COHb (all other system performance limits). It is acceptable to estimate COHb blood levels in personnel by solving the empirical equation given in paragraph 3.7.5 of MIL-HDBK-759A. When using the equations to estimate the percent COHb blood levels for combat vehicle occupants, the following work stress levels (defined by MIL-HDBK-759A) shall be applied as appropriate: activities involving weapons fire - level 4; all other mission activities - level 3. An initial value of COHbo=1.0% shall be assumed for all estimates.

5.13.7.5 Radiation. Radiation emitting systems and equipment require special consideration to minimize hazards to operators and maintenance personnel. Ionizing radiation exposure rates produced by any device shall not exceed 0.5 milliroentgens/hr at a distance of 50 mm (2") from any point on the external surface. Microwave, radio frequency, X and laser radiation limits shall conform to those specified in Requirement 1, MIL-STD-454. Definitive and specific data should be obtained from the service agency responsible for control of personnel exposure to radiation.

5.13.7.5 Trainers. Training materials, devices, simulators and other systems utilizing embedded training, should incorporate appropriate safety safeguards, warnings and other procedures developed during the material design process.

5.13.9 Stealth and covert operations. Systems and equipment designed for use in combat may require stealth for covert operations. The need for low-observable exterior and camouflage may preclude the use of brightly colored warning signs, warning lights and/or auditory alarms. For such systems and equipment, emphasis must be placed on barriers, interlocks and other techniques which insure safe operations.

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10 SCOPE

The documents listed in this appendix provide supplementary information, criteria and guidance that may be used, as applicable, to assist the designer in complying with the requirements of this standard. Their application is not to be regarded as mandatory, unless so specified by the procuring activity.

20 TRI-SERVICE PUBLICATIONS

MIL-HDBK-761	Human Engineering Guidelines for Management Information Systems
DOD-HDBK-763	Human Engineering Procedures Guide
MIL-H-46855	Human Engineering Requirements for Military Systems, Equipment, and Facilities
MIL-HDBK-141	Optical Design
TB MED 81 NAVMED P-5052-29 AFR 161-11	Cold Injury
CSC-STD-002-85	Department of Defense Password Management Guide (Fort George G. Meade, MD: Department of Defense Security Center.)
MIL-STD-1474	Noise Limits for Military Materiel

30 ARMY PUBLICATIONS

30.1 Regulations

AR 40-10	Health Hazard Assessment Program in Support of the Army Materiel Acquisition Decision Process
AR 40-14	Control and Recording Procedures, Occupational Exposure to Ionizing Radiation
AR 385-16	Safety for Systems, Associated Subsystems and Equipment
AR 700-52	Licensing and Control of Sources of Ionizing Radiation

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30.2 Pamphlets & Bulletins

AMCP 706-134	Maintainability Guide for Design (AD 823 539)
DA PAM 40-501	Hearing Conservation
TB MED 521	Diagnostic X-Ray, Therapeutic X-Ray, and Gamma Beam Protection for Energies up to 10 Million Electron Volts
TB MED 270	Control of Hazards to Health from Microwave Radiation
TB MED 279	Control of Hazards to Health from Laser Radiation
TB MED 288	Medical Problems of Man at High Terrestrial Elevations
TB MED 508	Cold Injury

30.3 Design Criteria Handbook

MIL-HDBK-759	Human Factors Engineering Design for Army Materiel
DOD-HDBK-743	Military Handbook, Anthropometry of U.S. Military Personnel
DOD-HDBK-761	Human Engineering Guide for Management Information Systems

30.4 Reports

AVSCOM Rept 75-47	Study to Determine the Impact of Aircrew Anthropometry on Airframe Configuration
Natick Laboratories TR EPT-2	Reference Anthropometry of the Arctic Equipped Soldier (AD 449 4831)
Natick Laboratories TR 73-51-CE	The Carrying of Loads within an Infantry Company (AD 762 559)
Natick RDEC TR 89/040	1988 Anthropometric Survey of U.S. Army Personnel Methods and Summary Statistics (AD A225094)
USAAMRDL TR 71-22	Crash Survival Design Guide (Revised 1971)
USAHEL TM 4-77	A Human Factors Evaluation of a Vertical Scale Instrument Display System for the OV-1D Aircraft (AD A03 6050)

40 NAVY PUBLICATIONS

40.1 Manual

NAVAIR 00-807-99	U.S. Naval Aerospace Physiologist's Manual, 1972

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40.2 Reports

NATC Rept TM 77-1 SY	Analysis of Flight Clothing Effects on Aircrew Station Geometry (AD AO46260)
NAMRL Report 1164	Empirical Reduction in Potential user Population as the Result of Imposed Multivariate Anthropometry Limits (AD 752 032)
NAVMISCEN Report TP-74-6	Reduction in Potential user Population as the Result of Imposed Anthropometry Limits: Monte Carlo Estimation (AD 919 319L)
NAVSHIPS 94323	Human Engineering Guidelines for Maintainability
NEL Report 688	Listening to Differentially Filtered Competing Voice Messages
NRL Report 155	Premodulation Speech Clipping and Filtering: Their Effects on the Intelligibility of Speech
PACMISTESTCEN Report TM-75-46	The Accommodated Population of a Potential User Population: Compilation and Comparisons of Methods for Estimation
PACMISTESTCEN Report TP-75-49	Computerized Accommodated Percentage (CAPE) Model for Cockpit Analysis and other Exclusion Studies (AD B008 948L)
PACMISTESTCEN Report TP-76-1	Improved Seat, Console and Workplace Design (AD AO40 479)
PACMISTESTCEN Report TP-76-36	Recommended Human Exposure Limits for Very-Low-Frequency Vibration
PACMISTESTCEN Report TP-76-46	Computerized Accommodated Percentage (CAPE): Review and Prospectus (AD AO35 205)

40.3 Notes

NAVMEDNOTE 6260	Hazardous Noise Areas, Equipment, Machine and Tools; Identification of

50 AIR FORCE PUBLICATIONS

50.1 Manuals

AFM 127-201	Missile Safety Handbook
AFP 160-6-7	Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radio-Nuclides in Air and Water for Occupational Exposure

50.2 Reports

AFFDL-TDR-64-86	Investigation of Aerospace Vehicle Crew Station Criteria (AD 452 187)
AFSWC TR 59-11	Human Factors Handbook for Design of Transporting, Positioning, and Lifting Ground Support Equipment (AD 227 311)
AFSWC TR 59-12	Human Factors Handbook for Design of Testing and Monitoring Ground Support Equipment (AD 227 312)
AFSWC TR 59-13	Human Factors Handbook for Design of Protective and Storage Ground Support Equipment (AD 227 313)
AMRL TDR 64-59	Reach Capability of the USAF Population (AD 608269)
AMRL TR 65-73	Anthropometry of Common Working Positions (AD 632 241)
AMRL TR 66-27	Aperture Sizes and Depths of Reach for One and Two-Handed Tasks (AD 646 716)
AMRL TR 68-24	Clearance and Performance Values for the Bare-Handed and the Pressure-Gloved (AD 681 457)
AMRL TR 69-6	Anthropometric Dimensions of Air Force Pressure-Suited Personnel for Workspace and Design Criteria (AD 697 022)
AMRL TR 70-114	Horizontal Static Forces Exerted by Men Standing in Common Working Positions on Surfaces of Various Tractions (AD 720 252)
ASD TR 54-520	The Anthropometry of Work Positions (AD 110 573)
ASD TR 56-218	Guide to the Design of Electronic Equipment for Maintainability (AD 101 729)
ASD TN 57-248	Acoustical Criteria for Work Spaces, Living Quarters, and Other Areas on Air Bases (AD 130 839)
ASD TR 61-381	Guide to the Design of Mechanical Equipment for Maintainability (AD 269 332)
ASD TR 61-424	Guide to Integrated System Design for Maintainability (AD 271 477)
ESD TDR 62-4	A Test of the 20 Band and Octave Band Methods of Computing the Articulation Index (AD 271 606)

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ESD-TR-63-403	Psychoacoustic Speech Test: A Modified Rhyme Test (AD 411 983)
ESD TR 86-278	Guidelines for Designing User Interface Software (AD-A 177 198)
RADC-TDR-62-315	Criteria for Group Display Chains for The 1962-1965 Time Period (AD 283 390)
WADC TR 52-204	Handbook of Acoustic Noise Control (AD 018 260 and AD 012 015)
WADC TR 55-159	Space Requirements of the Seated Operator (AD 087 892)
WADC TR 58-474	The Effect of Team Size and Intermember Communication on decision-Making Performance (AD 215 621)
WADD TR 60-814	Audio Warning Signals for Air Force Weapon Systems (AD 258 477)

50.3 Air Force Systems Command Design Handbooks

Copies of Air Force Systems Command design criteria handbooks may be obtained by nongovernmental organizations when compliance therewith is required by a Government contract, or when possession of the handbook will otherwise benefit the Government. Requests for the following handbooks should be directed to 4950/TZHM, Wright-Patterson AFB, OH 45433:

AFSC DH 1-1	General Index and Reference
AFSC DH 1-3	Human Factors Engineering
AFSC DH 1-6	System Safety
AFSC DH 2-1	Airframe
AFSC DH 2-2	Crew Stations and Passenger Accommodations
AFSC DH 2-3	Propulsion and Power
AFSC DH 2-6	Ground Equipment and Facilities

60 NATIONAL AERONAUTICS AND SPACE ADMINISTRATION PUBLICATIONS

60.1 Standards

Copies of the following documents can be obtained by qualified requesters from MSIS Custodian/SP34, NASA-Johnson Space Center, Houston, TX 77058

Supersedes page 285 of 14 March 1989

NASA-STD-3000, Volume I Man-Systems Integration Standards

NASA-STD-3000, Volume II Man-Systems Integration Standards-Appendices

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60.2 Book

Copies of the following documents can be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington DC 20402

NASA SP-3006	Bioastronautics Data Book, Second Edition, J.F. Parker and V.R. West, eds.

70 VOLUNTARY STANDARDS AND GUIDES

70.1 American National Standards Institute (ANSI)

Copies of the following standards can be obtained at a nominal cost from the ANSI, 1440 Broadway, New York, New York 10018.

ANSI A12.1	Floor and Wall Openings, Railings, and Toeboards, Safety Requirements for
ANSI A14.3	Ladders-Fixed-Safety Requirements
ANSI C2	national Electrical Safety Code (NBS H30)
ANSI S1.11	Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters (ASA 65)
ANSI Z136.1	Safe use of Lasers

70.2 American Society for Testing and Materials. Copies of the following documents can be obtained at a nominal cost from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM F 1166-8	Standard Practice for Human Engineering Design Criteria for Marine Systems, Equipment and Facilities.

70.3 American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Copies of the following documents can be obtained at a nominal cost from the ASHRAE, 1791 Tullie Circle, NE, Atlanta, GA 30329.

ASHRAE 55-81	Thermal Environmental Conditions for Human Occupancy
ASHRAE 62-81	Ventilation for Acceptable Indoor Air Quality Guide and Data Book (latest edition)

70.4 Illuminating Engineering Society (IES) of North America. Copies of the following document can be obtained at a nominal cost from the IES, 345 East 47th Street, New York, NY 10017.

IES Lighting HDBK	SEC 9 Application-87, Industrial Lighting

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METRIC

NOTICE OF CHANGE

MIL-STD-1472D
NOTICE 3
10 February 1994

MILITARY STANDARD
HUMAN ENGINEERING DESIGN CRITERIA FOR MILITARY
SYSTEMS, EQUIPMENT AND FACILITIES

TO ALL HOLDERS OF MIL-STD-1472D:

1. THE FOLLOWING PAGES OF MIL-STD-1472D HAVE BEEN REVISED AND SUPERSEDED THE PAGES LISTED:

NEW PAGE	DATE	SUPERSEDED PAGE	DATE
5	10 February 1994	5	14 March 1989
6	10 February 1994	6	14 March 1989
7	10 February 1994	7	20 March 1991
8	14 March 1989	8	REPRINTED WITHOUT CHANGE
11	10 February 1994	11	14 March 1989
12	10 February 1994	12	14 March 1989
61	10 February 1994	61	14 March 1989
62	10 February 1994	62	14 March 1989
123	10 February 1994	123	14 March 1989
124	10 February 1994	124	14 March 1989
127	10 February 1994	127	14 March 1989
128	14 March 1989	128	REPRINTED WITHOUT CHANGE
136a	30 June 1992	136a	DELETE
233	10 February 1994	233	14 March 1989
234	10 February 1994	234	14 March 1989
285	10 February 1994	285	30 June 1992
286	10 February 1994	286 288	14 March 1989

2. MAKE THE FOLLOWING PEN AND INK CHANGES:

a. Page 13, para 3.45, second line, change "paragraph 4" to "paragraph 6."

b. Page 16, para 3.72, third line: Change "on-set" to "onset."

AMSC N/A AREA HFAC

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

c. Page 18, para 4.4.g., first line: Change "insuring" to "ensuring."

d. Page 24, para 5.1.4, change "Control display movement ratio" to "Control/display movement ratio."

e. Page 27, para 5.2.1.1, third line: Delete "his."

f. Page 28, para 5.2.1.3.1, third line: Change "that which is" to "information."

g. Page 29, para 5.2.1.4.4, fifth line: Change "insure" to "ensure."

h. Page 32, para 5.2.1.4.12, third line: Change "never be" to "be not."

i. Page 32, para 5.2.1.5.2, second line: Delete "coding."

j. Page 35, para 5.2.2.1.17, third line: Change "insure" to "ensure."

k. Page 35, para 5.2.2.1.18e., third line: Delete "etc."

l. Page 36, para 5.2.2.1.19, first line: Change "indicator" to "display."

m. Page 41, para 5.2.3.1.10.1, third line: Change to read, "level, caution, undesirable <u>condition</u> and inefficient <u>operation</u>."

n. Page 41, para 5.2.3.2, change "indicators" to "displays."

o. Page 46, para 5.2.3.3.3, 4th line: Delete "space before bat."

p. Page 65, para 5.3.12.1.a., second line: Change "S3.2-1960" to "ANSI S3.2".

para 5.3.12.1.c., third line: Delete "-1969".

q. Page 71, para 5.4.1.4.3, fifth and sixth lines: Change "not be" to "be not."

r. Page 72, para 5.4.1.8.1, fourth line: Change "degredation" to "degradation" and "functions" to "performance."

s. Page 73, para 5.4.1.8.4.f, third line: Add "is" after "control."

t. Page 73, para 5.4.1.8.5, second line: Add "or input" after "force."

u. Page 75, para 5.4.2.1.2.1, second line: Change "go no-go" to "go/no-go."

v. Page 91, figure 11, change "9.5" to "10".

w. Page 94, para 5.4.3.1.4.1, fourth line: Edit to read "...control or legend switch control is not feasible or when the toggle...".

x. Page 99, para 5.4.3.1.7.3, third line: Delete third line.

y. Page 113, para 5.4.3.2.5.1, fourth line: Delete "etc."

z. Page 175, para 5.8.3.2, third line: Add "DA PAM 40-501" after "5100.238".

aa. Page 177, para 5.8.3.4.3, third line: Delete ", as defined by ANSI S1.1,"

bb. Page 193, para 5.9.11.3.3, second line: Change "XXIV" to "XXIII."

cc. Page 237, Change "5.13.7.5 Trainers" to "5.13.8 Trainers".

3. RETAIN THIS NOTICE AND INSERT BEFORE TABLE OF CONTENTS.

4. Holders of MIL-STD-1472D will verify that page changes and additions indicated above have been entered. These notice pages will be retained as a separate check list. This issuance, together with appended pages, is a separate publication. Each notice is to be retained by stocking points until the military standard is completely revised or cancelled.

Custodians:
Army - MI
Navy - AS
Air Force - 11

Preparing activity:
Army - MI

(Project HFAC-0058)

Review activities:
Army - AR, AT, AV, CR, ER, GL, ME, MD, MR, TE, TM, EA
Navy - EC, MC, MS, OS, PE, SH, TD
Air Force - 13, 14, 19, 26

User activities:
Army - AL
Navy - YD

Civilian agencies:
NASA - MSFC
DOT - RDS

MIL-STD-783	Legends for Use in Aircrew Stations and on Airborne Equipment
MIL-STD-850	Aircrew Station Vision Requirements for Military Aircraft
MIL-STD-1179	Lamp, Reflectors and Associated Signalling Equipment for Military Vehicles
MIL-STD-1180	Safety Standards for Military Ground Vehicles
MIL-STD-1247	Markings, Functions and Hazard Designations of Hose, Pipe, and Tube lines for Aircraft, Missile and Space Systems
MIL-STD-1280	Keyboard Arrangements
MIL-STD-1294	Acoustical Noise Limits in Helicopters
MIL-STD-1333	Aircrew Station Geometry for Military Aircraft
MIL-STD-1348	Knobs, Control, Selection of
MIL-STD-1473	Standard General Requirements for Color and Marking of Army Materiel
MIL-STD-1474	Noise Limits for Military Materiel
MIL-STD-1787	Aircraft Display Symbology

HANDBOOKS

MILITARY

DOD-HDBK-743	Anthropometry of US Military Personnel
MIL-HDBK-759	Human Factors Engineering Design for Army Materiel

(Unless otherwise indicated, copies of federal and military specifications, standards and handbooks are available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.1.2 Other Government documents, drawings, and publications. The following other government documents, drawings and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

PUBLICATIONS

ARMY

DA PAM 40-501 - Hearing Conservation

NAVY

OPNAVINST 5100.23B Hearing Conservation Program

AIR FORCE

AFR 161-35 - Hazardous Noise Exposure (Regulation)

FEDERAL REGULATION

29 CFR 1910 - Occupational Safety and Health Standards

(Copies of other government documents, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Non-Government publications. The following document(s) form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

Human Engineering Guide to Equipment Design, 1972 Edition

(Application for copies should be addressed to the Superintendent of Documents, US Government Printing Office, Washington, DC 20402)

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS (ACGIH)

Threshold Limit Values

(Application for copies should be addressed to the ACGIH Inc., 6500 Glenway Ave. Bldg. D-7, Cincinnati, OH 45211)

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI S1.4 Sound Level Meters (ASA 47)

ANSI S1.6 Preferred Frequencies and Band Numbers for Acoustical Measurements (ASA 53)

ANSI S3.2 Method for Measuring the Intelligibility of Speech Over Communication Systems (ASA 85)

ANSI S3.5 Articulation Index, Methods for the Calculation of.

(Application for copies of ANSI S1.4, S1.6, and S3.2 (ASA 47, 53 and 85) should be addressed to Professional Book Distributors, Inc., ASA Standards Distribution Center, 1650 Bluegrass Lake Parkway, P.O. Box 6996, Alpharetta, GA 30239-6996. Application for copies of other ANSI standards should be addressed to the American National Standards Institute, Inc., 11 West 42nd Street, New York, NY 10036.)

AMERICAN SOCIETY OF TESTING AND MATERIALS (ASTM)

ASTM E 380	Metric Practice, Standard for

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103)

HUMAN FACTORS AND ERGONOMICS SOCIETY (HFES)

ANSI/HFS 100	American National Standard for Human Factors Engineering of Visual Display Terminal Workstations

(Application for copies should be addressed to the Human Factors and Ergonomics Society, Inc., P.O. Box 1369, Santa Monica, CA 90406)

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO DIS 2631	Guide to the Evaluation of Human Exposure to Whole Body Vibration

(Application for copies should be addressed to the American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

SAE J925	Minimum Access Dimensions for Construction and Industrial Machinery

(Application for copies should be addressed to the Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096-0001)

(Non-Government standards an other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of preference. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, superseded applicable laws and regulation unless a specific exemption has been obtained.

Supersedes page 7 of 20 March 1991

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3.22 Dialogue. A structured series of interchanges between a use and a computer terminal. Dialogues can be computer initiated, e.g., question and answer, or user initiated, e.g., command languages.

3.23 Dichotic. The condition in which the sound stimulus presented at one ear differs from the sound stimulus presented at th other ear. The stimulus may differ in sound pressure, frequency, phase, time, duration, or bandwidth or other characteristics.

3.24 Display format. The organization of different types of data in a display, including information about the data such as labels, and other user guidance such as prompts, error messages.

3.25 Effective temperature. An empirically determined index whic combines into a single value the effect of temperature, humidity, an air movement on the sensation of warmth or cold felt by the human body. The numerical value is that of the temperature of still, saturated air which would induce an identical sensation.

3.26 Enter. An explicit user action that effects computer processing of user entries. For example, after typing a series of numbers, a user might press an ENTER key that will add them to a dat base, subject to data validation.

3.27 Equipment. General term designating any item or group of items.

3.28 Equipment failure. Cessation of the ability to meet the minimum performance requirements of the equipment specifications. Further, equipment failure shall imply that the minimum specified performance cannot be restored through permissible readjustment of operator controls.

3.29 Facilities. A physical plant, such as real estate and improvements thereto, including building and equipment, which provides the means for assisting or making easier the performance of a system function. The facilities to which this standard apply are those in which personnel perform system operational or maintenance duties.

3.30 Fail-safe design. Design where a failure will not adversely affect the safe operation of the system, equipment, or facility.

3.31 Field. See "Data Field."

3.32 File. A collection of data that is stored in a computer, treated as a single unit by the operating system of the computer.

3.33 Function key. A key, such as the SHIFT key, which initiates or modifies a machine function, (e.g., effects a control entry, instructs the computer to perform a step, or a series of steps) but Standard Code of Information Exchange (ASCII).

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3.34 Help. A capability that displays information upon user request for on-line guidance. HELP may inform a user generally about the system capabilities, or may provide more specific guidance in information handling transactions.

3.35 Highlighting. Emphasizing displayed data or format features in some way, e.g., through the use of underlining, bolding, or inverse video.

3.36 Human engineering design criteria. Stated limits on design to achieve the objectives of human engineering.

3.37 Information. Organized data that users need to perform their tasks successfully. Information serves as an answer to a user's questions about data and implies effective assimilation of data by a user. Data that have been processed and formulated by automated or manual means to satisfy a knowledge requirement for use by a decision maker.

3.38 Interrupt. Stopping an ongoing transaction in order to redirect the course of the processing. Examples of interrupt options are ABORT, BACKUP, CANCEL, and RESTART.

3.39 Luminance contrast. The contrast between the background and a figure equals the difference between the higher luminance (L1) and the lower luminance (L2) divided by the lower luminance (L2); i.e.,

$$C = \frac{L_1 - L_2}{L_2}$$

Conversions to the other contrast formulae are as follows:

L_1 (brighter)	L_2 (dimmer)	$\frac{L_1-L_2}{L_2}$	$\frac{L_1-L_2}{L_1}$	$\frac{L_1-L_2}{L_1+L_2}$	$\frac{L_1}{L_2}$
100	50	1.0	0.50 (50%)	0.33	2.0
100	25	3.0	0.75 (75%)	0.60	4.0
100	10	9.0	0.90 (90%)	0.82	10.0

3.40 Luminance ratio (LR). The ratio of the target, subject or symbol luminance to the surrounding field or background luminance. For projection systems, the luminance ratio is equal to the light output of a projector (measured with no film in the projector) reflected off the screen (image luminance) divided by all the light falling on the screen (measured from the greatest viewing angle) other than that actually forming the image (nonimage background); i.e.,

$$LR = \frac{L_i}{L_n} \quad \text{where: } L = \text{Image or subject luminance}, \quad L_n = \text{Nonimage or background luminance}$$

3.41 Macro. The capability to allow the user to assign a single name or function key to a defined series of commands for use with subsequent command entry. Sometimes called "smart key" or "script." Examples of use are storage of addresses or signature blocks that are frequently used. Usually initiated through use of a function key.

3.42 Maintainability, design for. Design considerations directed toward achieving those combined characteristics of equipment and facilities which will enable the accomplishment of necessary maintenance quickly, safely, accurately, and effectively with minimum requirements for personnel, skills, special tools, and cost.

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5.3.5.5 Message content. In selecting words to be used in audio warning signals, priority shall be given to intelligibility, aptness, and conciseness in that order.

5.3.5.6 Critical warnings and message priorities.

5.3.5.6.1 Critical warning signals. Critical warning signals shall be repeated with not more than a 3-second pause between messages until the condition is corrected or overridden by the crew.

5.3.5.6.2 Message priorities. A message priority system shall be established and more critical messages shall override the presentation of any message occurring below it on the priority list. If two or more incidents or malfunctions occur simultaneously, the message having the higher priority shall be given first. The remaining messages shall follow in order of priority. In the event of a complete subsystem failure, the system shall integrate previous messages via electronic gating and report the system rather than the component failure.

5.3.6 Controls for audio warning devices.

5.3.6.1 Automatic or manual shut-off. When an audio signal is designed to persist as long as it contributes useful information, a shut-off switch controllable by the operator, the sensing mechanism, or both, shall be provided, depending on the operational situation and personnel safety factors.

5.3.6.2 Automatic reset. Whether audio warning signal are designed to be terminated automatically, by manual control, or both, an automatic reset function shall be provided. The automatic reset function shall be controlled by the sensing mechanism which shall recycle the signal system to a specified condition as a function of time or the state of the signalling system so that the warning device can sound again if the condition repeats.

5.3.6.3 Redundant Visual Warning. All non-verbal aural annunciations shall be accompanied by a visual annunciation which defines the condition. In a cockpit, this may be an illuminated display. In the case of a warning horn on a backing vehicle, the vehicle's backward motion is adequate visual annunciation.

5.3.6.4 Volume control.

5.3.6.4.1 Automatic or manual. The volume (loudness) of an audio warning signal shall be designed to be controlled by the operator, the sensing mechanism, or both, depending on the operational situation and personnel safety factors. Control movements shall be restricted to prevent reducing the volume to an inaudible level or increasing it to an unacceptably high level.

5.3.6.4.2 Ganging to mode switches. Volume controls may be ganged to mode switches to provide maximum output during mission phases in which intense noise may occur and to provide reduced volume at other times. Ganging shall not be accomplished if there is a possibility that intense noise may occur in an emergency situation during a mission phase in which the volume would be decreased below an audible level.

5.3.6.4.3 Caution signal controls. Audio caution signals shall be provided with manual reset and volume controls.

5.3.6.5 Duration. Audio warning signal duration shall be at least 0.5 second, and may continue until the appropriate response is made. Completion of a corrective action by the operator or by other means shall automatically terminate the signal.

5.3.6.6 Duration limitations. In an emergency situation, signals that persist or increase progressively in level shall not be used if manual shut-off may interfere with the corrective action required.

5.3.7 Speech transmission equipment.

5.3.7.1 Frequency. Microphones and associated system-input devices shall respond optimally to that part of the speech spectrum most essential to intelligibility (i.e., 200 to 6,100 Hz). Where system engineering necessitates speech-transmission bandwidths narrower than 200 to 6,100 Hz, the minimum acceptable frequency range shall be 250 to 4,000 Hz.

5.3.7.2 Dynamic range. The dynamic range of a microphone used with a selected amplifier shall be great enough to admit variations in signal input of at least 50 dB.

5.3.7.3 Noise canceling microphones. In very loud, low frequency noise environments (100 dB overall), noise canceling microphones shall be used and shall be capable of effecting an improvement of not less than 10 dB peak-speech to root-mean-square-noise ratio as compared with non-noise-canceling microphones of equivalent transmission characteristics.

5.3.7.4 Pre-emphasis. If necessary, speech system input devices should employ frequency pre-emphasis with a positive slope frequency characteristic no greater than 18 dB per octave from 140 to 1,500 Hz, and no greater than 9 dB per octave over the frequency range 1,500 to 4,800 Hz, when no clipping is used.

5.3.7.5 Peak-clipping of speech signals. Where speech signals are to be transmitted over channels showing less than 15 dB peak speech to root-mean-square-noise ratios, peak clipping of 12 to 20 dB may be employed at system input and may be preceded by frequency pre-emphasis as specified in 5.3.7.4.

5.3.7.6 Noise shields. When the talker is in an intense noise field, the microphone should be put in a noise shield. Noise shields should be designed to meet the following requirements:

5.5.5 Design of label characters.

5.5.5.1 Black characters. Where the ambient illuminance will be above 10 lux (0.9 ft-c), black characters shall be provided on a light background.

5.5.5.2 Dark adaptation. Where dark adaptation is required, the displayed letters or numerals shall be visible without interfering with night vision requirements. Where possible, markings shall be white on a dark background.

5.5.5.3 Style. Style of label characters shall conform to MIL-M-18012, where consistent with 5.5.5.4, 5.5.5.5, 5.5.5.7, and 5.5.5.8, herein.

5.5.5.4 Capital vs lower case.

5.5.5.4.1 Labels. Labels shall be printed in all capitals; periods shall not be used after abbreviations.

5.5.5.4.2 Legends. Legends shall be printed in all capitals; periods or commas shall not be used.

5.5.5.4.3 Placards. Instructional material placards may employ capitals and lower case when the amount of material consists of several lines; however, for short, instructional material, all-capitals are preferred. All-capital material, consisting of larger caps for the initial letter in a paragraph, line of instruction or procedural step, may be used.

5.5.5.4.4 Signs. Signs shall consist of all-capitals, except when the sign is instructional and involves several lines of extended sentences, in which case capitals and lower case letters may be used.

5.5.5.5 Letter width. The width of letters should be 3/5 of the height, except for "M" and "W", which shall be 4/5 of the height, and "I", which shall be one stroke wide.

5.5.5.6 Numeral width. The width of numerals shall preferably be 3/5 of the height, except for the "4", which shall be one stroke width wider, and the "1" which shall be one stroke wide.

5.5.5.7 Wide characters. Where conditions indicate the use of wider characters, as on a curved surface, or where numerals must be aligned vertically in columns, the basic height-to-width ratio may be increased to as much as 1:1.

5.5.5.8 Stroke width, normal. For black characters on a white (or light) background, the stroke width shall be 1/6 to 1/7 of the height.

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5.5.5.9 Stroke width, dark adaptation. Where dark adaptation is required or legibility at night is a critical factor, and white characters are specified on a black background, the stroke width of the characters shall be from 1/7 to 1/8 of the height (i.e., narrower than specified for normal daytime vision). The stroke width shall be the same for all letters and numerals of equal height.

5.5.5.10 Stroke width, transilluminated characters. For transilluminated characters, the stroke width shall be 1/10 to 1/11 of the height.

5.5.5.11 Character spacing. The minimum space between characters shall be one stroke width.

5.5.5.12 Word spacing. The minimum space between words shall be the width of one character.

5.5.5.13 Line spacing. The minimum space between lines shall be one-half character height.

5.5.5.14 Label size vs luminance. The height of letters and numerals shall conform to Table XII.

5.5.5.15 Character height and viewing distance. For general dial and panel design, with the luminance normally above 3.5 cd/m^2 (1 fL), character height should be not less than 0.006 X the viewing distance.

5.5.6 Equipment labeling.

5.5.6.1 Units, assemblies, subassemblies and parts.

5.5.6.1.1. General requirements. Each unit, assembly, subassembly and part shall be labeled with a clearly visible, legible, and meaningful name, number, code, mark or symbol, as applicable.

5.5.6.1.2 Location. The gross identifying label on a unit, assembly or major subassembly shall be located:

a. Externally in such a position that it is not obscured by adjacent items.

b. On the flattest, most uncluttered surface available.

c. On a main chassis of the equipment.

c. The units of measurement (e.g., volts, psi, meters) shall be labeled on the panel.

d. Labels shall be used to identify functionally grouped controls and displays. The labels shall be located above the functional groups they identify. When a line is used to enclose a functional group and define its boundaries, the label shall be centered at the top of the group either in a break in the line or just below the line. When colored pads are used, the label shall be centered at the top within the pad area.

e. Label location throughout a system and within panel groupings shall be uniform.

f. Adjacent labels should be separated by sufficient space so they are not read as one continuous label.

5.5.6.2.5 Hierarchical labeling. A hierarchical labeling scheme should be used on control and display panels to reduce confusion and search time. Major labels should be used to identify major systems or operator work stations and component labels should identify each panel or console element. Labels should not repeat information contained in higher-level labels.

5.5.6.2.6 Size graduation. To reduce confusion and operator search time, labels shall be graduated in size. The characters in group labels shall be larger than those used to identify individual controls and displays. The characters identifying controls and displays shall be larger than the characters identifying control positions. With the smallest characters determined by viewing conditions, the dimensions of each character shall be at least approximately 25 percent larger than those of the next smaller label.

5.5.6.2.7 Overhead items. Items that are located overhead and out of view should be identified with labels on walls with an arrow pointing in the direction of the item or by a label on the floor directly below the item.

5.5.6.3 Storage cabinets. The contents of storage cabinets should be labeled on the outside of the cabinet door. For large storage cabinets, labels should be placed at standing eye height, i.e., from 1.270 to 1.650 meters (50 to 65 inches) above the standing surface. A prominent redundant label that identifies the cabinet's contents should be visible when the door is open.

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5.13 Hazards and safety.

5.13.1 General. Design shall reflect the safety related human engineering criteria below as well as in other sections of this standard.

5.13.2 Safety labels and placards.

5.13.2.1 Warning placards. Conspicuous placards shall be mounted adjacent to any equipment which presents a hazard to personnel (e.g., from high voltage, heat, toxic vapors, explosion, radiation).

5.13.2.2 Center-of-gravity and weight. Where applicable, the center of gravity and the weight of equipment shall be distinctly marked.

5.13.2.3 Weight capacity. The weight capacity shall be indicated on stands, hoists, lifts, jacks, and similar weight-bearing equipment, so as to prevent overloading.

5.13.2.4 Identification of protective items. Areas of operation or maintenance where special protective clothing, tools, or equipment are necessary (e.g., insulated shoes, gloves, suits) shall be specifically identified.

5.13.2.5 "NO-STEP" markings. "NO-STEP" markings shall be provided when necessary to prevent injury to personnel or damage to equipment.

5.13.2.6 Electrical labels. All receptacles shall be marked with their voltage, phase, and frequency characteristics, as appropriate. For other electrical labeling and warning requirements, see MIL-STD-454.

5.13.2.7 Hand grasp areas. Hand grasp areas shall be conspicuously and unambiguously identified on the equipment.

5.13.3 Pipe, hose, and tube line identification. Pipe, hose, and tube lines for liquids, gas, and steam shall be clearly and unambiguously labeled or coded as to contents, pressure, heat, cold, or other specific hazardous properties in accordance with MIL-STD-1247.

5.13.4 General workspace hazards.

5.13.4.1 Alerting device. A hazard alerting device shall be provided to warn personnel of impending danger or existing hazards (e.g., fire, the presence of combustible or asphyxiating gas, and radiation).

5.13.4.2 Emergency doors and exits. Emergency doors and exits shall be constructed so that they:

a. are simple to operate,

b. are readily accessible,

c. are unobstructed,

d. are simple to locate and operate in the dark,

e. are quick opening in three seconds or less,

f. require 44 to 133 N (10 to 30 lbs) of operating force to open,

g. do not themselves, or in operation, constitute a safety hazard, and

h. permit one person egress in 5 seconds or less.

5.13.4.3 Stairs. Stairs, including incline, step risers, and treads, shall conform to standard safe design practice. Skid-proof flooring, stair, and step treads shall be provided. Where conditions warrant special precaution, surfaces shall conform to the nonslip coating requirements of MIL-W-5044 and MIL-W-5050.

5.13.4.4 Obstructions. Workspace around areas where maintenance is performed shall be free of obstructions which could cause injury to personnel, either through accidental contact with the obstruction or because the obstruction requires an awkward or dangerous body position.

5.13.4.5 Illumination. Adequate illumination shall be provided in all areas. Warning placards, stairways, and all hazardous areas shall be illuminated, in accordance with the recommended levels of Table XXI.

5.13.4.6 Thermal contact hazards. Equipment which, in normal operation, exposes personnel to surface temperatures greater or less than those shown below, shall be appropriately guarded. Surface temperatures induced by climatic environment are exempt from this requirement. Cryogenic systems shall also be appropriately guarded.

Temperature limits

Exposure	Metal	Glass	Plastic or wood
Momentary contact	60° C (140° F)	68° C (154° F)	85° C (185° F)
Prolonged contact or handling	49° C (120° F)	59° C (138° F)	69° C (156° F)
Momentary contact	0° C (32° F)	0° C (32° F)	0° C (32° F)
Prolonged contact or handling	0° C (32° F)	0° C (32° F)	0° C (32° F)

ESD-TR-63-403	Psychoacoustic Speech Test: A Modified Rhyme Test (AD 411 983)
ESD TR 86-278	Guidelines for Designing User Interface Software (AD-A 177 198)
RADC-TDR-62-315	Criteria for Group Display Chains for The 1962-1965 Time Period (AD 283 390)
WADC TR 52-204	Handbook of Acoustic Noise Control (AD 018 260 and AD 012 015)
WADC TR 55-159	Space Requirements of the Seated Operator (AD 087 892)
WADC TR 58-474	The Effect of Team Size and Intermember Communication on decision-Making Performance (AD 215 621)
WADD TR 60-814	Audio Warning Signals for Air Force Weapon Systems (AD 258 477)

60 NATIONAL AERONAUTICS AND SPACE ADMINISTRATION PUBLICATIONS

60.1 Standards

Copies of the following documents can be obtained by qualified requesters from MSIS Custodian/SP34, NASA-Johnson Space Center, Houston, TX 77058

NASA-STD-3000, Volume I	Man-Systems Integration Standards
NASA-STD-3000, Volume II	Man-Systems Integration Standards-Appendices

60.2 Book

Copies of the following document can be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington DC 20402

NASA SP-3006	Bioastronautics Data Book, Second Edition, J.F. Parker and V.R. West, eds.

70 VOLUNTARY STANDARDS AND GUIDES

70.1 American National Standards Institute (ANSI). Copies of ANSI A12.1, A14.3, C2, and Z136.1 can be obtained at a nominal cost from the ANSI, 11 West 42nd Street, New York, New York 10036. Copies of ANSI S1.11 can be obtained at a nominal cost from the Professional Book Distributors, Inc., ASA Standards Distribution Center, 1650 Bluegrass Lake Parkway, P.O. Box 6996, Alpharetta, Georgia 30239-6996

ANSI A12.1	Floor and Wall Openings, Railings, and Toeboards, Safety Requirements for
ANSI A14.3	Ladders-Fixed-Safety Requirements
ANSI C2	National Electrical Safety Code (NBS H30)
ANSI S1.11	Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters (ASA 65)
ANSI Z136.1	Safe use of Lasers

70.2 American Society for Testing and Materials. Copies of the following documents can be obtained at a nominal cost from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103

ASTM F 1166-8	Standard Practice for Human Engineering Design Criteria for Marine Systems, Equipment and Facilities

70.3 American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Copies of the following documents can be obtained at a nominal cost from the ASHRAE, 1791 Tullie Circle, NE, Atlanta, GA 30329

ASHRAE 55-81	Thermal Environmental Conditions for Human Occupancy
ASHRAE 62-81	Ventilation for Acceptable Indoor Air Quality Guide and Data Book (latest edition)

70.4 Illuminating Engineering Society (IES) of North America. Copies of the following document can be obtained at a nominal cost from the IES, 345 East 47th Street, New York, NY 10017

IES Lighting HDBK SEC 9 Application-87, Industrial Lighting

70.5 National Fire Protection Association (NFPA). Copies of the following document may be obtained from the NFPA, 60 Batterymarch Street, Boston, MA 02110

NFPA 101 Code for Safety to Life from Fire in Buildings and Structures

80 BOOKS

The documents listed below are normally available in general and technical libraries:

a. A Collation of Anthropometry, J. W. Garett and K. W. Kennedy. Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio. 1971. (2 Volumes) (AD 723 629; Library of Congress Catalog Card No. 74-607818)

b. Directions in Human/Computer Interaction. A. Badre and B. Schneiderman, Eds., Ablex Publishing, Norwood, NJ, 1982

c. Fundamentals of Interactive Computer Graphics, J. D. Foley and A. Van Dam, Addison-Wesley, Reading, MA, 1982

d. General Safety Requirements - U.S. Army Engineer Manual 385-1-1.

e. Guide to Human Engineering Design for Visual Displays, D. Meister and D. J. Sullivan, The Bunker-Ramo Corp., Contract No. N0001468-C-027E, Work Unit No. NR196-080 (AD 693 237), Office of Naval Research, 30 August 1969.

f. Human Engineering Guide to Equipment Design - H. P. Van Cott, and R. G. Kinkade, eds., Wiley, 605 Third Ave., New York, NY 10158, 1972 (Library of Congress Catalog Card No. 72600054).

g. Industrial Ventilation, Manual of Recommended Practice - Latest Edition, American Conference of Governmental Industrial Hygienists, Committee on Industrial Ventilation, P.O. Box 453, Lansing, Michigan.

h. Lighting Handbook, Illuminating Engineering Society (IES), latest edition.

i. Software Psychology: Human Factors in Computer and Information Systems. B. Schneiderman, Winthrop Publishers, Cambridge, MA, 1980.

j. Symbol Source Book, H. Dreyfuss, 1972, McGraw-Hill Book Company, Library of Congress Card No. 71-172261.

k. The Human Body in Equipment Design, A. Damon, H. W. Stoudt, and R. A. McFarland, Harvard University Press, Cambridge, Mass, 1966. (Library of Congress Catalog Card No. 65-22067).

l. Engineering Anthropometry Methods. J. A. Roebuck, K. H. E. Kroemer and W. G. Thomson, John Wiley and Sons, New York, NY 1975 (Library of Congress) Catalog No. 74-34272.)

Copies of specification, standards, and other publications required by contractors in connection with specific procurement functions should be obtained from the procuring agency or as directed by the contracting officer.

Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal Agencies.

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