International Space Station Flight Crew Integration Standard (NASA−STD−3000/T)

International Space Station

Revision E

30 June 2006

Japan Aerospace Exploration Agency

Canadian Space Agency
Agence spatiale canadienne

esa
european space agency

agenzia spaziale italiana
(Italian Space Agency)

National Aeronautics and Space Administration
Space Station Program Office
Johnson Space Center
Houston, Texas

REVISION AND HISTORY PAGE

REV.	DESCRIPTION	PUB. DATE
−	Initial Release (Reference SSCBD 000002, Dated 2−7−94)	4−18−94
A	Revision A (Reference SSCBD 000008R1, Dated 6−3−94)	8−09−94
B	Revision B incorporates ECP 145 (SSCBD 000145, Effective 10−31−95)	11−21−95
	DCN 001 incorporates ECP 258 (SSCBD 000258, Effective 08−19−98)	11−17−98
	The following DCNs have been cancelled. The content of the SSCNs authorizing release of the DCNs has been incorporated into Revision C.	
	DCN 002 (SSCN 000354) DCN 006 (SSCN 000549) DCN 005 (SSCN 000721) DCN 003 (SSCN 000434) DCN 004 (SSCN 000554) DCN 007 (SSCN 000821)	
C	Revision C icorporates SSCNs 000354, 000434, 000549, 000554, 000721, 000821, and 001202.	09−27−01
	DCN 008 incorporates SSCN 002199B	09−27−01
	DCN 009 for SSCN 002446 Cancelled per SSCN 2446A	
	DCN 010 incorporates SSCN 005389	05−08−03
	DCN 011 incorporates SSCN 004122	11−24−03
D	Revision D incorporates SSCN 005389 Supplemental.	10−04−04
E	Revision E incorporates SSCN 009086.	06−26−06

ERU: /s/ J. Rivas 06−26−06

PREFACE

Flight Crew Integration design requirements for the International Space Station (ISS) are defined and controlled herein. These requirements are applicable as referenced by the System Specification, Segment Specifications, and End Item Specifications only.

This document is an extraction of the requirements contained in NASA−STD−3000, Volume IV, Revision A, tailored to the International Space Station Program. Where possible, the paragraph numbering of this document is consistent with the NASA−STD−3000 paragraph format to retain traceability to the source of the requirements.

The contents of this document are intended to be consistent with the tasks and products to be prepared by NASA Work Package Centers and Space Station Program (SSP) participants as defined in SSP 41000, System Specification for the International Space Station. The International Space Station Flight Crew Integration Standard (NASA−STD−3000/T)) shall be implemented on all new SSP contractual and internal activities and shall be included in any existing contracts through contract changes. This document is under the control of the Space Station Control Board, and any changes or revisions will be approved by the Program Manager.

INTERNATIONAL SPACE STATION PROGRAM

FLIGHT CREW INTEGRATION STANDARD (NASA−STD−3000/T)

30 JUNE 2006

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INTERNATIONAL SPACE STATION PROGRAM

FLIGHT CREW INTEGRATION STANDARD
(NASA−STD−3000/T)

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INTERNATIONAL SPACE STATION PROGRAM

FLIGHT CREW INTEGRATION STANDARD (NASA−STD−3000/T)

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For NASA DATE

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FLIGHT CREW INTEGRATION STANDARD
(NASA−STD−3000/T)

30 JUNE 2006

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COL−RQ−ESA−013“Meets or Exceeds” this document.

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INTERNATIONAL SPACE STATION PROGRAM

FLIGHT CREW INTEGRATION STANDARD
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INTERNATIONAL SPACE STATION PROGRAM

FLIGHT CREW INTEGRATION STANDARD (NASA−STD−3000/T)

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INTERNATIONAL SPACE STATION PROGRAM

FLIGHT CREW INTEGRATION STANDARD (NASA−STD−3000/T)

LIST OF CHANGES 30 JUNE 2006

All changes to paragraphs, tables, and figures in this document are shown below:

SSCBD	ENTRY DATE	PARAGRAPH	TITLE
9086	6/30/06	9.5.3.1.13	Caution and warning labels design requirements
Edit		2.0	Applicable documents

TABLE(S)

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FIGURE(S)

None

APPENDIX

None

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FIGURES

1.0 INTRODUCTION

1.1 PURPOSE

This document provides Flight Crew Interface requirements applicable to the International Space Station Program extracted from NASA−STD−3000, Volume IV, Revision A. The requirements in this document are applicable only as invoked by the System Specification, Segment Specifications, Prime Item Development Specifications, and lower level components specifications.

1.2 OVERVIEW

1.3 SCOPE, PRECEDENCE, AND LIMITATIONS

1.3.1 SCOPE

This document establishes performance, design, development, and integration requirements for Flight Crew interfaces.

1.4 HOW TO USE THE DOCUMENT

This document was extracted from the Man−Systems Integration Standards ((MSIS) NASA−STD−3000, Volume IV, Revision A). The paragraph numbering remains consistent with the MSIS document.

It is recommended that those designing hardware and systems for the International Space Station acquire a copy of Volume IV, Revision A and Volume I of the MSlS, because the considerations and examples sections of each of the chapters in those volumes contain background and supporting information which could be of considerable value in the design process.

1.5 HOW TO USE THE STANDARD RELATIONAL DATABASE

1.6 DEFINITIONS AND ABBREVIATIONS

A set of basic definitions is herewith established for orientation and simplification of organization and coordination of work. The definitions are followed by a set of updated names, agreed−to abbreviations, and corresponding comments.

1.6.1 HUMAN FACTORS/ERGONOMICS

The terms Human Factors and Ergonomics are often used interchangeably. Both are concerned with the interaction of the operator and the task demands. However, they have somewhat different focuses. Human Factors relates to the consideration of the user in the design of equipment, operations, and systems with the goal of enhancing functional effectiveness while maintaining or enhancing human well−being (e.g., physical and mental health, safety, and satisfaction) in the process. Ergonomics focuses on the effect equipment, operations, and systems have on the user. This includes the physiological responses of the user to physically demanding tasks and environmental stressors such as vibration, heat, and noise.

1.6.2 HUMAN ENGINEERING

Human Engineering (or Human Factors Engineering) is the systematic application of relevant data, principles, and practices of Human Factors and Ergonomics to the design of equipment, operations, and systems. These data, principles, and practices come from a number of fields of study, including:

A. Anatomy and physiology of sense organs and skeletal musculature

B. Anthropometry

C. Kinematics and dynamics of body motion

D. Physical work performance

E. Environmental stresses

F. Psychology

G. Sensory and perceptual behavior

H. Learning and training

I. Motivation

J. Sociology

1.6.3 MAN−SYSTEMS INTEGRATION

Man−Systems Integration applies the systems' approach to the integration of the user and the "machine" to form an effective, symbiotic Man−Machine System. Hardware, software, and operations development must take into account the limitations and capabilities of the human operator. Selection and training of personnel are also considered important facets of Man−Systems Integration.

1.6.4 MAN−MACHINE SYSTEMS

A Man−Machine System is a combination of one or more human beings and one or more physical components that are integrated through the common purpose of achieving some objective. In this concept, the human is considered a component or subsystem of the larger system. These components interact within the system environment to bring about, from given inputs, some desired output. The major elements of a system that must be addressed during system development are hardware and software, personnel, operating procedures, and technical data.

1.6.5 MAN−MACHINE INTERFACE

The Man−Machine Interface is the interface through which the human is able to sense the state of the system and environment and respond accordingly. This includes hardware, its spatial interrelationships, and the display of information. The latter includes the modality, quantity, quality, arrangement, and organization of the information presentation.

1.6.6 HUMAN−COMPUTER INTERFACE

The Human−Computer Interface is the communication interface between the user and the computer. Since data and information is transmitted and received via this interface, it is considered a matter of dialogue management. This is a software interface. To facilitate the real−time interactions between the user and computer, the Human−Computer Interface employs a variety of tools, including methods for moving between displays, windowing techniques, methods for selecting information from a display, user guidance, and interactive dialogue techniques.

1.6.7 INTERFACE LANGUAGE

Through the use of the interface language, the operator conveys commands or queries to the computer and the computer conveys information to the user. Linguistic styles involve the use of menus, windows, forms, etc.

1.6.8 HABITABILITY

Habitability is defined as the quality of life in an environment. It is a general term which denotes a level of perceived environmental acceptability. The term includes quality standards to support the crew's health and well being during the duty and off−duty periods. The basic level of habitability deals with the direct environment, like climate, food, noise, light, etc., influencing primarily human physical condition.

The extended level of habitability is introduced to take care of the long−term condition of the on−orbit stay time and supply not only the individuals' physical health but also the mental/psychological health. Experience has shown that with the passage of time deleterious effects of isolation and confinement gain prominence.

1.6.9 ANTHROPOMETRY

Anthropometry is the study of body dimensions. Anthropometric data falls into two categories:

A. Static anthropometry, which deals with simple dimensions of the stationary human; e.g., weight, stature, and the lengths, breadths, depths, and circumferences of the human body.

B. Dynamic anthropometry, which deals with the body dimensions during motion; e.g., reach and angular ranges of various joints.

1.6.10 BIOMECHANICS

Biomechanics is the study of the mechanics of living things. Its application in ergonomics deals with the mechanisms, range, and accuracy of human movement, as well as strength (force), speed, and endurance of the human body.

1.6.11 PHYSIOLOGY

Physiology is the study of the function of the body, i.e., how the body works. In ergonomics, the main emphasis is on how work and exposure to the working environment affect the normal working of the body, which can affect the health and well−being of the individual. The aim is to reduce fatigue and physical stress, increase comfort, and reduce monotony and boredom.

1.6.12 PSYCHOLOGY

Psychology is the study of human behavior. Particular emphasis is placed on psychomotor skills (acquired abilities to perform tasks with the muscles in response to sensory stimuli, involving learning and feedback), perception, mental abilities, and mental workload.

1.6.13 SOCIAL FACTORS

Social factors are social, psychological, and sociological items which deal with group behavior, interpersonal behavior, and the social and cultural influences within group dynamics.

1.6.14 OCCUPATION HEALTH (INDUSTRIAL MEDICINE)

Occupational health (industrial medicine) deals with the physical and mental health effects of a person's job and the working environment.

1.6.15 ENVIRONMENT

The environment includes all external factors that affect the human being, such as:

A. Climate

B. Vibro−acoustics

C. Lighting

D. Working/living space

E. Psycho−socio−cultural environment

F. Micro−g environment

G. Radiation

Many of these factors overlap or interact with each other.

2.0 APPLICABLE DOCUMENTS

The following applicable documents of the exact issue shown in the current issue of SSP 50257 form a part of this specification to the extent specified herein. Inclusion of applicable documents herein does not in any way supercede the order of precedence identified in 1.3. The references show where each applicable document is cited in this document.

DOCUMENT NO.	TITLE
	American Hospital Formulary Service
References:	10.9.3.1.2.B.(2)
ACGIH	American Conference of Governmental Industrial Hygienists Standards, Threshold Limit Values and Biological Exposure Indices for 1997
References:	5.7.3.2.1.B, 5.7.3.2.1.C
ASTM D1003	Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics
References:	11.11.3.1.3.1.C, 11.11.3.1.3.2.C, 11.11.3.2.G
ASTM D1044	Standard Test Method for Resistance of Transparent Plastics to Surface Abrasion
References:	11.11.3.1.3.1.C, 11.11.3.1.3.2.C, 11.11.3.2.G
ANSI Z136.1	ANSI Standard for the Safe Use of Lasers
References:	5.7.3.2.1.B, 5.7.3.2.2.A.(1)
CIE	Commision International De L'Eclairage Coordinates Chart Chromaticity Diagram 1931
References:	9.4.2.3.1.1.B.(1), 9.5.3.2
FED−STD−595	Colors Used in Government Procurement
References:	9.2.2.2.4.A, 9.3.3.4.1.2.L.(2), 9.5.3.2.I.(8)a
ISO 2631	Guide for the Evaluation of Human Exposure to Whole Body Vibration
References:	5.5.3.3.4.D
JSC 32283	Nutritional Requirements for Extended Duration Orbiter Missions and Space Station
References:	7.2.2.3.1.A.(1), 7.2.2.3.1.B.(1)
JSC 27260	Decal Process Document and Catalog
References:	9.5.3.1.13.D.(9)

MIL−A−25165	Identification of Aircraft Emergency Escape System
References:	8.8.3.4
MIL−C−25050	Color, Aeronautical Lights and Lighting Equipment, General Requirements for
References:	6.6.3.3.D, 9.5.3.2.I.(4)a, 9.5.3.2.I.(4)b
MIL−G−174	Optical Glass
References:	11.11.3.1.5.A.(3), 11.11.3.1.5.A.(4), 11.11.3.2.B, 11.11.3.2F
MIL−G−25667	Aircraft Glazing Glass, Monolithic
References:	11.11.3.1.5.B.(1)
MIL−G−25871	Aircraft Glazing Glass, Laminated
References:	11.11.3.1.5.B.(2)
MIL−G−48497	Coating, Single or Multilayer, Interference: Durability Requirements for
References:	11.11.3.1.3.B, 11.11.3.1.3.C, 11.11.3.1.3.D.(1), 11.11.3.1.3.E
MIL−O−13830	Optical Components for File Control Instruments; General Specification Governing the Maufacturing, Assembly, and Inspection of
References:	11.11.3.1.5.A.(1), 11.11.3.2.C
MIL−STD−210	Climatic Information to Determine Design and Test Requirements for Military Systems and Equipment
References:	11.12.3.B
MIL−STD−1189	TBD
References:	9.5.3.1.15
MIL−STD−1474	Noise Limits for Military Material (Metric)
References:	5.4.3.1.B.(1), 5.4.3.2.4
MIL−STD−2073	DOD Material Procedures for Development and Application of Packaging Requirements
References:	11.12.3.B

NASA−TM−86538	Design and Verification Guidelines for Vibroacoustic and Transient Environmnents
References:	11.12.3.B
NASA−TM−103575	Space Transportation System and Associated Payloads: Glossary, Acronyms and Abbreviations
References:	9.6.2.8.K.(2)
IEEE C95.1	IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3KHZ to 300 GHZ
References:	5.7.3.2.1.A
SSP 30240	Space Station Grounding Standard Requirements
References:	6.4.3.1.G
SSP 30245	Space Station Electrical Bonding Requirements
References:	6.4.3.2
SSP 30233	Space Station Requirements for Materials and Processes
References:	6.4.3.8
SSP 30560	Glass, Window, and Ceramic Structural Design and Verification Requirements
References:	11.11.3
SSP 30575	Space Station Interior and Exterior Operational Location Coding System Document
References:	8.5.3.1, 9.5.3.1.7.2.B.(4), 9.5.3.1.7.1.C.(2), 9.5.3.1.7.1.C.(4)a, 9.5.3.1.7.1.D, 9.5.3.1.7.1.E.(1), 9.5.3.1.7.1.E.(2), 9.5.3.1.7.1.F.(2)a, 9.5.3.1.7.1.G.(1), 9.5.3.1.7.1.J.(1)b, 9.5.3.1.9.1.A, 9.5.3.1.9.2.A.(1)
SSP 41047	Space Station Freedom Program, Man Systems Stowage Units Standard Interface Development Document
References:	11.12.3.B
SSP 50007	Space Station Inventory Management System Label Specification
References:	11.2.3.5.F and 11.12.3.G

SSP 50008	International Space Station Interior Color Scheme
References:	8.5.3.3, 8.12.3, 9.2.2.2.4.E, 11.7.2.3.2.4.B
SSP 50254	Operations Nomenclature
References:	9.5.3.1.13.D.9
	USA Standard Typewriter Pairing of the American Standard Code for Information Interchange
References:	9.3.3.4.1.1.A

2.1 REFERENCE DOCUMENTS

The following documents are referenced in this specification as a guide for context and user convenience. The references to these documents are not listed in SSP 50257.

DOCUMENT NO.	TITLE
	Federal Register, Volume 51, No. 6,1986, Appendix B
AFSC DH 2−2	Crew Stations and Passenger Accommodations
JPL 86−14	NASA Aerospace Battery Safety Handbook
JSC 27260 Part 2	Decal Process Document and Catalog
JSC 20793	Manned Space Vehicle Battery Safety Handbook
MIL−H−8810	Handle Control, Aircraft (ASG)
MIL−HDBK−5	Metallic Materials and Elements for Aerospace Vehicle Structures
MIL−K−25049	Knobs, Control, Electronic Equipment, General Specifications for
MIL−M−3719/4	TBD
MIL−STD−1348	Knob, Control Selection of
MIL−STD−1472	Human Engineering Design Criteria for Military Systems, Equipment and Facilities
MS33739	TBD
NASA RP 1024 Volume 1	Anthropometric Source Book: Volume 1: Anthropology Staff/Web Associates

NASA RP 1024 Volume 2	Anthropometric Source Book: Volume 2: TBD
NASA−STD−3000 Volume I	Man−Systems Integration Standards
NASA−STD−3000 Volume IV Revision A	Man−Systems Integration Standards
NSTS 13830	TBD
NRC Regulations	Nuclear Regulatory Commission Regulations
SP−2−86L−064	Anthropometric Study of Astronaut Candidates, 1979 to 1980 (Unpublished data), NASA−JSC
SSP 41000	International Space Station System Specifications

3.0 ANTHROPOMETRY AND BIOMECHANICS

3.1 INTRODUCTION

This paragraph is not applicable for this document.

3.2 GENERAL ANTHROPOMETRICS AND BIOMECHANICS RELATED DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

3.3 GENERAL ANTHROPOMETRICS AND BIOMECHANICS RELATED DESIGN DATA

3.3.1 BODY SIZE

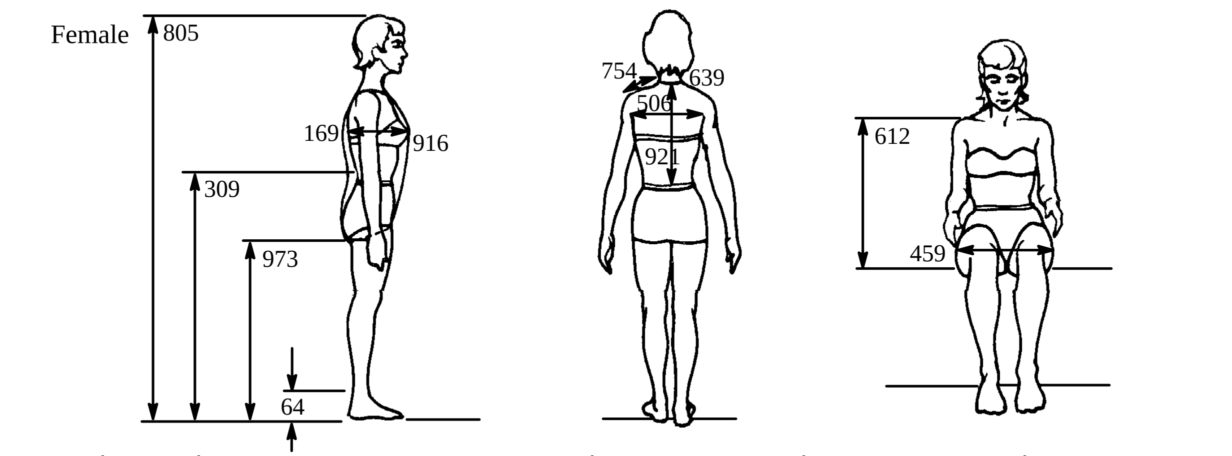
3.3.1.1 INTRODUCTION

This paragraph is not applicable for this document.

3.3.1.2 BODY SIZE DESIGN CONSIDERATIONS

3.3.1.3 BODY SIZE DATA DESIGN REQUIREMENTS

The data shown in Figure 3.3.1.3−1, dimensions of the projected year 2000, 40 year old American male and the 40 year old Japanese female, shall be used when designing all Space Station Intravehicular Activity (IVA) flight crew interfaces.



Notes	No.	Dimension	5th Percentile cm (inches)	50th Percentile cm (inches)	95th Percentile cm (inches)
1	805	Stature	148.9 (58.6)	157.0 (61.8)	165.1 (65.0)
1	973	Wrist height	70.8 (27.9)	76.6 (30.2)	82.4 (32.4)
	64	Ankle height	5.2 (2.0)	6.1 (2.4)	7.0 (2.8)
1	309	Elbow height	92.8 (36.5)	98.4 (38.8)	104.1 (41.0)
	169	Bust depth	17.4 (6.8)	20.5 (8.1)	23.6 (9.3)
1	916	Vertical trunk circumfrence	136.9 (53.9)	146.0 (57.5)	155.2 (61.1)
1, 2	612	Midshoulder height, sitting			
	459	Hip breadth, sitting	30.4 (12.0)	33.7 (13.3)	37.0 (14.6)
1	921	Waist back	35.2 (13.9)	38.1 (15.0)	41.0 (16.1)
	506	Interscye	32.4 (12.8)	35.7 (14.1)	39.0 (15.4)
	639	Neck circumfrence	34.5 (13.6)	37.1 (14.6)	39.7 (15.6)
	754	Shoulder length	11.3 (4.4)	13.1 (5.1)	14.8 (5.8)

General Notes:

(a) Gravity conditions − the dimensions apply to a 1−G condition only. Dimension expected to change significantly due to microgravity are marked.

(b) Measurement data − the number adjacent to each of the dimension are reference codes. The same codes are in NASA RP 1024, Volume 2. NASA RP 1024, Volume 2 provides additional data for these measurements plus an explanation of the measurement technique.

Notes for application of dimensions to microgravity conditions:

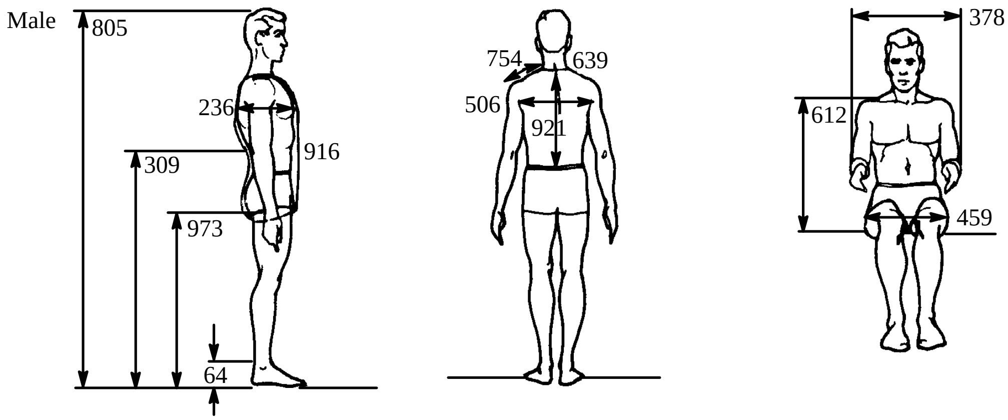
(1) Stature increases approximately 3 percent over the first 3 to 4 days in weightlessness (See NASA−STD−3000, Volume I, Figure 3.2.3.1−2, for information). Almost all of this change appears in the spinal column and thus affects (increases) other related dimensions, such as sitting height (buttock−vertex), shoulder height −sitting, eye height, sitting, and all dimensions that include the spine.

(2) Sitting height would be better named as buttock−vertex in microgravity conditions, unless the crewmember were measured with a firm pressure on shoulders pressing him or her against a fixed, flat "sitting" support surface. All sitting dimensions (vertex, eye, shoulder, and elbow) increase in weightlessness by two changes:

(a) Relief of pressure on the buttock surfaces (estimated increase of 1.3 to 2.0 cm (0.5 to 0.8 inches).

(b) Extension of the spinal column as explained in note (1) above (3 percent of stature on ground).

FIGURE 3.3.1.3−1 BODY SIZE OF 40−YEAR−OLD AMERICAN MALE AND 40−YEAR−OLD JAPANESE FEMALE FOR YEAR 2000 IN ONE GRAVITY CONDITIONS (PAGE 1 OF 12)



Notes	No.	Dimension	5th Percentile cm (inches)	50th Percentile cm (inches)	95th Percentile cm (inches)
1	805	Stature	169.7 (68.8)	179.9 (70.8)	190.1 (74.8)
1	973	Wrist height			
	64	Ankle height	12.0 (4.7)	13.9 (5.5)	15.8 (6.2)
1	309	Elbow height			
	169	Bust depth	21.8 (8.6)	25.0 (9.8)	28.2 (11.1)
1	916	Vertical trunk circumfrence	158.7 (62.5)	170.7 (67.2)	182.6 (71.9)
1, 2	612	Midshoulder height, sitting	60.8 (23.9)	65.4 (25.7)	70.0 (27.5)
	459	Hip breadth, sitting	34.6 (13.6)	38.4 (15.1)	42.3 (16.6)
1	921	Waist back	43.7 (17.2)	47.6 (18.8)	51.6 (20.3)
	506	Interscye	32.9 (13.0)	39.2 (15.4)	45.4 (17.9)
	639	Neck circumfrence	35.5 (14.0)	38.7 (15.2)	41.9 (16.5)
	754	Shoulder length	14.8 (5.8)	16.9 (6.7)	19.0 (7.5)
	378	Forearm−forearm breadth	48.8 (19.2)	55.1 (21.7)	61.5 (24.2)

General Notes:

(a) Gravity conditions − the dimensions apply to a 1−G condition only. Dimension expected to change significantly due to microgravity are marked.

(b) Measurement data − the number adjacent to each of the dimension are reference codes. The same codes are in NASA RP 1024, Volume 2. NASA RP 1024, Volume 2 provides additional data for these measurements plus an explanation of the measurement technique.

Notes for application of dimensions to microgravity conditions:

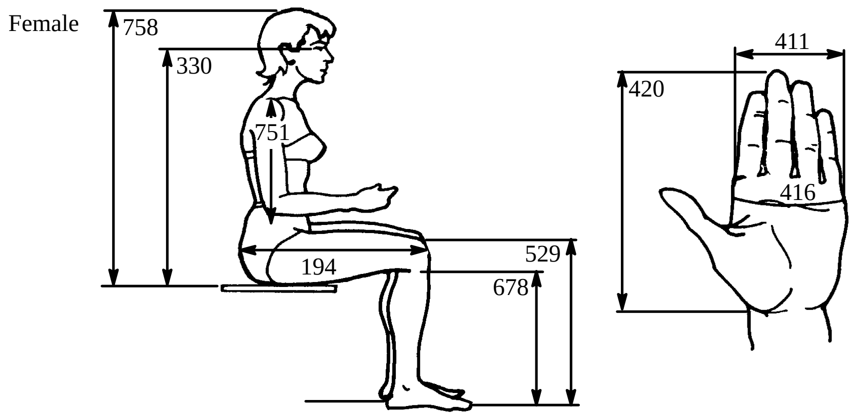
(1) Stature increases approximately 3 percent over the first 3 to 4 days in weightlessness (See NASA−STD−3000, Volume I, Figure 3.2.3.1−2, for information). Almost all of this change appears in the spinal column and thus affects (increases) other related dimensions, such as sitting height (buttock−vertex), shoulder height −sitting, eye height, sitting, and all dimensions that include the spine.

(2) Sitting height would be better named as buttock−vertex in microgravity conditions, unless the crewmember were measured with a firm pressure on shoulders pressing him or her against a fixed, flat ‘‘sitting” support surface. All sitting dimensions (vertex, eye, shoulder, and elbow) increase in weightlessness by two changes:

(a) Relief of pressure on the buttock surfaces (estimated increase of 1.3 to 2.0 cm (0.5 to 0.8 inches).

(b) Extension of the spinal column as explained in note (1) above (3 percent of stature on ground).

FIGURE 3.3.1.3−1 BODY SIZE OF 40−YEAR−OLD AMERICAN MALE AND 40−YEAR−OLD JAPANESE FEMALE FOR YEAR 2000 IN ONE GRAVITY CONDITIONS (PAGE 2 OF 12)



Notes	No.	Dimension	5th Percentile cm (inches)	50th Percentile cm (inches)	95th Percentile cm (inches)
1, 2	758	Sitting height	78.3 (30.8)	84.8 (33.4)	91.2 (35.9)
1, 2	330	Eye height, sitting	68.1 (26.8)	73.8 (29.1)	79.8 (31.4)
4	529	Knee height, sitting	41.6 (16.4)	45.8 (16.4)	49.5 (19.5)
	678	Popliteal height	34.7 (13.6)	38.3 (15.1)	41.9 (16.5)
	751	Shoulder−elbow length	27.2 (10.7)	29.8 (11.7)	32.4 (12.8)
	184	Buttock−knee length	48.9 (19.2)	53.3 (21.0)	57.8 (22.7)
	420	Hand length	15.8 (6.2)	17.2 (6.8)	18.7 (7.3)
	411	Hand breadth	6.9 (2.7)	7.8 (3.1)	8.6 (3.4)
	416	Hand circumference	16.6 (6.5)	17.9 (7.0)	19.3 (7.6)

General Notes:

(a) Gravity conditions − the dimensions apply to a 1−G condition only. Dimension expected to change significantly due to microgravity are marked.

(b) Measurement data − the number adjacent to each of the dimension are reference codes. The same codes are in NASA RP 1024, Volume 2. NASA RP 1024, Volume 2 provides additional data for these measurements plus an explanation of the measurement technique.

Notes for application of dimensions to microgravity conditions:

(1) Stature increases approximately 3 percent over the first 3 to 4 days in weightlessness (See NASA−STD−3000, Volume I, Figure 3.2.3.1−2, for information). Almost all of this change appears in the spinal column and thus affects (increases) other related dimensions, such as sitting height (buttock−vertex), shoulder height −sitting, eye height, sitting, and all dimensions that include the spine.

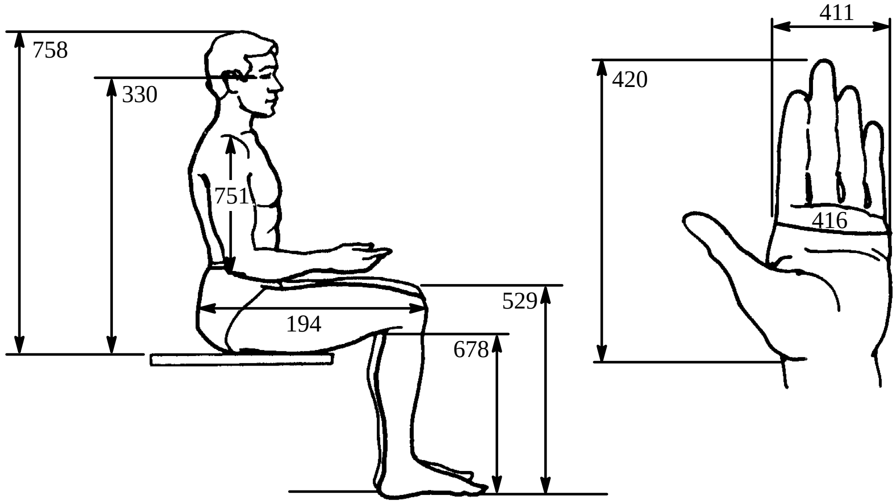
(2) Sitting height would be better named as buttock−vertex in microgravity conditions, unless the crewmember were measured with a firm pressure on shoulders pressing him or her against a fixed, flat ‘‘sitting” support surface. All sitting dimensions (vertex, eye, shoulder, and elbow) increase in weightlessness by two changes:

(a) Relief of pressure on the buttock surfaces (estimated increase of 1.3 to 2.0 cm (0.5 to 0.8 inches).

(b) Extension of the spinal column as explained in note (1) above (3 percent of stature on ground).

(4) Knee height−sitting may increase slightly in microgravity due to relief of the pressure on the heel which it occurs when it is measured on the ground. The increase is probably not more than 2 to 3 mm (0.1 inch).

FIGURE 3.3.1.3−1 BODY SIZE OF 40−YEAR−OLD AMERICAN MALE AND 40−YEAR−OLD JAPANESE FEMALE FOR YEAR 2000 IN ONE GRAVITY CONDITIONS (PAGE 3 OF 12)



Notes	No.	Dimension	5th Percentile cm (inches)	50th Percentile cm (inches)	95th Percentile cm (inches)
1, 2	758	Sitting height	88.9 (35.0)	94.2 (37.1)	99.5 (39.2)
1, 2	330	Eye height, sitting	76.8 (30.3)	81.9 (32.2)	86.9 (34.2)
4	529	Knee height, sitting	52.6 (20.7)	56.7 (22.3)	60.9 (24.0)
	678	Popliteal height	40.6 (16.0)	44.4 (17.5)	48.1 (19.0)
	751	Shoulder−elbow length	33.7 (13.3)	36.6 (14.4)	39.4 (15.5)
	184	Buttock−knee length	56.8 (22.4)	61.3 (24.1)	65.8 (25,9)
	420	Hand length	17.9 (7.0)	19.3 (7.6)	20.6 (8.1)
	411	Hand breadth	8.2 (3.2)	8.9 (3.5)	9.6 (3.8)
	416	Hand circumference	20.3 (8.0)	21.8 (8.6)	23.4 (9.2)

General Notes:

(a) Gravity conditions − the dimensions apply to a 1−G condition only. Dimension expected to change significantly due to microgravity are marked.

(b) Measurement data − the number adjacent to each of the dimension are reference codes. The same codes are in NASA RP 1024, Volume 2. NASA RP 1024, Volume 2 provides additional data for these measurements plus an explanation of the measurement technique.

Notes for application of dimensions to microgravity conditions:

(1) Stature increases approximately 3 percent over the first 3 to 4 days in weightlessness (See NASA−STD−3000, Volume I, Figure 3.2.3.1−2, for information). Almost all of this change appears in the spinal column and thus affects (increases) other related dimensions, such as sitting height (buttock−vertex), shoulder height −sitting, eye height, sitting, and all dimensions that include the spine.

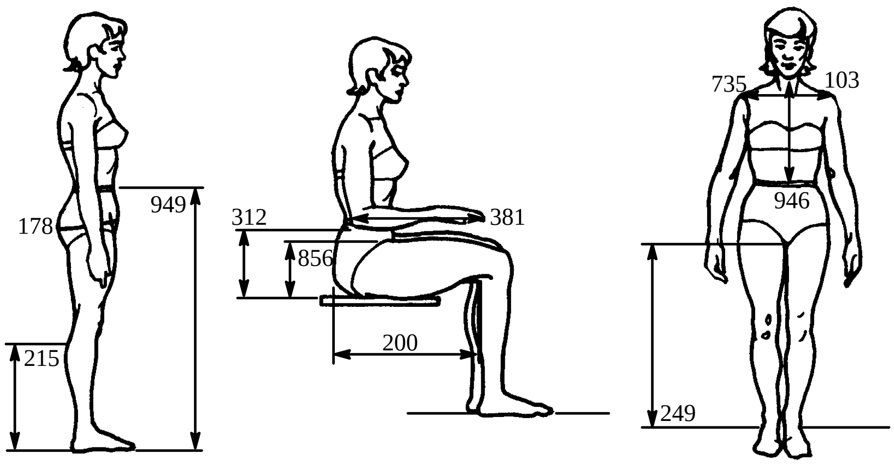
(2) Sitting height would be better named as buttock−vertex in microgravity conditions, unless the crewmember were measured with a firm pressure on shoulders pressing him or her against a fixed, flat “sitting” support surface. All sitting dimensions (vertex, eye, shoulder, and elbow) increase in weightlessness by two changes:

(a) Relief of pressure on the buttock surfaces (estimated increase of 1.3 to 2.0 cm (0.5 to 0.8 inches).

(b) Extension of the spinal column as explained in note (1) above (3 percent of stature on ground).

(4) Knee height−sitting may increase slightly in microgravity due to relief of the pressure on the heel which it occurs when it is measured on the ground. The increase is probably not more than 2 to 3 mm (0.1 inch).

FIGURE 3.3.1.3−1 BODY SIZE OF 40−YEAR−OLD AMERICAN MALE AND 40−YEAR−OLD JAPANESE FEMALE FOR YEAR 2000 IN ONE GRAVITY CONDITIONS (PAGE 4 OF 12)



Notes	No.	Dimension	5th Percentile cm (inches)	50th Percentile cm (inches)	95th Percentile cm (inches)
	949	Waist height	90.1 (35.5)	96.7 (38.1)	103.4 (40.7)
	249	Crotch height	65.2 (25.7)	70.8 (27.8)	76.1 (30.0)
	215	Calf height	25.5 (10.0)	28.9 (11.4)	32.3 (12.7)
	103	Biacromial breadth	32.4 (12.8)	35.7 (14.1)	39.0 (15.40
1	946	Waist front			
	735	Scye circumference	32.3 (12.7)	36.1 (14.2)	39.8 (15.7)
	178	Buttock circumference	79.9 (31.5)	87.1 (34.3)	94.3 (37.1)
1, 2	312	Elbow rest height	20.7 (8.2)	25.0 (9.9)	29.3 (11.5)
	856	Thigh clearance	11.2 (4.4)	12.9 (5.1)	14.5 (5.7)
	381	Forearm−hand length	37.3 (14.7)	41.7 (18.4)	44.6 (17.6)
	200	Buttock−popliteal length	37.9 (14.9)	41.7 (18.4)	45.5 (17.9)

General Notes:

(a) Gravity conditions − the dimensions apply to a 1−G condition only. Dimension expected to change significantly due to microgravity are marked.

(b) Measurement data − the number adjacent to each of the dimension are reference codes. The same codes are in NASA RP 1024, Volume 2. NASA RP 1024, Volume 2, provides additional data for these measurements plus an explanation of the measurement technique.

Notes for application of dimensions to microgravity conditions:

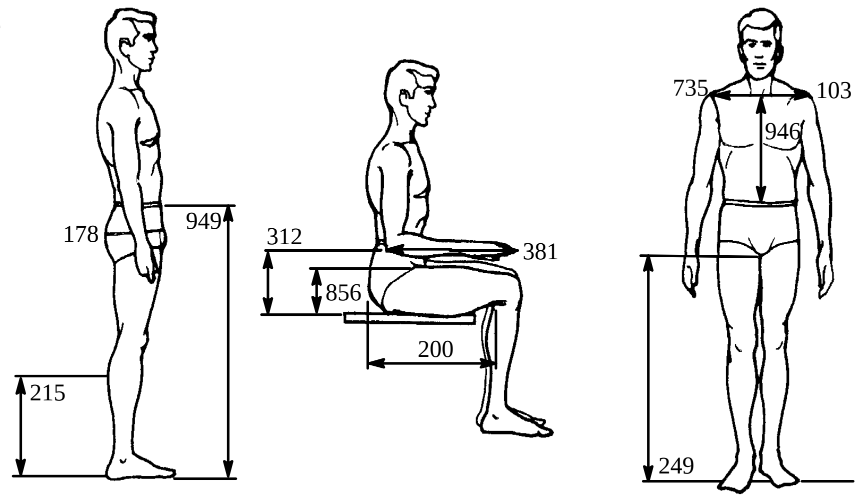
(1) Stature increases approximately 3 percent over the first 3 to 4 days in weightlessness (See NASA−STD−3000, Volume I, Figure 3.2.3.1−2, for information). Almost all of this change appears in the spinal column and thus affects (increases) other related dimensions, such as sitting height (buttock−vertex), shoulder height −sitting, eye height, sitting, and all dimensions that include the spine.

(2) Sitting height would be better named as buttock−vertex in microgravity conditions, unless the crewmember were measured with a firm pressure on shoulders pressing him or her against a fixed, flat ‘‘sitting” support surface. All sitting dimensions (vertex, eye, shoulder, and elbow) increase in weightlessness by two changes:

(a) Relief of pressure on the buttock surfaces (estimated increase of 1.3 to 2.0 cm (0.5 to 0.8 inches).

(b) Extension of the spinal column as explained in note (1) above (3 percent of stature on ground).

FIGURE 3.3.1.3−1 BODY SIZE OF 40−YEAR−OLD AMERICAN MALE AND 40−YEAR−OLD JAPANESE FEMALE FOR YEAR 2000 IN ONE GRAVITY CONDITIONS (PAGE 5 OF 12)



Notes	No.	Dimension	5th Percentile cm (inches)	50th Percentile cm (inches)	95th Percentile cm (inches)
	949	Waist height	100.4 (39.5)	108.3 (42.6)	116.2 (45.7)
	249	Crotch height	79.4 (31.3)	85.4 (34.0)	93.3 (36.7)
	215	Calf height	32.5 (12.8)	36.2 (14.3)	40.0 (15.7)
	103	Biacromial breadth	37.9 (14.9)	41.1 (16.2)	44.3 (17.5)
1	946	Waist front	37.2 (14.6)	40.9 (16.1)	44.6 (17.5)
	735	Scye circumference	44.4 (17.5)	49.0 (19.3)	53.6 (21.1)
	178	Buttock circumference	91.0 (35.8)	100.2 (39.4)	109.4 (43.1)
1, 2	312	Elbow rest height	21.1 (8.3)	25.4 (10.0)	29.7 (11.7)
	856	Thigh clearance	14.5 (5.7)	16.8 (6.6)	19.1 (7.5)
	381	Forearm−hand length			
	200	Buttock−popliteal length	46.9 (18.5)	51.2 (20.2)	55.5 (21.9)

General Notes:

(a) Gravity conditions − the dimensions apply to a 1−G condition only. Dimension expected to change significantly due to microgravity are marked.

(b) Measurement data − the number adjacent to each of the dimension are reference codes. The same codes are in NASA RP 1024, Volume 2. NASA RP 1024, Volume 2 provides additional data for these measurements plus an explanation of the measurement technique.

Notes for application of dimensions to microgravity conditions:

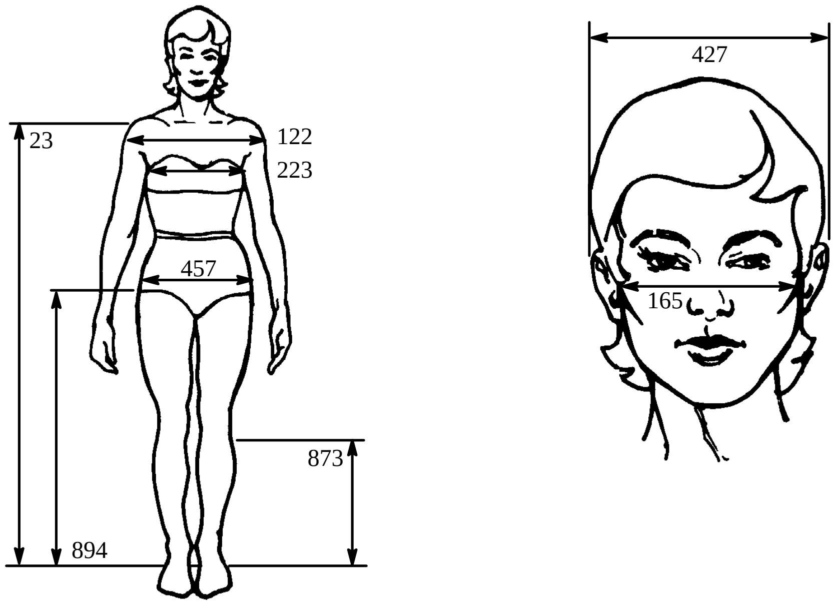
(1) Stature increases approximately 3 percent over the first 3 to 4 days in weightlessness (See NASA−STD−3000, Volume I, Figure 3.2.3.1−2, for information). Almost all of this change appears in the spinal column and thus affects (increases) other related dimensions, such as sitting height (buttock−vertex), shoulder height −sitting, eye height, sitting, and all dimensions that include the spine.

(2) Sitting height would be better named as buttock−vertex in microgravity conditions, unless the crewmember were measured with a firm pressure on shoulders pressing him or her against a fixed, flat ‘‘sitting” support surface. All sitting dimensions (vertex, eye, shoulder, and elbow) increase in weightlessness by two changes:

(a) Relief of pressure on the buttock surfaces (estimated increase of 1.3 to 2.0 cm (0.5 to 0.8 inches).

(b) Extension of the spinal column as explained in note (1) above (3 percent of stature on ground).

FIGURE 3.3.1.3−1 BODY SIZE OF 40−YEAR−OLD AMERICAN MALE AND 40−YEAR−OLD JAPANESE FEMALE FOR YEAR 2000 IN ONE GRAVITY CONDITIONS (PAGE 6 OF 12)

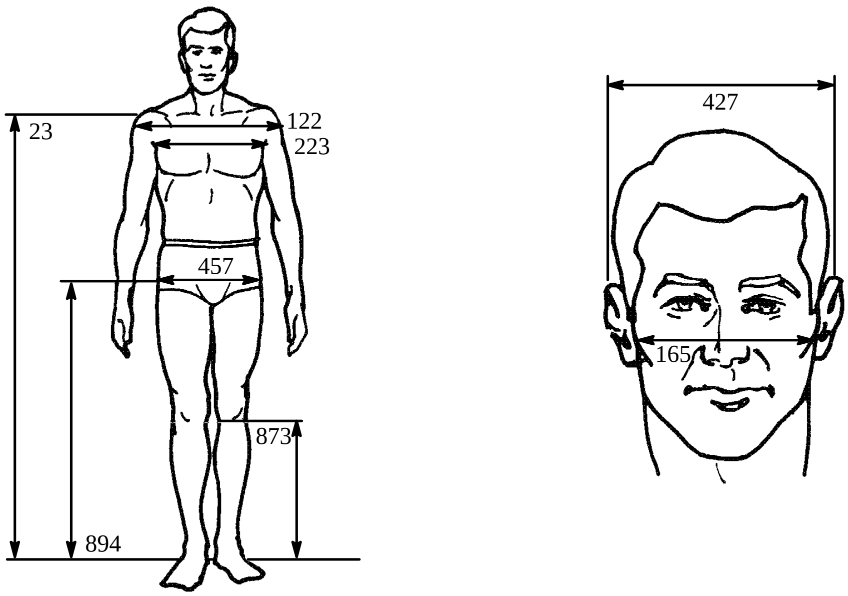


Notes	No.	Dimension	5th Percentile cm (inches)	50th Percentile cm (inches)	95th Percentile cm (inches)
1, 3	23	Acromial (shoulder) height	119.6 (47.1)	127.1 (50.0)	134.5 (53.0)
	894	Trochanteric height	71.0 (28.0	76.7 (30.2)	82.4 (32.5)
	873	Tibiale height	35.9 (14.1)	39.3 (15.5)	42.7 (16.8)
	122	Bideltoid (shoulder) height	35.6 (14.0)	38.9 (15.3)	42.1 (16.6)
	223	Chest breadth	24.5 (9.7)	26.8 (10.5)	29.0 (11.4)
	457	Hip breadth	30.5 (12.0)	32.9 (12.9)	35.3 (13.9)
	165	Bizygomatic (face) breadth	13.3 (5.2)	14.5 (5.7)	15.7 (6.2)
	427	Head breadth	14.4 (5.7)	15.6 (6.1)	16.8 (6.6)

General Notes:
(a) Gravity conditions − the dimensions apply to a 1−G condition only. Dimension expected to change significantly due to microgravity are marked.
(b) Measurement data − the number adjacent to each of the dimension are reference codes. The same codes are in NASA RP 1024, Volume 2. NASA RP 1024, Volume 2 provides additional data for these measurements plus an explanation of the measurement technique.

Notes for application of dimensions to microgravity conditions:
(1) Stature increases approximately 3 percent over the first 3 to 4 days in weightlessness (See NASA−STD−3000, Volume I, Figure 3.2.3.1−2, for information). Almost all of this change appears in the spinal column and thus affects (increases) other related dimensions, such as sitting height (buttock−vertex), shoulder height −sitting, eye height, sitting, and all dimensions that include the spine.
(3) Shoulder or acromial height, sitting or standing, increases during weightlessness due to two factors:
(a) Removal of the gravitational pull on the arms
(b) Extension of the spinal column as explained in Note (1) above (3 percent of stature on ground).

FIGURE 3.3.1.3−1 BODY SIZE OF 40−YEAR−OLD AMERICAN MALE AND 40−YEAR−OLD JAPANESE FEMALE FOR YEAR 2000 IN ONE GRAVITY CONDITIONS (PAGE 7 OF 12)



Notes	No.	Dimension	5th Percentile cm (inches)	50th Percentile cm (inches)	95th Percentile cm (inches)
1, 3	23	Acromial (shoulder) height	138.0 (54.3)	147.6 (58.1)	157.3 (61.9)
	894	Trochanteric height	88.3 (34.8)	96.6 (37.6)	102.9 (40.5)
	873	Tibiale height	x	x	x
	122	Bideltoid (shoulder) height	44.6 (17.6)	48.9 (19.3)	53.2 (20.9)
	223	Chest breadth	29.7 (11.7)	33.2 (13.1)	36.7 (14.4)
	457	Hip breadth	32.7 (12.9)	35.8 (14.1)	39.0 (15.4)
	165	Bizygomatic (face) breadth	13.4 (5.3)	14.3 (5.6)	15.1 (6.0)
	427	Head breadth	14.8 (5.8)	15.7 (6.2)	16.5 (6.5)

General Notes:

(a) Gravity conditions − the dimensions apply to a 1−G condition only. Dimension expected to change significantly due to microgravity are marked.

(b) Measurement data − the number adjacent to each of the dimension are reference codes. The same codes are in NASA RP 1024, Volume 2. NASA RP 1024, Volume 2 provides additional data for these measurements plus an explanation of the measurement technique.

Notes for application of dimensions to microgravity conditions:

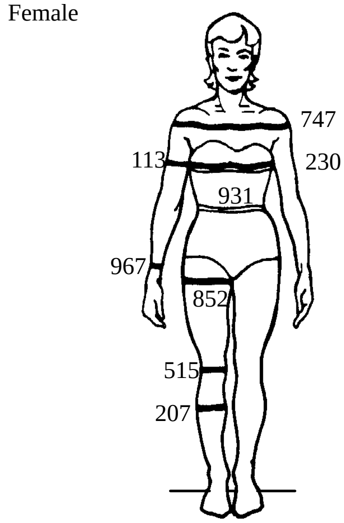
(1) Stature increases approximately 3 percent over the first 3 to 4 days in weightlessness (See NASA−STD−3000, Volume I, Figure 3.2.3.1−2, for information). Almost all of this change appears in the spinal column and thus affects (increases) other related dimensions, such as sitting height (buttock−vertex), shoulder height −sitting, eye height, sitting, and all dimensions that include the spine.

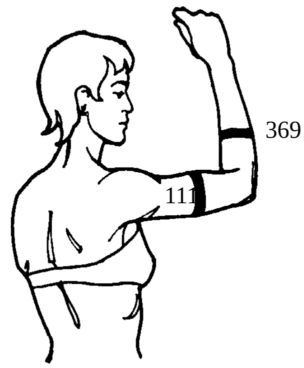
(3) Shoulder or acromial height, sitting or standing, increases during weightlessness due to two factors:

(a) Removal of the gravitational pull on the arms

(b) Extension of the spinal column as explained in Note (1) above (3 percent of stature on ground).

FIGURE 3.3.1.3−1 BODY SIZE OF 40−YEAR−OLD AMERICAN MALE AND 40−YEAR−OLD JAPANESE FEMALE FOR YEAR 2000 IN ONE GRAVITY CONDITIONS (PAGE 8 OF 12)





Notes	No.	Dimension	5th Percentile cm (inches)	50th Percentile cm (inches)	95th Percentile cm (inches)
	747	Shoulder circumference	x	x	x
	230	Chest circumference	73.2 (28.8)	82.1 (32.3)	90.9 (35.8)
6	931	Waist circumference	55.3 (21.8)	63.2 (24.9)	71.2 (28.0)
5	852	Thigh circumference	45.6 (17.9)	51.6 (20.3)	57.7 (22.7)
5	515	Knee circumference	31.0 (12.2)	34.6 (13.6)	38.2 (15.0)
5	207	Calf circumference	30.3 (11.9)	34.1 (13.4)	37.8 (14.9)
	113	Biceps circumference, relaxed	21.8 (8.8)	25.5 (10.1)	29.3 (11.5)
	967	Wrist circumference	13.7 (5.4)	15.0 (5.9)	16.2 (6.4)
	111	Biceps circumference, flexed	x	x	x
	369	Forarm circumference, relaxed	19.9 (7.8)	22.0 (8.7)	24.1 (9.5)

General Notes:

(a) Gravity conditions − the dimensions apply to a 1−G condition only. Dimension expected to change significantly due to microgravity are marked.

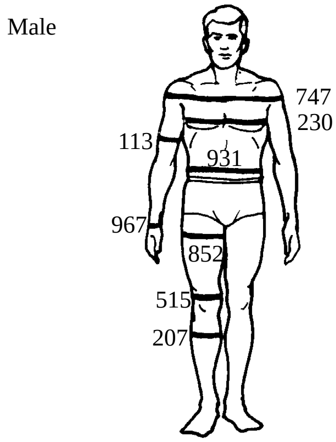
(b) Measurement data − the number adjacent to each of the dimension are reference codes. The same codes are in NASA RP 1024, Volume 2. NASA RP 1024, Volume 2 provides additional data for these measurements plus an explanation of the measurement technique.

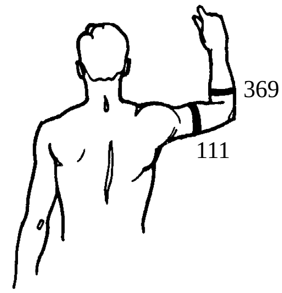
Notes for application of dimensions to microgravity conditions:

(5) Leg circumferences and diameters significantly decrease during the first day in microgravity. See NASA RP 1024, Volume 1, appendix C, for details and measurements of actual persons.

(6) Waist circumference will decrease in microgravity due to fluid shifts to the upper torso. See Figure 3.2.3.1−2 for measurements on actual persons.

FIGURE 3.3.1.3−1 BODY SIZE OF 40−YEAR−OLD AMERICAN MALE AND 40−YEAR−OLD JAPANESE FEMALE FOR YEAR 2000 IN ONE GRAVITY CONDITIONS (PAGE 9 OF 12)





Notes	No.	Dimension	5th Percentile cm (inches)	50th Percentile cm (inches)	95th Percentile cm (inches)
	747	Shoulder circumference	109.5 (43.1)	119.2 (46.9)	128.8 (50.7)
	230	Chest circumference	89.4 (35.2)	100.0 (39.4)	110.6 (43.6)
6	931	Waist circumference	77.1 (30.3)	89.5 (35.2)	101.9 (40.1)
5	852	Thigh circumference	52.5 (20.7)	60.0 (23.6)	67.4 (26.5)
5	515	Knee circumference	35.9 (14.1)	39.4 (15.5)	42.9 (16.9)
5	207	Calf circumference	33.9 (13.3)	37.6 (14.8)	41.4 (16.3)
	113	Biceps circumference, relaxed	27.3 (10.7)	31.2 (12.3)	35.1 (13.8)
	967	Wrist circumference	16.2 (6.4)	17.7 (7.0)	19.3 (7.6)
	111	Biceps circumference, flexed	29.4 (11.6)	33.2 (13.1)	36.9 (14.5)
	369	Forarm circumference, relaxed	27.4 (10.8)	30.1 (11.8)	32.7 (12.9)

General Notes:

(a) Gravity conditions − the dimensions apply to a 1−G condition only. Dimension expected to change significantly due to microgravity are marked.

(b) Measurement data − the number adjacent to each of the dimension are reference codes. The same codes are in NASA RP 1024, Volume 2. NASA RP 1024, Volume 2 provides additional data for these measurements plus an explanation of the measurement technique.

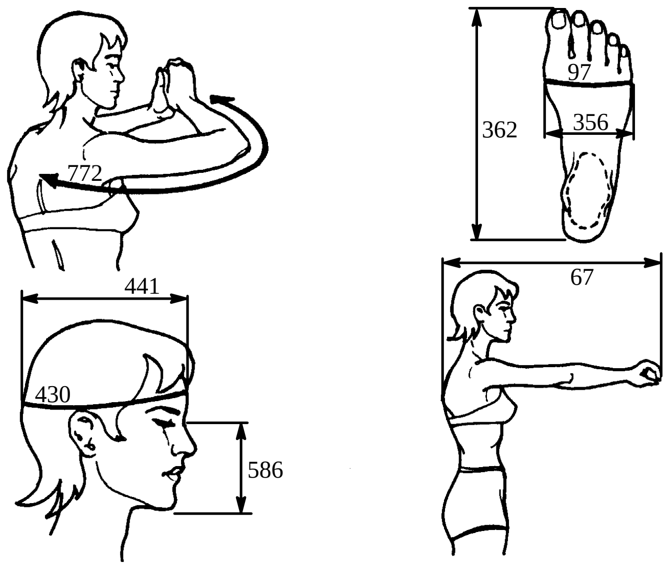
Notes for application of dimensions to microgravity conditions:

(5) Leg circumferences and diameters significantly decrease during the first day in microgravity. See NASA RP 1024, Volume 1, appendix C, for details and measurements of actual persons.

(6) Waist circumference will decrease in microgravity due to fluid shifts to the upper torso. See Figure 3.2.3.1−2 for measurements on actual persons.

FIGURE 3.3.1.3−1 BODY SIZE OF 40−YEAR−OLD AMERICAN MALE AND 40−YEAR−OLD JAPANESE FEMALE FOR YEAR 2000 IN ONE GRAVITY CONDITIONS (PAGE 10 OF 12)

Female



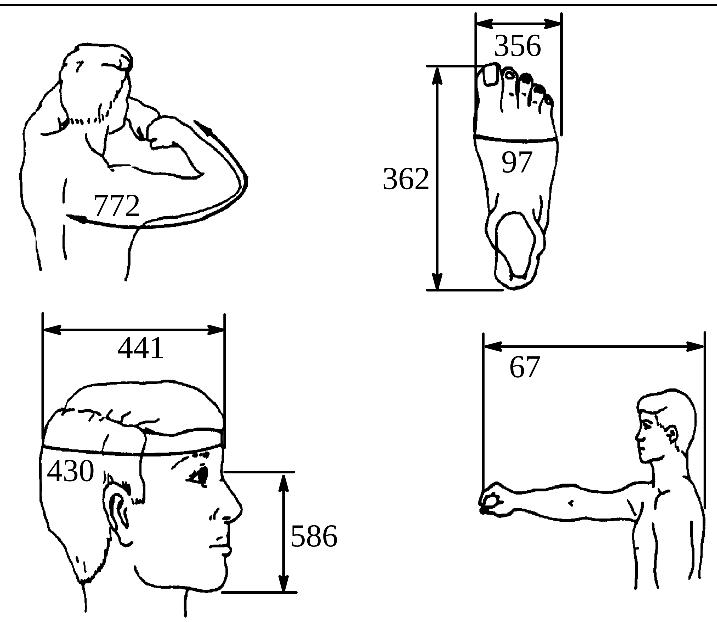
Notes	No.	Dimension	5th Percentile cm (inches)	50th Percentile cm (inches)	95th Percentile cm (inches)
	67	Thumb−tip reach	65.2 (25.7)	71.6 (28.2)	78.0 (30.7)
	772	Sleeve length	x	x	x
	441	Head length	16.7 (6.6)	18.2 (7.2)	19.6 (7.7)
	430	Head circumference	53.2 (20.9)	55.2 (21.7)	57.2 (22.5)
	586	Menton−sellion (face) length	9.0 (3.5)	10.8 (4.2)	12.6 (5.0)
	362	Foot length	21.3 (8.4)	22.9 (9.0)	24.4 (9.6)
	356	Foot breadth	8.6 (3.4)	9.3 (3.7)	10.0 (3.9)
	97	Ball of foot circumference	21.0 (8.3)	22.7 (8.9)	24.3 (9.6)

General Notes:

(a) Gravity conditions − the dimensions apply to a 1−G condition only. Dimension expected to change significantly due to microgravity are marked.

(b) Measurement data − the number adjacent to each of the dimension are reference codes. The same codes are in NASA RP 1024, Volume 2. NASA RP 1024, Volume 2 provides additional data for these measurements plus an explanation of the measurement technique.

FIGURE 3.3.1.3−1 BODY SIZE OF 40−YEAR−OLD AMERICAN MALE AND 40−YEAR−OLD JAPANESE FEMALE FOR YEAR 2000 IN ONE GRAVITY CONDITIONS (PAGE 11 OF 12)



Notes	No.	Dimension	5th Percentile cm (inches)	50th Percentile cm (inches)	95th Percentile cm (inches)
	67	Thumb−tip reach	74.9 (29.5)	81.6 (32.1)	88.2 (34.7)
	772	Sleeve length	86.2 (33.9)	92.0 (36.2)	97.9 (38.5)
	441	Head length	18.8 (7.4)	20.0 (7.9)	21.1 (8.3)
	430	Head circumference	55.5 (21.8)	57.8 (22.8)	60.2 (23.7)
	586	Menton−sellion (face) length	11.1 (4.4)	12.1 (4.8)	13.1 (5.2)
	362	Foot length	25.4 (10.0)	27.3 (10.8)	29.3 (11.5)
	356	Foot breadth	9.0 (3.6)	9.9 (3.9)	10.7 (4.2)
	97	Ball of foot circumference	23.1 (9.1)	25.1 (9.9)	27.2 (10.7)

General Notes:
(a) Gravity conditions − the dimensions apply to a 1−G condition only. Dimension expected to change significantly due to microgravity are marked.
(b) Measurement data − the number adjacent to each of the dimension are reference codes. The same codes are in NASA RP 1024, Volume 2. NASA RP 1024, Volume 2 provides additional data for these measurements plus an explanation of the measurement technique.

FIGURE 3.3.1.3−1 BODY SIZE OF 40−YEAR−OLD AMERICAN MALE AND 40−YEAR−OLD JAPANESE FEMALE FOR YEAR 2000 IN ONE GRAVITY CONDITIONS (PAGE 12 OF 12)

3.3.2 JOINT MOTION

3.3.2.1 INTRODUCTION

This paragraph is not applicable for this document.

3.3.2.2 JOINT MOTION DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

3.3.2.3 JOINT MOTION DATA DESIGN REQUIREMENTS

The data shown in Figure 3.3.2.3.1−1, single joint movement ranges for both males and females, shall be used when designing all Space Station IVA flight crew interfaces.

3.3.2.3.1 JOINT MOTION DATA FOR SINGLE JOINT DESIGN REQUIREMENTS

Figure 3.3.2.3.1−1 shows single joint movement ranges for both males and females.

Figure	Joint movement (2)	Range of motion (degrees)			
		Males (1)		Female (1)	
		5th percentile	95th percentile	5th percentile	95th percentile
1	Neck, rotation right	73.3	99.6	74.9	108.8
	Neck, rotation left	74.3	99.1	72.2	109.0
2	Neck, flexion	34.5	71.0	46.0	84.4
	Neck, extension	65.4	103.0	64.9	103.0
3	Neck, lateral right	34.9	63.5	37.0	63.2
	Neck, lateral left	35.5	63.5	29.1	77.2
4	Shoulder, abduction	173.2	188.7	172.6	192.9
5	Shoulder, rotation lat	46.3	96.7	53.8	85.8
	Shoulder, rotation med	90.5	126.6	95.8	130.9
6	Shoulder, flexion	164.4	210.9	152.0	217.0
	Shoulder, extension	39.6	83.3	33.7	87.9
7	Elbow, flexion	140.5	159.0	144.9	165.9
8	Forearm, pronation	78.2	116.1	82.3	118.9
	Forearm, supination	83.4	125.8	90.4	139.5
9	Wrist, radial	16.9	36.7	16.1	36.1
	Wrist, ulner	18.6	47.9	21.5	43.0
10	Wrist, flexion	61.5	94.8	68.3	98.1
	Wrist, extension	40.1	78.0	42.3	74.7
11	Hip, flexion	116.5	148.0	118.5	145.0
12	Hip, abduction	26.8	53.5	27.2	55.9
13	Knee, flexion	118.4	145.6	125.2	145.2
14	Ankle, plantar	36.1	79.6	44.2	91.1
	Ankle, dorsi	8.1	19.9	6.9	17.4

Notes:
(1) Data was taken 1979 and 1980 at NASA−JSC by Dr. William Thornton and John Jackson. The study was made using 192 males (mean age 33) 22 females (mean age 30) astronaut candidates (see SP−2−86L−064).
(2) Limb range is average of right and left limb movement.

FIGURE 3.3.2.3.1−1 JOINT MOVEMENT RANGES FOR MALES AND FEMALES (PAGE 1 OF 3)

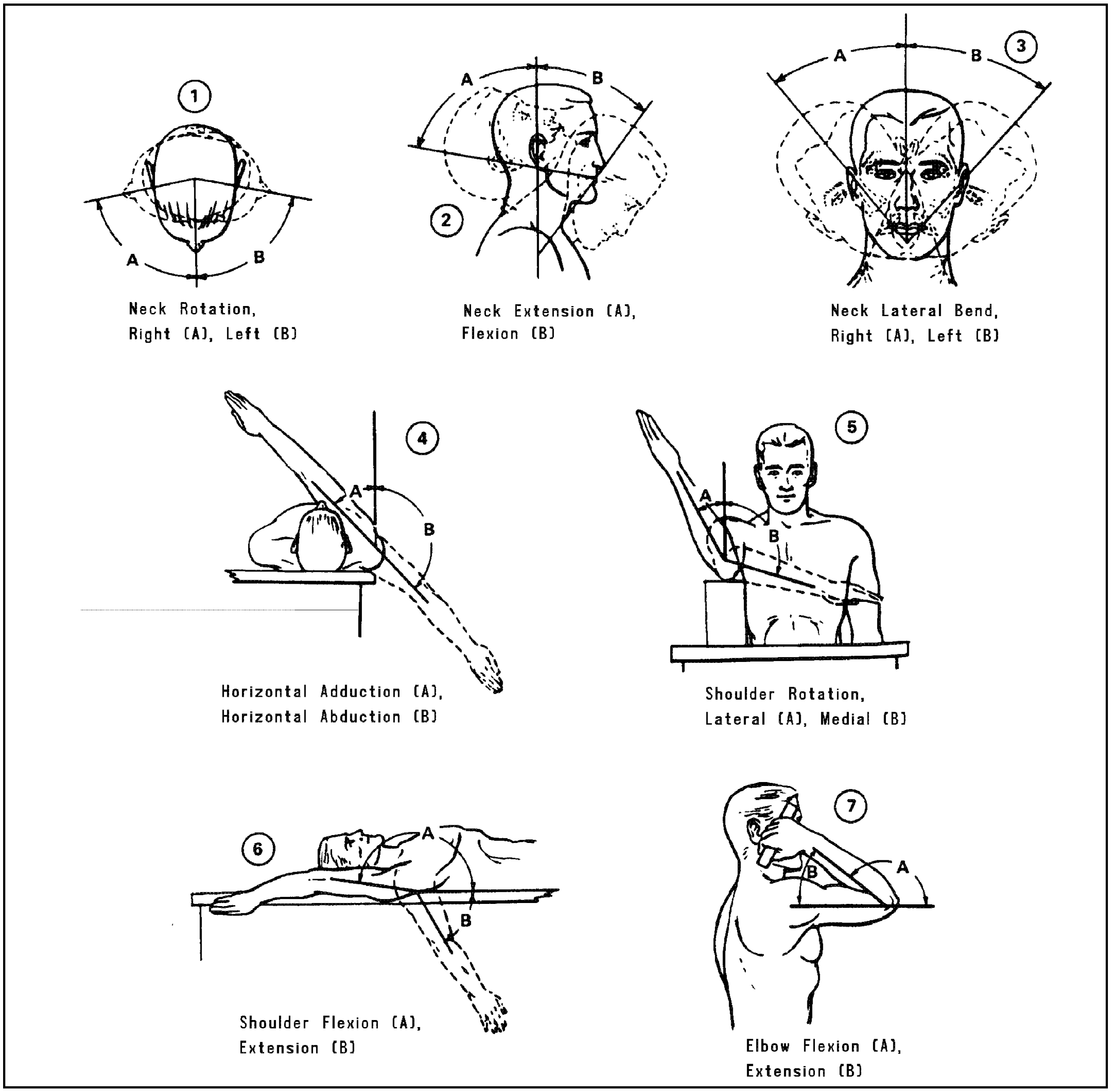


FIGURE 3.3.2.3.1−1 JOINT MOVEMENT RANGES FOR MALES AND FEMALES (PAGE 2 OF 3)

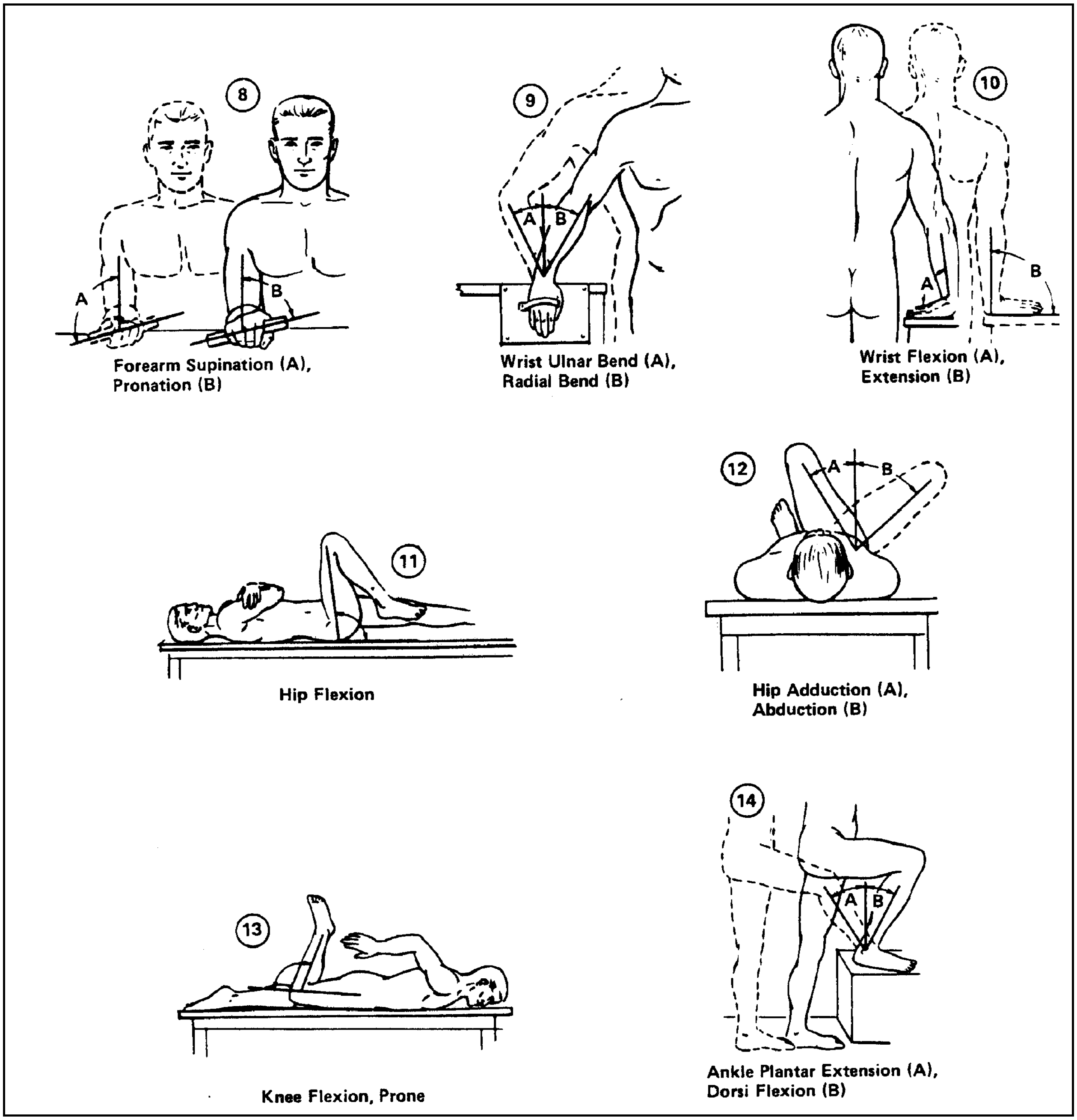


FIGURE 3.3.2.3.1−1 JOINT MOVEMENT RANGES FOR MALES AND FEMALES (PAGE 3 OF 3)

3.3.2.3.2 JOINT MOTION DATA FOR TWO JOINTS DESIGN REQUIREMENTS

The data shown in Figure 3.3.2.3.2−1, changes in range of motion with movement in adjacent joint, shall be used when designing all Space Station IVA flight crew interfaces.

Figure 3.3.2.3.2−1 contains the following information:

A. Single Joint Movement Baseline Range − The baseline values of given joint motions with the adjacent joint in neutral position.

B. Effect (in Degrees) of Movement of an Adjacent Joint − The increment or decrement which takes place when an adjacent joint is flexed or extended in varying amounts (one−third, one−half, two−thirds, and/or full).

C. Effect (in Terms of Percent of the Baseline Range) of Movement of an Adjacent Joint.

Two−joint movement	Full range of A (degrees)	Change in range of movement of A (degrees)				
		Movement of B (fraction of full range)				
		Zero	1/3	1/2	2/3	Full
Shoulder extension (A) with elbow flexion (B)	59.3		+1.6 deg (102.7%)		+0.9 deg (101.5%)	+5.3 deg (108.9%)
Shoulder flexion (A) with elbow flexion (B)	190.7		−24.9 deg (86.9%)		−36.1 deg (81.0%)	−47.4 deg (75.0%)
Elbow flexion (A) with shoulder extension (B)	152.2			−3.78 deg (97.5%)		−1.22 deg (99.2%)
Elbow flexion (A) with shoulder flexion (B)	152.2		−0.6 deg (99.6%)		−0.8 deg (99.5%)	−69.0 deg (54.7%)
Hip flexion (A) with shoulder flexion (B)	53.3	−35.6 deg (1) (33.2%)	−24.0 deg (55.0%)		−6.2 deg (88.4%)	−12.3 deg (76.9%)
Ankle plantar flexion (A) with knee flexion (B)	48.0		−3.4 deg (92.9%)		+0.2 deg (100.4%)	+1.6 deg (103.3%)
Ankle dorsi flexion (A) with knee flexion (B)	26.1		−7.3 deg (72.0%)		−2.7 deg (89.7%)	−3.2 deg (87.7%)
Knee flexion (A) with ankle plantar flexion (B)	127.0			−9.9 deg (92.2%)		−4.7 deg (96.3%)
Knee flexion (A) with ankle dorsi flexion (B)	127.0					−8.7 deg (93.0%)
Knee flexion (A) with hip flexion (B)	127.0			−19.6 deg (84.6%)		−33.6 deg (73.5%)

Notes:
(1) The knee joint is locked and the unsupported leg extends out in front of the subject.
(2) The following is an example of how the figure is to be used. The first entry is read as follows: the shoulder can be extended as far as 59.3 degrees (the mean of the subjects tested) with the elbow in a neutral position (locked in hyperextension). When shoulder extension was measured wiht the elbow flexed to 1/3 of its full joint range, the man value of shoulder extension was found to increase by 1.6 degrees, or 102.7% of the base value. The results for other movements and adjacent joint positions are presented in a similar manner.

FIGURE 3.3.2.3.2−1 CHANGE IN RANGE OF MOVEMENT WITH MOVEMENT IN ADJACENT JOINT

3.3.3 REACH

3.3.3.1 INTRODUCTION

This paragraph is not applicable for this document.

3.3.3.2 REACH DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

3.3.3.3 REACH DATA DESIGN REQUIREMENTS

The data in this section will be used as appropriate to achieve effective integration of the flight crew reach requirements into the ISS.

3.3.3.3.1 FUNCTIONAL REACH DESIGN REQUIREMENTS

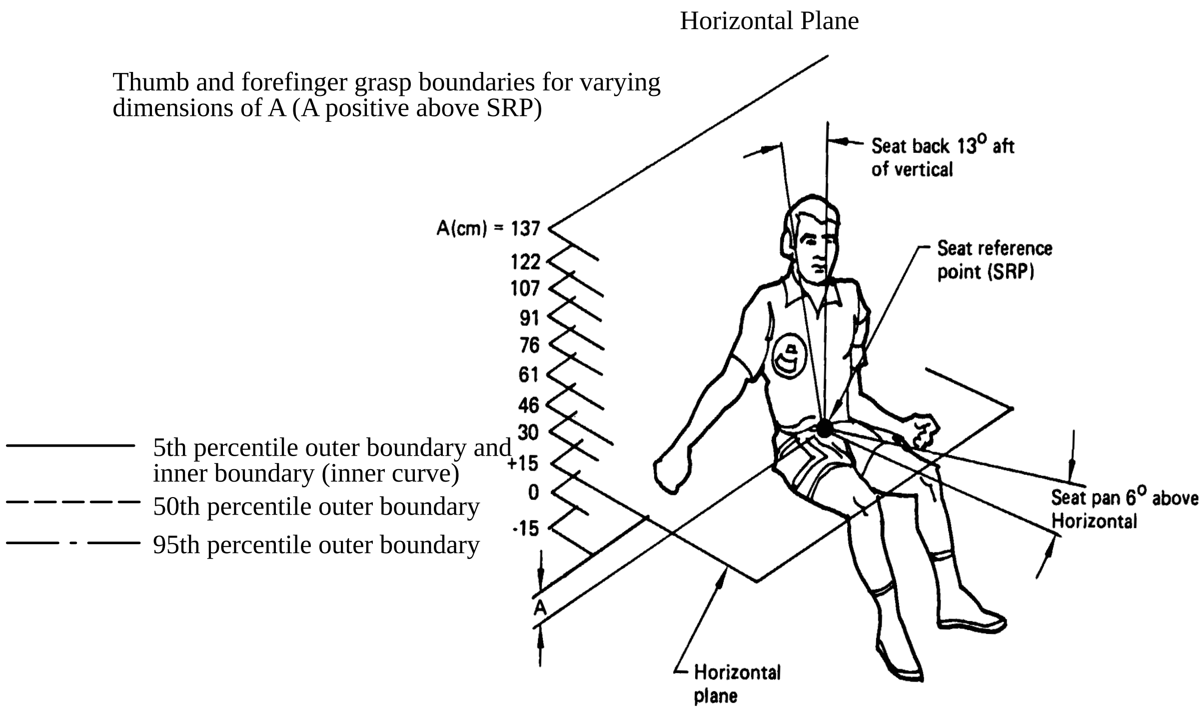
Equipment and controls required to perform a task shall be within the IVA reach envelopes of the 5th percentile female to 95th percentile male as shown in Figures 3.3.3.3.1−1, 3.3.3.3.1−2, 3.3.3.3.1−3, 3.3.3.3.1−4, 3.3.3.3.1−5, and 3.3.3.3.1−6.

A. Torso Restrained Reach Boundaries − The functional reach boundaries for males and females with their shoulders against a flat backrest are given in Figure 3.3.3.3.1−1. The functional reach boundaries apply to tasks requiring thumb and forefinger grasp. Figure 3.3.3.3.1−6 defines adjustment for other grasp requirements.

B. Waist Restrained − Adjustments can be made to the data in Figure 3.3.3.3.1−1 for bending at the waist to achieve different back rest angles. Figure 3.3.3.3.1−2 provides data for making these best angle adjustments. This data applies to 1−g conditions only, and require adjustments for spinal lengthening in microgravity.

C. Microgravity Handhold Restraint − Microgravity handhold restraint reach boundaries for the 5th percentile American female and the 95th percentile American male are shown in Figure 3.3.3.3.1−3. The reach boundary considers fingertip reach only. Other types of reach are to be estimated using Figure 3.3.3.3.1−6.

D. Microgravity Foot Restraint − Microgravity foot restraint reach boundaries for the 5th percentile American female and the 95th percentile American male are shown in Figures 3.3.3.3.1−4 and 3.3.3.3.1−5. The reach boundary considers fingertip reach only. Other types of reach are to be estimated using Figure 3.3.3.3.1−6.



Notes:
(1) Gravity conditions − the boundaries apply to 1−G conditions only. Microgravity will cause the spine to lengthen and adjustments should be made based on a new shoulder pivot location.
(2) Subjects − the subjects used for this study are representative of the 1967 Air Force population estimates defined in NASA RP 1024, Volume 1, chapter III.

FIGURE 3.3.3.3.1−1 GRASP REACH LIMITS WITH RIGHT HAND FOR AMERICAN MALE AND FEMALE POPULATIONS (PAGE 1 OF 19)

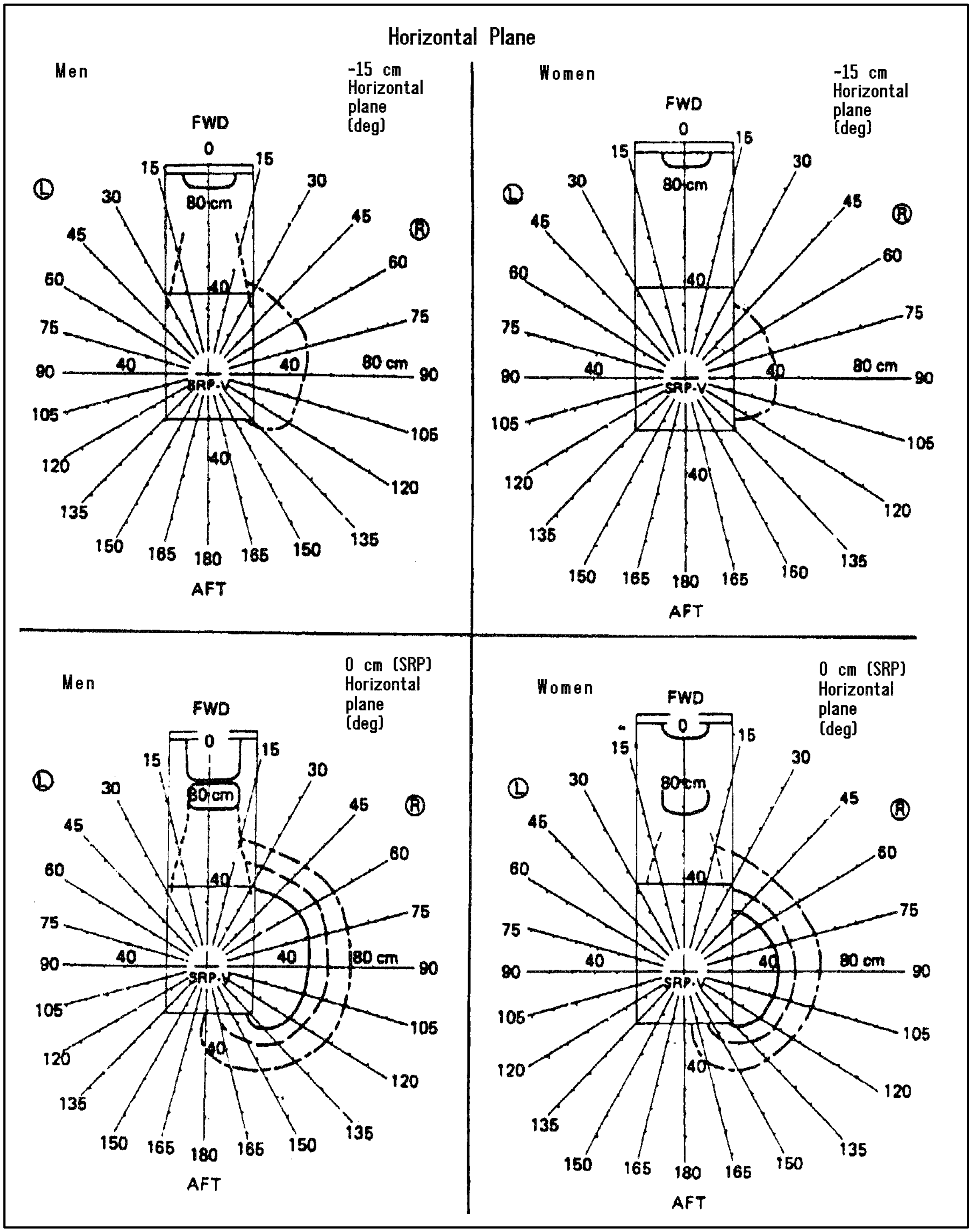


FIGURE 3.3.3.3.1−1 GRASP REACH LIMITS WITH RIGHT HAND FOR AMERICAN MALE AND FEMALE POPULATIONS (PAGE 2 OF 19)

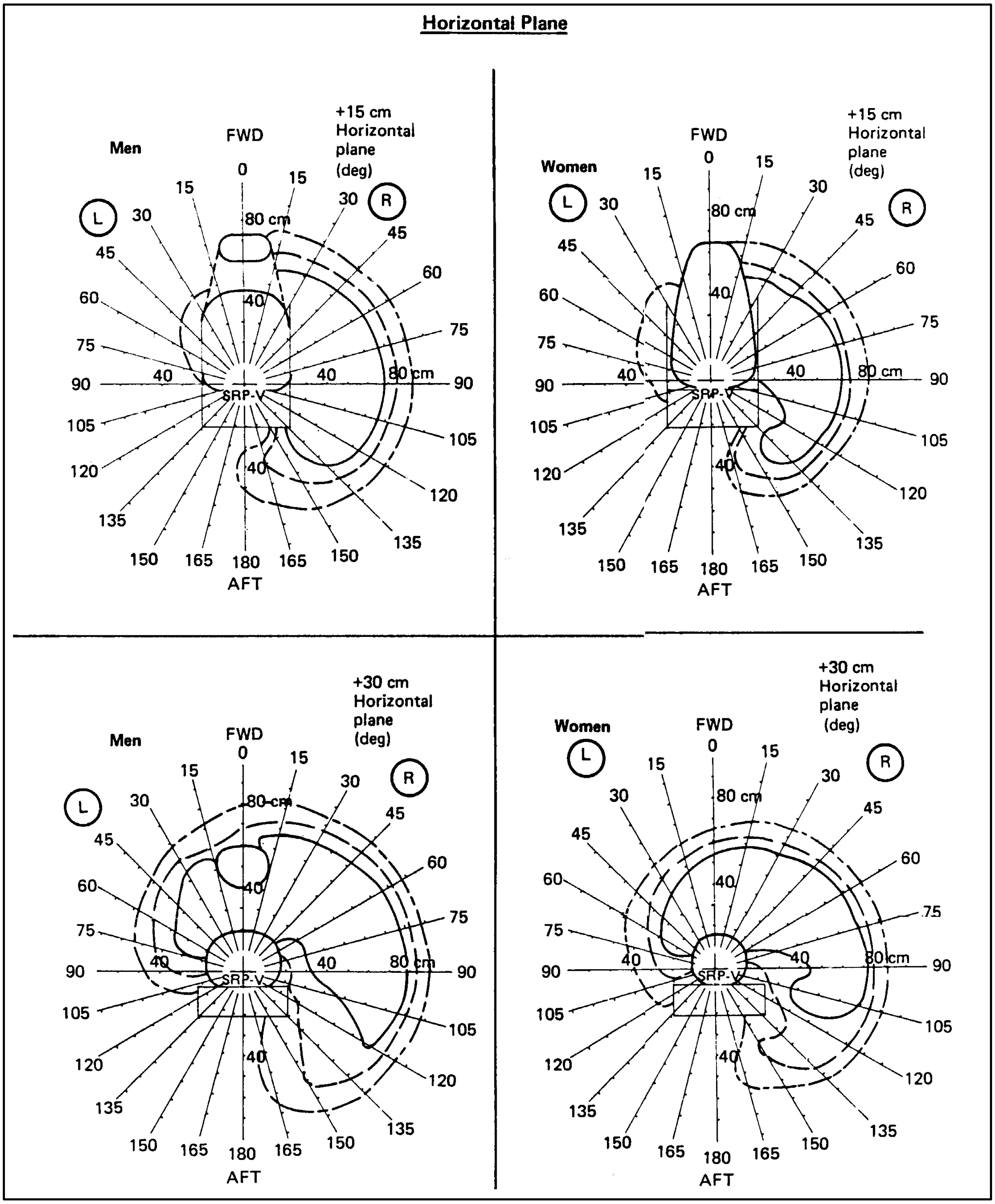


FIGURE 3.3.3.3.1–1 GRASP REACH LIMITS WITH RIGHT HAND FOR AMERICAN MALE AND FEMALE POPULATIONS (PAGE 3 OF 19)

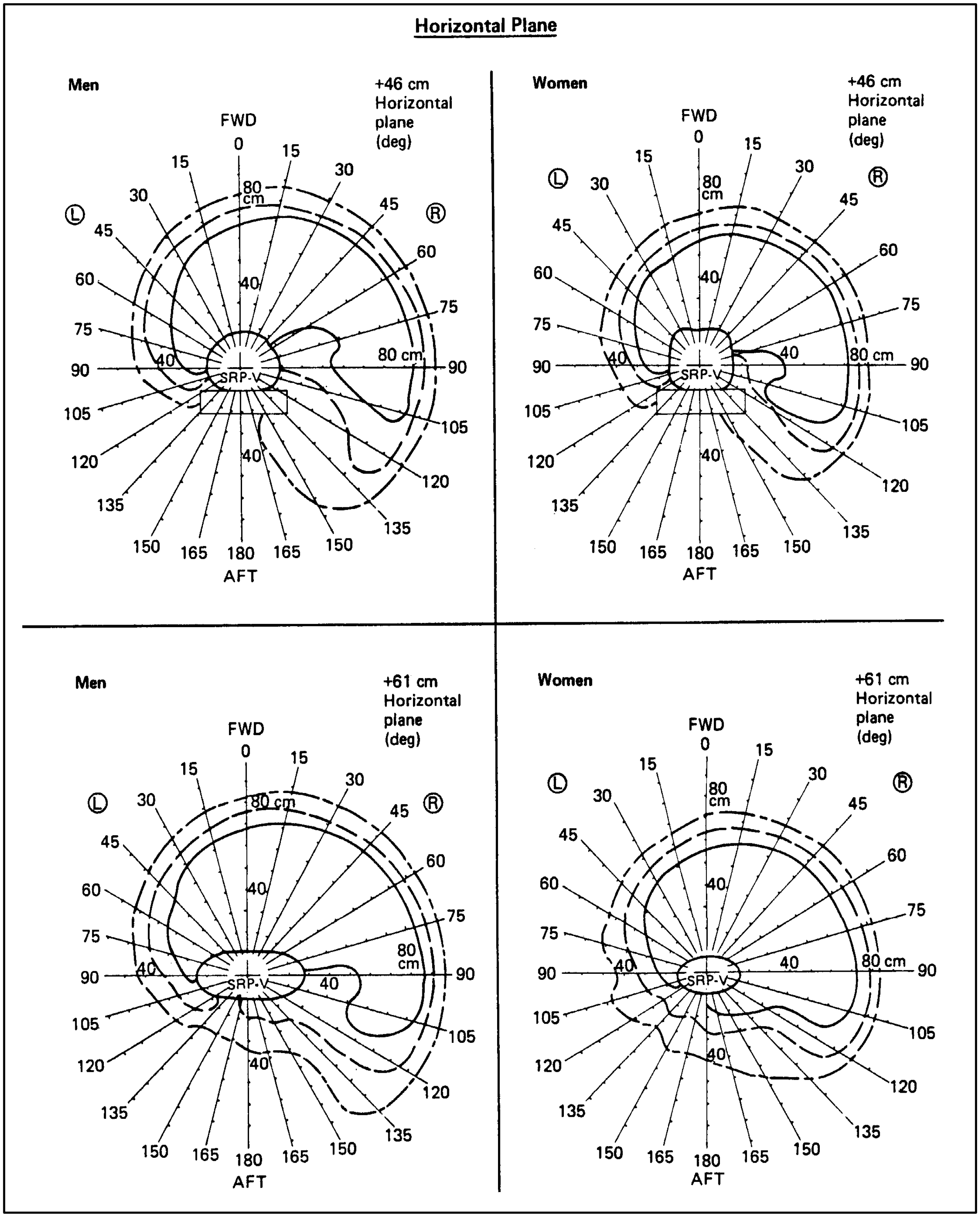


FIGURE 3.3.3.3.1−1 GRASP REACH LIMITS WITH RIGHT HAND FOR AMERICAN MALE AND FEMALE POPULATIONS (PAGE 4 OF 19)

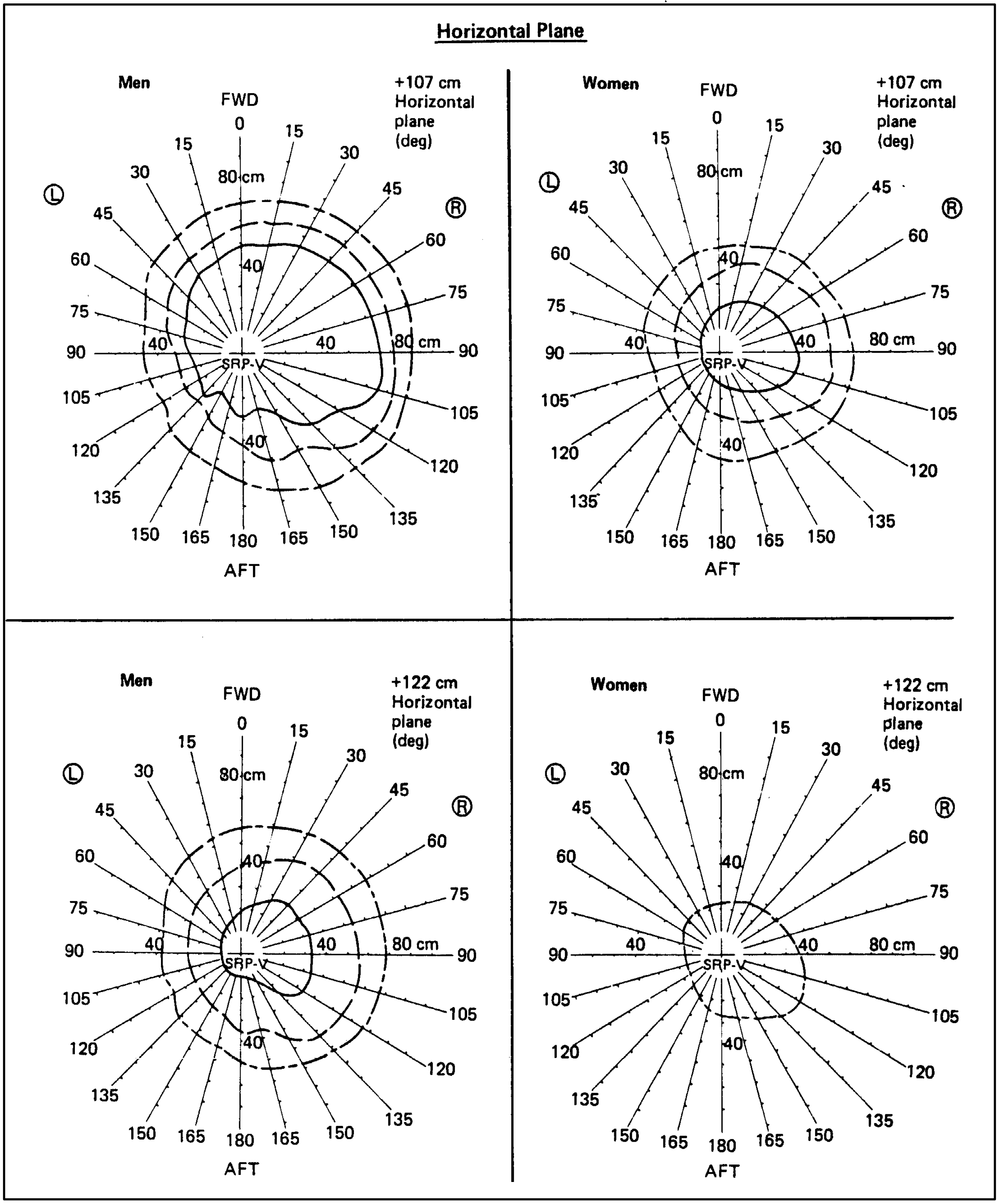


FIGURE 3.3.3.3.1−1 GRASP REACH LIMITS WITH RIGHT HAND FOR AMERICAN MALE AND FEMALE POPULATIONS (PAGE 5 OF 19)

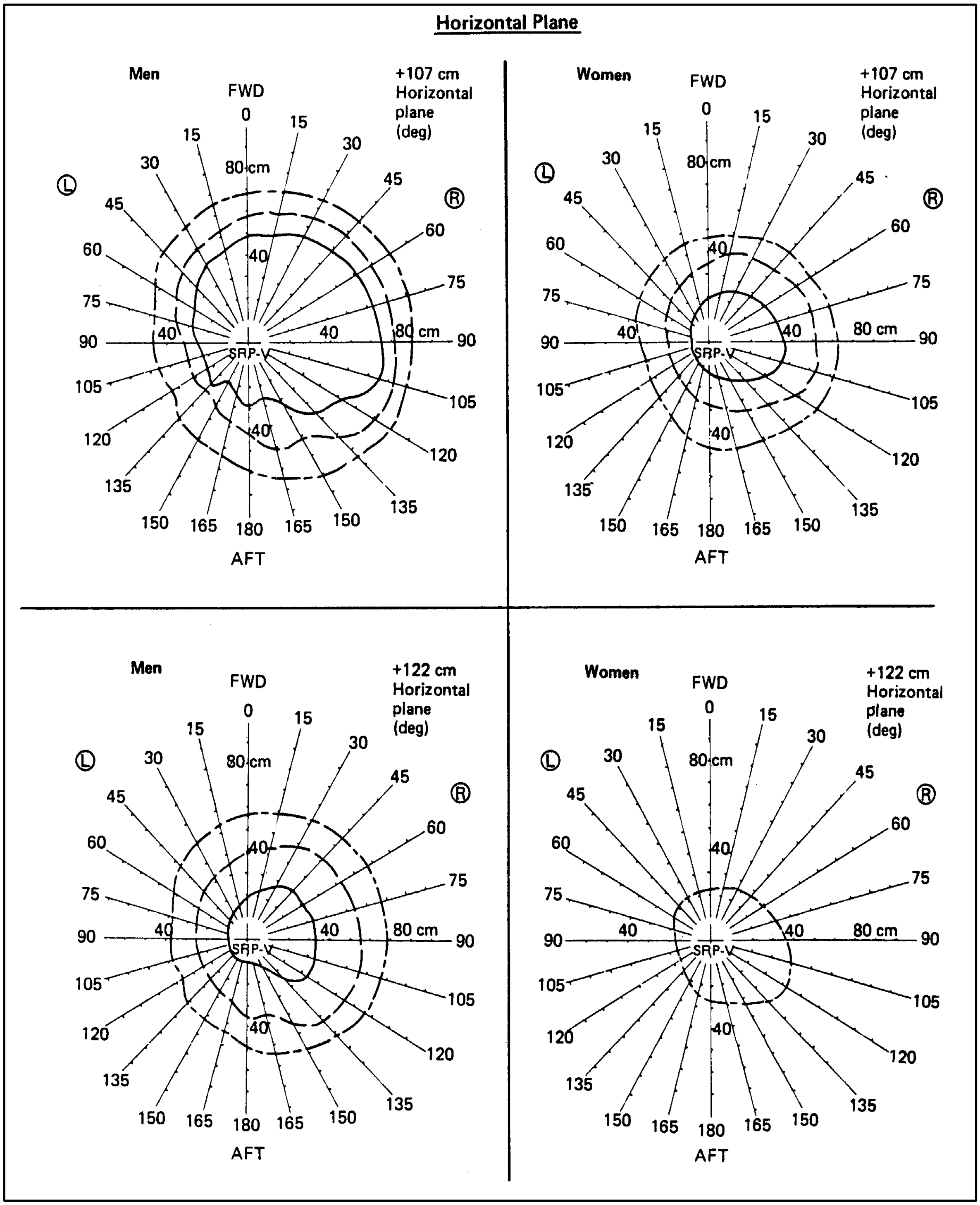


FIGURE 3.3.3.3.1−1 GRASP REACH LIMITS WITH RIGHT HAND FOR AMERICAN MALE AND FEMALE POPULATIONS (PAGE 6 OF 19)

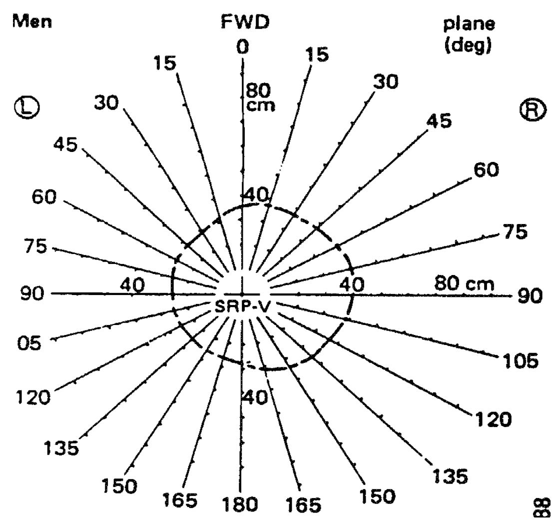
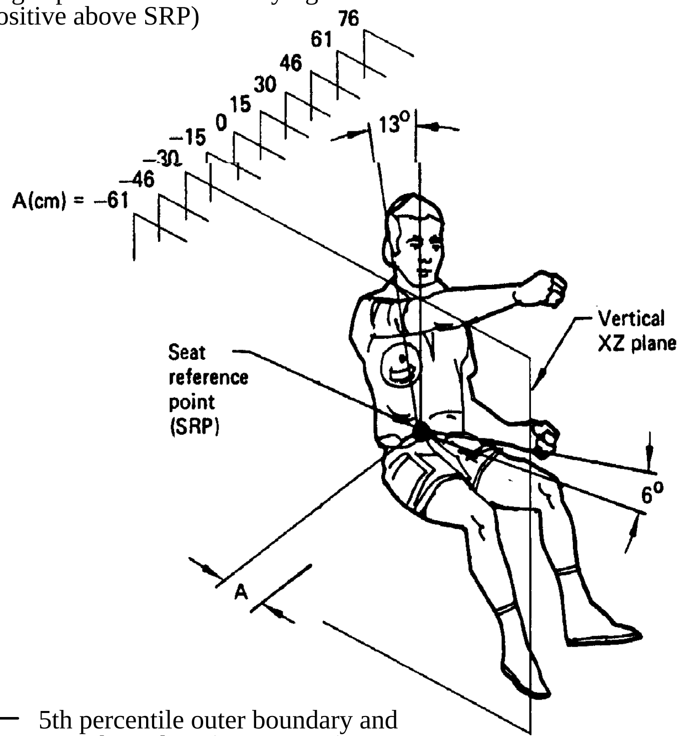


FIGURE 3.3.3.3.1−1 GRASP REACH LIMITS WITH RIGHT HAND FOR AMERICAN MALE AND FEMALE POPULATIONS (PAGE 7 OF 19)

XZ Plane

Thumb and forefinger grasp boundaries for varying dimensions of A (A positive above SRP)



5th percentile outer boundary and inner boundary (inner curve)

50th percentile outer boundary

95th percentile outer boundary

Notes:
(1) Gravity conditions − the boundaries apply to 1−G conditions only. Microgravity will cause the spine to lengthen and adjustments should be made based on a new shoulder pivot location.
(2) Subjects − the subjects used for this study are representative of the 1967 Air Force population estimates defined in NASA RP 1024, Volume 1, chapter III.

FIGURE 3.3.3.3.1−1 GRASP REACH LIMITS WITH RIGHT HAND FOR AMERICAN MALE AND FEMALE POPULATIONS (PAGE 8 OF 19)

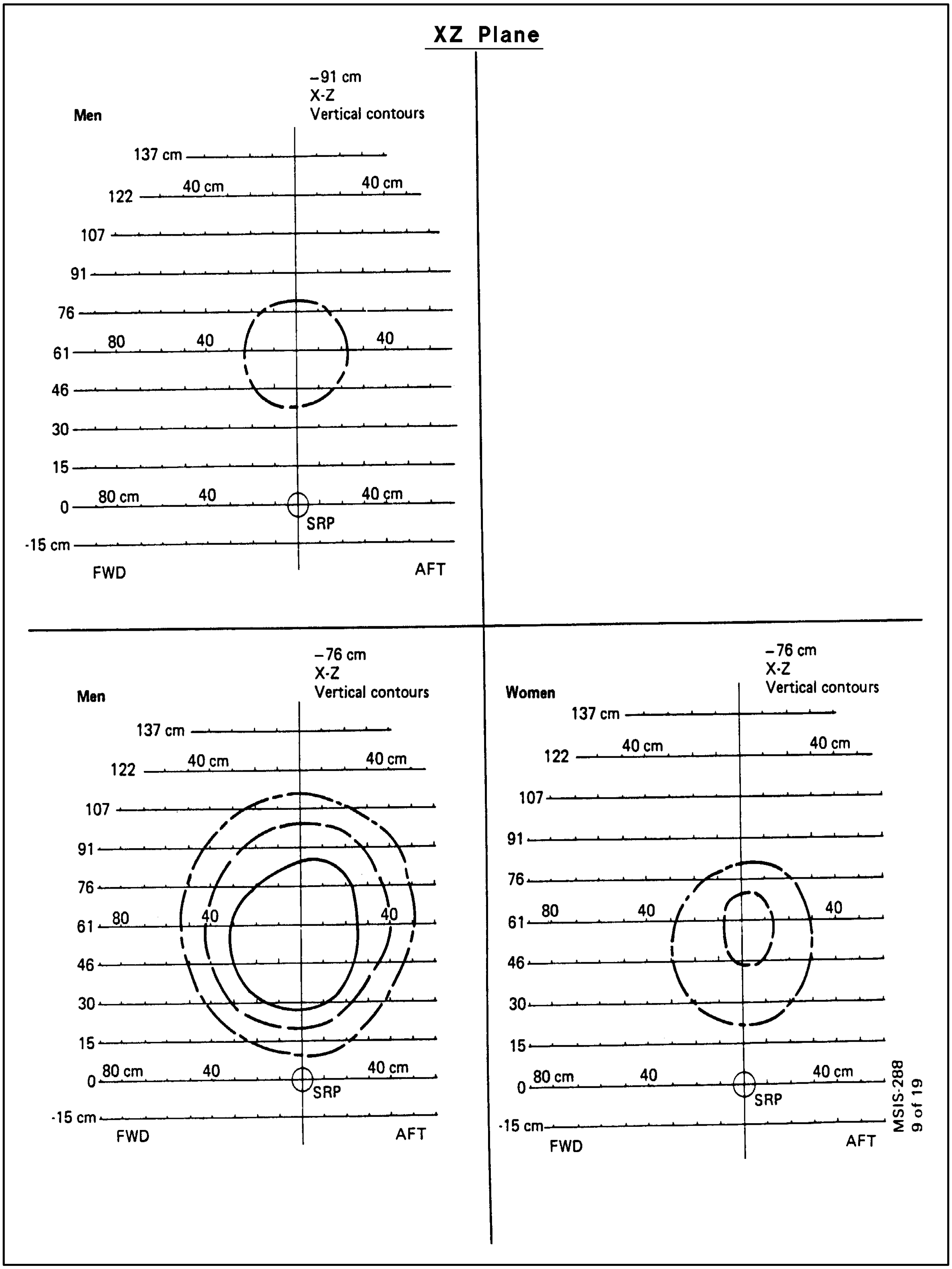


FIGURE 3.3.3.3.1−1 GRASP REACH LIMITS WITH RIGHT HAND FOR AMERICAN MALE AND FEMALE POPULATIONS (PAGE 9 OF 19)

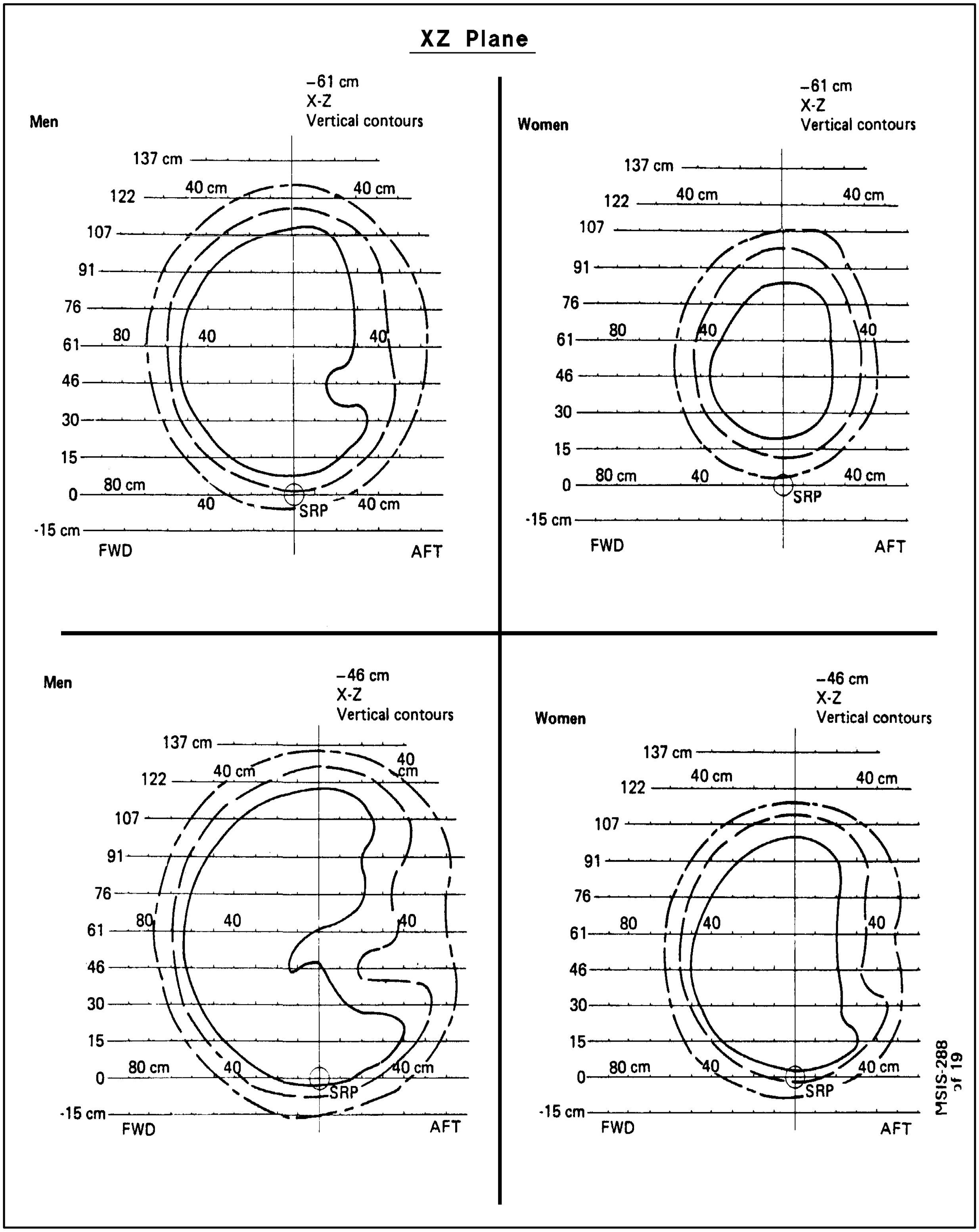


FIGURE 3.3.3.3.1−1 GRASP REACH LIMITS WITH RIGHT HAND FOR AMERICAN MALE AND FEMALE POPULATIONS (PAGE 10 OF 19)

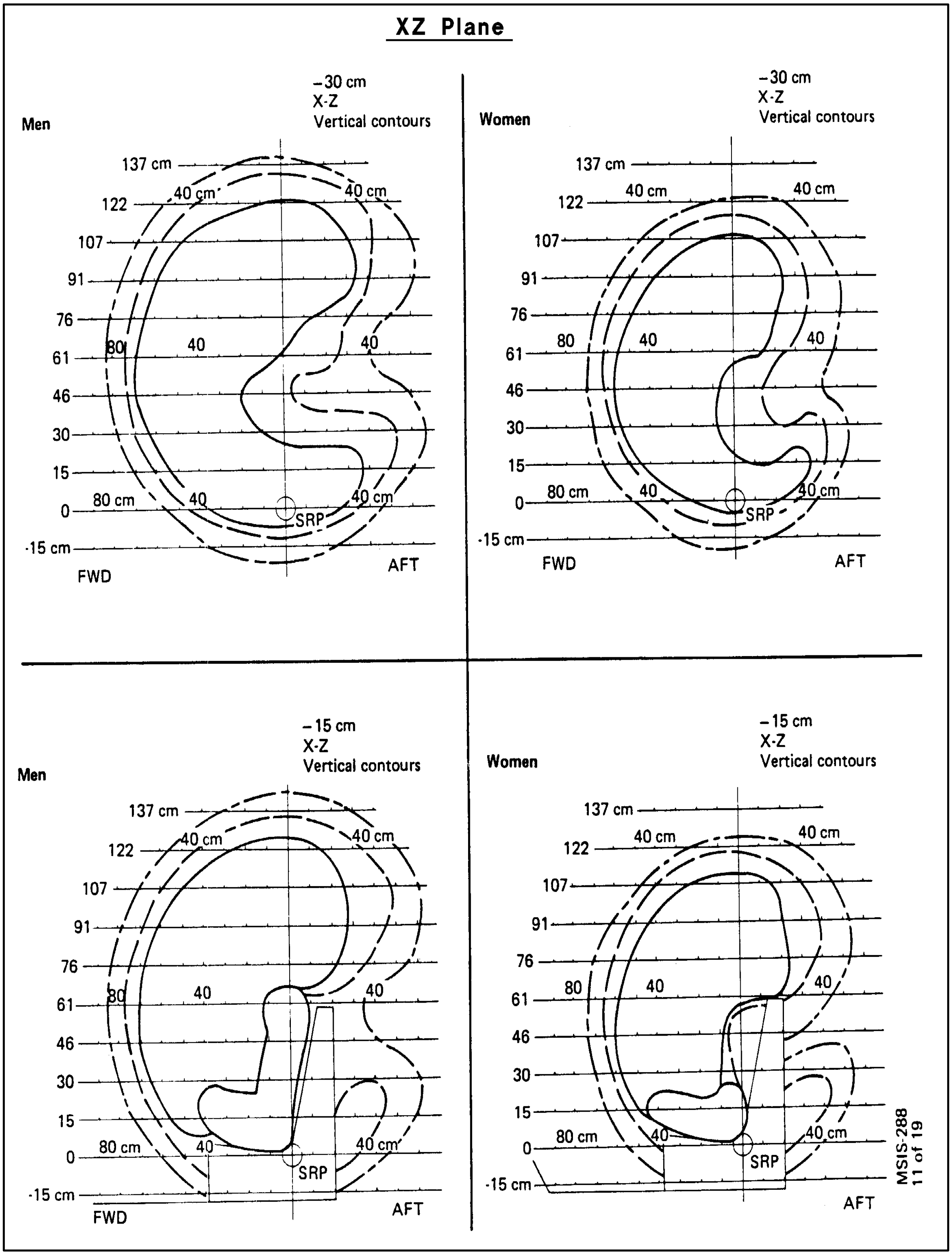


FIGURE 3.3.3.3.1−1 GRASP REACH LIMITS WITH RIGHT HAND FOR AMERICAN MALE AND FEMALE POPULATIONS (PAGE 11 OF 19)

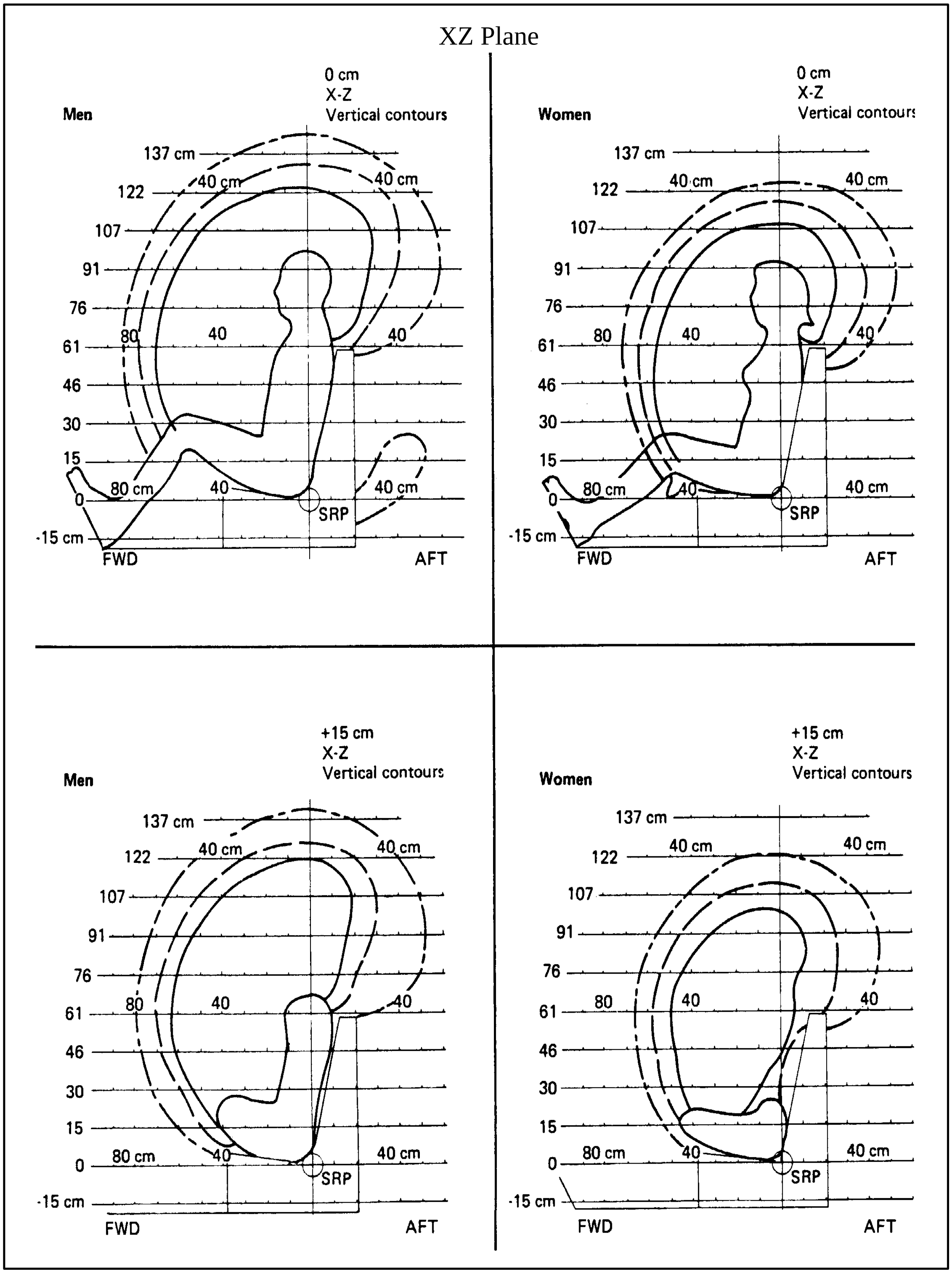


FIGURE 3.3.3.3.1−1 GRASP REACH LIMITS WITH RIGHT HAND FOR AMERICAN MALE AND FEMALE POPULATIONS (PAGE 12 OF 19)

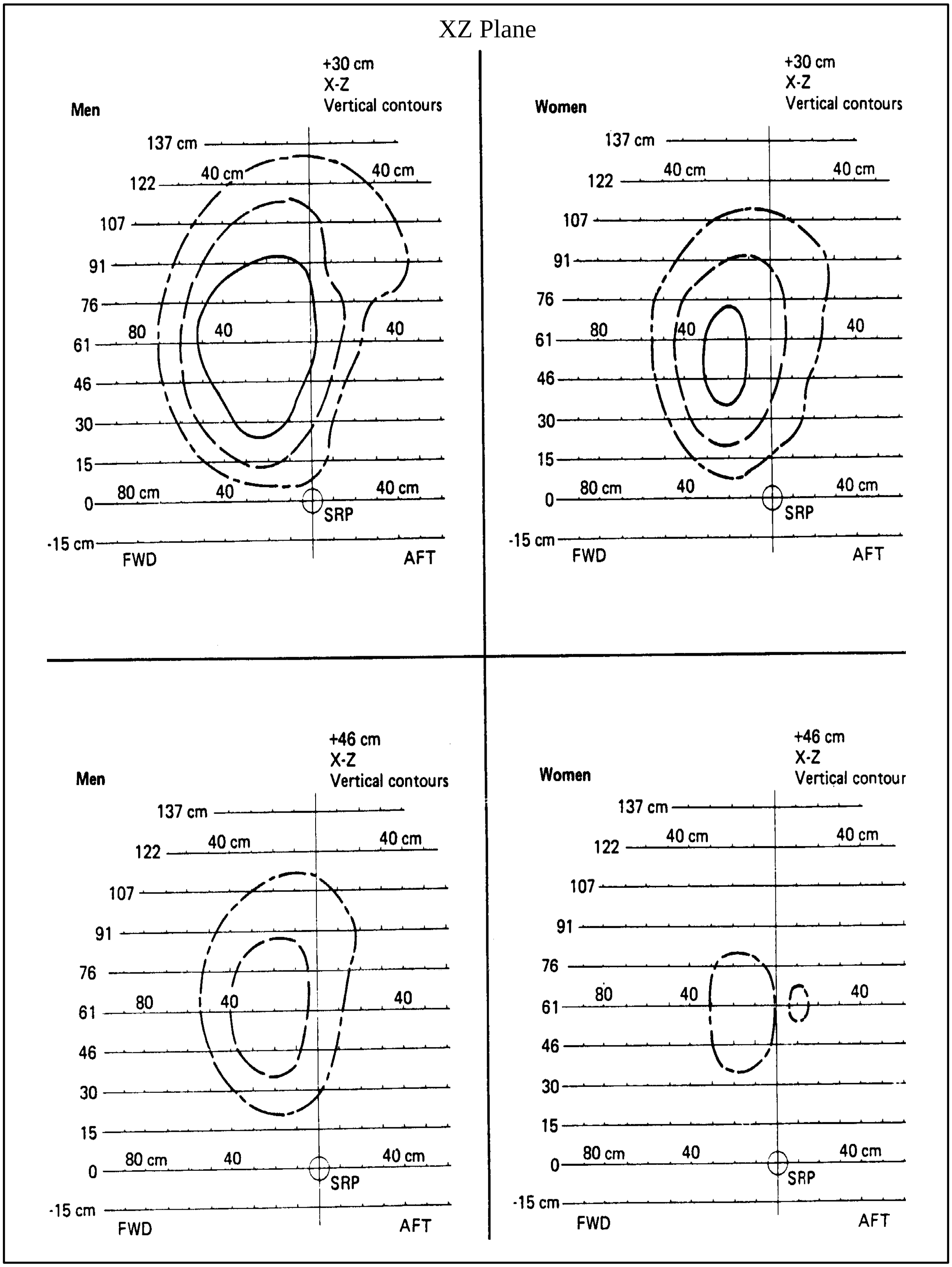
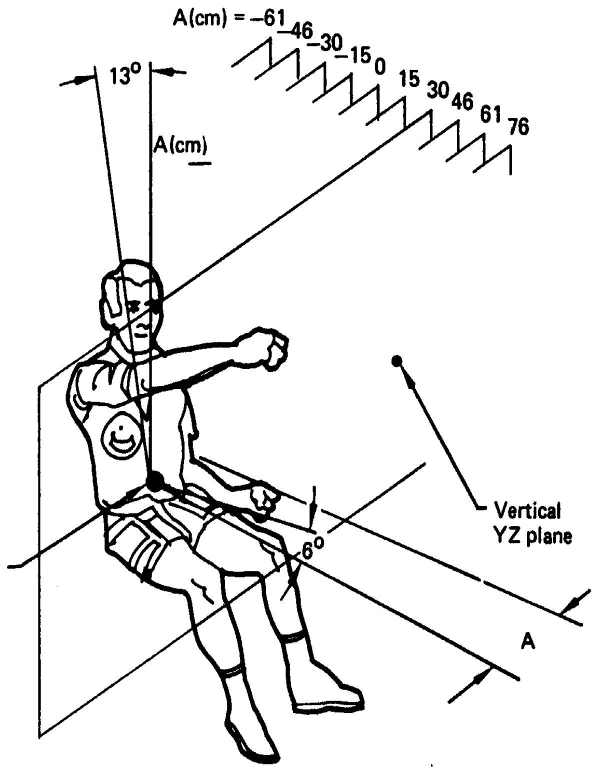


FIGURE 3.3.3.3.1−1 GRASP REACH LIMITS WITH RIGHT HAND FOR AMERICAN MALE AND FEMALE POPULATIONS (PAGE 13 OF 19)

Thumb and forefinger grasp boundaries for varying dimensions of A (A positive above SRP)

Y Z Plane



5th percentile outer boundary and inner boundary (inner curve)

50th percentile outer boundary

95th percentile outer boundary

Reference: 310, pages 35 to 52

Notes:
(1) Gravity conditions − the boundaries apply to 1−G conditions only. Microgravity will cause the spine to lengthen and adjustments should be made based on a new shoulder pivot location.
(2) Subjects − the subjects used for this study are representative of the 1967 Air Force population estimates defined in NASA RP 1024, Volume 1, chapter III.

FIGURE 3.3.3.3.1−1 GRASP REACH LIMITS WITH RIGHT HAND FOR AMERICAN MALE AND FEMALE POPULATIONS (PAGE 14 OF 19)

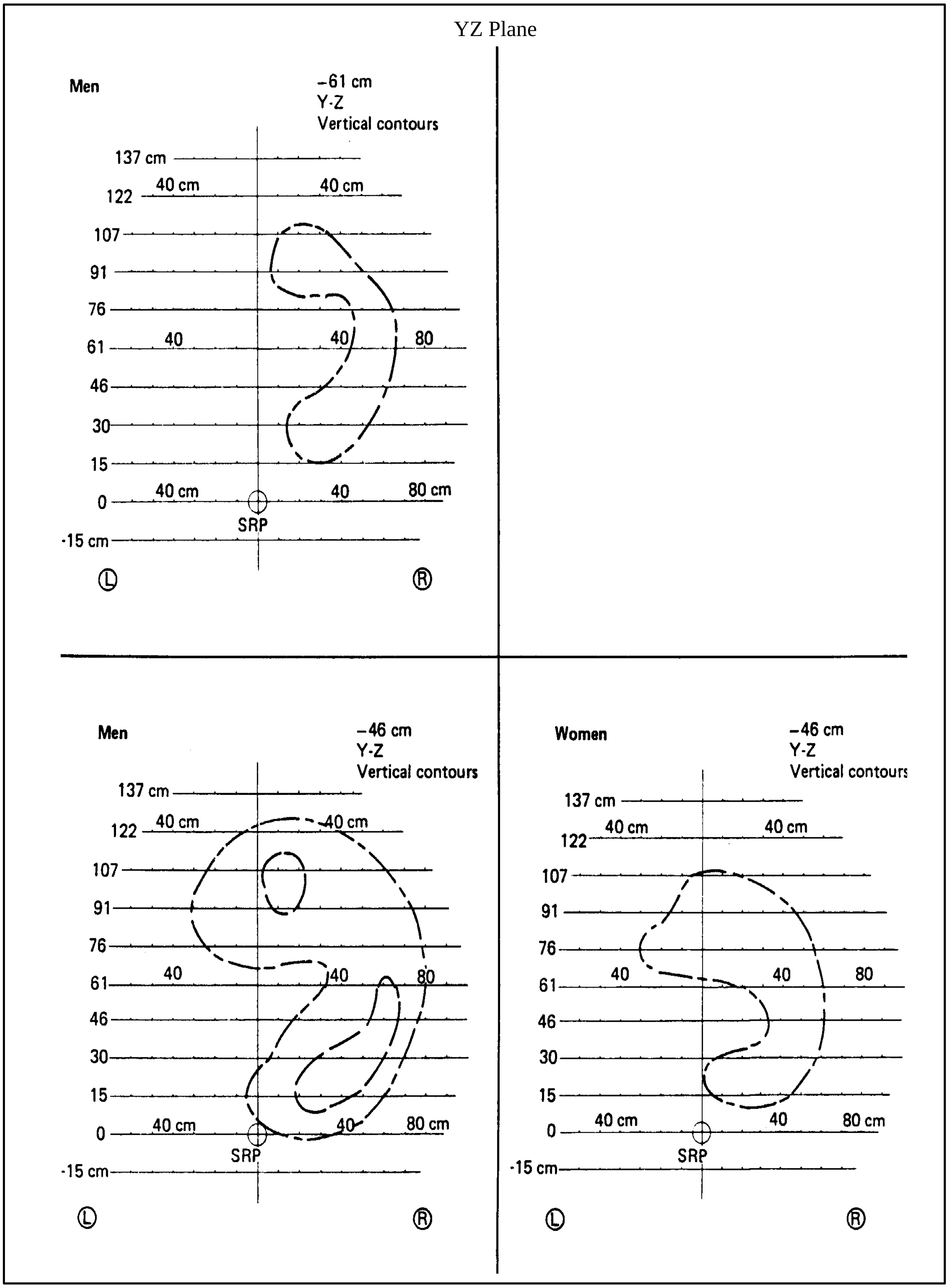


FIGURE 3.3.3.3.1−1 GRASP REACH LIMITS WITH RIGHT HAND FOR AMERICAN MALE AND FEMALE POPULATIONS (PAGE 15 OF 19)

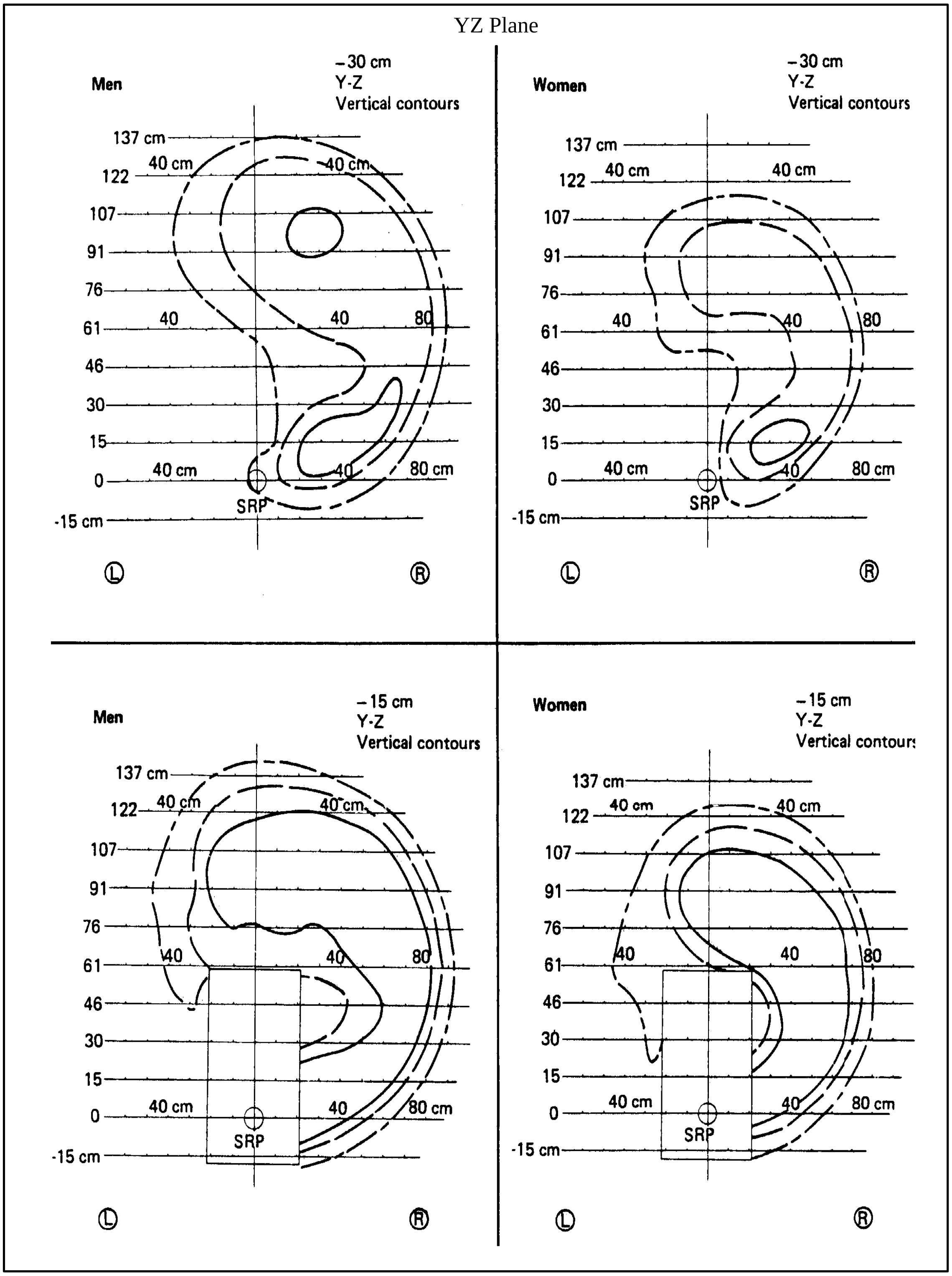


FIGURE 3.3.3.3.1−1 GRASP REACH LIMITS WITH RIGHT HAND FOR AMERICAN MALE AND FEMALE POPULATIONS (PAGE 16 OF 19)

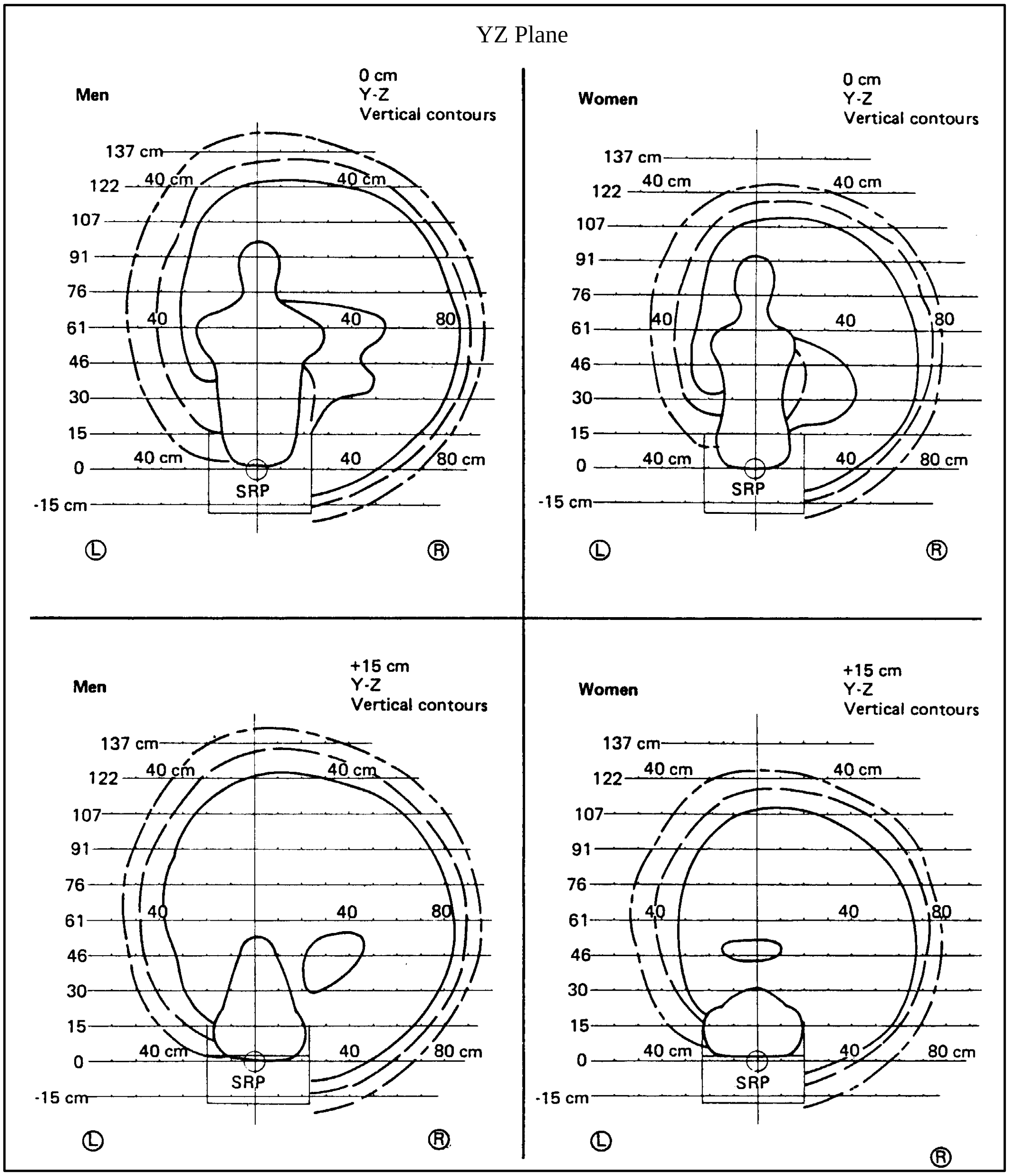


FIGURE 3.3.3.3.1−1 GRASP REACH LIMITS WITH RIGHT HAND FOR AMERICAN MALE AND FEMALE POPULATIONS (PAGE 17 OF 19)

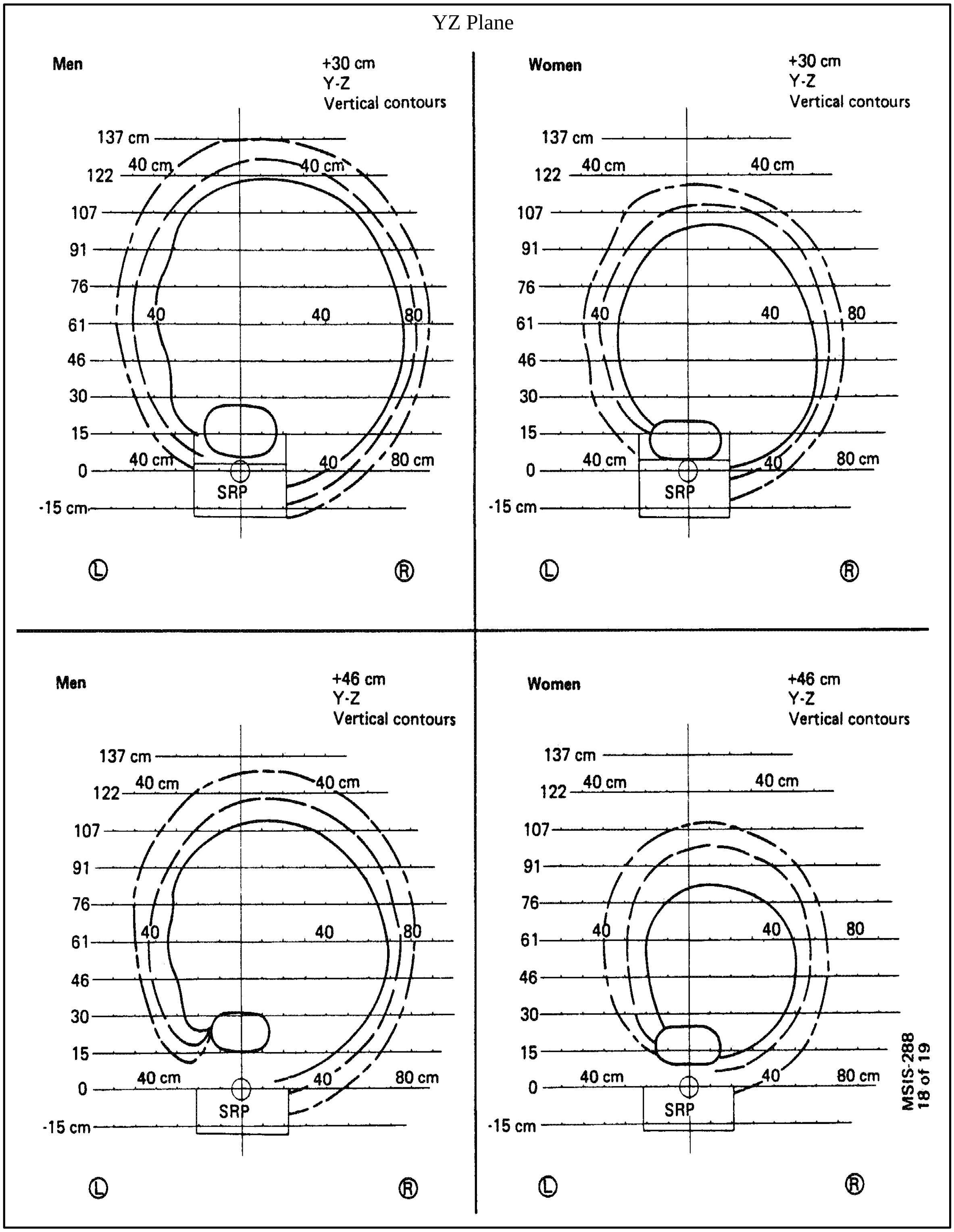


FIGURE 3.3.3.3.1−1 GRASP REACH LIMITS WITH RIGHT HAND FOR AMERICAN MALE AND FEMALE POPULATIONS (PAGE 18 OF 19)

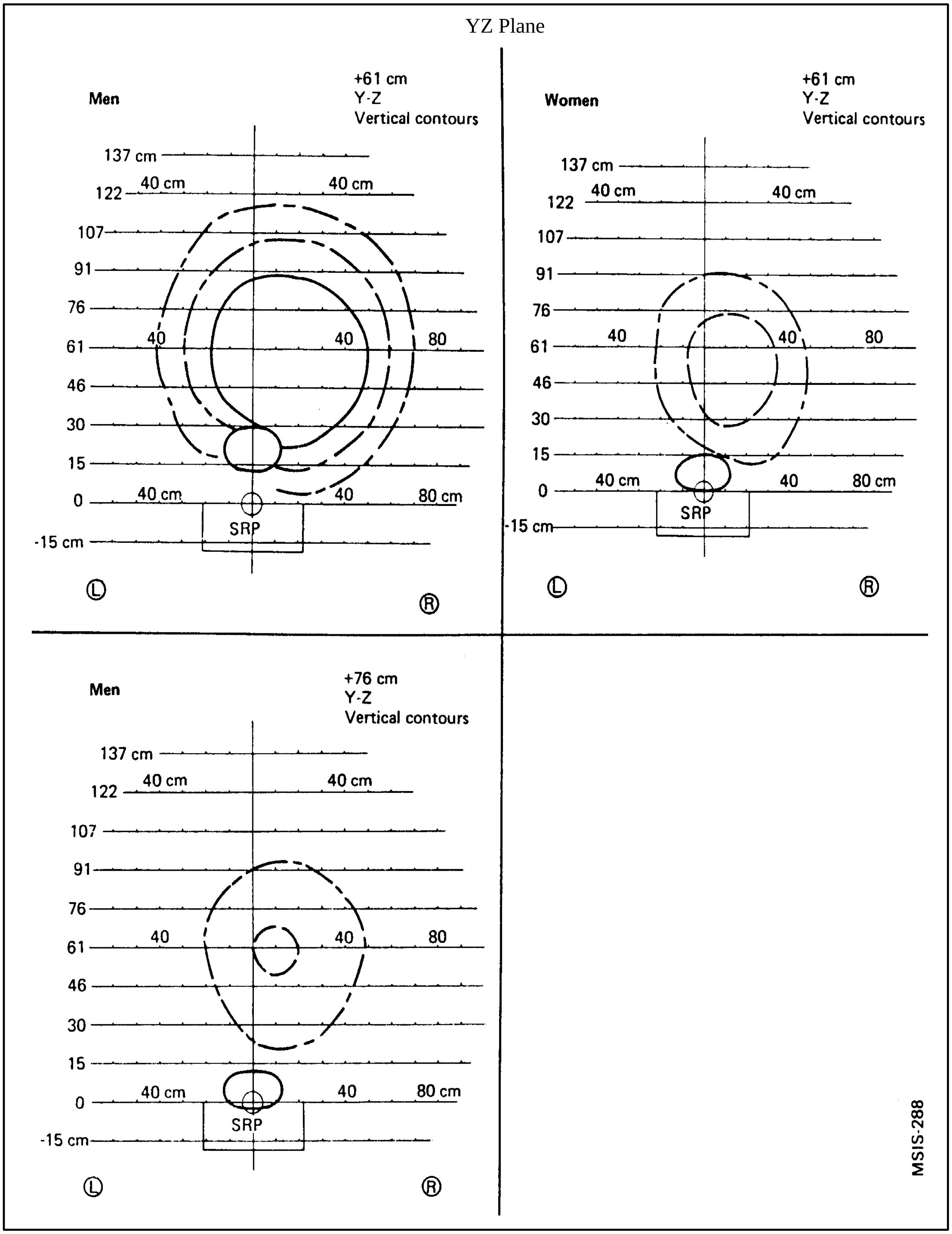
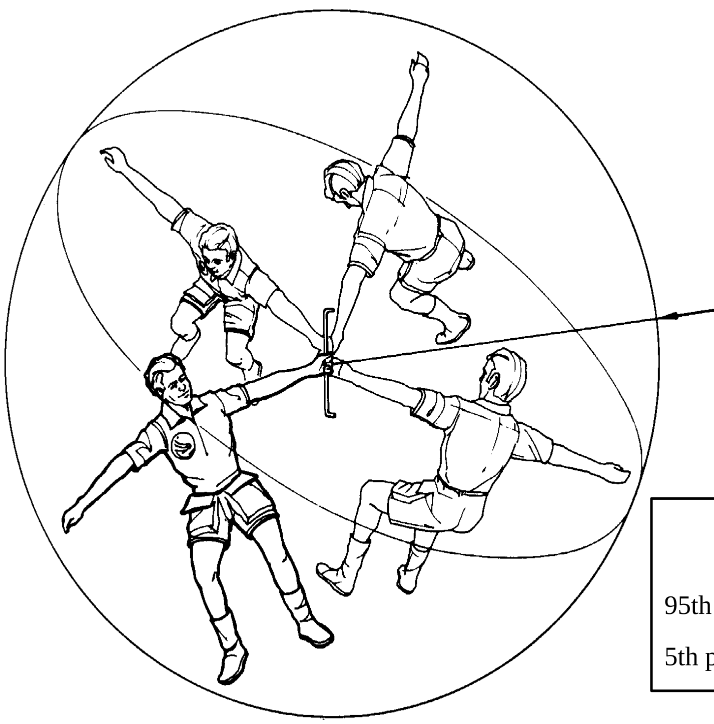


FIGURE 3.3.3.3.1−1 GRASP REACH LIMITS WITH RIGHT HAND FOR AMERICAN MALE AND FEMALE POPULATIONS (PAGE 19 OF 19)

Direction of arm reach (from 0 deg or ”straight ahead” to 90 deg to the right (deg)	Appropriate changes in reach for each single degree of change in backrest angle (reach increases as backrest moves to vertical, and vice versa)
0	+/− 1.02 cm (+/− 0.40 in.)
15	+/− 1.27 cm (+/− 0.50 in.)
30	+/− 1.14 cm (+/− 0.45 in.)
45	+/− 0.94 cm (+/− 0.37 in.)
60	+/− 0.66 cm (+/− 0.26 in.)
75	+/− 0.36 cm (+/− 0.14 in.)
90	+/− 0.25 cm (+/− 0.10 in.)

FIGURE 3.3.3.3.1−2 CHANGES IN ARM REACH BOUNDARIES AS A FUNCTION OF VARIATION IN BACKREST ANGLE OF 13 DEGREES FROM VERTICAL



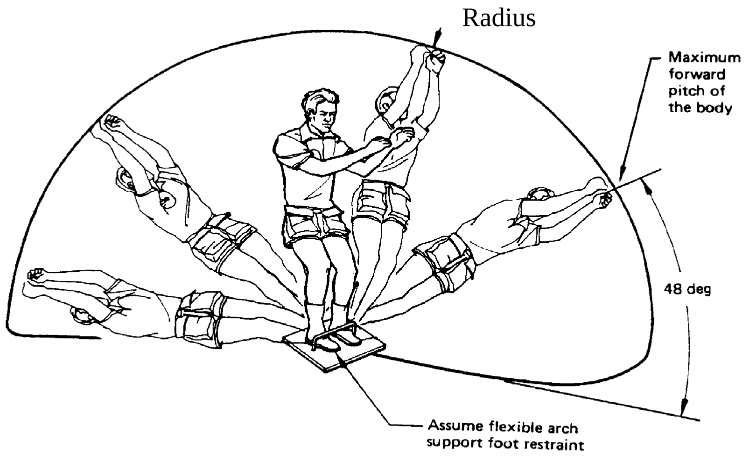
	Radius of fingertip reach boundary
95th percentile male	195 cm (77 in.)
5th percentile female	150 cm (63 in.)

Notes:

(1) Subjects − These data were generated using computer−based antrhopometric model. The computer model was developed using a sample of 192 male astronaut candidates and 22 female astronaut candidates measured in 1979 and 1980 (SP−2−86L−064). The 5th percentile stature of the male population is 167.9 cm (66.1 in.) and the 95th percentile male stature is 189.0 cm (74.4 in.). The 5th percentile stature of the female population is 157.6 cm (62.0 in.) and the 95th percentile female is 175.7 cm (69.2 in.).

(2) Gravity conditions − Although the motions apply to a microgravity condition, the effects of spinal lengthening have not been considered.

FIGURE 3.3.3.3.1−3 MICROGRAVITY HANDHOLD RESTRAINT REACH BOUNDARIES



	Radius of reach fingertip boundary in X−Z plane	
	Flexible arch support foot restraint	Fixed "flat" foot restraint
95th percentile male	222 cm (87 in.)	212 cm (83 in.)
5th percentile female	188 cm (74 in.)	172 cm (68 in.)

Notes:

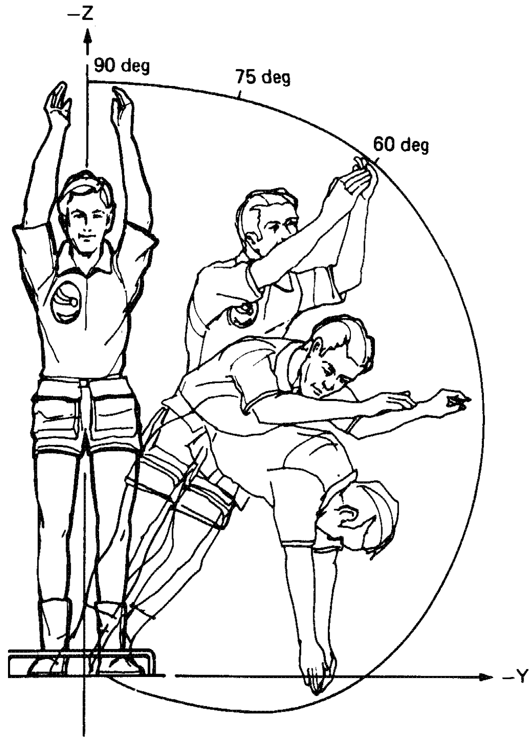
(1) Subjects − These data were generated using computer−based antrhopometric model. The computer model was developed using a sample of 192 male astronaut candidates and 22 female astronaut candidates measured in 1979 and 1980 (SP−2−86L−064). The 5th percentile stature of the male population is 167.9 cm (66.1 in.) and the 95th percentile male stature is 189.0 cm (74.4 in.). The 5th percentile stature of the female population is 157.6 cm (62.0 in.) and the 95th percentile female is 175.7 cm (69.2 in.).

(2) Gravity conditions − Although the motions apply to a microgravity condition, the effects of spinal lengthening have not been considered.

(3) Restraint configuration − two sets of dimensions are given for the fore/aft reach boundary. One set, the larger dimensions, apply to a fairly snung, but flexible, arch support that allows the toes and heels to raise slightly from the floor. The other set of dimensions apply to a foot restraint that secures the feet flat to the floor.

FIGURE 3.3.3.3.1−4 MICROGRAVITY FOOT RESTRAINT REACH BOUNDARIES − FORE/AFT

Dimensions of fingertip reach boundary in Y−Z plane			
	Angle (degrees)	Y−axis dimension	Z−axis dimension
95th percentile male	90	0	222cm
	75	80 cm (31 in.)	193 cm (76 in.)
	60	110 cm (43 in.)	160 cm (63 in.)
5th percentile female	90	0	188 cm (74 in.)
	75	28 cm (11 in.)	175 cm (69 in.)
	60	80 cm (31 in.)	140 cm (55 in.)



Notes:

(1) The angle is measured between the x−axis and a line drawn from the center of the foot restraint to the reach boundary.

(2) The full reach boundary (up to 0 degrees angle) will be provided in the next revision of this document.

(3) Subjects − These data were generated using computer−based antrhopometric model. The computer model was developed using a sample of 192 male astronaut candidates and 22 female astronaut candidates measured in 1979 and 1980 (SP−2−86L−064). The 5th percentile stature of the male population is 167.9 cm (66.1 in.) and the 95th percentile male stature is 189.0 cm (74.4 in.). The 5th percentile stature of the female population is 157.6 cm (62.0 in.) and the 95th percentile female is 175.7 cm (69.2 in.).

(4) Gravity conditions − Although the motions apply to a microgravity condition, the effects of spinal lengthening have not been considered.

FIGURE 3.3.3.3.1−5 MICROGRAVITY FOOT RESTRAINT REACH BOUNDARIES − SIDE TO SIDE (USING FLEXIBLE ARCH SUPPORT FOOT RESTRAINT CONFIGURATION

Type of Task	Adjustment
Finger tip operation	+7.0 cm (2.8 in.)
Full hand grasp	−5.5 cm (2.2 in.)

FIGURE 3.3.3.3.1−6 ADJUSTMENT TO THUMB AND FOREFINGER GRASP REACH BOUNDARIES FOR OTHER TYPES OF GRASPING TASKS

3.3.4 NEUTRAL BODY POSTURE

3.3.4.1 INTRODUCTION

This paragraph is not applicable for this document.

3.3.4.2 NEUTRAL BODY POSTURE DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

3.3.4.3 NEUTRAL BODY POSTURE DATA DESIGN REQUIREMENTS

Space station crew stations shall accommodate the neutral body posture, as shown in Figure 3.3.4.3−1.

3.3.5 BODY SURFACE AREA

3.3.5.1 INTRODUCTION

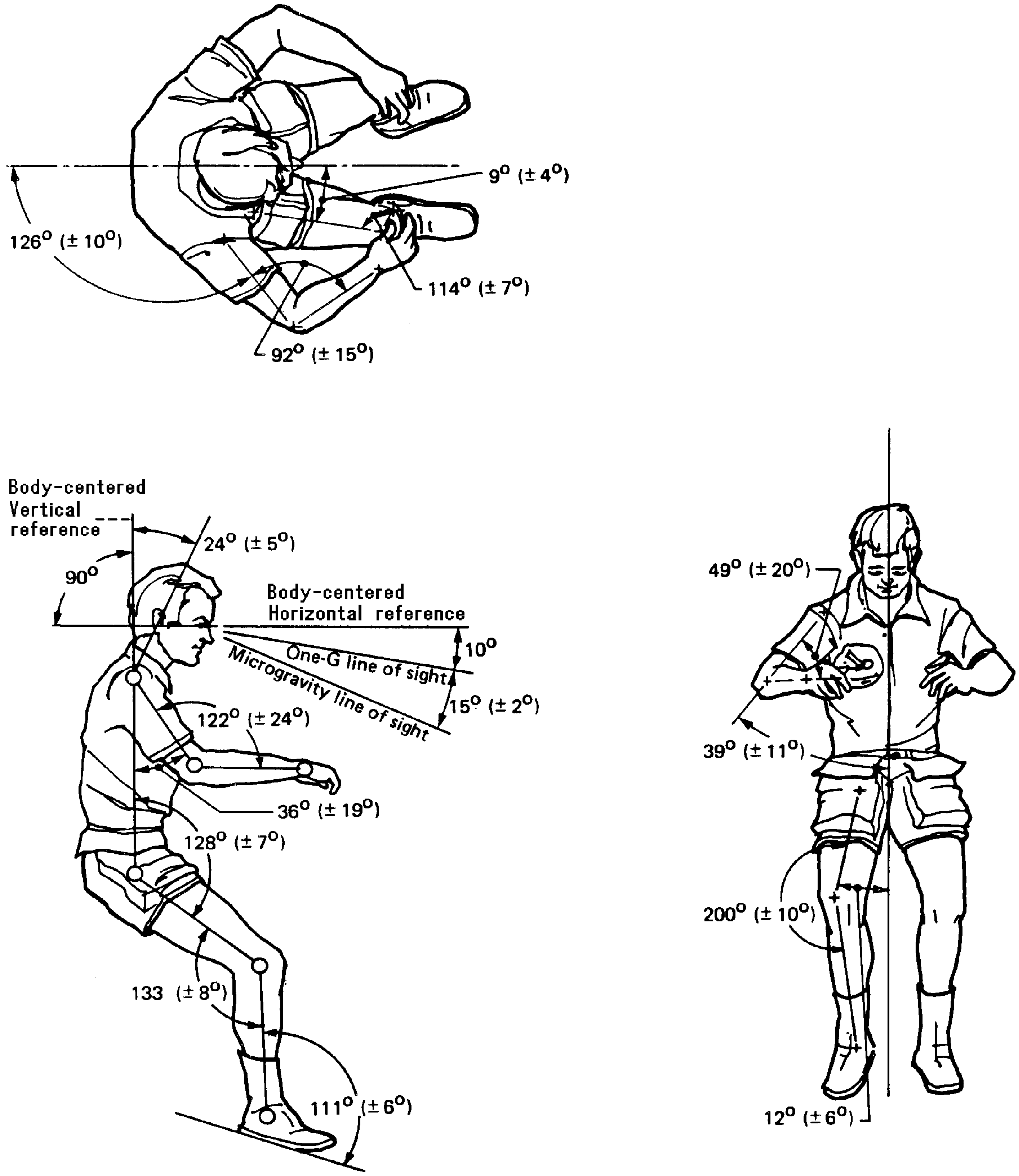
This paragraph is not applicable for this document.

3.3.5.2 BODY SURFACE AREA DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

3.3.5.3 BODY SURFACE AREA DATA DESIGN REQUIREMENTS

The data shown in Figure 3.3.5.3−1 shall be used when designing all Space Station flight crew interfaces.



Note:

(1) The segment angles shown are means. Values in parentheses are standard deviations about the mean.

(2) The data was developed in Skylab studies and is based on the measurement of three subjects.

FIGURE 3.3.4.3−1 NEUTRAL BODY POSITION

	American male crewmember body surface area
5th percentile	17,600 cm^2 (2730 in^2)
50th percentile	20,190 cm^2 (3130 in^2)
95th percentile	22,690 cm^2 (3520 in^2)
Notes: (1) American male crewmember population is defined in 3.2.1. (2) Data applies to 1−g conditions.	

FIGURE 3.3.5.3−1 ESTIMATED BODY SURFACE AREA OF THE AMERICAN MALE CREWMEMBER

3.3.6 BODY VOLUME

3.3.6.1 INTRODUCTION

This paragraph is not applicable for this document.

3.3.6.2 BODY VOLUME DATA DESIGN CONSIDERATIONS

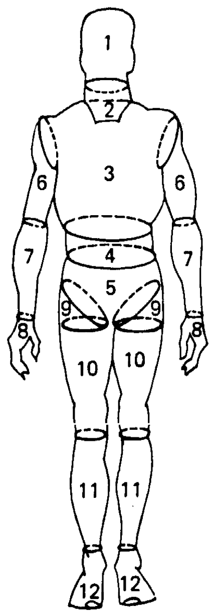
This paragraph is not applicable for this document.

3.3.6.3 BODY VOLUME DATA DESIGN REQUIREMENTS

The data shown in Figures 3.3.6.3.1−1 and 3.3.6.3.2−1 shall be used when designing all Space Station flight crew interfaces.

	American male crewmember body surface area
5th percentile	17,600 cm^2 (2730 in^2)
50th percentile	20,190 cm^2 (3130 in^2)
95th percentile	22,690 cm^2 (3520 in^2)
Notes: (1) American male crewmember population is defined in 3.2.1. (2) These data applies to 1−g conditions only.	

FIGURE 3.3.6.3.1−1 WHOLE BODY SURFACE VOLUME OF THE AMERICAN MALE CREWMEMBER



Segment		Volume, cm^3 (in^3) 5th percentile	50th percentile	95th percentile
1	Head	4260 (260)	4400 (270)	4550 (280)
2	Neck	930 (60)	1100 (70)	1270 (80)
3	Thorax	20420 (1250)	26110 (1590)	31760 (1940)
4	Abdomen	2030 (120)	2500 (150)	2960 (180)
5	Pelvis	9420 (570)	12300 (750)	15150 (920)
6	Upper arm (1)	100 (100)	2050 (130)	2500 (150)
7	Forearm (1)	1180 (70)	1450 (90)	1720 (100)
8	Hand	460 (30)	530 (30)	610 (40)
9	Hip flap (1)	2890 (180)	3640 (220)	4380 (270)
10	Thigh minus flap (1)	5480 (330)	6700 (410)	7920 (480)
11	Calf (1)	3320 (200)	4040 (250)	4760 (290)
12	Foot (1)	840 (50)	1010 (60)	1180 (70)
5+4+3	Torso	31870 (1940)	40910 (2450)	49870 (3040)
9+10	Thigh (1)	8360 (510)	10340 (630)	12300 (750)
7+8	Forearm plus hand (1)	1640 (100)	1980 (120)	2320 (140)

Notes:
(1) Average of right and left sides.
(2) These data apply to 1−g conditions only.
(3) The American male crewmember population is defined in 3.2.1.

FIGURE 3.3.6.3.2−1 BODY SEGMENTS VOLUME OF THE AMERICAN MALE CREWMEMBER

3.3.7 BODY MASS PROPERTIES

3.3.7.1 INTRODUCTION

This paragraph is not applicable for this document.

3.3.7.2 BODY MASS PROPERTIES DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

3.3.7.3 BODY MASS PROPERTIES DATA DESIGN REQUIREMENTS

The data shown in Figures 3.3.7.3.1.1−1, 3.3.7.3.1.2−1, 3.3.7.3.2.1−1, 3.3.7.3.2.1−2, 3.3.7.3.2.2−1, 3.3.7.3.3.1−1, and 3.3.7.3.3.2−1 shall be used when designing all Space Station flight crew interfaces.

3.3.7.3.1 BODY MASS DATA DESIGN REQUIREMENTS

3.3.7.3.1.1 WHOLE−BODY MASS DATA DESIGN REQUIREMENTS.

Whole−body mass data for the crewmember population in l−g are in Figure 3.3.7.3.1.1−1.

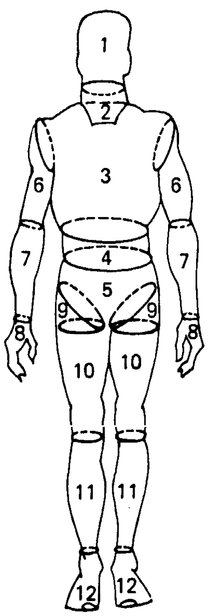
Male (American)			Female (Japanese)		
5th percentile	50th percentile	95th percentile	5th percentile	50th percentile	95th percentile
65.8 kg (145.1 lb)	82.2 kg (181.3 lb)	98.5 kg (217.2 lb)	41.0 kg (90.4 lb)	51.5 kg (113.5 lb)	61.7 kg (136.0 lb)

Notes:
(1) These data apply to 1−g conditions only. Fluid losses in microgravity reduce these masses.
(2) Year−2000 crewmember population is defined in 3.2.1.

FIGURE 3.3.7.3.1.1−1 WHOLE BODY MASS FOR YEAR 2000 CREWMEMBER POPULATION (AGE 40)

3.3.7.3.1.2 BODY SEGMENT MASS DATA DESIGN REQUIREMENTS.

Body segment mass data for the American male crewmember in l−g are in Figure 3.3.7.3.1.2−1.



Segment		Mass, gm (oz, weight) 5th percentile	50th percentile	95th percentile
1	Head	4260 (150)	4400 (160)	4550 (160)
2	Neck	930 (30)	1100 (40)	1270 (40)
3	Thorax	20420 (720)	26110 (920)	31760 (1120)
4	Abdomen	2030 (70)	2500 (90)	2960 (100)
5	Pelvis	9420 (330)	12300 (430)	15150 (530)
6	Upper arm (1)	100 (60)	2050 (70)	2500 (90)
7	Forearm (1)	1180 (40)	1450 (50)	1720 (60)
8	Hand	460 (20)	530 (20)	610 (20)
9	Hip flap (1)	2890 (100)	3640 (130)	4380 (150)
10	Thigh minus flap (1)	5480 (190)	6700 (240)	7920 (280)
11	Calf (1)	3320 (120)	4040 (140)	4760 (170)
12	Foot (1)	840 (30)	1010 (40)	1180 (40)
5+4+3	Torso	31870 (1120)	40910 (1440)	49870 (1760)
9+10	Thigh (1)	8360 (290)	10340 (360)	12300 (430)
7+8	Forearm plus hand (1)	1640 (60)	1980 (70)	2320 (80)

Notes:
(1) Average of right and left sides.
(2) These data apply to 1−g conditions only.
(3) The American male crewmember population is defined in 3.2.1.

FIGURE 3.3.7.3.2.1−1 MASS OF BODY SEGMENTS FOR THE AMERICAN MALE CREWMEMBER

3.3.7.3.2 CENTER OF MASS DATA DESIGN REQUIREMENTS

3.3.7.3.2.1 WHOLE−BODY CENTER OF MASS DATA DESIGN REQUIREMENTS

The whole−body center of mass location data for the American male crewmember in l−g are in Figure 3.3.7.3.2.1−1. Equations for locating the whole−body center of mass in males of different sizes are given in Figure 3.3.7.3.2.1−2.

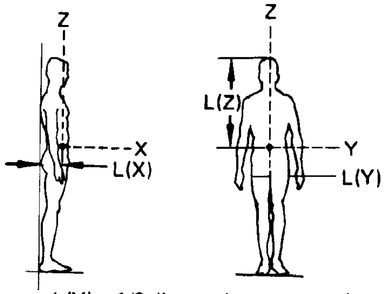
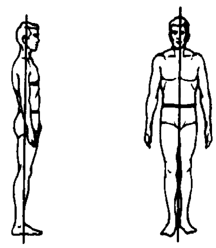
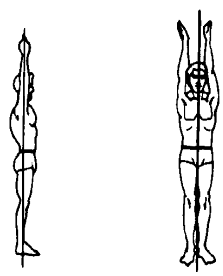
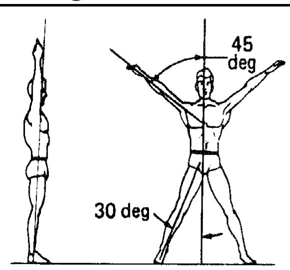
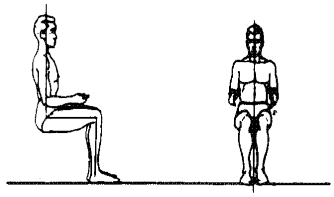
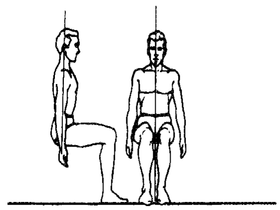
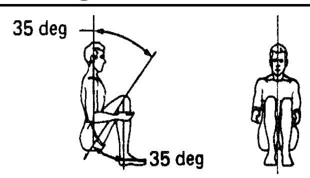
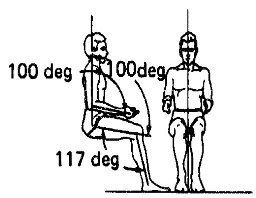
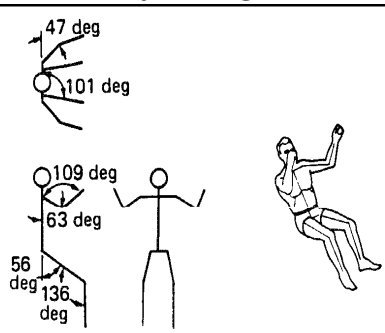
	cm (in.)			
	Dimension	5th percentile	50th percentile	95th percentile
 L(Y) = 1/2 distance between anterior superior iliac spine landmarks (1/2 bispinous breadth)				
	L(X)	8.6 (3.4)	9.1 (3.6)	9.6 (3.8)
	L(Y)	11.7 (4.6)	12.5 (4.9)	13.3 (5.2)
1. Standing	L(Z)	75.7 (29.8)	80.2 (31.6)	84.7 (33.3)
	L(X)	8.7 (3.4)	9.1 (3.6)	9.4 (3.7)
	L(Y)	11.7 (4.6)	12.5 (4.9)	13.3 (5.2)
2. Standing, Arms Over Head	L(Z)	69.9 (27.5)	80.2 (29.1)	77.9 (30.7)
	L(X)	8.2 (3.2)	8.6 (3.4)	9.0 (3.6)
	L(Y)	11.7 (4.6)	12.5 (4.9)	13.3 (5.2)
3. Spread Eagle	L(Z)	69.4 (27.3)	73.5 (28.9)	77.5 (30.5)

FIGURE 3.3.7.3.2.1−1 WHOLE BODY CENTER OF MASS LOCATION OF THE AMERICAN MALE CREWMEMBER (PAGE 1 OF 2)

	cm (in.)			
 4. Sitting	L(X)	19.4 (7.7)	20.6 (9.1)	21.8 (8.6)
	L(Y)	11.7 (4.6)	12.5 (4.9)	13.3 (5.2)
	L(Z)	65.2 (25.7)	68.6 (27.0)	71.9 (28.3)
 5. Sitting, Forearms Down	L(X)	18.9 (7.4)	20.0 (7.9)	21.1 (8.3)
	L(Y)	11.7 (4.6)	12.5 (4.9)	13.3 (5.2)
	L(Z)	66.0 (26.0)	69.3 (27.3)	72.5 (28.6)
 6. Sitting, Thighs Elevated	L(X)	17.6 (6.9)	18.8 (7.4)	20.1 (7.9)
	L(Y)	11.7 (4.6)	12.5 (4.9)	13.3 (5.2)
	L(Z)	57.3 (22.5)	59.4 (23.4)	61.5 (24.2)
 7. Mercury Configuration	L(X)	19.4 (7.6)	20.5 (8.1)	21.5 (8.5)
	L(Y)	11.7 (4.6)	12.5 (4.9)	13.3 (5.2)
	L(Z)	66.8 (26.3)	69.9 (27.5)	73.0 (28.7)
 8. Relaxed (weightless)	L(X)	18.0 (7.1)	18.8 (7.4)	19.6 (7.7)
	L(Y)	11.7 (4.6)	12.5 (4.9)	13.3 (5.2)
	L(Z)	68.0 (26.8)	70.9 (27.9)	73.7 (29.0)

Notes:
(1) These data apply to 1−g conditions. To estimate center of mass location in microgravity, multiply the L(z) figure by 0.9.
(2) The American male crewmember population is defined in 3.2.1.

FIGURE 3.3.7.3.2.1−1 WHOLE BODY CENTER OF MASS LOCATION OF THE AMERICAN MALE CREWMEMBER (PAGE 2 OF 2)

Location of center of mass, cm = [A x (stature, cm)] + [B x (weight, lbs)] + [C]						
Posture	Dimension	A	B	C	SE (2) (cm)	R (3)
1. Standing	L(X) L(Y) L(Z)	− 0.035 0 0.486	0.024 0.021 −0.014	11.008 8.609 − 4.775	0.33 0.89 1.33	0.7636 0.4310 0.9329
2. Standing (arms over head)	L(X) L(Y) L(Z)	− 0.040 0 0.416	0.020 0.021 − 0.007	12.632 8.609 0.305	0.45 0.89 1.52	0.5823 0.4310 0.8927
3. Spread eagle	L(X) L(Y) L(Z)	− 0.031 0 0.392	0.020 0.021 0.002	10.443 8.609 2.547	0.36 0.89 1.48	0.6706 0.4310 0.8921
4. Sitting	L(X) L(Y) L(Z)	0.080 0 0.344	0.010 0.021 − 0.004	4.450 8.609 7.327	0.56 0.89 1.46	0.7900 0.4310 0.8632
5. Sitting (thighs elevated)	L(X) L(Y) L(Z)	0.041 0 0.212	0.022 0.021 − 0.002	7.405 8.610 21.582	0.66 0.89 1.24	0.7104 0.4310 0.7801
6. Sitting (with arms down)	L(X) L(Y) L(Z)	0.075 0 0.355	0.010 0.021 − 0.010	4.628 8.609 7.389	0.51 0.89 1.56	0.8030 0.4310 0.8489
7. Mercury configuration	L(X) L(Y) L(Z)	0.076 0 0.311	0.008 0.021 − 0.002	5.253 8.609 14.425	0.54 0.89 1.80	0.7828 0.4310 0.7841
8. Weightless	L(X) L(Y) L(Z)	0.077 0 0.218	0.001 0.021 0.017	4.692 8.609 28.552	0.60 0.89 3.16	0.6973 0.4310 0.5015

Notes:
(1) − Refer to Figure 3.3.7.3.2.1−1 for measurement landmarks.
(2) SE = Standard error of the estimate.
(3) R = Multiple correlation coefficient.
(4) These data apply to 1−g conditions. To estimate center of mass location in microgravity, multiply the L(z) figure by 0.9.
(5) The American male crewmember population is defined in 3.2.1.

FIGURE 3.3.7.3.2.1−2 WHOLE BODY CENTER OF MASS LOCATION FOR AMERICAN MALE CREWMEMBERS OF DIFFERENT SIZES

3.3.7.3.2.2 BODY SEGMENTS CENTER OF MASS DATA DESIGN REQUIREMENTS.

Center of mass of body location data for body segments of the American male crewmember in l−g are in Figure 3.3.7.3.2.2−1.

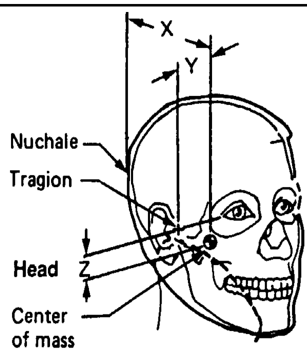
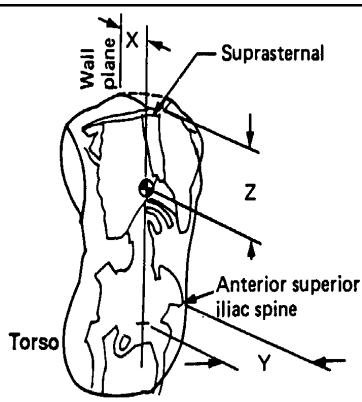
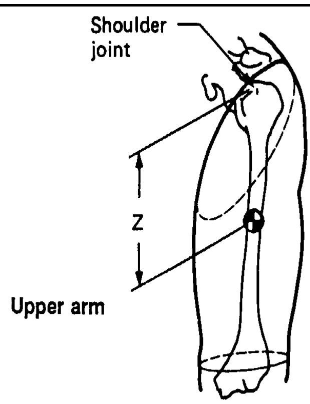
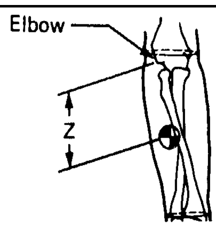
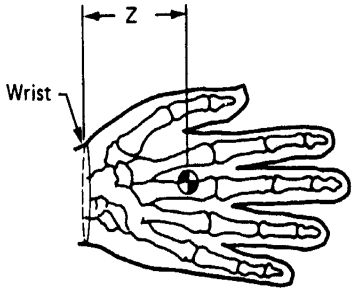
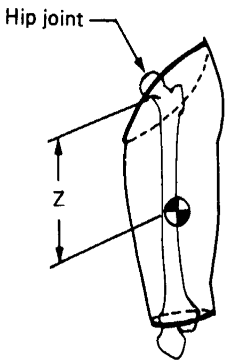
Center of mass location, cm (in.)									
	5th percentile			50th percentile			95th percentile		
	X	Y	Z	X	Y	Z	X	Y	Z
	9.4 (3.7)	6.8 (2.7)	2.1 (0.8)	10.4 (4.1)	7.2 (2.8)	2.3 (0.9)	11.5 (4.5)	7.7 (3.0)	2.5 (1.0)
	8.4 (3.3)	13.8 (5.4)	21.0 (8.3)	10.0 (3.9)	15.8 (6.2)	21.8 (8.6)	11.6 (4.6)	17.8 (7.0)	22.6 (8.9)
	*	*	14.1 (5.6)	*	*	14.9 (5.0)	*	*	15.7 (6.2)
	*	*	10.9 (4.3)	*	*	11.5 (4.5)	*	*	12.1 (4.8)

FIGURE 3.3.7.3.2.2−1 BODY SEGMENT OF MASS FOR AMERICAN MALE CREWMEMBER (PAGE 1 OF 2)

Center of mass location, cm (in.)									
	5th percentile			50th percentile			95th percentile		
	X	Y	Z	X	Y	Z	X	Y	Z
	*	*	5.1 (2.0)	*	*	5.6 (2.2)	*	*	6.0 (2.4)
	*	*	17.0 (6.7)	*	*	18.0 (7.1)	*	*	19.1 (7.5)

Notes:
(4) These data apply to 1−g conditions only.
(2) The American male crewmember population is defined in 3.2.1.
(3) * Assume symmetry.

FIGURE 3.3.7.3.2.2−1 BODY SEGMENT OF MASS FOR AMERICAN MALE CREWMEMBER (PAGE 2 OF 2)

3.3.7.3.3 MOMENT OF INERTIA DATA DESIGN REQUIREMENTS

3.3.7.3.3.1 WHOLE−BODY MOMENT OF INERTIA DATA DESIGN REQUIREMENTS

Whole−body moments of inertia data for the American male crewmember in l−g are in Figure 3.3.7.3.3.1−1.

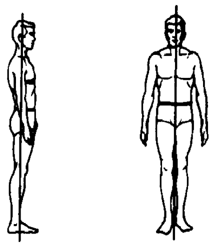
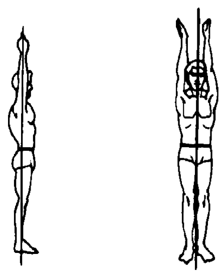
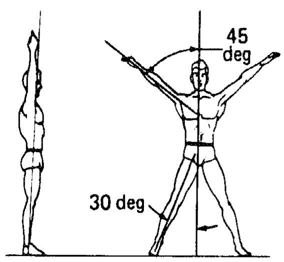
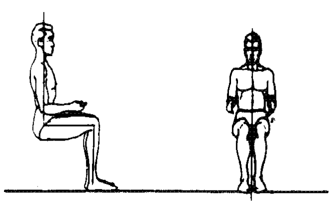
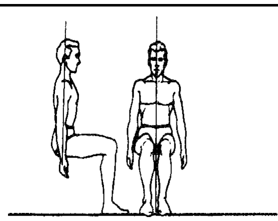
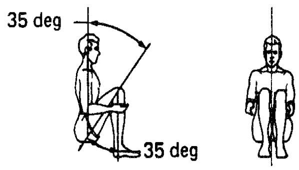
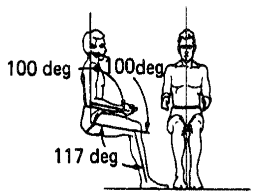
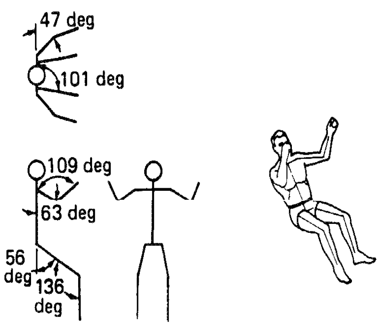
Moment of inertia, g−cm^2 x 10^6, (lb−in−sec^2)				
Posture	Axis	5th percentile	50th percentile	95th percentile
 1. Standing	X	106.5 (94.2)	144.5 (101.3)	182.3 (161.2)
	Y	94.9 (83.9)	129.2 (114.3)	163.4 (144.5)
	Z	10.3 (9.1)	14.4 (12.7)	18.5 (16.4)
 2. Standing, Arms Over Head	X	141.0 (124.7)	191.9 (169.7)	242.6 (214.5)
	Y	124.6 (110.2)	172.9 (152.9)	221.0 (195.5)
	Z	10.6 (9.4)	14.1 (121.5)	17.5 (15.5)
 3. Spread Eagle	X	137.2 (121.3)	190.4 (168.4)	243.4 (215.3)
	Y	104.2 (92.2)	144.8 (128.1)	185.2 (163.8)
	Z	32.0 (28.3)	46.6 (41.2)	61.3 (54.2)
 4. Sitting	X	57.3 (50.7)	76.9 (68.0)	96.5 (85.3)
	Y	62.0 (54.8)	83.2 (73.6)	104.3 (92.2)
	Z	30.7 (27.2)	42.4 (37.3)	54.0 (47.8)

FIGURE 3.3.7.3.3.1−1 WHOLE BODY MOMENT OF INERTIA FOR THE AMERICAN MALE CREWMEMBER (PAGE 1 OF 2)

 5. Sitting, Forearms Down	X	59.2 (52.4)	77.6 (68.6)	96.0 (84.9)
	Y	63.9 (56.5)	86.3 (76.3)	108.6 (96.0)
	Z	30.9 (27.3)	42.8 (37.9)	54.6 (48.3)

Moment of inertia, g−cm² x 10⁶, (lb−in−sec²)				
Posture	Axis	5th percentile	50th percentile	95th percentile
 6. Sitting, Thighs Elevated	X	37.6 (33.3)	48.7 (43.1)	59.8 (52.9)
	Y	37.2 (32.9)	46.6 (41.2)	55.8 (49.3)
	Z	23.9 (21.1)	33.7 (29.8)	43.5 (38.5)
 7. Mercury Configuration	X	62.5 (55.3)	82.2 (72.7)	101.8 (90.0)
	Y	69.6 (61.6)	95.5 (84.5)	121.3 (107.3)
	Z	31.9 (28.2)	43.0 (38.0)	54.0 (47.8)
 8. Relaxed (weightless) (Does not account for spinal lengthening)	X	88.0 (77.8)	114.5 (101.3)	140.9 (124.6)
	Y	84.1 (74.4)	109.6 (96.9)	134.8 (119.2)
	Z	39.8 (35.2)	50.5 (44.7)	61.2 (54.1)

Notes:
(4) These data apply to 1−g conditions only.
(2) The American male crewmember population is defined in 3.2.1.

FIGURE 3.3.7.3.3.1−1 WHOLE BODY MOMENT OF INERTIA FOR THE AMERICAN MALE CREWMEMBER (PAGE 2 OF 2)

3.3.7.3.3.2 BODY SEGMENTS MOMENT OF INERTIA DATA DESIGN REQUIREMENTS

Body segment moments of inertia data for the American male crewmember in l−g are in Figure 3.3.7.3.3.2−1.

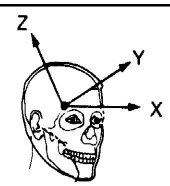
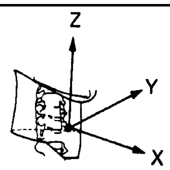
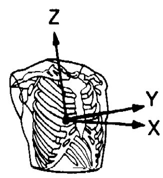
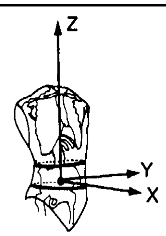
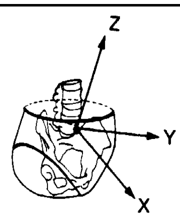
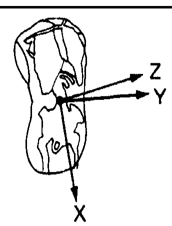
Moment of inertia, g−cm^2 x 10^3, (lb−in−sec^2 x 10^3)				
Segment	Axis	5th percentile	50th percentile	95th percentile
Head 	X	195.2 (172.7)	207.1 (183.2)	218.9 (193.6)
	Y	221.8 (196.2)	236.8 (209.4)	251.6 (222.6)
	Z	144.9 (128.1)	153.2 (135.5)	161.4 (142.7)
Neck 	X	13.4 (11.9)	18.2 (16.1)	23.0 (20.3)
	Y	16.6 (14.7)	22.0 (19.5)	27.4 (24.2)
	Z	20.3 (17.9)	27.5 (24.3)	34.6 (30.6)
Thorax 	X	3509.6 (3103.9)	5312.0 (4697.9)	7100.2 (6279.4)
	Y	2556.3 (2260.8)	3920.6 (3467.4)	5274.0 (4664.3)
	Z	2153.8 (1904.8)	3320.1 (2936.3)	4475.5 (3958.1)
Abdomen 	X	116.6 (103.1)	175.2 (155.0)	233.2 (205.2)
	Y	63.3 (56.0)	98.2 (86.8)	132.6 (117.3)
	Z	173.6 (153.5)	265.4 (234.7)	356.1 (315.0)
Pelvis 	X	713.7 (631.2)	1123.4 (993.6)	1528.9 (1352.1)
	Y	646.4 (571.7)	1033.5 (914.0)	1416.4 (1252.7)
	Z	820.0 (752.2)	1303.6 (1152.9)	1782.0 (1576.0)
Torso 	X	10731.4 (9490.9)	15957.8 (14113.0)	21141.0 (18597.1)
	Y	2556.3 (2260.8)	3320.1 (2936.3)	5274.0 (4664.3)
	Z	2153.8 (1904.8)	3320.1 (2936.3)	5274.0 (4664.3)

FIGURE 3.3.7.3.3.2−11 BODY SEGMENT MOMENT OF INERTIA FOR THE AMERICAN CREWMEMBER (PAGE 1 OF 4)

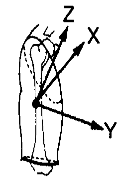
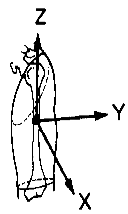
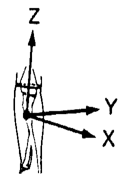
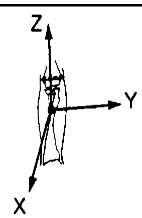
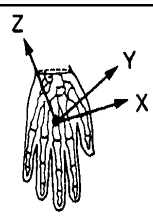
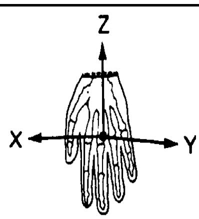
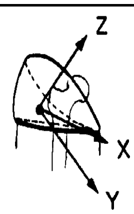
Moment of inertia, g−cm^2 x 10^3, (lb−in−sec^2 x 10^3)				
Right upper arm 	X	92.6 (81.9)	141.7 (125.4)	190.5 (168.6)
	Y	97.6 (86.3)	151.2 (133.7)	204.4 (180.8)
	Z	18.5 (16.3)	29.2 (25.8)	39.8 (35.2)
Left upper arm 	X	89.1 (78.8)	1372 (121.43)	185.0 (163.6)
	Y	93.3 (82.5)	145.7 (128.9)	197.8 (174.9)
	Z	17.8 (15.8)	28.2 (24.9)	38.4 (34.0)
Right forearm 	X	65.3 (57.7)	93.9 (83.1)	122.4 (108.3)
	Y	66.3 (58.6)	95.6 (84.6)	124.8 (110.4)
	Z	9.6 (8.5)	14.2 (12.6)	18.8 (16.6)
Left forearm 	X	63.7(56.3)	88.9 (78.6)	113.9 (100.7)
	Y	65.4 (57.8)	91.5 (80.9)	117.4 (103.9)
	Z	8.9 (7.9)	12.9 (11.4)	16.9 (14.9)
Right hand 	X	10.7 (9.4)	13.8 (12.2)	16.8 (14.9)
	Y	8.7 (7.7)	11.2 (9.9)	13.7 (12.1)
	Z	3.4 (3.0)	4.5 (4.0)	5.5 (4.9)
Left hand 	X	10.8 (9.5)	13.6 (12.0)	16.4 (14.5)
	Y	9.0 (7.9)	11.3 (10.0)	13.6 (12.0)
	Z	3.5 (3.1)	4.4 (3.9)	5.3 (4.7)
Right hip flap 	X	88.8 (78.5)	134.1 (118.6)	178.9 (158.2)
	Y	116.3 (108.2)	173.1 (153.1)	229.4 (202.9)
	Z	150.4 (133.1)	226.5 (200.3)	301.7 (266.9)

FIGURE 3.3.7.3.3.2−1 BODY SEGMENT MOMENT OF INERTIA FOR THE AMERICAN CREWMEMBER (PAGE 2 OF 4)

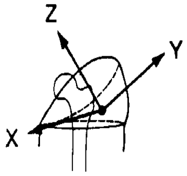
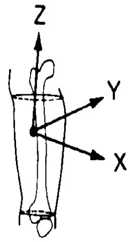
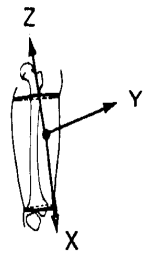
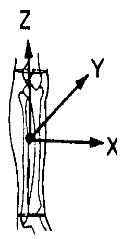
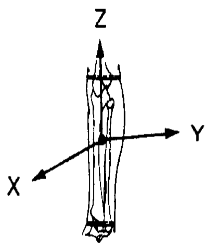
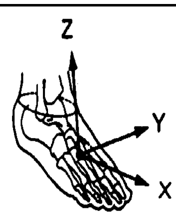
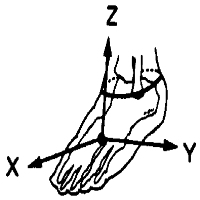
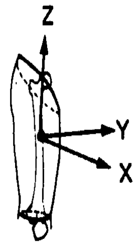
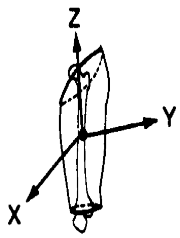
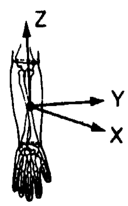
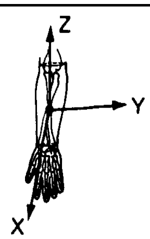
Moment of inertia, g−cm^2 x 10^3, (lb−in−sec^2 x 10^3)				
Left hip flap 	X	85.0 (75.1)	128.8 (133.9)	172.2 (152.3)
	Y	113.4 (100.3)	169.2 (149.7)	224.5 (198.5)
	Z	146.7 (129.8)	219.2 (193.8)	290.8 (257.2)
Right Thigh minus flap 	X	453.6 (401.2)	653.1 (577.6)	852.3 (753.8)
	Y	469.2 (415.0)	673.4 (595.6)	877.3 (775.9)
	Z	178.4 (157.8)	255.2 (225.7)	331.3 (293.0)
Left Thigh minus flap 	X	437.3 (386.8)	620.9 (549.1)	804.0 (711.1)
	Y	460.7 (407.5)	653.4 (577.9)	845.7 (747.9)
	Z	172.3 (152.4)	246.9 (218.3)	321.0 (283.8)
Right Calf 	X	430.7 (381.0)	618.1 (546.6)	804.8 (711.8)
	Y	437.7 (387.1)	627.1 (554.6)	816.0 (721.7)
	Z	51.8 (45.8)	72.0 (63.7)	92.1 (81.5)
Left Calf 	X	434.1 (383.9)	629.6 (556.8)	824.7 (729.4)
	Y	441.4 (390.3)	639.7 (565.8)	837.7 (740.9)
	Z	50.7 (44.9)	72.8 (64.4)	94.7 (83.7)
Right Foot 	X	6.5 (5.7)	8.7 (7.7)	10.9 (9.6)
	Y	33.8 (29.9)	46.1 (29.9)	58.3 (51.5)
	Z	36.0 (31.8)	48.8 (31.8)	61.7 (54.5)

FIGURE 3.3.7.3.3.2−1 BODY SEGMENT MOMENT OF INERTIA FOR THE AMERICAN CREWMEMBER (PAGE 3 OF 4)

Moment of inertia, g−cm^2 x 10^3, (lb−in−sec^2 x 10^3)				
Left Foot 	X	6.1 (5.7)	8.3 (7.4)	10.6 (9.3)
	Y	32.4 (29.9)	44.7 (39.5)	57.0 (50.4)
	Z	34.2 (30.2)	47.0 (41.6)	59.8 (52.9)
Right Thigh 	X	1163.7 (1029.2)	1689.8 (1494.4)	2213.9 (1958.0)
	Y	1225.4 (1083.8)	1780.9 (1575.0)	2334.2 (2064.4)
	Z	316.5 (279.9)	464.6 (410.9)	611.3 (540.6)
Left Thigh 	X	1122.6 (992.6)	1623.0 (1435.4)	2121.1 (1875.9)
	Y	1186.3 (1049.2)	1713.2 (1515.1)	2237.5 (1978.8)
	Z	306.2 (270.8)	448.5 (396.6)	589.5 (521.3)
Right forearm plus hand 	X	238.5 (210.9)	327.8 (289.9)	416.7 (368.5)
	Y	237.5 (210.0)	326.5 (288.8)	415.1 (367.2)
	Z	13.4 (11.9)	19.2 (17.0)	25.0 (22.1)
Left forearm plus hand 	X	234.1 (207.0)	314.1 (277.8)	293.8 (348.3)
	Y	232.8 (205.9)	312.2 (276.1)	391.2 (346.0)
	Z	12.8 (11.4)	17.9 (15.9)	23.0 (20.3)

Notes:
(4) These data apply to 1−g conditions only.
(2) The American male crewmember population is defined in 3.2.1.

FIGURE 3.3.7.3.3.2−1 BODY SEGMENT MOMENT OF INERTIA FOR THE AMERICAN CREWMEMBER (PAGE 4 OF 4)

4.0 HUMAN PERFORMANCE CAPABILITIES

4.1 INTRODUCTION

This paragraph is not applicable for this document.

4.2 VISION

This paragraph is not applicable for this document.

4.3 AUDITORY SYSTEM

This paragraph is not applicable for this document.

4.4 OLFACTION AND TASTE

This paragraph is not applicable for this document.

4.5 VESTIBULAR SYSTEM

This paragraph is not applicable for this document.

4.6 KINESTHESIA

This paragraph is not applicable for this document.

4.7 REACTION TIME

This paragraph is not applicable for this document.

4.8 COORDINATION

This paragraph is not applicable for this document.

4.9 STRENGTH

4.9.1 INTRODUCTION

This paragraph is not applicable for this document.

4.9.2 STRENGTH DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

4.9.3 STRENGTH DESIGN REQUIREMENTS

Strength data that shall be used to criteria for design are provided below:

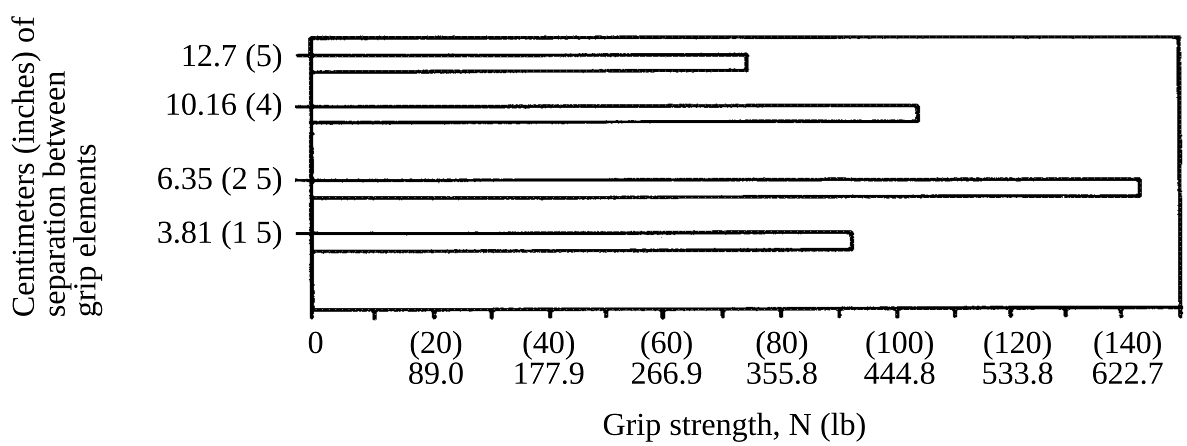
A. For operation and control of Space Station hardware equipment:

(1) Grip strength required to operate or control hardware or equipment shall be less than the 5th percentile female strength values shown in Figure 4.9.3−3.

(2) Linear Forces − Linear forces required to operate or control hardware or equipment shall be less than the strength values for the 5th percentile female, defined as 50.0 percent of the strength values shown in Figure 4.9.3−4 and 60.0 percent of the strength values shown in Figure 4.9.3−7.

(3) Torsional Forces − Torsional forces required to operate or control hardware or equipment shall be less than the strength values for the 5th percentile female, defined as 60.0 percent of the calculated 5th percentile male capability shown in Figure 4.9.3−8.

B. Forces required for maintenance of Space Station hardware and equipment shall be less than the 5th percentile male strength values shown in Figures 4.9.3−1, 4.9.3−3, 4.9.3−4, 4.9.3−6, 4.9.3−7, and 4.9.3−8.



Note:
(1) 44 subjects, all pilots or aviation cadets.

FIGURE 4.9.3−1 MALE GRIP STRENGTH AS A FUNCTION OF THE SEPARATION BETWEEN GRIP ELEMENTS

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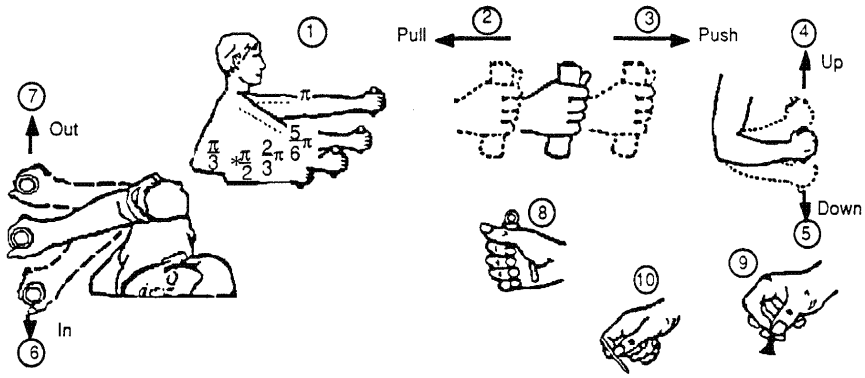
FIGURE 4.9.3−2 DELETED

Population	Percentiles, N (lbf) 5th	50th	95th	Population SD
U.S. Navy personnel Mean of both hands	258 (58)	325 (73)	387 (87)	39.1 (8.8)
U.S. Industrial workers Preferred hand	254 (57)	329 (74)	405 (91)	45.8 (10.3)

FIGURE 4.9.3−3 GRIP STRENGTH FOR FEMALES



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
5/6 π	187	249	133	187	67	80	80	89	67	89	36	67
2/3 π	151	187	116	160	76	107	93	116	89	98	45	67
1/2 π	142	165	98	160	76	89	93	116	71	80	45	71
1/3 π	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

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	15
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

FIGURE 4.9.3−4 ARM, HAND, AND THUMB/FINGER STRENGTH (5TH PERCENTILE MALE DATA) (PAGE 1 OF 2)

Hand and thumb−finger strength (lb)				
	(8)		(9)	(10)
	Hand grip		Thumb−finger grip (Palmer)	Thumb−finger grip (tips)
	L	R		
Momentary hold	56	59	13	13
Sustained hold	33	35	8	8
L = Left; R = Right				
* Elbow angle shown in radians				

FIGURE 4.9.3−4 ARM, HAND, AND THUMB/FINGER STRENGTH (5TH PERCENTILE MALE DATA) (PAGE 2 OF 2)

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FIGURE 4.9.3−5 DELETED

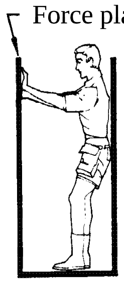
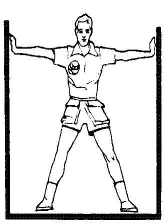
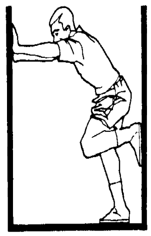
	Force−plate (1) height	Distances (2)	Force, N (lbf) Means	Force, N (lbf) SD
			Both hands	
Force plate 	100 percent of shoulder height	50	583 (131)	142 (32)
		60	667 (150)	160 (36)
		70	983 (221)	271 (61)
		80	1285 (289)	400 (90)
		90	979 (220)	302 (68)
		100	645 (145)	254 (57)
			Preferred hand	
		50	262 (59)	67 (15)
		60	298 (67)	71 (16)
		70	360 (81)	98 (22)
		80	520 (117)	142 (32)
		90	494 (111)	169 (38)
		100	427 (96)	173 (39)
		Percent of thumb−tip reach (3)		
	100 percent of shoulder height	50	369 (83)	138 (31)
		60	347 (78)	125 (28)
		70	520 (117)	165 (37)
		80	707 (159)	191 (32)
		90	325 (73)	133 (30)
		Percent of span (4)		

FIGURE 4.9.3−6 MAXIMAL STATIC PUSH FORCES (PAGE 1 OF 2)

	Force−plate (1) height	Distances (2)	Force, N (lbf)	
			Means	SD
	50	100	774 (174)	214 (48)
	50	120	78 (175)	165 (37)
	70	120	818 (184)	138 (31)
	Percent of shoulder height		1−g applicable data	

Notes:
(1) Height of the center of the force place − 200 mm (8 in.) high by 254 mm (10 in.) long − upon which force is applied.
(2) Horizontal distance between the vertical surface of the force plate and the opposing vertical surface (wall or footrest, respectively) against which the subjects brace themselves.
(3) Thumb−tip reach − distance from backrest to tip of subject's thumb as thumb and fingertips are pressed together.
(4) Span − the maximal distance between a person's fingertips as he extends his arms and hands to each side.
(5) 1−g data.

FIGURE 4.9.3−6 MAXIMAL STATIC PUSH FORCES (PAGE 2 OF 2)

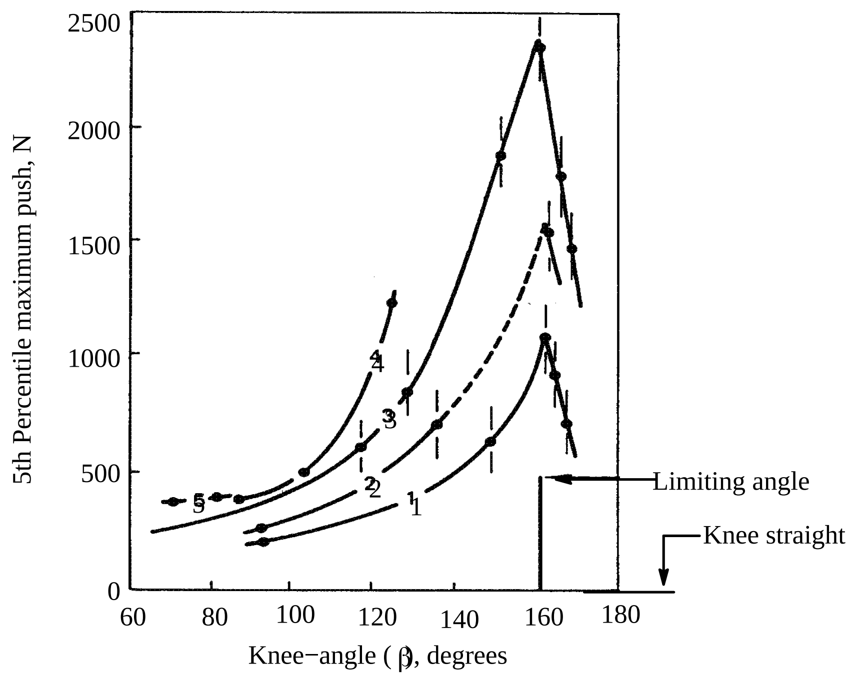


FIGURE 4.9.3−7 LEG STRENGTH AT VARIOUS KNEE AND THIGH ANGLES (5TH PERCENTILE MALE DATA)

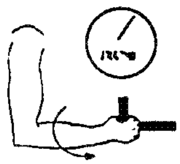
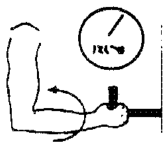
	Unpressurized suit, bare handed	Unpressurized suit, bare handed	
	Mean	Mean	SD
	13.73 (121.5)	13.73 (121.5)	3.41 (30.1)
	17.39 (153.9)	17.39 (153.9)	5.08 (45.0)

FIGURE 4.9.3−8 TORQUE STRENGTH

C. Deleted.

D. Deleted.

E. Deleted.

F. Deleted.

4.10 WORKLOAD

This paragraph is not applicable for this document.

5.0 NATURAL AND INDUCED ENVIRONMENTS

5.1 ATMOSPHERE

5.1.1 INTRODUCTION

This paragraph is not applicable for this document.

5.1.2 ATMOSPHERE DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

5.1.3 ATMOSPHERE DESIGN REQUIREMENTS

Paragraph 5.1.3.2 presents requirements for the design of respirable atmospheres for the Space Station.

5.1.3.1 DELETED

5.1.3.2 ATMOSPHERE MONITORING DESIGN REQUIREMENTS

5.1.3.2.1 ATMOSPHERE TOXICOLOGICAL MONITORING DESIGN REQUIREMENTS

Design requirements for monitoring of volatile organic and compound specific monitoring are as follows:

A. Monitoring Volatile Organics − The monitoring of volatile organics shall be accomplished as specified in Figure 5.1.3.2.1−1.

(1) Deleted.

(2) Deleted.

B. Compound−Specific Monitors

(1) Compound specific monitors shall be located near equipment, chemical operations, and processing activities which are potential sources of chemical contamination of the space module.

These monitors shall be used to monitor for specific chemical contaminants in the air.

These analyzers shall have continuous real−time monitoring capabilities.

(2) These monitors shall be equipped with audible and visible alarms.

C. Deleted.

COMPOUND	Detection Limits (mg/m^3)
methanol	0.5
ethanol	5
2−propanol	5
2−methyl−2−propanol	5
n−butanol	5
ethanal (acetaldehyde)	0.5
benzene	0.1
xylenes	10
methyl benzene (toluene)	3
dichloromethane	0.5
dichlorodifluoromethance (Freon 12)	10
chlorodifluoromethane (Freon 22)	5
trichlorofluoromethance (Freon 11)	10
1,1,1−trichloroethane	1
1,1,2−trichloro−1,2,2−trifluoroethane (Freon 113)	5
n−hexane	5
n−pentane	10
methane	180
2−methyl−1,3−butadiene	10
propanone (acetone)	1
2−butane	3
hydrogen	10
carbon monoxide	2
hexamethylcyclotrisiloxane	10
trimethylsilanol	3
2−butoxyethanol	1
trifluorobromomethance (Halon 1301)	10
carbonyl sulfide	0.5
acetic acid	0.5
4−hydroxy−4−methyl−2−pentanone	1
ACCURACY	
Concentration	Percent Accuracy (1)
5−10 mg/m^3	+/− 20
2−5 mg/m^3	+/− 30
0.5−2 mg/m^3	+/− 40
< 0.5 mg/m^3	+/− 50

Note:
(1) Percent accuracy = [measured concentration − actual concentration] / (measured concentration) x 100

FIGURE 5.1.3.2.1−1 TRACE GAS DETECTION LIMIT AND ACCURACY

5.1.3.2.2 ATMOSPHERE MICROBIOLOGICAL MONITORING AND CONTROL DESIGN REQUIREMENTS

5.1.3.2.3 BARO−THERMAL MONITORING DESIGN REQUIREMENTS

To ensure that all environmental control systems are functioning properly, a means shall be provided to monitor and record atmospheric parameters from each habitable Space Station element.

5.2 MICROGRAVITY

5.2.1 INTRODUCTION

This paragraph is not applicable for this document.

5.2.2 MICROGRAVITY DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

5.2.3 MICROGRAVITY DESIGN REQUIREMENTS

Microgravity design requirements are given in other paragraphs where applicable.

5.3 ACCELERATION

This paragraph is not applicable for this document.

5.4 ACOUSTICS

5.4.1 INTRODUCTION

This paragraph is not applicable for this document.

5.4.2 ACOUSTICS DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

5.4.3 ACOUSTICS DESIGN REQUIREMENTS

This section defines the basic acoustic environmental limitations and criteria which the designer shall apply to the design of crew stations and other habitable compartment areas.

5.4.3.1 GENERAL ACOUSTIC DESIGN REQUIREMENTS

The following general acoustic design requirements shall be observed:

A. Deleted.

B. Equipment Noise

(1) Equipment noise shall be measured according to the instrumentation and measurement sections of MIL−STD−1474.

(2) Deleted.

(3) System designs shall include noise control provisions.

(4) Deleted.

5.4.3.2 NOISE EXPOSURE REQUIREMENTS

A. The following types of noise shall be taken into account:

(1) Wide band random noise (22.4 to 11,200 Hz).

(2) Narrow band noise and tones.

(3) Impulse noise.

(4) Infrasonic and ultrasonic noise.

B. There are three sets of noise requirements that shall be satisfied depending on crewmember tasks:

(1) Hearing conservation,

(2) voice communication, and

(3) annoyance.

5.4.3.2.1 HEARING CONSERVATION NOISE EXPOSURE REQUIREMENTS

The following types of hearing conservation noise exposure criteria shall apply:

A. Deleted.

B. Hearing Protection Devices − Hearing protection devices shall be provided for use during exposure to noise levels of 85.0 dB(A) or greater.

5.4.3.2.1.1 WIDE BAND, LONG−TERM HEARING CONSERVATION NOISE EXPOSURE REQUIREMENTS

The following long−term, wide band hearing conservation noise exposure criteria shall apply:

A. Hazard Level − Noise of constant sound levels of 85.0 dB(A) and greater are considered hazardous regardless of the duration of exposure.

B. Deleted.

C. Deleted.

5.4.3.2.1.2 NARROW BAND, LONG−TERM HEARING CONSERVATION NOISE EXPOSURE REQUIREMENT

The relative Sound Pressure Levels (SPL) of narrow band components, pure−tones, and beat frequencies shall be limited to a level at least 10.0 dB lower than the maximum SPL of the octave−band which contains the component.

5.4.3.2.1.3 WIDE BAND, SHORT−TERM HEARING CONSERVATION NOISE EXPOSURE REQUIREMENTS

This paragraph is not applicable for this document.

5.4.3.2.1.4 IMPULSE HEARING CONSERVATION NOISE EXPOSURE REQUIREMENTS

Impulse sound is a change in SPL of more than 10.0 dB in one second or less. Impulse noise shall not exceed 140 dB peak pressure level to meet hearing conservation criteria for unprotected ears.

[See MIL−STD−l474 regarding the relationship between the number of daily exposures, the corresponding peak levels, B−duration values, and the required hearing protection devices when impulse peak pressure corresponding levels exceed 140 dB.].

5.4.3.2.1.5 INFRASONIC, LONG−TERM ANNOYANCE NOISE EXPOSURE REQUIREMENTS

The following infrasonic noise annoyance criteria shall apply:

A. Infrasound SPL − Infrasound SPL shall be less than 120 dB in the frequency range of 1.0 to 16.0 Hz for 24−hour exposure.

B. Deleted.

5.4.3.2.1.6 ULTRASONIC, LONG−TERM NOISE EXPOSURE REQUIREMENTS

The following ultrasonic noise annoyance criteria shall apply:

A. Deleted.

B. Hearing Protection − Ultrasonic noise hearing protection shall be provided.

5.4.3.2.2 VOICE COMMUNICATIONS NOISE EXPOSURE REQUIREMENTS

5.4.3.2.2.1 DIRECT VOICE COMMUNICATIONS NOISE EXPOSURE REQUIREMENTS

The following noise level criteria shall apply to areas where voice communications are necessary:

A. Voice Communication Criteria − The communication criteria shown in Figure 5.4.3.2.2.1−1 shall be used to define maximum noise level based on voice communication requirements.

B. Background Noise Level − Background noise for work areas shall not exceed the NC 50 contour unless otherwise specified. (Refer to Figure 5.4.3.2.2.1−1.)

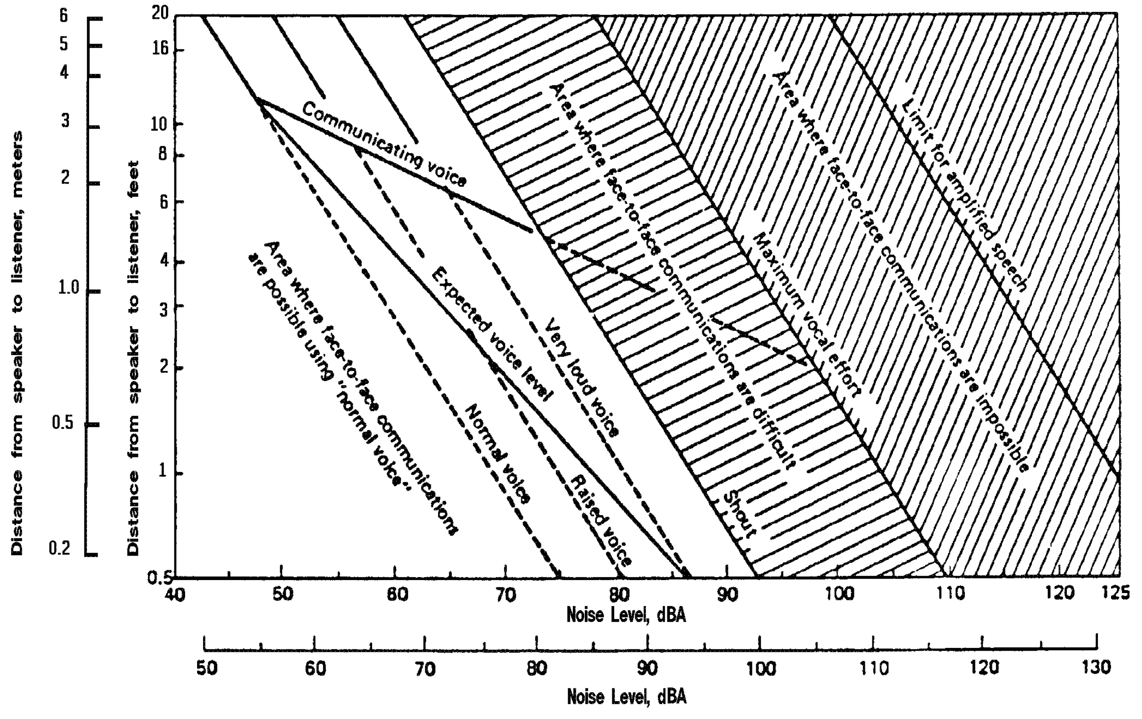


FIGURE 5.4.3.2.2.1−1 PSIL AND EFFECTIVE VOICE COMMUNICATION DISTANCE

C. Room Reverberation Time −

(1) The reverberation time of a spacecraft compartment shall be adjusted according to room volume and the criterion for conversational speech as shown in Figure 5.4.3.2.2.1−2.

(2) In areas where crewmembers must communicate by voice, room reverberation time of 0.5 +/− 0.1 second for the octave band centered at 1000 Hz shall be provided.

5.4.3.2.2.2 INDIRECT VOICE COMMUNICATIONS NOISE EXPOSURE REQUIREMENTS

5.4.3.2.3 ANNOYANCE NOISE EXPOSURE REQUIREMENTS

5.4.3.2.3.1 WIDE−BAND, LONG−TERM ANNOYANCE NOISE REQUIREMENTS

The following long−term, wide band annoyance noise criteria shall apply:

A. Maximum Continuous Noise −The maximum allowable continuous broadband SPLs produced by the summation of all the individual SPLs from all operating systems and subsystems considered at a given time shall not exceed the NC 50 contour for work periods and the NC 40 contour for sleep compartments shown in Figure 5.4.3.2.3.1−1.

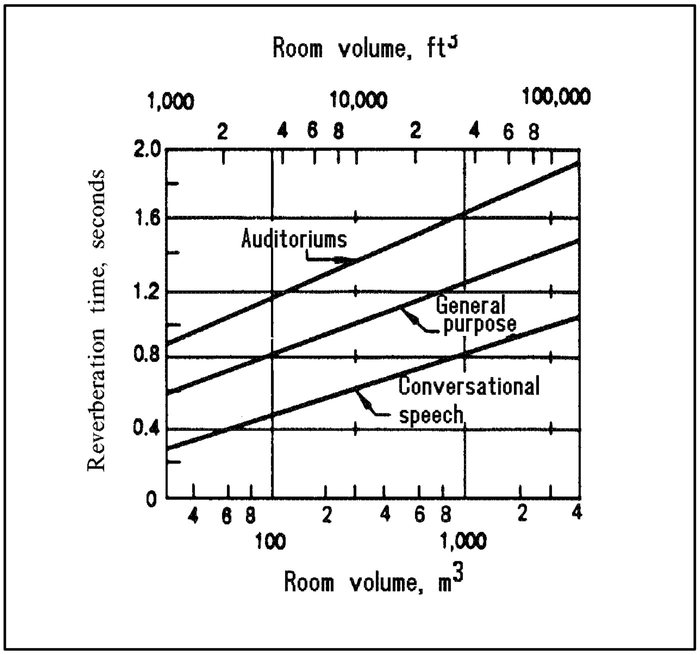


FIGURE 5.4.3.2.2.1−2 PREFERRED REVERBERATION TIME

B. Sleep Compartment Noise Level −

(1) In sleep areas, the continuous broadband noise level shall not be less than the NC 25 contour.

(2) Hearing protection devices shall be available in sleep areas to provide aural isolation as needed.

C. The A−weighted SPL [L_A = dB(A)] for any given NC curve shall not exceed the level shown in Figure 5.4.3.2.3.1−2.

5.4.3.2.3.2 NARROW−BAND ANNOYANCE NOISE EXPOSURE REQUIREMENTS

A. The maximum SPL of any narrow band continuous component or tone shall be at least 10 dB less than the broadband SPL of the octave−band which contains the component.

B. The A−Weighted SPL L_A=dB(A) for any given NC Curve shall not exceed the levels shown in Figure 5.4.3.2.3.1−2.

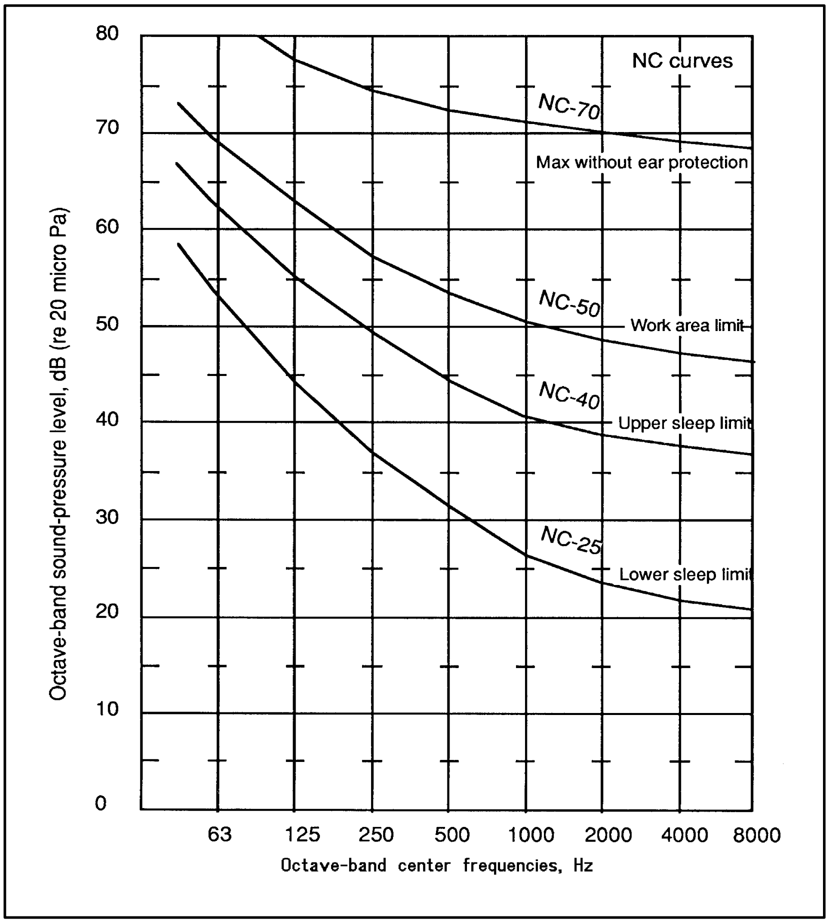


FIGURE 5.4.3.2.3.1−1 NOISE CRITERIA CURVES

NC Curve	A−Weighted SPL dB(A)
70	78
65	71
60	66
55	61
50	56
45	52
40	47
35	42
30	38
25	34
20	30
15	25

FIGURE 5.4.3.2.3.1−2 A−WEIGHTED OVERALL SPL AS WEIGHTED TO THE NC CURVE

5.4.3.2.3.3 WIDE−BAND, SHORT−TERM ANNOYANCE NOISE EXPOSURE REQUIREMENTS

The wide band annoyance noise level as a result of long−term and short−term (less than five minutes) noise shall not exceed an L_{eq} (8 hours) of 55.0 dB during the sleep period.

5.4.3.2.3.4 IMPULSE ANNOYANCE NOISE EXPOSURE REQUIREMENTS

The following impulse noise annoyance criteria shall apply:

A. Sleep/Rest Periods − Anticipated impulse or transient noises shall not exceed background noise by more than 10 dB during sleep/rest periods.

B. Deleted.

5.4.3.2.4 MEASUREMENT OF NOISE LEVELS

Acoustic noise measurements shall be conducted in accordance with the requirements conforming to the sections on Instrumentation and Measurement in MIL−STD−1474.

5.5 VIBRATION

5.5.1 INTRODUCTION

This paragraph is not applicable for this document.

5.5.2 VIBRATION DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

5.5.3 VIBRATION DESIGN REQUIREMENTS

The basic environmental limitations and criteria for the design of crew stations and other habitable compartment areas within space station are included herein.

A. Rectilinear vibrations transmitted to crewmembers shall be measured in the appropriate directions of an orthogonal coordinate system having its origin at the heart. (See Figure 5.5.3−1). Limiting criteria are defined in the following sections for vibration accelerations in the x, y, and z axes.

B. Included are the various vibration environmental parameters essential to crew safety and comfort during a complete mission. The vibratory environment of Space Station shall be designed to protect the crewmembers and preserve their ability to perform their operational functions throughout the total mission.

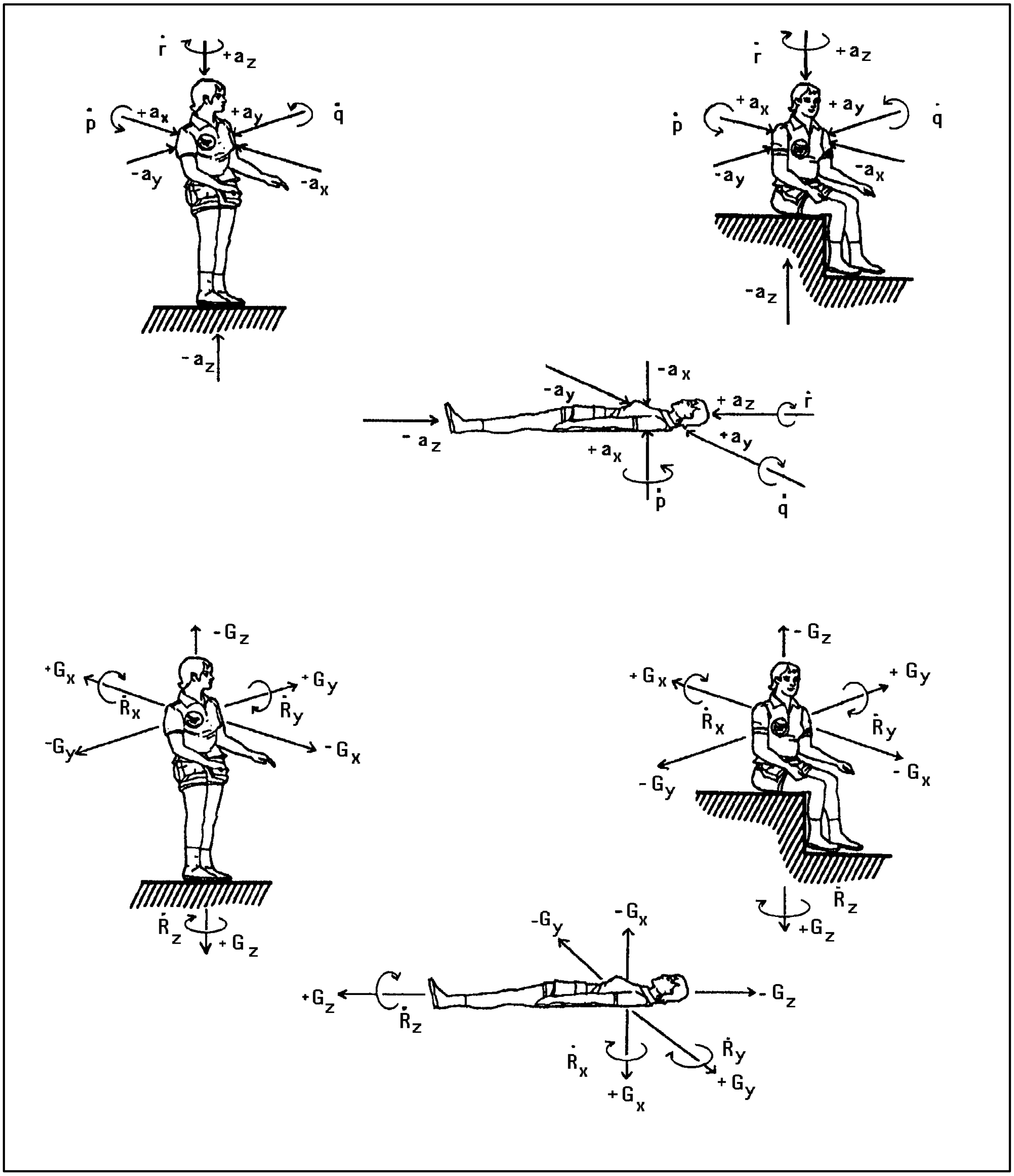


FIGURE 5.5.3−1 ACCELERATION ENVIRONMENT COORDINATE SYSTEM USED IN MSIS (PAGE 1 OF 2)

LINEAR MOTION	Direction of Acceleration		Inertial Resultant of Body Acceleration	
	Acting Force	Acceleration Description	Reaction Force	Verticular Description
Forward	$+a_X$	Forward accel.	$+G_X$	Eye Balls In
Backward	$-a_X$	Backward accel.	$-G_X$	Eye Balls Out
Upward	$-a_Z$	Headward accel.	$+G_Z$	Eye Balls Down
Downward	$+a_Z$	Footward accel.	$-G_Z$	Eye Balls Up
To Right	$+a_Y$	R. Lateral accel.	$+G_Y$	Eye Balls Left
To Left	$-a_Y$	L. Lateral accel.	$-G_Y$	Eye Balls Right
ANGULAR MOTION				
Roll Right	$+\dot{p}$		$-\dot{R}_X$	Cartwheel
Roll Left	$-\dot{p}$		$+\dot{R}_X$	
Pitch Up	$+\dot{q}$		$-\dot{R}_Y$	Somersault
Pitch Down	$-\dot{q}$		$+\dot{R}_Y$	
Yaw Right	$+\dot{r}$		$+\dot{R}_Z$	Pirouette
Yaw Left	$-\dot{r}$		$-\dot{R}_Z$	

FOOTNOTES
Large letter, G, used as unit to express inertial resultant to whole body acceleration in multiples of the magnitude of the acceleration of gravity.
Acceleration of gravity, g_o, = 980,665 cm/sec^2 or 32.1739 ft/sec^2

FIGURE 5.5.3−1 ACCELERATION ENVIRONMENT COORDINATE SYSTEM USED IN MSIS (PAGE 2 OF 2)

5.5.3.1 GENERAL VIBRATION DESIGN REQUIREMENTS

The following general vibration design criteria shall be observed:

A. Deleted.

B. Equipment Vibration

(1) Deleted.

(2) System design shall include vibration control provisions.

(3) Deleted.

C. Long Duration Vibrations − For vibration of duration longer than 8 hours in the 0.1 to 0.63 Hz band, or 24 hours in the 1.0 to 80.0 Hz band, the values at 8 hours and 24 hours, respectively, are applicable. Refer to 5.5.3.2.1 and 5.5.3.3.2.

5.5.3.2 VIBRATION EXPOSURE (0.1 TO 1.0 HZ) DESIGN REQUIREMENTS

5.5.3.2.1 SEVERE DISCOMFORT BOUNDARY

The following vibration acceleration limits for 0.1 to 0.63 Hz shall apply:

A. Longitudinal Vibration −

(1) Figure 5.5.3.2.1−1 acceleration limits shall not be exceeded for the corresponding periods of time in the z−axis at any crewmember station.

(2) If other modes of vibration exist, particularly pitch and roll, boundary accelerations shall be reduced by 25.0 percent.

B. Transverse Vibration − Use 30.0 percent of value for longitudinal vibration requirements.

C. Rotational Tolerance −

(1) Tumbling or rotational rates shall not exceed 60.0 rpm about the axis of the heart or 40 rpm about the axis of the hips.

(2) If rotational vibration exists, the levels in Figure 5.5.3.2.1−1 shall be reduced by 25 percent in the frequency range 0.1 to 0.63 Hz.

5.5.3.2.2 DECREASED PROFICIENCY BOUNDARY

The following vibration limits for 0.1 to 0.63 Hz for crewmember stations and work areas shall apply:

A. Longitudinal Vibration − For tasks requiring writing and fine manual control, vibration rms−values shall not exceed 1.75 m per s^2.

B. Transverse Vibration − For transverse vibration use 25 percent of values shown in Figure 5.5.3.2.1−1.

5.5.3.2.3 REDUCED COMFORT BOUNDARY

See note in Figures 5.5.3.3.2−1 and 5.5.3.3.2−2

5.5.3.2.4 VIBRATION DURATION

The following vibration duration criteria for determining effective daily exposure shall apply:

A. Whole Body z−Axis Vibration (0.1 to 0.63 Hz) −

(1) Figure 5.5.3.2.1−1 shall be used to define the severe discomfort boundary for one−half, two− and eight−hour exposures.

(2) The relationship a^{2t} constant and values in Figure 5.5.3.2.1−1 shall be used if interpolation of summation of a varying acceleration time history is required.

B. Deleted.

5.5.3.2.5 DELETED

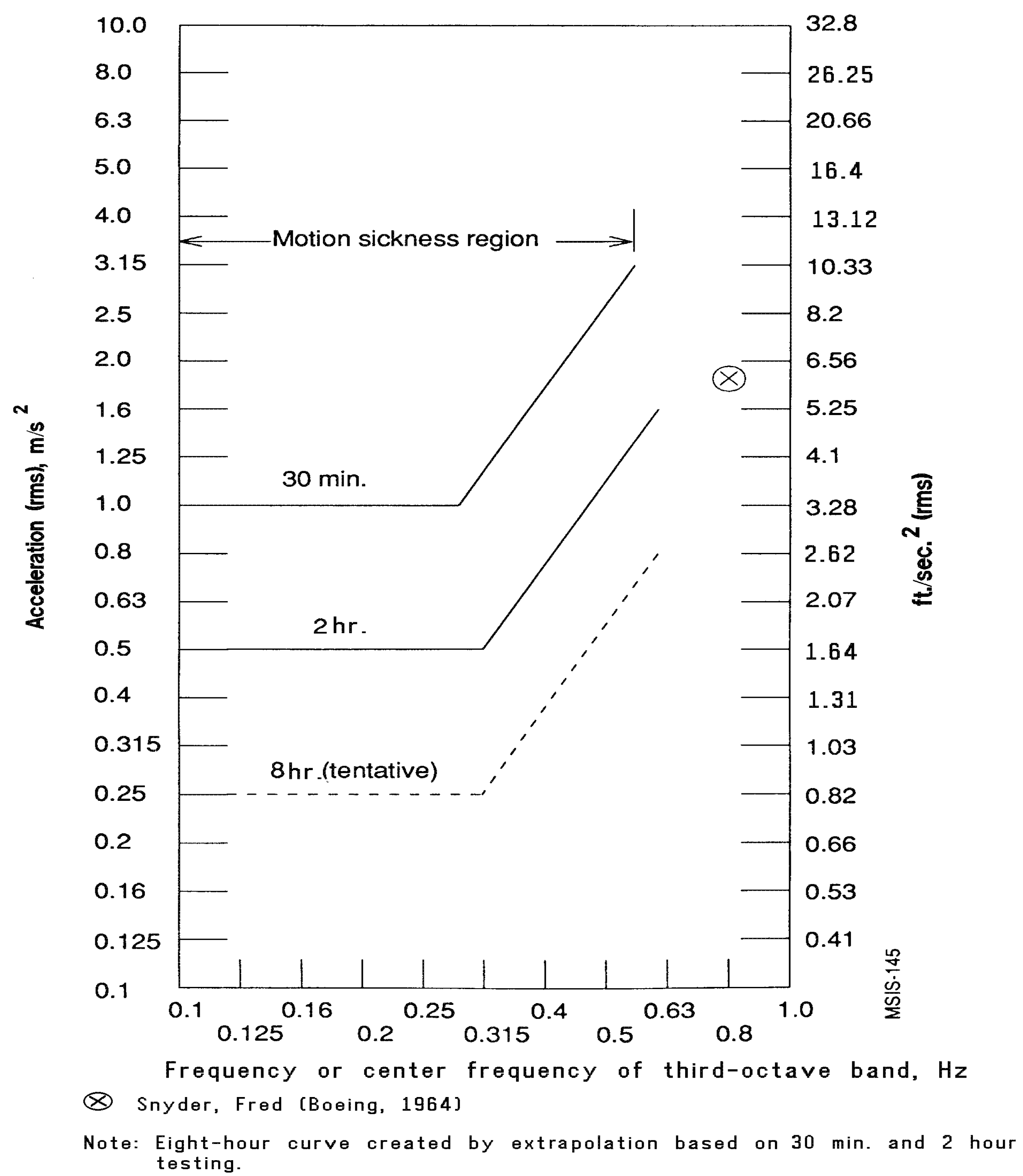


FIGURE 5.5.3.2.1−1 LONGITUDINAL (Z−AXIS) ACCELERATION LIMITS (0.1 TO 0.63 HZ) "SEVERE DISCOMFORT BOUNDARIES"

5.5.3.3 VIBRATION EXPOSURE (1.0 TO 80 HZ) DESIGN REQUIREMENTS

5.5.3.3.1 VIBRATION EXPOSURE LIMIT

This paragraph is not applicable for this document.

5.5.3.3.2 FATIGUE−DECREASED PROFICIENCY BOUNDARY

The following vibration acceleration limits for 1.0 to 80 Hz for crewmember stations and work areas during orbital conditions shall apply:

A. Longitudinal Vibration − Vibration acceleration exposure shall not exceed the limits shown in Figure 5.5.3.3.2−1 for z−axis direction, unless specified otherwise.

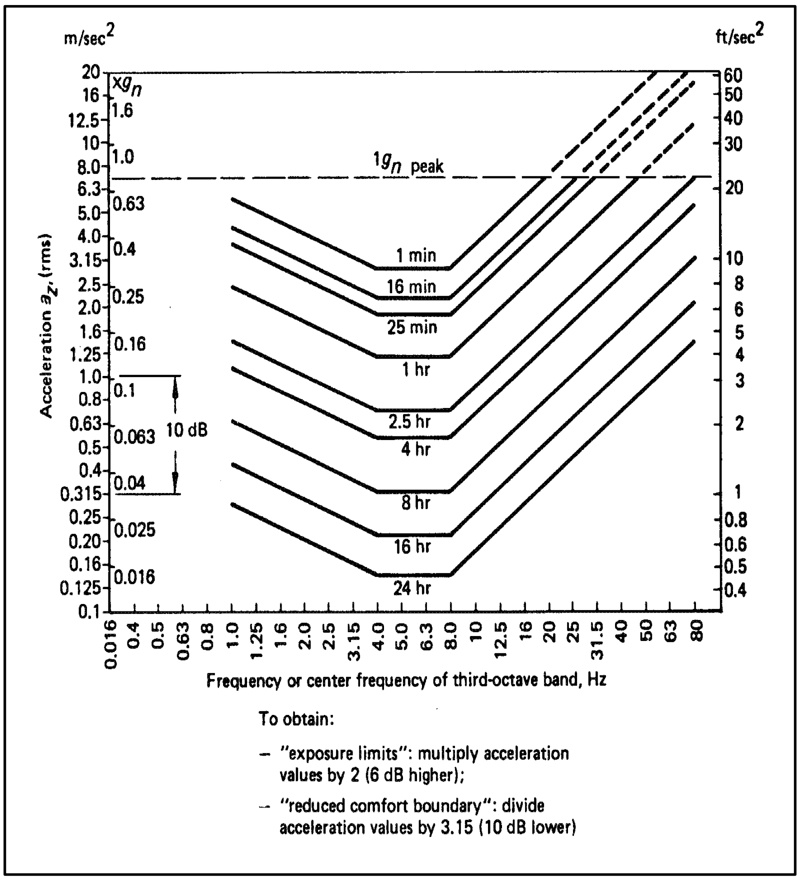


FIGURE 5.5.3.3.2−1 LONGITUDINAL (Z−AXIS) ACCELERATION LIMITS "FATIGUE−DECREASED PROFICIENCY BOUNDARY"

B. Transverse Vibration − Vibration acceleration exposure shall not exceed the limits shown in Figure 5.5.3.3.2−2 for x−axis, y−axis directions, unless specified otherwise.

C. Visual Acuity Effects − For whole body vibration in the ranges of 3.0 to 11.0 Hz or 22.0 to 30.0 Hz, provisions shall be made to protect the crew from loss of visual acuity.

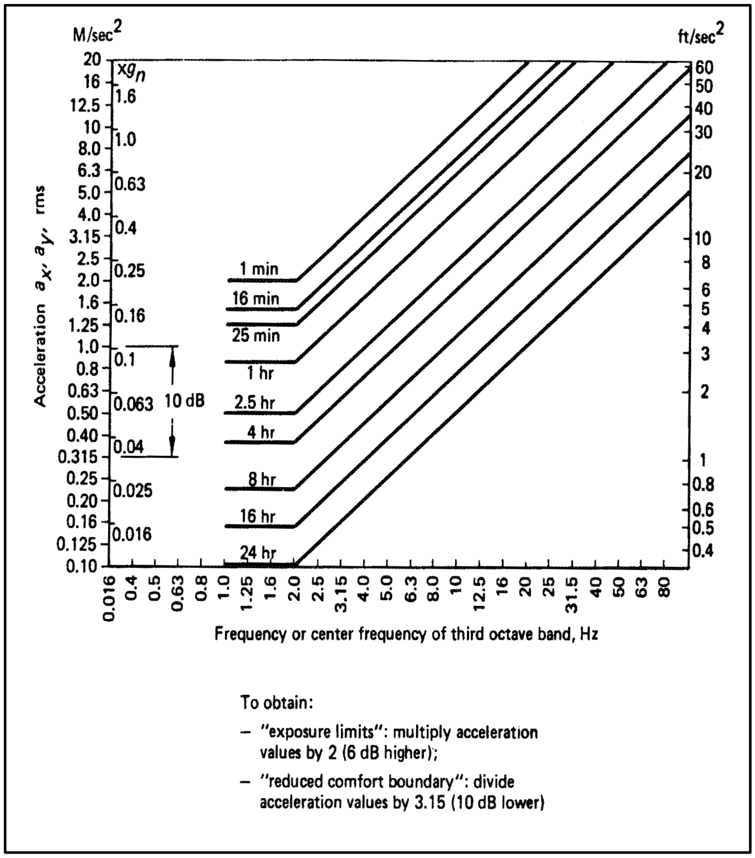


FIGURE 5.5.3.3.2−2 TRANSVERSE (X−AXIS, Y−AXIS) ACCELERATION LIMITS "FATIGUE−DECREASED PROFICIENCY BOUNDARY"

5.5.3.3.3 REDUCED COMFORT BOUNDARY

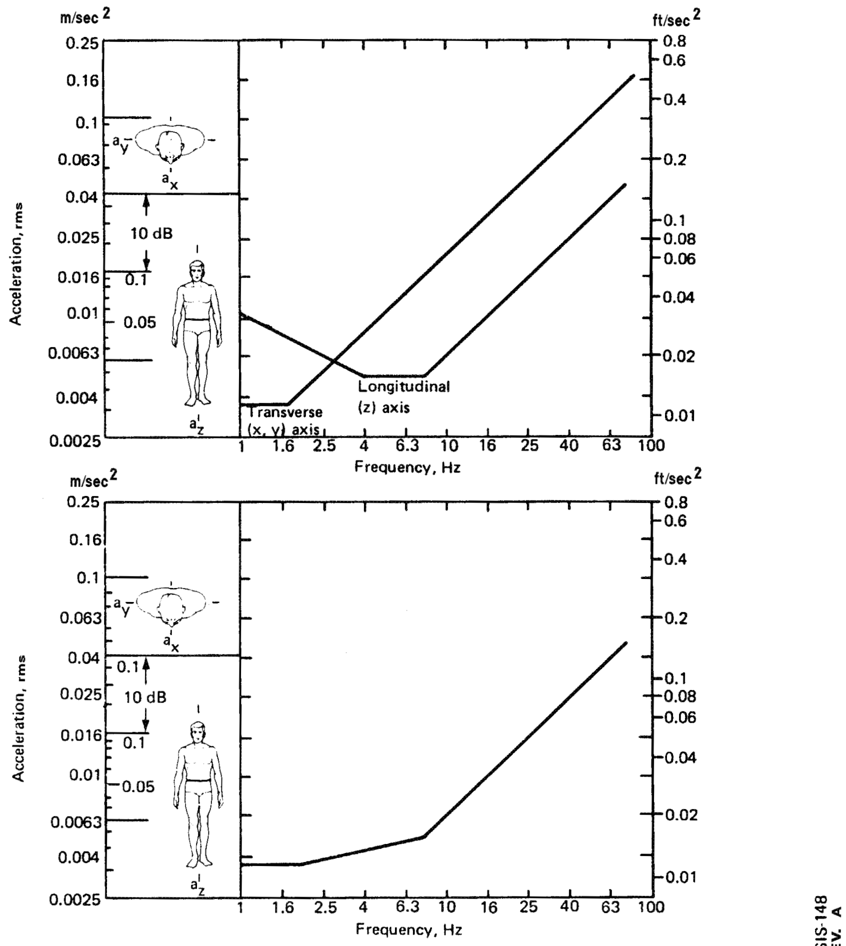
Longitudinal vibration acceleration exposure for 1.0 to 80.0 Hz shall not exceed the limits shown in Figure 5.5.3.3.3−1 for x−axis and y−axis vibration in areas in which crewmembers are resting or sleeping.

5.5.3.3.4 VIBRATION DURATION

The following vibration duration criteria for determining effective exposure shall apply:

A. Whole Body z−Axis Vibration (1.0 to 80.0 Hz) − Figure 5.5.3.3.4−1 shall be used to define the fatigue−decreased proficiency boundary for longitudinal vibration duration time between l.0 minute and 24 hours.

B. Whole Body x−Axis, y−Axis Vibration (1.0 to 80.0 Hz) − Figure 5.5.3.3.4−2 shall be used to define the fatigue−decreased proficiency boundary for transverse vibration time between 1 minute and 24 hours.



Vibration exposure criteria for longitudinal and transverse (upper curve) and combined (lower curve) directions with respect to body axis.

Reference: 2, Figure 44, page 177

FIGURE 5.5.3.3.3−1 VIBRATION EXPOSURE CRITERIA

C. Interrupted Vibration − If the exposure to vibration is interrupted by pauses during a 24−hour period but the intensity of exposure remains the same, then the effective total daily exposure time shall be determined by adding up the individual exposure times.

D. Variable Amplitude Vibration − If the acceleration amplitude varies with time or if the total daily exposure is composed of several individual exposure times, at different levels, then an ”equivalent total exposure” shall be determined by the procedure given in ISO 2631.

5.6 ULTRAVIOLET RADIATION

Exposure to ultraviolet radiation shall not exceed the values specified by 5.7.3.2.1, Item C(3).

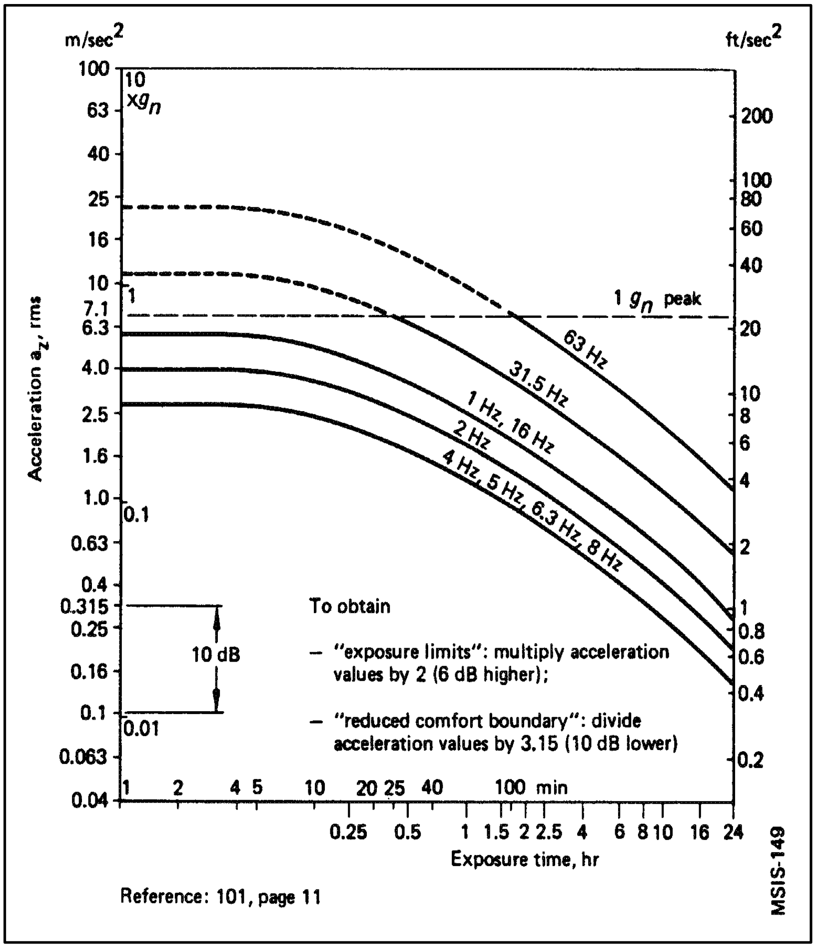


FIGURE 5.5.3.3.4−1 LONGITUDINAL (Z−AXIS) ACCELERATION LIMITS "FATIGUE−DECREASED PROFICIENCY BOUNDARY"

5.7 RADIATION

5.7.1 INTRODUCTION

This paragraph is not applicable for this document.

5.7.2 IONIZING RADIATION

5.7.2.1 IONIZING RADIATION DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

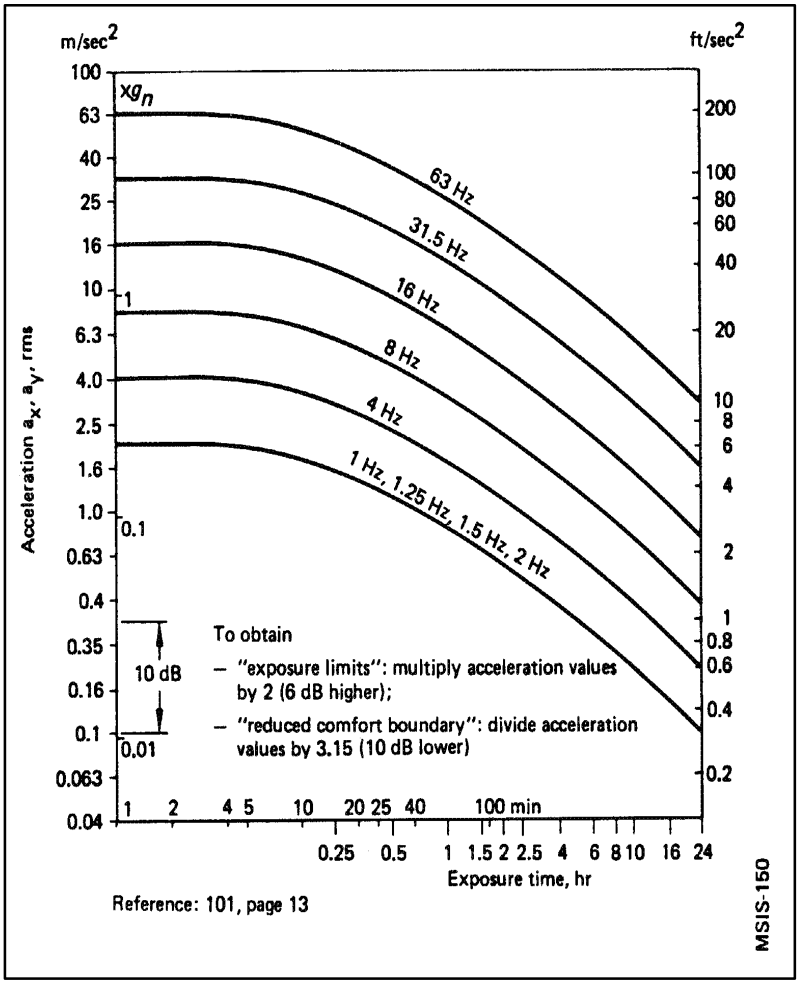


FIGURE 5.5.3.3.4−2 TRANSVERSE (X−AXIS, Y−AXIS) ACCELERATION LIMITS "FATIGUE−DECREASED PROFICIENCY BOUNDARY"

5.7.2.2 IONIZING RADIATION DESIGN REQUIREMENTS

5.7.2.2.1 IONIZING RADIATION EXPOSURE LIMITS

5.7.2.2.2 IONIZING RADIATION PROTECTION DESIGN REQUIREMENTS

A. The projected dose rates in pressurized modules shall not exceed a dose equivalent to the blood forming organs of 40.0 rem per year.

B. Use of on−board mass − The design and layout of onboard mass shall be parametrically evaluated to determine the impact on radiation shielding for purpose of ALARA.

C. The use of radioactive isotopes and radiation producing equipment onboard the space station shall require adherence to established safety review and use authorization procedures/constraints for flight approval.

Each radiation source shall be documented using a completed JSC Form 44 (for reference see NSTS 13830).

D. Near−continuous near real−time radiation dose and dose rate data shall be provided from the Space Station to the ground to support normal and contingency operations.

E. Deleted.

F. Deleted.

5.7.2.2.3 IONIZING RADIATION MONITORING AND DOSIMETRY DESIGN REQUIREMENTS

A. Crewmember Radiation Dose Monitoring − The radiation dose for each individual crewmember shall be monitored. This data will be used as part of the crewmember's radiation exposure history.

B. Area Radiation Monitoring − The accumulated radiation dose within occupied areas of the space module shall be monitored and recorded for all missions.

C. Effective dose equivalent −

(1) The time resolved Linear Energy Transfer (LET) spectrum shall be measured to determine the effective dose equivalent.

(2) LET spectral monitoring data shall be available through telemetry on the ground and be capable of being read out on command from the ground.

D. Charged particle monitoring −

(1) Proton and other particle fluxes as a function of time and energy spectrum internal and external to the Space Station shall be monitored and recorded.

(2) Particle radiation characteristics such as particle direction and secondary particle flux shall be monitored.

(3) Charged particle spectral monitoring data shall be available through telemetry on the ground and be capable of being read out on command from the ground.

E. Location of Radiation detectors − the location and characteristics of onboard radiation detectors shall be consistent with the expected radiation environment.

F. Deleted.

5.7.2.2.4 IONIZING RADIATION PERSONNEL PROTECTION DESIGN REQUIREMENTS

5.7.3 NONIONIZING RADIATION

5.7.3.1 NONIONIZING RADIATION DESIGN CONSIDERATIONS

A. Procedures for RF Sources and Optical Sources − Procedures for the safe operation of RF sources and optical radiation sources shall be provided.

B. Based on the mission plan, the possibility of providing power shutoff for applicable RF and optical radiation−emitting equipment shall be considered.

5.7.3.2 NONIONIZING RADIATION DESIGN REQUIREMENTS

A. Personnel Protective Devices − Based on the safety requirements and the results of the nonionizing radiation hazard analysis, personnel protective devices commensurate with the hazard shall be provided.

B. Safety Guidelines − Systems employing laser equipment shall be designed and operated in accordance with ANSI Z136.1

Where the mission requirements require implementation in violation of these standards, a hazard analysis shall be performed.

5.7.3.2.1 NONIONIZING RADIATION EXPOSURE LIMITS

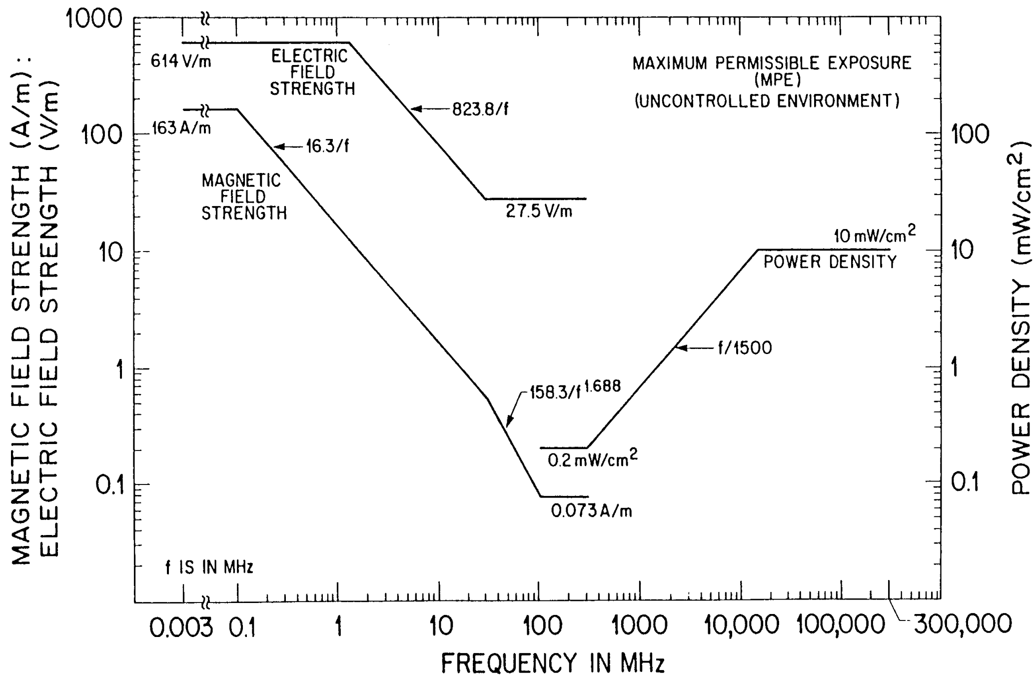
A. Radio−Frequency Electromagnetic Field Exposure Limits − The IEEE C95.1 document shall apply as the standard for radio−frequency nonionizing radiation exposure. These limits are shown in Figures 5.7.3.2.1−1 and 5.7.3.2.1−2.

1 Frequency Range (MHz)	2 Electric Field Strength (E) (V/m)	3 Magnetic Field Strength (H) (A/m)	4 Power Density (S) E−Field: H−Field (mW/cm^2)	5 Averaging Time (Minutes)	
				$\|E\|^2$, S	or $\|H\|^2$
0.003 − 0.1	614	163	(100: 1,000,000)+	6	6
0.1 − 1.34	614	$163/f$	$(100: 10,000)f^2)^+$	6	6
1.34 − 3.0	$823.8/f$	$16.3/f$	$(180/f^2: 10,000/f^2)^+$	$f^2/0.3$	6
3.0 − 30	27.5	$16.3/f$	$(180/f^2: 10,000/f^2)^+$	30	6
30 − 100	27.5	$158.3/f^{1.668}$	$(0.2: 940,000/f^{3.336})^+$	30	$0.0636f^{1.337}$
100 − 300		0.0729	0.2	30	
300 − 3,000			$f/1,500$	30	
3,000 − 15,000			$f/1,500$	$616,000/f^{1.2}$	
15,000 − 300,000			10	$90.000/f$	

Note:
(1) + The exposure values in terms of electric field and magnetic field strengths are the values obtained by spatially averaging values over an area equivalent to the vertical cross−section area of the human body (projected area).
(2) These plane−wave equivalent power density values, although not appropriate for near−field conditions, are commonly used as a convenient comparison with MPEs at higher frequency and are displayed on some instruments in use.

FIGURE 5.7.3.2.1−1 OCCUPATIONAL EXPOSURE LIMITS FOR RADIO FREQUENCY ELECTROMAGNETIC FIELDS

B. Laser Exposure Limits − The ANSI Z136.1 shall apply as the standard for limiting skin and ocular exposure to both continuous and repetitively pulsed lasers. This standard allows for differing skin and ocular exposure limits, and further allows for differing ocular exposure limits according to the angle subtended by the source measured at the eye. These angles (“alpha minimums”) are shown in Figure 5.7.3.2.1−3. A source subtending an angle less than that shown is to be considered as a “point” source. A source subtending an angle greater than or equal to the value shown is to be considered an “extended” source.



Graphic Representation of Maximum Permissible Exposure in Terms of Field and Power Density

FIGURE 5.7.3.2.1−2 OCCUPATIONAL EXPOSURE LIMITS ILLUSTRATED TO SHOW WHOLE BODY RESONANCE EFFECTS AROUND 100 MHZ

(1) Point Source Laser Ocular Exposure Limits − The ocular exposure limits given in Figure 5.7.3.2.1−4 shall apply to all point source lasers.

(2) Extended Source Laser Ocular Exposure Limits − The ocular exposure limits given in Figure 5.7.3.2.1−5 shall apply to all extended source lasers.

(3) Maximum Permissible Exposure for Skin Exposure to a Laser Beam − The skin exposure limits shown in Figure 5.7.3.2.1−6 shall apply in all cases of laser skin exposure.

(4) Exposure Limits for Commonly Available Types of Lasers − The eye and skin exposure limits for specific types of lasers given in Figure 5.7.3.2.1−7 shall apply (these limits are derived from the above information).

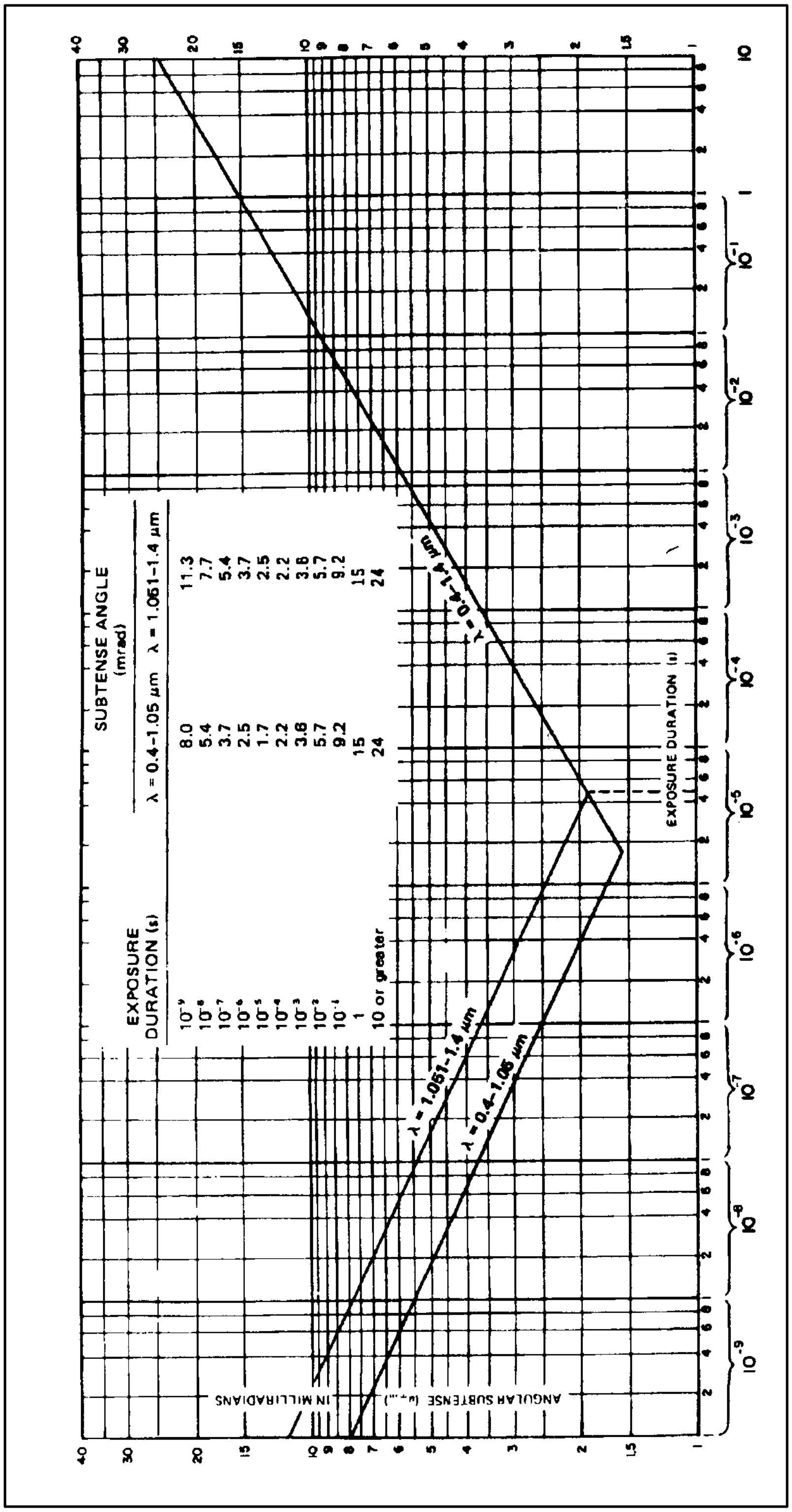


FIGURE 5.7.3.2.1−3 ALPHA−MINIMUM USED TO DETERMINE "POINT SOURCE" OR "EXTENDED SOURCE" LASER EXPOSURES

Wavelength, λ (µm)	Exposure Duration, t (s)	Maximum Permissible Exposure (MPE)	Notes for Calculation and Measurement
Ultraviolet			
0.200 to 0.302	10^{-9} to 3 x 10^{4}	3 x10^{-3} J • cm^{-2}	
0.303	10^{-9} to 3 x 10^{4}	4 x10^{-3} J • cm^{-2}	
0.304	10^{-9} to 3 x 10^{4}	6 x10^{-3} J • cm^{-2}	or 0.56$t^{1/4}$ J • cm^{-2},
0.305	10^{-9} to 3 x 10^{4}	1.0 x10^{-2} J • cm^{-2}	
0.306	10^{-9} to 3 x 10^{4}	1.6 x10^{-2} J • cm^{-2}	whichever is lower
0.307	10^{-9} to 3 x 10^{4}	2.5 x10^{-2} J • cm^{-2}	
0.308	10^{-9} to 3 x 10^{4}	4.0 x10^{-2} J • cm^{-2}	
0.309	10^{-9} to 3 x 10^{4}	6.3 x10^{-2} J • cm^{-2}	
0.310	10^{-9} to 3 x 10^{4}	1.0 x10^{-1} J • cm^{-2}	1 mm limiting aperture
0.311	10^{-9} to 3 x 10^{4}	1.6 x10^{-1} J • cm^{-2}	
0.312	10^{-9} to 3 x 10^{4}	2.5 x10^{-1} J • cm^{-2}	
0.313	10^{-9} to 3 x 10^{4}	4.0 x10^{-1} J • cm^{-2}	
0.314	10^{-9} to 3 x 10^{4}	6.3 x10^{-1} J • cm^{-2}	
0.315 to 0.400	10^{-9} to 10	0.56 $t^{1/4}$ J • cm^{-2}	
0.315 to 0.400	10 to 3 x 10^{4}	1 J • cm^{-2}	
0.315 to 0.400	10^{3} to 3 x 10^{4}	1 x 10^{-3} J • cm^{-2}	
Visible & Near Infrared			
0.400 to 0.700	10^{-9} to 1.8 x 10^{-5}	5 x 10^{-7} J • cm^{-2}	
0.400 to 0.700	1.8 x 10^{-5} to 10	1.8 $t^{3/4}$ x 10^{-3} J • cm^{-2}	
0.400 to 0.550	10 to 10^{4}	10 x 10^{-3} J • cm^{-2}	
0.550 to 0.700	10 to T_1	1.8 $t^{3/4}$ x 10^{-3} J • cm^{-2}	
0.550 to 0.700	T_1 to 10^{4}	10 C_B x 10^{-3} J • cm^{-2}	
0.400 to 0.700	10^{4} to 3 x 10^{4}	C_B x 10^{-6} W • cm^{-2}	7 mm limiting aperture
0.700 to 1.050	10^{-9} to 1.8 x 10^{-5}	5 C_A x 10^{-7} J • cm^{-2}	
0.700 to 1.050	1.8 x 10^{-5} to 10^{3}	1.8 $C_A t^{3/4}$ x 10^{-3} J • cm^{-2}	
1.051 to 1.400	10^{-9} to 5 x 10^{-5}	5 x 10^{-6} J • cm^{-2}	
1.051 to 1.400	5 x 10^{-5} to 10^{3}	9 $t^{3/4}$ x 10^{-3} J • cm^{-2}	
0.700 to 1.400	10^{3} to 3 x 10^{4}	320 C_A x 10^{-6} W • cm^{-2}	
Far Infrared			
1.4 to 10^{3}	10^{-9} to 10^{-7}	10^{-2} J • cm^{-2}	
	10^{-7} to 10	0.56 $t^{1/4}$ J • cm^{-2}	
	>10	0.1 W • cm^{-2}	
1.54 only	10^{-9} to 10^{-6}	1.0 J • cm^{-2}	

Notes: C_A = 1 for λ = 0.400 to 0.700 µm,
$C_A = 10^{2.0(\lambda - 0.700)}$ for λ = 0.700 to 1.050 µm
C_A = 5 for λ = 1.050 to 1.400 µm
C_B = 1 for λ = 0.400 to 0.550 µm
$C_B = 10^{15(\lambda - 0.550)}$ for λ = 0.550 to 0.700 µm
$T_1 = 10 \times 10^{20(\lambda - 0.550)}$ for λ = 0.550 to 0.700 µm

FIGURE 5.7.3.2.1−4 "POINT SOURCE" LASER EYE EXPOSURE LIMITS

Wavelength, λ (μm)	Exposure Duration, t (s)	Maximum Permissible Exposure (MPE)	
Ultraviolet			
0.200 to 0.302	10^{-9} to 3×10^{4}	3×10^{-3} J • cm^{-2}	or $0.56\, t^{1/4}$ J • cm^{-2}, whichever is lower; 1 mm limiting aperture
0.303	10^{-9} to 3×10^{4}	4×10^{-3} J • cm^{-2}	
0.304	10^{-9} to 3×10^{4}	6×10^{-3} J • cm^{-2}	
0.305	10^{-9} to 3×10^{4}	1.0×10^{-2} J • cm^{-2}	
0.306	10^{-9} to 3×10^{4}	1.6×10^{-2} J • cm^{-2}	
0.307	10^{-9} to 3×10^{4}	2.5×10^{-2} J • cm^{-2}	
0.308	10^{-9} to 3×10^{4}	4.0×10^{-2} J • cm^{-2}	
0.309	10^{-9} to 3×10^{4}	6.3×10^{-2} J • cm^{-2}	
0.310	10^{-9} to 3×10^{4}	1.0×10^{-1} J • cm^{-2}	
0.311	10^{-9} to 3×10^{4}	1.6×10^{-1} J • cm^{-2}	
0.312	10^{-9} to 3×10^{4}	2.5×10^{-1} J • cm^{-2}	
0.313	10^{-9} to 3×10^{4}	4.0×10^{-1} J • cm^{-2}	
0.314	10^{-9} to 3×10^{4}	6.3×10^{-1} J • cm^{-2}	
0.315 to 0.400	10^{-9} to 10	$0.56\, t^{1/4}$ J • cm^{-2}	
0.315 to 0.400	10 to 3×10^{4}	1 J • cm^{-2}	
Visible	10^{-9} to 10	$10\, t^{1/3}$ J • cm^{-2} • sr^{-1}	1 mm limiting aperture or α_{min}, whichever is greater
0.400 to 0.700	10 to 10^{4}	21 J • cm^{-2} • sr^{-1}	
0.400 to 0.550	10 to T_1	$3.83\, t^{3/4}$ J • cm^{-2} • sr^{-1}	
0.550 to 0.700	T_1 to 10^{4}	$21\, C_B$ J • cm^{-2} • sr^{-1}	
0.550 to 0.700	10^{3} to 3×10^{4}	$2.1\, C_B \times 10^{-3}$ W • cm^{-2} • sr^{-1}	
0.400 to 0.700			
Near Infrared	10^{-9} to 10	$10\, C_A\, t^{1/3}$ J • cm^{-2} • sr^{-1}	
0.700 to 1.400	10 to 10^{3}	$3.83\, C_A\, t^{3/4}$ J • cm^{-2} • sr^{-1}	
0.700 to 1.400	10^{-3} to 3×10^{4}	$0.64\, C_A$ W • cm^{-2} • sr^{-1}	
1.051 to 1.400			
Far Infrared	10^{-9} to 10^{-7}	10^{-2} J • cm^{-2}	
$1.4 - 10^{3}$	10^{-7} to 10	$0.56\, t^{1/4}$ J • cm^{-2}	
	>10	0.1 W • cm^{-2}	
1.54 Only	10^{-9} to 10^{-6}	1.0 J • cm^{-2}	

Notes: $C_A = 1$ for $\lambda = 0.400$ to 0.700 μm,
$C_A = 10^{2.0(\lambda - 0.700)}$ for $\lambda = 0.700$ to 1.050 μm
$C_A = 5$ for $\lambda = 1.051$ to 1.400 μm
$C_B = 1$ for $\lambda = 0.400$ to 0.550 μm
$C_B = 10^{15(\lambda - 0.550)}$ for $\lambda = 0.550$ to 0.700 μm
$T_1 = 10 \times 10^{20(\lambda - 0.550)}$ for $\lambda = 0.550$ to 0.700 μm

FIGURE 5.7.3.2.1−5 "EXTENDED SOURCE" LASER EYE EXPOSURE LIMITS

Wavelength, λ (μm)	Exposure Duration, t (s)	Maximum Permissible Exposure (MPE)	Notes for Calculation and Measurement
Ultraviolet			
0.200 to 0.302	10^{-9} to 3 x 10^{4}	3 x 10^{-3} J • cm^{-2}	
0.303	10^{-9} to 3 x 10^{4}	4 x 10^{-3} J • cm^{-2}	
0.304	10^{-9} to 3 x 10^{4}	6 x 10^{-3} J • cm^{-2}	0.56 $t^{1/4}$ J • cm^{-2},
0.305	10^{-9} to 3 x 10^{4}	1.0 x 10^{-2} J • cm^{-2}	whichever is lower
0.306	10^{-9} to 3 x 10^{4}	1.6 x 10^{-2} J • cm^{-2}	
0.307	10^{-9} to 3 x 10^{4}	2.5 x 10^{-2} J • cm^{-2}	
0.308	10^{-9} to 3 x 10^{4}	4.0 x 10^{-2} J • cm^{-2}	
0.309	10^{-9} to 3 x 10^{4}	6.3 x 10^{-2} J • cm^{-2}	1 mm limiting aperture
0.310	10^{-9} to 3 x 10^{4}	1.0 x 10^{-1} J • cm^{-2}	
0.311	10^{-9} to 3 x 10^{4}	1.6 x 10^{-1} J • cm^{-2}	
0.312	10^{-9} to 3 x 10^{4}	2.5 x 10^{-1} J • cm^{-2}	
0.313	10^{-9} to 3 x 10^{4}	4.0 x 10^{-1} J • cm^{-2}	
0.314	10^{-9} to 3 x 10^{4}	6.3 x 10^{-1} J • cm^{-2}	
0.315 to 0.400	10^{-9} to 10	0.56 $t^{1/4}$ J • cm^{-2}	
0.315 to 0.400	10 to 10^{3}	1 J • cm^{-2}	
0.315 to 0.400	10^{3} to 3 x 10^{4}	1 x10^{-3} J • cm^{-2}	
Visible & Near Infrared			
0.400 to 1.400	10^{-9} to 10^{-7}	*2* C_A x 10^{-2} J • cm^{-2}	1 mm limiting aperture
	10^{-7} to 10	*1.1* C_A $t^{1/4}$ J • cm^{-2}	
	10 to 3 x 10^{4}	0.2 C_A W • cm^{-2}	
Far Infrared			
1.4 to 10^{3}	10^{-9} to 10^{-7}	10^{-2} J • cm^{-21}	1 mm limiting aperture for 1.4 to 100 μm
	10^{-7} to 10	0.56 $t^{1/4}$ J • cm^{-2}	
	>10	0.1 W • cm^{-2}	11 mm limiting aperture for 0.1 to 1 mm
1.54 Only	10^{-9} to 10^{-6}	1.0 J • cm^{-2}	

FIGURE 5.7.3.2.1−6 MAXIMUM PERMISSIVE EXPOSURE FOR SKIN EXPOSURE TO A LASER BEAM

Helium−Cadmium Argon	441.6 488/514.5	a) 2.5 mW • cm^{-2} for 0.25 s b) 10 mJ • cm^{-2} for 10 to 10^4 s c) 1 µ W • cm^{-2} for t > 10^4 s	0.2 W • cm^{-2} for t >10s
Helium−Neon	632.8	a) 2.5 mW • cm^{-2} for 0.25 s b) 10 mJ • cm^{-2} for 10 s c) 170 mJ • cm^{-2} for t > 453 s d) 17 µW • cm^{-2} for t > 10^4 s	0.2 W • cm^{-2} for t >10s
Krypton	647	a) 2.5 mW • cm^{-2} for 0.25 s b) 10 mJ • cm^{-2} for 10 s c) 280 mJ • cm^{-2} for t > 871 s d) 28 µW • cm^{-2} for t > 10^4 s	0.2 W • cm^{-2} for t >10s
Neodymium: YAG Gallium−Arsenide at room temp	1,064 905	1.6 m W • cm^{-2} for t >1000 s 0.8 m W • cm^{-2} for t >1000 s	1.0 W • cm^{-2} 0.5 W • cm^{-2} for t > 10s
Helium−Cadmium Nitrogen	325 337.1	1 J • cm^{-2} for 10 to 3 x 10^4s	a) 1 J • cm^{-2} for 10 to 1000s b) 1 mW • cm^{-2} for t > 1000s
Carbon−dioxide (and other lasers 1.4 µm to 1000 µm)	10,600	0.1 W • cm^{-2} for t > 10 s	0.1 W • cm^{-2} for t > 10 s

FIGURE 5.7.3.2.1−7 INTRABEAM MPE FOR THE EYE AND SKIN FOR SELECTED LASERS

C. Limits on Exposure to Incoherent Electromagnetic Radiation (200 nm − 3 µm) − For the purposes of limiting crew exposure to the electromagnetic spectrum from the ultraviolet to the far infrared, the methodology given in the American Conference of Industrial Hygienists (ACGIH) Standards, Threshold Limit Values and Biological Exposure Indices, shall be adopted. These standards allow for the quantification of the relationship between source strength and acceptable exposure times for each of four potential injury pathways (retinal thermal injury due to exposure to visible light, retinal photochemical injury due to chronic exposure to blue−light, thermal injury to the ocular lens and cornea due to infrared exposure, and exposure of the unprotected skin or eye to ultraviolet radiation). These limits DO NOT apply to laser exposure (see laser exposure limits). Because of the difference in the ambient environment in space and the environment on the Earth's surface, the numerical values used by the ACGIH are amended for use by NASA by the insertion of a factor of one−fifth in the source term of each calculation, with the exception of the calculation for ultraviolet exposure, which is not amended, as follows:

(1) Exposure Limits for the Prevention of Retinal Thermal Injury from a Visible Light Source (400−1400 nm).

The spectral radiance of the source weighted against the Retinal Thermal Hazard Function R_λ (given in Figure 5.7.3.2.1−8) shall not exceed:

$$\sum_{400}^{1400} 0.2 * L_\lambda * R_\lambda * \Delta\lambda \le \frac{5}{\alpha * t^{1/4}}$$

Where L_λ is the source spectral radiance expressed in W/cm^2•sr•nm, R_λ is the dimensionless retinal thermal hazard function, t is the viewing duration expressed in seconds, and α is the angular subtense of the source in radians.

(2) Exposure Limits to Prevent Retinal Photochemical Injury Caused by Chronic Exposure to Blue−Light (400−700 nm).

Blue−light sources are to be distinguished according to their angular subtense.

a. Exposures to blue−light sources subtending an angle less than 11 milliradians are limited such that the spectral irradiance weighted against the blue−light hazard function B_λ (given in Figure 5.7.3.2.1−8) shall not exceed:

$$\sum_{400}^{700} 0.2 * E_\lambda * t * B_\lambda * \Delta\lambda \leq 10\, mJ/cm^2 \quad \text{for}\, t \leq 10^4 s$$

or

$$\vdots \sum_{400}^{700} 0.2 * E_\lambda * B_\lambda * \Delta\lambda \leq 1.0\, \mu W/cm^2 \quad \text{for}\, t > 10^4 s$$

Note that the maximum weighted irradiance above is 2 μW per centimeter squared. For a source whose weighted irradiance exceeds 2 μW per centimeter squared, the maximum permissible exposure duration is given by:

$$t_{\max} \leq \frac{10\, mJ/cm^2}{\sum_{700}^{400} 0.2 * E_\lambda * B_\lambda * \Delta\lambda}$$

b. Exposures to blue−light sources subtending an angle equal to or greater than 11 mradians are limited such that:

$$\sum_{400}^{700} 0.2 * E_\lambda * t * B_\lambda * \Delta\lambda \leq 100\, J/(cm^2 * sr) \quad \text{for}\, t \leq 10^4 s$$

or

$$\sum_{400}^{700} 0.2 * E_\lambda * B_\lambda * \Delta\lambda \leq 10^{-2}\, W/(cm^2 * sr) \quad \text{for}\, t > 10^4 s$$

Note that the above maximum radiance in this case is 100 J/(cm^2•sr), so that the maximum permissible viewing time becomes:

$$t_{\max} \leq \frac{100\ J/(cm^2 * sr)}{\sum_{700}^{400} 0.2 * E_\lambda * B_\lambda * \Delta\lambda}$$

For individuals who have had a lens removal as corrective surgery for cataract treatment, B_λ is not an accurate indicator if the increase in risk of photochemical injury. In this case the alternate Aphakic Hazard Function A_λ

(also given in Figure 5.7.3.2.1−8) should be inserted into the above calculations in the place of B_λ.

Wavelength, (nm)	Aphakic Hazard	Blue−Light Hazard	Retinal Thermal Hazard
	Function, A_λ	Function, B_λ	Function, R_λ
305	6.00	−−	−−
310	6.00	−−	−−
315	6.00		−−
320	6.00	−−	−−
325	6.00	−−	−−
330	6.00	−−	−−
335	6.00	−−	−−
340	5.88	−−	−−
345	5.71	−−	−−
350	5.46	−−	−−
355	5.22	−−	−−
360	4.62	−−	−−
365	4.29	−−	−−
370	3.75	−−	−−
375	3.56	−−	−−
380	3.19	−−	−−
385	2.31	−−	−−
390	1.88	−−	−−
395	1.58	−−	−−
400	1.43	0.10	1.0
405	1.30	0.20	2.0
410	1.25	0.40	4.0
415	1.20	0.80	8.0
420	1.15	0.90	9.0
425	1.11	0.95	9.5
430	1.07	0.98	9.8
435	1.03	1.0	10.0
440	1.0	1.0	10.0

FIGURE 5.7.3.2.1−8 BLUE−LIGHT, RETINAL THERMAL, AND APHAKIC HAZARD FUNCTIONS FOR USE IN ASSESSING EXPOSURE LIMITS FOR BROADBAND OPTICAL SOURCES (PAGE 1 OF 2)

Wavelength, (nm)	Aphakic Hazard	Blue−Light Hazard	Retinal Thermal Hazard
	Function, A_λ	Function, B_λ	Function, R_λ
445	0.97	0.97	9.7
450	0.94	0.94	9.4
455	0.90	0.90	9.0
460	0.80	0.80	8.0
465	0.70	0.70	7.0
470	0.62	0.62	6.2
475	0.55	0.55	5.5
480	0.45	0.45	4.5
485	0.40	0.40	4.0
490	0.22	0.22	2.2
495	0.16	0.16	1.6
500 to 600	$10^{-\frac{(450-\lambda)}{50}}$	$10^{-\frac{(450-\lambda)}{50}}$	1.0
500 to 700	0.001	0.001	1.0
700 to 1050	−−	−−	$10^{\frac{(1700-\lambda)}{500}}$
1050 to 1400	−−	−−	0.2

FIGURE 5.7.3.2.1−8 BLUE−LIGHT, RETINAL THERMAL, AND APHAKIC HAZARD FUNCTIONS FOR USE IN ASSESSING EXPOSURE LIMITS FOR BROADBAND OPTICAL SOURCES (PAGE 2 OF 2)

(3) Exposure Limits to Protect the Eye from Thermal Injury Caused by Overexposure to Infrared Radiation (770 to 3000 nm) −

To protect the eye from thermal injury caused by overexposure to infrared radiation, including delayed effects to the lens (cataractogenesis), the infrared radiation exposure should be limited to:

$10 mW/cm^2 \text{ for } exposures\ longer\ than\ 1000s$

and to

$$\sum_{400}^{3000} 0.2 * E_\lambda * \Delta\lambda \le 1.8 * t^{-3/4}\ W/cm^2 \quad \text{for } t < 1000s$$

Please note that this TLV applies to an environment with an ambient temperature of 37 degrees Celsius, and can be increased by 0.8 mW per centimeter squared for every degree Celsius below 37.

(4) Exposure Limits for Ultraviolet Exposure of the Unprotected Eye or Skin (200−400 nm) −

To protect the eye and skin from injury caused by overexposure to ultraviolet radiation, the spectral irradiance weighted against the spectral effectiveness function S_λ (given in Figure 5.7.3.2.1−9) should be limited to:

$$\sum_{200}^{400} E_\lambda * S_\lambda * t * \Delta\lambda \leq 3\, mJ/cm^2 \ \ in\ any\ 24\ hr\ period$$

A table of weighted spectral irradiances versus recommended exposure times is given in Figure 5.7.3.2.1−10.

Wavelength	TLV (J/m^2)	TLV (mJ/cm^2)	Relative Spectral Effectiveness, S_λ
180	2500	250	0.012
190	1600	160	0.019
200	1000	100	0.030
205	590	59	0.051
210	400	40	0.075
215	320	32	0.095
220	250	25	0.120
225	200	20	0.150
230	160	16	0.190
235	130	13	0.240
240	100	10	0.300
245	83	8.3	0.360
250	70	7.0	0.430
255	58	5.8	0.520
260	46	4.6	0.650
265	37	3.7	0.810
270	30	3.0	1.000
275	31	3.1	0.960
280	34	3.4	0.880
285	39	3.9	0.770
290	47	4.7	0.640
295	56	5.6	0.540
300	100	10	0.300
305	500	50	0.06
310	2000	200	0.015
315	$1.0*10^4$	1000	0.003

FIGURE 5.7.3.2.1−9 ULTRAVIOLET RADIATION EXPOSURE TLV AND SPECTRAL WEIGHTING FUNCTION (PAGE 1 OF 2)

Wavelength	TLV (J/m^2)	TLV (mJ/cm^2)	Relative Spectral Effectiveness, S_λ
320	$2.9*10^4$	2900	0.0024
325	$6.0*10^4$	6000	0.00050

Wavelength	TLV (J/m^2)	TLV (mJ/cm^2)	Relative Spectral Effectiveness, S_λ
330	$7.3*10^4$	7300	0.00041
335	$8.8*10^4$	8800	0.00034
340	$1.1*10^5$	$1.1*10^4$	0.00028
345	$1.3*10^5$	$1.3*10^4$	0.00024
350	$1.5*10^5$	$1.5*10^4$	0.00020
355	$1.9*10^5$	$1.9*10^4$	0.00016
360	$2.3*10^5$	$2.3*10^4$	0.00013
365	$2.7*10^5$	$2.7*10^4$	0.00011
370	$3.2*10^5$	$3.2*10^4$	0.000093
375	$3.9*10^5$	$3.9*10^4$	0.000077
380	$4.7*10^5$	$4.7*10^4$	0.000064
385	$5.7*10^5$	$5.7*10^4$	0.000053
390	$6.8*10^5$	$6.8*10^4$	0.000044
395	$8.3*10^5$	$8.3*10^4$	0.000036
400	$1.0*10^6$	$1.0*10^5$	0.000030

FIGURE 5.7.3.2.1−9 ULTRAVIOLET RADIATION EXPOSURE TLV AND SPECTRAL WEIGHTING FUNCTION (PAGE 2 OF 2)

Duration of Exposure per Day	Effective Irradiance, $\mu W/cm^2$
8 hrs.	0.1
4 hrs.	0.2
2 hrs.	0.4
1 hr.	0.8
30 min.	1.7
15 min.	3.3
10 min.	5
5 min.	10
1 min.	50
30 sec.	100
10 sec.	300
1 sec.	3000
0.5 sec.	6000
0.1 sec.	30000

FIGURE 5.7.3.2.1−10 PERMISSABLE ULTRAVIOLET EXPOSURES

5.8 THERMAL ENVIRONMENT

5.8.1 INTRODUCTION

This paragraph is not applicable for this document.

5.8.2 THERMAL ENVIRONMENT DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

5.8.3 THERMAL ENVIRONMENT DESIGN REQUIREMENTS

5.8.3.1 TEMPERATURE, HUMIDITY, AND VENTILATION DESIGN REQUIREMENTS

5.8.3.2 THERMAL MONITORING AND CONTROL DESIGN REQUIREMENTS

The following requirements shall apply to the monitoring and control of the space cabin thermal environment:

A. Routine monitoring of Thermal Environment −

    (1) Monitoring of cabin temperature and relative humidity shall be provided.

    (2) Routine monitoring of the thermal environment shall be automated.

    The number, type, and location of temperature sensors and the frequency of monitoring shall be such as to ensure measurement of representative cabin temperature and to allow stable control of those temperatures.

    (3) Visual and audible alarms shall be automatically initiated when thermal parameters exceed the limits.

B. Adjustment of Thermal Environment by the Crew − Crewmembers shall be provided with controls that allow them to modify temperatures, humidity, and ventilation rates inside the Space Station.

C. Sleep Compartment, Personal Hygiene Area, and Waste Management Compartment Thermal Environment Controls − Temperature and ventilation shall be maintained in each of the private crew accommodations and the waste management compartment and be controllable within the range of these parameters.

D. Exercise Station Perspiration Control − Each exercise station shall be provided with a method of sweat removal and collection.

5.9 DELETED

6.0 CREW SAFETY

6.1 INTRODUCTION

This safety chapter is not intended to be a comprehensive guide to Space Station safety. It deals only with general safety requirements that are a specialized subset of the total safety discipline. This specialized subset addresses only the following topics: (1) mechanical hazards, (2) electrical hazards, (3) touch temperature, and (4) fire protection and control.

Additional sections of this document listed below are considered by the Space Station Program Office to contain information which is directly related and/or applicable to the overall safety of the ISS crewmembers.

5.1.3.2 Atmosphere Monitoring Design Requirements

5.1.3.2.1 Atmosphere Toxicological Monitoring Design Requirements

5.7.2.2 Ionizing Radiation Design Requirements

5.7.3.2 Nonionizing Radiation Design Requirements

5.8.3.2 Thermal Monitoring And Control Design Requirements

7.2.2.3.2 Potable Water Quality Design Requirements

7.2.5.3.6 Personal Hygiene Water Design Requirements

7.2.7.3 Routine Health Monitoring Design Requirements

8.7.3.4 Emergency And Escape Route Design Requirements

9.4.4.3 Caution And Warning System Design Requirements

9.5.3.1.13 Caution And Warning Labels Design Requirements

11.7.2.3.2.3 Foot Restraint Loads Design Requirements

11.7.2.3.3.2 Body Restraint Loads Design Requirements

11.8.2.2.4 Handhold And Handrail Design Loads Design Requirements

11.10.3.1 Fluid Connectors Design Requirements

11.10.3.2 Electrical Connectors Design Requirements

14.4.3.4 EVA Crew Restraint Design Requirements

Paragraph 3.3.6, of the System Specification for the Space Station, provides overall safety requirements. In case of conflict between that section of the System Specification and this chapter of the FCI requirements, the System Specification takes precedence.

6.2 GENERAL SAFETY

6.2.1 INTRODUCTION

This paragraph is not applicable for this document.

6.2.2 GENERAL SAFETY DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

6.2.3 DELETED

6.3 MECHANICAL HAZARDS

6.3.1 INTRODUCTION

This paragraph is not applicable for this document.

6.3.2 MECHANICAL HAZARD DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

6.3.3 MECHANICAL HAZARD DESIGN REQUIREMENTS

6.3.3.1 EXPOSED EDGE REQUIREMENTS FOR FACILITIES AND MOUNTED HARDWARE

A. Exposed edges 6.4 mm (0.25 in) thick or greater shall be rounded to a minimum radius of 3.0 mm (0.12 in.). See Figure 6.3.3.1−1.

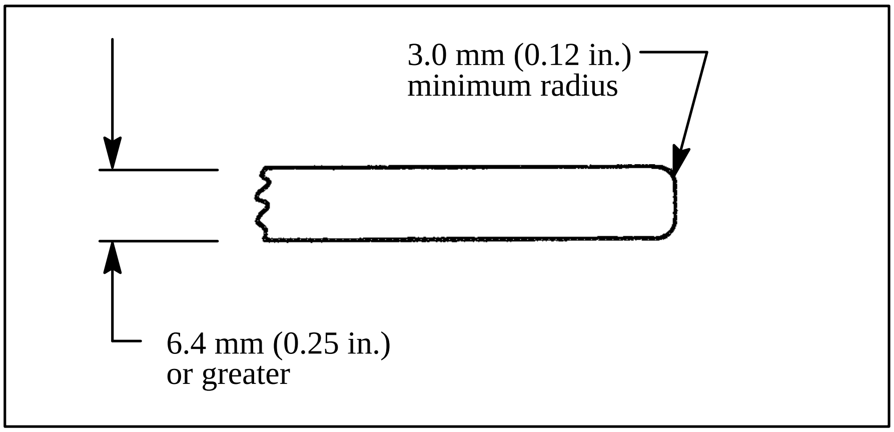


FIGURE 6.3.3.1−1 REQUIREMENTS FOR ROUNDING EXPOSED EDGES 6.4 MM (0.25 IN.) THICK OR THICKER

B. Exposed edges 3.0 to 6.4 mm (0.12 to 0.25 in) thick shall be rounded to a minimum radius of 1.5 mm (0.06 in.). See Figure 6.3.3.1−2.

C. Exposed edges 0.5 to 3.0 mm (0.02 to 0.12 in.) thick shall be rounded to a full radius. See Figure 6.3.3.1−3.

D. The edges of thin sheets less than 0.5 mm (0.02 in.) thick shall be rolled or curled. See Figure 6.3.3.1−4.

6.3.3.2 EXPOSED CORNER REQUIREMENTS FOR FACILITIES AND MOUNTED HARDWARE

A. Exposed corners of materials less than 25.0 mm (1.0 in.) thick shall be rounded to a minimum radius of 13.0 mm (0.5 in.). See Figure 6.3.3.2−5.

B. Exposed corners of materials that exceed 25.0 mm (1.0 in.) thick shall be rounded to 13.0 mm (0.5 in). See Figure 6.3.3.2−6.

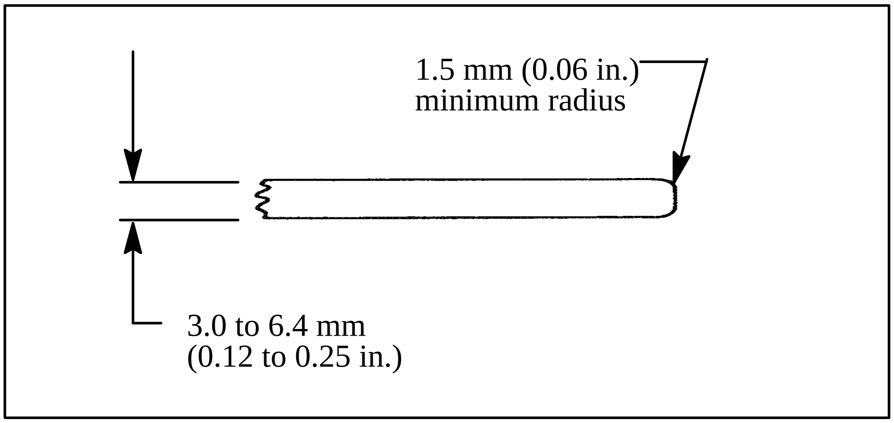


FIGURE 6.3.3.1−2 REQUIREMENTS FOR ROUNDING EXPOSED EDGES 3.0 TO 6.4 MM (0.12 TO 0.25 IN.) THICK OR THICKER

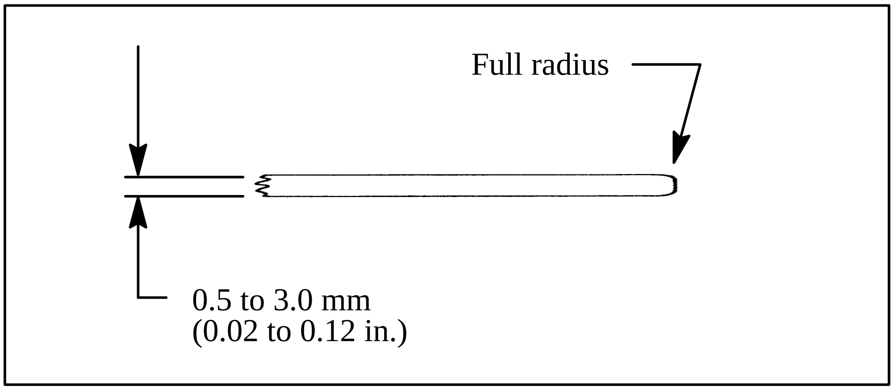


FIGURE 6.3.3.1−3 REQUIREMENTS FOR ROUNDING EXPOSED EDGES 0.5 TO 3.0 MM (0.02 TO 0.12 IN.) THICK OR THICKER

6.3.3.3 PROTECTIVE COVERS FOR PORTABLE EQUIPMENT

Portable equipment which does not meet the corner and edge requirements of 6.3.3.1 and 6.3.3.2 shall be covered or shielded when not in use.

6.3.3.4 HOLES

Holes that are are round or slotted in the range of 10.0 to 25.0 mm (0.4 to 1.0 in.) shall be be covered.

6.3.3.5 LATCHES

Latches that pivot, retract, or flex so that a gap of less than 35 mm (1.4 in.) exists shall be designed to prevent entrapment of a crewmember’s appendage.

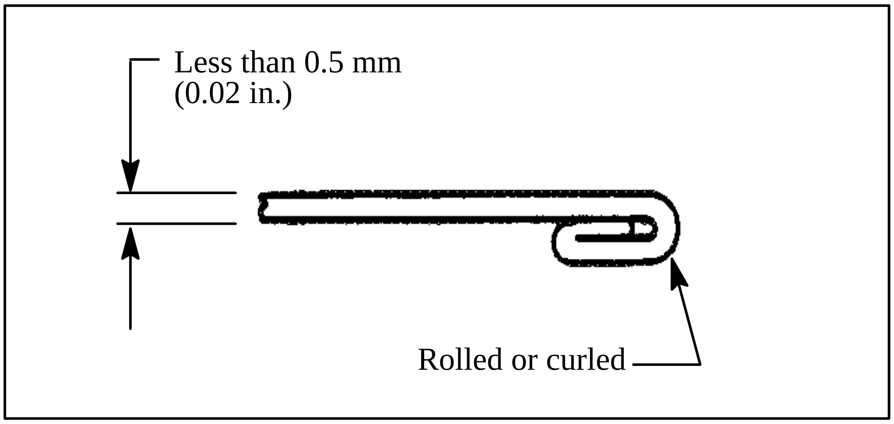


FIGURE 6.3.3.1−4 REQUIREMENTS FOR CURLING OF SHEETS LESS THAN 0.5 MM (0.02 IN.) THICK

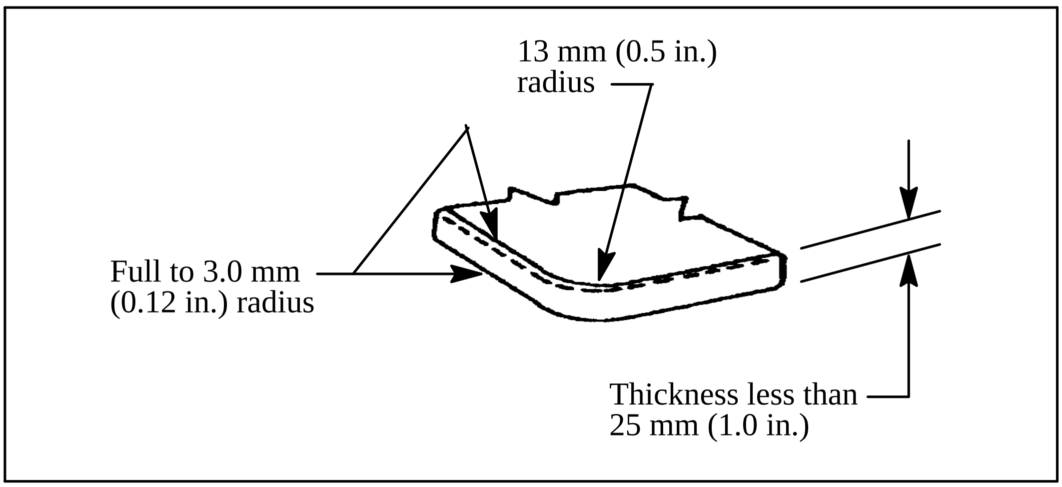


FIGURE 6.3.3.2−5 REQUIREMENTS FOR ROUNDING OF CORNERS LESS THAN 25 MM (1.0 IN.) THICK

6.3.3.6 SCREWS AND BOLTS

Threaded ends of screws and bolts accessible by the crew and extending more than 3.0 mm (0.12 in.) shall be capped to protect against sharp threads.

6.3.3.7 SECURING PINS

Securing pins in hand rails shall be designed to prevent their inadvertently backing out above the handhold surface.

6.3.3.8 LEVERS, CRANKS, HOOKS, AND CONTROLS

Levers, cranks, hooks, and controls shall not be located where they can pinch, snag, or cut the crewmembers or their clothing.

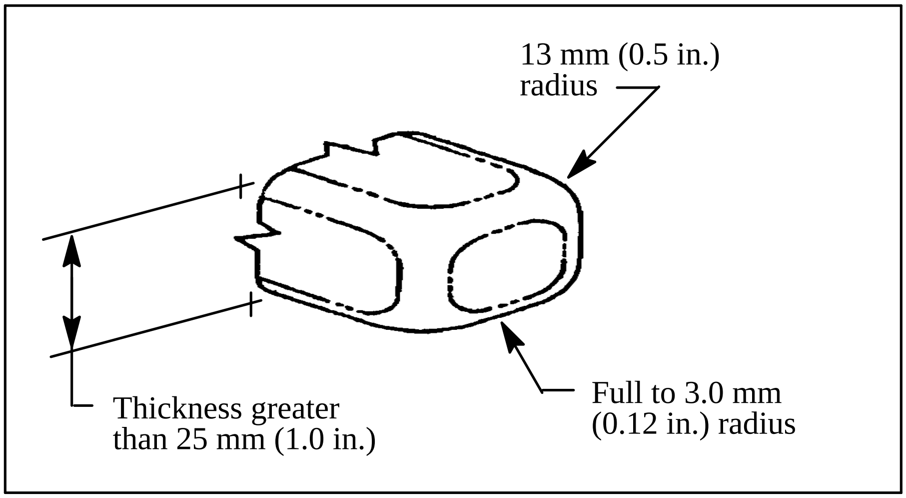


FIGURE 6.3.3.2−6 REQUIREMENTS FOR ROUNDING OF CORNERS GREATER THAN 25 MM (1.0 IN.) THICK

6.3.3.9 BURRS

Exposed surfaces shall be free of burrs.

6.3.3.10 LOCKING WIRES

Refer to 11.9.3.2, Item H. and 11.9.3.3, Item I.

6.3.3.11 LOOSE EQUIPMENT

Loose equipment edge and corner radiusing shall be per Figure 6.3.3.11−1.

Mass (Kg)	Edge Radius (mm)	Corder Radius (mm)
0.0 to 0.25	0.3	0.5
0.25 to 0.5	0.8	1.5
0.5 to 3.0	1.5	3.5
3.0 to 15.0	3.5	7.0
15.0 to 50.0	3.5	13.0
Mass (lb)	Edge Radius (in.)	Corder Radius (in.)
0.0 to 0.5	0.01	0.02
0.5 to 1.1	0.03	0.06
1.1 to 6.6	0.03	0.14
6.6 to 33.0	0.14	0.3
33.0 to 110.0	0.14	0.5

FIGURE 6.3.3.11−1 LOOSE EQUIPMENT EDGE AND CORNER RADIUSING REQUIREMENTS

6.4 ELECTRICAL HAZARDS

6.4.1 INTRODUCTION

This paragraph is not applicable for this document.

6.4.2 ELECTRICAL HAZARDS DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

6.4.3 ELECTRICAL HAZARDS DESIGN REQUIREMENTS

A. Equipment design shall protect the crewmembers from electrical hazards.

B. In designing to minimize electrical shock hazards, if the worst case credible failure for nonpatient equipment can result in a crewmember exposure that:

(1) is below the threshold for electrical shock, that is, no internal voltage exceeding 30 volts rms, no controls shall be required;

(2) exceeds the threshold for shock and is below the threshold of let−go (critical hazard) as defined in Figure 6.4.3−1, two independent controls (e.g., a safety (green) wire; bonding; insulation; leakage current levels below maximum requirements as described in Figure 6.4.3.18.1.1−1) shall be required such that no single failure, event, or environment can eliminate more than one control; or,

(3) equals or is greater than the threshold of let−go as defined in Figure 6.4.3−1 (catastrophic hazardous event), three independent controls shall be required such that no single failure, event, or environment can eliminate more than one control.

Frequency (Hz)	Threshold of Let−Go (milliamperes) (Based on 99.5 Percentile Rank of Adults) Maximum Total Peak Current (ac + dc components combined)
dc	40.0
15	8.5
2000	8.5
3000	13.5
4000	15.0
5000	16.5
6000	17.9
7000	19.4
8000	20.9
9000	22.5
10000	24.3
50000	24.3

FIGURE 6.4.3−1 LET−GO CURRENT PROFILE THRESHOLD VERSUS FREQUENCY

C. If two independent controls are provided, the physiological effect of the combination of the highest internal voltage applied to or generated within the equipment and the frequency and wave form associated with a worst case credible failure that can be applied to the crewmember shall be below the threshold of let−go.

D. Deleted.

E. If the hazard classification between critical and catastrophic is marginal or unclear, three independent hazard controls shall be required to protect the crewmember from exposure to electrical shock.

F. For nonpatient equipment, a crew electrical shock hazard protection system utilizing design to minimum risk criteria when approved by the Safety Review Panel may be used in lieu of the fault tolerance approach described within this paragraph.

6.4.3.1 GROUNDING

A. All electrical powered equipment external, nonisolated metal parts subject to user contact shall be at ground potential.

B. A permanent bonding means shall be provided to facilitate the connection of metal parts to ground prior to the connection of any electrical signals or power.

C. A permanent bonding means shall be provided to facilitate the removal of all electrical signals and power prior to the removal of metal parts from ground.

D. Grounding conductors internal to an Orbital Replaceable Unit (ORU) shall be secured internally to the ORUs metal enclosure by means of a fastening technique unlikely to be removed during any servicing operation.

E. Solder alone shall not be used for securing the grounding conductor.

F. Each grounding or bonding means shall be capable of conducting the maximum ground fault current amplitude and duration which might occur as the result of discharges (static, plasma, etc.), induced RF voltages, internal power−faulted equipment, and accidental short circuits.

G. All grounding shall conform to SSP 30240.

6.4.3.1.1 HINGED OR SLIDE MOUNTED PANELS AND DOORS GROUNDING

A. Hinges or slides shall not be used for grounding paths.

B. A ground shall be considered satisfactory if the electrical connection between the conductive door or panel, in both the open and closed position, and the equipment tie point exhibits a resistance of less than 0.1 ohms and has sufficient ampacity to insure the reliable and immediate tripping of associated equipment over−current protection devices.

6.4.3.2 ELECTRICAL BONDING

On−orbit electrical bonding shall meet the requirements of SSP 30245 to prevent damage to the vehicle or injury to crewmembers due to discharges (static, plasma, etc.), induced RF voltages, internal power−faulted equipment, and accidental short circuits. Each independent bonding path is considered a hazard control for electrical shock.

6.4.3.3 PROTECTIVE COVERS

A. Equipment shall provide grounded or nonconductive protective covering for all electrical hardware.

B. Electrical termination points shall be protected from inadvertent contact by crewmembers, inadvertent contact from foreign objects entering electrical junctions, and moisture accumulation.

6.4.3.4 INTERLOCKS

This paragraph is not applicable for this document.

6.4.3.5 WARNING LABELS

A. Warning labels shall be provided where inadvertent contact with electrical potentials are hazardous to crewmembers.

B. Warning labels shall comply with the requirements in 9.5.3.

6.4.3.6 WARNING LABELS PLUS RECESSED CONNECTORS

This paragraph is not applicable for this document.

6.4.3.7 PLUGS AND RECEPTACLES

Plugs and receptacles shall meet the requirements in 11.10.

In addition:

A. Plugs and receptacles (connectors) shall be selected and applied such that they cannot be mismated or cross−connected in the intended system as well as adjacent systems. Although required, the use of identification alone is not sufficient.

B. Connectors shall be selected and applied such that they have sufficient mechanical protection to mitigate inadvertent crewmember contact with exposed electrical contacts.

C. Connectors shall be specifically designed and approved for mating and demating in the existing environment under the loads being carried, or connectors shall not be mated or demated until voltages have been removed (dead−faced) from the powered side(s) of the connectors.

6.4.3.8 INSULATION

All materials shall meet the requirements of SSP 30233.

In addition:

A. All exposed electrical conductors and terminations shall be insulated.

B. The crew shall be protected from electrical hazards when utilizing tools within 24 inches of exposed electrical potentials.

6.4.3.9 PORTABLE EQUIPMENT/POWER CORDS

A. Nonbattery powered portable equipment and portable equipment power cords with internal voltages exceeding 30 volts rms shall incorporate a three−wire power cord; i.e., a power supply lead (+), a power supply return lead (−), and a safety (green) wire with one end connected to the portable equipment chassis (and all exposed conductive surfaces of the portable equipment) and the other end connected to the electrical power source structure.

B. Deleted.

C. Portable equipment power cords with internal voltages exceeding 30 volts rms shall provide a second independent ground between the portable equipment exposed electrically conductive surfaces and the portable equipment power source structure (i.e., cable shield or wire connected to conductive backshells of power cord where the cable shield or wire has sufficient ampacity to clear a worst case credible fault), or provide a double insulation enclosure isolating all electrically conductive surfaces likely to come in contact with crewmembers.

6.4.3.10 MOISTURE PROTECTION

Equipment shall be designed so that moisture collection will not present a safety hazard to the crew.

6.4.3.11 STATIC DISCHARGE PROTECTION

Equipment shall be designed so that the crewmembers are protected from static charge buildup.

6.4.3.12 OVERLOAD PROTECTION

A. The functioning of an overload protective device shall not result in a fire, electric shock, or crewmember injury.

B. An overload protective device shall not be accessible without opening a door or cover, except that the operating handle or operating button of a circuit breaker, the cap of an extractor−type fuseholder, and similar parts may project outside the enclosure.

C. The arrangement of extractor−type fuseholders shall be such that the fuse shall not be positively held or gripped by any part of the fuseholder while energized parts are exposed at any time during replacement.

   The load shall be connected to the fuseholder terminal that terminates the removable cap assembly.

D. Overload protection (fuses and circuit breakers) intended to be manually replaced or physically reset on−orbit shall be located where they can be seen and replaced or reset without removing other components.

E. Each overload protector (fuses and circuit breakers) intended to be manually replaced or physically reset on−orbit shall be readily identified or keyed for its proper value.

F. Overload protection shall be designed and rated for on−orbit use including the maximum environmental range expected as the result of contingencies.

6.4.3.13 BATTERIES

A. Unless intentionally designed for the purpose, batteries shall not be connected to or disconnected from a current drawing load. Batteries and their utilization will conform to the requirements of JSC 20793 and JPL 86−14.

B. Batteries/battery packs with potentials above 30 volts dc shall provide hazard controls as specified in 6.4.3.

6.4.3.13.1 NONORU BATTERIES

A. Batteries not configured as ORUs shall be located so that they can be easily disconnected and removed without special equipment.

B. Mounting provisions shall ensure retention for all service conditions.

C. Polarity of the battery terminals shall be prominently marked or battery terminal connections be polarized to mitigate erroneous installation.

6.4.3.14 MECHANICAL ASSEMBLY

A. A switch, fuseholder, lampholder, attachment plug receptacle, or other energized component that is handled by a crewmember shall not rely on friction alone to prevent turning in its mounting panel.

B. The mounting of components to a printed wiring board and the mounting of the printed wiring board itself shall be such that any forces that might be exerted on the components or board will not displace the components or deflect the board so as to produce an electric shock or fire.

6.4.3.15 SWITCHES/CONTROLS

A. Switches/controls shall be designed such as to prevent hazardous unexpected manual or automatic operation.

B. Switches/controls which provide automatic starting after an overload initiated shutdown shall not be employed.

6.4.3.15.1 POWER SWITCHES/CONTROLS

A. Switches/controls performing ON/OFF power functions shall open or dead−face all supply circuit conductors except the power return and the equipment grounding conductor while in the power OFF position.

B. Power OFF markings and/or indications shall only be used if all parts, with the exception of overcurrent devices and associated electromagnectic interference filters, are disconnected from the supply circuit.

C. STANDBY, CHARGING, or other appropriate nomenclature shall be used to indicate that the supply circuit is not completely disconnected for this power condition.

6.4.3.16 DELETED

6.4.3.17 GROUND FAULT CIRCUIT INTERRUPTERS − PORTABLE EQUIPMENT SOURCING VOLTAGE

A Ground Fault Circuit Interrupter (GFCI) is not required. All portable equipment with internal voltages greater than 30 volts rms is required to demonstrate two fault tolerance in its operating configuration without using GFCI.

6.4.3.18 LEAKAGE CURRENT DESIGN REQUIREMENTS

A. Deleted.

B. For nonpatient portable equipment with internal voltages exceeding 30 volts rms, if the safety analysis shows the design can defeat verification of the 1 meg−ohm isolation (reference SSP 30240, paragraph 3.2.1.2), the equipment developer shall perform the following measurements as indicated, using a test setup as specified in Figure 6.4.3.18−1.

(1) Measurement #1, using an rms voltmeter, measure the voltage across R−1, where R−1 is a 100,000 ohm +/− 2 percent, noninductive resistor. If the voltage measured across R−1 is less than or equal to 30 volts rms then no shock hazard is present and no additional measurements are required. If the voltage measured across R−1 is greater than 30 volts rms, then a possible shock hazard exists, perform Measurement #2.

(2) Measurement #2, using an oscilloscope, measure the voltage across R−1, where R−1 is a 1000 ohm +/− 2 percent, noninductive resistor. If the calculated current through R−1, determined from the voltage measured across R−1 is less than or equal to 8.5 ma peak, then no catastrophic shock hazard is present and no additional measurements are required. If the calculated current through R−1, determined from the voltage measured across R−1, is greater than 8.5 ma peak, then a possible catastrophic shock hazard exists, perform Measurement #3.

(3) Measurement #3, using an oscilloscope, measure the voltage across R−1, where R−1 is a 1,000 ohm +/− 2 percent, noninductive resistor. If the calculated current through R−1, determined from the voltage measured across R−1 is more than 8.5 ma peak and less than or equal to 24.3 ma peak, then a possible catastrophic shock hazard exists, perform Measurement #4. If the calculated current through R−1, determined from the voltage measured across R−1, is greater than 24.3 ma peak, then a catastrophic shock hazard is present and the equipment fails the shock hazard testing.

(4) Measurement #4, using a Spectrum Analyzer or Fast Fourier Transform Oscilloscope, measure the rms voltage across R−1, where R−1 is a 1,000 ohm +/− 2 percent, noninductive resistor. Compare the calculated peak current through R−1 at each frequency to the peak current at each frequency in Figure 6.4.3−1. If the calculated peak current is equal to or greater than the peak current value at the indicated frequency in Figure 6.4.3−1, then a catastrophic shock hazard is present and the equipment fails the shock hazard testing.

C. Deleted.

D. For isolated patient connection lead leakage current, the equipment developer shall perform the following measurement using the test setup as specified in Figure 6.4.3.18−1.

Using an RMS voltmeter, measure the voltage across R−1, where R−1 is a 1000 ohm +/− 2 percent, noninductive resistor. If the equivalent leakage current, calculated from the voltage measurement, through R−1 is greater than the patient connection leakage current specified in Figure 6.4.3.18.1.2−1, the equipment fails the shock hazard testing.

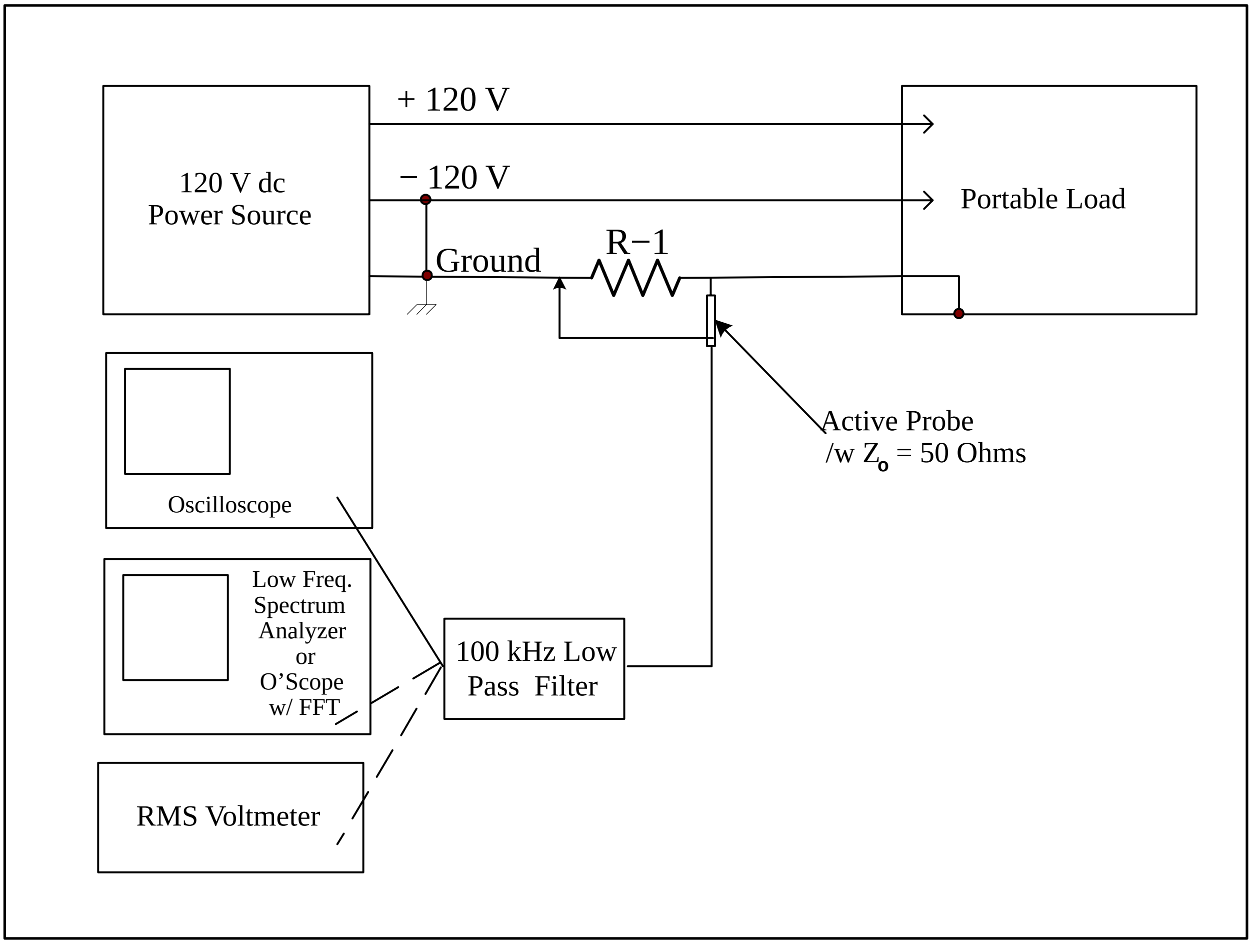


FIGURE 6.4.3.18−1 LEAKAGE CURRENT VERIFICATION NETWORK

6.4.3.18.1 CHASSIS LEAKAGE CURRENT

A. Deleted.

B. Deleted.

C. Leakage current test procedures for dc powered equipment shall not include reversed polarity input power tests.

6.4.3.18.1.1 CHASSIS LEAKAGE CURRENT − NONPATIENT EQUIPMENT

A. The chassis leakage currents for nonpatient equipment shall not exceed the values shown in Figure 6.4.3.18.1.1−1.

B. Deleted.

Enclosure or Chassis Leakage Current			
Grounded		Double Insulated	
dc	ac ma	dc	ac ma
ma	rms	ma	rms
0.700	0.500	0.350	0.250

FIGURE 6.4.3.18.1.1−1 NONPATIENT EQUIPMENT MAXIMUM CHASSIS LEAKAGE CURRENT

DCN 010

6.4.3.18.1.2 CHASSIS LEAKAGE CURRENT − PATIENT CARE EQUIPMENT

A. The chassis leakage currents for patient care equipment shall not exceed the values shown in Figure 6.4.3.18.1.2−1.

B. Deleted.

Patient Connection Leakage Current				
	Isolated (1)		Ordinary	
Patient	dc	ac ma	dc	ac ma
Interface	ma	rms	ma	rms
Invasive	0.014	0.010	Not Permitted	
Noninvasive	0.070 (1)	0.050 (1)	0.070	0.050
Enclosure or Chassis Leakage Current				
	Grounded		Double Insulated	
Patient	dc	ac ma	dc	ac ma
Interface	ma	rms	ma	rms
Noninvasive	0.140	0.100	0.070	0.050
Note: (1) If equipment labeling indicates "isolated," the maximum current is 0.014 ma dc/0.010 ma rms.				

FIGURE 6.4.3.18.1.2−1 PATIENT CARE EQUIPMENT MAXIMUM LEAKAGE CURRENT

6.4.3.18.2 CREWMEMBER APPLIED CURRENT

A. Crewmembers shall not be exposed to excessive levels of leakage current from direct or indirect contact with electrically powered equipment.

B. Deleted.

C. Leakage current test procedures for dc powered equipment shall not include reversed polarity input power tests.

D. The leakage currents for patient care equipment as seen from the patient end of cables or terminals shall not exceed the values shown in Figure 6.4.3.18.1.2−1.

E. Leakage currents shall be tested:

(1) lead to ground

a. between each patient lead and ground, and

b. between combined patient leads and ground; and

(2) between leads

a. between any pair of patient leads, and

b. between any single patient lead and all other patient leads.

6.4.3.18.2.1 LEAKAGE CURRENT − PATIENT CARE EQUIPMENT − PATIENT CONNECTION − ISOLATED

A. Isolated, patient connected, patient care equipment leakage current shall not exceed 0.014 ma dc for isolated, patient connected, patient care equipment, such as intra−aortic pressure monitors (i.e., invasive interface).

B. Isolated, patient connected, patient care equipment leakage current shall not exceed 0.070 ma dc for isolated, patient connected, patient care, equipment, such as muscle stimulators utilizing attached body surface electrodes (i.e., noninvasive interface) provided that equipment labeling does not indicate the equipment is isolated.

6.4.3.18.2.2 LEAKAGE CURRENT − PATIENT CARE EQUIPMENT − PATIENT CONNECTION − ORDINARY

Ordinary, patient connected, patient care equipment leakage current shall not exceed 0.070 ma dc for ordinary, patient connected, patient care equipment, such as blood pressure cuffs, thermometers, and limb muscle stimulators.

6.4.3.18.2.3 HEALTH MAINTENANCE SYSTEM INSTRUMENTATION GROUNDING

A. Any two exposed conductive surfaces in the instrumented crewmember's vicinity shall not exceed a 40.0 millivolt potential difference at frequencies of 1000 Hertz or less measured across a 1000 ohm noninductive resistor.

B. Conductive surfaces which can be contacted by an attending crewmember while the attending crewmember is in contact with the instrumented crewmember shall be considered as within the crewmember's vicinity.

6.4.3.18.2.4 COUNTERMEASURE SYSTEM

A. Any two exposed conductive surfaces in the instrumented crewmember's vicinity shall not exceed a 40.0 millivolt potential difference at frequencies of 1000 Hertz or less measured across a 1000 ohm noninductor resistor.

B. Conductive surfaces which can be contacted by an attending crewmember while the attending crewmember is in contact with the instrumented crewmember shall be considered as within the crewmember's vicinity.

6.4.3.18.2.5 AMBULATORY CREWMEMBER INSTRUMENTATION

While attached to an ambulatory crewmember, electrically powered medical instrumentation shall be:

A. Battery powered,

B. Double insulated,

C. Electrically isolated from ground, and

D. Not connected to vehicle power (e.g., charging).

6.4.3.19 BIOINSTRUMENTATION SYSTEM MICROSHOCK PROTECTION

A. All bioinstrumentation systems shall be designed with sufficient series resistance/isolation to limit to safe levels electrical shock currents that could flow through an instrumented crewmember including as the result of:

   (1) contact with available electric sources, including those sources applied by an attending crewmember's simultaneous contact with the instrumented crewmember and other equipment or ground, and

   (2) transients that may occur when the bioinstrumentation is either energized (turned ON) or de−energized (turned OFF).

B. Bioinstrumentation shall be designed with fault tolerant protection to prevent exceeding the current limit requirements defined within Figure 6.4.3.19−1.

Classification	Number of Faults	Maximum Current (ma dc/rms)
Invasive (reference 6.4.3.18.2.1)	0	0.014/0.010
	1	0.014/0.010
	2	0.020/0.020
Noninvasive (reference 6.4.3.18.2.2)	0	0.070/0.050
	1	0.140/0.100
	2	0.500/0.500

FIGURE 6.4.3.19−1 MAXIMUM PERMISSABLE BIOINSTRUMENTATION FAULT CURRENT

6.4.3.20 POWER DRIVEN EQUIPMENT CONTROL REQUIREMENTS

If a risk of injury to a crewmember or damage to equipment can result from the motion of power driven equipment:

A. The controls for that mechanism shall be of a reversible type and not continue operation of the moving part in the same direction when a switch readily accessible to that crewmember is activated to initiate operation in the other direction, or

B. The power driven equipment shall be mechanically constructed such that the injurous forces are immediately removed by activation of a switch readily accessible to that crewmember.

6.5 TOUCH TEMPERATURE

6.5.1 INTRODUCTION

This paragraph is not applicable for this document.

6.5.2 TOUCH TEMPERATURE DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

6.5.3 TOUCH TEMPERATURE DESIGN REQUIREMENTS

The following apply to IVA surface touch temperature design requirements:

Requirements shall be based on the Maximum Permissable Material Temperature (TmPT) derived using the formula below:

$$TmPT = Y_1\left[(kpc)^{-1/2} + 31.5\right] + 41$$

where:

$$Y_1 = antilog[Y_2(a_1) + \log Y_3]$$

$$Y_2 = 1.094(t)^{-0.184}$$

$$Y_3 = 0.490(t)^{-0.412}$$

$TmPT$ is defined as the Maximum Permissable Material Temperature (in degrees Celsius)

$(kpc)^{-1/2}$ is defined as the Thermal Inertia of Contact Material, (k is defined as the Coefficient of heat transfer, p is defined as the density, and c is defined as the specific heat)

a_1 is defined as Epidermal thickness (mm), (~Nominal 0.25 mm)

t is defined as Time of Exposure (in seconds) (Time of exposure is limited to values ≥ 1 second for the incidental contact case and ≥ 10 seconds for the intentional contact case.)

The latest version of MIL−HDBK−5, or equivalent documents can be used to determine k, p, and c for material being used.

A. Deleted.

B. Continuous contact − high temperature.

Surfaces which are subject to continuous contact (time or exposure ≥ 10 seconds) with crewmember bare skin, shall be provided with guards or insulation to prevent contact, for temperatures at or above the TmPT calculated for t = 10 seconds and applicable values of k, p, and c.

C. Incidental or momentary contact − high temperature.

For incidental or momentary contact, the following apply:

(1) Warning labels shall be used when surface temperatures are between 113 degrees Fahrenheit and the temperature derived from the TmPT calculation with t = 1 second and applicable values of k, p, and c.

(2) Guards or insulation shall be used when surface temperatures exceed the temperature derived from the TmPT calculation with t = 1 second and applicable values of k, p, and c.

D. Internal volume low touch temperature.

When surfaces below 39.0 degrees Fahrenheit which are subject to continuous or incidental contact, are exposed to crewmember bare skin contact, protective equipment shall be provided to the crew and warning labels be provided at the surface site.

6.6 FIRE PROTECTION AND CONTROL

6.6.1 INTRODUCTION

This paragraph is not applicable for this document.

6.6.2 FIRE PROTECTION AND CONTROL DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

6.6.3 FIRE PROTECTION AND CONTROL DESIGN REQUIREMENTS

6.6.3.1 GENERAL REQUIREMENTS

6.6.3.1.1 FIRE PROTECTION SYSTEM

A fire protection system comprising detection, warning, location, and extinguishing devices shall be provided during all mission phases.

6.6.3.1.2 MATERIAL SELECTION

Only fire−retardant materials shall be used.

6.6.3.2 DETECTION

6.6.3.2.1 WARNING SYSTEM

The fire detection system shall provide signals to the vehicle warning system.

6.6.3.2.2 RESET AND SELF−TEST

The detection system shall have reset and self−test capabilities.

6.6.3.2.3 SENSOR REPLACEMENT

All sensors shall be replaceable and accessible.

6.6.3.3 WARNING SYSTEM

A. The caution and warning system shall include a fire warning system to alert the crew in case of a fire.

B. The fire warning system shall be capable of operating independently.

C. Warnings shall be both visual and auditory.

D. The visual fire warning display shall be aviation red in accordance with MIL−C−25050.

6.6.3.4 EXTINGUISHING

A. Deleted.

B. Design of the Space Station and its components shall provide for access with fire fighting equipment.

C. Chemical agents used for fire extinguishing shall be compatible with the toxicity requirements of space station.

D. Portable fire extinguishers shall be provided for both open areas and enclosed areas.

E. Capability for removal of expended fire extinguishing material during post−fire cleanup shall be provided.

F. Automatic extinguishing systems shall incorporate a disabling feature to prevent inadvertent activation during servicing.

7.0 HEALTH MANAGEMENT

7.1 INTRODUCTION

The Space Station will provide the on−orbit medical capabilities necessary to maintain crew health, safety, and productivity. Capabilities will be provided to monitor, treat, and maintain the health of the crew through preventive, diagnostic, and therapeutic care, and to stabilize for transport a crewmember with an illness or injury not treatable on the Space Station. Capabilities will be provided to mitigate the deconditioning effects of a microgravity environment, to perform periodic fitness evaluations, and to perform physiological monitoring. In addition, capabilities will be provided to monitor internal and external radiation levels, air and water quality and microbial surface contamination.

7.2 PREVENTIVE CARE

A. Health care capability shall be provided on board the Space Station.

B. This shall include scheduled routine medical examinations, physiological monitoring, and periodic fitness evaluations.

7.2.1 INTRODUCTION

This paragraph is not applicable for this document.

7.2.2 NUTRITION

7.2.2.1 INTRODUCTION

This paragraph is not applicable for this document.

7.2.2.2 NUTRITION DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

7.2.2.3 NUTRITION DESIGN REQUIREMENTS

7.2.2.3.1 FOOD DESIGN REQUIREMENTS

The food provided will meet the following requirements:

A. Minimum Nutritional Requirements −

(1) The Space Station diet shall meet the nutritional standards as required by JSC 32283.

(2) Additional nutritional requirements are required for Extravehicular Activity (EVA) as per body size, EVA tasks, and duration of EVA.

Foods and fluids shall be specifically allocated for this requirement per 14.2.3.3.

(3) Deleted.

B. Nutritional Program Monitoring −

(1) An automated nutrient monitoring process shall be provided which meets the nutrient monitoring requirements as specified in JSC 32283.

(2) Parameters required for medical or investigative purposes shall include documenting:

a. which crewmember consumed the food,

b. amount of food consumed,

c. time and date of consumption, and

d. food item/lot number/serial number.

(3) Data shall be downlinked periodically for analysis and must provide information in format acceptable for post flight analysis.

C. Deleted.

D. Microbiology − Microbiological acceptability limits shall be as given in Figure 7.2.2.3.1−1.

Area/Item	Microorganism Tolerances	
1. Food Production Area	Samples Collected (1)	Limits (CFU) (2)
a. Surfaces	3 surfaces sampled per day	</= $3/cm^2$
b. Packaging Film	Before use	</= $3/cm^2$
c. Food Processing Equipment	2 pieces sampled per day	</= $3/cm^2$
d. Air	1 sample of 0.282 M^3 (10 ft^3)	< 13/320 liters
2. Food Production Area	Factor	Limits (CFU) (2)
a. Nonthermostabilized	Total aerobic count	</= 10,000/gm
	Escherichia coli	< 1/gm
	Coagulase positive Staphylococci	< 1/5gm
	Salmonella	< 1/25gm
	Clostridium Perfringens	</= 100/gm
	Yeast and molds	</= 100/gm

Notes:
(1) Sample collected only on days that food facility is in operation.
(2) Total aerobic count.

FIGURE 7.2.2.3.1−1 MICROBIOLOGY CONTAMINATION CONTROL SPECIFICATION FOR CREW FOOD

7.2.2.3.2 POTABLE WATER DESIGN REQUIREMENTS

A. Quality − The potable water quality requirements shall be per Figure 7.2.2.3.2−1.

QUALITY PARAMETERS	POTABLE
PHYSICAL PARAMETERS	
Total Solids (mg/1)	100
Color, true (Pt/Co units)	15
Taste (TNN)	3
Odor (TON)	3
Particulates (max size−microns)	40
pH	6.0−8.5
Turbidity (NTU)	1
Dissolved Gas (free @ 37 deg C)	(1)
Free Gases (@ STP)	(1)
INORGANIC CONSTITUENTS (mg/l) (7)(10)	
Ammonia	0.5
Arsenic	0.01
Barium	1.0
Cadmium	0.005
Calcium	30
Chlorine (Total−Includes chloride)	200
Chromium	0.05
Copper	1.0
Iodine (Total−Includes organic iodine and iodide)	15
Iron	0.3
Lead	0.05
Magnesium	50
Manganese	0.05
Mercury	0.002
Nickel	0.05
Nitrate (NO_3−N)	10
Potassium	340
Selenium	0.01
Silver	0.05
Sulfate	250
Sulfide	0.05
Zinc	5.0
BACTERICIDE (mg/l)	
Residual Iodine (minimum)	1.0
Residual Iodine (maximum)	4.0
AESTHETICS (mg/1)	
Cations	30
Anions	30
Carbon Dioxide	15

FIGURE 7.2.2.3.2−1 POTABLE WATER QUALITY REQUIREMENTS (MAXIMUM CONTAMINATION LEVELS) (PAGE 1 OF 2)

QUALITY PARAMETERS	POTABLE
MICROBIAL	
Total Count, CFU/100 ml Bacteria (2)/Fungi (3)	100 (6)
Total Coliform(6)	Nondetectable (8)
Virus	Nondetectable (5)
RADIOACTIVE CONSTITUENTS (pCi/1)	(8)
ORGANIC PARAMETERS (ug/1) (7)	
Total Acids	500
Cyanide	200
Halogenated Hydrocarbons	10
Total Phenois	1
Total Alcohols	500
Total Organic Carbon (TOC)	500
Uncharacteristic TOC (UTOC) (9)	100
ORGANIC CONSTITUENTS (mg/l) (7)(10)	

Notes:

(1) No detectable gas using volumetric gas versus fluid measurement system. Excludes carbon dioxide used for aesthetic purposes.
(2) Incubation time: 48 hours; Temperature: 30 degrees C; Media: R2A
(3) Incubation time: 48 hours; Temperature: 30 degrees C; Media: DG−18
(4) Incubation time: 24 hours; Temperature: 35 degrees C; Media: M−Endo
(5) Tissue culture assay
(6) Membrane Filtration Method
(7) Each parameter/constituent must be considered individually and independently of others.
(8) The maximum contaminant levels for radioactive constituents in potable and personal hygiene water shall conform to Nuclear Regulatory Commission regulations (10CFR20 et al.). These maximum contaminant levels are listed in the Federal Register, Vol 51, No. 6, 1986, appendix B, as Table 2 (Reference Level Concentrations), Column 2 (Water). Control/containment/monitoring of radioactive constituents used on Space Station shall be the responsibility of the user. Prior to the introduction of any radioactive constituents on Space Station approval shall be obtained from the Radiation Constraints Panel (RCP). The RCP will approve or disapproval proposed monitoring and decontamination procedures on a case−by−case basis.
(9) UTOC equals TOC minus the sum of analyzed organic constituents expressed in equivalent TOC.
(10) In the event a quality parameter not listed in this table is projected, or found, to be present in the reclaimed water, the Water Quality Manager/JSC shall be contacted for a determination of the MCL for that parameter.

FIGURE 7.2.2.3.2−1 POTABLE WATER QUALITY REQUIREMENTS (MAXIMUM CONTAMINATION LEVELS) (PAGE 2 OF 2)

B. Quantity − The supply of water for drinking and hydration of food shall be per Figure 7.2.2.3.2−2.

	Mode		
Units	Operational	90 Day Degraded (1)	Emergency (3)
lb/person−day (2)	6.26 to 11.35	6.26	6.26
kg/person−day	2.84 to 5.16	2.84	2.84

Notes:
(1) Degraded levels meet "fail operational criteria."
(2) Based on 2950 kcal/person−day IVA work rate. Actual amount depends on degree of hydration of the food.
(3) Safe Haven conditions shall be maintainable for up to 45 days.

FIGURE 7.2.2.3.2−2 POTABLE WATER QUANTITY REQUIREMENTS

C. Temperature − Drinking water temperatures shall be as follows:

(1) Cold Water − Cold water temperature shall be 1.6 degrees to 7.2 degrees C (35.0 degrees to 45.0 degrees F).

(2) Ambient Water − Ambient water temperature shall be 15.5 degrees to 26.7 degrees C (60.0 degrees to 80.0 degrees F).

(3) Hot Water − Means shall be provided for heating water up to 68.0 degrees +/− 2.8 degrees C (155 degrees +/− 5.0 degrees F).

7.2.3 MICROGRAVITY COUNTERMEASURES

7.2.3.1 INTRODUCTION

This paragraph is not applicable for this document.

7.2.3.2 MICROGRAVITY COUNTERMEASURES DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

7.2.3.3 EXERCISE COUNTERMEASURES

7.2.3.3.1 INTRODUCTION

This paragraph is not applicable for this document.

7.2.3.3.2 EXERCISE COUNTERMEASURES DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

7.2.3.3.3 EXERCISE COUNTERMEASURES DESIGN REQUIREMENTS

Exercise countermeasure requirements shall apply to space missions that expose crewmembers to microgravity conditions for longer than 10 days.

The following are the exercise countermeasure design requirements:

A. Types of Exercise − Space station shall provide facilities for the following types of exercise:

   (1) Equipment for placing isokinetic, isotonic, and isometric force upon the major muscle groups of the body shall be provided in order to mitigate “disuse atrophy” caused by microgravity.

   (2) Devices for exercising the cardiorespiratory system as a countermeasure to cardiovascular deconditioning shall be provided.

B. Duration of Exercise − Facilities shall be provided for establishing and updating individualized exercise prescriptions and goals for each crewmember.

C. Exercise Prescription − Capability shall be provided for establishing and updating individualized exercise regimens and goals for each crewmember.

D. Deleted.

E. Data Monitoring of Microgravity Countermeasures −

   (1) The capability shall be provided to monitor control devices and physiological parameters during microgravity countermeasures, store the data, and downlink this information to Earth.

   (2) The following physiological parameters shall be monitored:

      a. Routine Monitoring

         1) Heart Rate

         2) Duration of Exercise Period

         3) Power Output from Instrumented Exercise Device

      b. Periodic Monitoring

         1) Electrocardiogram

         2) Blood Pressure

         3) Maximal and Submaximal Expired Gases

         4) Muscle Performance

         5) Body Mass Measurement

7.2.3.4 NONEXERCISE COUNTERMEASURES

7.2.3.4.1 INTRODUCTION

This paragraph is not applicable for this document.

7.2.3.4.2 NONEXERCISE COUNTERMEASURES DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

7.2.3.4.3 NONEXERCISE COUNTERMEASURES DESIGN REQUIREMENTS

7.2.4 SLEEP

7.2.4.1 INTRODUCTION

This paragraph is not applicable for this document.

7.2.4.2 SLEEP DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

7.2.4.3 SLEEP DESIGN REQUIREMENTS

The following are design requirements for crew sleep:

A. Facilities − Sleep facilities shall be provided (see 10.4 for sleep facility design requirements).

B. Deleted.

C. Pharmaceuticals − Sleep aid medication shall be made available to crewmembers.

7.2.5 PERSONAL HYGIENE

7.2.5.1 INTRODUCTION

This paragraph is not applicable for this document.

7.2.5.2 PERSONAL HYGIENE DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

7.2.5.3 PERSONAL HYGIENE DESIGN REQUIREMENTS

7.2.5.3.1 BODY GROOMING DESIGN REQUIREMENTS

The following body grooming measures shall be provided in Space Station:

A. Skin Care − The capability shall be provided for crewmembers to condition their skin to prevent drying and/or cracking.

B. Shaving − Provisions shall be made for crewmembers to shave body hair.

C. Hair Grooming − Provisions shall be made for crewmembers to cut hair.

D. Nail Care − Provisions shall be made for crewmembers to maintain nails.

E. Body Deodorant − Deodorant products shall be provided for crewmembers to control body odor.

F. Menstruation − Provisions shall be provided for the collection and disposal of menstrual discharge.

7.2.5.3.2 PARTIAL BODY CLEANING DESIGN REQUIREMENTS

The capability shall be provided for crewmembers to perform selected body area cleansing as needed.

7.2.5.3.3 ORAL HYGIENE DESIGN REQUIREMENTS

A. The capability shall be provided for crewmembers to maintain oral hygiene, including tooth, mouth, and gum care.

B. Water for oral hygiene shall meet potable water quality standards.

7.2.5.3.4 WHOLE BODY CLEANING DESIGN REQUIREMENTS

The capability shall be provided for crewmembers to perform whole body skin and hair cleansing.

7.2.5.3.5 PERSONAL CLOTHING AND EQUIPMENT CLEANING DESIGN REQUIREMENTS

The capability shall be provided to supply each crewmember with clean clothing and other washables, including bedding and linens, over the duration of the mission.

7.2.5.3.6 PERSONAL HYGIENE WATER DESIGN REQUIREMENTS

Personal hygiene water is that water which is used for external body cleansing. Personal hygiene water requirements are listed below:

A. Quality − Personal hygiene water quality requirements shall be per Figure 7.2.5.3.6−1.

QUALITY PARAMETERS	POTABLE
PHYSICAL PARAMETERS	
Total Solids (mg/1)	500
Color, true (Pt/Co units)	15
Taste (TTN)	NA
Odor (TON)	3
Particulates (max size−microns)	40
pH	5.0−8.5
Turbidity (NTU)	1
Dissolved Gas (free @ 37 deg C)	NA
Free Gases (@ STP)	(1)
INORGANIC CONSTITUENTS (mg/l) (7)(10)	
Ammonia	0.5
Arsenic	0.01
Barium	1.0
Cadmium	0.005
Calcium	30
Chlorine (Total−Includes chloride)	200
Chromium	0.05
Copper	1.0
Iodine (Total−Includes organic iodine)	1.5
Iron	0.3
Lead	0.05
Magnesium	50
Manganese	0.05
Mercury	0.002
Nickel	0.05
Nitrate (NO_3−N)	10
Potassium	340
Selenium	0.01
Silver	0.05
Sulfate	250
Sulfide	0.05
Zinc	5.0
BACTERICIDE (mg/l)	
Residual Iodine (minimum)	1.0
Residual Iodine (maximum)	6.0

FIGURE 7.2.5.3.6−1 HYGIENE WATER QUALITY REQUIREMENTS (MAXIMUM CONTAMINATION LEVELS) (PAGE 1 OF 2)

QUALITY PARAMETERS	POTABLE
AESTHETICS (mg/1)	
Cations	NA
Anions	NA
Carbon Dioxide	NA
MICROBIAL	
Total Count, CFU/100 ml Bacteria (4)/Fungi (5)	100 (8)
Total Coliform (6)	Nondetectable (8)
Virus	Nondetectable (7)
RADIOACTIVE CONSTITUENTS (pCi/1)	(10)
ORGANIC PARAMETERS (ug/1) (9)	
Total Acids	500
Cyanide	200
Halogenated Hydrocarbons	10
Total Phenois	1
Total Alcohols	500
Total Organic Carbon (TOC)	10,000
Uncharacteristic TOC (UTOC) (11)	1,000
ORGANIC CONSTITUENTS (mg/l) (9)(12)	

Notes:

(1) No detectable gas using volumetric gas versus fluid measurement system. Excludes carbon dioxide used for aesthetic purposes.
(2) Incubation time: 48 hours; Temperature: 30 degrees C; Media: R2A
(3) Incubation time: 48 hours; Temperature: 30 degrees C; Media: DG−18.
(4) Incubation time: 24 hours; Temperature: 35 degrees C; Media: M−Endo.
(5) Tissue culture assay.
(6) Membrane Filtration Method.
(7) Each parameter/constituent must be considered individually and independently of others.
(8) The maximum contaminant levels for radioactive constituents in potable and personal hygiene water shall conform to Nuclear Regulatory Commission regulations (10CFR20 et al.). These maximum contaminant levels are listed in the Federal Register, Vol 51, No. 6, 1986, appendix B, as Table 2 (Reference Level Concentrations), Column 2 (Water) Control/containment/monitoring of radioactive constituents used on Space Station shall be the responsibility of the user. Prior to the introduction of any radioactive constituents on Space Station approval shall be obtained from the RCP. The RCP will approve or disapproval proposed monitoring and decontamination procedures on a case−by−case basis.
(9) UTOC equals TOC minus the sum of analyzed organic constituents expressed in equivalent TOC.
(10) In the event a quality parameter not listed in this table is projected, or found, to be present in the reclaimed water, the Water Quality Manager/JSC shall be contacted for a determination of the MCL for that parameter.

FIGURE 7.2.5.3.6−1 HYGIENE WATER QUALITY REQUIREMENTS (MAXIMUM CONTAMINATION LEVELS) (PAGE 2 OF 2)

B. Quantity − Personal hygiene water quantity requirements shall be per Figure 7.2.5.3.6−2.

	Mode		
Units	Operational	90 Day Degraded (1)	Emergency (3)
lb/person−day	51.5 to 64.5 (2)	12.0	TBD
kg/person−day	23.4 to 29.3	5.44	TBD

Notes:
(1) Degraded levels meet ”fail operational criteria.”
(2) Based on 5.4 kg (12 lb) minimum capacity for hygiene and 11.3 kg (23 lb) used in a 90 day chamber test. Includes laundry 12.5 kg/person−day (27.5 lb/person−day) and dishwashing 5.4 kg/person−day (12 lb/person−day) quantities.
(3) Safe Haven conditions shall be maintainable for up to 45 days.
(4) Based on 5.4 kg/person−day (12 lb/person−day) capacity for hygiene and 1.8 kg/person−day (4 lb/person−day) for laundry.
(5) Based on 5.4 kg/person−day (12 lb/person−day) for minimum capacity for hygiene use.

FIGURE 7.2.5.3.6−2 PERSONAL HYGIENE WATER QUANTITY REQUIREMENTS

C. Temperature−Adjustable range from 21 +/− 4 degrees C (70 +/− 10 degrees F) to a maximum of 45 degrees C (113 degrees F).

7.2.6 PRE/POST MISSION HEALTH MANAGEMENT

This paragraph is not applicable for this document.

7.2.7 ROUTINE HEALTH MONITORING

7.2.7.1 INTRODUCTION

This paragraph is not applicable for this document.

7.2.7.2 ROUTINE HEALTH MONITORING DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

7.2.7.3 ROUTINE HEALTH MONITORING DESIGN REQUIREMENTS

7.2.7.3.1 ROUTINE CREW HEALTH MONITORING DESIGN REQUIREMENTS

The Space Station will have the following routine crew health monitoring capabilities:

A. Routine Diagnostic Physical Examination − The capability for conducting routine diagnostic physical examination of the crewmembers shall be provided.

B. Monitoring During Exercise − Requirements for physiological monitoring of the crewmember during exercise are defined in 7.2.3.3.3, Item E.

C. Deleted.

7.2.7.3.2 WATER QUALITY MONITORING DESIGN REQUIREMENTS

The following water quality monitoring requirements apply to all Space Station water that comes into direct contact with personnel (through ingestion, personal hygiene, housekeeping, etc.).

7.2.7.3.2.1 WATER QUALITY MONITORING SCHEDULE DESIGN REQUIREMENTS

Water quality shall be monitored according to the schedule shown in Figure 7.2.7.3.2.1−1.

	ON−LINE (1)	OFF−LINE (2)	
PARAMETER	POT	POT	HYG
PHYSICAL			
Total Solids	−	−	−
Color	−	+	+
Conductivity	X	X	X
Taste and Odor	−	+	+
Particulates	−	+	+
pH	X	X	X
Temperature	X	−	−
Turbidity	−	+	+
Dissolved Gas	−	+	−
Free Gas	−	+	−
INORGANICS			
Ammonia	−	+	+
Iodine	X	X	X
Specific Contributors (3)	−	+	+
AESTHETICS			
Specific Contributors[d]	−	+	+
MICROBIAL			
Total Count			
Bacteria/Fungi	−	X	X
Total Coliform	−	X	X
Virus	−	−	−
Microbe ID (3)	−	X	X
RADIONUCLIDES (6)			
ORGANICS			
TOC	X[g]	X	X
Specific Organics (3)	−	+	+

FIGURE 7.2.7.3.2.1−1 WATER MONITORING REQUIREMENTS (PAGE 1 OF 2)

Notes:
X Denotes that monitoring is required.
− Denotes that monitoring is not required.
+ Denotes that this monitoring requirement will be waived if verification testing and analysis indicate that the respective quality parameter limit will be reliably met.
(1) Analysis of these process stream samples will be performed to provide real−time or near real−time results for process control and presumptive water quality assessment. Requirements for on−line monitoring of additional parameters will be established if verification testing and analysis indicates that such monitoring is required for process control or water quality assessment.
(2) In addition to the on−line and off−line analyses, grab samples from the water systems will be obtained for ground, post−mission analysis.
(3) Specification of organic and inorganic elements and compounds to be monitored will be based on the potential for these elements and compounds being present in the product water and their toxicity. In the event a parameter not listed in this table is projected, or found, to be present in the reclaimed water, the Water Quality Manager/JSC will be contacted for a determination of the monitoring requirements.
(4) Selection will be based on determination of critical aesthetic parameters.
(5) This does not include identification of viruses.
(6) Inflight monitoring capability will be provided by the specific experiment or procedure utilizing radionuclides.
(7) Analytical procedure may provide an indirect equivalent of classical TOC.

FIGURE 7.2.7.3.2.1−1 WATER MONITORING REQUIREMENTS (PAGE 2 OF 2)

7.2.7.3.2.2 TOXICOLOGICAL MONITORING DESIGN REQUIREMENTS

The following requirements apply to monitoring of toxicological qualities of water:

A. Definition of Contaminants −

(1) A pre−operational assessment shall be made of the contaminants in the Space Station reclaimed water.

(2) Requirements for toxicological monitoring both off−line and ground based (post mission) (See Figure 7.2.7.3.2.1−1) shall be based on the results of this assessment.

B. Direct Measurement − Organics and inorganics specified in Figures 7.2.2.3.2−1 and 7.2.5.3.6−1 shall be monitored directly (not through a surrogate).

C. Exposure Limits − Exposure limits shall be established for organics and inorganics on an individual basis.

7.2.7.3.2.3 MICROBIOLOGICAL MONITORING & TREATMENT DESIGN REQUIREMENTS

The following requirements apply to monitoring and treatment of microbiological qualities of water:

A. Determination of Potability − Capability shall be provided to support real−time decisions on water potability if organisms are detected.

B. Sampling Technique − Water sampling techniques shall preclude contamination by the operator during sampling.

C. Iodine − Iodine shall be used as the primary agent to maintain water microbiological quality.

D. Alternative Microbial Control − On long−term missions when there is a potential for development of organisms resistant to iodine, an alternative microbial control technique shall be provided.

E. Recovery from Microbial Overgrowth − Provisions shall be made to recover potable and hygiene water microbial control in the event of overgrowth using processes that will not degrade the quality of water with respect to other parameters.

7.2.7.3.2.4 PHYSICAL MONITORING DESIGN REQUIREMENTS

Equipment shall be provided to meet the physical and aesthetic water quality monitoring requirements identified in Figure 7.2.7.3.2.1−1.

7.2.7.3.3 ENVIRONMENTAL MONITORING DESIGN REQUIREMENTS

Space Station will have the following environmental monitoring capabilities:

A. Deleted.

B. Microbial Contaminants Monitoring −

(1) The capability to monitor, detect, differentiate, and warn the crew of microbial contaminants in Space Station shall be provided.

(2) The capability to disinfect/sanitize contaminated areas/substances with an approved nontoxic agent which can be accommodated by the Life Support System shall be provided.

C. Chemical Contaminants Monitoring − The capability to detect, differentiate, and warn the crew of chemical contaminants listed in Figure 5.1.3.2.1−1 in the Space Station by real−time or near−real−time monitoring shall be provided.

D. Radiation Monitoring −

(1) Monitoring of real−time radiation levels, both internal and external to the Space Station and the cumulative radiation exposures to the crew shall be provided.

(2) The capability shall be provided for qualitative characterization of the radiation environment.

(3) The crewmembers shall be warned of excessive on−orbit radiation levels.

E. The capability to decontaminate contaminated areas shall be provided. See also 5.1.3.

7.2.8 BIOLOGICAL PAYLOADS

7.3 MEDICAL CARE

7.3.1 INTRODUCTION

This paragraph is not applicable for this document.

7.3.2 MEDICAL CARE DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

7.3.3 MEDICAL CARE DESIGN REQUIREMENTS

7.3.3.1 GENERAL DESIGN REQUIREMENTS

The Space Station shall have a Health Maintenance System (HMS) that provides preventive, diagnostic, and therapeutic medical capabilities.

7.3.3.2 PREVENTION DESIGN REQUIREMENTS

The HMS shall be capable of providing preventive medical care as defined in 7.2.7.3.1.

7.3.3.3 DIAGNOSIS DESIGN REQUIREMENTS

The HMS shall be capable of diagnosing identified illnesses and injuries, assessing their degree and severity, and tracking the overall health status of ill or injured crewmembers.

7.3.3.4 TREATMENT (THERAPEUTICS) DESIGN REQUIREMENTS

The HMS shall be capable of the following therapeutic measures:

A. Treatment − The system shall provide the capability to treat a crewmember for identified illnesses and injuries.

B. Stabilization − In the event an illness or injury is not treatable at the Space Station, the HMS shall provide the capability to stabilize the crewmember until transportation to an appropriate facility is available.

C. Handling a Deceased Crewmember − In the event of a crewmember death, the HMS shall provide the capability to handle the deceased crewmember.

D. Space Motion Sickness − The HMS shall provide prophylactic medication for the treatment of Space Motion Sickness.

8.0 ARCHITECTURE

8.1 INTRODUCTION

This paragraph is not applicable for this document.

8.2 OVERALL ARCHITECTURAL CONSIDERATIONS AND REQUIREMENTS

8.2.1 INTRODUCTION

This paragraph is not applicable for this document.

8.2.2 OVERALL ARCHITECTURAL DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

8.2.3 OVERALL ARCHITECTURAL DESIGN REQUIREMENTS

8.2.3.1 CREW STATION ARRANGEMENT AND GROUPING DESIGN REQUIREMENTS

Crew stations within the Space Station shall be arranged and grouped to accomplish the following:

A. Activity Level Accommodation − Each crew station shall be sufficiently large to accommodate the anticipated crew and their activity level.

B. Deleted.

C. Crew Station Accessibility −

(1) Crew stations shall be accessible**.**

(2) Stations that perform related functions shall be adjacent to each other.

8.2.3.2 DEDICATED VS. MULTIPURPOSE SPACE UTILIZATION DESIGN REQUIREMENTS

The interior accommodations will be designed so that multipurpose utilization of the space meets the following requirements:

A. Compatibility of Activities Within Crew Stations − Activities that occur within the same crew station shall not interfere with each other.

B. Deleted.

8.3 CREW STATION ADJACENCIES

This paragraph is not applicable for this document.

8.4 COMPARTMENT AND WORKSPACE ORIENTATION

8.4.1 INTRODUCTION

This paragraph is not applicable for this document.

8.4.2 ORIENTATION DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

8.4.3 ORIENTATION DESIGN REQUIREMENTS

The following are design requirements for establishing an orientation within the Space Station:

A. Consistent Orientation − Each crew station shall have a local vertical (a consistent arrangement of vertical cues within a given visual field) so that the vertical orientation within a specific work station or activity center remains consistent.

B. Visual Orientation Cue −

(1) A visual cue shall be provided to allow the crewmember to adjust to the orientation of the activity center or workstation.

(2) Such cues shall provide left−right orientation references.

C. Separation − When adjacent workstations or activity centers have vertical orientations differing by 90 degrees or more, then demarcations shall separate the two areas.

8.5 LOCATION CODING

8.5.1 INTRODUCTION

This paragraph is not applicable for this document.

8.5.2 LOCATION CODING DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

8.5.3 LOCATION CODING DESIGN REQUIREMENTS

8.5.3.1 ALPHANUMERIC CODING DESIGN REQUIREMENTS

An alphanumeric location coding system shall be in accordance with SSP 30575.

A. Deleted.

B. Deleted.

C. Deleted.

D. Deleted.

8.5.3.2 DIRECTIONAL DESIGNATION DESIGN REQUIREMENTS

A consistent directional orientation shall be established for the entire Space Station.

The following directional designation terms will apply to the Space Station:

A. Deleted.

B. Deleted.

C. Deleted.

8.5.3.3 LOCATION AND ORIENTATION BY COLOR CODING DESIGN REQUIREMENTS

Interior colors shall be selected in accordance with SSP 50008.

8.5.3.4 LOCATION CODING WITH PLACARDS DESIGN REQUIREMENTS

Visual markings and other cues will provide the crew with directional and spatial orientation. The specific requirements for location of coding placards are as follows:

A. Deleted.

B. Placards on Movable Items − Movable items and their stowage locations shall be labeled to ensure the item is returned to the proper location after use.

C. Markings − Detailed requirements for labels, placard format, and markings are contained in 9.5.

8.6 ENVELOPE GEOMETRY FOR CREW FUNCTIONS

8.6.1 INTRODUCTION

This paragraph is not applicable for this document.

8.6.2 ENVELOPE GEOMETRY DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

8.6.3 ENVELOPE GEOMETRY DESIGN REQUIREMENTS

8.6.3.1 CREW STATION BODY ENVELOPE DESIGN REQUIREMENTS

The following are requirements for crew station body envelope geometry:

A. Adequate Volume −

(1) Crew station volume shall be provided for the crew to perform their tasks and activities.

(2) The volume shall also accommodate tools and equipment used in the task.

B. Accessibility − The geometric arrangement of crew stations shall provide ingress and egress envelopes for all functions within the station.

C. Full Size Range Accommodation − All workstations shall be sized to meet the functional reach limits for the 5th percentile of the design population and yet not constrict or confine the body envelope for the 95th percentile of the design population.

8.6.3.2 DELETED

8.7 TRAFFIC FLOW

8.7.1 INTRODUCTION

This paragraph is not applicable for this document.

8.7.2 TRAFFIC FLOW DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

8.7.3 TRAFFIC FLOW DESIGN REQUIREMENTS

8.7.3.1 DELETED

8.7.3.2 DELETED

8.7.3.3 DELETED

8.7.3.4 EMERGENCY AND ESCAPE ROUTE DESIGN REQUIREMENTS

The design for traffic flow will take into account the possibility of a module or subsystem failure or damage that could require emergency egress or temporary isolation. Specifically, the following requirements will apply:

A. Deleted.

B. Protection of Entry/Exit Path −

(1) Provisions shall be made to ensure that compartment and pressurized element entry/exit paths are unimpeded.

(2) Translation paths shall not be impassable, per Figure 8.8.3.1−1.

C. Escape Routes and Isolation Areas − Crewmembers shall be provided with safe emergency IVA egress routes or the capability to isolate themselves when a hazardous condition occurs.

D. Deleted.

8.8 TRANSLATION PATHS

8.8.1 INTRODUCTION

This paragraph is not applicable for this document.

8.8.2 TRANSLATION PATH DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

8.8.3 TRANSLATION PATH DESIGN REQUIREMENTS

8.8.3.1 MINIMUM TRANSLATION PATH DIMENSIONS DESIGN REQUIREMENTS

Minimum cross sectional dimensions of microgravity translation paths for one crewmember in light clothing shall be as shown in Figure 8.8.3.1−1.

8.8.3.2 CLEARANCES DESIGN REQUIREMENTS

Minimum interior cross section dimensions of 50.0 inches shall be maintained to support equipment translation.

8.8.3.3 TRANSLATION PATH OBSTRUCTIONS AND HAZARDS DESIGN REQUIREMENTS

The following translation path obstructions and hazards requirements will apply:

A. Rounded corners, protective covers, and smooth surfaces shall be provided per 6.3.3.

B. Damage to Nearby Equipment − Equipment exposed to the translation path shall be designed to withstand a design load of 556 N (125.0 lbf) and a minimum ultimate load of 778 N (175.0 lbf).

C. Deleted.

D. Obstructions and Entanglements − The translation path shall be free of cables, hoses, and wires.

8.8.3.4 MARKING OF TRANSLATION PATHS DESIGN REQUIREMENTS

Emergency translation paths shall be marked in accordance with MIL−A−25165.

8.9 MOBILITY AIDS AND RESTRAINTS ARCHITECTURAL INTEGRATION

8.9.1 INTRODUCTION

This paragraph is not applicable for this document.

8.9.2 MOBILITY AIDS AND RESTRAINTS INTEGRATION DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

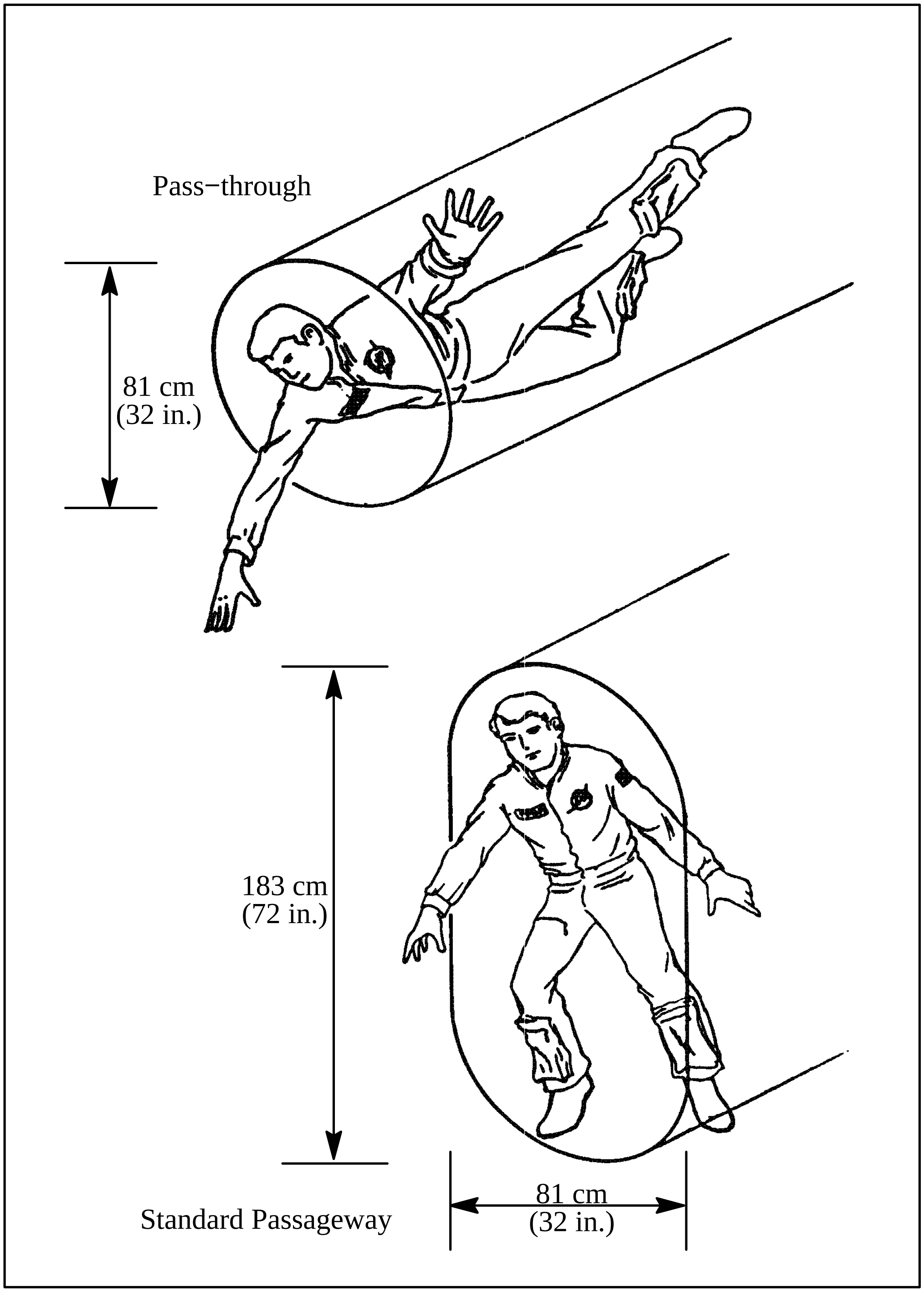


FIGURE 8.8.3.1−1 MINIMUM TRANSLATION PATH DIMENSIONS FOR MICROGRAVITY, ONE CREWMEMBER IN LIGHT CLOTHING

8.9.3 MOBILITY AIDS AND RESTRAINTS DESIGN REQUIREMENTS

8.9.3.1 IVA MOBILITY AID LOCATIONS DESIGN REQUIREMENTS

Fixed or portable IVA mobility aids shall be provided at the following locations:

A. Crew stations − Mobility aids shall be placed around workstations, access hatches, doors, windows, and pressure hatches.

B. Terminal and Direction Change Points − Mobility aids shall be located at designated terminal points and direction change points on established crew translation paths.

C. Deleted.

D. Deleted.

E. Contingency IVA Operations by EVA−suited crewmember − Crew mobility aid provisions shall be made for contingency EVA−suited operations.

F. Hazard Protection − Translation and mobility aids shall be located only where the crewmember is protected from identified hazards.

G. Orientation − The orientation and locations of translation and mobility handholds shall be consistent with the local vertical orientation of the module or crew station.

8.9.3.2 IVA RESTRAINT LOCATIONS DESIGN REQUIREMENTS

IVA crew restraints shall be provided at the following locations:

A. Areas Requiring High Force Application − Restraints shall be provided at identified locations where crewmembers are expected to exert forces which cause the body to move in reaction.

B. Health Maintenance Facility − Patient restraints shall be provided at the health maintenance facility.

C. Crew Stations − Personnel restraints shall be provided at crew stations.

D. Deleted.

E. Deleted.

8.10 HATCHES AND DOORS

8.10.1 INTRODUCTION

This paragraph is not applicable for this document.

8.10.2 HATCHES AND DOORS DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

8.10.3 HATCH AND DOOR DESIGN REQUIREMENTS

8.10.3.1 LOCATION DESIGN REQUIREMENTS

Hatches and doors shall meet the following location requirements:

A. Internal Door Placement −

(1) Enclosed crew stations shall have entrances.

(2) Crew station compartment doors shall not open into aisle way.

B. Deleted.

C. Deleted.

D. External Pressure Hatches − Hatches opening directly to space vacuum shall be inward opening.

8.10.3.2 PRESSURE HATCH INDICATOR AND VISUAL DISPLAY DESIGN REQUIREMENTS

Pressure hatch covers shall have the following:

A. Visual Inspection of Hatch Security − A means shall be provided on both sides of the hatch for visual safety check to ensure that access to an area at a different pressure level has been secured.

B. Deleted.

C. Pressure Difference Indicators − Differential pressure hatches shall have pressure difference indicators visible on both sides of the hatch.

D. Windows − Airlock hatches shall incorporate windows for visual observation of airlock operations.

E. Operating Instructions − All pressure hatches shall display hatch operational procedures on both sides of the hatch.

8.10.3.3 OPENING AND CLOSING MECHANISM DESIGN REQUIREMENTS

Personnel hatch and door opening and closing mechanisms will meet the following design requirements:

A. Deleted.

B. EVA Operation − All opening/closing mechanisms shall be operable by a pressure−suited crewmember.

C. Operation From Both Sides − Hatches shall be capable of being operated, locked, and unlocked from either side.

D. Interlock − Pressure hatches shall not open prior to pressure equalization.

E. Single Crewmember Operation − Hatches shall be capable of being operated by one crewmember.

F. Parts Tethering − All safety pins or other detachable parts required for the opening/closing shall be tethered and able to be stowed.

G. Deleted.

H. Deleted.

8.10.3.4 OPERATING FORCES DESIGN REQUIREMENTS

Hatch and door cover operating forces shall meet the following requirements:

A. Emergency Operation of Internal Doors − Forces for emergency backup operation or breakaway of jammed internal doors shall not exceed 445 Newtons (100.0 lbf).

B. Latch Operations − The force required to operate the door and hatch latches shall not exceed the strength of the fifth percentile design population as defined in 4.9.3.

C. Open/Close Force − The force required to move an unlatched hatch or door between its closed and its open position shall not exceed 22.0 Newtons (5.0 lbf) with zero delta pressure through the opening.

D. Restraints − Restraints shall be provided to counteract body movement when opening or closing hatches and doors.

8.10.3.5 MINIMUM SIZE DESIGN REQUIREMENTS

The minimum size of personnel hatch and door openings shall accommodate passage of the largest IVA ORU or crewmember (whichever is larger) intended to pass through the opening.

8.10.3.6 OPERATIONS INTERFACE REQUIREMENTS

A. The location and operation of crew interfaces for hatches in all pressurized elements shall be visually and functionally identical.

B. This shall include the procedures and protocols for opening, securing, closing, statusing and performing maintenance.

8.10.3.7 SHAPE

The hatch shall be shaped such that it can pass through the opening that it is designed to seal.

8.11 WINDOWS INTEGRATION

8.11.1 INTRODUCTION

This paragraph is not applicable for this document.

8.11.2 WINDOWS INTEGRATION DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

8.11.3 WINDOWS INTEGRATION DESIGN REQUIREMENTS

The following are requirements for the architectural integration and design of windows:

A. Required Windows − Windows shall be provided for the following functions:

(1) Off−duty recreational viewing

(2) To support EVA/Extravehicular Robotic (EVR) activities

(3) To support proximity operations

(4) To support inspection of adjacent modules, structures, and/or other spacecraft

(5) For celestial or Earth observations

(6) For observation of decompression through airlock and pressure hatch covers −

a. Windows shall be located and configured with minimum blind areas inside the decompression area.

b. Windows shall allow a 45.0 inch field of view for an eye reference point located along a normal to the window opening which passes through the geometric center of this opening.

c. This reference point shall be located half the window opening dimension from the inner pane.

B. Adequate Space Around Windows − The architectural arrangement of equipment near the windows shall accommodate performance of window tasks.

C. Restraints − Restraints shall be provided for window task performance.

D. Deleted.

E. Deleted.

F. Window Attachments − Mounting/pointing/aligning fixtures shall be removable and adjustable.

8.12 INTERIOR DESIGN AND DECOR

8.12.1 INTRODUCTION

This paragraph is not applicable for this document.

8.12.2 INTERIOR DESIGN AND DECOR DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

8.12.3 INTERIOR DESIGN AND DECOR DESIGN REQUIREMENTS

Interior colors shall be selected in accordance with SSP 50008.

8.13 LIGHTING

8.13.1 INTRODUCTION

This paragraph is not applicable for this document.

8.13.2 LIGHTING DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

8.13.3 LIGHTING DESIGN REQUIREMENTS

8.13.3.1 ILLUMINATION LEVEL DESIGN REQUIREMENTS

8.13.3.1.1 GENERAL INTERIOR ILLUMINATION LEVELS DESIGN REQUIREMENTS

A. The general illumination of the Space Station shall be a minimum of 108.0 lux (10.0 fc) of white light.

B. The lighting level shall be measured 30.0 inches above the floor equidistant from the walls where appropriate.

8.13.3.1.2 ILLUMINATION FOR TASK DESIGN REQUIREMENTS

A. The lighting level shall be measured on the primary work surfaces

B. Specific IVA task lighting requirements shall be as defined in Figure 8.13.3.1.2−1 which also defines illumination levels for workstations.

Area or Task		Lux	(Ft. C)
General		108	(10)
Passageways		54	(5)
	Hatches	108	(10)
	Handles	108	(10)
	Ladders	108	(10)
Stowage Areas		108	(10)
Wardroom		215	(20)
	Reading	538	(50)
	Recreation	323	(30)
Galley		215	(20)
	Dining	269	(25)
	Food Preparation	323	(30)

FIGURE 8.13.3.1.2−1 SPACE VEHICLE ILLUMINATION LEVELS (PAGE 1 OF 2)

Area or Task	Lux	(Ft. C)
Personal Hygiene	108	(10)
Grooming	269	(25)
Waste Management	164	(15)
Shower	269	(25)
Crew Quarters	108	(10)
Reading	323	(30)
Sleep	54	(5)
Health Maintenance	215	(20)
First Aid	269	(25)
Surgical	1076	(100)
I.V. Treatment	807	(75)
Exercise	538	(50)
Hyperbaric clinical lab	538	(50)
Imaging telvideo	538	(50)
Workstation	232	(30)
Maintenance	538	(25)
Controls	538	(20)
Assembly	323	(30)
Transcribing	538	(50)
Tabulating	538	(50)
Repair	323	(30)
Panels (Positive)	215	(20)
Panels (Negative)	54	(5)
Reading	538	(50)
Night Lighting	21	(2)
Emergency Lighting	32	(3)

Notes:
(1) Levels are measured at the task of 789 mm. (30 in.) above floor.
(2) All levels are minimum.

FIGURE 8.13.3.1.2−1 SPACE VEHICLE ILLUMINATION LEVELS (PAGE 2 OF 2)

8.13.3.1.3 ILLUMINATION LEVELS OF SLEEPING AREAS DESIGN REQUIREMENTS

The following requirements apply to the illumination of sleeping areas:

A. The lighting level shall be adjustable from “off” to the maximum for sleeping areas.

B. Minimum lighting of 32.0 Lux (3.0 fc), or other means of visual orientation shall be provided to permit emergency egress from sleeping areas.

8.13.3.1.4 ILLUMINATION LEVELS FOR DARK ADAPTATION DESIGN REQUIREMENTS

If maximum dark adaptation is required, red light or low level white lighting [Commission Internationale De L'Eclairage (CIE) color coordinates for x and y equals 0.330 +/− 0.030 (1932)] is acceptable. However, if color acuity is required, red lighting is not acceptable. All trans−illuminated displays and controls shall be visible when all other lighting is turned off.

When dark adaptation is required for performance of tasks, the following measures shall be taken:

A. Low Level Lighting − Low level lighting shall be provided for task performance.

B. Protection From Stray Light − Areas requiring low level illumination shall be protected from external light sources.

   (1) All external windows shall be provided with protective light shields.

   (2) All doorways shall be lightproof when closed.

8.13.3.2 LIGHT DISTRIBUTION DESIGN REQUIREMENTS

8.13.3.2.1 DELETED

8.13.3.2.2 REFLECTED GLARE DESIGN REQUIREMENTS

A. Surface Reflection − Work surface reflection shall be diffused and shall not exceed 20.0 percent specularity.

B. Angle of Incidence − Direct light sources shall be arranged so their angle of incidence to the visual work area is not the same as the operator's viewing angle.

C. Deleted.

D. Deleted.

8.13.3.2.3 LUMINANCE RATIO DESIGN REQUIREMENTS

The luminance ratios between the lightest and darkest areas and/or between task area and surroundings shall be no greater than specified in Figure 8.13.3.2.3−1.

	Environmental Classification		
Comparison	A (1)	B (1)	C (1)
Between lighter surfaces and darker surfaces within the task	5 to 1	5 to 1	5 to 1
Between tasks and adjacent darker surroundings	3 to 1	3 to 1	5 to 1
Between tasks and adjacent lighter surroundings	1 to 3	1 to 3	1 to 5
Between tasks and more remote darker surfaces	10 to 1	20 to 1	(2)
Between tasks and more remote lighter surfaces	1 to 10	1 to 20	(2)
Between luminaires and adjacent surfaces	20 to 1	(2)	(2)
Between the immediate work area and the rest of the environment	40 to 1	(2)	(2)

Notes:
(1) A − interior areas where reflectances of entire space can be controlled for optimum visual conditions.
B − Areas where reflectances of immediate work area can be controlled, but there is only limited control over remote surroundings.
C − Areas (indoors and outdoor) where it is completely impractical to control reflectances and difficult to alter environmental conditions.
(2) Brightness−ratio control not practical.

FIGURE 8.13.3.2.3−1 REQUIRED BRIGHTNESS RATIOS

8.13.3.3 LIGHT COLOR DESIGN REQUIREMENTS

Artificial light will meet the following color requirements:

A. White Light −

(1) The Space Station shall be illuminated with white light.

(2) Fluorescent lighting shall have a color temperature of 5000 K or greater while incandescent lighting shall have a color temperature of 3200 K or greater.

B. Color Temperature Variation − CCT may vary from module to module but will conform to the following intra−module variations:

(1) The CCT for the general interior lighting system shall be comprised of one source type (i.e., all sources are fluorescent, or all are incandescent, etc.) and not vary more than +/− 300 K operation at maximum intensity.

(2) If the general interior lighting system is operating simultaneously with any other lighting system, the CCT differential between the two systems may exceed +/− 300 K.

C. Color Rendition − Unless otherwise specified, the minimum CIE general color rendering index (R^a) of any light source shall be 90.0 +/− 10.0.

See 9.5.3.2 for color coding information relative to illuminated displays.

8.13.3.4 LIGHTING FIXTURES AND CONTROLS DESIGN REQUIREMENTS

The following design requirements apply to lighting fixtures and their controls:

A. Emergency Lights − An independent, self−energizing illumination system shall be provided that will be activated automatically in the event of a major primary power failure or main lighting circuit malfunction resulting in circuit breaker interruption.

Emergency illumination levels shall be per Figure 8.13.3.1.2−1.

B. Controls − Lighting controls shall meet the following requirements:

(1) Required Control − Each light fixture shall have its own control.

In addition, centralized lighting control shall be provided for each compartment and translation path.

a. Location − Lighting controls shall be provided at entrances and exits of habitable areas.

b. Sleeping − Sleeping area light controls shall be within the reach of a crewmember when in the sleep restraint.

c. Controls − Controls for artificial illumination at the workstation shall be located within the reach envelope of the operator at the display/control panel or workstation that is affected.

(2) Control Identification − Lighting controls shall be illuminated in areas that are frequently darkened.

(3) Variability − Dimmer controls shall be provided.

C. Flicker − Light sources shall not have a perceptible flicker.

D. Fixture Protection −The following protective measures shall be incorporated into lighting fixtures:

(1) Deleted.

(2) Deleted.

(3) Lamp or Lens Breakage − Provisions shall be incorporated into all light fixtures to contain all glass fragments in the case of lamp or lens breakage.

(4) Replacement of Lamps − Provisions shall be incorporated into all light fixtures to allow for replacement of lamps or luminaires.

E. Portable Lights − Portable lights shall be provided.

8.13.3.5 DELETED

8.13.3.6 WORKSTATION ILLUMINATION DESIGN REQUIREMENTS

Requirements pertaining to workstation illumination are provided below:

A. Illumination − Workstation illumination requirements shall be as given in Figure 8.13.3.1.2−1.

B. Adjustable Illumination − Workstation illumination shall be fully adjustable down to OFF.

C. Portable Lighting − Portable lighting shall be available for use at workstations.

D. Light Distribution − The minimum ratio for differences in illumination within a work area shall meet the following specifications.

   (1) Primary viewing areas (30.0 degree visual angle about primary lines of sight) − Maintain a 3:1 ratio.

   (2) Adjacent viewing areas (30.0 to 60.0 degree band surrounding primary viewing areas) Maintain a 5:1 ratio.

   (3) Workstation area outside ”adjacent viewing areas” − Maintain a 10:1 ratio.

E. Shadows − Placement of lighting sources shall be such that shadows are not created on working surfaces or information displays by design positioning of crewmembers or equipment.

F. Deleted.

G. Light Sources in Front or to the Side of Operators − Light sources shall not be located within the range of 60.0 degrees to any side of the center of the visual field.

H. Light Sources Behind Operator − Direct light sources shall not be placed behind operators within 60.0 degrees of normal to the operators visual field.

8.13.3.7 DELETED

9.0 WORKSTATIONS

9.1 INTRODUCTION

Requirements for both electromechanical displays and controls and computerized displays and controls are presented in this chapter on workstation requirements. Both type of systems will be employed on the Space Station, based upon analyses to determine which Space Station workstation functions are best served by electro−mechanical displays and controls and which are best served by computerization.

9.2 WORKSTATION LAYOUT

9.2.1 INTRODUCTION

9.2.2 GENERAL WORKSTATION DESIGN FACTORS

9.2.2.1 GENERAL WORKSTATION DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.2.2.2 GENERAL WORKSTATION DESIGN REQUIREMENTS

9.2.2.2.1 WORKSTATION ILLUMINATION DESIGN REQUIREMENTS

This paragraph is not applicable for this document.

9.2.2.2.2 CONGESTION AND INTERFERENCE DESIGN REQUIREMENTS

9.2.2.2.3 ORIENTATION DESIGN REQUIREMENTS

Workstations shall be designed using a local vertical orientation.

9.2.2.2.4 WORKSTATION COLOR DESIGN REQUIREMENTS

Workstation color selection requirements are specified below:

A. Color Selection − FED−STD−595 neutral colors shall be used in workstations.

B. Reflections − Workstations surface reflection shall be less than 10.0 percent.

C. Controls

(1) Controls shall be black or gray unless otherwise specified in 9.5.3.2, Item I.

(2) Toggle switch handles shall have a satin metallic finish.

(3) Control colors shall provide contrast between controls and background 9.5.3.2, Item I.(8)a.

D. Panel Color Finish − The panel color shall provide contrast between the labels and background per 9.5.3.2, Item I.(8)a.

E. Consoles and Pedestals − The color of structural members of control consoles and pedestals and overhead mountings for control units shall be in accordance with SSP 50008.

F. Meter Bezels − The meter bezels shall be the same color as the panel on which the meter will be used.

9.2.2.2.5 DELETED

9.2.2.2.6 DELETED

9.2.3 DISPLAY/CONTROL PLACEMENT AND INTEGRATION

9.2.3.1 DISPLAY/CONTROL PLACEMENT AND INTEGRATION DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.2.3.2 DISPLAY/CONTROL PLACEMENT AND INTEGRATION DESIGN REQUIREMENTS

9.2.3.2.1 CONTROL SPACING DESIGN REQUIREMENTS

Requirements for control spacing are provided below:

A. All spacing between controls shall meet the minimum requirements as shown in Figure 9.2.3.2.1−1 (for the ungloved condition).

B. Gloved Operation − Controls necessary for maintenance and recovery following a depressurization as a result of a micro−meteoroid hit shall be operable by a pressure−suited crewmember.

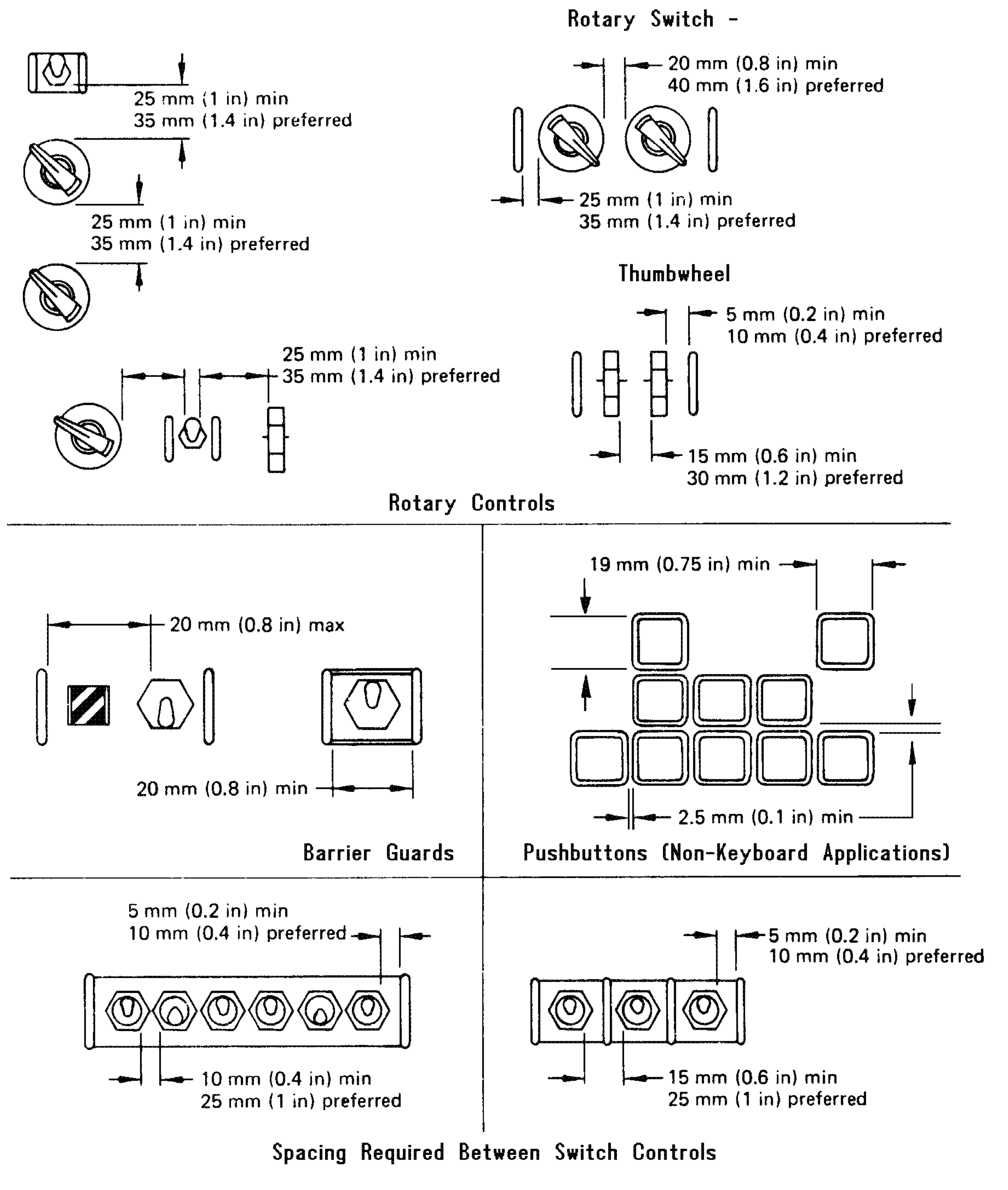
C. Miniature Controls − Spacing of miniature controls, intended for ungloved hand operation, shall maintain the same clearance ”footprint” about each control (i.e., the edge−to−edge separation between the pair of controls located on either side of a third control) as indicated in Figure 9.2.3.2.1−1.

9.2.3.2.2 DISPLAY READABILITY DESIGN REQUIREMENTS

Displays shall be located and designed so that they are within the visual cone of personnel in the normal operating or servicing positions without deviating from the neutral body posture defined in section 3.0. Requirements for designing readable displays are provided below:

A. Accessibility − Displays shall be located within a 30.0 degree visual cone from the design eye point.

B. Parallax Error − Displays shall be located so that the parallax error is less than 25.0 percent of the smallest increment marked on the display when read from the design eyepoint.



Note: See Figure 9.3.3.4.1.2−1 for Keyboard Layout Dimensions.

FIGURE 9.2.3.2.1−1 CONTROL SPACING REQUIREMENTS FOR UNGLOVED OPERATION

C. Orientation − The angle between the line−of−sight at the operating position as defined in 9.2.4.2.2 and the normal to the displays shall always be less than 30.0 degrees.

D. Simultaneous Use − A visual display that must be monitored concurrently with manipulation of a control shall be located so that it can be read to within 30.0 degrees of visual arc of the control.

9.2.3.2.3 DISPLAY/CONTROL GROUPING DESIGN REQUIREMENTS

Requirements for grouping displays and controls are listed below:

A. Functional Grouping − Functionally related displays and/or controls shall be arranged in functional groups.

B. Sequential Grouping −

(1) When a unique sequence of control actions exists, the displays and/or controls shall be arranged in relation to one another according to their sequence of use.

(2) Within a functional group, the sequence shall be from left to right or top to bottom.

C. Logical Flow Grouping − When there is not a unique sequence or functional grouping of control actions, displays and controls shall be arranged in a manner consistent with their operational logical flow.

D. Functional Group Markings − A means of coding functional groupings of displays and controls shall be provided.

E. 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.

F. Vertical and Horizontal Arrays − If a horizontal row of displays is 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.

G. Multiple Displays − When the manipulation of one control requires the reading of several displays, the control shall be placed within the reach of the 5th percentile Japanese female while maintaining the 30.0 degree visual cone to each display.

H. Separate Panels −

(1) When functionally related displays and controls must be located on separate panels and both panels are mounted within +/− 5.0 degrees of the same angle relative to the operator, the control positions on one panel shall correspond to the associated display positions on the other panel.

(2) The two panels shall not be mounted facing each other.

I. Switch/Control Labeling − Each switch/control shall be labeled.

9.2.3.2.4 PREFERRED DISPLAY/CONTROL LOCATION DESIGN REQUIREMENTS

Design requirements for the placement of displays and controls are provided below:

A. Deleted.

B. Deleted.

C. Deleted.

D. Display/Control Relationships

(1) The relationships of a control to its associated display and the display to the control shall be labeled.

(2) Controls shall be located adjacent to their associated displays.

(3) Operation of controls at a workstation shall not obscure displays located at the workstation.

9.2.3.2.5 CONSISTENT DISPLAY/CONTROL PLACEMENT − DESIGN REQUIREMENTS

Requirements for maintaining consistency in display and control design are provided below:

A. Deleted.

B. Mirror Images − Mirror image arrangements shall not be used.

9.2.3.2.6 MAINTENANCE DISPLAYS/CONTROLS − DESIGN REQUIREMENTS

Displays and controls used solely for maintenance and adjustments shall be covered or non−visible during normal equipment operation.

9.2.3.2.7 EMERGENCY DISPLAY/CONTROL PLACEMENT DESIGN REQUIREMENTS

Requirements for emergency displays and controls are provided below: (Refer to Figure 9.2.4.2.2−1.)

A. Emergency Display/Control Placement − Emergency displays and controls shall be located within a 30 degree cone about the operator's normal line of sight or within a 30 degree cone of the nearest available hand in its normal operation position.

B. Computer Generated Emergency Displays − Emergency information depicted on existing computer controlled displays shall be located within a 30.0 degree cone about the user's normal line of sight.

9.2.3.2.8 DISPLAY/CONTROL MOVEMENT COMPATIBILITY DESIGN REQUIREMENTS

Requirements for display/control movement compatibility are provided below:

A. Consistency of Movement − The movement of an indicator within a display shall always be in the same direction as the movement of the associated control.

B. Complex Movement Control − When the vehicle, the equipment, or the components are capable of motion in more than two dimensions, exception to 9.2.3.2.8, Item A. shall be made to:

(1) Maintain consistency with other systems

(2) Maintain control/display movement requirements

C. Deleted.

D. Deleted.

E. Movement Direction − When a rotary control and 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.

F. Labeling − Controls shall be clearly labeled to indicate the direction of control movement required.

G. Time Lag −

(1) Deleted.

(2) Feedback for operator entries shall have not more than a 0.2 second delay.

(3) Deleted.

(4) Changes of entire data pages shall be executed in less than 10.0 seconds.

(5) If processing requires more than 10 seconds, the system shall acknowledge a control input and provide updates showing the progress of the processing.

9.2.3.2.9 DISPLAY/CONTROL MOVEMENT RATIO DESIGN REQUIREMENTS

Requirements for designing the relative movement ratios between displays and controls are provided below:

A. Deleted.

B. Deleted.

C. Coarse/Fine Knob Setting − A rotary knob used for coarse control shall move an associated display element (linear scale) three to six times the distance of a fine control knob per revolution of the knob.

D. Bracketing − When bracketing is used to locate a maximum or minimum value (e.g., as in tuning a transmitter), the control knob shall swing through an arc of not less than 10.0 degrees nor more than 30.0 degrees either side of the target value in order to make the peak or dip associated with that value clearly noticeable.

E. Counter − When counters are provided, the display/control ratio shall be such that one revolution of the knob produces 50 +/− 5.0 counts.

9.2.3.2.10 DELETED

9.2.4 HUMAN/WORKSTATION CONFIGURATION

9.2.4.1 HUMAN/WORKSTATION CONFIGURATION DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.2.4.2 HUMAN/WORKSTATION CONFIGURATION DESIGN REQUIREMENTS

A positive indication of system state shall be used.

9.2.4.2.1 CREWMEMBER PHYSICAL CHARACTERISTICS

Workstations will accommodate the following features:

A. Microgravity − The physical dimensions and layout of workstations shall conform to user characteristics for microgravity neutral body posture given in 3.3.4.3.

B. The physical dimensions and layout of the workstation shall conform to the characteristics of the specific population of users given in 3.3.1.3.

C. Movement − Microgravity restraint features shall be incorporated into the design.

D. Deleted.

9.2.4.2.2 VISUAL SPACE DESIGN REQUIREMENTS

Good workstation design takes into account the visual abilities of users. Requirements and specifications regarding a crewmember’s visual space are provided below:

A. Viewing Distance

  (1) Minimum −

    a. The viewing distance to displays other than visual display terminals and collimated displays shall not be less than 33.0 cm (13.0 in.).

    b. The viewing distance to visual display terminals shall not be less than 40.6 cm (16.0 in.).

  (2) Maximum − The viewing distance to displays shall not be greater than the reach distance for the 5 percent Japanese female or 71.2 cm (28.0 in.).

B. Line of Sight − A crewmember’s line of sight depends on body position and varies as a function of gravity level and shall be defined as shown in Figures 3.3.4.3−1 and 9.2.4.2.2−1.

C. Deleted.

9.2.4.2.3 WORKSTATION RESTRAINTS AND MOBILITY AIDS

This section provides requirements for integrating restraints and mobility aids into the workstation environment.

A. Deleted.

B. Freedom of Movement − A workstation restraint shall allow the user to reach all required controls and view all required displays based on the anthropometric reach and line of sight limitations defined in 3.3.3.3.1 and 3.3.4.3.

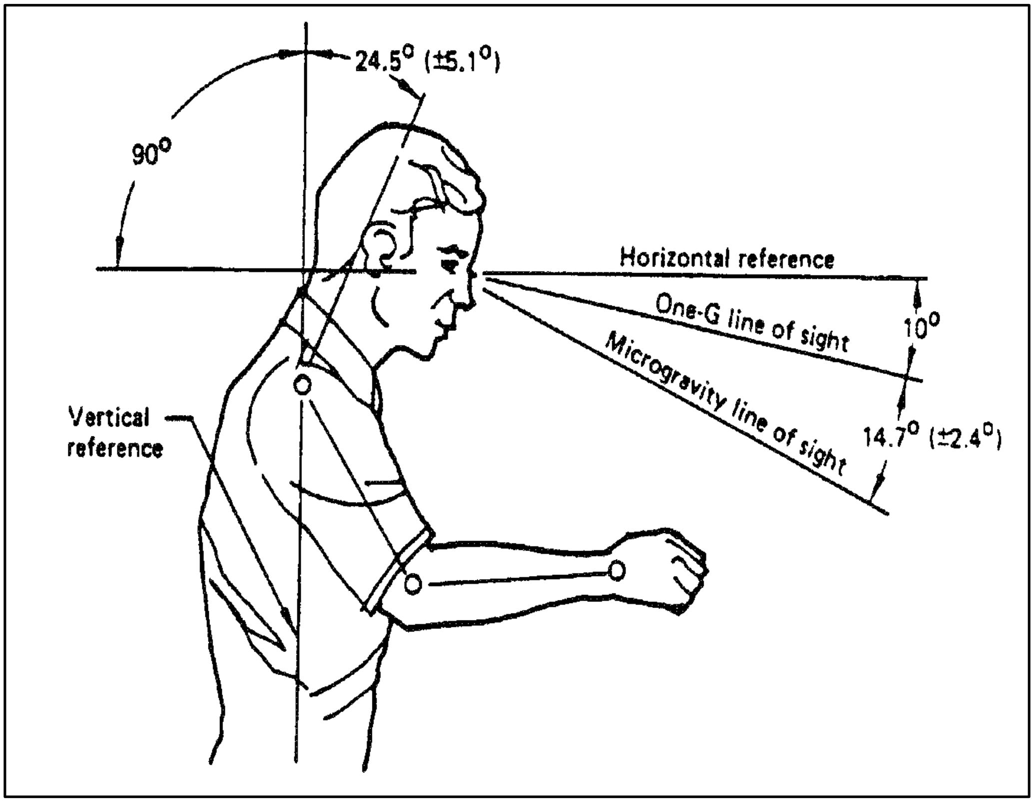


FIGURE 9.2.4.2.2−1 LINE−OF−SIGHT FOR ONE−G AND MICROGRAVITY

C. Restraint Adjustment −

(1) Eye Position and Reach − Restraints shall be adjustable to allow the 5.0 percent Japanese female through the 95.0 percent American male for eye position (relative to displays) and reach (relative to controls).

(2) Deleted.

D. Required Restraint Placement − Foot and waist restraint systems shall be located at all workstations that require a crewmember to perform the following type tasks:

(1) Greater than 4.0 hours of continuous visual monitoring.

(2) Manipulations requiring the use of both hands.

(3) Deleted.

E. Stability − Workstation restraints shall provide stability for:

(1) Deleted.

(2) Deleted.

(3) Deleted.

(4) Executing continuous control movement.

F. Handholds and Handrails − Handholds and handrails shall meet the requirements for the 5.0 percent Japanese female through the 95.0 percent American male populations as specified in 11.7.

G. Equipment Restraints − Equipment restraints shall be provided to anchor every loose item at the workstation.

9.2.5 SPECIALIZED WORKSTATIONS

9.2.5.1 WINDOW WORKSTATION

9.2.5.1.1 WINDOW WORKSTATION DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.2.5.1.2 WINDOW WORKSTATION DESIGN REQUIREMENTS

Design requirements for window workstations are provided below:

A. Field of View− The required field of view for a window workstation shall conform to the design eye volume of the 5.0 percent Japanese female to the 95.0 percent American male. Design eye volume is defined as the eye placement envelope constructed by the full range of head movement (+24.0 degree to −15.0 degrees in the YZ plane; +/− 54.0 degrees in the XZ plane) as defined by the Neutral Body Posture (Figure 3.3.4.3−1).

B. Deleted.

C. Multi−observer Windows − Windows shall accommodate a minimum of two observers. Work area layout shall be designed for two people.

D. Shielding

(1) Luminance Control − The capability to reduce window transmissivity through the addition of neutral filtering shall be provided.

(2) Complete Closure − The capability to completely block light transmittal through a window shall be provided.

(3) Sun Shades − When provided, external sun shades shall be adjustable.

E. Deleted.

F. Cleaning − Inside window surface shall be cleanable without damaging the window.

G. Deleted.

H. Dark Adaptation − Window workstations designed for operation in ambient light levels less that 5.0 fc shall provide dimming control of the ambient lighting.

I. Display Shielding − Displays shall be shielded from sunlight entering the window or be designed to be legible in sunlight.

J. Control Placement − Control placement and design shall allow crewmembers to assume a position relative to the window that places the window within the visual cone.

K. Restraints − The design and placement of window workstation restraints shall allow up to four continuous hours of use.

9.2.5.2 MAINTENANCE WORKSTATION DESIGN REQUIREMENTS

9.2.5.2.1 MAINTENANCE WORK AREA DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.2.5.2.2 MAINTENANCE WORK AREA DESIGN REQUIREMENTS

A. Utilities, including electrical power, data, telemetry and video interfaces shall be provided by the maintenance workstation to the maintenance work area to support the service, diagnostics, and repair of subsystem components and the downlink/uplink of video and data which supports maintenance operations.

    (1) Deleted.

    (2) Deleted.

    (3) Transparent Surfaces − All transparent surfaces shall be:

        a. scratch/mar resistant

        b. anti−fog and anti−icing

        c. shatter resistant

    (4) Capabilities − The maintenance work area shall provide the capability to operate the electrical, mechanical, vacuum, and fluid systems during corrective and preventive maintenance.

    (5) The maintenance work area shall have general purpose diagnostic equipment and shall accommodate special purpose diagnostic equipment.

    (6) The maintenance work area shall be equipped with a set of hand tools and with general purpose test and ancillary equipment and shall have ample stowage space for such tools, equipment, and materials. (e.g., wire, screws, tape, nuts, and raw stock.)

    (7) Deleted.

B. Contamination

    (1) Cleaning

        a. Exposed surfaces shall be cleanable.

        The maintenance work area shall be designed such that there are no crevices or narrow openings which can collect liquid or particulate matter.

        b. Grids or uneven surface shall be designed to permit cleaning of all areas without the use of special tools.

c. The maintenance work area shall have a vacuum or evacuation system for the purging and cleaning of replacement units/systems.

The vacuum effluence shall be contained to preclude internal and external environment contamination.

d. Means shall be provided to control odors and/or to remove particulates from a system.

All filters shall be accessible for cleaning and/or replacement.

Means shall be provided to prevent leakage of any entrapped material from a filter unit during removal.

e. Maintenance work area shall have the capability for the collection and disposal of debris, particulate matter, and liquid from the workstation atmosphere as well as from exposed interior surfaces of the work area.

f. Contamination Control −

1) A means shall be provided for passive contamination control in the transport of devices to and from the maintenance workstation.

2) The maintenance work area shall be provided with means to measure and monitor the contamination level within the work area, including the capability to measure the surface contamination level.

3) A means shall be provided for contamination control which assures prevention of mutual contamination between the ambient environment and the work area.

g. A means shall be provided for a passive contamination control method for IVA maintenance operations actions which will be performed remote from the maintenance work area.

(2) Hazardous Operations − The capability to seal hazardous operations from other areas shall be provided at the maintenance workstation for the duration of the operation.

(3) Particulate Matter Retention − The maintenance workstation shall be capable of particulate matter retention and effluent scrubbing/capture.

C. Deleted.

D. Deleted.

E. Deleted.

F. Illumination − Work area illumination shall be as specified in Figure 8.13.3.1.2−1.

9.2.6 PORTABLE WORKSTATIONS/TERMINALS

Requirements for portable workstations/terminals are given below:

A. One handed operation − Portable workstations shall provide for one−handed operation.

B. Restraints − Portable workstations shall have restraints in accordance with 11.7.3.3.

C. Deleted.

D. Connectors − If cable connections are required, dedicated connectors shall be used to interface the module with the facility by using a maximum cable length of 3.0 meters.

E. Handles − Portable workstations shall provide handles or grab areas per requirements given in 11.6.3.

9.3 CONTROLS

9.3.1 INTRODUCTION

This paragraph is not applicable for this document.

9.3.2 CONTROL DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.3.3 CONTROL DESIGN REQUIREMENTS

9.3.3.1 GENERAL REQUIREMENTS

General requirements for the design of controls are provided below:

A. Standardization − Controls shall be standardized using the following:

  (1) Control operation method

  (2) Control mounting and guarding

  (3) Control orientation

  (4) Control size and color coding

  (5) Deleted.

B. Detent Controls − Detent controls shall be selected over continuous controls whenever the operational mode requires control operation in discrete steps.

C. Stops − Stops shall be provided at the beginning and end of the range of control positions.

D. Load Limit − Controls shall withstand the crew−imposed limit loads given in Figure 9.3.3.1−1.

Item	Type of Load	Design Limit Load	Direction of Load
Levers, handles, operating wheels	Push or pull concentrated on most extreme tip or edge	220 N (49.46 lbf)	Any direction
Small knobs	Torsion	15 Nm (11 ft−lb)	Either direction

FIGURE 9.3.3.1−1 MAXIMUM CREW INDUCED DESIGN LIMIT LOADS (CONTROLS)

E. Blind Operation − Where actuation without visual observation is necessary, the controls shall be shaped−coded or separated from adjacent controls by at least 13.0 cm (5.0 in.).

F. High Force Controls − For IVA operations, the operating force of a control shall not exceed the minimum strength limit as defined in 4.9.3.

G. Miniature Controls −

(1) Miniature controls shall be used only when a space−to−functionality limitation exits and use by a pressure−suited crewmember is not required.

(2) Miniature controls shall not be used for nominal operations.

(3) The movements of miniature controls shall be consistent with those of standard controls.

(4) Miniature controls shall be protected to preclude accidental actuation.

H. Labeling/Coding − Emergency or Critical Controls shall be coded or labeled.

9.3.3.2 ACCIDENTAL ACTUATION

Requirements for reducing accidental actuation of controls are presented below:

A. Deleted.

B. Protective Methods − Protection shall be provided for controls to prevent accidental actuation. Protective methods include, but are not limited to, those listed below:

(1) 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.

(2) 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.

(3) Cover or guard the controls. Safety or lock wire shall not be used.

(4) If a cover guard is used, its location when open, the guard shall not cover or obscure the protected control or any adjacent controls.

(5) Provide the controls with interlocks so that extra movement (e.g., lifting switch out of a locked detent position) or the prior operation of a related or locking control is required.

(6) 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.

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

C. Noninterference − Protection devices shall not cover or obscure other displays and or controls.

D. High Traffic Areas − Critical controls shall not be located in translation paths.

E. Dead−Man Controls − For functions where continuous un−supervised, operations can pose any document program safety hazard (i.e., approved Hazard Analysis Report), a dead−man control device shall be used.

F. Barrier Guards

(1) Barrier guard spacing shall adhere to the requirements for use with toggle switches, rotary switches, and thumbwheels as shown in Figure 9.2.3.2.1−1 and 9.3.3.2−1.

(2) Barrier guards shall be designed and located so as to preclude their use as handholds.

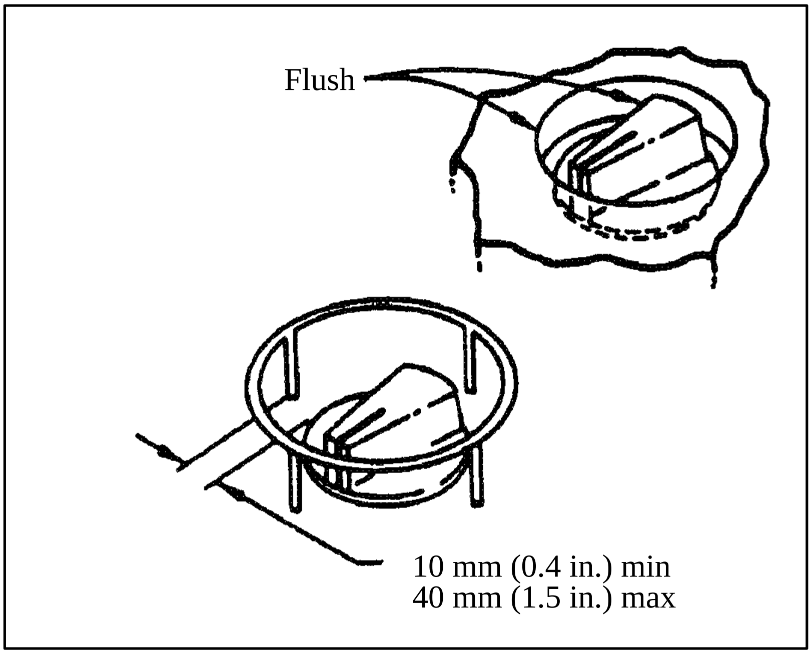


FIGURE 9.3.3.2−1 ROTARY SWITCH GUARD

G. Recessed Switch Protection − When a barrier guard is not used, rotary switches that control critical functions shall be recessed as shown in Figure 9.3.3.2−1.

H. Detachment − Covers and guards shall be designed to prevent inadvertent detachment.

I. Position Indication − When protective covers are used, control position shall be visible without requiring cover removal.

J. Hidden Controls − Controls that cannot be directly viewed shall be guarded to prevent inadvertent actuation.

K. Hand Controllers − Hand controllers shall have a separate on/off control to prevent inadvertent actuation when the controller is not in use.

9.3.3.3 CONTROL TYPES

9.3.3.3.1 KNOBS

Requirements for the design of knobs are provided below:

A. Discrete Rotary Selection Switches −

(1) General −

a. Rotary selector switches shall be used when four or more detented positions are required for discrete functions.

b. Deleted.

(2) Displacement − Up to twelve switch positions may be provided. Standard distance between positions shall be 30.0 degrees.

(3) Knob Dimensions − Pointer knobs of the type illustrated in Figure 9.3.3.2−1 are preferred for general use. Dimensions and alternate designs are, in order of preference, described within MIL−K−25049 or MIL−H−8810, MIL−STD−1472, AFSC DH 2−2, and MIL−STD−1348.

(4) Separation and Arrangement −

a. Rotary selector switches shall be designed with a moving pointer and a fixed scale.

b. Pointer knobs shall be mounted so that the parallax error does not exceed 25.0 percent of the distance between scale markings.

c. Deleted.

(5) Resistance −

a. 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.

b. The torque required to turn the switch from one detent position to another shall be no less than 9.0 N−cm (12.0 in. oz) at breakout and no more than 70.0 N−cm (100.0 in. oz) just prior to dropping into the next detent position.

(6) Direction of Movement − The order of positions shall be such that clockwise movement indicates ”on”, ascending order, increased performance.

B. Continuous Rotary Control Knobs −

(1) General −

a. Continuous rotary control knobs (e.g., rheostats, potentiometers) shall be used for precise adjustment of system parameters.

b. Continuous controls may be either single−turn or multi−turn.

(2) Displacement − Single−turn controls shall have a preferred standard deflection of 240 degrees, between limits located at the 8 o’clock and 4 o’clock positions.

(3) Resistance − The torque required to reposition the knob shaft shall be 6.0 to 25.0 N−cm (8.0 to 36.0 in. oz).

C. Ganged Control Knobs −

(1) Use − Use of ganged control knobs shall be limited to two−knob assemblies.

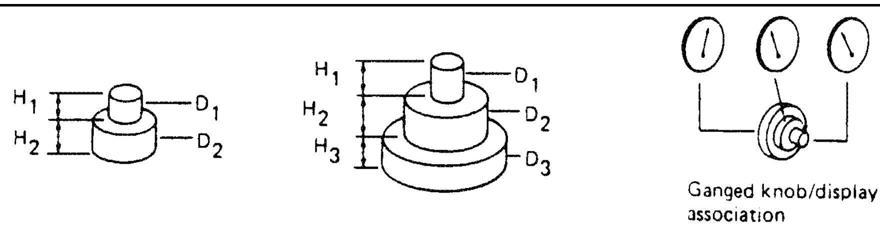
(2) Limitations − Ganged knob configuration shall not be used under the following conditions:

a. Accurate or rapid operations are required.

b. Frequent changes are necessary.

c. Gloved Operations are required.

(3) Dimensions, Torque, and Separation − Dimensions, torque, and separation of ganged control knobs shall conform to Figure 9.3.3.3.1−1.



	Dimensions									
	Two knob assembly, mm (in.)				Three knob assembly, mm (in.)					
	H_1	H_2	D_1	D_2	H_1	H_2	H_3	D_1	D_2	D_3
Minimum	16.0 (0.625)	13.0 (0.5)	13.0 (0.5)	22.0 (0.875)	19.0 (0.75)	19.0 (0.75)	6.0 (0.25)	13.0 (0.5)	44.0 (1.75)	75.0 (3.0)
Maximum				100.0 (4.0)						100.0 (4.0)

	Torque		Separation	
	To and including 25.0 mm (1.0 in.) diameter knobs	Greater than 25.0 mm (1.0 in.) diameter knobs	One hand individually Bare	Two hands simultaneously Bare
Minimum			25.0 mm (1.0 in.)	50.0 mm (2.0 in.)
Optimum			50.0 mm (2.0 in.)	75.0 mm (3.0 in.)
Maximum	32.0 mN−m (4.5 in−oz)	42.0 mN−m (6.0 in−oz)		

FIGURE 9.3.3.3.1−1 GANGED CONTROL KNOBS

(4) Serration of Ganged Control Knobs −

a. Knobs shall be serrated.

b. Fine serrations shall be used on precise adjustment knobs.

c. Coarse serrations shall be used on gross adjustment knobs.

(5) Marking of Ganged Control Knobs −

a. An indexing mark or pointer shall be provided on each knob.

b. Marks or pointers shall be uniquely labeled for each knob.

(6) 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 9.3.3.3.1−1).

(7) Inadvertent Operation − A secondary knob control movement shall be required to prevent inadvertent actuation of one knob as the other is being adjusted on a ganged assembly.

9.3.3.3.2 THUMBWHEEL CONTROLS

Design requirements for thumbwheel controls are provided below:

A. Discrete Position Thumbwheels −

(1) Discrete position thumbwheels shall have ten or fewer detent positions.

(2) The standard distance between positions shall be 36.0 degrees.

(3) Deleted.

(4) Each position around the circumference of a discrete thumbwheel shall have a concave surface or shall be separated by a high−friction (e.g., knurled) area that is raised from the periphery of the thumbwheel.

(5) 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 of discrete thumbwheel controls to movement shall be between 11.0 and 34.0 N−cm (16.0 to 48.0 in. oz).

(6) Movement of the thumbwheel forward, up, or to the right shall produce an increase in the setting value.

B. Continuous Type Thumbwheels −

(1) Continuous type thumbwheels shall have a standard deflection of 300 degrees.

(2) Hard stops shall be provided to limit the maximum travel of continuous thumbwheels.

(3) Continuous thumbwheels shall be serrated.

(4) The resistance of continuous thumbwheel controls to movement shall be between 1.0 and 4.0 N−cm (2.0 and 6.0 in. oz).

(5) Movement of the thumbwheel forward, up, or to the right shall produce an increase in the setting value.

C. Coding −

(1) Thumbwheel controls shall be coded by location, labeling, or color

(2) Where used as input devices, thumbwheel switch OFF or NORMAL positions shall be color coded to permit a visual check that the digits have been reset to these positions.

9.3.3.3.3 VALVE CONTROLS

Requirements for the design of valve controls are provided below:

A. Low−Torque Valves − Valves requiring 1 N−m (10 in−lb) or less for operation are classified as ”low−torque” valves and shall be provided with a ”central pivot” type of handle, 5.5 cm (2.25 in.) or less in diameter (see Item D. below).

B. Intermediate−Torque Valves − Valves requiring between 1.0 and 2.0 N−m (10.0 and 20.0 in−lb) for operation are classified as ”intermediate torque” valves and shall be provided with a ”central pivot” type handle, 5.5 cm (2.25 in.) or greater in diameter, or a ”level (end pivot) type” handle, 7.5 cm (3.0 in.) or greater in length.

C. High−Torque Valves − Valves requiring 2.0 N−m (20.0 in−lb) or more for operation are classified as ”high−torque” valves and shall be provided with ”lever type” handles greater than 7.5 cm (3.0 in.) in length.

D. Handle Dimensions −

(1) Valve handles shall adhere to the configuration illustrated in Figures 9.3.3.3.3−1 and 9.3.3.3.3−2.

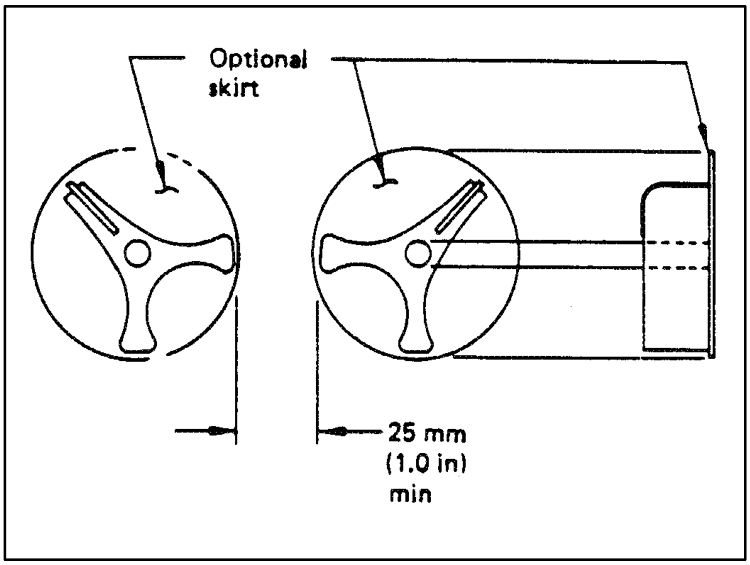


FIGURE 9.3.3.3.3−1 VALVE HANDLE − CENTRAL PIVOT TYPE

(2) Handles shall be contoured.

(3) Circular handles shall employ concave areas or convex projections along the periphery of the handle.

E. Valve Controls − Rotary valve controls shall open the valve with a counter−clockwise motion.

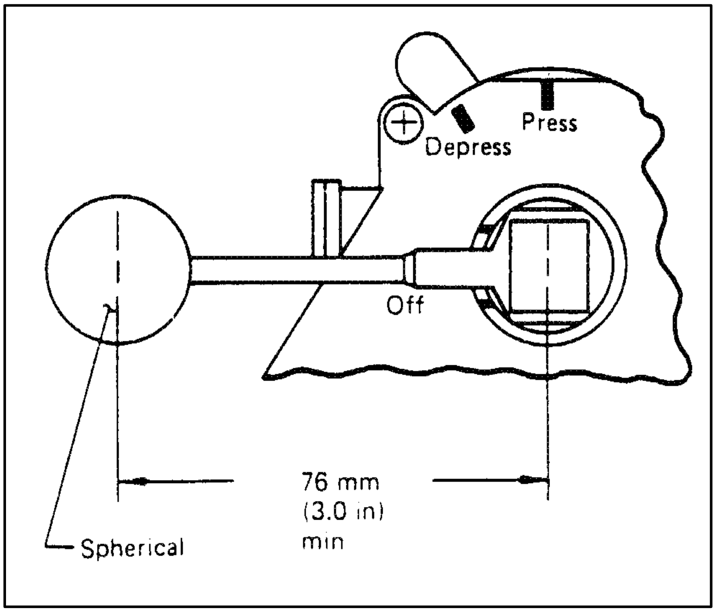


FIGURE 9.3.3.3.3−2 VALVE HANDLE − LEVER TYPE

9.3.3.3.4 CRANKS

Requirements for the design of cranks are provided below:

A. Dynamics −

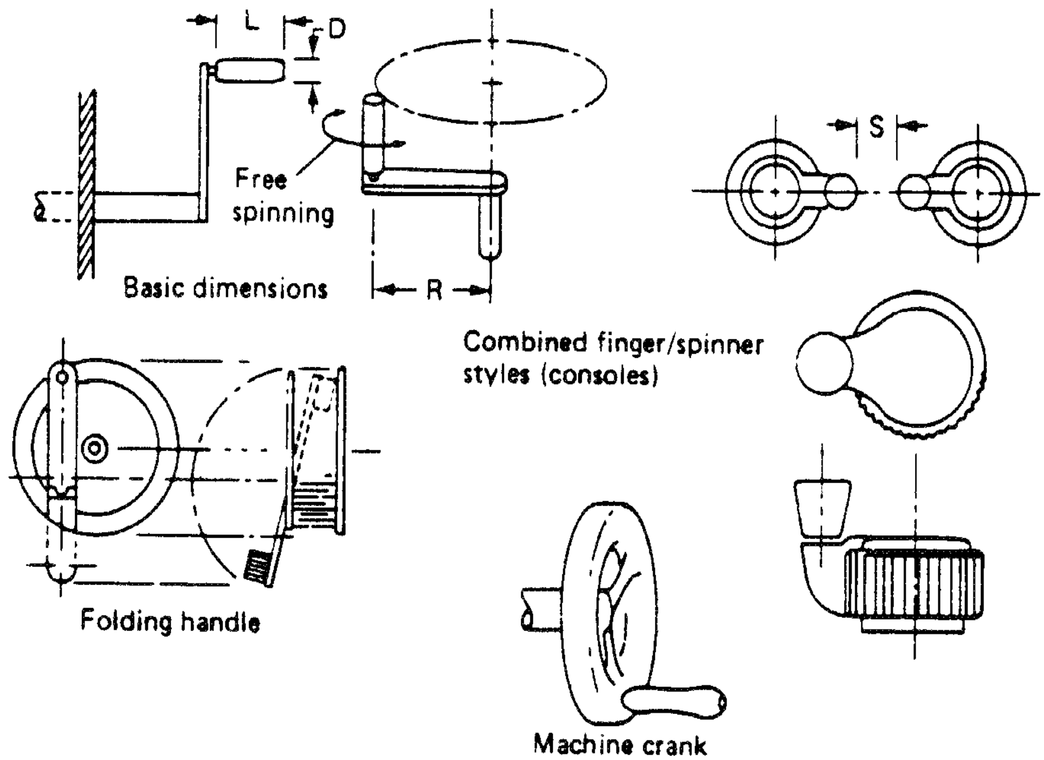
(1) Where cranks are used for tuning, or other processes involving numerical selection, each rotation shall correspond to a power of ten.

(2) The gear ratio and dynamic characteristics of such cranks shall allow placement of the follower without overshooting or undershooting.

B. Grip Handle − The crank grip handle shall be designed so that it turns around its shaft.

C. Dimensions, Resistance, and Separation − Dimensions, resistance, and separation between adjacent swept circular areas of cranks shall conform to the criteria of Figure 9.3.3.3.4−1.

D. Deleted.



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 22.0 N (5.0 lb) (wrist and finger movement	Minimum	25.0	1.0	10.0	0.375	38.0	1.5	13.0	0.5
	Preferred	38.0	1.5	13.0	0.5	75.0	3.0	65.0	2.5
	Maximum	75.0	3.0	16.0	5/8	125.0	5.0	115.0	4.5
Heavy loads More than 22.0 N (5.0 lb) (arm movement)	Minimum	75.0	3.0	25.0	1.0	190.0	7.5	125.0	5.0
	Preferred	95.0	3.75	25.0	1.0	–	–	–	–
	Maximum	–	–	38.0	1.5	510.0	20.0	230.0	9.0

Note:
(1) S, Separation between adjacent controls: 75.0 mm (3.0 in.) minimum.

FIGURE 9.3.3.3.4−1 CRANKS

9.3.3.3.5 HANDWHEELS

Requirements for the design of handwheels are provided below:

A. Restraints − Restraints shall be provided for the operator.

B. Turning Aids − Knurling, indentation, high−friction covering, or a combination of these shall be built into the handwheel.

C. Deleted.

9.3.3.3.6 LEVERS

Requirements for the design of levers are provided below:

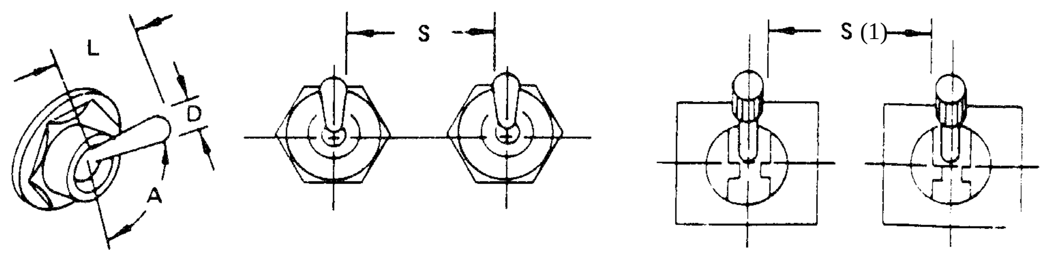
A. Coding − When several levers are grouped, the lever handles shall be coded.

B. Deleted.

9.3.3.3.7 TOGGLE SWITCHES

Requirements for the design of toggle switches are provided below:

A. Dimensions − Dimensions for a standard toggle switch shall conform to the values presented in Figure 9.3.3.3.7−1.



	Dimensions		Resistance	
	L Arm length	D Control tip	Small switch	Large switch
Minimum	13.0 mm (0.5 in.)	3.0 mm (0.125 in.)	2.8 N (10.0 oz)	2.8 N (10.0 oz)
Maximum	50 mm (2.0 in.)	25.0 mm (1.0 in.)	4.5 N (16.0 oz)	11.0 N (40.0 oz)
	Displacement between positions			
	A 2 position		3 position	
Minimum	30 degrees		17 degrees	
Maximum	80 degrees		40 degrees	
Desired			25 degrees	
	Separation			
	Single finger operation		S	
		(1)	Single finger sequential operation	Simultaneous operation by different fingers
Minimum	19.0 mm (0.75 in.)	25.0 mm (1.0 in.)	13.0 mm (0.50 in.)	16.0 mm (5/8 in.)
Optimum	50.0 mm (2.0 in.)	50.0 mm (2.0 in.)	25 mm (1.0 in.)	19.0 mm (0.75 in)

Note:
(1) Using a lever rock toggle switch.

FIGURE 9.3.3.3.7−1 TOGGLE SWITCHES

B. Indication of Actuation −

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

(2) Switch design shall preclude stoppage between positions.

(3) Switch position shall be visible from the design eye point.

C. Operating Force −

(1) Operating force shall be in the range of 3.0 to 30.0 N (0.63 to 6.25 lbf).

(2) Deleted.

(3) For lever lock (pull to unlock) toggle switches, resistance of lift−to−unlock mechanisms shall not exceed 13.0 N (3.0 lbf).

D. Orientation − The direction of toggle switch operation shall be vertical.

E. Position Designation − Switch actuation shall control the system functions as indicated in Figure 9.3.3.3.7−2.

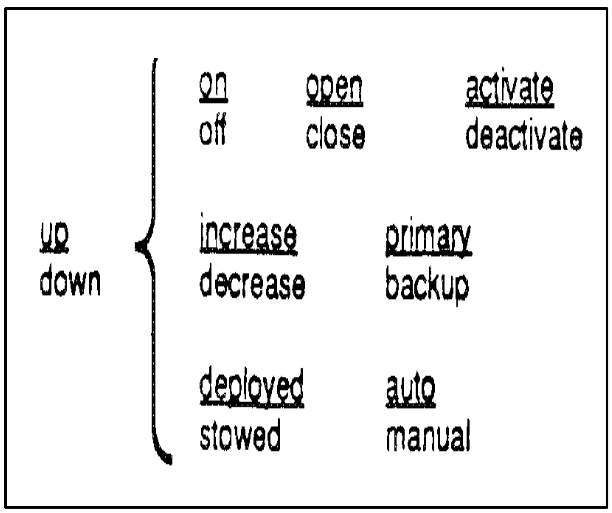


FIGURE 9.3.3.3.7−2 TOGGLE SWITCH POSITION DESIGNATION

F. Off Position − Where a third position is added for off, the off mode shall be either located in the center position (preferred) or in the bottom position when the center position is precluded by design.

9.3.3.3.8 PUSH BUTTONS

Requirements for the design of push button controls are provided below:

A. Activation −

(1) Latching Push Button (push−on, lock−on) −

a. The ”lock−on” state shall be visually identifiable by button displacement.

b. Activation shall be indicated by a drop in resistance or an audible click.

(2) Momentary Push Button (push−on, release−off) − Activation shall be indicated by positive feedback.

(3) Alternate Action Push Button (push−on, push−off) − Activation shall be indicated by a drop in resistance, an auditory click, and an associated display action.

(4) Touch Sensitive (non−mechanical) − Touch sensitive push buttons shall include positive feedback.

B. Resistance − The resistance of push buttons to movement shall be 3.0 to 24.0 N (10.0 to 85.0 oz).

C. Dimension −

(1) Deleted.

(2) Deleted.

(3) Deleted.

(4) The height and width (or diameter, as applicable) of push buttons shall be 2 cm (0.75 in.) minimum and 4.0 cm (1.50 in.) maximum.

(5) The illuminated area of push button signal lights shall not be less than 2.5 cm^2 (0.40 in^2) and not greater than 10.0 cm^2 (1.5 in^2).

D. Displacement −

(1) Momentary push buttons shall have a total displacement of 3.2 to 18.4 mm (0.125 to 0.725 in.).

(2) Latching push buttons shall have a total displacement of 6.4 to 18.4 mm (0.250 to 0.725 in.).

(3) Alternate action push buttons shall have a displacement of 3.2 to 18.4 mm (0.125 to 0.725 in.).

(4) Pre−travel shall be 0.32 to 1.52 cm (0.125 to 0.6 in.).

(5) Over−travel shall be 0.32 cm (0.125 in.) maximum.

9.3.3.3.9 FOOT OPERATED SWITCHES

Design requirements for foot operated switches are provided below:

A. Use −

(1) Deleted.

(2) Foot−operated switches shall be limited to noncritical or infrequent operations.

(3) Foot−operated switches shall be compatible with the restraint system being employed.

B. Operation −

(1) Foot−operated switches shall be positioned for operation by the toe and the ball of the foot rather than by the heel.

(2) Foot−operated switches shall be located so that the crewmember can center the ball of the foot on the switch button, consistent with section 3.0.

(3) Deleted.

(4) Foot−operated switches shall be operable by a crewmember wearing Government Furnished Equipment IVA footwear.

C. Feedback − A positive indication of control activation shall be provided (e.g., snap feel, audible click, associated visual display).

9.3.3.3.10 PEDALS

Design requirements for pedals are provided below:

A. Control Return −

(1) Except for controls which generate a continuous output, pedals shall return to the original null position without requiring assistance from the crewmember.

(2) For pedals in which the operator may normally rest the foot on the control between operations, resistance shall be provided to prevent inadvertent activation of the control (e.g., accelerator pedal).

B. Pedal Travel Path − The travel path shall be accessible to the crewmember, providing articulation paths for the operator’s limbs based on anthropometric requirements in section 3.0.

C. Nonslip Pedal Surface − Pedals shall be provided with a nonslip surface.

9.3.3.3.11 ROCKER SWITCHES

Where rocker switches are used, the following design requirements apply:

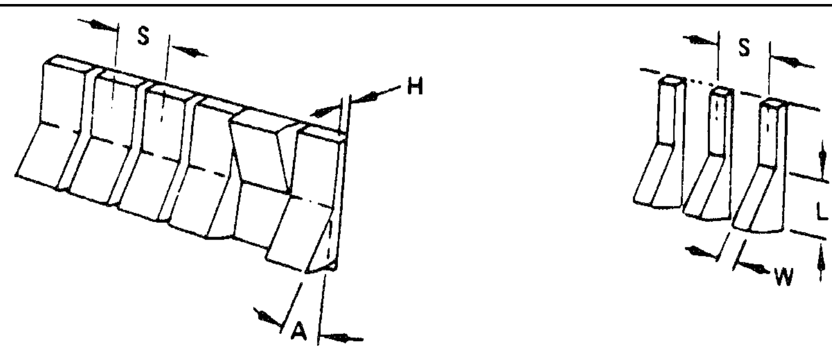
A. Positive Indication − An indication of control activation shall be provided (e.g., snap feel, audible click, associated or integral light).

B. Dimensions, Resistance, Displacement, and Separation −

(1) Dimensions, resistance, displacement, and separation between centers of rocker switches shall conform to the criteria in Figure 9.3.3.3.11−1.

(2) Resistance shall gradually increase, then drop when the switch snaps into position.

(3) The switch shall not be capable of being stopped between positions.



	Dimensions		
	W, Width	L, Length	Resistance
Minimum	6.0 mm (0.25 in.)	13.0 mm (0.5 in.)	2.8 N (10.0 oz)
Maximum			11.0 N (40.0 oz)
	Displacement		Separation (center−to−center)
	H, Ht, Depressed	A, Angle	S (bare hand)
Minimum	3.0 mm (0.125 in.)	30 degrees	19.0 mm (0.75 in.)
Reference: 2, page 96			

FIGURE 9.3.3.3.11−1 ROCKER SWITCHES

C. Orientation −

(1) Deleted.

(2) Activation of the upper wing of a rocker switch 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.

D. Deleted.

9.3.3.3.12 PUSH−PULL CONTROLS

Design requirements for push−pull controls are provided below:

A. Handle Dimensions, Displacement, and Clearances − Handle dimensions, displacement, and clearances for push−pull control handles shall conform to criteria in Figure 9.3.3.3.12−1.

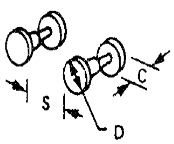
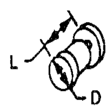
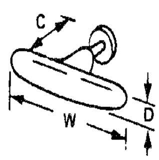
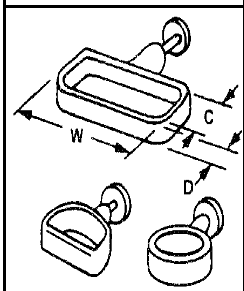
Configuration example	Application criteria	Design criteria				
		Dimensions			Displacement	Separation
	Push−pull control for two−position mechanical and/or electrical systems. Alternate three−position plus rotary function acceptable for application such as vehicle headlights plus parking lights, panel and dome lights provide serrated rim.	D, min dia 19.0 mm (0.75 in.)	C, min clearance 25.0 mm (1.0 in.) Add 13.0 mm (0.50 in.) for gloved hand		25.0 +/− 13.0 mm (1.0 +/− 0.5 in.) min between pull positions 13.0 mm (0.5 in.)	S, min space between 38.0 mm (1.5 in.) Add 13.0 mm (0.5 in.) for gloved hand
	Alternate handle; miniature electrical panel switch only. Avoid glove use application.	D, min dia 6.0 mm (0.25 in.)	NA	L, min length 19.0 mm (0.75 in.)	Minimum 13.0 mm (0.5 in.)	S, min space between 25.0 mm (1.0 in.)
	High−force push−pull, for two−position mechanical system only.	W, min width 100.0 mm (4.0 in.)	D, depth 16.0 to 38.0 mm (5/8 to 1.5 in.)	C, min clearance 38.0 mm (1.5 in.) Add 6.0 mm (0.25 in.) for gloved hand	Minimum 25.0 mm (1.0 in.) Preferred 50 mm (2.0 in.)	S, min space between 13.0 mm (0.5 in.)
	Same as above. Preferred where possible garment or cable−snag possibility exists. Note: One− and two−finger pulls also acceptable for less than 18.0 N (4.0 lb) applications.	W, min width 100.0 mm (4.0 in.) Add 25.0 mm (1.0 in.) for gloves	D, depth 16.0 to 38.0 mm (5/8 to 1.5 in.)	C, min clearance 32.0 mm (1.5 in.)	Minimum 25.0 mm (1.0 in.) Preferred 50.0 mm (2.0 in.)	

FIGURE 9.3.3.3.12−1 PUSH−PULL CONTROLS

B. Rotation −

(1) Except for combination push−pull/rotate switch configurations, push−pull control handles shall be keyed to a nonrotating shaft.

(2) 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.

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

D. Action of push−pull controls shall be:

(1) Pull towards the operator for ON or activation; push away for OFF or deactivation.

(2) Clockwise for activation or increasing function of combination pull/rotary switches.

E. Resistance − Force for pulling a panel control with fingers shall be not more than 18.0 N (4.0 lb); for pulling a T−bar with four fingers, force shall be not more than 45.0 N (10.0 lb).

9.3.3.3.13 CIRCUIT BREAKERS

Design requirements for circuit breakers are provided below:

A. General −

(1) Deleted.

(2) Circuit breakers shall be resettable.

(3) Circuit breakers shall be of the plunger type (”pop−out”, pull−to−release, push−to−reset).

(4) All tripped conditions shall be visually indicated.

B. Deleted.

C. Separation and Arrangement −

(1) A minimum 1.27 cm (0.5 in.) edge−to−edge distance shall exist between circuit breakers grouped in horizontal rows.

(2) A minimum of 2.5 cm (1.0 in.) shall be between rows.

D. Displacement −

(1) All tripped conditions of the plunger type circuit breaker shall be indicated by a white or silver band. When the circuit breaker is closed, the band shall not be visible (see Figure 9.3.3.3.13−1).

(2) The “off” or tripped condition of the switch type circuit breaker shall be indicated when the handle is in the ”down” position (see Figure 9.3.3.3.13−1)

E. Resistance −

(1) The force required to reset a plunger type circuit breaker shall not exceed 53.0 N (12.0 lb).

(2) The force required to manually trip a plunger type circuit breaker shall not exceed 35.0 N (8.0 lb).

9.3.3.3.14 SLIDE SWITCH CONTROLS

Design requirements for slide switch controls are provided below:

A. Dimensions, Resistance, and Separation −

(1) Dimensions, resistance, and separation of slide switch handles shall conform to criteria in Figure 9.3.3.3.14−1.

(2) Detents shall be provided for discrete control settings. Resistance shall increase, then drop when the switch snaps into position.

(3) The discrete control slide switch shall not be capable of stopping between positions.

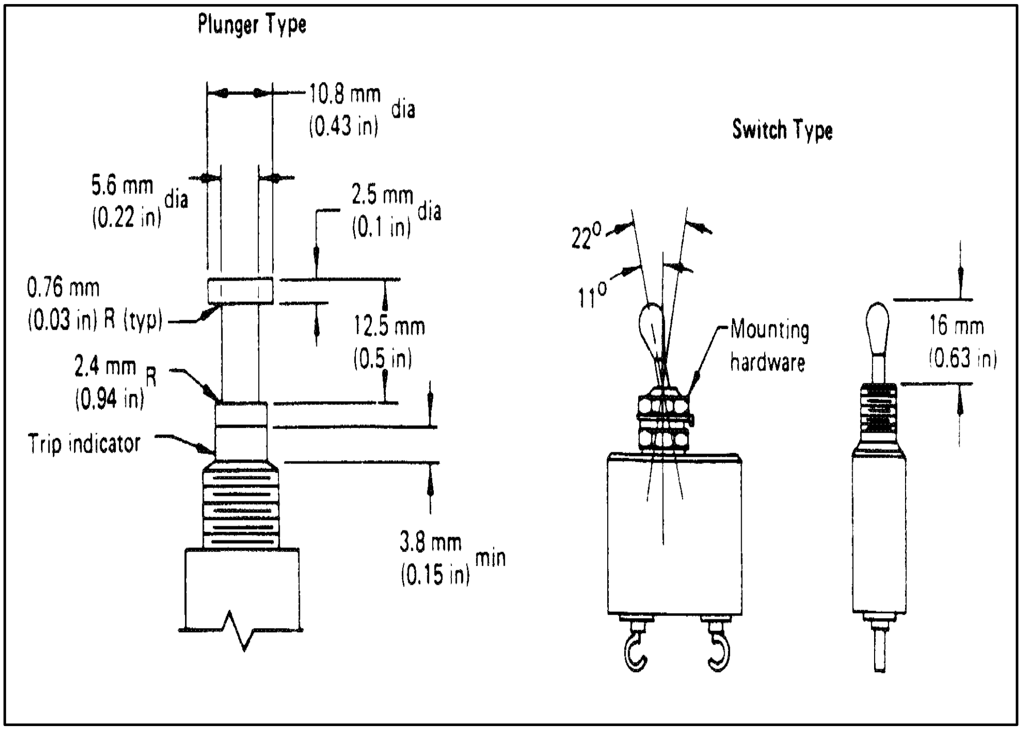
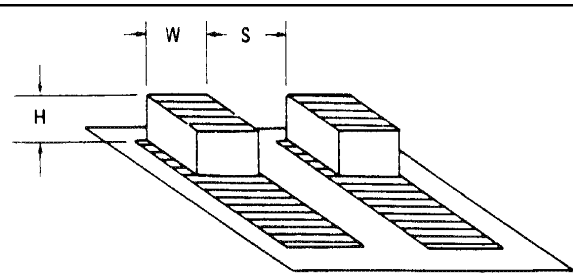


FIGURE 9.3.3.3.13−1 CIRCUIT BREAKERS



	Dimensions		Resistance	
	Actuator height, H	Actuator width, W	Small switch	Large switch
Minimum	6.0 mm (0.25 in.)	6.0 mm (0.125 in.)	2.8 N (10.0 oz)	2.8 N (10.0 oz)
Maximum	−	15.0 mm (1.0 in.)	4.5 N (16.0 oz)	11.0 N (40.0 oz)
	Separation, S			
	Single finger operation	Single finger sequential operation	Simultaneous operation by different fingers	
Minimum	19.0 mm (0.75 in.)	13.0 mm (0.5 in.)	16.0 mm (5/8 in.)	
Maximum	50.0 mm (2.0 in.)	25.0 mm (1.0 in.)	19.0 mm (0.75 in.)	

FIGURE 9.3.3.3.14−1 SLIDE SWITCHES

B. Deleted.

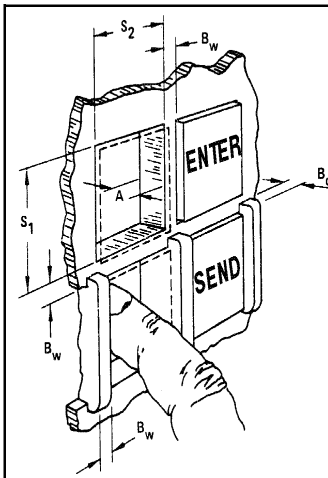
C. Positive Indication − Slide switch controls that are analog or involve more than two discrete positions shall be designed to provide positive indication of control setting.

D. Switch Action − Moving the slide up or away from the operator shall result in 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.

9.3.3.3.15 LEGEND SWITCHES

Design requirements for legend switches are provided below:

A. Dimensions, Resistance, Displacement, and Separation − Dimensions, resistance, displacement, and separation between adjacent edges of legend switches shall conform to the criteria in Figure 9.3.3.3.15−1.



	S_1, S_2 Size	A Displacement	Barriers B_w	Barriers B_d	Resistance
Minimum	19.0 mm (0.75 in.) (1)	3.0 mm (0.125 in.) (2)	3.0 mm (0.125 in.)	5.0 mm (0.1875 in.)	2.8 N (10 oz) (3)
Maximum	38.0 mm (1.5 in.)	6.0 mm (0.25 in.)	6.0 mm (0.25 in.)	6.0 mm (0.25 in.)	16.7 N (60.0 oz)

Note:
(1) 15.0 mm (5/8 in.) where switch is not depressed below the panel.
(2) 5.0 mm (0.1875 in.) for positive position switches.
(3) 5.6 N (20.0 oz) for use in moving vehicles

FIGURE 9.3.3.3.15−1 LEGEND SWITCHES

B. Barrier Height −

(1) Barrier height from panel surface shall conform to the criteria in Figure 9.3.3.3.15−1. Unless otherwise specified, barriers are required on critical switches and on switches likely to be inadvertently actuated.

(2) Barriers, when used, shall not obscure visual access to controls, labels, or displays.

C. Other Requirements −

(1) For positive indication of switch activation, the legend switch shall be provided with a detent or click.

When touch−sensitive switches are used, a positive indication of activation shall be provided.

(2) The legend shall be legible with or without internal illumination.

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

(4) 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.

(5) Legend switches with integral Light Emitting Diode (LED) shall be replaceable from the front as a complete unit.

(6) There shall be a maximum of three lines of lettering on the legend plate.

9.3.3.3.16 PRINTED CIRCUIT (DIP) SWITCHES

A. Use − Dual Inline Package (DIP) switches shall not be used for nominal operations or routine maintenance.

B. Dimensions, Resistance, Displacement, and Separation −

(1) Deleted.

(2) Deleted.

(3) The travel shall be at least twice the length of the actuator.

When actuators are rocker−type, the actuated wing shall be flush with the surface of the module.

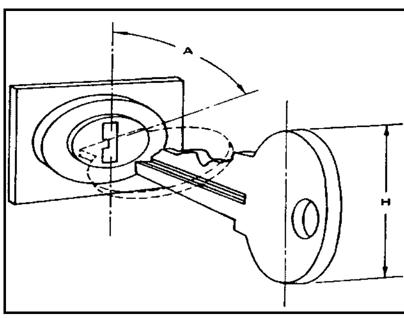
(4) Deleted.

C. Shape − The surface of the actuator shall be indented to accept the point of the stylus.

9.3.3.3.17 KEY−OPERATED SWITCHES

Design requirements for key−operated switches are provided below:

A. Dimensions, Displacement, and Resistance − Dimensions, displacement, and resistance shall conform to the criteria in Figure 9.3.3.3.17−1.



	Displacement, A	Height, H	Resistance
Minimum	30 degrees	13.0 mm (0.5 in.)	115.0 mN−m (1.0 in−lb)
Maximum	90 degrees	75.0 mm (3.0 in.)	680 mN−m (6.0 in−lb)

FIGURE 9.3.3.3.17−1 KEY OPERATED SWITCH

B. Color, Shape, and Size Coding −

(1) If color is used to aid in identifying various keys by function, or use location, red (#11105 or #21105 of FED−STD−595) shall be reserved for emergency functions.

(2) Deleted.

(3) If size coding is used, no more than two sizes shall be employed.

Dimensions shall reflect the minima and maxima shown in Figure 9.3.3.3.17−1.

C. Marking and Labeling − Key−operated switch applications shall include position markings and labels.

D. Other Requirements −

(1) Keys with teeth on both edges shall fit the lock with either side up or forward with respect to the normal position of the operator.

(2) Keys with a single row of teeth shall be inserted into the lock with the teeth pointing up or forward with respect to the normal position of the operator.

(3) Locks shall be oriented so the key's vertical position is the OFF position.

(4) Operators shall normally not be able to remove the key from the lock unless the switch is turned OFF.

(5) Activation of an item by a key−operated switch shall be accomplished by turning the key clockwise from the vertical OFF position.

9.3.3.4 COMPUTER INPUT DEVICES

9.3.3.4.1 KEYBOARDS

Requirements for keyboard design are provided below:

9.3.3.4.1.1 LAYOUT

A. Alphanumeric − The basic alphanumeric character arrangement for standard keyboards shall conform to USA Standard Typewriter Pairing of the American Standard Code for Information Interchange. See Figure 9.3.3.4.1.1−1.

B. Deleted.

C. Number Keypad −

(1) When used, a number keypad shall be to the right−hand side of the main keyboard.

(2) The arrangement of the numeric keypad shall conform to Figure 9.3.3.4.1.1−2.

D. Function Keys − The use of function keys will depend on the specific system that the keyboard is a part of.

(1) Deleted.

(2) Location of Function Keys − Certain functions that occur together should be placed in the same area.

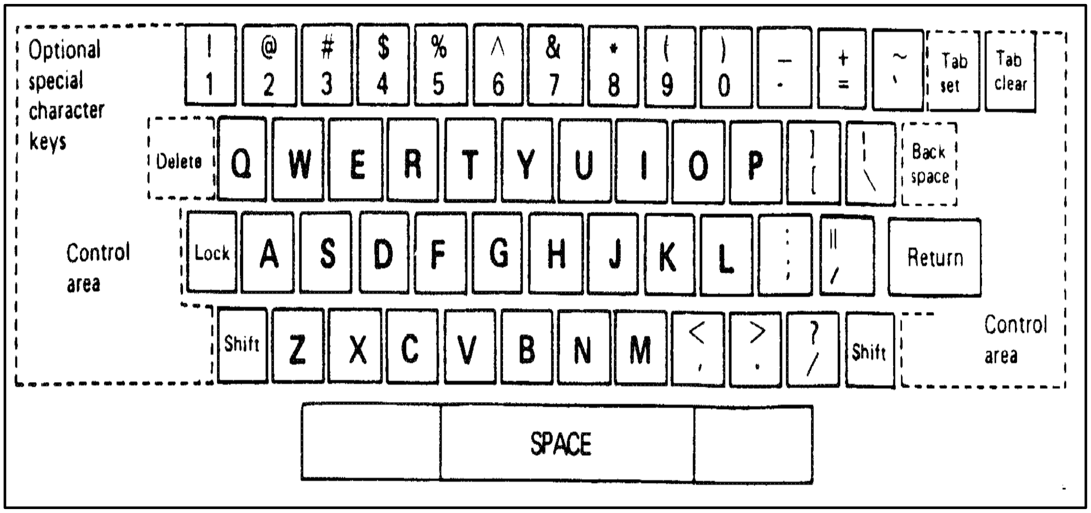


FIGURE 9.3.3.4.1.1−1 KEYBOARD LAYOUT

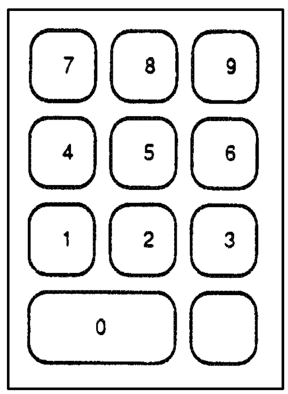


FIGURE 9.3.3.4.1.1−2 NUMERIC KEYBOARD

(3) Function Key Types −

a. Fixed Function Keys −

1) Programmable fixed function keys shall be provided.

2) In addition, at least one CONTROL key and a set of cursor control keys shall be provided.

b. Cursor Movement Keys − Cursor movement keys shall be arranged in a spatial configuration reflecting the direction of actual cursor movement (see Figure 9.3.3.4.1.1−3).

c. Deleted.

(4) Deleted.

(5) Deleted.

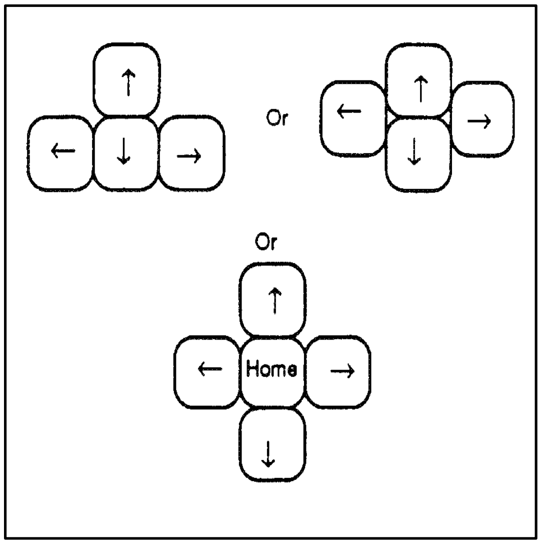


FIGURE 9.3.3.4.1.1−3 CURSOR MOVEMENT KEYS

9.3.3.4.1.2 GENERAL

A. Deleted.

B. Control Switches −

(1) All commonly used controls associated with keyboard functioning (e.g., on/off) shall be readily accessible to the user.

(2) Both the controls and their labels shall be visible to the user.

C. Key Markings −

(1) The key legends shall be placed on the key in such a way as to be resistant to wear and abrasion.

(2) If the label cannot be placed on the key, it shall be placed above it.

D. Finger Placement Aids − Two home−row keys (right hand and left hand) on a standard keyboard and the ”5” on number keyboards shall be distinguishable to facilitate the correct placement of the fingers for touch typists.

E. Keyboard Placement − The keyboard shall be placed within the reach envelope as defined by the neutral body posture, Figure 3.3.4.3−1, and the restraint system being employed.

F. Operating Force − The operating force of a terminal keyboard shall be per Figure 9.3.3.4.1.2−1.

	Dimensions	Resistance		
	Key−width Bare−handed	Numeric	Alpha−numeric	Dual function
Minimum	10 mm (0.385 in.)	1.0 N (3.5 oz)	250 mN (0.9 oz)	250 mN (0.9 oz)
Maximum	19 mm (0.75 in.)	4.0 N (14.0 oz)	1.5 N (5.3 oz)	1.5 N (5.3 oz)
Preferred	13 mm (0.5 in.)			
	Displacement			Separation
	Numeric	Alpha−numeric	Dual function	(between adjacent key tops)
Minimum	0.8 mm (0.03 in.)	1.3 mm (0.05 in.)	0.8 mm (0.03 in.)	6.4 mm (0.25 in.)
Maximum	4.8 mm (0.19 in.)	6.3 mm (0.25 in.)	4.8 mm (0.19 in.)	
Preferred				6.4 mm (0.25 in.)
(1) See Figure 9.2.3.2.1−1 for nonkeyboard pushbutton layout dimensions.				

FIGURE 9.3.3.4.1.2−1 KEYBOARD

G. Key Displacement − The key displacement for activation shall be 0.2 cm (0.08 in.) +/−0.02 cm with bottoming out occurring at 0.4 cm (0.16 in.) +/− 0.04 cm.

H. Feedback −

(1) The screen shall provide visual feedback each time a key is activated.

(2) Auditory feedback indicating key activation shall be provided. User shall have the option of deactivating this feedback.

(3) Deleted.

I. Keyboard Interlock − Keyboard interlock shall exist to prevent the outputs from two or more simultaneously depressed keys from either jamming the print mechanism or outputting an invalid keycode.

J. Size and Shape of Keys − The keys shall have a dished profile curvature.

K. Key Legend − Alphanumeric legends shall not be smaller than 0.3 cm (0.12 in.).

L. Color and Reflection of Keys −

(1) The surface of keys shall have a matte finish.

(2) The standard key set, including those keys in Figure 9.3.3.4.1.1−1, shall be FED−STD−595 neutral color (e.g., beige or gray).

M. Function Key Labels − Function keys shall be labeled with function symbols, the function title, function title abbreviations, or function codes, in that order of preference.

N. Key Repeat −

(1) Alphanumeric and symbol character keys shall automatically repeat when held down.

(2) The repeat shall have a delay of 0.5 +/− 0.25 seconds and a repeat rate of 0.1 +/− 0.05 seconds.

(3) The physical release of the key shall terminate the repeat.

O. Key Spacing − The spacing of keys shall be as indicated in Figure 9.3.3.4.1.2−1.

P. Deleted.

9.3.3.4.2 JOYSTICKS

Design requirements for joysticks are provided below:

A. Isotonic Joystick −

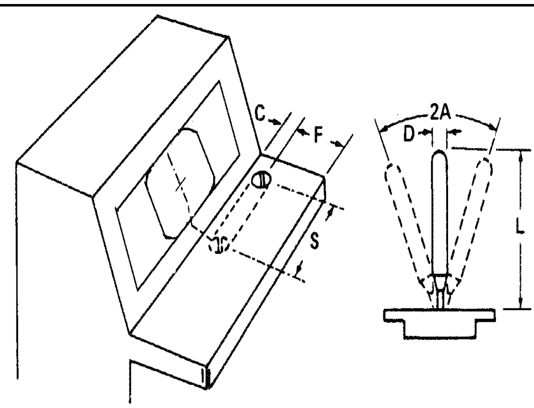
(1) Movement shall be smooth in all directions. Positioning of a follower on a display shall be attainable without noticeable backlash, cross−coupling, or the need for multiple corrective movements.

(2) Control ratios, friction, and inertia shall meet the dual requirements of rapid gross positioning and precise fine positioning.

(3) When used to create free−drawn graphics, the refresh rate for the follower on the Visual Display Terminal (VDT) shall be no less than 55.0 Hz.

(4) The delay between control movement and the confirming display response shall not exceed 0.1 second.

(5) Dimensions, resistance, and clearance shall conform to criteria in Figure 9.3.3.4.2−1.



	Dimensions. mm (in.)		Resistance,	Displacement	Clearance, mm (in.)		
	Dia, D	Length, L	N (oz)	A	Display ℄ to stick ℄, S	Around stick, C	Stick to shelf front, F
Minimum	6.5 (0.25)	75.0 (3.0)	3.3 (12.0)		0		120.0 (4.75)
Maximum	16.0 (0.62)	150.0 (6.0)	8.9 (32.0)	45.0 degrees	400 (15.75)	(1)	250 (9.88)

Note:
(1) Maximum stick excursion plus 100.00 mm (4.0 in.).

FIGURE 9.3.3.4.2−1 ISOTONIC JOYSTICK

(6) No other controls shall be placed within the envelope created by the largest amplitude motions of the joystick handle and the 95th percentile American male operator's hand when held with a finger−thumbtip grip.

No other controls shall be placed such that the operator must reach through the joystick−hand envelope to operate them.

(7) Joystick placement shall allow operation when the operator is using the restraint system provided and maintaining a viewing position with respect to the VDT.

B. Isometric Joystick −

(1) The output shall be proportional to the magnitude of the applied force.

(2) The isometric joystick shall deflect in response to applied force.

(3) Deleted.

9.3.3.4.3 LIGHT PENS

Requirements for the use of light pens are provided below:

A. Activating Device −

(1) Light pens shall be equipped with an activating device.

If the activating device is a push button switch located at the tip, the force required shall be from 0.6 N to 1.4 N (2.0 to 5.0 oz).

(2) Feedback shall be provided when the activating device is operated.

B. Position Indication −

(1) The computer software for light pens shall display a cursor under the light pen position.

(2) The cursor shall be visible to the operator and move with the light pen.

C. Feedback − Indication shall be provided that input by the light pen has been received.

D. Dimensions − Light pens shall be between 11.9 and 18.0 cm (4.7 and 7.1 in.) long and 0.8 and 2.0 cm (0.3 and 0.8 in.) in diameter.

E. Storage − Storage for light pens shall be provided.

F. Follower Movement −

(1) Light pens shall provide a movement of the follower when used as a two−axis controller.

(2) The refresh rate for the follower shall be no less than 55.0 Hz.

9.3.3.4.4 MOUSE

Design requirements for a mouse control device are provided below:

A. Use − When used, a mouse shall be only used for zero−order control or rate control.

B. Deleted.

C. Mouse Accuracy − The mouse shall be movable in any direction without a change of grip and result in movement of the cursor in the same direction (+/− 10 degrees).

D. Handedness − The mouse shall be operable with either hand.

E. Cursor Control − The controller shall not drive the cursor to a non−visible portion of the total display area.

F. Dimensions and Shape − The mouse shall have no sharp edges but shall have limiting dimensions, as indicated in Figure 9.3.3.4.4−1.

	Minimum	Maximum
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.)

FIGURE 9.3.3.4.4−1 MOUSE DIMENSIONS

G. Discrete Activation − Where activation switches are required on the mouse, they shall be limited to no more than three.

H. Activation Surface − a dedicated mouse interface surface shall be provided.

I. Stowage − The mouse shall be removable and/or stowable.

J. Deleted.

9.3.3.4.5 TRACKBALL (ROLLING BALL)

Design requirements for a trackball control device are provided below:

A. Zero−Order or Rate Control − When used, a trackball shall only be used for zero order control or rate control.

B. Cursor Control − The controller shall not drive the cursor to a nonvisible portion of the total display area.

C. Location −

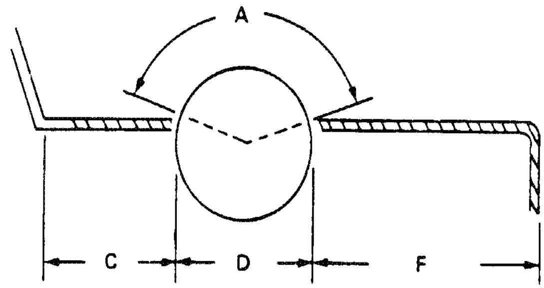
(1) Trackball placement shall allow use of the device by crewmembers using workstation restraints and maintenance view of associated VDT.

(2) The trackball shall be operable with either hand.

D. Dimensions, Resistance, and Clearance − Trackball dimensions, resistance, and clearance shall conform to the criteria in Figure 9.3.3.4.5−1.

E. Deleted.

F. Deleted.



	Dimensions		Resistance, N (oz)		Clearance, mm (in.)		
	Diameter, D, mm (in.)	Surface exposure, A, degrees	Precision required	Vibration or acceleration conditions	(1)	Around ball, C	Ball to shelf front, F
Minimum	50.0 (2.0)	100.0			0	50.0 (2.0)	120.0 (4.75)
Maximum	150.0 (6.0)	140.0	1.0 (3.6)	1.7 (6.0)	320 (12.62)		250 (9.75)
Preferred	100.0 (4.0)	120.0	0.3 (1.1)				

Note:
(1) Lateral distance from display centerline to ball centerline.

FIGURE 9.3.3.4.5−1 TRACKBALL DESIGN

9.3.3.4.6 STYLUS AND GRID

Design requirements for a stylus and grid control device are provided below:

A. Input − Movement of the stylus on the grid surface shall result in a movement of the follower in the same direction.

B. Stylus/Grid Correspondence − 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 provided the stylus is not moved.

C. Refresh Rate − The refresh rate for the follower shall be no less than 55.0 Hz.

D. Deleted.

E. Remote Grid Placement − Remote grids shall be placed such that both the grid and the display are located in front of the designated user position and such that the following directional relationships between the grid and the corresponding display are preserved:

(1) If the grid is placed in the same plane as the display, up−down and left−right directions shall be the same for both.

(2) If the grid is placed in a plane perpendicular to the display, grid forward (away from the user) shall be up on the display, grid backward (aft/toward the user) shall be down on the display, and grid left−right shall correspond to left−right on the display.

9.3.3.4.7 TOUCH−SENSITIVE DISPLAYS

Design requirements for touch−sensitive displays are provided below:

A. Touch Area Indication − The touch−sensitive areas of a display shall be indicated.

B. Touch Area Size − The touch area shall conform to the key size and spacing requirements listed in Figure 9.3.3.4.1.2−1.

C. Deleted.

D. Feedback − Positive feedback indicating that a touch has been registered shall be provided.

E. Deleted.

9.3.3.4.8 BAR CODE READERS

9.3.3.5 DELETED

9.3.3.6 OPERATING CONTROLS FOR VOICE COMMUNICATION EQUIPMENT

Requirements for the design of operating controls for voice communication equipment are provided below:

A. Volume Controls −

(1) 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 110.0 dB overall when using two earphones.

(2) The SPL shall be maintained within 3.0 dB when atmospheric pressure varies from 9.0 psi to 14.7 psi.

(3) The minimum setting of the volume control shall be 25.0 dB(A).

(4) Combination power and volume controls shall have a detent between the OFF position and the lowest end of the volume range.

B. Squelch Control −

(1) 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.

(2) A manually operated on−off switch, to deactivate the squelch when receiving weak signals, shall be provided.

9.3.3.7 DELETED

9.4 DISPLAYS

9.4.1 INTRODUCTION

This paragraph is not applicable for this document.

9.4.2 VISUAL DISPLAYS

9.4.2.1 INTRODUCTION

This paragraph is not applicable for this document.

9.4.2.2 VISUAL DISPLAY DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.4.2.3 VISUAL DISPLAY DESIGN REQUIREMENTS

9.4.2.3.1 DISPLAY READABILITY DESIGN REQUIREMENTS

9.4.2.3.1.1 ILLUMINATION DESIGN REQUIREMENTS

Workstation lighting requirements are provided below:

A. Luminance Control −

(1) When a display will be used under varied ambient illumination, a dimming control shall be provided.

The range of the control shall permit the displays to be legible under all expected ambient illumination levels for users with corrected 20/20 vision within the eye referent distance.

(2) Dimming to full OFF shall require a positive indication.

B. Dark Adaptation −

(1) Partial Dark Adaptation − In conditions where ambient lighting levels fluctuate between 5.0 fc and 100.0 fc, low level white light [CIE coordinates of x = 0.330 (+/−.03) y = 0.330 (+/− 0.03) − CIE Coordinates Chart Chromaticity Diagram 1931] shall be used.

(2) Complete Dark Adaptation − When complete dark adaptation is required, low luminance (0.07 to 0.34 cd per m^2) red light (greater than 620 nm) shall be provided.

C. Light Distribution − Where multiple displays are grouped together, lighting shall be balance across the instrument panel such that the mean indicator luminance of any two instruments on the panel does not differ by more than 33 percent across the range of full ON to full OFF.

D. 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.

9.4.2.3.1.2 DISPLAY CONTRAST DESIGN REQUIREMENTS

Requirements for contrast within an indicator are provided below:

A. Indicator Contrast − The luminance contrast within the indicator shall be at least 50.0 percent. However, this 50.0 percent contrast requirement does not apply to special displays specifically designed for legibility in sunlight.

B. Low Ambient Illumination − For illumination applications with lighting levels less than 54.0 Lux (5.0 fc), contrast shall be at least 90.0 percent, with the background luminance less than the figure luminance.

9.4.2.3.1.3 REFLECTIONS – DESIGN REQUIREMENTS

Design requirements pertaining to reflections are provided below:

A. Displays shall be constructed, arranged, and mounted to prevent reduction of information transfer due to the reflection of ambient illumination from the display cover.

B. Reflections in viewing surfaces (e.g., view ports, windshields, etc.) shall not exceed 2.0 percent for light incident on the surface.

C. Anti−reflection techniques (such as shields and filters) shall not be used if they degrade display quality.

9.4.2.3.1.4 DELETED

9.4.2.3.1.5 DELETED

9.4.2.3.2 INFORMATION PRESENTATION DESIGN REQUIREMENTS

Requirements for the presentation of information in visual displays are given below:

A. Deleted.

B. Equipment Response − Signal devices, including push button signal lights, shall display equipment response.

C. Signal Absence −

(1) Display devices shall have a positive indication of on or ready. The absence or extinguishment of a signal or visual indication shall not be used to indicate a ”ready” or ”in tolerance” condition.

(2) The absence or extinguishment of a signal or visual indicator 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.

D. Range and Accuracy − Display range and readout accuracy shall not exceed the accuracy of the input signal.

E. Duration − Nondynamic signals and display information shall remain displayed until a direct user action cancels them.

F. Timeliness − Displays requiring refreshed information shall be updated in a synchronous manner.

G. Display Failure Clarity − Failure of a display or display circuitry shall be displayed to the crew.

Where automatic switch−over to redundant power or signal sources (due to failure) is implemented, the automatic switch−over shall be displayed to the crew.

H. Display Functionality −

(1) Displays shall provide positive indication of system state (e.g., a light indicating ”power”, a blinking cursor indicating ”ready”).

(2) These positive indications shall be used consistently throughout the station.

9.4.2.3.3 DISPLAY TYPES

9.4.2.3.3.1 DELETED

9.4.2.3.3.2 DELETED

9.4.2.3.3.3 LEGEND LIGHT DESIGN REQUIREMENTS

Requirements for legend lights are provided below:

A. Deleted.

B. ON/OFF Legibility − When not energized, legends shall be legible.

C. Information Presentation − A maximum of three lines of information shall be presented on the display face of a legend light.

D. Deleted.

9.4.2.3.3.4 SCALES AND POINTERS DESIGN REQUIREMENTS

Requirements for the design of scales and pointers are provided below:

A. 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.

B. 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 of the pointer of vertical and horizontal scales and an increase in the magnitude of the reading.

C. Fixed Pointer Circular Scale − For circular fixed−pointer, moving−scale indicators, 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.

D. Fixed Pointer Linear Scale − For moving−scale indicators, 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.

E. Pointers −

(1) Length − The control or display pointer shall extend to, but not overlap, the shortest scale graduation marks.

(2) Tip Configuration − The pointer tip shall be tapered at a 20.0 degree angle (40.0 degree included angle), terminating in a flat tip equal in width to the minor scale graduations.

(3) Deleted.

(4) Color −

a. Pointer color from the tip to the center of the dial shall be the same as the color of the marks.

b. 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.

F. Pattern/Color Coding − Operational ranges on the scale shall be pattern or color coded on the face of the instrument.

G. Orientation − Alphanumeric on stationary scales shall be oriented in the local vertical position.

H. Zero Position and Direction of Movement −

(1) 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.

(2) The magnitude of positive values shall increase with clockwise movement of the pointer, and the magnitude of negative values shall increase with counterclockwise movement.

(3) When pointer movement is more than 360, the zero or reference point shall be located at the 12 o’clock position.

I. Scale Break − There shall be a break of at least 10.0 degrees of arc between the two ends of the scale, except on multi−revolution instruments such as clocks.

J. Number of Pointers − No more than two coaxial pointers shall be mounted on one indicator face.

K. 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.

L. Relative Position of Scale Marks and Numbers −

(1) Circular scale markings and location of associated numbers shall be arranged to prevent pointers from covering any portion of the scale marks or numerals.

(2) The pointer shall come to within 0.8 to 1.6 mm (0.03 to 0.06 in.) of all scale markings (see Figure 9.4.2.3.3.4−2).

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

Reserved

FIGURE 9.4.2.3.3.4−1 RESERVED

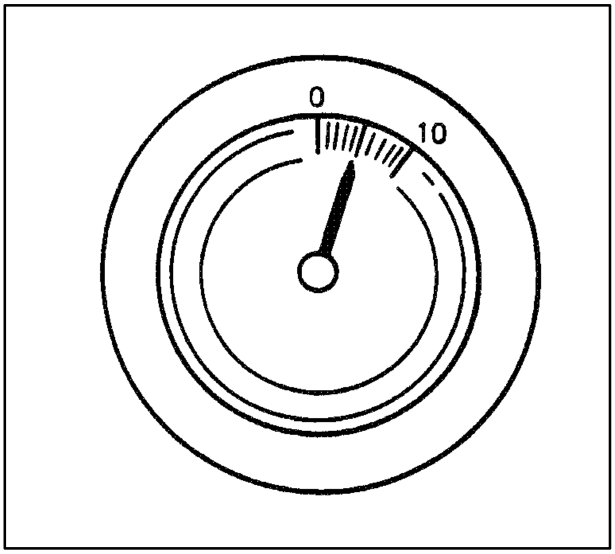


FIGURE 9.4.2.3.3.4−2 RELATIONSHIP BETWEEN POINTER AND SCALE MARKS TO MINIMIZE READING ACCURACY

N. 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.

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

9.4.2.3.3.5 CLOCK AND TIMER DESIGN REQUIREMENTS

Requirements for the design of clocks and timers are provided below:

A. Digital Clocks and Timers − Time measurement indicators shall be of the digital read out type. Where applications require the display of qualitative information (e.g., relative approximate time), other types of indicators (e.g., analog clocks and/or clocks of lesser accuracy) may be used; subject to the approval of the procuring activity.

B. Format −

(1) Time measurement indicators shall indicate time or time intervals in seconds (00 to 59), minutes (00 to 59), and hours (00 to 24).

(2) Values extending beyond 24 hours shall be displayed in terms of days unless otherwise specified. Greater or lesser resolution will be provided as required.

C. Deleted.

D. Control Modes − A start, stop, reset and slew/set control shall be provided for each time measurement indicator. In addition the following criteria will be met:

(1) Start − Upon activation of the start control line, the indicator shall begin to count within 100 milliseconds.

(2) Stop − Upon activation of the stop control line, the indicator shall stop within 100 milliseconds.

(3) Reset − Upon activation of the reset control line, the indicator shall reset to zero within 500 milliseconds.

(4) Slew/Set −

a. Individual digit slew control shall be provided.

b. A manually set indicator shall slew in an upward direction (from the lowest reading to the highest reading) at the rate of two digits per second. A downward slewing mode is not required.

c. For applications where a ”direct set” mode is provided in lieu of a slewing mode, the timer shall display the commanded reading within 500 milliseconds after the activation of the ”enter” or ”proceed” command.

d. Upon activation of the count up command and start command, the indicator shall count up and continue counting up through zero upon reaching maximum count (e.g., 59:58, 59:59, 00:00, 00:01, 00:02).

e. Upon activation of the countdown command and start command, timers shall count down to zero and upon reaching zero begin to count up (e.g., 00:02, 00:01, 00:00, 00:01, 00:02).

This control mode shall be implemented for event timers.

f. Deleted.

9.4.2.3.3.6 FLAG DISPLAY DESIGN REQUIREMENTS

Requirements for the design of flag displays are provided below:

A. Use − Flags shall not be used to display emergency conditions.

B. Location and Mounting −

(1) Flag indicators shall be located above the associated control switch, within meter windows, or with associated items.

(2) Panel flags shall be mounted as close to the surface of the panel without obscuring necessary information.

C. Snap Action − Flags shall operate by snap action.

D. Contrast − A minimum of 75 percent luminance contrast shall be provided between flags and their backgrounds under all expected lighting conditions.

E. Malfunction Indication − When flags are used to indicate the malfunction of a visual display, the malfunction position of the flag shall obscure the operator’s view of the malfunctioning display and be visible to the operator under all expected levels of illumination.

F. Positions − Flag indicators shall be restricted to three positions.

G. Information Content − Each flag indicator shall indicate a single event.

H. Legend − Alphanumeric legends shall be used. The lettering shall appear upright when the flag assumes the active or no−go position.

I. Gray Flag − A gray colored (blank position) mechanical ”talk back” flag shall mean that a particular system element is in an operational mode or is not inhibited from operation.

J. Barber Pole Flags − A barber pole (striped) flag shall mean that a particular system element is indeterminate, inactive, or inhibited from operation.

K. Red Flag − A red flag shall mean that a particular system element has failed.

L. Test Provision − A means shall be provided for testing the operation of flags.

9.4.2.3.3.7 DIGITAL DISPLAY DESIGN REQUIREMENTS

Requirements for the design of digital displays are provided below:

A. Deleted.

B. Spacing Between Numerals −

(1) The horizontal separation between numerals shall be between one quarter and one half the numeral width.

(2) Numbers having more than five digits shall have groups of three digits separated either by a blank space equivalent to one−half the width of one character or by commas.

(3) Grouping shall start from the right.

C. Movement −

(1) Snap Action − Numbers shall change by snap action in preference to continuous movement.

(2) Update Rate − The update rate shall not be faster than two per second.

(3) Reset − The rotation of a counter reset knob shall be clockwise to increase the counter indication or to reset the counter.

(4) Slew Rate −

a. Manual slewing modes, when provided, shall be capable of slewing individual digits at a normal rate of two characters per second.

b. A separate control shall be provided for each individual digit (e.g., ”units” digit, ”tens” digit, etc.), unless otherwise specified.

D. Illumination − Digital displays shall be self−illuminated when used in areas in which ambient illumination will provide display luminance below 3.5 cd per m2 (1.0 ft−L).

E. Individual characters shall be limited to the numbers 0 through 9, the capital letters of the English alphabet (A through Z), the plus (+) and minus (−) signs, and the decimal point.

F. Accuracy − Digital indicators shall possess an internal accuracy equal to or better than the least significant digit displayed by the indicator.

G. Analog Inputs −

(1) When analog−to−digital conversion is required in order to display an analog signal in digital form, the displayed digit(s) shall reflect the analog signal rounded off to the nearest whole number of the least significant digit displayed.

(2) The value 0.5 shall be rounded up.

9.4.2.3.3.8 LIGHT EMITTING DIODE DESIGN REQUIREMENTS

Requirements for the design of light emitting diodes are presented below:

A. The standards for LEDs shall be the same as the requirements for transilluminated displays in 9.5.3.2, Item I.

B. Deleted.

C. Color Coding − Use of LED color coding shall conform to 9.5.3.2.

D. Lamp Testing − LED indicator lights with less than 100,000 hours mean time between failure shall require a lamp testing capability.

9.4.2.3.3.9 VISUAL DISPLAY TERMINAL DESIGN REQUIREMENTS

Requirements for the design of VDT displays are presented below:

A. Resolution − All displays shall have a minimum resolution of 67 lines per inch.

B. Luminance − The minimum level of luminance for characters on a VDT, regardless of wavelength, shall be 70 cd per m^2 (20 f−L).

C. Contrast −

(1) Controls − Adjustment of brightness and contrast shall be provided.

(2) Tolerance − Pixel to pixel non−uniformity shall be less than or equal to 2.0 percent.

(3) Manual Control − A manual VDT brightness control shall be provided allowing selection of contrast between the lowest intensity symbology and its background of from 1:1 to at least 16:1.

(4) High Ambient − The contrast ratio between the lowest intensity−symbology and the background shall degrade to not less than 2:1.

(5) Deleted.

(6) Recommended Contrast −

a. The maximum contrast shall be 90 percent.

b. The minimum shall be 88 percent.

This narrow range applies specifically to alphanumeric displays with contrast defined as given below:

$$percentC = \{[(L_c+L_r)-(L_d-Lr)]/(L_c+L_d+2L_r)\} \times 100$$

C = contrast

L_c = character luminance

L_d = background luminance

L_r = reflected luminance

D. Glare − Glare from a VDT screen shall be controlled for viewing from any angle within 30.0 degrees of the axis normal to the screen.

E. Surround −

(1) The luminance range of surfaces immediately adjacent to the display shall be between 10.0 percent and 100 percent of screen background luminance.

(2) Surfaces adjacent to the display shall have a dull matte finish.

F. Flicker − The refresh rate for VDTs shall not be less than 55.0 Hz.

G. Viewing Distance and Angle −

(1) A nominal viewing distance of 51.0 cm (20.0 in.) for VDT viewing shall be provided.

(2) Viewing Angle − All areas of the display surface shall be readable from within at least 30.0 degrees of the axis centered on, and normal to the screen.

H. Installation − The face of VDT displays shall be flush with the surface of the panel in which it is installed.

I. VDT Alphanumeric −

(1) Character 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 rotations, a minimum of 8 by 11 is required, with 15 by 21 preferred.

(2) Character Font −

a. A standard font shall be used across an entire system.

b. The font shall include both upper and lower case characters and allow for descenders.

c. Superscripts and subscripts shall be provided.

(3) Character Size −

a. Character Height − For extended text, character height shall subtend a minimum of 15 minutes of arc for low definition characters (5 x 7). The maximum height shall be 22 minutes of arc.

b. Character Width − Character width shall be 75 percent +/− 5 percent of character height.

(4) Alphanumeric Spacing −

a. Vertical Spacing (line spacing) − Vertical spacing between lines shall be such that immediately adjacent ascenders and descenders are separated by at least one blank pixel.

b. Horizontal Spacing −

1) Between Words − In printed text, spacing between words on a line shall be one character width.

2) Between Characters − Minimum spacing between successive characters on a line shall be one pixel or 20.0 percent of character width (whichever is greater).

c. Descender Length − Descenders shall descend below the line by a distance of 10 percent to 15 percent of the upper case letter size.

(5) Case − Text longer than one sentence or phrase shall be in uppercase and lowercase letters.

J. Deleted.

K. Display Face Facsimiles − Images of scale indicators, digital indicators, signal devices, and other display faces synthesized on VDT screens shall conform to the general requirements previously listed for specific types of displays.

L. Color −

(1) The VDT shall possess the capability to display at least four colors (in addition to black and white) for alphanumeric and two−dimensional displays.

(2) For three−dimensional graphics displays, a minimum of nine colors shall be used.

(3) If more than one VDT is to be used within a workstation, a color VDT may be used in conjunction with a monochrome VDT.

M. Pixel Addressability − The VDT shall be pixel addressable so that bit−mapped graphics can be presented on the display.

N. Graphics and Symbol Generation − The VDT shall provide graphics and symbol generation capability.

O. Display Overlays − The VDT shall provide the capability to display video with text and graphics overlays.

P. Highlighting − The VDT, as a minimum, shall provide the following highlighting techniques: bold (high intensity) characters, reverse polarity, blinking.

Q. Windowing − The VDT shall provide windowing capability.

9.4.2.3.3.10 HARDCOPY DISPLAY DESIGN REQUIREMENTS

Requirements for the design of hardcopy displays are presented below:

A. Printers −

(1) Deleted.

(2) Printer delay shall be no more than 1.0 to 2.0 seconds to acknowledge a command if the user is interfacing with the computer through the printer.

(3) Printer noise level shall not exceed the NC 50 contour.

(4) A paper advance control or print head advance shall be provided to permit the operator to read the most recently printed line.

(5) A provision shall be made for taking up paper and retaining paper in microgravity.

(6) Deleted.

(7) There shall be an indicator of the remaining paper supply.

(8) Reloading paper or replacing the printing medium (e. g., ribbon, ink) shall be accomplished without disassembly or using special tools.

(9) Paper retainer shall be provided to reduce paper vibration.

(10) Guides shall be provided to facilitate accurate positioning of the paper.

(11) Where applicable, printers shall be designed to accept a variety of paper sizes.

(12) The printer shall have graphics capability.

(13) Printers shall have draft mode (high speed) and high print quality mode (lower speed).

(14) A print malfunction alarm shall be provided to alert the user when requested printing is not being done due to some malfunction.

(15) Matte finish paper shall be used to avoid smudged copy and glare.

(16) Hardcopy print shall be black characters on a white background unless otherwise specified.

B. Plotters and Recorders −

(1) Deleted.

(2) Visibility − Graphics that must be observed while the recording is being made shall not be obscured by hardware elements.

(3) Contrast − A minimum of 50.0 percent luminance contrast shall be provided between the plotted function and the background on which it is drawn.

(4) Take−Up Device − A take−up device for extruded plotting materials shall be provided.

(5) Deleted.

(6) Smudging/Smearing − The plot shall be resistant to smudging or smearing under operational use.

9.4.2.3.4 DISPLAY MAINTENANCE DESIGN REQUIREMENTS

A. Lamp Redundancy − Incandescent display lighting shall incorporate filament redundancy or dual lamps.

B. Lamp Testing − When indicator lights using incandescent bulbs are installed on a control panel, it shall be possible to test all control panel lights at one time.

C. Lamp Replacement − The procedure for lamp removal and replacement shall not require the use of tools.

D. 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.

9.4.3 AUDIO DISPLAYS

9.4.3.1 INTRODUCTION

This paragraph is not applicable for this document.

9.4.3.2 AUDIO DISPLAYS DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.4.3.3 AUDIO DISPLAYS DESIGN REQUIREMENTS

9.4.3.3.1 GENERAL DESIGN REQUIREMENTS

General requirements for the design of audio displays are provided below:

A. False Alarms − The design of audio display devices and circuits shall preclude false alarms.

B. Failure −

  (1) The audio display devices and circuits shall be designed to preclude warning signal failure related to system or equipment failure and vice versa.

  (2) Positive and attention demanding indication shall be provided if failure occurs.

C. Circuit Test − All audio displays shall be equipped with circuit test devices or other means of operability testing.

D. Disable − An interlocked, manual disable shall be provided if there is any failure mode which can result in a sustained activation of an audio display.

9.4.3.3.2 VOICE OUTPUT EQUIPMENT DESIGN REQUIREMENTS

Requirements for the design of speech output equipment are provided below:

A. Frequency Response −

(1) Microphones/input devices, loudspeakers/output devices, and associated audio system devices shall be designed to respond to 200 to 6,100 Hz.

(2) Amplitude variation across the frequency response bandwidth, referenced to 1.0 kHz, shall not be more than +/− 12.0 dB for the end to end, onboard distribution system, including speakers, earphones, and microphones.

B. Microphones/input devices −

(1) Dynamic Range − The dynamic range of a microphone/input device shall be great enough to admit variations in signal input of at least 50.0 dB.

(2) Noise Canceling − Noise canceling microphone/input devices shall be required for 85.0 dB (A) or above.

C. Loudspeakers/output devices −

(1) Sidetone − The speakers verbal input shall be in phase with its reproduction as heard on the output device.

(2) Audio equipment used to feed multiple channels fed into the same speaker or earphone shall comply with the frequency response characteristics as stated in 9.4.3.3.2, Item A.

(3) Headsets −

a. If listeners will be working in high ambient noise (85.0 dB(A) or above), binaural rather than monaural head sets shall be provided.

b. Their attenuation qualities shall be capable of reducing the ambient noise level to less than 85.0 dB(A).

c. Provisions shall be incorporated to furnish the same protection to those who wear glasses.

D. 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.

E. Deleted.

F. Earphone/Speaker To Microphone Feedback Isolation −

(1) Electrical, mechanical, and acoustical isolation shall be provided to preclude feedback oscillations (squeal problems) or echo effects (no discernible unwanted voice echo to speaker).

(2) Earphone/Speaker to microphone system loop gain shall be limited to less than 1.

9.4.3.3.3 OPERATOR COMFORT AND CONVENIENCE DESIGN REQUIREMENTS

Requirements for operator comfort and convenience are provided below:

A. Comfort − Metal parts of the headset shall not come in contact with the user's skin.

B. Hands−Free Operation − Operator microphones, and headphones, shall be designed to permit hands−free operation.

9.4.3.3.4 VOICE COMMUNICATION CONTROLS DESIGN REQUIREMENTS

Requirements for the design of operating controls for voice communication equipment are provided below:

A. Volume Controls −

(1) Volume or gain controls shall be provided for each communication channel.

Each channel shall provide sufficient electrical power to drive sound pressure level to at least 110 dB overall when using two earphones.

(2) Pressure operated gain control switches to compensate for attenuation in underpressurized areas shall be provided.

(3) The minimum setting of the volume control shall be limited to 25 dB(A).

(4) While separation of power (ON/OFF) and volume control adjustment functions into separate controls is preferred, if conditions justify their combination, a 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.

B. Squelch Control −

(1) 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.

(2) A manually operated, ON/OFF switch, to deactivate the squelch when receiving weak signals, shall be provided.

9.4.4 CAUTION AND WARNING DISPLAYS

9.4.4.1 INTRODUCTION

This paragraph is not applicable for this document.

9.4.4.2 CAUTION AND WARNING SYSTEM DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.4.4.3 CAUTION AND WARNING SYSTEM DESIGN REQUIREMENTS

9.4.4.3.1 ALARM CLASSIFICATION, ANNUNCIATION, AND IMPLEMENTATION REQUIREMENTS

The three classes that shall be used in Space Station are:

A. Emergency (class 1 alarm)

B. Warning (class 2 alarm)

C. Caution (class 3 alarm)

9.4.4.3.1.1 EMERGENCY DISPLAY AND ANNUNCIATION REQUIREMENTS

Requirements for the design of emergency displays are presented below:

A. Definition of Class 1 Alarm − A life threatening condition requiring immediate attention. Predefined crew responses may be required prior to taking corrective action. Safe haven concept activation may be necessary. Included are the presence of fire and smoke, the presence of toxicity in the atmosphere, and the rapid loss of atmospheric pressure.

B. Annunciation Requirements −

(1) Each condition shall trigger an emergency tone and a unique visual signal.

The emergency tone shall be a sine wave at 2000 to 2500 Hz +/− 10. percent with an on/off cycle of 50.0 to 400 milliseconds +/− 10.0 percent on and 50.0 to 400 milliseconds +/− 10.0 percent off.

a. Deleted.

b. Deleted.

c. Deleted.

(2) Deleted.

(3) Deleted.

(4) In designated pressurized elements, illuminated visual annunciation shall be present to indicate presence of specific emergency condition.

(5) Tones and visual annunciation shall be resettable at all major control consoles/areas.

(6) Corrective action information shall be available.

(7) Alarms shall have the ability to be manually activated.

(8) For an emergency condition, a visual display of condition location shall be provided at all integrated workstations.

(9) Methods shall be provided to indicate when conditions return within limits.

(10) For each Warning condition, visual display shall be provided.

If a Warning condition is detectable at the rack or functional unit level, indication of that specific location shall be provided.

9.4.4.3.1.2 WARNING SIGNAL AND ANNUNCIATION REQUIREMENTS

Requirements for the design of warning signals are presented below:

A. Definition of Class 2 Alarm − Conditions that require immediate correction to avoid loss of major impact to mission or potential loss of crew. Included are faults, failures, and out of tolerance conditions for functions critical to station survival and crew survival.

B. Annunciation Requirements −

(1) A warning condition shall trigger a warning tone and warning light in designated pressurized elements.

The tone shall be a sine wave which alternates between 400 to 500 Hz +/− 10 percent and 1024 to 2000 Hz +/− 10 percent for equal durations at 2.5 Hz +/− 10 percent.

(2) Tone and light shall be reset only by crew action.

(3) The volume of tone shall be adjustable.

(4) Message or light shall be provided to specify condition.

(5) Method shall be provided to indicate when condition returns within limits.

(6) Corrective action information shall be available upon crew request.

(7) For each Warning condition, visual display shall be provided. The JEM SLT is exempted from the indication requirement of C&W event location.

If a Warning condition is detectable at the rack or functional unit level, indication of that specific location shall be provided.

9.4.4.3.1.3 CAUTION DISPLAY AND ANNUNCIATION REQUIREMENTS

Requirements for the design of caution displays are provided below:

A. Definition of Class 3 Alarm −

(1) Conditions of a less time critical nature, but with the potential for further degradation if crew attention is not given. Included are faults, failures, and out of tolerance conditions for functions critical to mission success.

(2) Deleted.

B. Annunciation Requirements −

(1) A caution condition shall trigger a caution tone and light in designated pressurized elements.

The caution tone shall be a sine wave at 500 to 512 Hz +/− 10.0 percent.

(2) Data system message shall specify condition and corrective action at the discretion of the crew.

(3) The volume of tone shall be adjustable.

(4) A method shall be provided to determine if condition returns within limits.

(5) A method shall be provided to identify momentary out of limits condition.

(6) For each Caution condition, visual display shall be provided. The JEM SLT is exempted from the indication requirement of C&W event location.

If a Caution condition is detectable at the rack or functional unit level, indication of that specific location shall be provided.

9.4.4.3.2 GENERAL CAUTION AND WARNING SYSTEM DESIGN REQUIREMENTS

General requirements for Caution and Warning Systems (CWS) are provided below:

A. CWS Recovery − Any CWS that is software dependent shall be recoverable from a software system crash.

B. CWS Test Limits − Permanent limit or test conditions shall be stored redundantly in such a way that they are protected from system crashes and single operator errors involved with temporary limit changes.

C. System Failure − The system shall remain operable during and after system failures (power, data, etc.).

D. Life−Support − Life support and rescue systems status shall be provided to crewmembers at all times.

E. Deleted.

F. Sensor Changeout − Critical CWS sensors shall be accessible for changeout.

G. System Status During Alarm − After an alarm is triggered, indication shall be provided if the out−of−limit condition still exists and/or if a new out−of−limit condition occurs.

H. CWS Suppression − The CWS shall allow alarms to be suppressed.

I. Alarm Source − The source of an alarm condition shall be displayed.

J. Time History − The history of all alarms shall be maintained and shall be retrievable, with the time of occurrence noted.

K. Alarm Classification − The level of classification of an alarm shall be displayed.

L. CWS Status − After real−time modifications are made to CWS software, the status shall be displayed.

M. CWS Baseline Limits − After a modification or system failure, the CWS shall return to the baseline (default) configuration.

N. Multiple Alarms −

   (1) A single failure condition shall not cause a ”waterfall” of related alarms.

   All out−of−limit conditions shall be retrievable by crewmembers.

   (2) Multiple caution and warning tones shall be annunciated simultaneously for multiple simultaneous caution and warning events.

   (3) Multiple alarms shall be displayed in FIFO (first in − first out) order by default. Users shall have the ability to change the order of presentation according to their demands.

O. Deleted.

P. Deleted.

Q. Deleted.

R. Deleted.

S. Flexibility − The CWS design shall provide for processor upgrade or software reconfiguration to accommodate the addition or relocation of modules, payloads, or experiments.

9.4.4.3.3 VISUAL CAUTION AND WARNING DISPLAY DESIGN REQUIREMENTS

Requirements for the design of visual caution and warning systems are presented below:

A. Master Alarm Light −

(1) Deleted.

(2) Illumination of the master alarm light shall indicate that at least one or more caution, warning, or emergency lights have been energized.

(3) The capability shall be provided for master alarms lights to be energized simultaneously.

(4) Master alarm status lights shall be visible from any location in the open volume of a module.

B. Deleted.

C. Extinguishing Signal Lights − Signal lights shall be extinguished by one or more of the following methods:

(1) Restoration of a within tolerance condition without remedial action or as a result of automatic switch−over.

(2) Correction of the situation as a result of remedial action by the crew.

(3) Performance of some action by the crew which is directly related to the controls of the affected system or component. This action indicates one or more of the following:

a. An acknowledgment of the occurrence of the malfunction.

b. The completion of indirect remedial action.

c. The shutting down of the malfunctioning system component.

D. Deleted.

E. Color − The color of CWS indicator lights shall conform to the designation given in 9.5.3.2, Item I.

F. Brightness − Indicator lights shall be at least three times brighter than the other indicators on the same panel.

G. Flashing lights −

(1) When used, the flash rate shall be within three to five flashes per second with approximately equal duration on and off time.

(2) The light shall illuminate and burn steadily if the indicator is energized and the flasher device fails.

9.4.4.3.4 AUDIO CAUTION AND WARNING SYSTEM DISPLAY DESIGN REQUIREMENTS

9.4.4.3.4.1 AUDIO ALARM CHARACTERISTICS DESIGN REQUIREMENTS

Requirements for the design of audio alarm signals are provided below:

A. Frequency −

(1) Range −

a. The frequency range shall be between 200 and 5,000 Hz and, if possible, between 500 and 3,000 Hz.

b. Frequencies below 500 Hz shall be used when signals must bend around obstacles or pass through partitions.

c. The selected frequency band shall differ from the most intense background frequencies.

(2) Deleted.

B. Intensity −

(1) Deleted.

(2) Deleted.

(3) Discomfort − Audio alarm signals shall not exceed the limits established in 5.4.3.

(4) Audibility − A signal−to−noise ratio of at least 20.0 dB shall be provided in at least one octave band between 200 and 5,000 Hz at the operating position of the intended receiver.

C. Alerting Capability −

(1) Deleted.

(2) Deleted.

(3) Headset − When the operator is wearing earphones covering both ears during normal equipment operation, the audio alarm signal shall be directed to the operator's headset as well as to the work area.

D. Discriminability −

(1) Use of Different Characteristics −

a. When more than one audio signals is 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.

b. If absolute discrimination is required, the number of signals to be identified shall not exceed four.

(2) Action Segment − The identifying or action segment of an audio emergency signal shall specify the precise emergency or condition requiring action.

(3) Critical Signals − The first 0.5 second of an audio signal shall be discriminable from the first 0.5 second of any other signal that may occur.

(4) 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 normal operation noises.

(5) Prohibited Types of Signals − The following types of signals shall not be used as alarms:

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”).

E. Masking Other Critical Channels − Audio alarm signals shall not interfere with or mask voice communication.

9.4.4.3.4.2 AUDIO ALARM CONTROL DESIGN REQUIREMENTS

Requirements for the design of controls for audio alarm devices are presented below:

A. Deleted.

B. Deleted.

C. Volume Control −

(1) Control Restrictions − Control movements shall be restricted to prevent reducing the volume to less than 25.0 dB(A).

(2) Deleted.

9.4.4.3.4.3 DELETED

9.4.5 ADVISORY AND TUTORIAL DISPLAYS

9.4.5.1 ADVISORY AND TUTORIAL DESIGN REQUIREMENTS

9.4.5.1.1 ADVISORY DISPLAY & ANNUNCIATION REQUIREMENTS

Requirements for the design of advisory displays are presented below:

A. Definition of an Advisory Display − System initiated messages advising of a process status or other discrete event. Examples: Rendezvous solution complete, mass memory search for format in progress. Crew programmed reminder alerts keyed to time, orbit phase, bi−level state, parameter limit.

B. Annunciation Requirements −

(1) Deleted.

(2) Message shall accompany all alerts.

(3) A log of all messages shall be maintained and available for crew recall.

(4) If advisory display is crew programmed the option shall be provided to direct it to all workstations or to a single designated workstation.

(5) If advisory display is not crew programmed it shall be limited to the sending and/or receiving workstation.

(6) If advisory displays are crew programmed aural annunciation, the option shall be provided to direct them to one or more work locations.

9.4.5.1.2 TUTORIAL DISPLAY & ANNUNCIATION REQUIREMENTS

Requirements for the design of tutorial displays are provided below:

A. Definition of a Tutorial Display − Messages denoting illegal keyboard syntax, or for assisting in proper completion of required inputs. These are limited to software configuration requirements.

B. Annunciation Requirements −

(1) No tones/lights shall be used.

(2) Message shall be limited to the workstation in use.

9.5 IVA, EVA, AND EVR LABELING AND CODING

9.5.1 INTRODUCTION

The terms decal, placard, and label are used interchangeably throughout this section to refer to methods of marking. The use of any one term is inclusive of the other terms and is not intended to limit the requirements to a single method of marking.

9.5.2 LABELING AND CODING DESIGN CONSIDERATIONS

9.5.2.1 FUNCTION CONSIDERATIONS

Decals and placards should take into account the user, the purpose, the function, and/or the functional result of the use of equipment items. Engineering characteristics or nomenclature may be described as a secondary consideration. Instrument decals and placards, for example, should be labeled in terms of what is being measured or controlled. Calibration data may be included where applicable.

9.5.3 LABELING AND CODING DESIGN REQUIREMENTS

9.5.3.1 LABELING DESIGN REQUIREMENTS

A. Labeling requirements shall be as specified below or as approved by the NASA Crew Office or their designated representative.

B. Crew Office approval of label location, quantity, and orientation shall be indicated by signature on a label development master drawing.

C. The Crew Office signature shall satisfy verification that the location, quantity, viewing, and orientation of labels meets requirements.

9.5.3.1.1 LABELING STANDARDIZATION DESIGN REQUIREMENTS

Requirements for standardizing labeling are listed below:

A. Standardization − Decals and placards are standardized for content and appearance by complying to the label and coding design considerations and requirements specified in this section.

B. Standard Labels − Specific standard labels which comply to the Labeling Design Requirements specified in this section are provided for use by all ISS participants as listed in JSC 27260, Part II.

9.5.3.1.2 READABILITY DESIGN REQUIREMENTS

A. Brevity − Decals and placards text should be as concise as possible without distorting the intended meaning or information.

B. Simplicity − Decals and placards will convey verbal meaning in the most direct manner, by using simple words and phrases.

C. Abbreviations −

   (1) Abbreviations will conform to the operational nomenclature provided in SSP 50254.

   (2) Upper and lower case letters will be used as appropriate.

   (3) Periods should be omitted except when needed to preclude misinterpretation.

D. Nomenclature − Label nomenclature related to on−orbit operations will conform to SSP 50254. Labeling applicable only to ground−based (nonoperational) functions may use other common technical terms.

E. Symbols −

(1) Abstract symbols (e.g., squares and Greek letters) will be used only when they have an accepted meaning to all intended readers. Common, meaningful symbols (e.g., % or +) may be used if they are compatible with the procedure software specifications.

(2) Where applicable, symbols used for servicing and pre−cautioning will meet MS33739. Hazardous materials symbols will be per MIL−M−3719/4.

F. Decal and Placard Life − Decals and placards shall not lose their readability for the functional lifetime of the marking provided.

G. Background − Decal and placard colors should be chosen to contrast with the equipment background as listed in 9.5.3.2, Item I.(7).

H. Irrelevant Information − Trade names will not appear on decals or placards.

I. Language −

(1) Decals and placards shall be written in the English language.

(2) If dual languages must be used, English shall be used first and with lettering at least 25.0 percent larger than the secondary language.

J. Criticality − The design will take into account the criticality of the decal or placard.

K. Clutter − Decals and placards will be designed so as to minimize visual clutter.

9.5.3.1.3 LABEL PLACEMENT DESIGN REQUIREMENTS

Requirements for label placement are given below:

A. Orientation −

(1) All IVA markings and labels shall be oriented with respect to the local worksite plane so that they read from left to right.

(2) Vertical orientation is permissible only when the marking or label dimensionally does not fit in the required location.

(3) All EVA markings and labels shall be oriented with respect to the crewmember's position at the worksite.

(4) Typically, the label shall be read left to right unless otherwise required.

B. Display Labels − Labels identifying display functions shall be placed on the panel above the display. Labels may be placed in locations other than above the display only when they cannot dimensionally fit in the required location.

C. Deleted.

D. Visibility − Markings will be located such that they are perpendicular to the operator's normal line of sight whenever feasible and shall not be less than 45.0 degrees from the line of sight.

E. Overhead Panels − On overhead panels, markings and labeling shall be oriented such that they appear upright when observed from local vertical.

F. Deleted.

G. Association Errors − The arrangement of markings on panels will be such that errors of association of one marking or set of markings with adjacent ones is not possible.

9.5.3.1.4 SCALE MARKING DESIGN REQUIREMENTS

Requirements for the design of scale markings are provided below:

A. Accuracy −

(1) Deleted.

(2) The precision of scale markings shall be equal to or less than the precision of the input signal.

(3) In general, scales that are to be read quantitatively to the nearest graduation mark shall be designed so that interpolation between graduation marks is not necessary.

(4) Interpolation, shall be limited to one half the distance between minor graduation marks.

B. Interval Values −

(1) The graduation intervals shall progress by 1, 5, or 2 units of decimal multiples thereof, in that order of preference.

(2) The number of graduation marks between numbered graduation marks shall not exceed 9.

C. Scale Markings (High Luminance − above 1.0 ft−L) −

(1) The minimum width of major, intermediate, and minor marks will be 0.32 mm (0.0125 in.).

(2) The length of major, intermediate, and minor graduation marks will be at least 5.6 mm, 4.1 mm, and 2.5 mm (0.22, 0.16, and 0.09 in.), respectively.

(3) The minimum distance between major graduation marks will be 13.0 mm (0.5 in.).

(4) Minor graduation marks may be spaced as close as 0.89 mm (0.035 in.), but the distance will be at least twice the stroke width for white marks on black dial faces and at least one stroke width for black marks on white dial faces.

D. Scale Markings (Low Luminance − below 1.0 ft−L) −

(1) The minimum width of a major graduation will be 0.89 mm (0.035 in.), the minimum width of an intermediate graduation will be 0.76 mm (0.030 in.), and the minimum width of a mirror graduation will be 0.64 mm (0.025 in).

(2) The length of major, intermediate, and minor graduation marks will be at least 5.6 mm, 4.1 mm, and 2.5 mm (0.22, 0.16, and 0.10 in.), respectively.

(3) The minimum distance between major graduation marks will be 16.5 mm (0.65 in.).

(4) Graduation marks will be spaced a minimum of 1.5 mm (0.06 in.) between centerlines.

9.5.3.1.5 ALIGNMENT MARKS/INTERFACE IDENTIFICATION DESIGN REQUIREMENTS

9.5.3.1.5.1 IVA ALIGNMENT MARKS/INTERFACE IDENTIFICATION DESIGN REQUIREMENTS

Requirements for alignment marks and other interface identification are provided below:

A. Orientation − When a piece of hardware requires a specific orientation which cannot be identified by alignment marks, arrows and/or labels shall be used to indicate the proper orientation.

B. Color − For black and white labels, alignment marks shall be lusterless white on dark−colored hardware and lusterless black on light−colored hardware.

C. Identification − Unattached items that require an interface connection shall have interface identification marks on each mating part of the items involved in the interface.

D. Tethered Equipment − Interface identification is not be used for movable items tethered to a mating part (e.g., dust cap for an electrical connector, hinged lid for a stowage container).

9.5.3.1.5.2 EVA ALIGNMENT MARKS/INTERFACE IDENTIFICATION DESIGN REQUIREMENTS

A. Hardware EVA Interface Alignment Mark Convention − EVA hardware interfaces (such as fasteners, handles, levers, knobs, latches, locks, etc.) shall be provided with alignment marks as visual cues or other design features indicating hardware condition or state. Preferred alignment marks are as follows:

(1) Typical hardware interface conditions or state to be identified with alignment marks shall include unlocked/locked, released/captured, open/close, soft−dock/hard−dock, and disengaged/engaged.

(2) The locked conditions shall be indicated by black−to−black alignment marks or black indicators.

(3) The unlocked conditions shall be indicated by light−colored (white−to−white preferred) alignment marks or light−colored (white preferred) indicators.

(4) Background shall provide contrast to visual markings.

B. ORU/Hardware Mating Interface Alignment Marks − ORUs and other hardware to be installed by EVA shall provide alignment aides consisting of alignment guides and/or alignment marks depending on mass and volume of hardware, installation location sensitivity to damage, hardware sensitivity to damage, clearances, and other such factors. If alignment marks are used, the following are preferred:

(1) Location − Alignment marks shall be located at the mating edges of both the hardware and its mating interface in a position that is within the EVA crewmember's line−of−sight while at the nominal worksite position.

(2) Alignment Mark Configuration − Alignment marks shall be either a rectangular mark, a stripe, or an arrow.

a. Rectangular mark or stripe −

1) The rectangular mark or stripe shall be used where the marked mating interfaces lie within the crew's nominal work volume and are unaffected by off−axis viewing or parallax.

2) Where space is available, rectangular marks shall as a minimum range from 0.125 to 1.0 inch in width and 0.75 to 3.0 inch in length.

3) Where space is restricted, marks shall be a minimum of 0.09 inch in width and 0.25 inch in length.

b. Arrow −

1) The arrow shall be used where the marked mating interfaces lie outside the crew's nominal work volume and can be affected by off−axis viewing or parallax.

2) Arrow marks shall as a minimum range from 1.0 to 2.0 inches in width and 1.5 to 3.0 inches in length with the arrow head determining width and arrow head and shaft being proportionate.

(3) Alignment marks shall be black−to−black and have a contrasting background.

9.5.3.1.6 EQUIPMENT IDENTIFICATION DESIGN REQUIREMENTS

9.5.3.1.6.1 IVA EQUIPMENT IDENTIFICATION DESIGN REQUIREMENTS

Requirements for equipment identification are listed below:

A. Equipment Marking − Loose equipment shall be marked with nomenclature that describes the function of the item and its pertinent interfaces. However, items whose use is obvious to the crew (e.g., food table, windows, etc.) are exempt from this requirement.

B. Numbered Items − Multi−quantity items that require individual distinction but are not serialized shall be individually numbered.

C. Serial Numbers − Multi−quantity items that are serialized shall display the serial number as part of the identification.

D. Deleted.

E. Connecting Cables − Connecting cables shall be marked with nomenclature describing the connecting cables interface end points.

F. Cable Harness Identification − Each electrical line shall have a unique line or harness identifier at each end and at intervals not to exceed one meter. The identifier may be the manufacturer's cable harness part number or a reference designator number.

9.5.3.1.6.2 EVA EQUIPMENT IDENTIFICATION DESIGN REQUIREMENTS

A. ORU and Loose Equipment Identification − ORUs and loose equipment (such as EVA tools, FSE, Rigid Umbilicals, Antennas, External Television Cameras, External Lights, etc.) which are handled by the EVA crew shall be uniquely labeled with its operational name as follows:

(1) Location − The label shall be placed where it is visible while in the stowed and installed position by an EVA crewmember. Overlaying this label on the MIL−STD−130 nameplate is an acceptable option if the nameplate location meets the EVA labeling location requirements. The preferred orientation for the label will be:

a. Truss faces inside the Solar Alpha Rotary Joint (SARJ) −

1) For Faces 1 and 4, the base of the label will be oriented toward the S0/S1 interface plane of the mounting surface.

2) For Faces 2, 3, 5, and 6, the base of the label will be parallel to, and readable from, the direction of Face 1. Lettering on the label or marking shall be oriented horizontally to read left to right, unless label or marking size constraints require vertical lettering (reference Figure 9.5.3.1.6.2−1).

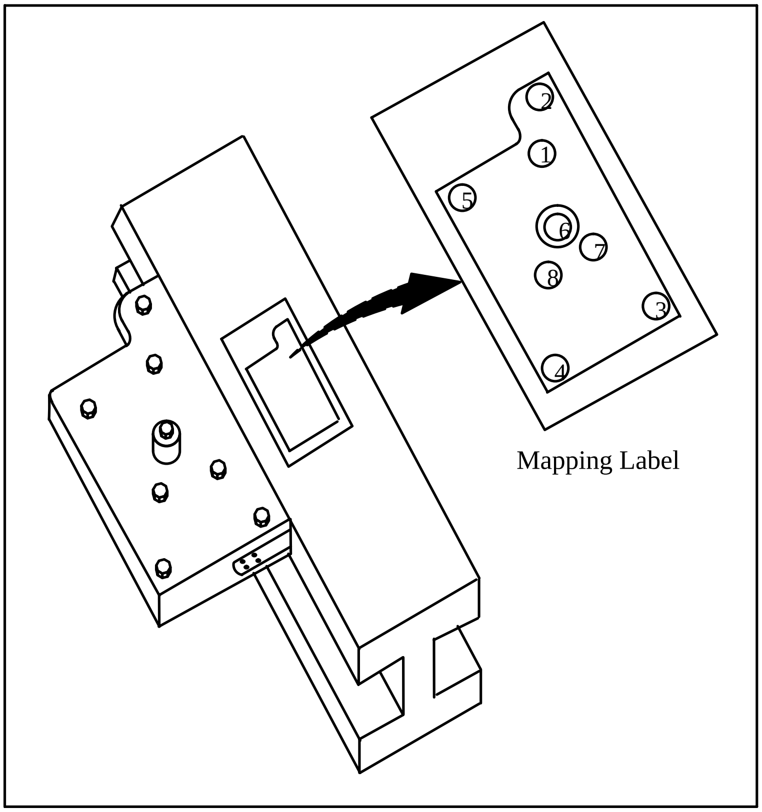


FIGURE 9.5.3.1.6.2−1 EXAMPLE OF MAPPING LABEL

3) For truss segment end bulkheads, the base of the label will be oriented toward Face 1 or Face 4.

b. Truss faces outside the SARJ and Japanese Experiment Module (JEM) Exposed Facility (EF) −

1) For Faces 1 and 3, the base of the label will be oriented toward the Integrated Truss Segment (ITS) S0/S1 interface plane.

2) For Faces 2 and 4, the base of the label will be oriented parallel to, and readable from, the direction of Face 1.

c. ITS Z1 faces −

1) For Faces 1 thru 4, the base of the label will be oriented toward the ITS Z1/Node 1 interface plane.

2) For the zenith and nadir bulkheads, the label will be oriented toward Face 1 or Face 3.

d. Pressurized modules − labels will maintain an orientation consistent with Micro−Meteoroid Orbital Debris (MMOD) shield labels.

(2) Character Height − The ORU or loose equipment item operational name shall have a character height of no less than 0.5 inch (bold, black on contrasting background). The preferred character height for large items such as rigid umbilicals, mast canister, radiators, etc, is 2.0 inches (minimum).

(3) Label Content −

a. The operational name shall provide space for the placement of a unique number Identification (ID) of up to four digits.

b. The unique number ID shall be separated from the operational name by a hyphen. For example, ”RPCM−0017” or ”RPCM(T3)−0015”.

(4) ORU Installed locations −

a. For banks of similar adjacent ORUs, each ORU mounting location shall be uniquely identified on the mounting location, the adjacent structure or with a mapping label.

b. The ORU mounting identification label shall be visible with the ORU installed.

B. Mapping labels − Mapping labels are simplified graphical depictions of surface areas or volumes, its contents (operational name and envelopes), and relative location and/or orientation of individual items. Mapping labels shall be used in labeling hardware, hardware interfaces or hardware contents that: (1) can not be labeled directly on the hardware itself due to space, quantity, or contour, (2) are hidden or obscured from view because they reside within some type of enclosure such as a tool box, stowage container, structural access panel or cover, or thermal covering or shroud, or (3) are located in some off−axis orientation within the worksite, but not in the crewmember's nominal line of site as follows: (reference Figures 9.5.3.1.6.2−1 and 9.5.3.1.6.2−2)

(1) Location − Mapping labels shall be placed where they are visible to the EVA crew member while at the nominal worksite position.

a. Mapping labels used to identify hardware interfaces (such as fasteners) that are placed on the hardware directly shall be located within 12.0 inches of one of the interfaces being referenced and within the crew's work envelope.

b. Mapping labels used to identify hardware interfaces (such as fasteners, levers, etc.) or hardware items (such as individual ORUs, connectors, etc.) that require the label to be located on adjacent surrounding surfaces or structure shall be placed within 12.0 inches of one of the interfaces or within 12.0 to 18.0 inches of the hardware items being referenced, and within the crew's work envelope.

c. Mapping labels used to identify hardware content (such as tools in a tool box) shall be placed on the exterior and interior sides of the tool box door.

d. Mapping labels used to identify hardware or hardware interface contents within a structural access panel or cover shall be placed on the exterior and within the crew's work envelope. This does not include module MMOD shielding.

e. Mapping label used to identify hardware or hardware interface contents within a soft−good (such as a thermal shroud) cover or access flap shall be placed within 4.0 inches of the exterior edge of the cover or flap area that is used to gain final access into the interior contents and is within the crew's nominal work envelope.

(2) Orientation −

a. The mapping label shall be oriented relative to the hardware being mapped.

b. The label diagram or graphical depiction of hardware, hardware interfaces, or hardware contents shall be oriented to duplicate the orientation of the hardware to which it refers.

c. Lettering on the label or marking shall be oriented to read left to right, unless label or marking size constraints require vertical lettering.

(3) Character Height − Crew interface identification labeling or marking lettering character height is in accordance with 9.5.3.1.14.4.2.

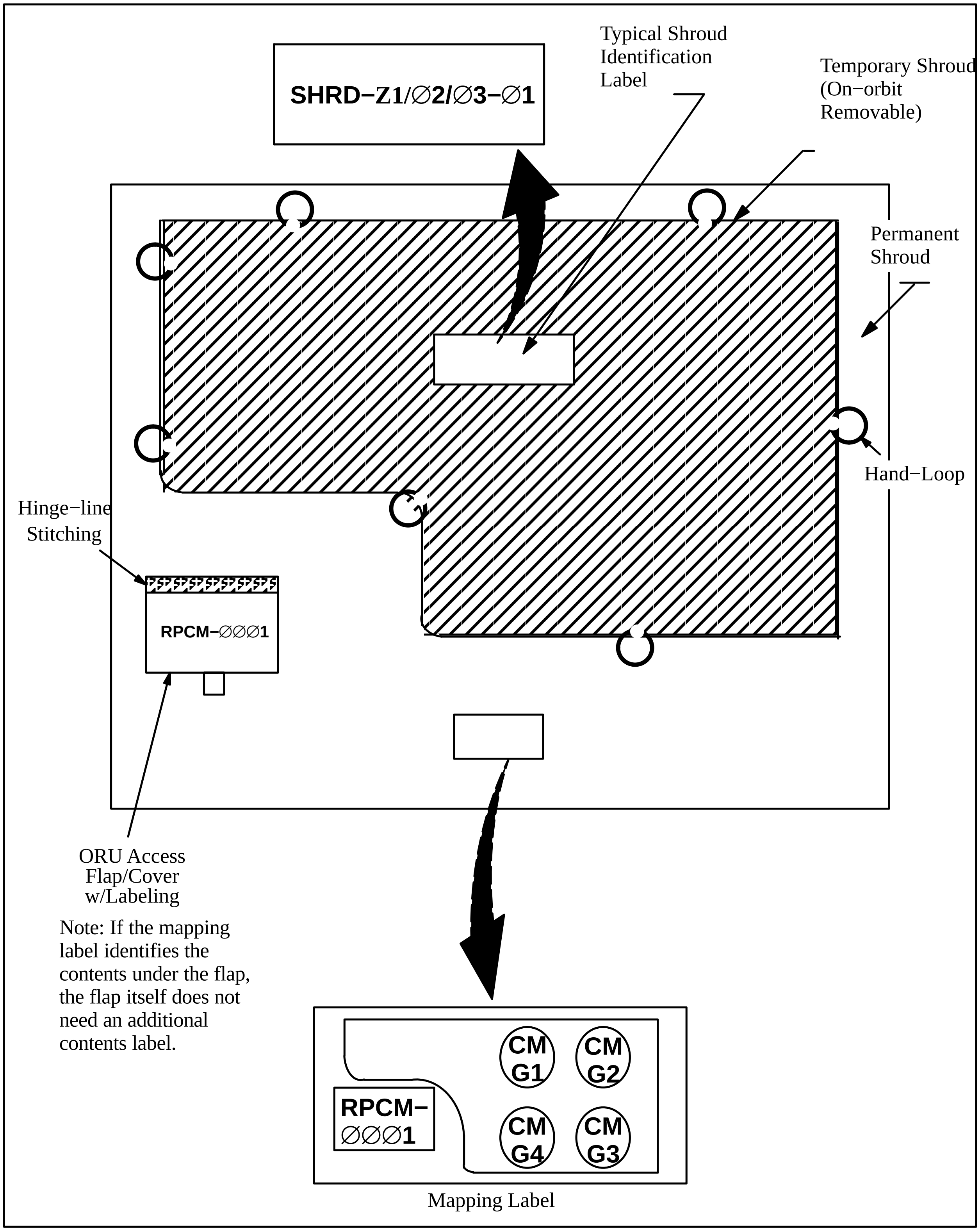


FIGURE 9.5.3.1.6.2−2 EXAMPLE OF SHROUD LABELING

C. Crew Hardware Interface Identification Labels and Markings − Hardware with EVA interfaces (such as fasteners, indicators, handles, locks, etc.) which have a unique operational function or are obscured, hidden, or not apparent from surrounding surfaces shall be labeled or marked as to their function or location as follows (reference Figure 9.5.3.1.6.2−3).

(1) Location − The crew interface identification label or marking shall be placed where it is visible to the EVA crewmember while at the nominal worksite position.

a. If the label is placed directly on the hardware, it shall be located within 2.0 inches of the interface, particularly if a marking such as a pointer (arrow) is used to identify its location.

b. If the label cannot be placed on the hardware itself, it shall be placed within 12.0 inches of the interface on adjacent structure or surface.

c. Where required, interfaces can be identified on a mapping label as defined above in 9.5.3.1.6.2, Item B.

(2) Orientation − Lettering on the label or marking shall be oriented horizontally to read left to right, unless label or marking size constraints require vertical lettering (reference Figure 9.5.3.1.6.2−1).

(3) Character height − Crew interface identification labeling or marking lettering character height shall be no less than 0.18 inch.

D. Hardware Mounting/Attachment Interface Identification labels − Hardware that is relocated by EVA (such as antennas, external lights, external video cameras, etc.) shall have their mounting locations or interface ports identified by labels as follows:

(1) Location −

a. The hardware mounting or attachment interface label shall be placed where it is visible to the EVA crewmember while at the nominal worksite position.

b. The label shall be placed within 4.0 inches of the mounting interface.

(2) Orientation −

a. The hardware mounting or attachment interface label at the worksite shall use the same orientation as that outlined in 9.5.3.1.6.2, Item A.(1).

b. Lettering on the label shall be oriented to read left to right, unless label size constraints require vertical lettering.

(3) Character Height − The hardware mounting or attachment interface label lettering character height shall be no less than 0.18 inches.

(4) Content − The hardware mounting or attachment interface label shall provide as a minimum the operation name of the port or location (such as for external video camera ports) or the operational name of the hardware that is mounted at that location (such as S−Band Antenna). Where appropriate, this attachment interface label can include alignment marks to assist with installation of the hardware.

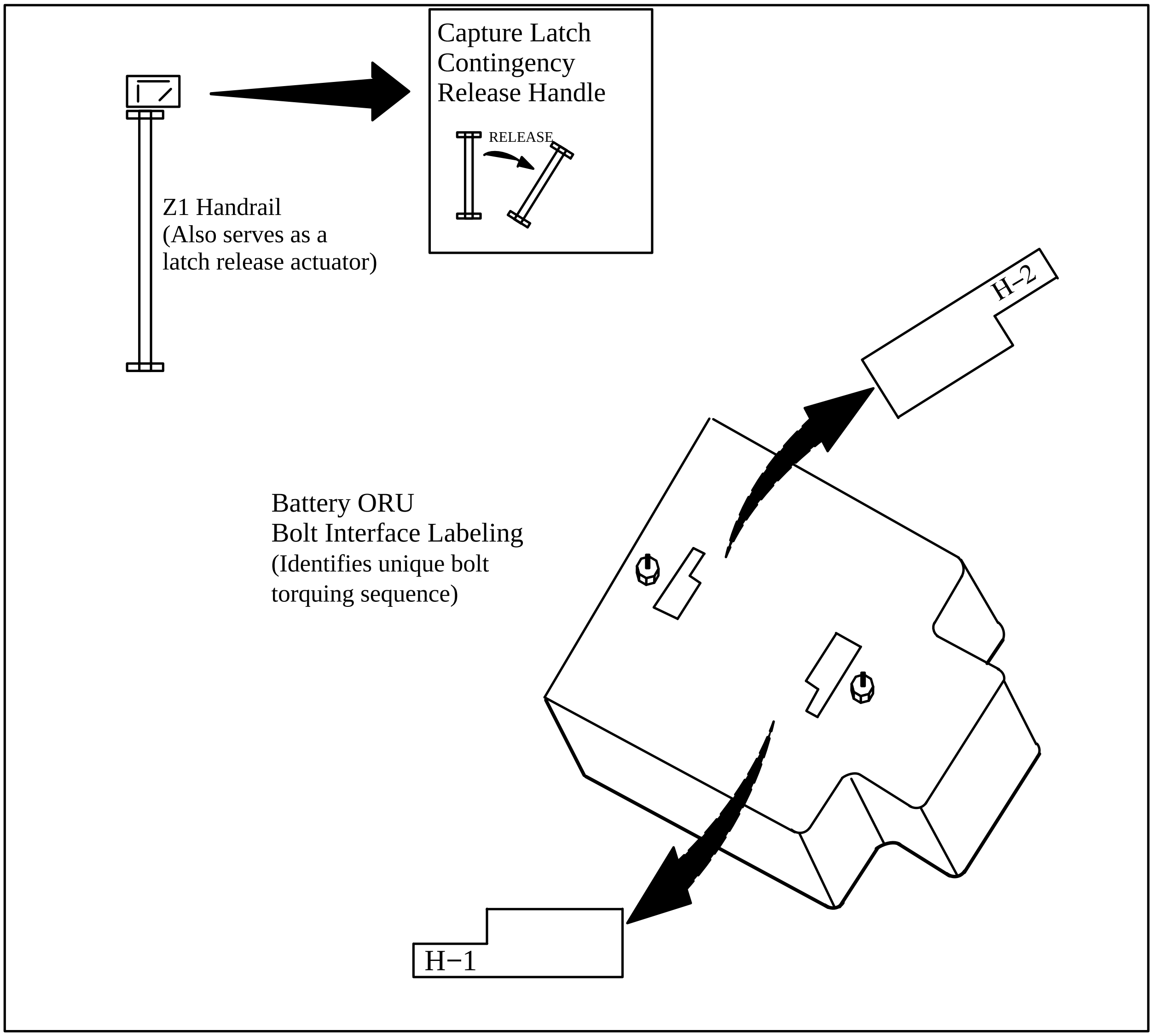


FIGURE 9.5.3.1.6.2−3 EXAMPLE OF CAPTURE LATCH AND BATTERY INTERFACE LABELS

E. Truss Segment Thermal Shroud identification Labels and Markings − Thermal shrouds shall be labeled and marked to identify the following: (1) EVA removable or re−installable surface shrouds, (2) shroud access flaps or individual ORU covers, (3) shroud removable perimeters within permanent shrouds, (4) hardware or hardware crew interfaces enclosed by a shroud, (5) shroud hinge or fold point, and (6) integral shroud stowage pockets.

(1) Location − Shroud labels and markings shall be placed where they are visible to the crewmember while at the nominal worksite position.

a. Shrouds which are removable or re−installable shall be labeled with the operation identifier (name) to distinguish it from permanent shrouds and be configured as shown in Figure 9.5.3.1.6.2−2. For removable (disposable) shrouds, the preferred location for the label will be on the exterior surface at the approximate geometric center of the shroud.

b. The exterior of shroud access flaps to ORU(s) and/or crew interface(s) shall be labeled with the operational name of the individual contents.

1) For shroud access flaps with linear dimensions less than or equal to 36.0 inches, a list of each ORU or hardware interface shall be labeled on the exterior of the shroud. The preferred location for the label is within 4.0 inches of the edge of the flap that is used to gain access to the contents and that is within the crew's nominal work envelope.

2) Shroud access flaps with linear dimensions greater than 36.0 inches and containing several ORUs and/or crew interfaces shall use a mapping label to identify contents as defined in 9.5.3.1.6.2, Item B. If this same surface contains four or less ORUs or crew interfaces, the shroud may be labeled in the same manner as is the case for the smaller areas.

c. Individual ORU covers shall be labeled with the operational name of the ORU and be located on the exterior surface of the cover that visible to the crew while at the nominal worksite position.

d. Shroud perimeters (removable and re−installable shrouds), hinge or fold−lines, and integral shroud stowage pockets are identified by seams, stitching, fasteners/fastening devices, or crew grasp points inherent in the shroud design. If necessary to detail folding or stowing instructions, a label can be used to diagram the instructions. This diagram shall be placed on the shroud surface that always remains visible to crewmember during the entire folding or stowing sequence.

1) For re−installable shrouds, an alignment mark shall be placed on one side (typically the side that is installed first) of the shroud and its mating interface.

2) For re−installable shrouds which are folded or stowed in an integral shroud pocket or pouch, the operational identifier (name) of the stowed shroud shall also be placed on the visible exterior surface of the folded shroud or pocket.

(2) Orientation −

a. The crew interface identification label shall be oriented relative to the crewmember's nominal line−of−sight while at the worksite.

b. Lettering on the label shall be oriented horizontally to read left to right, unless label size constraints require vertical lettering.

(3) Character Height − The character height for shroud labeling will be as follows:

a. For removable, disposable and re−installable shrouds:

1) The shroud operational identifier (as defined in SSP 30575, section 4.6) label shall enclose an area no larger than 15.5 square inches. The preferred character height is 2.0 inches (bold black on contrasting background).

2) However, where the 2.0 inch character height would force violation of the 15.5 sqare inch area requirement, the character height may be reduced, but shall be no less than 0.5 inches.

b. For re−installable shrouds, the shroud operational identifier (as defined in SSP 30575, section 4.6) labels found on the exterior of the folded shroud or pocket of a stowed shroud shall have a lettering character height of no less than 0.18 inches (bold, black on contrasting background).

c. For shroud access flaps, the ORUs and/or crew interfaces that are listed on a flap label shall have a lettering character height of no less than 0.5 inch (bold black on contrasting background).

d. For individual ORU covers, the ORU operation name label on the exterior of the cover shall have a lettering height of no less than 0.5 inch (bold black on contrasting background).

e. If shroud folding or stowing diagram labels are provided, the lettering height of any instruction shall be no less than 0.18 inch (bold black on contrasting background.

F. Connecting Cables/Lines − Connecting cables/lines shall be marked with nomenclature describing the connecting cables/lines interface end points. Detailed requirements for selecting connector identification coding are contained in 11.10.3.5.

G. Line/Umbilical/Harness Identification Coding − Each electrical line shall have a unique line or umbilical/harness identifier at each end and at increments not to exceed 5.0 meters. The identifier may be the manufacturer's line or harness part number or a reference designator number.

H. Line Clamps − EVA line clamps do not have to be labeled for identification.

9.5.3.1.7 LOCATION AND ORIENTATION CODING DESIGN REQUIREMENTS

The system of location and orientation coding used for operationally designating and locating crew interface items is established in SSP 30575. Requirements for incorporating location and orientation coding into ISS labels and markings are listed below:

9.5.3.1.7.1 INTERNAL LOCATION CODING

The following internal identification markings shall incorporate the location code per SSP 30575 to assist the crew in locating equipment and crew interface sites:

A. Equipment Racks − All ISS racks (system racks, International standard payload racks, Stowage racks, etc.) shall have a location code marking in the upper left corner on the face of the rack designating the rack bay corresponding to the racks on−orbit installed position.

Character − The Rack Identification label shall have a minimum font size of 72 point Helvetica bold in black text on a white background.

B. Stowage Trays − Stowage trays shall have a location code marking that designates the stowed location of the tray.

C. Standoff closeout panels − Each standoff bay shall have a location code marking on the left side of the standoff face panel designating the corresponding standoff bay

Character − The standoff Identification label shall have a character height of no less than 72 point Helvetica bold font in black text on a white background.

D. Access Panels − End cone maintenance access panel identification shall incorporate the location code corresponding to the panels installed position to assist the crew in locating the panel for maintenance activities.

Location − End cone maintenance access panel identification labels will be located in the lower left position on the panel with respect to the local vertical orientation.

E. Hatch entrance markings − Hatch entrances shall be labeled to indicate the module being entered as the crew member passes through the hatch.

(1) Hatch entrance markings shall have a character height of no less than 2.0 inches.

(2) Hatch entrance markings shall be located below the hatch entrance relative to the local vertical orientation corresponding to the operation of the hatch. For node radial hatches where the stowed location of the hatch obscures the label, the label may be placed adjacent to the hatch opening.

(3) Hatch entrance markings shall be oriented relative to the local vertical orientation of the module being exited.

9.5.3.1.7.2 EXTERNAL LOCATION CODING

The following external identification markings shall incorporate the location code in accordance with SSP 30575 to assist the crew in locating equipment and crew interface sites. Figure 9.5.3.1.7.2−1 shows a typical layout of markings for a truss segment.

A. Crew and Equipment Translation Aid (CETA) Rail Locator Label − CETA Rail Locator Labels provide a continuous reference point along the nadir−most CETA Cart/Mobile Transporter (MT) rail truss member of the Y−axis truss that allows the EVA crewmember to manually position the CETA cart at a defined truss location for a particular worksite access.

(1) Code − CETA Rail Locator Labels shall incorporate the CETA Rail Locator Coding in accordance with SSP 30575 and be configured as shown in Figure 9.5.3.1.7.2−2.

(2) Character Height − CETA Rail Locator Labels shall have a character height of no less than 0.7 inch.

(3) Location −

a. CETA Rail Locator Labels shall be placed on the CETA rail at increments not to exceed 30.0 cm.

b. CETA Rail Locator Labels shall be placed within 4.0 to 6.0 inches of the nadir CETA Cart translation handrail, so that it is visible to the EVA crewmember while on the CETA Cart translation foot restraint (reference Figure 9.5.3.1.7.2−1).

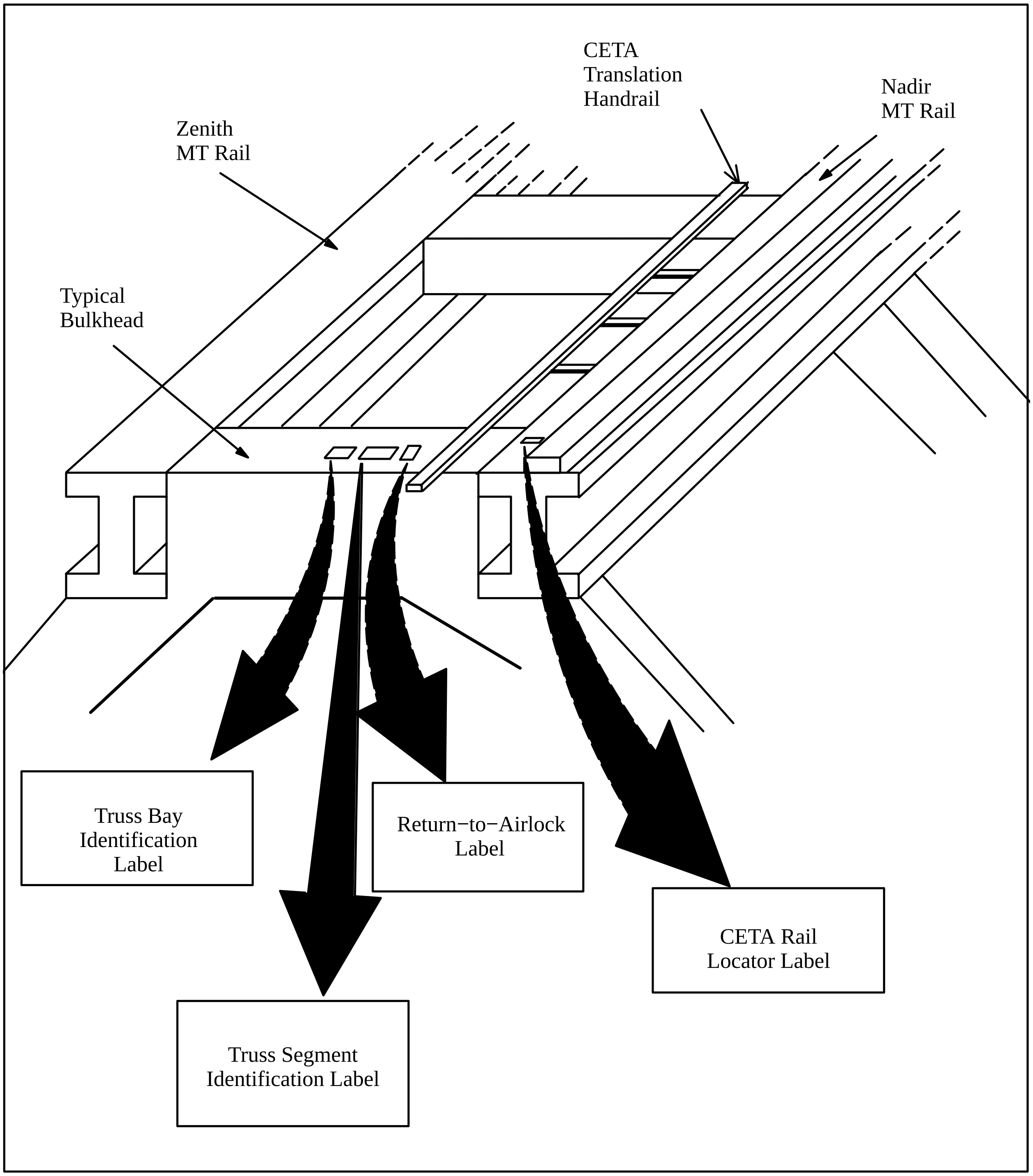


FIGURE 9.5.3.1.7.2−1 RELATIVE PLACEMENT (TYPICAL OF EVA TRUSS LABELING − SEGMENTS, BAYS, RETURN TO AIRLOCK, AND CETA RAIL LOCATOR)

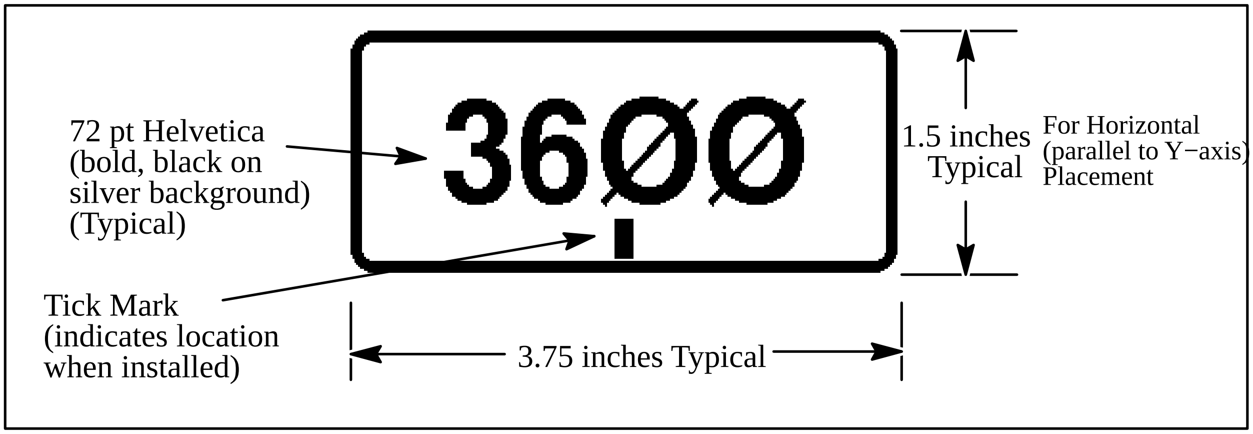


FIGURE 9.5.3.1.7.2−2 TYPICAL CETA RAIL LOCATOR LABEL

B. WIF Identification Label − A Worksite Interface (WIF) identification label shall be located at each Articulating Portable Foot Restraint (APFR) socket to uniquely identify each WIF location.

(1) The WIF label shall be placed 6 inches or less from the WIF it identifies.

(2) WIF labels shall be visible to the crewmember while translating to the WIF for APFR installation.

(3) Each WIF label shall apply to the closest WIF.

(4) The WIF label coding shall be in accordance with SSP 30575, paragraph 4.5.1, and configured as shown in Figure 9.5.3.1.7.2−3.

(5) The content of the label header designating Segment/Element and Bay/EndCone/Section will be dictated by the segment or element where the WIF is located.

C. Module Location Code Identification Label −

(1) Each module MMOD shield, Multi−layer Insulation (MLI) blanket, and Intermediate Debris Shield Layer (IDSL) shall be labeled.

(2) The MMOD label shall have a single module location code as defined in SSP 30575, paragraph 4.3.1.

(3) The MLI and IDSL labels shall be the item part number.

These labels provide module location code information, unique hardware item identification, and hardware installation/ orientation guides. Figure 9.5.3.1.7.2−4 shows typical label placement and Figure 9.5.3.1.7.2−5 shows typical label configuration.

(4) MMOD Shield Label −

a. Coding − The visible exterior surface of each module MMOD shield shall be labeled per the location code defined in SSP 30575, paragraph 4.3.1.

b. Character height − MMOD shield markings shall have a character height of no less than 1.75 inches (black on silver).

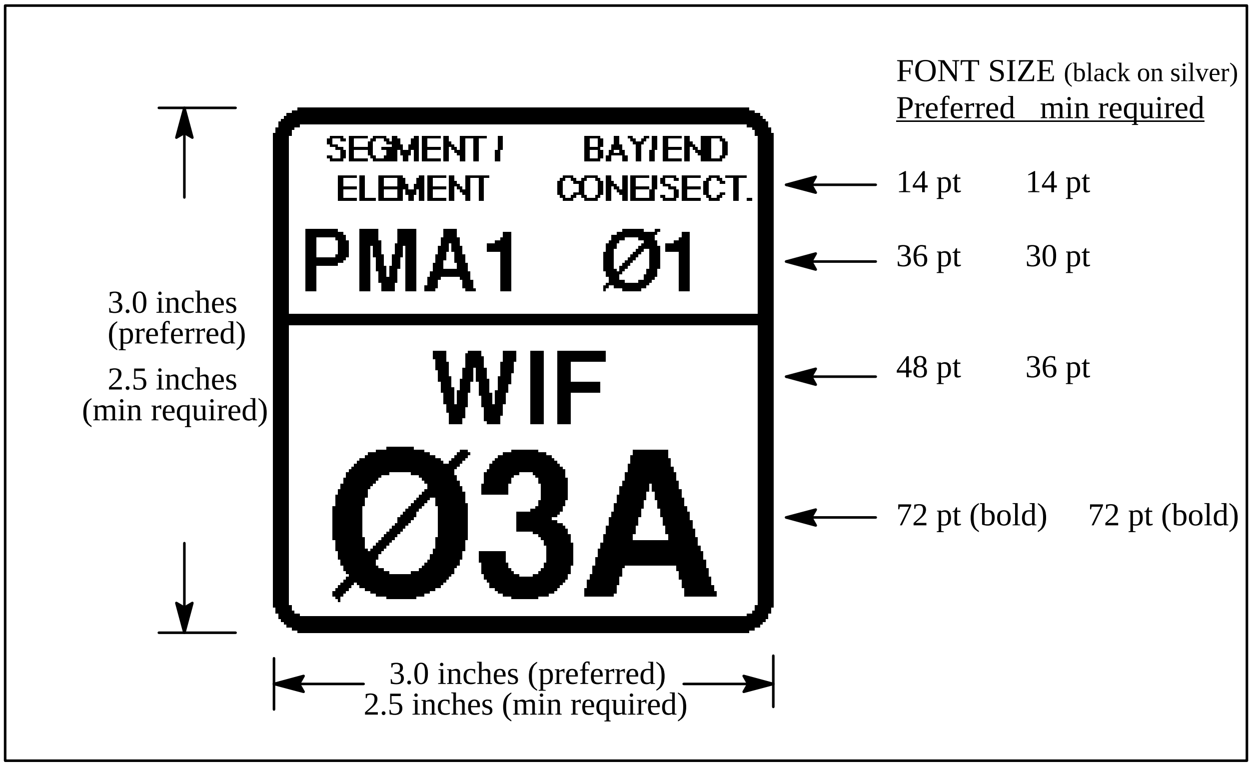


FIGURE 9.5.3.1.7.2−3 TYPICAL WIF LABEL

c. Orientation −

1) Cylindrical section − The MMOD shield Label on the cylindrical section of the module shall be oriented such that the label can be read left to right by the crewmember translating longitudinally along the module exterior starting from the ∅−point reference (defined in SSP 30575, paragraph 4.3.1).

2) End cone section − The MMOD shield label on the end cone section of the module shall be oriented such that the label can be read left to right by the crewmember when positioned outboard and perpendicular to the plane of the shield, looking radially inboard towards the Common Berthing Mechanism (CBM) origin.

d. Location −

1) Cylindrical section −

(a) With the exception of the Pressurized Mating Adapter (PMA), the MMOD shield label shall be located 6.0 +/− 0.25 inches to the right and up from the lower left corner of the MMOD shield. (Lower left is defined by the EVA crewmember’s line−of−sight being normal to the geometric center of the shield (while in its installed module position) with the crewmember oriented parallel to the longitudinal axis of the module with feet towards the module ∅−point reference).

(b) PMA MMOD shields shall be labeled.

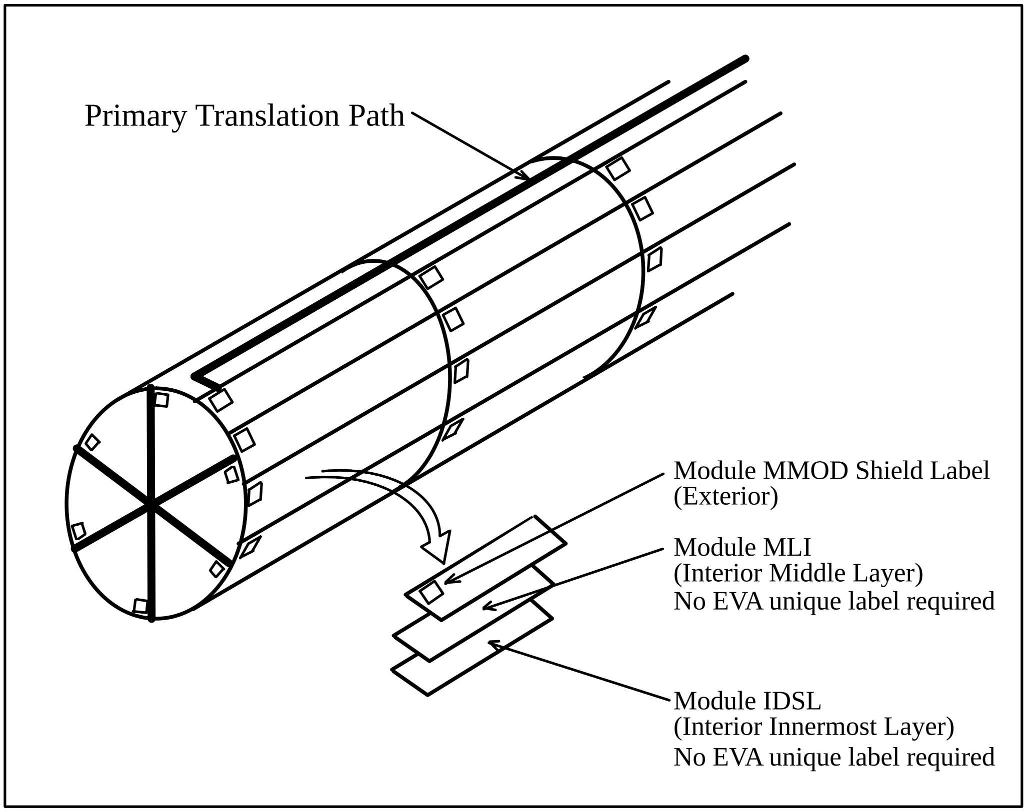


FIGURE 9.5.3.1.7.2−4 PLACEMENT (TYPICAL) OF EVA MODULE LABELING − MMOD SHIELD ONLY

2) End cone section − With the exception of the PMA, the MMOD shield label shall be located 6.0 +/− 0.25 inches right and down from the upper left corner of the MMOD shield. (Upper left is defined by the EVA crewmember's line−of−sight being normal to the geometric center of the shield (while in its installed module position) with the crewmember oriented parallel to the shield radial center line off of the module's longitudinal axis center line with feet towards the end cone CBM origin).

(5) MLI Blanket Label −

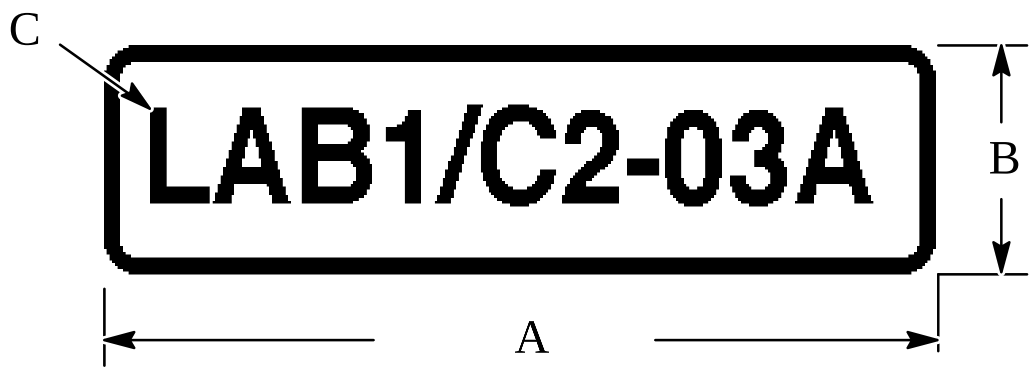
a. Coding − Each MLI blanket shall be labeled with the item part number.

b. Character height − MLI blanket markings shall have a character height of no less than 0.25 inch (black on a contrasting background).

(6) Intermediate Debris Shield Layer Label −

a. Coding − Each IDSL shall be labeled with the item part number.

b. Character height − The IDSL label shall have a character height of no less than 0.25 inch (black on contrasting background).



Recommended Typical configurations of Module Location Code Labels.

	A	B	C
MMOD Shield	7.0 inches	2.0 inches	175 pt Helvetica (bold) with 60% compression
Intermediate Debris Shield	4.0 inches	1.0 inch	48 pt Helvetica (bold)
MLI Blanket	4.0 inches	1.0 inch	48 pt Helvetica (bold)

FIGURE 9.5.3.1.7.2−5 MODULE LOCATION CODE LABELS

D. Opaque Window Protective Covers − The exposed exterior for both the stowed and installed positions of window external protective covers shall be identified with a label of its window identification (per internal window designation as described in SSP 30575).

(1) Location − The label shall be placed at the approximate geometric center of the cover.

(2) Character height − The label lettering height shall be no less than 2.0 inches (bold, helvetica or block style font black on silver).

(3) Orientation − The label shall be oriented to the nominal crewmember worksite position.

E. Robotics Truss Bay Placard − Truss bays shall be identified with a robotics truss bay placard that is visible from the shuttle to support Remote Manipulator System activities as follows:

(1) Code − Each Truss bay shall be labeled with the third and forth character of the truss location code as defined in SSP 30575, paragraph 4.2.1.

(2) Location − The robotics truss bay placard shall be located on Face 1 of the S∅, S1, S3, P1, and P3 truss segments as defined by SSP 30575.

(3) Character Height − The robotics truss bay placard shall have a character height of no less than 6.0 inches.

(4) Orientation − Truss code can be compressed horizontally and/or stacked vertically in order to meet space and mounting restrictions. A horizontal bar shall be placed beneath the code to establish a local vertical for the purposes of reading the code.

F. Truss Bay Identification Label − Truss bay labeling is based on the location code as defined in SSP 30575.

(1) Interfacing segment−to−segment truss bulkheads have the same bay/bulkhead identification. Therefore, only the inboard−most of the two adjoining bulkheads shall be labeled.

(2) Bays shall be labeled according to the assembly complete configuration and as follows:

a. Coding − The Truss Bay Label shall consist of the third and forth characters of the truss location code as defined in SSP 30575, paragraph 4.2.1, and an arrow as illustrated in Figure 9.5.3.1.7.2−6.

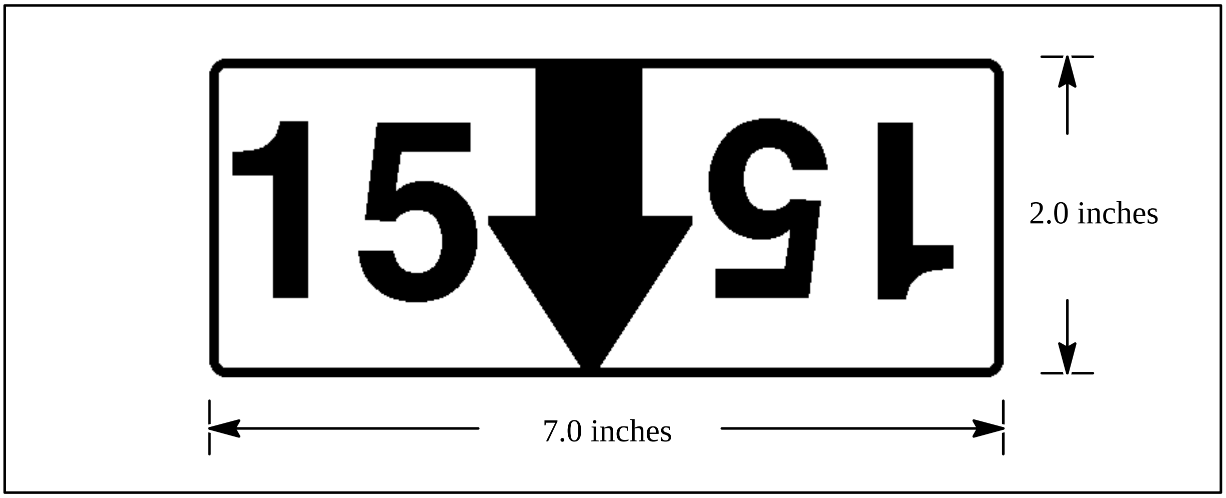


FIGURE 9.5.3.1.7.2−6 TYPICAL TRUSS BAY IDENTIFICATION LABEL

b. Character height − The truss bay label shall have a character height of no less than 1.75 inches (bold, black on silver).

c. Orientation − Truss bay label shall be oriented as follows:

1) Y−axis truss segments − The truss bay labels for Y−axis truss segments shall be oriented so that the arrow points outboard in a port (for port side truss segments) and starboard (for starboard truss segments) direction along the Y−axis, using the S∅ segment bay ∅ mid−point as the reference point

2) Z−axis truss segments − The truss bay labels for Z−axis truss segments shall be oriented so that the arrow points nadir (for nadir facing truss segments) and zenith (for zenith facing truss segments), using the Node 1 and Z−axis truss segment interface as the reference point.

3) EF truss segment − The EF truss bay labels shall be oriented so that the arrow points in the port direction, using the JPM and EF interface.

d. Location (reference Figure 9.5.3.1.7.2−1 for typical location) −

1) The truss bay label shall be spaced 11.5 +/− 0.25 inches from the truss return−to−airlock label standard location.

(a) S∅, S1/P1 and S3/P3 Truss Segments − Labels shall be placed on each segment bulkhead of Face 1.

(b) S4, S5, S6 (less Integrated Equipment Assembly (IEA)), P4, P5, and P6 (less IEA) − segments with CETA/MT Rail installed − Labels shall be placed at each segment defined bulkhead of the CETA/MT rail structure.

(c) For P6 and S6 IEAs, the label shall be placed at each defined bulkhead or on the MMOD cover.

(d) Z1 Segment − labels shall be placed on each bulkhead of Face 4 along the primary translation path.

(e) JEM EF − Labels shall be placed on each bulkhead of Face 1 along the zenith primary translation path.

G. Truss Segment Identification Label − The beginning and end points of each truss segment shall be identified with a truss segment label defined as follows:

(1) Coding − Truss Segment label shall consist of the first and second characters of the truss location code as defined in SSP 30575 paragraph 4.2.1 and an open arrow as illustrated in Figure 9.5.3.1.7.2−7.

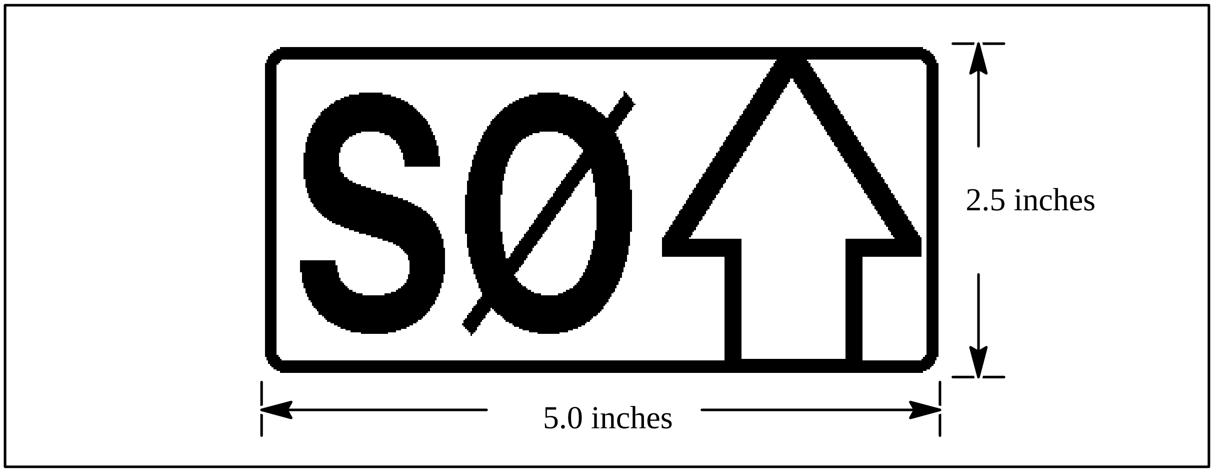


FIGURE 9.5.3.1.7.2−7 TYPICAL TRUSS SEGMENT IDENTIFICATION LABEL

(2) Character height − The truss segment label shall have a character height of no less than 2.0 inches.

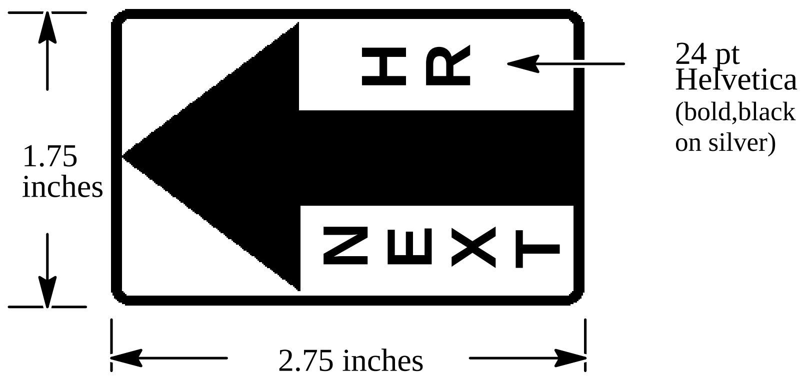
(3) Orientation − The truss segment label shall be oriented such that the arrow points inboard toward the truss segment being identified.

(4) Location − The truss segment label shall be spaced 3.0 +/− 0.25 inches from the Return−to−Airlock truss label (reference Figure 9.5.3.1.7.2−1 for typical location configuration).

H. Handrail/Handhold Advisory Labels − Two categories of advisories shall be provided along the translation path as applicable:

(1) “Next Handrail” label − The Next Handrail label shall be used on secondary translation paths when the next handrail in a translation path is not visible from design eye point 19.0 +/− 2.0 inches above the preceding handrail due to an obstruction or contour of the translation path.

a. Marking Content − The Next Handrail label shall be a black arrow no less than 2.0 inches in length with the text ”NEXT HR” as illustrated in Figure 9.5.3.1.7.2−8.



NOTE: Up to 25% of the label area may be cut away for installation provided the arrowhead and text are not removed.

FIGURE 9.5.3.1.7.2−8 TYPICAL NEXT HANDRAIL LABEL

b. Location − The Next Handrail Label shall be placed between the last visible handrail and the obstruction.

1) These labels shall be used in pairs such that the arrows point at each other from each of the two handrails being identified.

2) The label shall be placed within 4.0 inches of the end of the handrail.

c. Orientation − The arrow shall be pointed in the direction of the next handrail in the translation path.

(2) “Dead−End” Label − The dead−end label shall be used to indicate a secondary translation path that dead ends. For interior truss translation paths where there is only one defined entry and exit, Dead−End labels are not required.

a. Marking Content − The Dead−End label shall consist of the text, ”DEAD END” with an arrow positioned on both sides of the text as illustrated in Figure 9.5.3.1.7.2−9.

b. Character height − The dead−end label shall have a character height of no less than 0.5 inches.

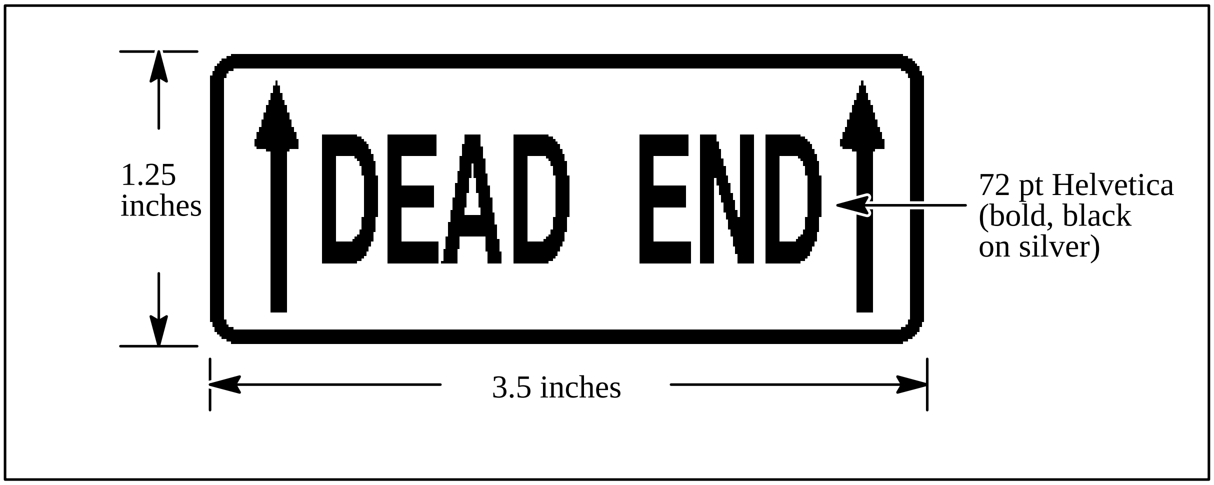


FIGURE 9.5.3.1.7.2−9 TYPICAL DEAD END LABEL

c. Location − This label shall be located within 4.0 inches of the first handrail in any path which branches from the primary or secondary translation path.

1) The dead end label shall be visible to the crewmember.

2) When a ”DEAD END” path requires a ”NEXT HANDRAIL” label, the ”DEAD END” and ”NEXT HANDRAIL” label shall be co−located.

d. Orientation − The arrows shall point in the direction of the translation path that ends in a ”dead−end”.

I. EVA Return to Airlock Label − EVA primary translation paths shall have a Return to Airlock label which indicates the direction to the airlock in accordance with the following requirements:

(1) Label Content − The Return−to−Airlock Label shall be configured as shown in Figure 9.5.3.1.7.2−10.

(2) Location − The Return−to−Airlock label shall be located as follows:

a. On modules −

1) The label shall be located:

(a) at the beginning and end of the primary translation path,

(b) at increments of 45.0 +/− 6.0 inches (maximum) on any non−intersected, planar, straight line along the primary translation path, and

(c) at any change in direction from the straight line translation path.

2) The label shall be spaced 5.0 +/− 0.25 inches to the right of the primary translation path handrail mounting centerline as viewed when translating towards the airlock.

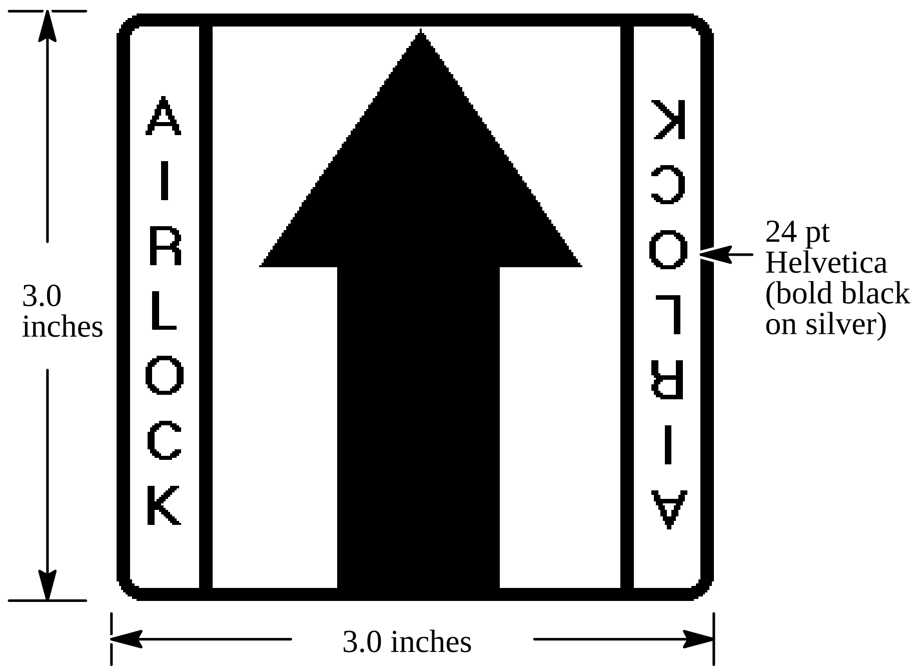


FIGURE 9.5.3.1.7.2−10 RETURN TO AIRLOCK LABLE

b. On truss segments, the label shall be located at every truss bulkhead.

1) On truss segments with the CETA Rail, the CETA translation handrail (primary path) shall be the reference point for label placement as shown in Figure 9.5.3.1.7.2−1.

2) For truss segments without the CETA rail, the Face 1 zenith (Y−axis truss and EF) or Face 4 aft (z−axis truss) primary translation path shall be the reference point for label placement.

c. For P6 and S6 IEAs and Z1, the label shall be located between handrails or handholds.

d. The primary translation path on Face 6 of the S∅ segment (between CETA handrail and CETA Spur) and the S∅ segment CETA spur, shall be labeled with the return−to−airlock label as follows:

1) at the beginning and end of each translation path segment,

2) at increments of 45.0 +/− 6.0 inches (maximum) on any nonintersected, planar, straight line along the primary translation path, and

3) at any change in direction from the straight line translation path.

e. For these two S∅ paths, the label shall be placed directly in line with the center line of the handrail mounting and, if necessary, for the spur, the label can be placed under the handrail, off−set to the edge of the spur structural beam.

f. The Return to Airlock label shall be visible to the crewmember.

(3) Orientation − The Return to Airlock label shall point in the direction an EVA crewmember should translate to return to the airlock both from the modules and from the truss.

a. The S1 and S∅ truss segment interface shall define the ∅−point reference for port and starboard orientation of Y−axis truss arrow orientation.

b. The primary translation path return−to−airlock labels shall orient the label arrow to follow the direction the crew member must follow to stay on the primary translation path (i.e., make 90.0 degree or other directional turns as required back to the airlock).

J. Electrical and Fluid Connector Panels − Dedicated external electrical and fluid connector panels used by EVA shall be uniquely identified by panel numbers. This includes such panels as those found at each truss segment−to−segment utilities interface connections, patch panels, or other such electrical cable or fluid umbilical junction or terminating points. This does not include connector interface points on ORUs or common module utilities connections (i.e., end ring connections).

(1) Coding −

a. PMA and truss segments inboard of solar array rotary joints shall allow use of "AXXX" alphanumeric desighnators for connector panel coding.

b. The remaining connector panels shall be labeled in accordance with the code defined in SSP 30575, paragraph 4.7.1 (reference Figure 9.5.3.1.7.2−11 below).

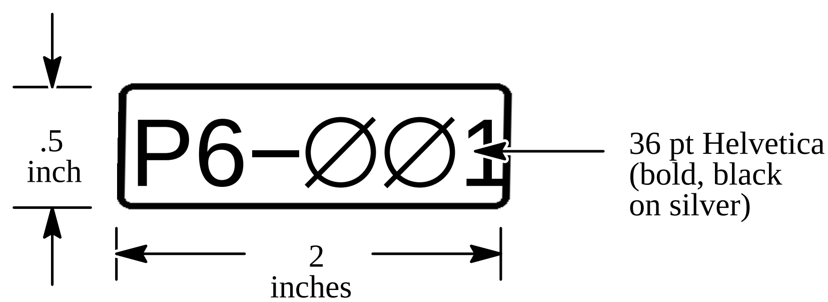


FIGURE 9.5.3.1.7.2−11 TYPICAL CONNECTOR PANEL LABEL

(2) Character height −

a. The character height for EVA connector panel label lettering for the PMA and truss segments inboard of solar array rotary joings shall be no less than 0.18 inch (bold, black on a contrasting background).

b. The character height of all remaining EVA connector panel number label lettering shall be no less than 0.25 inch (bold, black on a contrasting background).

(3) Location − The panel number label shall be placed such that it is visible to the crew member while at the worksite with and without line and connector obstructions.

a. The label shall be placed directly on the panel face if the panel has available space or it is normal to the crewmember's line−of−sight.

b. If the panel face does not have sufficient space for the label or the panel face is oriented at an angle to the crewmember's line−of−sight, the label shall be placed on visible, adjacent panel support structure or within 2.0 inches of a visible, adjacent surrounding surface or structure.

c. The label shall be placed typically at the top center of the panel as viewed by the crewmember in a nominal heads−up orientation. If top center is not possible, top left or right are options. Lower center, lower left, or right should be reserved for unique circumstances.

9.5.3.1.8 OPERATING INSTRUCTION DESIGN REQUIREMENTS

Requirements for the design and use of operating instructions are provided below:

A. Location − Equipment operating labels or placards shall be located on or adjacent to equipment.

B. Deleted.

C. Equipment Name − The label or placard shall have the title or name of the equipment to be operated centered above the text.

D. Grouping − Instructional text shall be grouped and titled by category (e.g., installation, removal, activation, calibration, etc.).

E. Case − Instructional text will use upper and lower case letters.

F. Title Selection − Title nomenclature will be consistent with SSP 50254.

Case − Titles will be upper case letters.

G. Required Tools − When tools are required to remove stowage items, markings shall be used to indicate the location of the fasteners to be removed.

9.5.3.1.9 STOWAGE CONTAINER LABELING DESIGN REQUIREMENTS

9.5.3.1.9.1 IVA STOWAGE CONTAINER LABELING DESIGN REQUIREMENTS

Requirements for stowage container labeling are provided below:

A. Purpose − Stowage containers shall be labeled in accordance with SSP 30575.

B. Deleted.

C. Contents − Each stowage container will display the contents on its front surface visible to the crewmember.

D. Label Revision − Provisions shall be made to permit in−flight revisions to or replacement of stowage labels on all stowage containers.

E. Individual−Crew Items − Items allocated to a specific crewmember shall be identified with the user's title, name, or other coding technique.

F. Subdivided Containers −

(1) If a stowage container is subdivided internally into smaller closed containers, the sub−containers shall carry a list of contents.

(2) Deleted.

(3) If the available marking space on a sub−container is insufficient to display the complete content titles, a contents list shall be displayed elsewhere and clearly identified as belonging to the sub−container.

(4) The specific contents of each sub−container and its code shall be listed on the front surface of its container or near it.

G. Similar Item Labeling − Containers with designated locations for placement of equipment set (e.g., socket wrenches in a tool kit) shall have each location identified with the title of the item stowed.

9.5.3.1.9.2 EVA STOWAGE LOCKER LABELING DESIGN REQUIREMENTS

A. EVA Stowage Locker Labels − EVA stowage lockers shall have a content identification label mounted on both the outside and inside of each stowage locker and use mapping labels as defined in 9.5.3.1.6.2, Item B.

(1) Location Coding − EVA stowage locker labeling shall incorporate the location coding system per SSP 30575 for designating the location of stowed items.

(2) Contents − Each stowage locker label will display the contents of the locker.

B. Label Revision − Where stowage contents are on−orbit re−configurable, the label shall be EVA replaceable.

C. Location − The Stowage Locker Label will be located so that is is visible relative to the crewmember's nominal position at the worksite.

9.5.3.1.10 DELETED

9.5.3.1.11 DELETED

9.5.3.1.12 GROUPED DISPLAYS AND CONTROLS DESIGN REQUIREMENTS

Requirements for labels of grouped displays and controls are provided below

A. Group Identification − Functional groups of controls shall be identified (e.g., by common color, by boundary lines).

B. Labels of Functional Groups − Labels shall be located above the functional groups they identify.

C. Boundary Lines −

(1) When a line is used to enclose a functional group and define its boundaries, the labels shall be centered at the top of the group, in a break in the line.

(2) The width of the line shall not be greater than the stroke width of the letters.

D. Related Controls − When displays and controls must be used together in adjustments or activation tasks, visible labels or markings shall indicate their functional relationships.

9.5.3.1.13 CAUTION AND WARNING LABELS DESIGN REQUIREMENTS

Caution and warning labels are required for indicating potentially undesirable conditions. Requirements are provided below:

A. Identification − Caution and warning labels shall identify the type of hazard.

B. Location − The caution markings shall be located in a visible area.

C. Immediate Action Controls −

(1) All controls, buttons, and small handles or levers requiring immediate access shall have their panel background colored in accordance with the applicable subsection of 9.5.3.2.

(2) Large handles or levers shall be striped on the handle or lever itself.

D. IVA Emergency−Use Items −

(1) Decals and placards on emergency−use items (e.g., repair kits, emergency lighting, fire extinguisher, etc.) shall display the words ”EMERGENCY USE” surrounded by diagonal red and white stripes either on the item or adjacent to it.

(2) The emergency type warning stripes shall be alternate red and white for IVA applications, or red and silver (metallic) for EVA applications.

(3) The red and white stripes will be of equal width.

(4) There shall be no fewer than four red stripes and three white stripes.

(5) The striping shall be applied at a 45.0 degree angle rotated clockwise from the vertical.

(6) The striping shall begin and end with a red stripe.

(7) The text shall be white letters on the red background or red letters on a white background for IVA applications, or black letters on a silver (metallic) background for EVA applications.

(8) For items located within a storage container, the diagonal striping shall be applied to the door of the container and the titles of the emergency items shall be included on the marking instead of the words ”EMERGENCY USE.”

(9) Fire ports shall be identified with two labels that include a port hole decal and a fire port identification label.

a. The fire port shall be identified with a circular decal placed around the fire port opening in accordance with the Decal Catalog JSC 27260.

1) The fire port decal shall be in accordance with drawing SDD32100397.

2) The fire port decal shall include a gray−filled red circle. The inner circle (gray−filled area) includes black dashed lines (in form of an X) that are perforated.

b. The fire port shall be identified with a separate fire port identification label that includes the words ”Emergency Use” and ”Fire Port”, and a location code in accordance with SSP 50254, Operations Nomenclature.

1) This fire port identification label shall be placed above the fire port opening/circular fire port decal. When space above the fire port opening cannot accommodate a label, the label shall be placed in any position allowing close proximity to the intended fire port/port decal.

2) The label shall be in accordance with drawing SDG32108589. The largest size label that will fit in the available space near the fire port on the hardware shall be selected from this drawing.

3) Strictly for the case of space limitations, the following guidelines shall be utilized to reduce the size of the overall label:

(a) ”Emergency Use” nomenclature shall be the first text omitted to reduce label dimensions.

(b) ”Fire Port” nomenclature shall be the second text omitted to further reduce label dimensions.

(c) At a minimum, location coding nomenclature and diagonal red and white stripes shall exist on all fire port labels to convey the emergency capability/interface information.

E. IVA, EVA, and EVR Warning Stripe Specification −

(1) Caution/warning decals and placards shall be surrounded by diagonal yellow (gold anodize for EVA/EVR applications) and black stripes.

(2) The caution/warning type stripes shall be alternate yellow (gold) and black.

(3) The yellow (gold) and black stripes will be of equal width.

(4) There shall be no fewer than four yellow (gold) stripes and three black stripes.

(5) The striping shall be applied at a 45.0 degree angle rotated clockwise from the vertical.

(6) The striping shall begin and end with a yellow (gold) stripe.

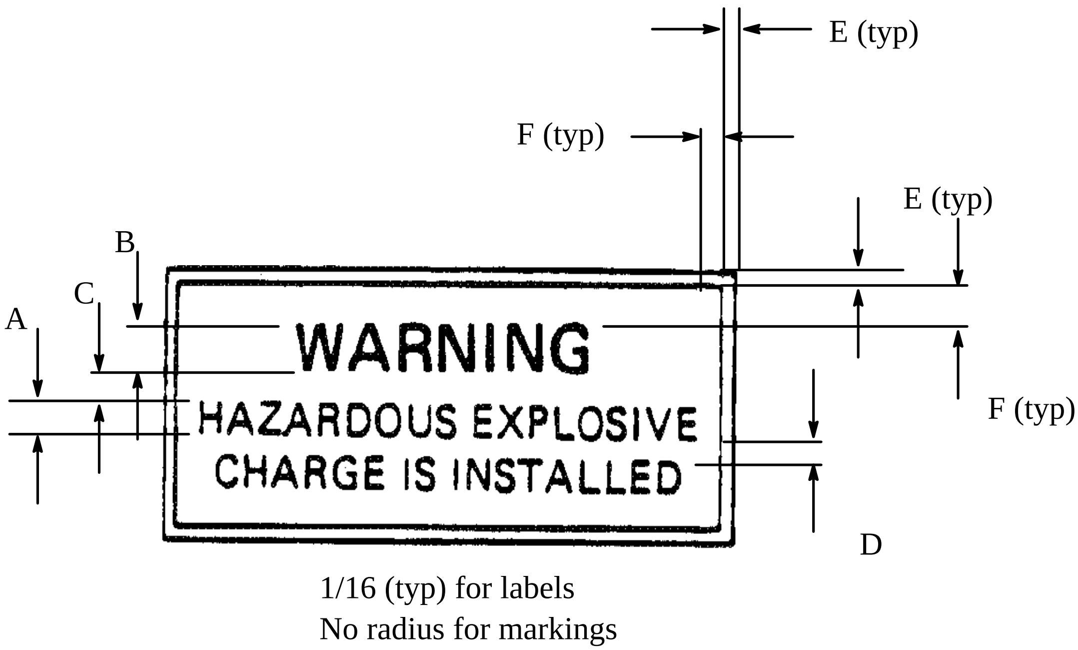
(7) The text shall be black letters on the yellow background for IVA applications, or black letters on a silver (metallic) background for EVA applications.

F. IVA Switches and Buttons −

(1) The striping around a switch or button shall not be wider than 25.0 mm (1.0 in.) or narrower than 3.0 mm (0.125 in.).

(2) If one side of a switch or button has less than 3.0 mm (0.125 in.) space, no striping shall be applied to that side.

G. Label Specifications − Hazard identification labels will use the letter size as specified in Figure 9.5.3.1.13−1.



A	−	Text or minor lines of lettering	= A
B	−	Heading or major line of lettering	= 1.25A to 2A
C	−	Spacing between heading and text	= 0.65A to A
D	−	Spacing between lines of text	= 0.50A
E	−	Border width	= 2A Minimum
F	−	Background border	= A

FIGURE 9.5.3.1.13−1 LETTER SIZE AND SPACING FOR CAUTION AND WARNING LABELS

H. Conflicting Federal Regulations − Equipment which is subject to federal regulations that establish industry standards related to safety or hazard labeling shall be exempt from the caution/warning and emergency labeling requirements specified within this document to the extent necessary to comply with the applicable federal regulation.

I. IVA Emergency Translation Path Markings − Hatch entrances shall have an emergency marking which indicates the direction to the emergency escape vehicle.

(1) IVA Emergency Translation Path Markings shall have a character height of no less than 2.0 inches.

(2) IVA Emergency Translation Path markings shall be located above the hatch entrance relative to the local vertical orientation corresponding to the operation of the hatch. For node radial hatches, the label may be placed adjacent to the Hatch Entrance Marking (9.5.3.1.7.1, Item E.).

(3) IVA Emergency Translation Path markings shall be oriented relative to the local vertical orientation of the module being exited.

J. EVA Specific Hazard or Warning and Keepout Zone Warning Demarcation Label −

(1) Each translation that comes within a keepout zone shall be labeled with a keep out zone warning label.

(2) Location −

a. A standard hazard or warning label shall be placed within 4.0 inches of the nearest handrail 4.0 to 6.0 feet from the outside boundary of the hazard zone as shown in Figure 9.5.3.1.13−2.

b. The standard keepout zone warning label shall be located at the perimeter or entry point of the zone.

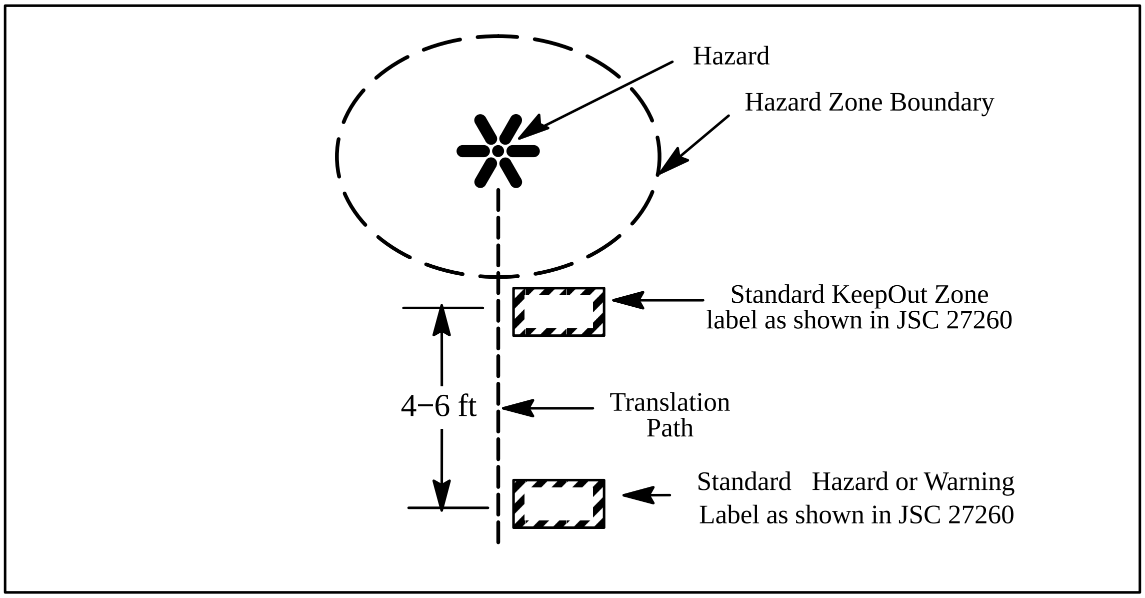


FIGURE 9.5.3.1.13−2 KEEPOUT ZONES

9.5.3.1.14 ALPHANUMERIC DESIGN REQUIREMENTS

9.5.3.1.14.1 FONT STYLE DESIGN REQUIREMENTS

A. The font style used on decals, placards, and labels will be Helvetica.

B. Fit Problems − The use of condensed type (Helvetica Condensed) or abbreviations is the preferred method of solving line length ”fit” problems rather than a reduction in type size.

C. Alternate Marking Methods − Marking methods such as engraving which are not able to match a Helvetica font style, will use a block style lettering.

9.5.3.1.14.2 PUNCTUATION

The use of punctuation marks will be kept to a minimum.

A. Periods − Periods will be omitted except when needed to preclude misinterpretation.

B. Hyphens − Hyphens will be avoided.

C. Parentheses and Ampersands − Parentheses and ampersands will not be used on the display or control panel or other crew equipment.

D. Slashes − The slash (/) may be used in place of the words ”and” and ”or” where appropriate, and may be used to indicate multiple functions.

9.5.3.1.14.3 SPECIAL CHARACTERS

A. Subscript and Superscript Size − Subscripts and superscripts will be 0.6 to 0.7 times the height of associated characters.

B. Subscripts − Subscripts will be centered on the baseline of associated characters.

C. Lower Case Letter Subscripts − The base of lower case letters and the ovals of g, p, q, etc., will be at the same level as the base of adjacent capital letters.

9.5.3.1.14.4 CHARACTER HEIGHT

The following minimum character heights apply to all decals, labels, placards, and engraved markings, except for cases where a specific character height is specified for the type of marking under consideration.

9.5.3.1.14.4.1 CHARACTER HEIGHT FOR INTERNAL MARKINGS

A. Character Height − Character height depends on viewing distance. At a viewing distance of 710 mm (28.0 in.), the height of letters and numerals shall be no less than the values given in Figure 9.5.3.1.14.4.1−1.

B. Variable Distance − For a distance (D) other than 710 mm (28.0 in.), the values in Figure 9.5.3.1.14.4.1−1 shall be multiplied by D/710 mm (D/28.0 in.) to obtain the minimum character height.

Markings	Character Height (1)
For critical markings, with position fixed (e.g., numerals on fixed scales, controls, and switch markings, or emergency instructions):	4.0 to 8.0 mm (0.16 to 0.31 in)
For noncritical markings (e.g., identification labels, routine instructions, or markings required only for familiarization):	1.3 to 5.0 mm (0.10 to 0.20 in)
Note: (1) The character height range indicates the minimum required height and the recommended maximum height for general applications. Specific applications may require larger character heights.	

FIGURE 9.5.3.1.14.4.1−1 CHARACTER HEIGHT − INTERNAL MARKINGS

C. Size Categories −

(1) To determine character height, all nomenclature on a label may be divided into three categories: titles, subtitles, and text. The recommended nominal height at a viewing distance of 710 mm (28.0 in.) for each category is:

a. Titles, 5.0 mm (0.19 in.)

b. Subtitles, 4.0 mm (0.16 in.)

c. Text, 3.0 mm (0.12 in.)

(2) When moving to the next larger character size, the character height will increase by approximately 25.0 percent.

9.5.3.1.14.4.2 CHARACTER HEIGHT FOR EXTERNAL MARKINGS

A. Character Height − Character height depends on viewing distance. At a viewing distance of 381 mm (15.0 inches) for EVR interfaces or 710 mm (28.0 inches) for EVA interfaces, the height of letters and numerals shall be no less than values given in Figure 9.5.3.1.14.4.2−1.

B. Variable Distance − For a distance (D) other than 381 mm (15.0 inches) for EVR or 710 mm (28.0 inches) for EVA, the values in Table 9.5.3.1.14.4.2−1 shall be multiplied by D/381 mm (D/15.0 inches) for EVR or D/710 (D/28.0 inches) for EVA to obtain the minimum character height.

Markings	Character height (1)
For critical markings, with position fixed (e.g., connectors, numerals on fixed scales, controls, and switch markings, caution and warning or emergency instructions):	5.0 to 9.0 mm (0.18 to 0.36 in)
For noncritical markings (e.g., identification labels, routine instructions, or markings required only for familiarization):	3.5 to 6.0 mm (0.14 to 0.24 in)
Note: (1) The character height range indicates the minimum required height and the recommended maximum height for general applications. Specific applications may require larger character heights.	

FIGURE 9.5.3.1.14.4.2−1 CHARACTER HEIGHT − EXTERNAL MARKINGS

C. Size Categories −

To determine character height, all nomenclature on a label may be divided into three categories: titles, subtitles, and text. The recommended nominal height for each category at a viewing distance of 381 mm (15.0 inches) for EVR interfaces is:

Titles, 28.0 mm (1.12 inch)

Subtitles, 23.0 mm (0.90 inch)

Text, 18.0 mm (0.72 inch)

(1) The recommended nominal height for each category at a viewing distance of 710 mm (28.0 inches) for EVA interfaces is:

Titles, 8 mm (0.32 inch)

Subtitles, 6.0 mm (0.24 inch)

Text, 5.0 mm (0.18 inch)

(2) When moving to the next larger character size, the character height will increase by approximately 25.0 percent.

9.5.3.1.14.5 SPACING

A. The spacing between lines of related text will be 0.5 of upper case letter height.

B. Spacing between headings and text will be 0.6 to 1.0 of upper case letter height.

9.5.3.1.15 BAR CODING

Decals, labels, or placards using bar coding for identification shall use a code 39 bar code number system per MIL−STD−1189.

9.5.3.2 IVA CODING DESIGN REQUIREMENTS

Requirements for the implementation of various types of coding are presented below:

A. Deleted.

B. Brightness Coding −

(1) Deleted.

(2) No more than three levels of brightness shall be used.

(3) Each level shall be separated from the nearest by at least a 2:1 ratio.

C. Size Coding −

(1) Symbols − Where size difference between symbols is employed, the major dimensions of the larger shall be at least 150.0 percent of the major dimensions of the smaller with a maximum of three size levels permitted.

(2) Controls −

a. No more than three different sizes of controls shall be used in coding controls for discrimination by absolute size.

b. Controls used for performing the same function on different items or equipment shall be the same size.

D. Deleted.

E. Deleted.

F. Shape Coding −

(1) Deleted.

a. Deleted.

b. Deleted.

c. Gloved Operation − Shapes shall be tactilely identifiable when IVA gloves are worn.

d. Mounting − Shape coded knobs and handles shall be positively and nonreversibly attached to their shafts to preclude incorrect attachment when replacement is required.

G. Deleted.

H. Flash Coding (non−VDT) −

(1) Deleted.

(2) Flash Rate −

a. No more than two flash rates shall be used.

b. Where one rate is used, the rate shall be between three and five flashes per second.

c. Where two rates are used, the second rate shall be less than two per second.

(3) Duty Cycle − Flashing lights shall have equal amounts of ON and OFF time.

(4) Simultaneous Signals − Flashing lights which are designed to be simultaneously active shall have synchronized flashes.

(5) Failure Indication − If the indicator is energized and the flasher device fails, the light shall illuminate and burn steadily.

I. Color Coding − Color identification numbers used below are per FED−STD−595.

(1) Color Difference − Each color shall always be associated with a single meaning.

a. Only one hue within a color category (e.g., reds, greens) shall be used on a decal or placard within the same system.

b. That color shall always be associated with a single meaning within the same system.

(2) Number of Colors − No more than nine colors, including white and black, shall be used in a coding system.

(3) Ambient Light −

a. Colors will be compatible with nominal ISS light sources.

b. Colors will 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, vary as the result of such factors as solar glare, filtration of light, or variation from natural to artificial light.

c. Where the ambient illuminance will be above 10.0 lux (0.9 ft−c), black characters will be provided on a light background.

d. Dark Adaptation − Where dark adaptation is required, the displayed letters or numerals will be visible without interfering with night vision requirements.

(4) Familiar Color Meaning − Colors which are consistent with common usage and existing standards with respect to application, are listed below. All color coordinates for transilluminated lighting are in accordance with CIE Coordinates Chart Chromaticity Diagram 1931.

a. Red #21105 − Emergency use items, warning, and master alarm lights; safety controls; critical controls requiring rapid identification; emergency shutdown; control panel outline of a functionally critical emergency nature. Transilluminated devices shall have coordinates of x = 0.633 (+/− 0.03), y = 0.255 (+/− 0.03) or be aviation red in accordance with MIL−C−25050.

b. Yellow #33538 − Caution; safety controls associated with emergencies of a less critical nature. Transilluminated devices shall have coordinates of x = 0.520 (+/− 0.03), y = 0.430 (+/− 0.03) or be aviation yellow in accordance with MIL−C−25050.

c. Yellow #33538 with black #37038 stripe − Immediate access; exit releases.

d. Orange #32246 − Hazardous moving parts; machinery; start switches, etc.

e. Green #14187 − Important and frequently operated controls having no urgent or emergency implications. Transilluminated devices shall have coordinates of x = 0.155 (+/− 0.05), y = 0.750 (+/− 0.05). Alternatively, for transilluminated devices, a wavelength of 520 nm − 540 nm is acceptable.

f. Green (Sage) #14260 − First aid and survival.

g. Blue #25102 − Advisory (not recommended for general use).

h. Purple #37142 (Magenta) − Radiation hazard.

i. White − Advisory (for transilluminated devices only) − Transilluminated devices shall have coordinates of x = 0.360 (+/− 0.03), y = 0.360 (+/− 0.03).

(5) Color Deficiency − To avoid confusion by color−deficient observers, do not use the color green if the color scheme uses more than six colors. If six or fewer colors including green #14260 and yellow are used, yellow #23655 shall be substituted for #33538. Red #11302 and blue #15177 may also be used; however, do not use red and green within the same complement.

(6) Placards − Placards shall adhere to the accepted combinations of markings and background color listed below:

Markings	Background
White	Black
Black	Yellow
Black	White
Yellow	Blue
White	Red
Red	White
Blue	Yellow
White	Grey

(7) Zone Markings − On indicators where zone markings are used:

a. The primary colors shall be limited to red, yellow, orange, and green consistent with the color selection criteria given above.

b. Zone markings shall be applied and located in a manner that facilitates easy removal.

c. Zone markings shall not interfere with the reading of quantitative markings.

(8) Color Contrast − An important factor to consider when selecting colors is the contrast among the colors. This is needed to ensure that each color is easily discriminated from the others. Although contrast is an important consideration, it should not be used without regard to other important factors such as convention or standard, inherent meaning, and consistency across displays.

a. The following color list per FED−STD−595 shall be used to select colors that contrast maximally with the color just preceding it and satisfactorily with the earlier colors in the list. Colors (1) through (9) yield satisfactory contrast for red−green deficient as well as color−normal crewmembers. The remaining 13 are useful only for color−normal crewmembers.

1) White #19875

2) Black #17038

3) Yellow #13655

4) Purple #17142

5) Orange #12246

6) Light Blue #15102

7) Red #11105

8) Buff #33594

9) Gray #36251

10) Green #34138

11) Purplish pink #31638

12) Blue #35180

13) Yellowish pink #33613

14) Violet #37142

15) Orange−yellow #33538

16) Purplish red #31136

17) Greenish yellow #33814

18) Reddish brown #30160

19) Yellow−green #34666

20) Yellowish brown #30260

21) Reddish orange #32246

22) Olive green #34108

b. Deleted.

9.6 USER/COMPUTER INTERACTION

9.6.1 INTRODUCTION

This paragraph is not applicable for this document.

9.6.2 DATA DISPLAY

9.6.2.1 DELETED

9.6.2.2 DELETED

9.6.2.3 TEXT

9.6.2.3.1 TEXT DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.6.2.3.2 TEXT DESIGN REQUIREMENTS

Requirements for display of text are provided below:

A. Upper and lower case − Text shall be presented using upper and lower case letters.

B. Justification −

(1) The default condition shall be to left justify all lines of text.

(2) Left, right and fill justification shall be provided.

C. User Control − The user shall be able to manipulate text justification, line length, line spacing, margins, font size, and font style.

9.6.2.4 TABLES

9.6.2.4.1 TABLES DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.6.2.4.2 TABLES DESIGN REQUIREMENTS

Requirements for the general display of tables are provided below:

A. Titles −

(1) All tables shall have a title.

(2) Table titles shall appear centered above the table.

B. Labels − Each row and column in a table shall have a label.

C. Consistent Widths of Characters −

(1) Alphanumeric characters within the same table shall use the same font.

(2) Nonproportional fonts shall be used in tables.

D. Deleted.

9.6.2.4.3 MATRIX TABLES

9.6.2.4.3.1 MATRIX TABLES DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.6.2.4.3.2 MATRIX TABLES DESIGN REQUIREMENTS

Requirements for the display of matrix tables are provided below:

A. Deleted.

B. Arrangement −

(1) Data in matrix tables shall be displayed in a left−to−right, top−to−bottom array.

(2) Alphanumeric data shall be left justified; numeric data shall be arranged with decimal points aligned vertically.

C. Deleted.

D. Labels −

(1) Labels for the row variables shall be located in the left−most column; labels for the column variables shall be located in the top row.

(2) When a column extends over more than one ”page” vertically (i.e., the user has to scroll or page to continue reading the column), the same column labels shall be displayed from ”page” to ”page”.

E. Readability − In tables with greater than seven rows or columns, a blank line, dots, or other distinctive features shall be inserted after every fifth row or column as appropriate to help maintain one's place across columns or across rows.

F. Deleted.

G. Deleted.

9.6.2.4.4 DELETED

9.6.2.5 GRAPHICS

9.6.2.5.1 GRAPHICS DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.6.2.5.2 GRAPHICS DESIGN REQUIREMENTS

Requirements for the display of graphics are provided below:

A. The capability to display graphics, both graphic primitives (lines, arcs, polygons, circles) as well as complex graphical representations of hardware devices shall be provided.

Graphical display capabilities shall be provided for icons, schematics, 3−D statistical data graphing, maps, flowcharts, and digitized photos.

B. Deleted.

C. Identification of Graphic Displays − All graphic displays shall have a title centered above the display.

D. Deleted.

(1) Deleted.

(2) When graphic symbols are used in a display, a legend providing the symbol and its reference shall be provided.

9.6.2.6 CODING

9.6.2.6.1 CODING DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.6.2.6.2 CODING DESIGN REQUIREMENTS

Requirements for the coding of displayed data are provided below:

A. Deleted.

B. Grouping − Coding shall be used to group functionally similar information and to indicate membership in a common group. Grouping allows users to perceive a large screen as consisting of smaller identifiable pieces. Spatial distance and shape coding are particularly powerful grouping techniques.

 (1) Grouping of information shall be accomplished by spatial distance, shape coding, lines, color coding, or other means consistent with the application.

 (2) Displays with high information density shall have an intermediate number of groups. The preferred range for number of groups is 19 to 40.

C. Symbols −

 Coding by means of graphic symbols, shapes, or color shall be a key method used to communicate the specific meaning of an element of a display to a user.

 The choice of a symbol shall not contradict highly overlearned associations (e.g., the use of red as a symbol for stop or danger and the use of an octagonal shape for stop).

 (1) As a symbolic code, color shall be redundant with at least one other coding technique.

 (2) Users shall have access to the reference for every symbol.

9.6.2.7 WINDOW DISPLAYS

9.6.2.7.1 WINDOW DISPLAYS DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.6.2.7.2 WINDOW DISPLAYS DESIGN REQUIREMENTS

Requirements for the display of windows are provided below:

A. Deleted.

B. Deleted.

C. Window Titles − All window displays shall have a title positioned at the top center of the display.

9.6.2.8 FORMAT DESIGN REQUIREMENTS

Requirements for the format of data displays are provided below:

A. Consistency − Display formats shall be consistent within a system.

(1) The same format shall be used for input and output.

(2) Deleted.

(3) Recurring data fields within a system shall have consistent names and consistent positions within displays.

B. Deleted.

C. Information Density − 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.

D. Deleted.

E. Deleted.

F. Deleted.

G. Deleted.

H. Deleted.

I. Deleted.

J. Identifying Location in Sequence of Displays − Cues shall be provided to the user to identify the currently displayed page and the total number of pages of a multiple page display (e.g., in a text file, the second page of a five page file might be labeled ”Page 2 of 5”).

K. Abbreviations and Acronyms −

(1) Deleted.

(2) Acronyms and abbreviations shall be consistent with NASA−TM−103575.

(3) Deleted.

(4) Deleted.

(5) No punctuation shall be used in abbreviations.

(6) Deleted.

L. Deleted.

9.6.2.9 INFORMATION DISPLAY RATE

9.6.2.9.1 INFORMATION DISPLAY RATE DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.6.2.9.2 INFORMATION DISPLAY RATE DESIGN REQUIREMENTS

Requirements for the rate of display of information are provided below:

A. Information Display Rate − Alphanumeric text shall not be updated at a rate greater than 1.0 Hz.

B. Deleted.

C. Display Freeze −

  (1) The user shall be capable of freezing the presentation of display data.

  (2) The user shall have the capability to resume a frozen display at the point it was frozen or at a user−specified time.

  (3) Indication that a display is frozen shall be provided.

D. System Response Time − The system shall provide feedback in response to a user command within two seconds of command initiation.

E. Keystroke Echo Response − Alphanumeric key input shall be echoed to a display within 100 milliseconds of entry.

9.6.3 REAL−TIME INTERACTION

9.6.3.1 USER COMPUTER DIALOGUES

9.6.3.1.1 USER COMPUTER DIALOGUE DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.6.3.1.2 USER COMPUTER DIALOGUES DESIGN REQUIREMENTS

General requirements for dialogues between users and computers are provided below:

A. Deleted.

B. Multiple dialogues − A minimum of two of the following dialogue types shall be supported:

  (1) Command Line Interface

  (2) Menus

  (3) Data Forms

  (4) Direct Manipulation

C. Deleted.

D. Feedback from commands −

(1) Deleted.

(2) Feedback for a user initiated command shall indicate the success or failure of command execution.

If a user initiated command fails to execute, the command feedback shall indicate the reason for failure.

(3) Deleted.

E. Arm−Fire Sequence for Critical Commands − User initiation of a potentially hazardous command shall require two independent user actions prior to execution.

9.6.3.1.3 COMMAND LANGUAGE

9.6.3.1.3.1 COMMAND LANGUAGE DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.6.3.1.3.2 DELETED

9.6.3.1.4 COMMAND KEYSTROKES DESIGN REQUIREMENTS

Requirements for command keystrokes are provided below:

A. Uses − The format and executed function of a command keystroke shall be the same across all applications.

B. Deleted.

9.6.3.1.5 FUNCTION KEYS DESIGN REQUIREMENTS

Requirements for function keys are provided below:

A. Deleted.

B. Consistency across applications − The consequence of pressing a fixed function key shall be consistent across applications.

9.6.3.1.6 MENUS

9.6.3.1.6.1 MENUS DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.6.3.1.6.2 MENUS DESIGN REQUIREMENTS

General requirements for menus are provided below:

A. Deleted.

B. Presentation of Menu Items − Each menu item, along with any associated information (e.g., selection codes and descriptors), shall be displayed on a single line.

C. Deleted.

D. Coding of Menu Items −

(1) When command keystrokes are redundant with menu item functions, the menu item label shall be display the command keystroke in addition to the menu item description.

(2) Deleted.

(3) Deleted.

E. Deleted.

F. Format Consistency − Menu formats shall be consistent throughout the system.

G. Deleted.

H. Deleted.

I. Feedback −

(1) When a menu item is selected, the text of the selected item shall reverse video to indicate selection.

(2) Deleted.

J. Deleted.

9.6.3.1.6.3 PERMANENT MENUS

9.6.3.1.6.3.1 PERMANENT MENUS DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.6.3.1.6.3.2 PERMANENT MENUS DESIGN REQUIREMENTS

Use − Permanent menus shall be used when (1) the user needs to see the menu items throughout a task, (2) the user needs to examine every option in detail, (3) the user does not have the ability to request that a menu be displayed (e.g., in the absence of a pointing device), or (4) the use of a user−requested menu would obscure information needed for a task.

9.6.3.1.6.4 USER−REQUESTED MENUS

9.6.3.1.6.4.1 USER−REQUESTED MENUS DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.6.3.1.6.4.2 USER−REQUESTED MENUS DESIGN REQUIREMENTS

Requirements for user−requested menus are provided below:

A. Deleted.

B. Menu design −

(1) Deleted.

(2) Menus shall have a titles centered above the items in the menu.

(3) Menu bars shall be placed in a consistent location in all displays.

(4) Deleted.

C. Activation −

(1) User requested menus shall be displayed after a single action by the user.

(2) After the menu option's selection process is complete, the menu shall revert to its hidden state.

9.6.3.1.7 DIRECT MANIPULATION

9.6.3.1.7.1 DIRECT MANIPULATION DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.6.3.1.7.2 DELETED

9.6.3.1.7.3 ICONS

9.6.3.1.7.3.1 ICON DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.6.3.1.7.3.2 ICON DESIGN REQUIREMENTS

Requirements for icons are provided below:

A. Icon Design −

(1) Deleted.

(2) Deleted.

(3) The minimum size of a selectable icon shall be 0.25 inches square.

(4) Deleted.

(5) Deleted.

B. Consistency − Visual features, meanings, and specific uses of icons shall be consistent within and among applications.

C. Feedback −

(1) When an icon is selected, it shall reverse video to indicate selection.

(2) The icon shall remain highlighted during the time that it is selected.

9.6.3.1.7.4 DELETED

9.6.3.1.7.5 INTERACTIONS WITH WINDOWS

9.6.3.1.7.5.1 INTERACTIONS WITH WINDOWS DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.6.3.1.7.5.2 INTERACTIONS WITH WINDOWS DESIGN REQUIREMENTS

Ground requirements (not applicable for onboard) for direct manipulation of windows are provided below:

A. Control Over Window Dimensions − Users shall be able to change the horizontal and vertical dimension of windows independently by direct physical action on the window.

B. Control Over Window Location − Users shall be able to move windows to different locations on a display by direct physical action on the window.

C. Opening and Closing a Window − Users shall be able to open or close a window by direct physical action on the window.

D. Deleted.

9.6.3.1.8 DATA FORMS/FORM−FILLING

9.6.3.1.8.1 DATA FORMS/FORM−FILLING DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.6.3.1.8.2 DATA FORMS/FORM−FILLING DESIGN REQUIREMENTS

Requirements for data forms and form filling user−computer dialogues are provided below:

A. Deleted.

B. Deleted.

C. Format and Content Consistency − If paper forms and computer−displayed forms are used in concert in a data entry task, the format and content of the two types of forms shall be consistent, within the constraints of the task and the differences in information format.

D. Deleted.

E. Deleted.

F. Cursor Placement −

  (1) When the form is displayed, a displayed cursor shall be positioned by the system at the first data entry field to which the user has to provide input.

  (2) The system shall advance the cursor to the next data field when the user has completed entry of the current field.

  (3) The user shall also have the ability to move the cursor to the next field, to the previous field, or, independently, to any field on the form.

G. Deleted.

H. Deleted.

I. Deleted.

J. Dimensional Units − When a consistent dimensional unit is used in a given field, the dimensional unit shall be provided and displayed by the system.

K. Deleted.

L. Deleted.

M. Prevent Entry of Inappropriate Characters − Error messages shall be displayed to the user when alphanumeric keyboard entry is inconsistent with the syntax of the command.

9.6.3.1.8.3 DEFAULT VALUES FOR DATA FORMS DESIGN REQUIREMENTS

Requirements for default values are provided below:

A. Default Values − Default values shall be displayed in data fields.

B. Default Modification − The user shall have the capability to modify the default value in a data field.

C. Default Substitution − The user shall have the capability to replace, one−time, the default value in a data field.

D. User Confirmation − User modification of a default value in a data field shall require confirmation by the user.

9.6.3.1.9 QUESTION AND ANSWER

9.6.3.1.9.1 QUESTION AND ANSWER DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.6.3.1.9.2 QUESTION AND ANSWER DESIGN REQUIREMENTS

Requirements for question and answer dialogues are provided below:

A. Deleted.

B. Structure −

(1) A question mark shall be the delimiter of the question from the system.

(2) Deleted.

(3) Deleted.

(4) Deleted.

(5) Deleted.

9.6.3.2 MOVEMENT WITHIN USER INTERFACES DESIGN REQUIREMENTS

Requirements for movement within a user interface are provided below:

A. The user shall be able to move the pointing cursor to any X,Y position within the display.

The pointing cursor shall change to a placeholding cursor when positioned in a data field requiring alphanumeric entry.

B. Users shall be able to move displayed information from the same data file by scrolling (i.e., the continuous vertical or horizontal movement of displayed information) and paging (the discrete movement from one ”page” to another in an information display).

C. Deleted.

9.6.3.2.1 POSITION DESIGNATION (CURSOR) DESIGN REQUIREMENTS

General requirements for the cursor are provided below:

A. Deleted.

B. Deleted.

C. Tracking − The major dimension of the cursor shall be at least 0.25 inches.

D. Deleted.

E. Deleted.

F. Home Position − The home position for the cursor shall be consistent across similar types of displays.

G. The relation between a cursor shape and function shall be consistent across applications.

H. Types of Cursors − Three types of cursors shall be supported − a pointing cursor, a text placeholding cursor, and a busy cursor.

9.6.3.2.1.1 POINTING CURSOR DESIGN REQUIREMENTS

Requirements for the pointing cursor are provided below:

A. Deleted.

B. Visual Characteristics −

(1) The pointing cursor shall not blink.

(2) The pointing cursor shall maintain its size and image quality across all screen and display locations.

(3) Deleted.

C. Deleted.

D. Deleted.

9.6.3.2.1.2 PLACEHOLDING CURSOR DESIGN REQUIREMENTS

Requirements for placeholding cursor are provided below:

A. Non−Interference − The capability shall be provided to position the placeholding cursor to the left or right of any character within a data input field.

B. Deleted.

C. Deleted.

9.6.3.2.2 SCROLLING DESIGN REQUIREMENTS

Requirements for scrolling are provided below:

A. Deleted.

B. Scroll Rate − The scroll rate shall allow the user to scroll in an increment of a line.

C. Direction of Scrolling − The user shall be capable of scrolling left−to−right and top−to−bottom.

D. Deleted.

9.6.3.2.3 PAGING DESIGN REQUIREMENTS

Requirements for paging are provided below:

A. Deleted.

B. Paging Increments − Users shall be able to move in increments of one or multiple pages.

C. Page Numbering − Each page of a multiple page display shall be numbered to identify the currently displayed page and the total number of pages.

D. Deleted.

9.6.3.2.4 DELETED

9.6.3.2.5 DELETED

9.6.3.3 MANIPULATING DATA DESIGN REQUIREMENTS

9.6.3.3.1 EDITING

9.6.3.3.1.1 DELETED

9.6.3.3.1.2 EDITING DESIGN REQUIREMENTS

Requirements for editing data are provided below:

A. Use − The user shall have the capability to modify the contents of data files and save those modifications.

B. Deleted.

C. Consistency of Procedures − All editing procedures shall be consistent in dialogue structure, independent of the type of information being edited.

D. Modifying Physical Features −

  (1) The user shall have the ability to set and modify the tab position for user−modifiable text files.

  (2) The user shall be able to set and modify the margins for user−modifiable text files.

E. Insert Mode vs. Overstrike Mode −

  (1) By default, the text editor shall operate in insert mode.

  (2) Text shall be inserted moving to the right.

  (3) However, the user shall be able to select text to be overstriken.

F. Selecting Data −

  (1) Users shall be able to select data from a data file.

  (2) Deleted.

  (3) Deleted.

G. Cutting Data −

(1) The user shall be capable of moving data from one section of a data file to another.

(2) When data is moved, the remaining data shall be reconstituted such that there is no gap between the remaining sections of data.

(3) Deleted.

H. Copying Data − The user shall be capable of copying data and replicating it at any point within a data file.

I. Deleting Data − The user shall be capable of deleting data within a data file.

When data is deleted, the remaining data shall be reconstituted such that there is no gap between the remaining data.

(1) Deleted.

(2) Data deletion shall require confirmation by the user requesting the deletion.

9.6.3.3.1.3 GRAPHICS EDITING DESIGN REQUIREMENTS

Requirements for editing of graphics are provided below:

A. Deleted.

B. Moving −

(1) The user shall have the capability to move a graphic object from one position on the display to another.

(2) An indication of the path of movement shall be provided to the user during the move.

C. Deleted.

D. Rotating −

(1) The user shall have the capability to rotate graphic objects.

(2) Users shall be able to rotate objects clockwise or counterclockwise.

9.6.3.3.2 SAVING

9.6.3.3.2.1 SAVING DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.6.3.3.2.2 SAVING DESIGN REQUIREMENTS

Requirements for saving and exiting data files are provided below:

A. Saving Data − The user shall have the ability to save data entered into an editable data file (1) while continuing to interact with that file or (2) while simultaneously exiting from that file.

B. Exiting a File − The user shall be able to exit a data file at any time without saving the changes to the file.

9.6.3.4 USER GUIDANCE DESIGN CONSIDERATIONS

9.6.3.4.1 DELETED

9.6.3.4.2 USER FEEDBACK

9.6.3.4.2.1 USER FEEDBACK DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.6.3.4.2.2 USER FEEDBACK DESIGN REQUIREMENTS

Requirements for providing feedback to the user are provided below:

A. Deleted.

B. Deleted.

C. Standby − If a system process causes the screen and input devices to be locked out, a progress message shall be displayed.

D. Process Outcome − When a process is completed or aborted by the system, positive indication shall be presented to the user.

E. Input Confirmation − Confirmation of user input shall be indicated.

F. Deleted.

G. Deleted.

9.6.3.4.3 SYSTEM STATUS MESSAGES

9.6.3.4.3.1 SYSTEM STATUS MESSAGES DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.6.3.4.3.2 SYSTEM STATUS MESSAGE DESIGN REQUIREMENTS

Requirements for providing messages concerning system status to the user are provided below:

A. Operational Mode − The system shall inform the user of the current operational mode.

B. Deleted.

C. Characteristics of Status Messages −

  (1) Status messages shall be provided to the user in a consistent location on the display.

  (2) Deleted.

  (3) Deleted.

  (4) If the user needs to be alerted that a status message is being displayed, status messages shall be accompanied by an advisory tone (see 9.4.4).

9.6.3.4.4 ERROR HANDLING DESIGN REQUIREMENTS

Requirements for handling of errors are provided below:

A. Deleted.

B. Deleted.

C. Timing of Feedback − If a user makes an incorrect command or data entry, the system shall detect the error and notify the user within two seconds from command or data entry.

D. Deleted.

E. Deleted.

F. Error Recovery and Process Change − The user shall be able to stop a process at any point in a sequence as a result of an indicated error.

G. Correction Entry and Confirmation −

(1) When the user enters correction of an error, such corrections shall be implemented only by an explicit action by the user (e.g., actuation of an "Enter" key).

(2) All error correction by the user shall be acknowledged by the system, either by indicating that a correct entry has been made or by another error message if an incorrect entry has been made.

H. Deleted.

I. Deleted.

J. Location of Error Messages − Error messages shall be placed on the display close to the point of the error and/or in a designated, consistent area of the display.

9.6.3.4.5 PROMPTS

9.6.3.4.5.1 PROMPTS DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.6.3.4.5.2 PROMPTS DESIGN REQUIREMENTS

Requirements for providing prompts to users are given below:

A. Deleted.

B. Standard Display − The location of prompts for data or commands shall be at the location of the desired input or in a standard message area.

C. Deleted.

9.6.3.4.6 DELETED

9.6.3.4.7 DELETED

9.6.3.5 DELETED

9.6.4 USER INPUT

9.6.4.1 USER INPUT DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

9.6.4.2 USER INPUT DESIGN REQUIREMENTS

General requirements for user input are provided below:

A. Consistent Consequences of User Input − The consequences of any user input shall be consistent (1) for any individual user across time and (2) from user to user.

B. Deleted.

C. Deleted.

D. Deleted.

9.6.4.3 DATA ENTRY DESIGN REQUIREMENTS

Requirements for the design of data entry are provided below:

A. Deleted.

B. Deleted.

C. Deleted.

D. Deleted.

E. System Acknowledgment of Data Entry − The system shall provide feedback to the user indicating the acceptance or rejection of a data entry and indicate to the user processing delays of more than 15.0 seconds.

F. Explicit Completion Action − Data entry shall require an explicit completion action, such as the depression of an ENTRY key after a string input.

G. Deleted.

H. Deleted.

I. Deleted.

J. Deleted.

K. Deleted.

9.6.4.4 INTERACTIVE CONTROL DESIGN REQUIREMENTS

Requirements for the design of interactive control sequences are provided below:

A. Deleted.

B. Deleted.

C. Deleted.

D. Deleted.

E. Deleted.

F. Deleted.

G. Deleted.

H. XY Controller Outputs − An XY cursor positioning and control device shall be able to produce any combination of X and Y output values.

I. XYZ Control Outputs − An XYZ cursor positioning and control device shall be able to produce any combination of X, Y, and Z output values.

10.0 ACTIVITY CENTERS

10.1 INTRODUCTION

This paragraph is not applicable for this document.

10.2 PERSONAL HYGIENE

10.2.1 INTRODUCTION

This paragraph is not applicable for this document.

10.2.2 PERSONAL HYGIENE DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

10.2.3 PERSONAL HYGIENE DESIGN REQUIREMENTS

The following requirements will apply to all Personal Hygiene Facilities:

A. The facility shall be capable of being cleaned, sanitized, and maintained.

B. One facility shall be supplied for every four crewmembers.

10.2.3.1 PARTIAL BODY CLEANSING DESIGN REQUIREMENTS

Partial body cleaning facility requirements are listed below:

A. Necessity for Facility − Facilities shall be provided on the Space Station to accomplish washing of selected body areas as required for the following functions:

   (1) Post−urination/defecation

   (2) Post−exercise

   (3) During medical/health maintenance

   (4) Pre− and post−experimentation or other work requiring specialized washing

   (5) Pre− and post−meals

   (6) Accidental exposure to toxic substances

B. Design Requirements − All partial washing equipment using water shall have the following design characteristics:

   (1) Method to allow application of water to the hands and face.

   (2) Method to remove excess water from the body and facility, and cleansing aids.

(3) Means to control water temperature.

(4) Means to control water flow/usage.

(5) Means to prevent water from escaping into the module environment.

(6) Accommodate the use of soap, shampoo, and antiseptic solutions, and accommodate hair.

(7) Means to prevent cross−contamination among crewmembers.

(8) Means for final drying of body part.

(9) Body and equipment restraints.

(10) Means to personally code crew hygiene items.

C. Cleansing Agents − Refer to 10.2.3.2, Item D.

10.2.3.2 WHOLE−BODY CLEANSING DESIGN REQUIREMENTS

Whole−body cleansing facility requirements are listed below:

A. Necessity for Facility − A whole−body cleansing facility shall be provided.

B. Equipment Design − Whole−body cleaning equipment with the following design characteristics shall be provided:

(1) Method to apply water to the body.

(2) Method to remove excess water from the body and facility.

(3) Means to control water temperature.

(4) Means to control water flow/usage.

(5) Means to prevent water from escaping into the module environment.

(6) Accommodate the use of soap, shampoo, and antiseptic solutions, and accommodate hair.

(7) Means to prevent cross−contamination among crewmembers.

(8) Means for final body drying after whole body cleansing.

(9) Body and equipment restraints.

(10) Means to personally code crew hygiene items.

(11) Air temperature and flow in the whole body cleansing facility must be adjustable by the user from within the shower stall.

C. Privacy − Privacy shall be provided for whole−body cleaning.

D. Cleansing Agents − Cleansing agents will be provided which meet the following requirements:

(1) Soap, shampoo, and other cleansing agents shall be provided which are compatible with the Life Support System and the Space Station environment.

(2) Personal selection of cleaning agents, including off−the−shelf commercial brand name preparations, shall be permitted as long as all items are compatible with the Space Station environment and with onboard water reclamation and/or water and solid waste disposal systems.

E. Dressing area −

(1) The capability for private body drying and dressing and a dry area for clothes shall be provided adjacent to the whole−body cleansing facility.

(2) The area provided for body drying and dressing shall be temperature controlled.

F. Capacity − The whole−body washing system shall have the capacity to allow each crewmember to wash a minimum of three times a week.

10.2.3.3 ORAL HYGIENE DESIGN REQUIREMENTS

Oral hygiene facilities shall be provided for Space Station crewmembers and will meet the following requirements:

A. Functional Requirement − Facilities shall allow the crew to daily maintain tooth, oral cavity, and gum cleaning and care.

B. Cross−Contamination − The facilities shall prevent cross−contamination among crewmembers.

C. Expectoration − Facilities shall allow the user to expectorate washing fluids and spittle.

10.2.3.4 HAIR CUTTING DESIGN REQUIREMENTS

The hair cutting facility will meet the following requirements:

A. Necessity for Facility − A facility shall be provided to keep facial, body, and head hair the length dictated by mission requirements and personal grooming preferences.

B. Facility Design −

(1) The facility shall allow a crewmember to assist in hair cutting and trimming.

(2) The facility shall be equipped with storage areas, restraints, and mirrors.

C. Debris Containment − The facility shall ensure that hair is contained and does not escape into the Space Station environment.

D. Lighting − Lighting shall be 325 to 540 lux (30.0 to 50.0 fc).

10.2.3.5 GROOMING AND SHAVING DESIGN REQUIREMENTS

Facilities shall be provided for the crewmember to maintain personal grooming. The facilities will meet the following requirements:

A. Debris Containment − The capability shall be provided for collection and containment of body hair and nails.

B. Supplies − Each crewmember shall have available a supply of items as required for skin care, shaving, hair removal (depilatory), hair grooming, nail care, and body deodorizing.

(1) Grooming supplies, including soap, shampoo, and other cleaning agents, shall be compatible with the Life Support system, the selected crew skin types, and the Space Station environment.

(2) Personal selection of cleansing agents, including off−the−shelf brand name preparations, shall be permitted as long as the items are compatible with the Space Station environment and with on−board waste reclamation and/or water and solid waste disposal systems.

C. Facility Design − Grooming facilities shall consist of a designated space equipped with stowage areas, restraints, mirrors, and access to a water supply.

D. Lighting − Lighting shall be 260 to 540 lux (25.0 to 50.0 fc). (See 8.13 for further lighting information).

10.3 BODY WASTE MANAGEMENT

10.3.1 INTRODUCTION

This paragraph is not applicable for this document.

10.3.2 BODY WASTE MANAGEMENT FACILITIES DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

10.3.3 BODY WASTE MANAGEMENT FACILITIES DESIGN REQUIREMENTS

10.3.3.1 DEFECATION AND URINATION FACILITIES DESIGN REQUIREMENTS

The following are requirements for the design of crew defecation and urination facilities:

A. Use Accommodation − The collection module shall allow a male or female crewmember to defecate and urinate simultaneously while seated.

B. Vomitus Collection − Accommodations shall also be provided for vomitus collection within reach of the seated crewmember.

C. Ease of Urination − The urine receiver shall be located so that any crewmember may also urinate in the standing position without removing lower clothing.

D. Number of Facilities − One facility shall be provided for every four crewmembers.

E. Fecal Collection − Fecal collection facilities will meet the following requirements:

(1) The facilities shall provide crew interfaces to accommodate the collection of fecal solids, liquids, gases, particulates, and the disposal of associated consumable material (i.e., wipes).

(2) The facilities shall capture, isolate, stabilize, and store all wastes and wipes generated during defecation.

(3) Capacity − The fecal collection system will have the following capacity:

a. The average per person per day amount of fecal matter which the fecal collection device shall accommodate is 142.0 grams (5.0 ounces) by weight and 142.0 ml (8.5 cubic inches) by volume.

b. The capability to accommodate a maximum of 1000 ml (61.0 cubic inches) of diarrhea discharge shall be provided.

c. The fecal collector shall accommodate a maximum bolus length of 33.0 cm (13.0 inches).

d. Quantities in excess of these amounts shall not result in a Waste Management System failure.

F. Urine Collection − Urine collection facilities will meet the following requirements:

(1) The facilities shall provide crew interfaces to accommodate liquid capture and splash control, and disposal of associated consumable material (e.g., wipes).

(2) The facilities shall capture, isolate, stabilize, and store all wastes and wipes generated during urination.

(3) Capacity − The urine collection system will have the following capacity:

a. The urine collection devices shall accommodate a maximum urine output volume of 4000 ml (244 cubic inches) per person per day.

b. The urine collection system shall be designed to accommodate urinary discharge up to 800 ml (49.0 cubic inches) in a single micturition at a delivery rate of 50.0 ml per second (3.0 cubic inches per second).

c. Urine volumes in excess of these amounts shall not result in a Waste Management System failure.

G. Sanitation − The defecation and urination facilities will meet the following sanitation requirements:

(1) The facilities shall be designed to allow repeated cleansing and disinfection of crew interfaces and subsystems.

(2) The facilities shall prevent cross−contamination among the crewmembers.

(3) The facilities shall not contaminate other areas of the Space Station.

H. Noise − A means shall be provided to control noise of the facility equipment and crewmembers in operating the equipment.

I. Odors − Means shall be provided to control odors from the facility and from storage and handling facilities.

J. Privacy − Defecation and urination facilities shall provide both visual and auditory privacy for the user.

K. Deleted.

L. Contingency System − A contingency urination and defecation capacity shall be provided for use in the event of systems failure.

M. Restraints − Restraints shall be provided for facility use and post−use cleanup.

N. Body Cleansing − Provisions shall be provided in the urination and defecation facilities for inspecting and cleaning the body after use and disposal of used materials.

O. Anatomical Accommodation −

(1) Urination and defecation facilities shall be provided to accommodate the physiological differences of male and female crewmembers and the anatomical size range of the crew specified in section 3.0.

(2) The crew interface hardware shall be designed to allow interface with other personal hygiene equipment, personal hygiene supplies, and crewmember clothing.

P. Handling of Feces and Urine − If a crewmember is required to handle urine or feces samples for transfer to another area, the following requirements apply:

(1) Crewmembers shall be protected from direct contact with waste material.

(2) Means shall be provided to control waste material odors.

(3) Methods shall be provided to prevent escape of waste material into the environment.

(4) Transfer containers shall be so constructed as to prevent microbial escape during transfer.

Q. Inspection − The capability shall be provided for a crewmember to visually inspect his or her fecal waste products.

10.3.3.2 FACILITIES FOR OTHER WASTE PRODUCTS DESIGN REQUIREMENTS

In addition to facilities for urination and defecation, the waste management facility will have the following capabilities:

A. Vomitus − The waste management facility shall be able to collect, contain, transport, and treat vomit.

B. Menses −

(1) A means of collection, treatment, and disposal of menstrual discharge and associated absorbent material shall be provided to female crewmembers.

(2) The facility shall be private.

C. Transfer Containers − Transfer containers shall be constructed to prevent microbial escape during transfer.

10.4 CREW QUARTERS

10.4.1 INTRODUCTION

This paragraph is not applicable for this document.

10.4.2 INDIVIDUAL CREW QUARTERS DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

10.4.3 INDIVIDUAL CREW QUARTERS DESIGN REQUIREMENTS

For Space Station, a private crew area shall be provided for each crewmember.

A. Deleted.

B. Environmental Controls − Independent lighting and ventilation shall be provided in the crew sleep areas and be adjustable from a sleep restraint.

C. Noise − The noise levels in the crew privacy accommodations shall be as defined in 5.4.3.2.3.1.

D. Deleted.

E. Stowage − Stowage shall be provided for bedding, clothing, and personal use items.

F. Volume − Volume shall be provided for sleeping (1.50 cubic meters (53.0 cubic feet)), temporary and permanent stowage of operational and personal equipment (0.63 cubic meters (22.0 cubic feet)), and donning and doffing clothing (1.19 cubic meters (42.0 cubic feet)).

(1) Deleted.

(2) Deleted.

(3) Deleted.

(4) The internal dimensions of the crew privacy provisions shall accommodate the 95th percentile American male.

G. Exit and Entry − The opening shall be large enough to allow contingency entry by a pressure suited crewmember.

H. Privacy − the individual crew privacy provisions shall provide visual privacy to and from the occupant.

I. Restraints − Restraints shall be provided for activities such as sleeping, dressing, recreation, and cleaning.

10.5 GALLEY AND WARDROOM

10.5.1 INTRODUCTION

This paragraph is not applicable for this document.

10.5.2 GALLEY, AND WARDROOM DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

10.5.3 GALLEY AND WARDROOM DESIGN REQUIREMENTS

10.5.3.1 OVERALL GALLEY AND WARDROOM LAYOUT DESIGN REQUIREMENTS

The following requirements apply to the overall layout of the Space Station galley and wardroom:

A. Traffic Flow − The galley and wardroom shall be configured to provide clear traffic paths for the crew to perform the following tasks:

(1) Food Selection and Inventory Control

(2) Food Retrieval

(3) Food Preparation

(4) Food Consumption

(5) Cleanup

B. Size of Crewmembers − Galley and wardroom hardware shall accommodate the full size range of crewmembers as specified in section 3.0.

C. Restraints − Restraints shall be provided for crewmembers, food, utensils, cooking equipment, and other loose items at galley and wardroom locations.

D. Lighting Conditions − The capability to adjust light levels and directionality shall be provided.

10.5.3.2 FOOD SELECTION, PREPARATION, AND CONSUMPTION DESIGN REQUIREMENTS

The Space Station galley and wardroom will provide the following facilities for food selection, preparation, and consumption:

A. Inventory Update and Review − The galley shall provide a system which allows for update and review of the food, beverage, and water inventory.

B. Identification − All food items shall be identifiable in terms of contents and method of preparation.

C. Accessibility − A pantry or stowage area for a minimum 14−day food supply for the entire crew shall be provided in the galley.

D. Heating − A means shall be provided in the galley for heating food and liquids to at least 66.0 degrees C (150.0 degrees F) in less than 30.0 minutes and maintaining that temperature.

E. Chilling − A means shall be provided in the galley for cooling food and liquids to 4.0 +/− 2.0 degrees C (39.0 +/− 3.0 degrees F).

F. Rehydration − A means shall be provided in the galley for injecting necessary potable water for rehydration of food.

G. Serving and Preparation Utensils − Area shall be provided in the galley for stowage of the following serving and preparation items:

(1) Eating utensils.

(2) Servicing equipment (trays, plates, containers, etc.).

(3) Preparation tools and containers.

H. Table − A table shall be provided for eating.

10.5.3.3 FOOD PACKAGING AND STORAGE DESIGN REQUIREMENTS

In addition to the general packaging design requirements given in 11.12.3, all food packaging will be designed to meet the following requirements:

A. Deleted.

B. Rehydration Provisions − For foods that require water for reconstitution, provisions shall be made for the package to accept water directly from a probe without contaminating the probe and to hold the water and contents without spillage after removal of the probe.

C. Kneading Provisions − For foods that require in−package mixing, provisions shall be made for kneading of the enclosed contents without spillage and with adequate visibility.

D. Integration With Food Preparation System − For foods that require heating, chilling, mixing, or repackaging, the food packaging and food preparation system(s) shall be compatible.

E. Deleted.

F. Toxicity − Food packaging materials shall be approved by the Food and Drug Administration, Department of Health and Human Services.

10.5.3.4 GALLEY AND WARDROOM CLEANING DESIGN REQUIREMENTS

The following facilities shall be provided for galley and wardroom cleaning and sanitation:

A. Design for Cleaning −

(1) The surfaces in the galley and wardroom shall be accessible for cleaning and sanitation.

(2) The surface texture shall be capable of being wiped clean.

(3) Closeouts shall be provided to preclude contamination in areas that are inaccessible.

B. Cleaning Supplies and Equipment −

(1) Cleaning supplies and equipment shall be available to the galley and wardroom.

(2) The equipment and supplies shall be capable of the following:

a. Sanitizing the galley and wardroom.

b. Collection, containment, and stabilization (as necessary) of debris, spills, and odors.

c. Washing and sanitizing of reusable utensils, serving equipment, and preparation equipment.

C. Trash Collection −

(1) A trash collection point shall be provided in the galley and wardroom for both wet and dry trash.

(2) Trash shall be kept out of sight and a method be provided to control odor.

10.6 MEETING FACILITY

10.6.1 INTRODUCTION

This paragraph is not applicable for this document.

10.6.2 MEETING FACILITY DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

10.6.3 MEETING FACILITY DESIGN REQUIREMENTS

The following are design requirements for the meeting facility:

A. Size − The meeting facility shall accommodate a meeting of the entire Space Station crew.

B. Physical Arrangement − The meeting facility furnishings and restraints shall be repositionable for various formats.

C. Acoustics − The acoustic environment of the meeting facility shall meet the requirements of 5.4.3.2.2.1.

D. Lighting −

(1) The lighting controls shall be capable of providing variable intensity lighting.

(2) Lighting levels shall meet the requirements of 8.13.3.

E. Deleted.

10.7 RECREATION FACILITY

10.7.1 INTRODUCTION

This paragraph is not applicable for this document.

10.7.2 RECREATION FACILITY DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

10.7.3 RECREATION FACILITY DESIGN REQUIREMENTS

The following are the design requirements for a Space Station recreation facility:

A. Size − The facility shall be sized to accommodate all crewmembers scheduled for leisure activities.

B. Deleted.

C. Deleted.

D. Window − An outside viewing window shall be provided for recreational purposes.

E. Environment −

(1) Capability shall be provided to maintain the thermal environment within the requirements defined in 5.8.3.

(2) A system shall be available to control debris and odors generated during recreational activities.

10.8 MICROGRAVITY COUNTERMEASURES

10.8.1 INTRODUCTION

This paragraph is not applicable for this document.

10.8.2 MICROGRAVITY COUNTERMEASURES DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

10.8.3 MICROGRAVITY COUNTERMEASURES DESIGN REQUIREMENTS

10.8.3.1 EXERCISE COUNTERMEASURE MODALITIES DESIGN REQUIREMENTS

The microgravity countermeasure facility shall support the following countermeasure modalities.

A. Cardiovascular (Aerobic) Exercise.

B. Muscle Performance (upper arm, forearm, thigh, lower leg, trunk) and musculoskeletal integrity.

C. Deleted.

10.8.3.1.1 EXERCISE EQUIPMENT

The following equipment shall be provided:

A. Aerobic and anaerobic equipment.

B. Resistance and musculoskeletal maintenance equipment.

C. Deleted.

10.8.3.1.2 MICROGRAVITY COUNTERMEASURE MONITORING DESIGN REQUIREMENTS

The following capabilities shall be provided for monitoring the microgravity countermeasures program:

A. Deleted.

B. Routine Monitoring − The capability to monitor the following parameters shall be provided on a routine basis:

(1) Heart Rate − The heart rate monitor, specifically designed for use during exercise, shall measure heart rate continuously.

(2) Duration of microgravity countermeasure regimen.

(3) Data output from instrumented exercise device.

C. Periodic Monitoring − The capability to monitor the following parameters on a periodic basis shall be provided:

(1) Blood pressure and electrocardiograph − The blood pressure/electrocardiograph device shall measure and record blood pressure (mm Hg), heart rate, and waveform during periodic fitness evaluations and Lower Body Negative Pressure.

(2) Metabolic gas monitor − The metabolic gas monitor shall provide respiratory quotient, minute ventilation (VE), ventilatory threshold, VO_2, VCO_2, identify maximum VO_2, vital capacity, forced expiratory volume in 1.0 second ($FEV_{1.0}$), Ti:Ttot, PET CO_2, respiratory rate, and respiratory quotient.

(3) Muscle Performance − The electromyograph and accelerometers shall record movements (force and direction) and measure neuromuscular efficiency and function.

(4) Deleted.

10.8.3.1.3 MICROGRAVITY COUNTERMEASURE DISPLAY CAPABILITIES FOR EXERCISING CREWMEMBERS DESIGN REQUIREMENTS

The following display capabilities shall be provided for exercising crewmembers:

A. Exercise Parameters − Heart rate, elapsed time, power output.

B. Trend Data − Trend analysis comparisons of crewmember performance over time.

C. Deleted.

10.8.3.1.4 MICROGRAVITY COUNTERMEASURE ENVIRONMENT DESIGN REQUIREMENTS

The Space Station shall provide the following capabilities for the exercise facilities:

10.8.3.1.4.1 RESOURCES

Cooling and ventilation capabilities shall be provided at 80.0 feet per minute to handle increased metabolic rates during exercise.

10.8.3.1.4.2 ADDITIONAL CAPABILITIES

The Space Station exercise facilities shall provide the following additional capabilities:

A. Noise and Vibration Control.

B. Deleted.

C. Monitoring and Recording − Facilities for monitoring the extent of microgravity countermeasure use, the effects of the countermeasure, and the condition of the crewmembers shall be provided.

D. Schedule and Prescription Adjustment − A means to adjust the countermeasure and prescription based on the status of the crewmembers shall be provided.

10.8.3.2 NONEXERCISE COUNTERMEASURES

10.8.3.2.1 NONEXERCISE COUNTERMEASURE DESIGN REQUIREMENTS

The following capabilities will be provided:

10.8.3.2.1.1 PRESSURIZED COUNTERMEASURES

A. Deleted.

B. Lower Body Negative Pressure − A lower body negative pressure device shall be provided for use in microgravity in the prevention of orthostatic intolerance upon 1−g entry and landing, and maintenance of overall cardiovascular conditioning.

10.8.3.2.1.2 PHARMACOLOGICAL COUNTERMEASURE

A. Oral rehydration (fluid loading) shall be provided to increase total fluid volume of the body, just prior to 1−g entry.

B. Pharmacological countermeasures shall be provided

10.8.3.2.1.3 SPACE MOTION SICKNESS COUNTERMEASURES

10.8.3.3 MICROGRAVITY COUNTERMEASURE PROGRAM ADMINISTRATION DESIGN REQUIREMENTS

The following shall be provided for administration of the microgravity countermeasure program:

A. Prescription − Prescription for application of the microgravity countermeasures shall be provided.

B. Monitoring and Recording − Facilities shall be provided for monitoring the extent of countermeasures and the condition of the crewmembers.

C. Schedule and Prescription Revision − A means to adjust the countermeasures schedule and prescription based on the status of the crewmembers shall be provided.

10.9 HEALTH MAINTENANCE SYSTEM

10.9.1 INTRODUCTION

This paragraph is not applicable for this document.

10.9.2 HMS DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

10.9.3 HMS PERFORMANCE REQUIREMENTS

A. Diagnostic and Therapeutic Capabilities − The HMS shall include diagnostic and therapeutic capabilities to provide routine and emergency medical care for the crew.

B. Uplink and Downlink Capabilities − The HMS shall include uplink of audio and data, and downlink of audio, video, data, and images via the Command and Data Handling and Communication and Tracking systems to support remote diagnosis and guidance to the Crew Medical Officer (CMO).

C. Provisions and Equipment − The HMS shall include medical provisions and equipment to support HMS outpatient treatment for the entire crew and critical care for one crewmember.

D. Stabilization and Transport − The HMS shall provide for stabilization and support of vehicular transport of one critically injured or ill crewmember.

10.9.3.1 MAJOR HMS SUBSYSTEM PERFORMANCE REQUIREMENTS

HMS subsystems are functionally classified according to the following general capabilities: diagnostic, therapeutic, and preventive. A synopsis of each subsystem follows.

10.9.3.1.1 DIAGNOSTIC SUBSYSTEMS

Diagnostic subsystems shall include:

A. Physician's Instruments − The HMS Physician's Instruments subsystem shall include:

(1) Diagnostic instrumentation sufficient to perform a physical examination.

(2) Capability to acquire, record, and transmit the visual and auditory information from a physical examination.

B. A means shall be provided for laboratory capability to monitor blood chemistry values and hemotological values.

C. Imaging − The HMS Imaging subsystem shall produce and process essential medical nonradiographic (microscopic and macroscopic) images for use onboard the Space Station and by ground consultants in diagnosis and treatment.

D. The HMS shall accommodate:

(1) Patient resuscitation and stabilization.

(2) Physiological monitoring at the HMS.

(3) Deleted.

(4) Transport from Space Station to the ground.

E. Medical Equipment Computer − The HMS Medical Equipment Computer shall:

(1) Provide the CMO with access to a medical diagnostic and decision support computer system.

(2) Assist with medical record inventory management.

(3) Accommodate two−way communication between the CMO and ground−based medical personnel.

F. Consultant Network − The HMS Consultant Network shall include a data and communications network consisting of:

(1) The HMS.

(2) NASA JSC flight surgeon's console and mission support room.

(3) Ground network.

(4) Deleted.

10.9.3.1.2 THERAPEUTIC SUBSYSTEMS

Therapeutic subsystems shall include:

A. Fluid Therapy −

(1) The HMS Fluid Therapy subsystem shall provide fluids for intravenous injection.

(2) The subsystem shall administer intravenous fluids at variable flow rates.

(3) An air−fluid separator shall be provided.

B. Pharmacy and Central Supply −

(1) The HMS Pharmacy and Central Supply subsystem shall contain a pharmaceutical formulary and central supply inventory.

(2) The American Hospital Formulary Service classification shall be utilized to identify and track the Space Station formulary.

(3) Low temperature storage (i.e., freezer (−30.0 degrees C) and refrigerator (2.0 degrees to 8.0 degrees C) shall be provided for selected items.

C. Respiratory Support − The Respiratory Support system shall provide respiratory support including an automated mechanical ventilator, respiratory flow monitor, pulse oximeter, and manual pulmonary resuscitator.

D. Surgery −

(1) The HMS Surgery Subsystem shall provide the following items to support surgical procedures:

a. Deleted.

b. Restraints for the patient and CMO.

c. Surgical instruments and supplies.

d. Deleted.

(2) Local anesthesia capabilities shall be provided.

E. Deleted.

10.9.3.1.3 PREVENTATIVE COUNTERMEASURES

The HMS will provide the following preventive countermeasures support:

A. Interface to the Crew Health Care Control and Monitor Subsystem to collect and display physiological data and to monitor trends.

B. Establishment of physiological laboratory norms of spaceflight and monitoring program for long−duration flight.

10.9.3.2 HYPERBARIC TREATMENT DESIGN REQUIREMENTS

10.10 LAUNDRY

10.11 TRASH MANAGEMENT FACILITY

10.11.1 INTRODUCTION

This paragraph is not applicable for this document.

10.11.2 TRASH MANAGEMENT FACILITY DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

10.11.3 TRASH MANAGEMENT FACILITY DESIGN REQUIREMENTS

The following are the design requirements for a Space Station trash management facility:

A. Trash Sorting − Where it is necessary to sort trash before depositing in a receptacle, the following requirements will be met:

  (1) Receptacle Labeling − Each of the receptacles shall be labeled defining acceptable and nonacceptable trash.

  (2) Transfer Package Labeling − If trash must be transferred from one receptacle to another, there shall be a method of identifying the trash so that it is placed in the proper receptacle.

  (3) Deleted.

B. Trash Receptacles −

  (1) Deleted.

  (2) Receptacles Location − The location of trash receptacles will meet the following requirements:

    a. Deleted..

    b. Trash receptacles shall be located in the galley, waste management compartment, and additional areas where trash is generated.

    c. The location shall not interfere with crew translation.

C. Odor and Contamination Control − The following requirements will apply to control of odor and contamination:

  (1) Trash handling equipment shall be designed to preclude module contamination during introduction of trash.

  (2) Trash storage areas shall preclude contamination of the living environment by harmful microorganisms or odor.

  (3) The trash management equipment area shall be capable of being cleaned and sanitized.

(4) Harmful Waste Disposal − There shall be a safe means for disposal of any harmful chemical or radioactive wastes.

a. Trash containers which contain hazardous or toxic materials shall be sealed prior to stowage.

b. Potentially harmful trash containers/packages shall be marked to indicate the type of hazardous/toxic material which they contain.

D. Operation − All trash collection, handling, and disposal equipment shall be capable of being operated by the full size and strength range of crewmembers as specified in section 3.0 and 4.9.

E. Receptacle Capacity − Crewmembers shall be capable of visually determining the level of trash (in relationship to capacity) in each of the trash receptacles.

10.12 STOWAGE FACILITY

10.12.1 INTRODUCTION

This paragraph is not applicable for this document.

10.12.2 STOWAGE FACILITY DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

10.12.3 STOWAGE FACILITY DESIGN REQUIREMENTS

The following are design requirements for Space Station stowage facilities:

A. Location − The following are requirements for the location of stowage areas:

(1) Proximity − Items shall be stowed in the area of use.

(2) Safety − Hazardous items shall be stowed away from heat originations sources and away from crew congregation areas.

(3) Interference − Stowage facilities shall not interfere with normal or emergency crew operations.

B. Accessibility −

(1) Stowed items shall be accessible by the full size range of the Space Station crew per section 3.0.

(2) Deleted.

C. Labeling and Coding − Stowage locations shall be coded to allow for location, replacement, or inventory of items.

D. Environment − Stowage areas which require human occupancy shall meet habitability requirements.

E. Hand Operation − On−orbit stowage retainers shall be designed to be operated by hand.

F. Commonality − Latching devices, containers, and container covers shall have design commonality throughout all module stowage facilities.

G. Inventory Management − The stowage facility shall be compatible with the Space Station inventory management system.

H. Retention Devices −

(1) Stowage items shall be secured within the container such that the item remains in the container/enclosure when the container is opened.

(2) Removal of retention devices shall not release other items.

11.0 HARDWARE AND EQUIPMENT

11.1 INTRODUCTION

This paragraph is not applicable for this document.

11.2 TOOLS

11.2.1 INTRODUCTION

This paragraph is not applicable for this document.

11.2.2 TOOL DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

11.2.3 TOOL DESIGN REQUIREMENTS

The tool design requirements in the following subsections apply to tools that are intended to be used to activate, operate, maintain, and deactivate manned and unmanned equipment in both EVA and IVA environments.

11.2.3.1 HAND AND TOOL INTEGRATION DESIGN REQUIREMENTS

11.2.3.1.1 TOOL HANDGRIP SIZE AND SHAPE DESIGN REQUIREMENTS

The following handgrip size and shape requirements apply to power and manual handtools:

A. Deleted.

B. Sleeve Type Adapters − If sleeve type handle cover adapters are used, they shall be secured so they will not slip, rotate, or come off.

C. Orientation − Tool handles shall be oriented to allow the operators wrist to remain in the neutral position without flexion, extension or rotation while force or guidance inputs are applied.

D. Auxiliary Controls − If an auxiliary control on the tool must be manipulated while the operator is holding the tool, the control shall be located where:

   (1) The thumb or finger of the holding hand can manipulate it without moving the tool/fastener holding position.

   (2) Unintentional or inadvertent operations are impossible.

11.2.3.1.2 TOOL HANDEDNESS DESIGN REQUIREMENTS

The following requirements apply to hand held manual tools and hand held power tools:

A. Deleted.

B. Tool Installation/Alignment − One hand only shall be required for tool installation and alignment.

C. Tool Handle Design − Tool handles shall be designed to allow the operator to use either the left or the right hand.

11.2.3.1.3 TOOL ACTUATION FORCES AND DIRECTION OF ACTION DESIGN REQUIREMENTS

The following requirements apply to hand tools:

A. Deleted.

B. Throw Angles − Ratcheting tools shall be capable of providing torque with a minimum throw angle of ten degrees.

C. Plier−Type Tools − Plier−type tools shall be spring−actuated in the open direction.

D. Driver−Type Tools − Driver−type hand tools shall not require a push force to maintain tool engagement while providing torque.

11.2.3.2 TOOL COMMONALITY DESIGN REQUIREMENTS

To assure the tool complement is kept at a minimum, the following requirements will apply:

A. Deleted.

B. Standard Attaching Hardware and Fasteners − Size and type of attaching hardware and fastener head configurations shall be standardized throughout the Space Station.

C. Deleted.

D. Removal/Replacement − For every type and size of fastener used onboard, a corresponding tool(s) shall be available for ORU/AMI removal/replacement.

11.2.3.3 TOOL TETHERING/RETENTION DESIGN REQUIREMENTS

The following requirements apply to tool tethering and tool retention:

A. Tool Restraints − A means shall be provided on all tools for restraining the tool during use.

B. Tool Transporter Devices − Tool carriers shall be provided to transport tools and to retain these tools during the maintenance activity.

C. Retention of Small Parts − Tool carriers/transfer devices shall provide a means of retaining small parts and attaching hardware. Items retainable in this manner shall be visible for retrieval.

D. Tool Restraint During Translation − Tools shall be restrained in the tool carrier/transfer device to prohibit detachment during translation.

E. Tool Carrier Attachment − Tool carriers and tool retention devices shall have provisions to attach the device to the crewmember or to adjacent structure or equipment.

F. Inadvertent Tool Disassembly − A means shall be provided to preclude tool disassembly while installing, using, removing, or transporting the tool.

11.2.3.4 TOOL STOWAGE DESIGN REQUIREMENTS

Tool stowage must allow for retrieval, retention, identification, and replacement. To accomplish this, the following requirements apply:

A. Deleted.

B. Stowage Provisions − Provisions for launch, entry, and temporary in−flight stowage shall be provided.

C. Stowage Location −

(1) Specialized tools shall be stowed in areas which correspond to their functional applications.

(2) All general purpose tools shall be stowed in one specific area.

D. Tool Stowage List − A tool summary or listing of the entire tool inventory, including stowage locations, shall be available onboard the Space Station.

E. Deleted.

F. Deleted.

11.2.3.5 TOOL LABELING AND IDENTIFICATION DESIGN REQUIREMENTS

The following requirements apply to tool and tool stowage labeling and identification:

A. Selection of Names for General Tools − The name of the tool on the tool label shall be the same as the name on the tool stowage label and on the tool list.

B. Deleted.

C. Identification of Specialized Tools − Special tools shall be coded and/or marked to indicate intended use.

D. Tool Labels − Labels shall be provided adjacent to each tool in the stowage container/kit.

E. Tool Metric/English Identification − All tools shall be labeled or coded to indicate whether the tool is sized in metric or English units.

F. Tool Inventory Management Labeling − Where size permits, tools shall be labeled per SSP 50007.

G. EVA Tool Compatibility − IVA tools that are EVA compatible shall be so identified.

11.2.3.6 TOOL ACCESS DESIGN REQUIREMENTS

The following tool access volume and operational constraints requirements are applicable to both IVA and EVA hardware design (refer to Figure 11.2.3.6−1 for IVA requirements and Figure 14.6.2.3 for EVA requirements).

A. Tool Head Clearance − Clearance shall be provided around the fastener or drive stud for insertion, actuation, and removal of the drive end of the tool.

B. Tool Handle Clearance −

(1) A minimum of 7.61 cm (3.0 in.) shall be provided for clearance between a tool handle engaged on a fastener or drive stud and the nearest piece of hardware. The tool handle should be able to maintain this clearance through a full 180 degree swept envelope.

(2) For a driver−type tool, clearance shall be maintained through 360 degrees.

C. Deleted.

D. Tool Handle Offset − The maximum tool offset between the tool handle and the tool head shall be 35.5 cm (14.0 in.).

E. Access for Tools − Minimal tool access clearance for hand tool actuation is given in Figure 11.2.3.6−2.

11.2.3.7 SPECIAL TOOL FEATURES DESIGN REQUIREMENTS

Compliance with the following special features will be required when designing or providing tools for IVA servicing and maintenance tasks:

A. Nonsparking Tools − Nonsparking materials shall be used for general purpose tools.

B. Deleted.

C. Finish − Tools shall be capable of being refinished in flight in order to remove burrs.

D. Battery Pack −

(1) Power tools shall be designed so the battery packs can be replaced at the worksite.

(2) Power tools using battery packs shall have a level−of−charge indicator or an indication as to when a battery pack is required to be replaced or recharged.

(3) Deleted.

11.3 DRAWERS/TRAYS AND RACKS

11.3.1 INTRODUCTION

This paragraph is not applicable for this document.

11.3.2 DRAWER/TRAY AND RACK DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

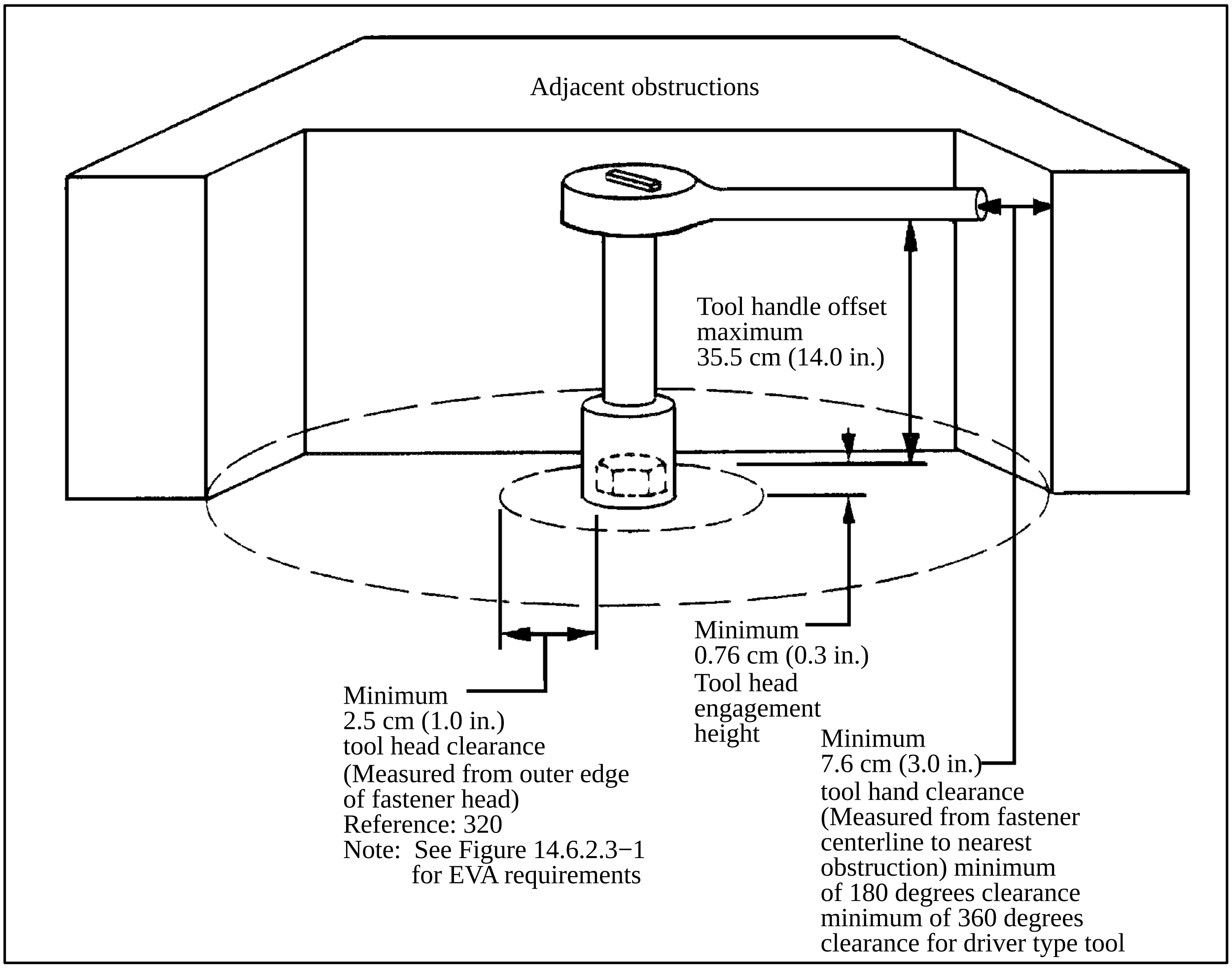


FIGURE 11.2.3.6−1 TOOL ACCESS REQUIREMENTS (IVA)

11.3.3 DRAWER/TRAY AND RACK DESIGN REQUIREMENTS

11.3.3.1 DRAWER/TRAY AND RACK INTERFACING REQUIREMENTS

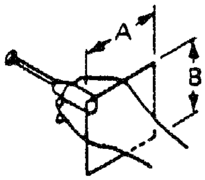
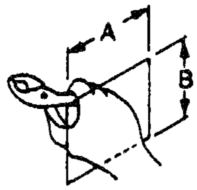
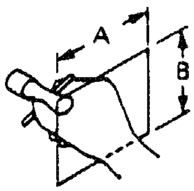
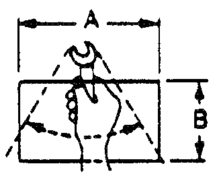
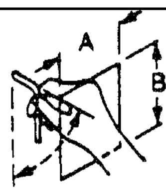
Stowage drawers/trays, equipment drawers, and racks will be designed to provide the following interfacing features:

A. Size − Stowage racks shall be compatible with both stowage and standard subsystem rack structure design.

B. Deleted.

C. Unobstructed Volume for Use − Clearance shall be provided such that the drawers can be opened, removed, and replaced without interference from permanently mounted equipment/hardware.

D. Easily Removable − Rack and drawer/tray interfaces shall be designed such that the drawers can be removed from their rack or cabinet without using tools.

Opening Dimensions		Task
	A = 117 mm (4.6 in.) B = 107 mm (4.2 in.)	Using common screwdriver with freedom to turn hand throughout 180 degrees
	A = 133 mm (5.2 in.) B = 115 mm (4.5 in.)	Using pliers and similar tools
	A = 155 mm (6.1 in.) B = 135 mm (5.3 in.)	Using T−handle wrench with freedom to turn wrench through 180 degrees
	A = 203 mm (8.0 in.) B = 135 mm (5.3 in.)	Using open−end wrench with freedom to turn wrench through 62 degrees
	A = 122 mm (4.8 in.) B = 155 mm (6.1 in.)	Using Allen−type wrench with freedom to turn wrench through 62 degrees

Notes:

(1) Also refer to Figure 12.3.1.2−1 for other hand and arm access hole dimensions.

(2) Also refer to Figure 11.2.3.6−1.

FIGURE 11.2.3.6−2 MINIMAL CLEARANCE FOR TOOL−OPERATED FASTENERS

E. Limit Stops −

(1) Deleted.

(2) The stowage rack/tray system shall be designed such that individual trays are supported in a two−thirds extended position to allow inspection of tray contents by the crew.

(3) Stowage trays shall be marked to provide visual indication on when the tray is at the two−thirds extended position.

F. Drawer/tray Movement Forces − Drawer/tray opening/closing or removal/installation shall not require a force greater than 156.0 N (35.0 lb).

Minimum drawer/tray opening forces shall be sufficient to prevent inadvertent opening due to an acceleration no greater than 0.2 feet per second squared.

G. Alignment Guides − Alignment guides shall be provided to aid in alignment when replacing a drawer/tray into its rack or cabinet.

H. Shuttle Compatibility − The Space Station stowage system shall accommodate on−orbit installation of Space Transportation System (STS) mid−deck locker stowage trays.

I. Visually Distinguishable − Space Station stowage trays shall be visually distinguishable from the shuttle mid−deck locker stowage trays.

J. Individually Removable − The stowage rack/tray system shall allow the removal of an individual tray without disturbing the remaining trays in the rack or cabinet.

K. Stowed Item Identification − Stowage tray decals, which provide a listing of the contents of the stowage rack/trays shall be visible to the crew in the on−orbit installed position.

L. Launch Support Equipment − Any stowage rack launch support structure required only during launch and return shall be removable on−orbit.

Removable launch support structure shall have a dedicated location to be stowed on−orbit.

M. Stowage Compartment Doors − Doors or closeouts on stowage racks, compartments, or lockers shall be removable on−orbit.

N. Stowage Tray Kick Loads − Stowage tray surfaces which are exposed to the translation path shall withstand a crew induced kick off load of 125.0 lbf.

11.3.3.2 DESIGN REQUIREMENTS COMMON TO BOTH STOWAGE AND EQUIPMENT DRAWERS/TRAYS

In addition to the requirements given in 11.3.3.1, all stowage and equipment drawers/trays will be designed to provide the following features:

A. Latches/Handles/Operating Mechanisms − All latches, handles, and operating mechanisms shall be designed to be latched/unlatched and opened/closed with one hand by the 95th percentile American male to the 5th percentile female.

B. Latch/Unlatch Status − The design of latches shall be such that their status (locked/unlocked) can be determined through visual inspection.

11.3.3.3 STOWAGE DRAWER/TRAY DESIGN REQUIREMENTS

In addition to the requirements given in 11.3.3.1 and 11.3.3.2, stowage drawers/trays will be designed to meet the following requirements.

A. Restraint of Contents −

(1) Drawer/tray contents shall be restrained in such a way that the items shall not float free when the drawer/tray is opened or jam the drawer/tray so it cannot be opened or closed.

(2) Drawer/tray contents shall be restrained in such a way that the contents can be removed/replaced without using a tool.

B. Deleted.

C. Access to Contents − The contents of drawers shall be arranged such that the contents are visible and accessible when the drawer/tray is in the open position.

D. Identification of Contents − In the stowed position, the contents of drawers/trays shall be identified by labeling on the visible exterior of the drawer/tray.

11.3.3.4 EQUIPMENT DRAWER DESIGN REQUIREMENTS

In addition to the requirements given in 11.3.3.1 and 11.3.3.2, equipment drawers will be designed to meet the following requirements:

A. Utility Connections −

(1) The utility connections shall be designed such that they can be disconnected/ connected when the drawer is in the fully opened position.

(2) If the utility connection is via a flexible umbilical, sufficient cable length shall be provided such that the drawer can be fully opened without disconnecting the cables.

B. Equipment Layout on Rack −

(1) Components shall be mounted in an array on a two−dimensional surface.

A lower layer shall not support an upper layer.

(2) Items of the same or similar form and having different functional properties, shall be mounted with a standard orientation throughout the unit, but not be physically interchangeable.

(3) Deleted.

11.4 CLOSURES AND COVERS

11.4.1 INTRODUCTION

This paragraph is not applicable for this document.

11.4.2 CLOSURES AND COVERS DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

11.4.3 CLOSURES AND COVERS DESIGN REQUIREMENTS

Equipment housings (e.g., electrical bays, cabinets, lockers, and consoles) shall be designed to provide closures and covers for inaccessible areas. The following requirements will apply:

A. Sealing − The inaccessible areas shall be sealed to prevent any loose item from drifting into them.

B. Removal − Closures shall be removable to allow maintenance of equipment.

C. Securing − Closures shall have a positive means of indicating that it is locked.

D. Loads − Nonstructural closures shall be capable of sustaining a crew−imposed minimum design load of 556 N (125.0 lbf) and a minimum ultimate load of 778 N (175.0 lbf).

E. Deleted.

F. Clearance − Bulkheads, brackets, and other units shall not interfere with removal or opening of covers.

G. Application − An access cover shall be provided whenever routine maintenance operations would otherwise require removing the entire case or cover, or dismantling an item of equipment.

H. Self−Supporting Covers − All access covers that are not completely removable shall be self−supporting in the open position.

I. Ventilation Screen Access − Where ventilation screens, holes, or grids are used, the ventilation surface shall be accessible for vacuuming in its installed position.

11.5 MOUNTING HARDWARE

11.5.1 INTRODUCTION

This paragraph is not applicable for this document.

11.5.2 MOUNTING HARDWARE DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

11.5.3 MOUNTING HARDWARE DESIGN REQUIREMENTS

11.5.3.1 GENERAL MOUNTING DESIGN REQUIREMENTS

The following general requirements apply to mounting hardware:

A. Equipment Mounting − Equipment items shall be designed so that they cannot be mounted improperly.

B. Drawers and Hinged Panels − Subsystem components which are pulled out of their installed positions for routine checkout shall be mounted on equipment drawers or on hinged panels.

C. Deleted.

D. Deleted.

E. Installation/Removal Force − Hardware mounted into a capture−type receptacle that requires a push−pull action shall require a force less than 156.0 N (35.0 lbf) to install or remove.

F. Rear Access − Equipment to which rear access is required shall be free to open or rotate to its full distance and remain in the "open" position without being supported by hand.

G. Tools − Items shall be replaceable with a common hand tool.

H. Direction of Removal − Replaceable items shall be removable along a straight path until they have cleared the surrounding structure.

I. Visibility − All forward edges of the equipment item shall be visible to the restrained crewmember during alignment and attachment.

J. Mounting Bolt and Fastener Spacing − Mounting bolts and fasteners shall be spaced the required distance from other surfaces according to Figures 11.2.3.6−1 and 12.3.1.2−1.

K. Number of Mounting Bolts − The number of mounting bolts used shall be dictated by stress vibration analysis and crew strength requirements.

L. Shims and Washers − Where shims or washers are permitted in an IVA application, the following rules will be followed:

  (1) Shims shall be bound together in an assembly.

  (2) Shims shall be tethered or restrained at the location or point of use and identified as to location or point of use.

  (3) Deleted.

11.5.3.2 ALIGNMENT DEVICES DESIGN REQUIREMENTS

If alignment marks are used, the following alignment methods for replaceable hardware will be used:

A. Alignment Marks − A method of visual alignment shall be provided. The hardware design for applicable items shall incorporate alignment marks and/or orientation arrows at both sides of the interface.

  (1) If alignment marks are used, alignment marks shall be applied to both mating parts and the marks shall align when the parts are in the operational position.

  (2) An alignment mark shall consist of a straight or curved line of a width and length to allow accurate alignment.

B. Alignment Devices − Guide pins or their equivalent shall be provided to assist in alignment of hardware during mounting, particularly on modules that have integrated (built in) electrical or fluid connectors.

C. Keying − All replaceable hardware shall be keyed so that it will be physically impossible to install it in the wrong location.

D. Replaceable Hardware Identification − Replaceable hardware shall be identified with nomenclature that includes the hardware name, alignment of the hardware, and the correct use of attaching parts.

11.6 HANDLES AND GRASP AREAS (FOR PORTABLE ITEMS)

11.6.1 INTRODUCTION

This paragraph is not applicable for this document.

11.6.2 HANDLE AND GRASP AREA DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

11.6.3 HANDLE AND GRASP AREA DESIGN REQUIREMENTS

11.6.3.1 GENERAL HANDLE AND GRASP AREA DESIGN REQUIREMENTS

The following general requirements will be observed:

A. Provide Handles − All removable or portable units greater than 1.0 cubic foot in size shall be provided with handles or other suitable means for grasping, tethering, handling, and carrying.

B. Deleted.

C. Deleted.

11.6.3.2 HANDLE AND GRASP AREA LOCATION DESIGN REQUIREMENTS

The following general location requirements of handles or grasp areas shall apply:

A. Interference − Handles and grasp areas shall be located so that they do not interfere with equipment location or maintenance.

B. Clearance − IVA clearances shall be provided between handles and obstructions consistent with anthropometric dimensions given in 3.3.1.3.

C. Tether Attachments − Handles and grasp areas shall be suitable as tether or bracket attachment positions.

D. Location − Handles and grasp areas relocated in passageways shall be recessed and shall be designed so they do not pose a personnel safety hazard.

E. Location/Front Access − Handles and grasp areas shall be placed on the accessible surface of an item consistent with the removal direction.

11.6.3.3 NONFIXED HANDLES DESIGN REQUIREMENTS

Hinged, foldout, or attachable (i.e., nonfixed) handles will comply with the following:

A. Locked or Use Position − Nonfixed handles shall have a stop position for holding the handle perpendicular to the surface on which it is mounted.

B. One Handed Operation − Nonfixed handles shall be capable of being placed in the use position by one hand and shall be capable of being removed or stowed with one hand.

C. Tactile or Visual Indicators − Attachable/removable handles shall incorporate tactile and/or visual indication of locked/unlocked status.

11.6.3.4 HANDLE DIMENSIONS DESIGN REQUIREMENTS

IVA handles for movable or portable units shall be designed in accordance with the minimum applicable dimensions in Figure 11.6.3.4−1.

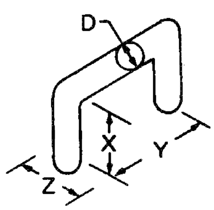
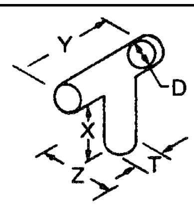
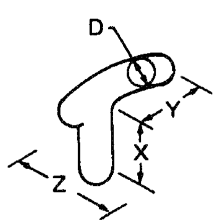
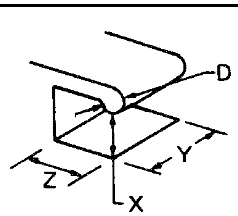
Illustration	Type of handle	Dimensions in mm (in inches) (Bare hand)		
		X	Y	Z
	Two−finger bar	32 (1.25)	65 (2.5)	75 (3)
	One−hand bar	48 (1.875)	111 (4.375)	75 (3)
	Two−hand bar	48 (1.875)	215 (8.5)	75 (3)
	T−bar	38 (1.5)	100 (4)	75 (3)
	J−bar	50 (2)	100 (4)	75 (3)
	Two−finger recess	32 (1.25)	65 (2.5)	75 (3)
	One−hand recess	50 (2)	110 (4.25)	90 (3.5)

FIGURE 11.6.3.4−1 MINIMUM IVA HANDLE DIMENSIONS FOR IVA APPLICATIONS (PAGE 1 OF 2)

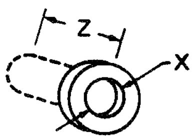
<table>
<tr><th rowspan="3">Illustration</th><th rowspan="3">Type of handle</th><th colspan="3">Dimensions in mm (in inches)</th></tr>
<tr><th colspan="3">(Bare hand)</th></tr>
<tr><th>X</th><th>Y</th><th>Z</th></tr>
<tr><td rowspan="2"></td><td>Finger−tip recess</td><td>19 (.75)</td><td>−</td><td>13 (0.5)</td></tr>
<tr><td>One−finger recess</td><td>32 (1.25)</td><td>−</td><td>50 (2)</td></tr>
<tr><td rowspan="6">Curvature of handle or edge (Does not preclude use of oval handles)</td><td>Weight of turn</td><td colspan="2">Minimum diameter</td><td rowspan="6">Gripping efficiency is best if finger can curl around handle or edge to any angle of 2/3 π (120 degrees) or more.</td></tr>
<tr><td>Up to 6.8 kg (up to 15 lbs)</td><td colspan="2">D = 6 mm (0.25 in.)</td></tr>
<tr><td>6.8 to 9.0 kg (15 to 20 lbs)</td><td colspan="2">D = 13 mm (0.5 in.)</td></tr>
<tr><td>9.0 to 18 kg (20 to 40 lbs)</td><td colspan="2">D = 19 mm (0.75 in.)</td></tr>
<tr><td>Over 18 kg (over 40 lbs)</td><td colspan="2">D = 25 mm (1.0 in.)</td></tr>
<tr><td>T−bar post</td><td colspan="2">D = 13 mm (0.5 in.)</td></tr>
</table>

FIGURE 11.6.3.4−1 MINIMUM IVA HANDLE DIMENSIONS FOR IVA APPLICATIONS (PAGE 2 OF 2)

11.7 RESTRAINTS

11.7.1 INTRODUCTION

This paragraph is not applicable for this document.

11.7.2 PERSONNEL RESTRAINTS

11.7.2.1 INTRODUCTION

This paragraph is not applicable for this document.

11.7.2.2 PERSONNEL RESTRAINTS DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

11.7.2.3 PERSONNEL RESTRAINTS DESIGN REQUIREMENTS

11.7.2.3.1 GENERAL PERSONNEL RESTRAINTS DESIGN REQUIREMENTS

All EVA and IVA personnel restraints (i.e., seat belts, shoulder harnesses, body restraints, foot restraints, and sleep restraints) shall comply with the following requirements:

A. Deleted.

B. Deleted.

C. Muscular Tension − Restraint design shall eliminate muscular tension.

D. Anthropometric Range − All personnel restraints shall accommodate the full range of anthropometric requirements per section 3.0.

E. Deleted.

F. Cleaning −The personnel restraint system shall be capable of on−orbit cleaning and repair.

11.7.2.3.2 FOOT RESTRAINT DESIGN REQUIREMENTS

11.7.2.3.2.1 GENERAL FOOT RESTRAINT DESIGN REQUIREMENTS.

The following general requirements apply to all IVA fixed and portable foot restraints:

A. Range of Motion − All foot restraints shall maintain foot position to allow the crewmember a complete range of motion (roll, pitch, and yaw).

B. Deleted.

C. Interchangeability − Attachment interfaces for foot restraints (portable to portable and fixed to fixed) shall be interchangeable throughout the internal Space Station.

D. Deleted.

E. Abrasion Resistance − Reinforcements shall be provided for any fabric areas which are exposed to high abrasion.

F. Ventilation − IVA foot restraints and covers shall allow ventilation to the feet.

G. Foot Restraints − The foot restraint shall be capable of being removed for replacement/repair.

H. Foot Restraints − The portable foot restraint shall be capable of being installed and removed without tools.

11.7.2.3.2.2 FOOT RESTRAINT DONNING/DOFFING DESIGN REQUIREMENTS.

Foot restraints will comply with the following donning and doffing requirements:

A. Deleted.

B. Deleted.

C. No−Hand Operation − The use of hands for placing/removing the foot shall not be required for foot restraint ingress/egress.

D. Handholds − Handholds or structure between waist and shoulder shall be available at all positions to aid foot restraint ingress and egress.

E. Entrapment − A positive means of releasing the foot from the restraint shall be provided.

11.7.2.3.2.3 FOOT RESTRAINT LOADS DESIGN REQUIREMENTS.

IVA restraints must meet the following load requirements:

A. Tension Loads − Foot restraints shall be designed to withstand a tension load of 445 N (100.0 lbf) as a minimum (see Figure 11.7.2.3.2.3−1).

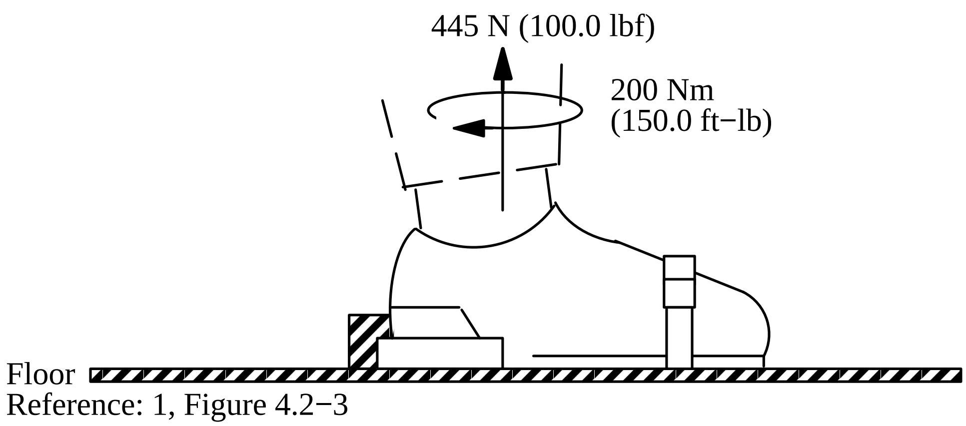


FIGURE 11.7.2.3.2.3−1 IVA FOOT RESTRAINT LOAD LIMITS

B. Torsion Loads − The restraints shall withstand a torsion load of 200 Nm (150.0 ft−lb) as a minimum with the torsion vector normal to the floor (see Figure 11.7.2.3.2.3−1).

11.7.2.3.2.4 FOOT RESTRAINT DURABILITY AND COLOR DESIGN REQUIREMENTS.

The durability and color of IVA and EVA foot restraints shall comply with the following:

A. Deleted.

B. Color − Color for all foot restraints shall be per SSP 50008.

11.7.2.3.3 BODY RESTRAINT DESIGN REQUIREMENTS

11.7.2.3.3.1 BODY RESTRAINT DONNING/DOFFING DESIGN REQUIREMENTS.

The following personal body restraint donning and doffing requirements will apply to all tether attachments, seat belts, and shoulder harnesses:

A. Latching Mechanisms − The latching mechanism attachment shall require a positive action by the crewmember to both latch and unlatch the mechanism.

B. One−Handed Operation − The latching mechanism shall have the capability of being latched and unlatched with one hand.

11.7.2.3.3.2 BODY RESTRAINT LOADS DESIGN REQUIREMENTS.

The following load requirements shall apply to seat belts, shoulder harnesses, and IVA tethers:

A. Seat Belts and Shoulder Harnesses − Not applicable.

B. Tether Attachments −

  (1) IVA tether attachments shall be capable of sustaining a load of 756 N (170.0 lbf) along the longitudinal axis.

  (2) They shall be designed to prevent any side loading.

C. Attach Points for Tether Attachment − IVA translation and mobility handhold tether attachment attach points shall be designed to a minimum ultimate load of 902 N (250.0 lb) in any direction.

11.7.2.3.3.3 BODY RESTRAINT FINISH AND COLOR DESIGN REQUIREMENTS

This paragraph is not applicable for this document.

11.7.2.3.3.4 BODY RESTRAINT DIMENSIONAL DESIGN REQUIREMENTS

11.7.2.3.4 SLEEP RESTRAINTS DESIGN REQUIREMENTS

Sleep restraint design will meet the following requirements:

A. Extremity Restraint − Sleep restraints shall be provided to prevent movement of legs, arms and head during sleep

B. Trapped Air − Sleep restraints shall include provisions for releasing unevenly distributed trapped air.

C. Individual Sleep Restraints − Individual sleep restraints shall be provided for each crewmember.

D. Stowage, Transport, Cleanability − Sleep restraints shall be stowable, transportable, and cleanable on−orbit.

E. Features − A sleep restraint shall incorporate the following features:

  (1) Adjustable, flexible restraint straps.

  (2) Arm slits.

  (3) Adjustable, removable pillows/headstrap.

  (4) Adjustable thermal protection.

F. Opening/Closing − A sleeping bag opening/closing device which extends the full length of the bag shall be provided.

G. Torso Restraint − Torso restraining straps shall be provided.

H. Opening/Closing − The opening/closing device shall allow emergency crew egress from the crew restraint.

I. Opening/Closing Device Replacement − The opening/closing device shall be replaceable.

11.7.3 EQUIPMENT RESTRAINTS

11.7.3.1 INTRODUCTION

This paragraph is not applicable for this document.

11.7.3.2 EQUIPMENT RESTRAINT DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

11.7.3.3 EQUIPMENT RESTRAINT DESIGN REQUIREMENTS

All IVA equipment restraints will be designed to the following requirements:

A. Hand Operated −

   (1) Equipment restraints shall be designed such that tools are not required to attach or detach the restraint.

   (2) Equipment restraints shall be designed such that they can be attached/detached by either the left or right hand.

B. Blind Operation − The equipment restraints shall be designed such that they can be attached/detached without having to look at them.

C. Adjustability − Both adjustable and fixed−length tethers shall be provided.

D. Deleted.

E. Cause No Damage − The equipment restraint shall be designed such that it cannot damage the item to be restrained or the spacecraft interfacing surfaces and adjacent hardware.

F. No Adhesive Residue − Adhesive equipment restraints shall not leave an adhesive residue on the item or on the spacecraft surface when the adhesive restraint is detached.

G. Tethers −

   (1) Common attachment method − All equipment tethers shall use a common attachment method.

   (2) Tether attachment points −

      a. All equipment items which will require tethering shall provide a tether attach point which is an integral part of the item.

      b. This attach point shall also be provided on the interfacing surface to which the item is to be secured.

   (3) Tether lock status indication − The tether hook shall be designed in such a way that it will provide a positive indication that it is locked/unlocked in both day and night lighting conditions.

H. Deleted.

I. Color − Equipment restraints shall be of a standardized color to make them distinguishable from other types of loose equipment and the items that will be restrained.

J. Deleted.

K. Deleted.

L. Deleted.

M. Group Restraints −

(1) Deleted.

(2) Group restraints shall provide a system which allows the removal of one item at a time.

N. Throw−Away Restraints − Any restraint device that is utilized during vehicle launch, and upon activation or usage removal is discarded, will meet the following requirements:

(1) Throw−away restraints shall be designed to be torn apart or be of soft, crushable materials to accommodate the openings of onboard trash collection/disposal systems.

(2) The throw−away restraints shall be color coded as a throw−away item.

O. Hook and Loop − When hook and loop fasteners are used as a restraint, the item to be restrained (i.e., the free item) shall be equipped with hook type fastener and the restraining surface shall be equipped with pile type fastener.

11.8 MOBILITY AIDS

11.8.1 INTRODUCTION

This paragraph is not applicable for this document.

11.8.2 PERSONNEL MOBILITY AIDS

11.8.2.1 HANDHOLD AND HANDRAIL DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

11.8.2.2 HANDHOLD AND HANDRAIL DESIGN REQUIREMENTS

This section provides the design requirements for handholds and handrails. These requirements shall apply to both IVA and EVA applications, except where EVA−unique requirements are specifically identified.

11.8.2.2.1 HANDHOLD AND HANDRAIL DIMENSIONS DESIGN REQUIREMENTS

All handholds and handrails will adhere to the following cross−section design requirements:

A. Standardization − Cross−sectional dimensions of IVA handholds and handrails shall be standardized throughout Space Station.

B. Cross−Section Shape − IVA handholds and handrails cross−section shape shall be designed as indicated in Figure 11.8.2.2.1−1.

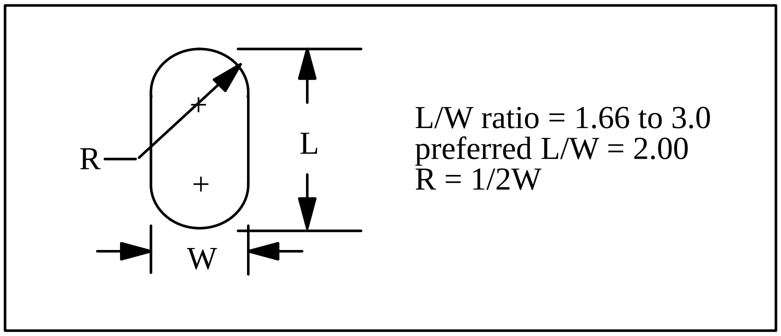


FIGURE 11.8.2.2.1−1 IVA HANDHOLD CROSS SECTION

C. IVA Handhold Minimum Dimensions − All IVA handholds shall have a minimum of 14.0 cm (5.5 in.) grip length and a minimum of 3.8 cm (1.5 in.) clearance between the lower surface of the handgrip and the surface on which it is mounted. (Refer to Figure 11.8.2.2.1−2.)

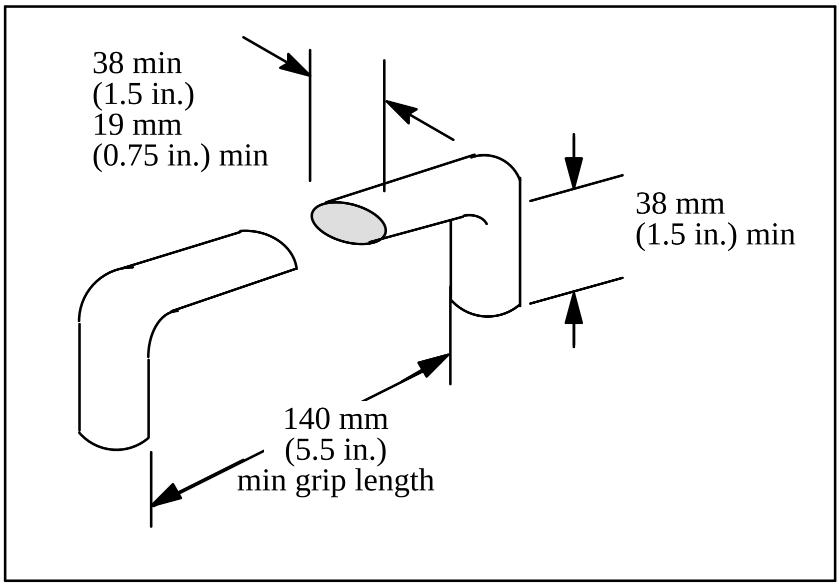


FIGURE 11.8.2.2.1−2 IVA HANDHOLD DIMENSIONS

11.8.2.2.2 HANDHOLD AND HANDRAIL CODING DESIGN REQUIREMENTS

Handholds and handrails shall be color coded:

A. Standard Color − The color of all IVA handholds/handrails shall be standard.

B. Contrast Ratio − The color of IVA handholds/handrails shall have a contrast ratio of 10:1 or greater with the background.

11.8.2.2.3 HANDHOLD AND HANDRAIL TEXTURE DESIGN REQUIREMENTS

A. Identical Finish − The finish of all handholds/handrails shall be identical.

B. Nonslip Surface − Handholds and handrails shall have a nonslip surface.

11.8.2.2.4 HANDHOLD AND HANDRAIL DESIGN LOADS DESIGN REQUIREMENTS

All fixed and portable IVA handholds and handrails shall be designed to a minimum ultimate load of 1113 N (250 lb) applied in any direction without failure or damage.

11.8.2.2.5 DELETED

11.8.2.2.6 HANDHOLD AND HANDRAIL MOUNTING DESIGN REQUIREMENTS

The following requirements will apply to all handhold and handrail mounting:

A. Deleted.

B. Portable Handhold and Handrail Lock Status Indication − Portable handholds and handrails shall provide a positive indication of when they are in the locked position.

C. Visibility and Accessibility − Handholds and handrails shall be mounted so that they are visible and accessible.

D. Handhold Removal − Fixed handholds shall be removable with common tools.

11.8.3 EQUIPMENT MOBILITY AIDS

11.8.3.1 EQUIPMENT MOBILITY AID DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

11.8.3.2 EQUIPMENT MOBILITY AID DESIGN REQUIREMENTS

The following equipment mobility aid requirements are applicable to both IVA and EVA:

A. Maximum Movable Equipment Size − Equipment shall be sized such that it can be moved from its cargo location, to its storage location, and to its place of designed use.

B. Access − Design shall provide physical and visual accessibility around the mass.

C. Containers for Small Items − Containers shall be provided for simultaneous transfer of small equipment items.

  (1) Single items shall be individually removable.

  (2) The container shall be attachable to the crewmember and Space Station.

D. Bump Protection − Bump protectors shall be designed so they can be used as a mobility aid.

11.9 FASTENERS

11.9.1 INTRODUCTION

This paragraph is not applicable for this document.

11.9.2 FASTENER DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

11.9.3 FASTENER DESIGN REQUIREMENTS

This section provides the fastener design requirements.

11.9.3.1 GENERAL FASTENER DESIGN REQUIREMENTS

This section provides the fastener design requirements that pertain to both IVA and EVA applications.

A. Commonality − The number and kinds of fasteners used shall be dictated by stress vibration analysis and crew strength requirements.

B. Deleted.

C. Hand−Actuated Fasteners Preferred − Hand−actuated fasteners shall be used, where size, location, structural, and 50th percentile female strength requirements are met.

D. Deleted.

E. Captive Fasteners − All fastener components shall be captive.

F. Accessibility −

   (1) Deleted.

   (2) Separation − IVA fasteners shall be separated to provide hand and tool clearance in accordance with Figure 11.2.3.6−2.

   (3) Deleted.

   (4) Direct access − Fasteners shall be located so that they can be actuated without removing other parts or units first.

   (5) Access holes − Covers or shields through which mounting fasteners must pass for attachment to the basic chassis of the unit shall have holes for passage of the fastener without precise alignment (and tool/hand if tool/hand is required to replace).

G. One−Handed Actuation − All fasteners shall allow actuation by one hand, and by either right or left hand.

H. Engagement Status Indication − An indication of incorrect engagement of fasteners shall be provided.

I. Multiple Fasteners −

(1) Number of fasteners − When several fasteners are required, they shall be of identical type.

(2) Arrangement − When several fasteners are used on one item, they shall be arranged so that the unit can be assembled in only the correct manner.

J. Safety − Fasteners shall be designed so as to preclude injury to the crewmember when the fastener is released.

K. Deleted.

L. Actuation Force/Torque − Fastener actuation/torque shall be less than that specified in Figure 4.9.3−4, using the tools on the standard on−orbit tool list.

11.9.3.2 HAND−ACTUATED FASTENER DESIGN REQUIREMENTS

In addition to the general fastener design requirements given in 11.9.3.1, IVA and EVA hand−actuated fasteners shall be designed to the following requirements:

A. Deleted.

B. Deleted.

C. Fastener Knobs − Fastener knobs shall be textured.

D. Quick−Release Fasteners −

(1) Quick−release captive fasteners shall require a maximum of one complete turn to operate (quarter−turn fasteners are preferred).

(2) Quick−release captive fasteners shall require only one hand to operate.

(3) Quick−release captive fasteners shall be positive locking in open and closed positions.

E. Threaded Fasteners −

(1) Hand−actuated threaded fasteners shall have a locking feature that provides an audible, tactile, or visual feedback to the crewmember.

(2) Such locking features shall assure that threaded fasteners will not unthread themselves without crew activation.

F. Pin Fasteners (IVA) −

(1) Designed for launch only − Pin fasteners shall be used for launch loads only.

(2) Locking devices − Locking devices used in conjunction with pin fasteners shall be made accessible and visible.

G. Over−Center Latches

(1) Nonself−latching − Over−center latches shall include a provision to prevent undesired latch element realignment, interference, or reengagement.

(2) Latch lock − Latch catches shall have locking features.

(3) Latch handles − If the latch has a handle, the latch handle and latch release shall be operable by one hand.

H. Safety Wire − Safety wires shall not be used on fasteners.

11.9.3.3 TOOL−ACTUATED FASTENER DESIGN REQUIREMENTS

In addition to the general fastener design requirements given in 11.9.3.1, IVA and EVA tool−actuated fasteners shall meet the following design requirements:

A. Nonstandard Tools − Fasteners requiring nonstandard tools shall not be used.

B. Deleted.

C. Fastener Head Type −

(1) Hex type external or internal grip or combination head fasteners shall be used where on−orbit crew actuation is planned, e.g., ORU replacement.

(2) Flush or oval head internal hex grip fasteners shall be provided only where a smooth surface is required. Phillips or Torq−Set fasteners may be used where fastener installation is permanent relative to planned orbital operations or maintenance, or where tool−fastener interface failure can be corrected by replacement of the unit containing the affected fastener with a spare unit.

(3) No straight−slot fasteners shall be used.

D. Precision Torquing − Where precise torque or preload is required, station shall use fasteners that incorporate torque−indicating features or will mate with onboard torquing features.

E. Torque Instructions − When fastener torquing to specifications is required, instructions shall be provided.

F. Deleted.

G. Deleted.

H. Left−Hand Threads −

(1) Left−hand threads shall not be used unless system requirements demand them.

(2) Left−hand threaded fasteners shall be identified by marking.

I. Locking − Threaded fasteners shall incorporate features that allow them to be locked so they will not unthread without using a tool.

J. Hand Tool Operable − All fasteners installed with power tools shall be removable by a hand operated tool.

11.9.3.4 IVA FASTENER DESIGN REQUIREMENTS

In addition to the fastener design requirements given in 11.9.3.1 through 11.9.3.3, all IVA fasteners shall meet the following requirements.

A. Deleted.

B. Cadmium Plating − Cadmium plated IVA fasteners shall not be used.

C. Wing−Head Fasteners − Wing−head IVA fasteners shall fold down and be retained flush with surfaces.

D. Cotter Keys −

(1) Fit − Keys and pins shall fit without requiring being driven in or out using a tool.

(2) Large heads − Cotter keys shall be removable by hand.

(3) Deleted.

E. Access − Minimal requirements for access and/or clearance areas for tool−actuated fasteners shall be as shown in Figures 11.2.3.6−1 and 11.2.3.6−2.

F. Tool−Actuated Fastener Head Types − In addition to the general tool−actuated fastener design requirements given in 11.9.3.3, the following IVA−specific tool−actuated fastener selection requirements shall apply. (Note: Special mission or program requirements may create the need to use other types of fastener heads than those listed below.)

(1) Fastener heads directly exposed to crew impact shall meet the requirements for burrs, edges, and sharp corners, or be provided with protective covers, or be flush with the surface.

(2) Fastener heads not directly exposed to crew impact within habitable and stowage areas shall be internal or external hex head.

(3) External hex, internal hex, or double hex fastener heads shall be provided on all machine screws, bolts, or other ORU mounting fasteners.

11.10 CONNECTORS

11.10.1 INTRODUCTION

This paragraph is not applicable for this document.

11.10.2 CONNECTOR DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

11.10.3 CONNECTOR DESIGN REQUIREMENTS

All types of IVA and EVA connectors shall meet the following general requirements.

A. One−Handed Operation − All connectors, whether operated by hand or tool, shall be designed so they can be mated/demated using one hand, either right or left hand.

B. Accessibility − It shall be possible to mate/demate or replace individual connectors without having to remove or replace other connectors.

11.10.3.1 FLUID CONNECTORS DESIGN REQUIREMENTS

All IVA and EVA liquid and gas connectors shall be designed to meet the following requirements:

A. Brazed or Welded Fluid Lines − All brazed or welded gas and liquid lines shall be provided with permanently installed connectors that permit on−orbit maintenance.

B. Indication of Pressure Flow −

(1) All nonbrazed or nonwelded gas and liquid lines shall be provided with a positive indication of the gas pressure/fluid flow to verify that the line is passive before disconnection of connectors.

(2) Any liquid or gas lines equipped with quick disconnect connectors which are designed to be operated under pressure shall not be required to be fitted with pressure/flow indicators.

C. Deleted.

11.10.3.2 ELECTRICAL CONNECTORS DESIGN REQUIREMENTS

All IVA and EVA electrical connectors shall comply with the following general requirements in addition to the requirements in 6.4.3.3.

A. Ease of Disconnect − Electrical connector plugs shall require no more than one turn to disconnect.

B. Self−Locking − Electrical connector plugs shall provide a self−locking safety catch.

C. Access − Electrical connectors and cable installations shall permit disconnection and reconnection without damage to wiring or connectors.

D. Arc Containment − Electrical connector plugs shall be designed to confine/isolate the mate/demate electrical arcs or sparks.

E. Demating of Powered Connectors − See 6.4.3.7, Item C.

F. Contact Protection − All demated connectors shall be protected against physical damage and contamination.

11.10.3.3 STRUCTURAL CONNECTORS DESIGN REQUIREMENTS

All IVA and EVA structural connectors shall meet the following requirements:

A. Alignment Provisions − All structural connectors shall incorporate alignment features.

B. Soft Latching − All structural connectors shall provide the capability to ”soft latch” prior to full firm connection or full release.

C. Lock Indication − All structural connectors shall provide an indication of positive locking.

11.10.3.4 OPTICAL CONNECTORS DESIGN REQUIREMENTS

All IVA and EVA fiber optic connectors shall align for signal fidelity.

11.10.3.5 CONNECTOR IDENTIFICATION/ALIGNMENT DESIGN REQUIREMENTS

All IVA and EVA connectors shall be selected, designed, and installed so they cannot be mismated or cross−connected. Where applicable, the following requirements are to ensure that connectors are properly mated and can be verified by visual inspection.

Labeling requirements shall be as specified below or as approved by the NASA Crew Office or their designated representative.

Crew Office approval of label location, quantity, and orientation shall be indicated by signature on a label development master drawing.

The Crew Office signature shall satisfy verification that the location, quantity, viewing, and orientation of labels meets requirements.

A. Connector Shape − Connectors which are of different shapes and physically incompatible shall be used when lines differ in content (i.e., different voltages, liquids, gases, etc.).

B. Alignment Provisions −

(1) Mating connectors shall be provided with aligning pins or equivalent devices to aid in alignment and to preclude inserting in other than the desired orientation.

(2) If aligning pins are used on electrical connectors, they shall extend beyond the plug's electrical pins to ensure that alignment is obtained before the electrical pins engage.

C. Deleted.

D. Alignment Marks −

(1) Alignment marks shall be applied to mating parts. EVA zero−g electrical (Amphenal) and Symetrics connectors do not require alignment marks.

(2) Alignment marks shall consist of a straight or curved line of a width and length sufficient to allow accurate alignment

E. Coding − Connector code label font will be in accordance with 9.5.3.1.14.

(1) IVA Connector Coding −

a. Both halves of mating connectors shall display a code or identifier which is unique to that connection.

b. The labels or codes on connectors shall be located so they are visible when connected or disconnected

(2) EVA Electrical Connector Coding −

a. Both halves of mating electrical connectors shall display a code or identifier which is unique to that connection.

1) Each line connector shall have a unique code or identifier, a "plug" (P)−number (e.g., P205), on the connector shell or on the line immediately after the connector.

2) The line mating half of the connector shall have a unique code or identifier, a "jack" (J)−number (e.g., J205), on or near the connector mounting interface.

3) If mating halves of line connectors do not match then the line's P−number label shall be expanded to include its mating J−number (e.g., if P101 mates to J432, then the line connector label will be as follows: P101/J432).

4) If a line has multiple mating halves because of on−orbit reconfigurations due to assembly, maintenance, or contingencies (e.g., Laboratory Power Data Grapple Fixture Rigid Umbilical or PMA−2), then the line's P−number label shall include a listing (in connection sequence) of all its connection possibilities (e.g., if P43 mates to J43, J172, and J187 on sequential assembly flights, then the line connector label will be as follows: P43/J43/J172/J687 (J−numbers can be listed horizontally as shown or vertically without preceding slashes on J−numbers for all but the first connection)).

Repetitive connector matings shall not require multiple listings of the same J−number.

5) If the mating half (jack) of a connector mates to multiple lines between segments or elements, then it is preferred that the J−number will match the P−number for each of its mating lines.

6) Common ORU connectors (like Photovoltaic Radiators, heat exchangers, etc.) shall maintain a common connector J−number. If the ORUs exist in multiples at the same worksite, the line P−number should not match the J−number to prevent confusion in multiple ORU change out.

b. The P and J connector labels shall be visible by the crewmember while nominally positioned at the worksite for both the stowed and installed positions of the connectors. If the connector is covered, the following rules apply:

1) If the connectors are individually covered with nonremoveable thermal or contamination covers (jackets or sleeves), then P− and J−numbers shall be labeled on the exterior of the covers.

2) If a bank of connectors has a thermal or contamination cover, then the exterior of the cover shall identify each connector's relative location with a labeled circle and its respective J−number (or P−number).

3) If the cover is, or can be, removed, the connector label shall be both on the connector and either on the cover or on adjacent structure within 4.0 inches of that cover.

(3) EVA Fluid Connector Coding −

a. Both halves of mating fluid connectors shall display a code or identifier which is unique to that connection.

1) Each line connector shall have a unique code or identifier of "quick−disconnect female (F)−number" (e.g., F37), on the connector body or on the line immediately after the connector.

2) The line mating half of the connector shall have a unique code or identifier of "quick−disconnect male (M)−number" (e.g., M107), on or near the connector mounting interface.

3) If mating halves of line connectors do not match, then the line's F−number label shall be expanded to include its mating M−number (e.g., if F233 mates to M177, then the line connector label will be as follows: F233/M177).

4) If a line has multiple mating halves because of on−orbit reconfigurations due to assembly, maintenance, or contingencies, then the line's F−number label shall include a listing (in connection sequence) of all its connection possibilities (e.g., if F20 mates with M20, M37, and M102 sequentially, then the line connector label will be as follows: F20/M20/M37/M102 (M−numbers can be listed horizontally as shown or vertically without preceding slashes on M−numbers for all but the first connection)).

   Repetitive connector matings shall not require multiple listings of the same M−number.

5) If the mating half (M) of a connector mates to multiple lines between segments or elements, then it is preferred that the M−number match the F−number for each of its mating lines.

6) Common ORU connectors (like photovoltaic radiators, heat exchangers, etc.) shall maintain a common connector M−number. If the ORU exists in multiples at the same worksite, the line F−number should not match the M−number to prevent confusion in multiple ORU change out.

b. The F and M connector labels shall be visible by the crewmember while nominally positioned at the worksite for both the stowed and installed positions of the connectors. If the connector is covered, the following rules apply:

1) If the connectors are individually covered with nonremoveable thermal or contamination covers (jackets or sleeves), then the F− and M−numbers shall be labeled on the exterior of the covers.

2) If a bank of connectors has a thermal or contamination cover, then the exterior of the cover shall identify each connectors relative location with a circle labeled with its respective M−number (or F−number).

3) If the cover is, or can be, removed, the connector label shall be both on the connector and either on the cover or on adjacent structure within 4.0 inches of that cover.

F. Pin Identification − Each pin shall be identified in each electrical plug and each electrical receptacle.

G. Orientation − Grouped plugs and receptacles shall be oriented so that the aligning pins or equivalent devices are in the same relative position (i.e., all keyed connectors oriented the same direction − key up).

H. Loose Hoses or Cables −

(1) If the connectors on the ends of a loose electrical cable are not identical, each end shall be identified.

(2) The loose ends of electrical cables or fluid lines shall be restrained.

I. Connector Caps or Plugs for Dead−Facing, Terminating, and Shorting − Individual connector caps or plugs used for dead−facing, terminating, and shorting shall be identified by its applicable P− and J−number followed by a dash and D (dead−facing), or T (terminating), or S (shorting) (e.g., terminating plug for line P21 would be labeled as P21−T).

11.10.3.6 CONNECTOR ARRANGEMENT DESIGN REQUIREMENTS

All types of IVA and EVA connectors shall comply with the following arrangement and spacing requirements:

A. Deleted.

B. Connectors and Adjacent Obstructions − Space between connectors and adjacent obstructions shall be a minimum of 25.0 mm (1.0 in.) for IVA and 40.6 mm (1.6 in.) for EVA access.

C. Connectors in Rows Which Are Removed Sequentially −

(1) Connectors in a single row or staggered rows which are removed sequentially by the crew (IVA) shall provide 25.0 mm (1.0 in.) of clearance from other connectors and/or adjacent obstructions for 270 degrees of sweep around each connector beginning at the start of its removal/replacement sequence.

(2) For single rows or staggered rows of EVA connectors, 40.6 mm (1.6 in.) of clearance for 270 degrees sweep shall be provided.

D. Deleted.

E. Deleted.

11.11 WINDOWS

11.11.1 INTRODUCTION

This paragraph is not applicable for this document.

11.11.2 WINDOW DESIGN CONSIDERATIONS

Requirements for three different categories of window ports are provided in this section. A window port is defined as the finished assembly which includes all window panes that would normally be used at a specific location. For each specific requirement it will be stated whether the requirement applies to individual window panes or to the entire window port which includes all finished window panes. The three categories of window ports will be referred to by the designated letter:

A. Window ports to support crew viewing and limited crew photography (i.e. hatch windows).

B. Window ports to support crew viewing and crew photography.

C. Window ports to support crew viewing and science including support of telescopes with aperture diameters of at least six inches.

11.11.3 WINDOW DESIGN REQUIREMENTS

All window port and window pane designs shall meet the requirements of SSP 30560. **DCN 008**

11.11.3.1 DESIGN REQUIREMENTS FOR ALL WINDOWS

These requirements apply to test conditions prior to launch. The verification of optical requirements can be performed in the unloaded condition.

11.11.3.1.1 WINDOW SIZE

A. Category A (Hatch) Window Ports –

(1) Category A (Hatch) window ports shall have a minimum clear viewing area equal to that of an 8.0 inch (20.3 cm) diameter circle.

(2) The length to width aspect ratio shall not exceed 1:1.7.

B. Category B and C (Observation) Window Ports –

(1) Category B and C (observation) window ports shall have a minimum clear viewing area equal to that of a 20.0 inch (50.8 cm) diameter circle.

(2) The length to width aspect ratio shall not exceed 1:1.7.

11.11.3.1.2 SURFACE REFLECTIONS

A. Anti−Reflection Coatings – When anti−reflection coatings are applied to window panes, they shall not cause resolution degradation exceeding 0.007 milliradians (1.5 arc seconds).

B. Specular Reflectance – Window panes shall be designed such that the specular reflectance from each anti−reflection coated surface, disregarding red−reflector coated surfaces, from 450 to 700 nanometers normally incident light shall not exceed 2.0 percent absolute.

11.11.3.1.3 OPTICAL AND DURABILITY CHARACTERISTICS FOR ALL WINDOWS

All finished window panes, with accepted coatings, and completed tempering and lamination processes, if applicable, shall meet the following requirements:

A. Parallelism – Each surface of a multi−element window shall be parallel to all other surfaces to within 1.5 degrees.

B. Visual Uniformity Requirements − All window coatings will be uniform in quality and condition and hence shall conform to MIL−C−48497, paragraphs 3.3.1, 3.3.2, and 3.3.3.

C. Verification of Uniformity Requirements − Visual uniformity requirements shall be verified by following the test procedures described in MIL−C−48497, paragraphs 4.5.2.1, 4.5.2.2, and 4.5.2.3.

D. Durability for Window Surfaces Exposed to Crew Contact −

(1) Windows with coatings deposited on glass substrates − Window coatings exposed to crew contact shall exhibit durability per MIL−C−48497, section 3.4, with the following exceptions: (1) paragraph 3.4.2.1, shall be amended to require exposure of +20 and –20 degrees Fahrenheit be added to the maximum and minimum design temperatures, (2) paragraph 3.4.3.1, shall be eliminated, and (3) paragraph 3.4.3.2, shall be eliminated.

(2) Windows with coatings deposited on substrates other than glass − Window coatings exposed to crew contact shall exhibit durability per MIL−C−48497, section 3.4, with the following exceptions: (1) paragraph 3.4.2.1, shall be amended to require exposure of +20 and –20 degrees Fahrenheit be added to the maximum and minimum design temperatures, (2) paragraph 3.4.2.2, shall be amended to eliminate immersion in trichloroethylene and acetone, (3) paragraph 3.4.3.1, shall be eliminated, (4) paragraph 3.4.1.3, shall be eliminated, and instead the coating shall be required to pass a Taber abrasion resistance test per ASTM D1044 with no more than 4.27 percent haze after 100 revolutions and no more than 27.06 percent haze after 500 revolutions of a CS10F wheel under a load of 500 grams, and (5) the requirement to exhibit salt resistance, per paragraph 3.4.3.2, shall be eliminated.

E. Durability for Window Surfaces Not Exposed to Crew Contact – The window coatings shall exhibit durability per MIL−C−48497, section 3.4, with the following exceptions: (1) paragraph 3.4.2.1, shall be amended to require exposure of +20 and –20 degrees Fahrenheit be added to the maximum and minimum design temperatures, (2) paragraph 3.4.3.1, shall be eliminated, and (3) the requirement to exhibit salt resistance, per paragraph 3.4.3.2, shall be eliminated.

11.11.3.1.3.1 OPTICAL CHARACTERISTICS OF CATEGORY A WINDOWS

All finished Category A window panes with accepted coatings will meet the following optical requirements within the specified clear viewing area.

A. Deviation −

(1) Light at normal incidence at any point on nontempered window panes shall not be deviated by more than 1.45 milliradians (5.0 arc minutes).

(2) Light at normal incidence at any point on tempered window panes shall not be deviated by more than 2.9 milliradians (10.0 arc minutes).

B. Wedge − The wedge of any individual window pane shall be limited to 5 arc minutes in any direction.

C. Haze − The haze, after all coatings have been applied, shall be less than 1.0 percent per ASTM D1003, Procedure A.

11.11.3.1.3.2 OPTICAL CHARACTERISTICS OF CATEGORY B WINDOWS

A. Wavefront −

(1) The peak−to−valley transmitted wavefront error through the combination of all window panes for the window port shall not exceed four waves over any 101.6 mm (4.0 inches) diameter sub−aperture within the central 80 percent (minimum) of the physical diameter (excluding flight loads and pressure loads), where the reference wavelength is 632.8 nm.

Note (a): Wavefront variation of 1 wave over any 101.6 mm (4.0 inch) diameter sub−aperture is highly desirable.

Note (b): For viewing angles of 30 degrees from normal incidence, it is a goal that the wavefront variation not exceed 5 waves peak−to−valley over any 4.0 inch diameter sub−aperture within the central 60 percent (minimum) of the physical diameter.

(2) The transmitted wavefront error shall not exceed 1 wave per inch up to a 4 inch diameter sub−aperture peak−to−valley over the central 80 percent (minimum) of the physical diameter with a reference wavelength of 632.8 nm.

(3) Wavefront requirements shall be met after all optical coatings have been applied, and if applicable, all tempering and lamination steps have been completed.

(4) Wavefront requirements shall apply when viewing through the window port at normal incidence.

B. Wedge − The wedge of any individual window pane shall be limited to 30.0 arc−seconds in any direction.

C. Haze − The haze, after all coatings have been applied, shall be less than 0.5 percent per ASTM D1003, Procedure A.

11.11.3.1.3.3 WAVEFRONT VERIFICATION

Either Method A or Method B shall be used to demonstrate wavefront compliance for Category B and C Window Ports.

11.11.3.1.3.3.1 METHOD A OF WAVEFRONT VERIFICATION

A. Each individual pane shall be tested over at least six sub−apertures distributed within the test area (defined as a minimum of 80 percent of the physical diameter of the pane) with one test aperture being nominally located in the center of this area, and with one test aperture being nominally located over the optically worst part of the pane within the test area. This test will measure the wavefront error at a nominal angle of zero degrees for the six sub−apertures.

Note: The transmitted wavefront error should be tested over the full test area defined, but may be tested over smaller sub−apertures if the wavefront errors are too large, or instrumentation is not available to test over the entire test area.

B. An additional test shall be conducted to measure wavefront of four sub−apertures distributed over the central 60 percent of the physical diameter for a nominal view angle of +/− 30 degrees.

C. To demonstrate compliance with the wavefront requirement specification, the worst area of each individual pane shall be summed via a root−sum−square and this total shall be less than the specified wavefront requirement. For example, if the worst measured wavefront for three panes are values “a”, “b”, and “c”, then the total wavefront will be:

Wavefront total = $\sqrt{a^2 + b^2 + c^2}$

D. Each surface of all individual panes shall be tested in reflectance at normal incidence over at least the test area in order to record the surface figure for Category C Window Ports only.

11.11.3.1.3.3.2 METHOD B OF WAVEFRONT VERIFICATION

A. An interferometric test shall be performed on all panes together of the window port configuration. This test will measure the wavefront error over at least six sub−apertures distributed within the test area of the assembly (defined as a minimum of 80 percent of the physical diameter of the assembly) with one test aperture being nominally located in the center of the clear aperture, and with one test aperture being nominally located over the optically worst area of the pane within the test area.

Note: The transmitted wavefront error should be tested over the full test aperture defined, but may be tested over smaller sub−apertures if the wavefront errors are too large, or instrumentation is not available to test entire test area.

B. An additional test shall be conducted to measure wavefront of four sub−apertures distributed over 60 percent of the physical diameter for a nominal view angle of +/− 30 degrees.

C. Each surface of all individual panes shall be tested in reflectance at normal incidence over at least the test area defined in order to record the surface figure for Category C Window Ports only.

11.11.3.1.3.3.3 DATA REQUIREMENTS FOR BOTH METHODS

The data pack shall include images of the interferograms recorded at all test apertures (including the large apertures), the total peak−to−valley wavefront error measured at each test aperture, and a breakdown of the total wavefront error measured at each test aperture into the individual third order aberrations (tilt, power, coma, spherical aberration, and astigmatism). Any spare panes fabricated shall also be tested by Method A or Method B.

11.11.3.1.4 OPTICAL TRANSMITTANCE FOR ALL WINDOW PORTS

A. Crew Safety Considerations −

(1) For the purposes of ensuring crew safety, the transmittance of the window assembly shall be evaluated according to the limits specified in 5.7.3.

(2) This evaluation shall be carried out assuming that the solar spectrum is modeled by that given in Figure 11.11.3.1.4−1, and further that the Sun subtends an angle of 9.3E−03 radians and a solid angle of 6.8E−05 steradians at the eye of the observer in Low Earth Orbit (LEO).

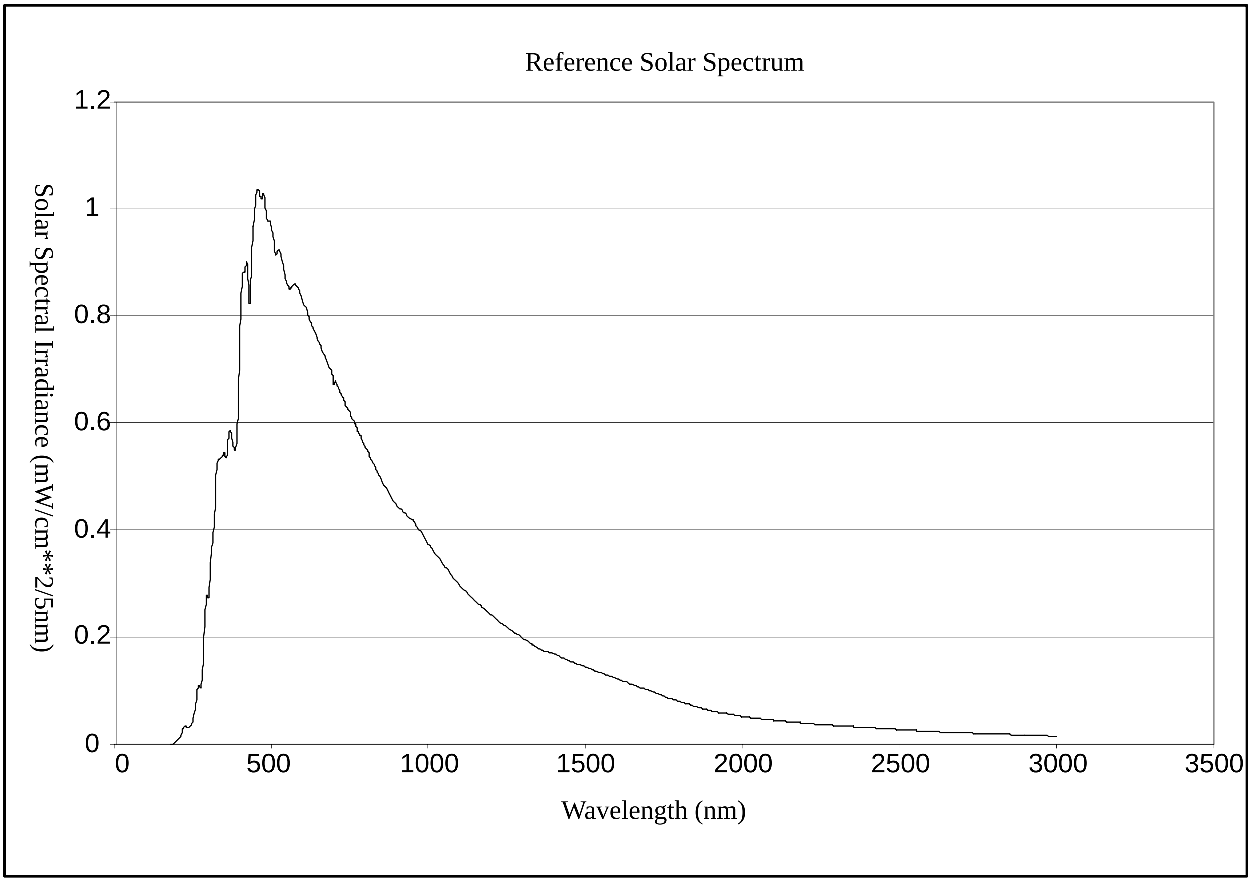


FIGURE 11.11.3.1.4−1 SOLAR SPECTRUM

B. Damage Mechanism Exposure Limits − The requirements of 5.7.3 are considered to have been met if the window port being considered has transmittance values which yield acceptable viewing times that are less than or equal to those specified in Figure 11.11.3.1.4−2 when using the source terms discussed in 11.11.3.1.4, Item A. The infrared requirement is applicable to cases where a strong visual stimulus is present. If the window port does not meet the values defined in Figure 11.11.3.1.4−2, additional means (sunglasses, additional films, etc.) can be used to meet the required attenuation. To utilize alternate means, the Radiation Health Officer shall concur.

	Solar Irradiance
Mechanism	Exposure Time Limit
Retinal Thermal Damage	3 seconds
Retinal Photochemical Damage	5 seconds
Infrared Exposure	10 minutes
Ultraviolet Exposure	8 hours

FIGURE 11.11.3.1.4−2 EXPOSURE LIMITS FOR DIFFERENT DAMAGE MECHANISMS

C. Color Balance for Category B and C Window Ports − The maximum allowable color shift for a D65 Standard Illuminant, when viewed through Category B or C windows, is bounded by a rectangular color space on the 1931 CIE Chromaticity Diagram. The boundaries of the rectangular color space range between 0.312 and 0.321 (inclusive) in the x coordinate, and between 0.329 and 0.340 (inclusive) in the y coordinate. The bounding box representing the allowable color shift, along with the location of the unshifted D65 Standard Illuminant, are illustrated schematically in Figure 11.11.3.1.4−3.

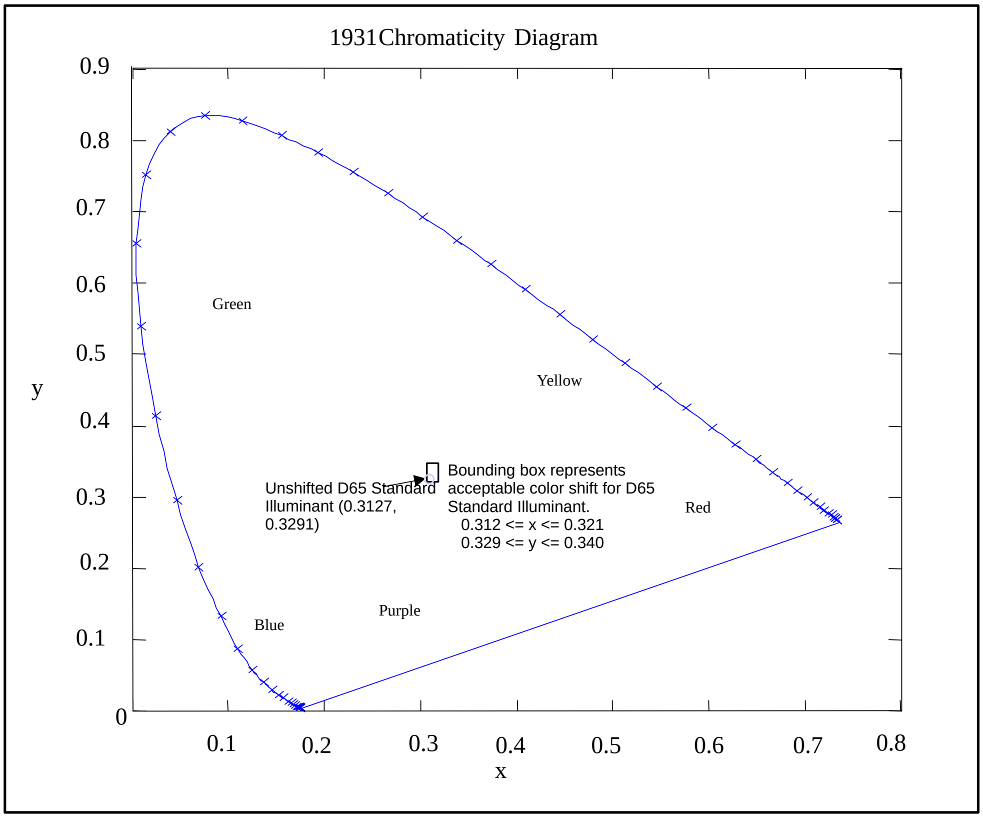


FIGURE 11.11.3.1.4−3 CHROMATICITY DIAGRAM

D. Transmittance Requirements in the Visible Spectrum for Category B and C Window Ports − The transmittance shall be greater than or equal to 75.0 percent for wavelengths between 425 and 700 nanometers for all Category B and C window ports.

Note: The coating designer should consider the field−of−view requirements of instruments designed for viewing or acquiring images through Category B and C windows, together with the maximum tilt of the instrument with respect to the window, to design a coating which will accommodate the expected range of incident angles of light through the window, or exhibit the appropriate off−angle transmittance characteristics.

E. Transmittance Requirements in the Visible Spectrum for Category A Window Ports − The transmittance shall be greater than or equal to 70.0 percent for wavelengths between 450 and 700 nanometers for all Category A window ports.

11.11.3.1.5 GLASS QUALITY FOR CATEGORY A AND B WINDOW PANES

A. Annealed Glass Window Pane Material −

(1) Surface Finish − The surface of each window pane shall be polished to meet or exceed the requirements of a scratch dig code of 80−50 or better as defined in MIL−O−13830.

(2) Open Inclusions −

a. The maximum number of open inclusions per surface shall not exceed three and shall not exceed 0.050 inches (1.27 mm) in diameter. Open inclusions separated by less than two inches are not permitted.

b. Open inclusions equal or less than 0.00315 inches (0.08 mm) in diameter shall be disregarded.

(3) Inclusions − Inclusions shall be per MIL−G−174, Class 1, Inclusion number 2, with the following exceptions:

a. The maximum size inclusion diameter shall be limited to 0.50 mm.

b. The permissible number of maximum diameter inclusions shall be one per 100 cubic centimeters of glass.

c. Inclusions with a cross−section equal to or less than 0.08 mm diameter shall be disregarded when evaluating the maximum total cross−section area (mm squared per 100 cubic centimeters).

(4) Striae − Striae shall be per MIL−G−174 Grade A or better.

(5) Birefringence − Birefringence shall be 12.0 nanometers per centimeter maximum or equivalent.

B. Tempered Float Glass Window Pane Material −

(1) Tempered float glass shall be aircraft quality or better per MIL−G−25667, or better.

(2) Laminated tempered float glass shall be per MIL−G−25871, or better.

11.11.3.1.6 DELETED

11.11.3.1.7 VISUAL PROTECTION DESIGN REQUIREMENTS

A. Sun Shades/Shields −

(1) Observation windows shall be provided with crew−operated, opaque sun shields that are capable of restricting all sunlight from entering the habitable compartments.

(2) External Sun Shade Repositioning − If external sun shades are designed to cast a shadow over a window, they shall be provided with a means to be positioned by the window user.

B. Heat Rejection − The sun shade, whether internal or external, shall be capable of rejecting radiant energy away from the window assembly.

C. Deleted.

11.11.3.1.8 PHYSICAL PROTECTION DESIGN REQUIREMENTS

A. Contamination Protection – Window design shall take into account all sources of external contamination. Window design shall provide a means for cleaning and replacing.

B. Between Pane Contamination Protection –

(1) Window design shall take into account all sources of contamination that can occur between the panes.

(2) Window design shall provide a means for reduction of optical degradation due to these contaminants.

C. Internal Surface Contamination Protection – Window design shall take into account all sources of internal contamination and provide a means for cleaning.

(1) Anti−fogging – All innermost panes, except hatch, shall be designed for anti−fog protection such that breath condensation does not occur from a mouth−to−pane distance of 4.0 inches (10.0 cm).

(2) Inner Pane Coatings – The innermost surface of the innermost pane shall have no coatings except for anti−reflective coatings.

D. Crew Induced Environment −

(1) IVA – The Window Assembly hardware exposed to the IVA environment shall be capable of withstanding a crew induced limit load of 125 lbs force distributed evenly over 16 square inches in diameter at any point on the exposed surface and normally incident to that surface.

(2) EVA − The Window Assembly hardware exposed to the EVA environment shall be capable of withstanding a crew induced limit load of 125 lbs force distributed evenly over a circle 1.0 inch in diameter at any point on the exposed surface and normally incident to that surface.

E. Protective Covers – Removable or retractable covers shall be provided where the window assembly does not meet crew and equipment impact load criteria or the launch and reentry pressure profiles.

F. Retractable External Protective Covers – If external protective covers are opaque, then IVA controls shall be provided with backup EVA capability to override the IVA system.

11.11.3.1.9 WINDOW MAINTENANCE DESIGN REQUIREMENTS

A. Window Servicing − Equipment and supplies shall be provided for contingency window cleaning.

B. Protective Covers − Where surface scratching, pitting, or staining cannot be prevented by other means, removable window protective surfaces shall be provided.

C. Window Replacement −

(1) Window assemblies shall be designed to eliminate the need for depressurization of the Space Station in order to replace window panes or the entire window assembly.

(2) Partial depressurization during change−out shall be allowed for pre−launch verification purposes.

(3) Depressurization of the cupola shall be allowed for the installation of an external pressure cover.

11.11.3.1.10 DELETED

11.11.3.2 OPTICAL CHARACTERISTICS FOR CATEGORY C WINDOWS

A. Wavefront −

(1) The peak−to−valley transmitted wavefront error through the combination of all window panes for the window port shall not exceed 1/7 wave over any 152.4 mm (6.0 inch) diameter sub−aperture within the central 80 percent (minimum) of the physical diameter (excluding flight loads, pressure loads, and temperature gradients), where the reference wavelength is 632.8 nm.

Note (a): Removal of protective window pane(s) is permissible.

Note (b): For viewing angles of 30 degrees nominal incidence, it is a goal that the wavefront variation not exceed 1/4 wave peak−to−valley over any 6 inch diameter sub−aperture within the central 60 percent (minimum) of the physical diameter.

(2) Wavefront requirements shall be met after all optical coatings have been applied, and if applicable, all tempering and laminating steps.

(3) The wavefront requirement may be met by rotating the window panes.

(4) Wavefront requirements shall apply when viewing through the window port at normal incidence.

B. Glass Quality − The glass shall meet or exceed Inclusion Number 2 as defined in MIL−G−174 with the following exceptions:

(1) The maximum size inclusion diameter shall be limited to 0.50 mm.

(2) The permissible number of maximum diameter inclusions shall be one per 100 cubic centimeters glass.

(3) Inclusions with a cross−section equal to or less than 0.08 mm diameter shall be disregarded when evaluating the maximum total cross−section area (mm squared per 100 cubic centimeters).

C. Surface Finish − The surface of each window pane shall be polished to meet or exceed the requirements of a scratch−dig code of 80 to 50 as defined in MIL−O−13830.

D. Wedge − The wedge of any individual window pane shall be limited to 2.5 arc−seconds in any direction.

E. Open Inclusions − The maximum number of open inclusions per surface shall not exceed three and shall not exceed 0.020 inch (0.51 millimeters) in diameter. Open inclusions separated by less than 2.0 inches are not permitted. Open inclusions equal to or less than 0.00315 inch (0.08 millimeters) in diameter will be disregarded.

F. Striae − Striae shall be per MIL−G−174 Grade A, or better.

G. Haze − The haze, after all coatings have been applied, shall be less than 0.5 percent per ASTM D1003, Procedure A.

H. Birefringence − Birefringence shall be 12 nanometers per centimeter maximum, or equivalent.

11.12 PACKAGING

11.12.1 INTRODUCTION

This paragraph is not applicable for this document.

11.12.2 PACKAGING DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

11.12.3 PACKAGING DESIGN REQUIREMENTS

All IVA and EVA packaging will meet the following design requirements:

A. Deleted.

B. Compatible With Environments − All packaging shall withstand the physical environments to which it will be exposed during handling, during ground and air transportation, during launch, on−orbit, and (if returnable) reentry per MIL−STD−210, SSP 41047, NASA−TM−86538, and MIL−STD−2073.

C. Compatible With Contents − All packaging shall resist the physical characteristics of the contents for the 10 year Station, or mission life/use, expectancy for which the contents must be packaged.

D. Compatible With Trash Disposal System − All nonreusable packaging shall be compatible with the trash collection and disposal system.

E. Packaging Restraint − A means shall be provided for physically attaching or restraining the package at all designated use locations.

F. Labeling − All packages shall be labeled according to 9.5.3.1.

G. Inventory Control Compatibility − All packages shall be designed to incorporate the coding features required by the Inventory Management System labeling requirements per SSP 50007.

  (1) Deleted.

H. Deleted.

I. Deleted.

J. Hazards −

  (1) Packaging features shall be designed to preclude injury to the crewmember.

  (2) Packaging materials shall not introduce contaminants into the atmosphere.

K. Loose Packaging Materials − Loose, void−filling materials shall not be used within a package.

L. Deleted.

11.13 CREW PERSONAL EQUIPMENT

11.13.1 CLOTHING

11.13.1.1 INTRODUCTION

This paragraph is not applicable for this document.

11.13.1.2 CLOTHING DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

11.13.1.3 CLOTHING DESIGN REQUIREMENTS

11.13.1.3.1 GENERAL CLOTHING DESIGN REQUIREMENTS

All IVA clothing will be designed to meet the following general requirements:

(NOTE: In this paragraph, the word ”garments” is used to include outerwear, underwear, footwear, gloves, and headwear.)

A. Suitable for the Environment −

(1) Garments shall be provided to protect the user from the full range of anticipated working and off duty environments in the Space Station.

(2) Deleted.

B. Deleted.

C. Deleted.

D. Deleted.

E. Sizing − Sizing of crew clothing shall accommodate micro−gravity anthropometric changes as specified in section 3.0.

F. Exclusive Use − All crewmembers shall be provided with garments for their exclusive use.

G. Unassisted Donning/Doffing − All garments shall be capable of being donned/doffed by a crewmember unassisted.

H. Deleted.

I. Deleted.

J. Deleted.

K. Outerwear Hazards − All outwear garments shall be free of loops, straps which can snag on equipment.

L. Deleted.

11.13.1.3.2 CLOTHING PACKAGING AND STORAGE DESIGN REQUIREMENTS

All IVA garments (outwear, innerwear, footwear, gloves, and headwear) will be designed to provide the following packaging and stowage requirements:

A. Identification/Removal From Stowage − The type and size of packaged or stowed garments shall be discernible without removing them from stowage.

B. Preserve Garment Appearance − Stowage and packaging of clean garments shall be designed to preserve the garment appearance.

C. Soiled Garment Storage − Stowage for soiled garments shall be provided.

D. Restowage On−orbit − Garment stowage shall be designed to provide restorage of garments on−orbit.

E. Overnight Stowage − A stowage area for stowing garments overnight without having to fold or package them shall be provided.

11.13.2 PERSONAL ANCILLARY EQUIPMENT

11.13.2.1 INTRODUCTION

This paragraph is not applicable for this document.

11.13.2.2 PERSONAL ANCILLARY EQUIPMENT DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

11.13.2.3 PERSONAL ANCILLARY EQUIPMENT DESIGN REQUIREMENTS

A. Eyeglasses and sunglasses shall be made of nonshatterable material.

B. All eyeglasses and sunglasses shall be equipped with straps or devices to assure retention on the user.

11.14 CABLE MANAGEMENT

11.14.1 INTRODUCTION

This paragraph is not applicable for this document.

11.14.2 CABLE MANAGEMENT DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

11.14.3 CABLE MANAGEMENT DESIGN REQUIREMENTS

The following cable management design requirements will apply:

A. Routing − Cables shall be routed so that they:

   (1) Deleted.

   (2) Deleted.

   (3) Deleted.

   (4) Can be accessed by crew for inspection, maintenance, and servicing.

   (5) Deleted.

B. Cable Clamps − Conductors, bundles or cables, shall be secured by means of clamps unless they are contained in wiring ducts or cable retractors.

C. Identification −

   (1) Cables shall be labeled to indicate the equipment to which they belong and the connectors with which they mate.

   (2) All replaceable wires and cables shall be uniquely identified with distinct number or color codes in accordance with 9.5.3.

D. Deleted.

E. Coding − Cables containing individually insulated conductors with a common sheath shall be coded.

F. Protection − Guards or other protection shall be provided for conductors.

G. Retention − The ends of cables which will be disconnected shall have retention provisions for routine maintenance.

12.0 DESIGN FOR MAINTAINABILITY

12.1 INTRODUCTION

This maintainability chapter is not intended to be a comprehensive guide to Space Station maintainability. It deals only with crew interface maintainability requirements, which are a specialized subset of the total maintainability discipline.

12.2 DESIGN FOR MAINTAINABILITY DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

12.3 DESIGN FOR MAINTAINABILITY DESIGN REQUIREMENTS

12.3.1 EQUIPMENT DESIGN REQUIREMENTS

12.3.1.1 GENERAL MAINTAINABILITY DESIGN REQUIREMENTS

General requirements to be followed when designing for maintainability are presented below:

A. Deleted.

B. Deleted.

C. Maintenance Support Services − Maintenance support services shall be accessible at maintenance locations.

D. Deleted.

E. Deleted.

F. Deleted.

G. Equipment and tools identified for maintenance shall comply with standard tool and equipment lists.

H. Hazardous Conditions − System design shall control hazardous conditions, identified by hazard analysis, during maintenance procedures.

I. Critical Operations − Critical systems shall be capable of undergoing maintenance without the interruption of critical services and be “fail safe” while being maintained.

J. Deleted.

K. Deleted.

L. Connectors − Components of liquid and gas systems with a predicted maintenance rate greater than one removal in five years shall be installed with quick disconnect devices.

M. Deleted.

N. Quick−Release Fasteners − Quick−release fasteners shall be used where consistent with other requirements (e.g., strength, sealing).

O. Deleted.

P. Deleted.

Q. Restraints − Personnel and equipment mobility aids and restraints shall be provided to support on−orbit maintenance.

R. Deleted.

S. Deleted.

T. Deleted.

12.3.1.2 PHYSICAL ACCESSIBILITY DESIGN REQUIREMENTS

Design requirements for physical access to equipment for the purpose of maintainability are provided below.

A. Deleted.

B. Access Dimensions − The minimum sizes for access openings for two hands, one hand, and fingers are shown in Figure 12.3.1.2−1.

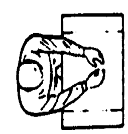
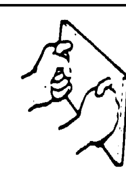
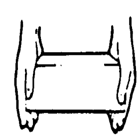
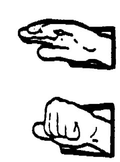
Minimal two−hand access openings without visual access			
Reaching with both hands to depth of 150.0 mm (6.0 in.) to 490 mm (19.25 in.)			
Light clothing	Width:	200 mm (8.0 in.) or the depth of reach	
	Height:	125.0 mm (5.0 in.)	
Reaching full arm's length (to shoulders) with both arms (light clothing)			
	Width:	500 mm (19.5 in.)	
	Height:	125 mm (5.0 in.)	
Inserting box grasped by handles in the front:			
13 mm (0.5 in.) clearance around box, assuming adequate clearance around handles			
Inserting box with hands on the sides:			
Light clothing:	Width:	Box plus 115.0 mm (4.5 in.)	
	Height: (2)	125.0 mm (5.0 in.) or 13.0 mm (0.5 in.) around box (1)	
Minimal one−hand access openings without visual access			
	Height x Width		
Empty hand, to wrist:			
Bare hand, rolled	95.0 mm (3.75 in.) sq. or dia.		
Bare hand, flat	55.0 mm (2.25 in.) x 100.0 mm (4.0 in.) or 200 mm (4.0 in.) dia.		

FIGURE 12.3.1.2−1 MINIMUM SIZES FOR ACCESS OPENINGS FOR TWO HANDS, ONE HAND, AND FINGERS (PAGE 1 OF 2)

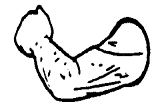
Minimal one−hand access openings without visual access			
Clenched hand, to wrist:			
Bare hand:	95.0 mm (3.75 in.) x 125.0 mm (5.0 in.) or 125.0 mm (5.0 in.) dia.		
Arm to elbow:			
Light clothing:	100.0 mm (4.0) x 115.0 mm (4.5 in.)		
Arm to shoulder:			
Light clothing:	125.0 mm (5.0 in.) sq. or dia.		
Minimal finger−access to first joint			
Push button access:	Bare hand:	32.0 mm dia. (1.26 in.)	
	Thermal gloved hand:	38.0 mm dia. (1.5 in.)	
Two finger twist access:	Bare hand:	object plus 50.0 mm (1.97 in.)	
	Thermal gloved hand:	object plus 65.0 mm (2.56 in.)	
Notes: (1) Whichever is larger. (2) If hands curl around bottom, allow an extra 30.0 mm (1.5 in.) for light clothing.			

FIGURE 12.3.1.2−1 MINIMUM SIZES FOR ACCESS OPENINGS FOR TWO HANDS, ONE HAND, AND FINGERS (PAGE 2 OF 2)

C. Access − Access to inspect or replace an item (e.g., an ORU) shall not require removal of more than one access cover.

D. Deleted.

E. Deleted..

F. Shape − Accesses shall be designed to the shape that will enable the crewmember to do his/her job and not be limited only to conventional shapes.

G. Deleted.

H. Protective Edges − Protective edges or fillets shall be provided on accesses that might injure crewmembers or their equipment.

I. Covers − Where physical access is required, one of the following practices shall be followed, with the order of preference as given.

(1) Provide a sliding or hinged cap or door where debris, moisture, or other foreign materials might otherwise create a problem.

(2) Provide a quick−opening cover plate if a cap will not meet stress requirements.

J. Self−Supporting Covers − All access covers that are not completely removable shall be self−supporting in the open position.

K. Rear Access − Sliding, rotating, or hinged equipment to which rear access is required shall be free to open or rotate its full distance.

L. Damage Inspection and Repair − The design of Space Station structures and equipment, including their interfaces, shall be such that all portions of the pressure shell, bulkhead, and seals will be accessible for maintenance.

M. Use of Tools and Test Equipment −

(1) Check points, adjustment points, test points, cables, connectors, and labels shall be accessible and visible during maintenance.

(2) Space shall be provided for the use of test equipment and other required tools.

N. Deleted.

O. Slide−Out Stops − Limit stops shall be provided on racks and drawers which are required to be pulled out of their installed positions for maintenance.

P. Service Points for Fluid Systems − Service points for filling, draining, and purging or bleeding shall be in accessible locations.

Q. Plug Connectors − Access shall be provided to plug connectors.

R. Cables −

(1) Cable Access − Cables shall be routed so as to be accessible for inspection and repair.

(2) Cable Trays − Wire harness and fluid lines mounted in cable trays shall be accessible for inspection.

(3) Cable Loops − Panel, console, and rack−mounted components shall have slack cable lengths or maintenance loops sufficient for removal of the connectors after the component has been extracted from its installed location, unless internal access is provided.

(4) Cable Routing − Cables shall not be routed external to the face of the equipment rack.

S. Fuses and Circuit Breakers −

(1) Fuses and circuit breakers shall be accessible for removal, replacement, and resetting.

(2) The condition of fuses shall be discernible.

(3) The condition of circuit breakers shall be discernible.

T. Deleted.

U. Stowage − Placement of stowed equipment shall not preclude access to components.

V. Hazardous Conditions −

(1) If a hazardous condition, defined by hazard analysis, exists behind an access, a safety indicator shall be provided.

(2) The access shall be equipped with an interlock that will de−energize the hazardous condition when the barrier is opened or removed, and a manual override capability be provided.

W. Structural Loads and Deformations − Compartment doors, access panels, and structural attachments for equipment that is to be removed and reinstalled shall be designed to be operated in both ground and orbit environments, being insensitive to structural deformation caused by change in g−loading, pressure differential, etc.

12.3.1.3 VISUAL ACCESS DESIGN REQUIREMENTS

Requirements for visual access are provided below:

A. Visual Access − Where visual access only is required for inspection or viewing, the following practices shall be followed, with the order of preference as given:

(1) Provide a transparent window.

(2) Provide a quick−opening metal cover if a transparent cover will not meet requirements.

B. Visual and Physical Access − If the crewmember must view a task, access must be provided as follows:

(1) One access shall be provided to accommodate both visual and physical access, based on anthropometric requirements;

(2) Alternately, separate visual and physical access openings shall be provided, based on anthropometric requirements.

C. Labeling −

(1) Deleted.

(2) Visibility − Labels and mounting instructions relating to the maintenance task in progress shall be visible during all maintenance activities.

(3) Identification Labels − Each access shall be labeled with a number, letter, or other symbol which is directly cross−referenced to the maintenance procedures.

(4) Plug Configuration Labels − When a plug−in device has to be inserted through a hole with no visual access, a label adjacent to the access shall indicate how the pins on the device will align with the holes in the socket.

(5) Component Identification Labels − Electrical cables, fluid lines, and other subsystem protective shields shall be labeled to allow for positive identification.

(6) Hazard Labels − Access shall be labeled with warning labels, advising of hazards, as identified by hazard analysis, existing beyond the access and stating necessary precautions.

(7) Hinged Cover Labels − Instructions labeled on a hinged door, which apply to operations on equipment behind the door, shall be oriented to be read when the door is open.

D. Fluid and Gas Line Connectors − Fluid and gas connectors shall be located and configured so that they can be inspected.

12.3.1.4 REMOVAL, REPLACEMENT, AND MODULARITY DESIGN REQUIREMENTS

Design requirements for removal, replacement, and modularity are provided below.

A. Removal − Systems and subsystems shall be designed so that failed components can be removed without damaging other components.

B. Surface Removal − Replaceable units shall be designed for removal through the surface facing the crewmember as (s)he works on the equipment.

C. Independence − It shall not be necessary to remove or disable an operable unit to obtain access to a defective replaceable unit.

D. Deleted.

E. Isolation Valves − Subsystems which contain liquids or high pressure gases (pressures exceeding 125.0 psia) and require maintenance shall be provided with isolation or disconnect valves to permit isolation and servicing and to aid in leak detection.

F. Spillage Control − ORUs shall be designed to control spillage and the release of gases during removal or replacement.

G. Energized Units − ORUs and payloads which supply or receive energy shall be designed so that the power can be removed before repair, removal, or replacement is attempted.

H. Fastener Coatings − Paint and/or coatings shall not affect removal or installation of fasteners.

I. Deleted.

J. Guide Pins − For mounting and replacement of replaceable units, guides and guide pins shall be provided for alignment.

K. Replacement Specificity − All replaceable items shall be designed so that it will be physically impossible to insert the unit incorrectly.

L. Items which have different functional properties shall be identifiable and distinguishable and not be physically interchangeable.

12.3.2 TESTABILITY DESIGN REQUIREMENTS

12.3.2.1 FAULT DETECTION AND ISOLATION DESIGN REQUIREMENTS

Design requirements for fault detection and isolation are provided below.

A. General − Equipment design shall provide for fault detection and isolation of defective items to at least the on−orbit maintainable level

B. Deleted.

C. Deleted.

D. Deleted.

E. Sensors − The status of sensors on ORUs shall be verifiable with respect to accuracy and proper operation.

F. Manual Override − Manual override capability for all failure detection, isolation and recovery automatic control functions shall be provided.

G. Portable Equipment − When test equipment is required and built−in test equipment is not available, diagnostic tools and portable equipment shall be provided for fault isolation to the replacement item level.

H. Critical Malfunction Alarm − If critical equipment is not regularly monitored, an alarm (auditory, visual, or both) shall be designed to ensure detection.

I. Power Failure Indication − An indication shall be provided to reveal power failures.

J. Deleted.

K. Out of Tolerance − An indication shall be provided when equipment has failed.

L. Deleted.

M. Test Equipment Verification − All on−orbit electronic test equipment shall have built−in test capability.

N. Test Equipment Accuracy − The accuracy of all test equipment shall exceed that of the equipment being tested.

O. Adjustment Controls − Feedback shall be provided for all adjustment controls and shall be discernible to the operator while making the adjustment.

P. Calibration Damage − Calibration or adjustment controls shall be provided with stops to prevent damage to the system.

12.3.2.2 TEST POINT DESIGN REQUIREMENTS

Design requirements for test points are provided below.

A. Self−Checking − When testing is required and built−in test equipment is not available, test points shall be provided.

B. Deleted.

C. Adjustment − Test points used in adjusting a unit shall be in physical and visual proximity of the displays and controls used in the instrument.

D. Labeling − Each test point shall be clearly labeled with a description of its function or, at a minimum, with a code number keyed to the maintenance manual.

E. Warning Labels −Test points shall be marked with appropriate warning labels when the application of conventional test probes could cause damage to internal circuits (e.g., integrated circuits) or injury to personnel.

F. Deleted.

G. Test Cable Termination − If it is essential that test cables terminate on display and control panels, the panel test receptacles shall be located so that the test cables will not interfere with displays and controls.

H. Layout − Primary test points shall be grouped in a line or matrix that reflects the sequence of tests to be performed.

I. Grouping − A control panel or a series of functionally autonomous panels shall be used to group test points.

J. Deleted.

12.3.3 MAINTENANCE INFORMATION MANAGEMENT SYSTEMS DESIGN REQUIREMENTS

Design requirements for maintenance information management systems are provided below.

A. System Capabilities − As a minimum, the information management system for onboard maintenance shall provide:

(1) Command and status indications to/from all subsystems for the purpose of system maintenance and troubleshooting procedures.

(2) Trend data acquisition and analysis.

(3) Status of consumables.

(4) Fault detection/isolation.

(5) Scheduled maintenance data.

(6) Repair/replacement information.

(7) Replacement unit maintenance history and maintenance checklists.

B. Recording and Retrieval − The system shall provide means for the recording and retrieving of maintenance information.

C. Fail−Operational Systems − All systems that incorporate an automated fail−operational capability shall be designed to provide crew notification and data management system cognizance of malfunctions until the failures have been corrected.

D. Replacement Unit Characteristics − A characteristic matrix of all replacement units shall include the following:

(1) Replacement unit ID number.

(2) Built−In−Test−Equipment (replacement units containing Built−In−Test−Equipment).

(3) Hazardous system factors.

(4) Critical system status.

(5) Availability.

(6) Shelf−life limits.

(7) Storage constraints.

E. Sparing Status − Replacement unit sparing status shall be provided to ensure that procedures and onboard repair materials are provided for each mission.

F. Spares Inventory − The automated information management system shall contain an on−orbit spares inventory to identify the numbers and locations of replacement units stowed in ISS.

13.0 FACILITY MANAGEMENT

13.1 INTRODUCTION

This paragraph is not applicable for this document.

13.2 HOUSEKEEPING

13.2.1 INTRODUCTION

This paragraph is not applicable for this document.

13.2.2 HOUSEKEEPING DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

13.2.3 HOUSEKEEPING DESIGN REQUIREMENTS

13.2.3.1 GENERAL HOUSEKEEPING DESIGN REQUIREMENTS

All systems shall be designed to accommodate housekeeping requirements.

The following requirements shall be observed:

A. Contamination Control During Ground Handling − Precautions shall be taken to prevent debris and surface contamination within Space Station and individual systems and components during ground operations from manufacture to launch.

B. Surface Materials − Materials used for exposed interior surfaces shall be selected to preclude particulate and microbial contamination and be smooth, solid, and nonporous.

C. Grids and Uneven Surfaces − Grids and uneven surfaces shall be removable and cleanable.

D. Deleted.

E. Closures − Closures shall be provided for any area not designed for routine cleaning.

F. Fluid and Debris Collection/Containment − Means shall be provided for collecting and/or containing any loose fluids or debris.

G. Built−ln Control − Subsystems which utilize containers of liquids or particulate matter shall have built−in equipment/methods for control of vaporization, material overflow, or spills.

   (1) The capture elements including grids, screens, or filter surfaces shall be accessible for replacement or cleaning without dispersion of the trapped materials.

   (2) Grid, screen, or filter surfaces shall be directly accessible for cleaning.

H. Transfer Containers − Transfer containers shall not leak.

13.2.3.2 SURFACE CLEANING DESIGN REQUIREMENTS

The following surface cleaning provisions are required:

A. Bacteria Sampling/Biocide Selection − A means shall be provided for taking microbial samples from all types of surfaces and for identifying biocides.

B. Cleaning Chemicals − Cleaning chemicals will meet the following requirements:

  (1) Cleaning chemicals shall be low sudsing per industry standards.

  (2) Cleaning chemicals shall be compatible with life support systems.

  (3) Deleted.

  (4) Cleaning chemicals shall not stain or discolor the surface being cleaned.

  (5) Cleaning chemicals shall be in a controllable content container.

  (6) Deleted.

C. Illumination − 108.0 Lux (10.0 fc) minimum lighting shall be provided.

D. Wipes − The following types of wipes for use in general housekeeping shall be provided.

  (1) Dry Wipes − Utility wipes used for compartment and equipment cleaning and spill clean−up.

  (2) Detergent Wipes − Detergent saturated tissues used for interior surface and window cleaning.

  (3) Disinfecting Wipes − Saturated wipes used for disinfecting food spills and waste management systems.

  (4) Reusable Wipes − Utility handwipes that can be impregnated or dampened with premixed evaporative detergent/biocidal solutions or with water.

  (5) Utensil Wipes − Wipes used for cleaning and sanitizing eating utensils.

E. Cleaning Implements − Provide means for dislodging and collecting dirt and debris from surfaces, cracks, and crevices.

F. One−Handed Operation − Cleaning equipment and supplies shall be designed for one−handed operation or use.

G. Housekeeping Cleansing Agents −

  (1) A nonbiocidal cleansing agent or agents shall be provided for general purpose surface cleansing in which specific biological control is not required.

  (2) A disinfecting cleansing agent or agents shall be provided for cleanup of biological spills and biologically contaminated surfaces.

13.2.3.3 VACUUM CLEANING DESIGN REQUIREMENTS

An onboard vacuum cleaner shall be provided.

It shall meet the following requirements:

A. Suction − The system shall provide suction capability for the collection and retention of both wet and dry particulate matter and of liquids.

B. Deleted.

C. Attachments − The system shall provide attachments which conform to the various surfaces that need to be cleaned.

D. Disposable Bags − The system shall provide disposable bags:

(1) Suitable for containing both dry and liquid wastes.

(2) Compatible for compaction in a trash compactor.

(3) Deleted.

E. Deleted.

F. Nonpropulsive − Propulsive characteristics and self−generated torques of the system shall be compensated for in the design.

13.2.3.4 AIR FILTER DESIGN REQUIREMENTS

Equipment filters will be designed to provide the following housekeeping features:

A. Access − Air filters shall be accessible for cleaning and replacement.

B. Configuration − Nondisposable air filters shall be configured to allow them to be cleaned by a vacuum cleaner attachment.

C. A visual indication that the air filter needs to be changed shall be provided.

13.3 INVENTORY CONTROL

13.3.1 INTRODUCTION

This paragraph is not applicable for this document.

13.3.2 INVENTORY CONTROL DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

13.3.3 DELETED

13.4 INFORMATION MANAGEMENT

13.4.1 INTRODUCTION

This paragraph is not applicable for this document.

13.4.2 INFORMATION MANAGEMENT DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

13.4.3 INFORMATION MANAGEMENT DESIGN REQUIREMENTS

13.4.3.1 GENERAL INFORMATION MANAGEMENT DESIGN REQUIREMENTS

The following general requirements apply to both hardcopy and electronic information management systems:

A. Minimum Onboard Information − At a minimum, the following information shall be accessible onboard: system maintenance and trouble−shooting procedures, trend data acquisition and analysis, consumable status, payload data collection, experiment procedures, repair and replacement information, medical history, and inventory control data.

B. Information Management Facilities − Information management facilities shall be provided in Space Station for stowing, receiving, displaying, processing, and updating mission data.

C. Information Display Orientation − The information display provisions shall allow orientation of the data for use while performing the mission tasks that use the information.

D. Hands−Free Use of Information − The information display provisions shall leave the crewmember's hands free once the data has been positioned.

E. Data File Organization − Means shall be provided to stow mission data in segmented data files.

F. Flight Data Hardcopy − Hardcopy file data shall be maintained onboard for all procedures for emergency operations of the Space Station, continued crew safety, rescue, or escape.

13.4.3.2 HARDCOPY INFORMATION MANAGEMENT DESIGN REQUIREMENTS

The following requirements pertain to hardcopy information media and associated hardcopy equipment and supplies:

A. Restraints −

(1) Equipment restraints − Means shall be provided for restraining documents, loose sheets of paper, writing implements, and supplies required for documentation update (tape, scissors, etc.) at each information management workstation.

(2) Personnel restraints − Means shall be provided to restrain the crewmembers at the various workstations in a manner which leaves both hands free for documentation update and recording.

(3) Document restraints − Means shall be provided to hold documents open to specific pages.

B. Writing/Working Surfaces − Fixed and portable writing/working surfaces shall be provided.

C. Writing Instruments, scissors, tape − Writing instruments, scissors, and tape shall be provided.

D. Stowage of Writing Instruments, Supplies, and Documents − Consolidated stowage shall be provided for writing instruments, supplies, and documents.

E. Deleted.

F. Onboard Printer/Copier − Capability for onboard preparation and duplication of hardcopy documentation shall be provided.

13.4.3.3 ELECTRONIC INFORMATION MANAGEMENT DESIGN REQUIREMENTS

14.0 EXTRAVEHICULAR

14.1 GENERAL EVA INFORMATION

14.1.1 GENERAL EVA INFORMATION INTRODUCTION

This paragraph is not applicable for this document.

14.1.2 GENERAL EVA DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

14.1.3 GENERAL EVA SAFETY DESIGN REQUIREMENTS

The following safety requirements will be followed, in addition to the requirements in section 6.0, to ensure the safety of the EVA crewmembers. In the event of conflict with section 6.0, concerning EVA safety issues, section 14.0 shall take precedence.

A. Deleted.

B. Radiation −Radiation exposure during EVA shall be monitored to facilitate operational maintenance of the crew exposure limits in 5.7.

C. Deleted.

D. Deleted.

E. Deleted.

F. Deleted.

G. Deleted.

H. Power Sources − Design of any nuclear reactor power source or radioisotopic generator power source located in the Space Station shall protect crewmembers from radiation exposure.

I. Transmitters − High power electromagnetic wave transmitters requiring EVA approaches shall protect crewmember from harmful exposure to nonionizing radiation.

J. Tethers − Crew safety tether points shall be provided along all routes and at worksites.

K. Deleted.

L. Deleted.

M. Deleted.

N. External ISS components in the EVA translation path and made of glass or other brittle materials shall be designed to withstand an unintentional impact by EVA tools without resulting in any new hazards, such as sharp edges or contamination hazards.

   (1) The maximum tool impact load shall be determined by analysis or test, using the APFR mass of 60.0 lbs and a translation velocity of 1.0 foot per second.

   (2) For test purposes, the contact shall be made with an impactor having a 0.04 inch radius point made of aluminum.

14.2 EVA PHYSIOLOGY

14.2.1 EVA PHYSIOLOGY INTRODUCTION

This paragraph is not applicable for this document.

14.2.2 EVA PHYSIOLOGY DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

14.2.3 EVA PHYSIOLOGICAL DESIGN REQUIREMENTS

14.2.3.1 EVA STRENGTH RELATED DESIGN REQUIREMENTS

Space Station hardware requiring EVA crewmember manual actuation shall be limited to the following:

A. Fine motor skills (gloved hands and/or finger activity) shall be less than 5.0 lbf or 40.0 in−oz torque.

B. Gross motor skills (tool operations) shall be less than 20.0 lbf or 25.0 ft−lb torque.

14.2.3.2 DELETED

14.2.3.3 EVA FOOD AND DRINKING WATER DESIGN REQUIREMENTS

Food and drinking water requirements are variable based on the frequency and length of scheduled EVAs as follows:

A. General Water Requirements − Space Station Life Support shall supply and the Extravehicular Mobility Unit (EMU) shall store during EVA 240 cc (8.0 oz) of water for each scheduled hour of EVA beyond 3.0 hours.

B. Food Requirements − The Space Station galley shall store and the EVA system supply EMU food sticks of 200 kcal (795 BTU) for EVAs of less than 4.0 hours and 500 kcal (1987 BTU) for EVAs greater than 4.0 hours duration and at least 48.0 hours apart.

   (1) Deleted.

   (2) Deleted.

C. Deleted.

14.2.3.4 DELETED

14.2.3.5 DELETED

14.2.3.6 DELETED

14.2.3.7 EVA RADIATION DOSAGE DESIGN REQUIREMENTS

Radiation monitoring requirements are discussed in 5.7.

14.2.3.8 DELETED

14.3 EVA ANTHROPOMETRY

14.3.1 INTRODUCTION

This paragraph is not applicable for this document.

14.3.2 EVA ANTHROPOMETRIC DESIGN CONSIDERATIONS

14.3.2.1 SPACE SUIT DESIGN CONSIDERATIONS AND DIMENSIONS

This paragraph is not applicable for this document.

14.3.2.2 SPACE SUIT JOINT MOTION DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

14.3.2.3 EVA MOVEMENT RANGES

14.3.2.3.1 FUNCTIONAL DATA DESIGN REQUIREMENTS

A. Space Station equipment and controls required to perform EVA tasks shall be located within the reach limits of the EVA crewmembers as shown in Figure 14.3.2.3.1−1.

B. Space Station equipment, controls, displays, and markings required to be seen to perform EVA tasks shall be located within the field−of−view of the EMU as shown in Figure 14.3.2.3.1−2.

C. Space Station equipment and structures requiring EVA interfaces shall maintain minimum clearance envelopes of 20.0 cm (8.0 in.) high by 27.0 cm (10.5 in.) wide with maximum depth of 46.0 cm (18.0 in.) for gloved hand access as shown in Figure 14.3.2.3.1−3.

D. A minimum work volume of 48.0 inches in diameter shall be maintained to preclude entrapment of the suited crewman in the surrounding structure.

14.3.3 EVA ANTHROPOMETRY DESIGN REQUIREMENTS

The anthropometric data for EVA crewmembers are provided in this section. These include joint motion, movement ranges, neutral body posture, and working envelopes as well as pressure suit dimensions. These data will be used as appropriate to achieve effective integration of the EVA crew and the Space Station systems.

14.3.3.1 DELETED

14.4 EVA WORKSITES AND RESTRAINTS

14.4.1 EVA WORKSITES AND RESTRAINTS INTRODUCTION

This paragraph is not applicable for this document.

14.4.2 EVA WORKSITES AND RESTRAINT DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

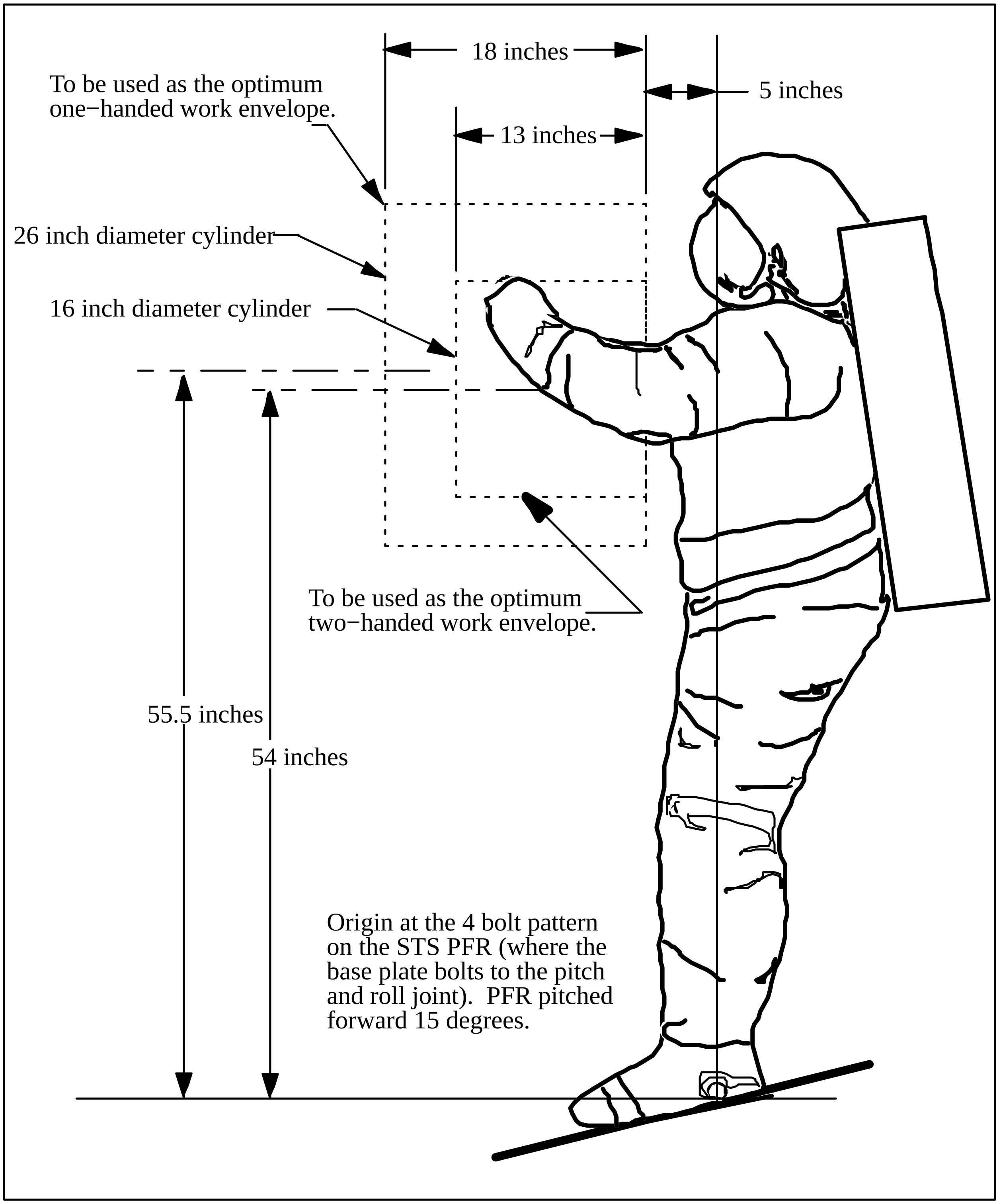


FIGURE 14.3.2.3.1−1 CREWMEMBER OPTIMUM WORK ENVELOPE

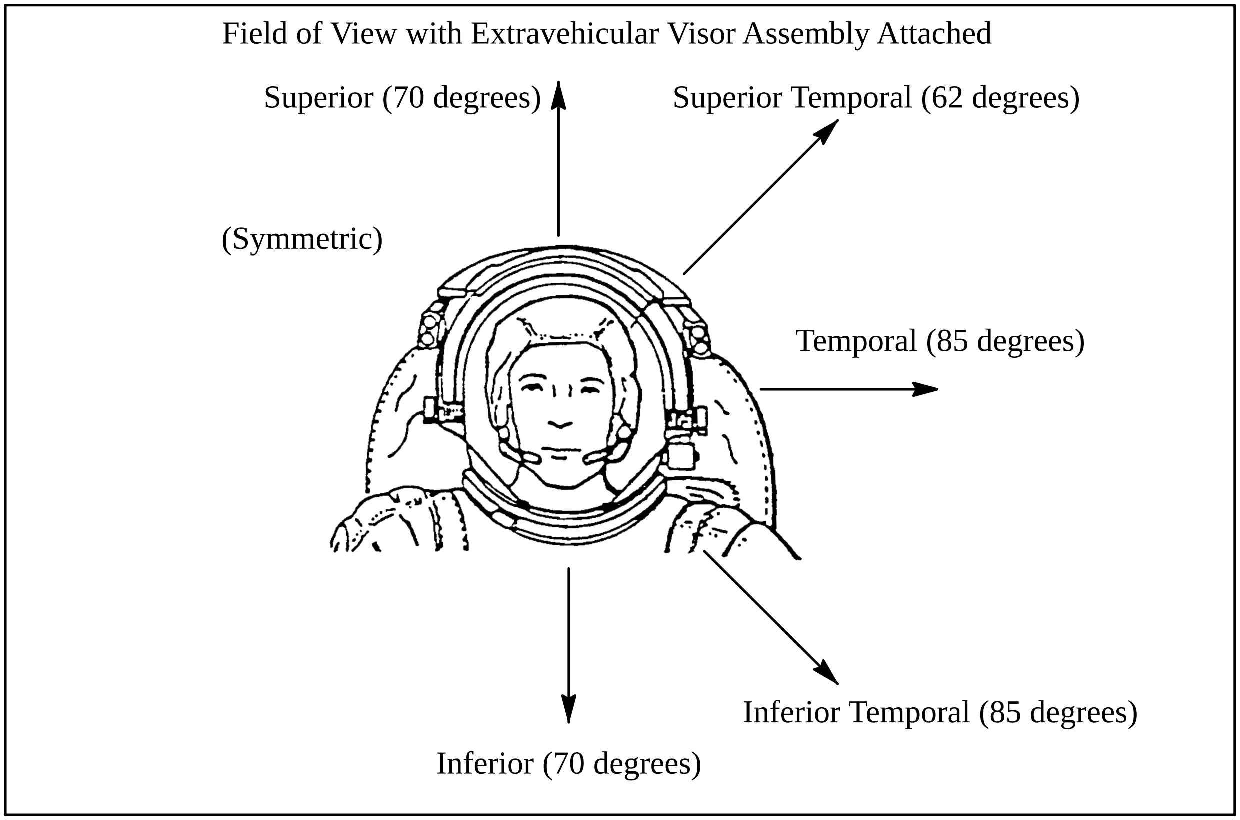


FIGURE 14.3.2.3.1−2 CREWMEMBER FIELD OF VIEW

14.4.3 EVA WORKSITES AND RESTRAINT DESIGN REQUIREMENTS

This section defines the design requirements for EVA worksites and restraints. Requirements driven by EVA anthropometry, crew restraints, hardware design for EVA access, control, and display specifications, and lighting required at the worksite are included.

14.4.3.1 EVA WORK ENVELOPE DESIGN REQUIREMENTS

EVA worksites shall be designed based on the reach envelopes and field−of−view of the EVA crewmember as shown in 14.3.2.

14.4.3.2 EVA CONTROL AND DISPLAY DESIGN REQUIREMENTS

A. EVA controls design will conform to the requirements in 9.2 and 9.3 and subparagraphs, with the following additions and exceptions:

   (1) Deleted.

   (2) Switches − EVA actuated switches shall provide tactile and/or visual indication of position.

   (3) Deleted.

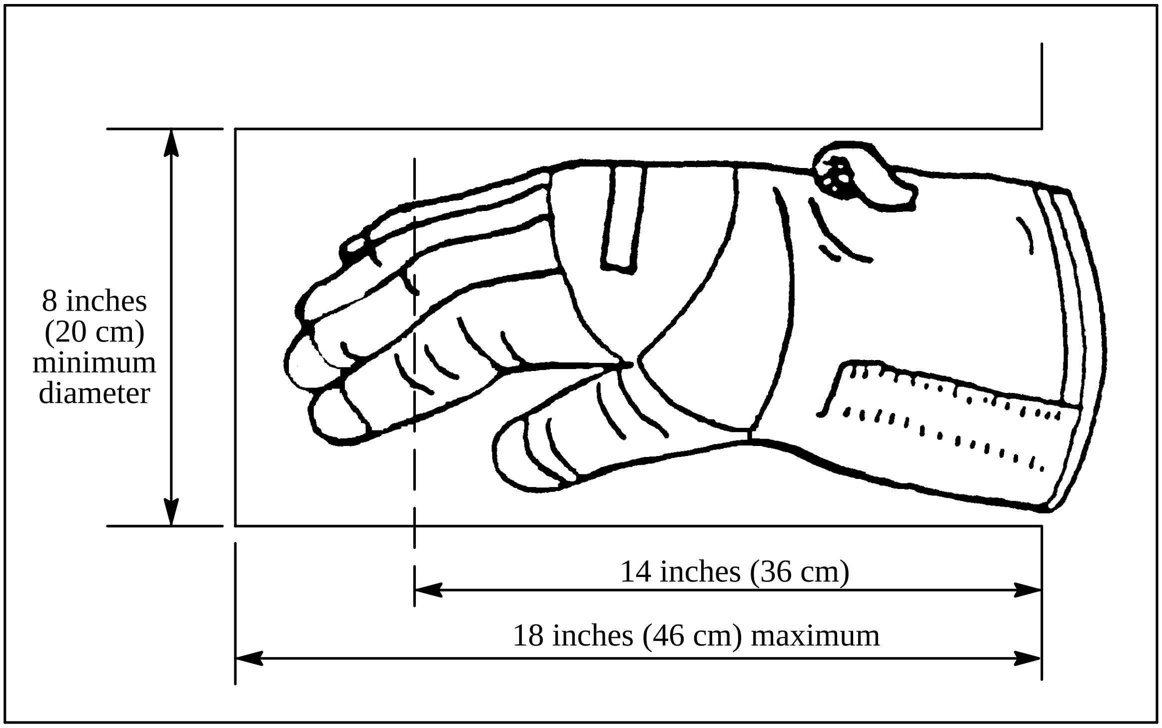


FIGURE 14.3.2.3.1−3 WORK ENVELOPE FOR GLOVED HAND

(4) Deleted.

(5) Inadvertent actuation − EVA controls shall be protected from inadvertent actuation.

(6) Deleted.

(7) Deleted.

B. Displays − EVA display types and locations shall conform to the requirements in 9.2 and 9.4 and subparagraphs, with the following:

(1) Deleted.

(2) Deleted.

(3) Field of View − EVA displays shall be located within the filed of view permitted by the EMU as defined in 14.3.2.

C. Labeling − Labeling and color coding at EVA workstations shall conform to the labeling and color coding requirements in 9.5.

(1) Deleted.

(2) Deleted.

14.4.3.3 DELETED

14.4.3.4 EVA CREW RESTRAINT DESIGN REQUIREMENTS

EVA crew restraints shall conform to the mobility aids and restraints requirements in 8.9.3 and 11.7.2.3, in addition to the following:

A. Deleted.

B. Foot Restraints −

(1) EVA foot restraints shall allow independent insertion and release of boots by the crewmember.

(2) EVA foot restraints shall accommodate all EMU boot sizes.

(3) EVA foot restraints shall preclude inadvertent boot release.

(4) EVA foot restraints shall provide a contingency method for release of a jammed boot from a foot restraint.

(5) Deleted.

(6) Deleted.

C. EVA Safety Tethers and Safety Hooks −

(1) EVA Safety Tethers and tether hooks shall have handles of a minimum length of 9.5 cm (3.75 in).

(2) EVA Safety Tethers and tether hooks shall indicate latch lock status and direction for engaging and disengaging the lock.

(3) Safety tether attachment hooks shall allow single−handed operation.

Safety tether attachment hooks shall employ a redundant lock feature which must be operated to disengage or release a tether.

(4) EVA Safety Tethers and tether hooks shall provide a contingency method for removal of a tether.

D. Deleted.

E. Deleted.

14.4.3.5 EVA EQUIPMENT TETHER DESIGN REQUIREMENTS

EVA equipment tethers will be designed to the following requirements:

A. One−Handed Operation − All EVA equipment tethers shall allow one−handed operation.

B. Deleted.

C. Tether Attachment Points −

(1) EVA Equipment Tether Attachment Points − All equipment items shall be provided a standardized tether hook receptacle shown in Figure 14.4.3.5−1.

This standardized receptacle shall also be provided on the interfacing surface to which the item is to be secured.

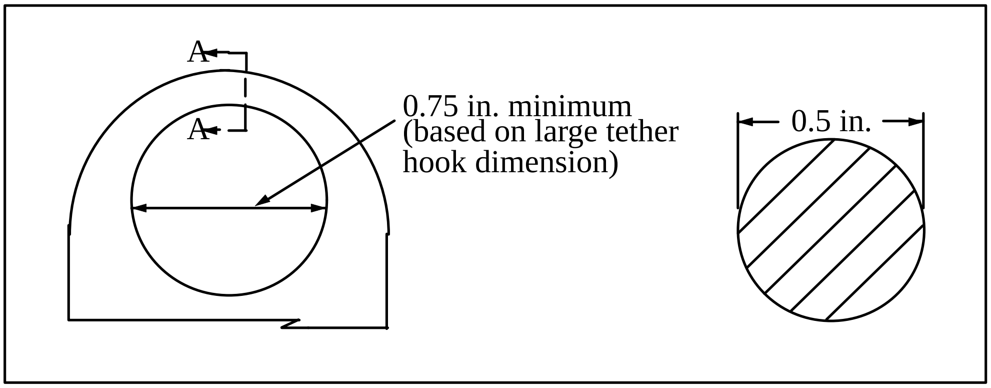


FIGURE 14.4.3.5−1 EVA EQUIPMENT TETHER ATTACHMENT POINTS

(2) EVA Handrail/hold Tether Point − The EVA handrail/hold tether point shall be designed as shown in Figure 14.4.3.5−2.

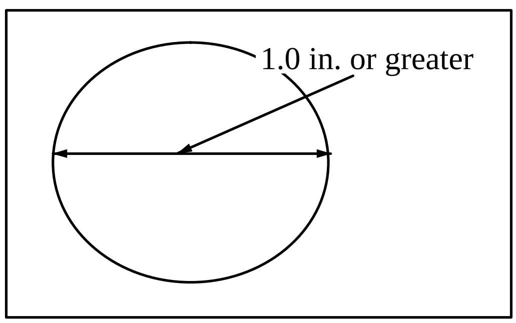


FIGURE 14.4.3.5−2 EVA HANDRAIL/HOLD TETHER POINT

D. Tether Lock Status Indication − The tether hook shall indicate whether the hook is locked or unlocked.

14.5 EVA MOBILITY AND TRANSLATION

14.5.1 INTRODUCTION

This paragraph is not applicable for this document.

14.5.2 EVA MOBILITY AND TRANSLATION DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

14.5.3 EVA MOBILITY AND TRANSLATION DESIGN REQUIREMENTS

14.5.3.1 EVA TRANSLATION ROUTE DESIGN REQUIREMENTS

EVA translation routes will conform to the following requirements:

A. Equipment − All EVA translation routes shall support a translational envelope of minimum 43.0 inches in diameter with no protrusions.

B. Translation Aids −

(1) Mobility aids shall be located at terminal points and direction change points on established crew translation paths.

(2) Deleted.

(3) Deleted.

C. Handholds −

(1) Deleted.

(2) Handholds shall be oriented such that the plane formed by the handhold longitudinal axis and the cross−section major axis is parallel with the body torso frontal plane.

D. Danger Warnings − Translation and mobility handholds located within three feet of flight equipment which poses a critical or catastrophic hazard to the crewmember or to the equipment, shall be identified and color coded.

E. Deleted.

(1) Deleted.

(2) Deleted.

F. EVA Hatches and Doors −

(1) The EVA hatches shall be operable from either side of the hatch.

(2) EVA translation aids shall be placed around the hatchway on both sides to support ingress/egress.

(3) EVA hatches shall meet the requirements of 8.10.3.

The latch mechanism shall require less than 110.0 N (25.0 lbf) to operate.

Opening the hatch shall not require more than 200 N (45.0 lbf), and closing the hatch shall not require more than 200 N (45.0 lbf).

G. Equipment Accessibility − Translation and mobility handholds shall be positioned such that crew−operated equipment and consoles are accessible and are not obstructed visually or physically by the handholds.

14.5.3.2 EVA MOBILITY AIDS DESIGN REQUIREMENTS

EVA handholds/handrails will conform to the following design requirements:

A. Dimensions − EVA handhold and handrail dimensions shall conform to Figure 14.5.3.2−1.

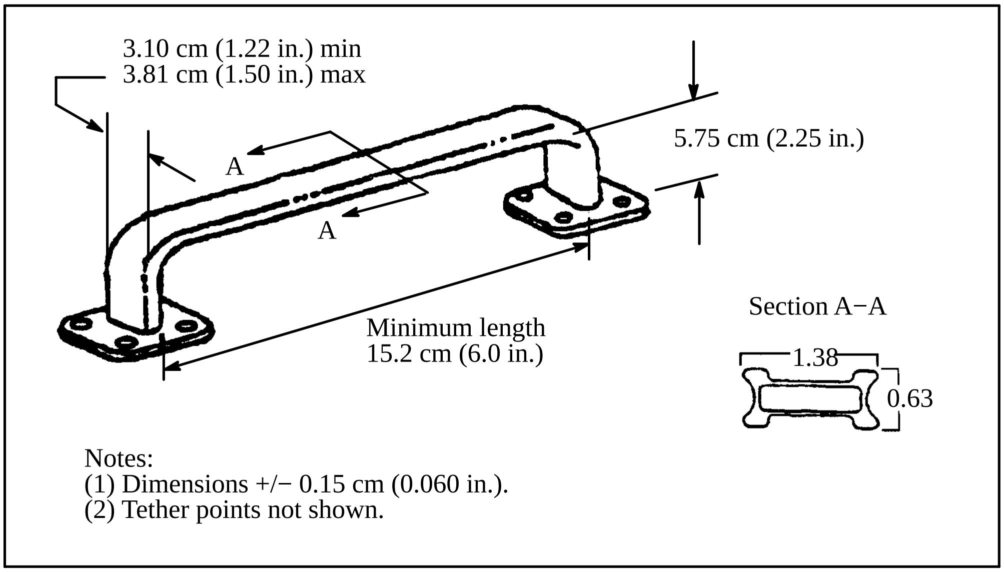


FIGURE 14.5.3.2−1 STANDARD EVA HANDHOLD DIMENSIONAL REQUIREMENTS

B. Mounted Clearance − The minimum clearance distance between the low surface of the handrail/handhold and the mounting surface shall be 5.7 cm (2.25 in.).

C. Deleted.

D. Spacing for Worksites − Handrails/handholds shall not exceed 46.0 cm (18.0 in.) above or below the shoulder or 61.0 cm (24.0 in.) to the left or right of the body centerline when working in a foot restraint position.

E. Safety Tether Attachment − EVA handrails/handholds shall accommodate safety tether hooks.

F. Deleted.

G. Color − EVA handholds/handrails and safety tether points shall be yellow.

H. Deleted.

14.5.3.3 DELETED

14.5.3.4 DELETED

14.5.3.5 EVA PASSAGEWAY DESIGN REQUIREMENTS

EVA specific passageway design requirements include:

A. Minimum Cross−section − The cross−section of EVA hatches shall not be less than 1.27 m (50.0 in.) in diameter.

B. Translation paths with direction change angles greater than 30 degrees shall have a minimum diameter at the change point of 74 inches.

14.5.3.6 EVA EQUIPMENT TRANSFER DESIGN REQUIREMENTS

EVA Equipment transfer requirements are in 11.8.3.2 and the following:

All EVA equipment and EVA cargo shall have attachment points or restraints so it can be secured or tethered at all times during transfer and at the worksite.

14.6 EVA TOOLS, FASTENERS, AND CONNECTORS

14.6.1 INTRODUCTION

This paragraph is not applicable for this document.

14.6.2 EVA TOOLS

14.6.2.1 EVA TOOLS INTRODUCTION

This paragraph is not applicable for this document.

14.6.2.2 EVA TOOLS DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

14.6.2.3 EVA TOOLS DESIGN REQUIREMENTS

Design requirements that pertain to EVA, in addition to those in 11.2.3, are as follows:

A. Throw Angles − Equipment and structures surrounding bolts requiring EVA ratcheting shall protect a 90 degree throw angle and allow right or left handed operations.

B. Handles − Tool handles shall be designed with a gripping surface which will allow application of up to 20.0 lbf and 25.0 ft−lb torque without slippage due to grip or damage to the glove due to gripping texture.

C. Access − Structure surrounding tool actuated fasteners shall provide three inches clearance for EVA gloved−hand access around the tool handle for the sweep of the handle, as shown in Figure 14.6.2.3−1.

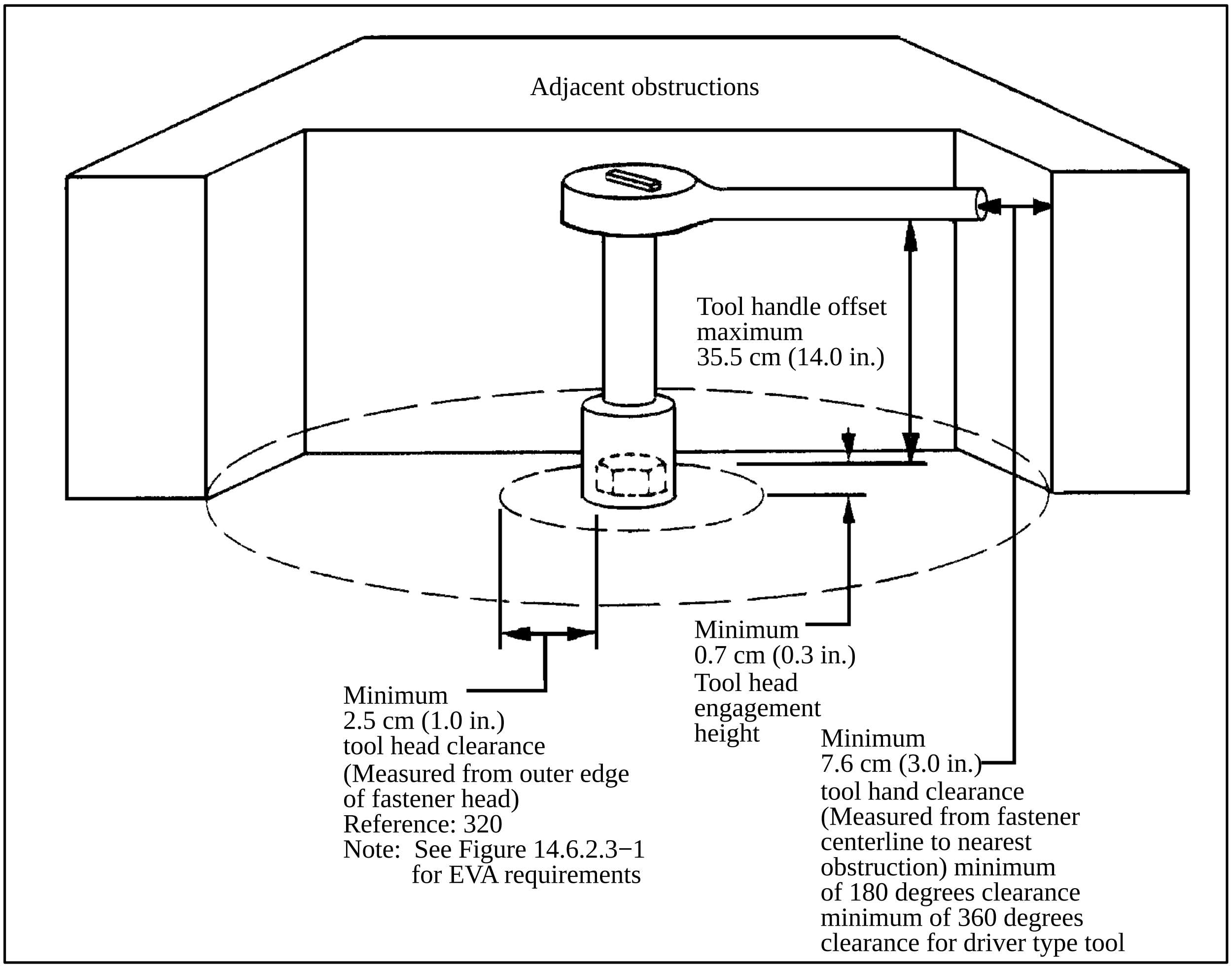


FIGURE 14.6.2.3−1 TOOL ACCESS REQUIREMENTS (IVA)

D. Tethering −

(1) A means shall be provided on all EVA tools for tethering the tool at all times to prevent inadvertent loss.

(2) The design shall be such that the attachment and removal methods permit one−handed operation using a pressure suit glove.

E. Battery−Powered Tools − Battery−powered tools shall:

(1) support EVA translation with extra battery packs

(2) provide glove clearances for EVA removal and installation of batteries

(3) protect against safety hazards during EVA removal and installation of batteries

(4) restrain all fasteners used during battery replacement

(5) support tethering of tool and batteries

F. Battery Packs − Power tools using battery packs shall have a level of charge indicator or an indication as to when a battery pack is required to be replaced.

G. EVA Tool Clearance − EVA tool head clearance requirements are defined in Figure 14.6.2.3−1, except when fasteners are released using a robotic interface.

14.6.3 EVA FASTENERS

14.6.3.1 EVA FASTENERS INTRODUCTION

This paragraph is not applicable for this document.

14.6.3.2 EVA FASTENERS DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

14.6.3.3 EVA FASTENERS DESIGN REQUIREMENTS

The following requirements pertain to EVA fasteners and are in addition to 11.9.3 through 11.9.33:

A. EVA Fastener Size −

(1) Fasteners and knobs for suited gloved hand operation shall have minimum head diameter of 1.5 in and maximum diameter of 2.0 in.

(2) Fasteners and knobs shall have a minimum head height of 0.75 in.

B. Captive −

(1) External fasteners shall be captive or shall have special provisions to restrain the fasteners.

(2) External hardware shall preclude the use of temporary fasteners.

C. Indication of Status − EVA actuated fasteners/devices shall be visually accessible to ensure proper seating or restraint in stowed or installed locations.

D. Contingency Operation − All EVA hand actuated rotational fasteners shall be provided with a standard−sized internal or external hexagonal feature for contingency override with a hand tool.

E. Cotter keys shall not be used for EVA.

14.6.4 EVA CONNECTORS

14.6.4.1 EVA CONNECTORS INTRODUCTION

This paragraph is not applicable for this document.

14.6.4.2 EVA CONNECTORS DESIGN CONSIDERATIONS

This paragraph is not applicable for this document.

14.6.4.3 EVA CONNECTORS DESIGN REQUIREMENTS

The following requirements pertain to EVA connectors and are in addition to 11.10.3 through 11.10.3.6:

A. Deleted.

B. Deleted.

C. Multiple Connectors − See 11.10.3.6 for basic connector spacing data. Where wing connectors are used, the minimum clearance between adjacent wing tabs shall be 63.5 mm (2.5 in.).

D. Deleted.

E. Status − Methods shall be provided to indicate connector mating status.

F. Pressure − Pressurized pneumatic connectors and lines shall be tethered or otherwise captured to the main structure.

G. Protecting Caps − All connector protective caps shall be tethered.

H. Strain Relief − EVA connectors shall relieve strain to prevent breakage due to induced loads.

I. Alignment − All connectors shall have provisions to ensure proper alignment during mating and demating and visible alignment markings.

J. Scoop Proof − All connectors shall be scoop proof. Scoop proof refers to the impossibility of a mating receptacle connector being inadvertently cocked into a mating plug and damaging or electrically shorting the contacts.

K. Deleted.

L. Electrical Hazards − All electrical connectors shall have provisions for alignment and mating of connector shells prior to electrical path completion.

14.7 DELETED

14.7.1 DELETED

14.7.2 DELETED

14.7.3 DELETED

APPENDIX A NOTES

A.1 DEFINITIONS

DEAD−FACED − An electrically conductive surface incapable of supplying sufficient energy under normal conditions to present a hazard (e.g., the output of a solid−state switch when in the "STANDBY" state).

DIRECT CONTACT − The personal contact of a crewmember to electrically powered surfaces.

DOUBLE INSULATED ENCLOSURE/CHASSIS − An enclosure/chassis which incorporates an insulation system comprised of basic insulation and supplementary insulation with the two insulations physically separated and so arranged that they are not subject to the same deteriorating influences (e.g., temperature, contaminants, and the like) to the same degree.

ENCLOSURE/CHASSIS − The outer casing of an electrical/electronic device such as an Orbital Replaceable Unit.

GROUNDED ENCLOSURE/CHASSIS − An enclosure/chassis electrically connected to the ground return.

IN−LINE CIRCUIT LEAKAGE CURRENTS − Unintentional currents which can flow in a conductor. These currents may result from the inability of solid−state electronics to reach an "infinite" impedance "OFF" state, as is the ability of a mechanical switch. The solid−state electronic device has a finite impedance which undesirably completes the input/output circuit thus providing a means for current to flow. Connections to in−line circuits are normally isolated from crewmember inadvertent contact by barriers and may be considered a hazard if accessible to inadvertent crewmember contact. In−line circuits with leakage currents are referred to as in "STANDBY" when placed in the high impedance state since a complete disconnect is not possible and the circuit output is still energized.

INDIRECT CONTACT − The contact of a crewmember to electrically powered surfaces through an electrically conducting medium (e.g., probe, rod).

ISOLATED PATIENT CONNECTION − A direct or indirect patient contact that is deliberately separated from the supply circuit and ground by virtue of spacings, insulation, protective impedance, or a combination thereof (e.g., intra−aortic pressure monitor).

LEAKAGE CURRENTS − Unintentional currents which can be applied to a crewmember.

MEAN PERCEPTION − A mild shock perceived by 50 percent of the population.

NO SENSATION − The level of perception only perceived by a fractional percentage of the population.

ORDINARY PATIENT CONNECTION − A direct patient contact that does not have the spacing, insulation, or protective impedance associated with an isolated patient connection (e.g., blood pressure cuff).

ORU CHASSIS LEAKAGE CURRENTS − Currents generated by such internal sources as filter capacitors terminated to accessible parts or ground, and capacitive and inductive coupling to accessible parts or ground. These currents can be conveyed from accessible parts to ground or to other accessible parts and subsequently applied to a crewmember.

PATIENT − A crewmember instrumented with electrical/electronic equipment.

PATIENT CONNECTION LEAKAGE CURRENT − Leakage currents measured between patient leads at the patient interface, or between patient leads at the patient interface and ground.

PERCEPTION − A mild shock.

STANDBY − A high impedance state of an electronic device, usually to minimize the amount of energy consumed or supplied (e.g., the off state of an electronic switch).

A.2 ABBREVIATIONS AND ACRONYMS

ac	alternating current
ACGIH	American Conference of Industrial Hygienists
AMI	
ANSI	American National Standards Institute
APFR	Articulating Portable Foot Restraint
Btu, BTU	British thermal unit
C	Celsius
CBM	Common Berthing Mechanism
cc	cubic centimeters
CETA	Crew and Equipment Translation Aid
CFU	Colony Forming Unit
CIE	Commission Internationale De L’Eclairage
cm	centimeter
CMO	Crew Medical Officer
CWS	Caution and Warning Systems
dB	decibel
dB(A)	Acoustic decibel level
dc	direct current
deg	degree(s)
DIP	Dual Inline Package
e.g.	exempli grata (latin−for example)
EF	Exposed Facility
EMU	Extravehicular Mobility Unit
EVA	Extravehicular Activity
EVR	Extravehicular Robotic
F	Fahrenheit
fc	foot candle
FIFO	first in − first out
ft	foot, feet
g, G	gravity
GFCI	Ground Fault Circuit Interrupter
GHz	Giga Hertz
gm	gram
HMS	Health Maintenance System
Hz	Hertz

i.e.	id est (latin − that is)
ID	Identification
IEA	Integrated Equipment Assembly
in.	inch
IDSL	Intermediate Debris Shield Layer
ISS	International Space Station
ITS	Integrated Truss Segment
IVA	Intravehicular Activity
J	Joule
JEM	Japanese Experiment Module
JSC	Johnson Space Center
K	Kelvin
kcal	kilocalorie
kg	kilograms
KHz	Kilo Hertz
l	liter
L	(ft−L)
lb(s)	pound(s)
lbf	pounds force
LED	Light Emitting Diode
LET	Linear Energy Transfer
m, M	meter
ma	milliamperes
MCL	maximum contamination level
mg	milligrams
MHz	Mega Hertz
ml	milliliters
MLI	Multi−layer Insulation
mm	millimeter
MMOD	Micro−Meteoroid Orbital Debris
MPE	Maximum Permissable Exposure
mr	milli−roentgen
MSIS	Man−Systems Integration Standards
MT	Mobile Transporter
mW	milliwatts
N	Newtons
NA	Not applicable
NASA	National Aeronautics and Space Administration
NC	Noise Criteria
nm	nanometer
No.	Number
NTU	Turbidity
ORU	Orbital Replaceable Unit
oz	ounce
PFR	Portable Foot Restraint
PMA	Pressurized Mating Adapter
PSIL	Preferred Speech Interference Level
pt	point
Pt/Co	Standard Color Scale

RCP	Radiation Constraints Panel
rem	roentgen equivalent man
RF	Radio Frequency
rms	root mean squared
RMS	Remote Manipulator System
SD	Standard Deviation
s, sec	second
SARJ	Solar Alpha Rotary Joint
SPL	Sound Pressure Level
SRP	Seat Reference Point
SSP	Space Station Program
STP	Standard Temperature and Pressure
STS	Space Transportation System
TLV	Threshold Limit Values
TmPT	Maximum Permissable Material Temperature
TOC	Total Organic Carbon
TON	Threshold Odor Number
TTN	Threshold Taste Number
typ	typical
U.S.	United States
UTOC	Uncharacterized Total Organic Carbon
UV	Ultraviolet
VDT	Visual Display Terminal
WIF	Worksite Interface