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An American National Standard

Standard Practice for Human Engineering Design for Marine Systems, Equipment, and Facilities[1,2]

This standard is issued under the fixed designation F1166; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This practice provides ergonomic design criteria from a human-machine perspective for the design and construction of maritime vessels and structures and for equipment, systems, and subsystems contained therein, including vendor-purchased hardware and software.

1.1.1 The focus of these design criteria is on the design and evaluation of human-machine interfaces, including the interfaces between humans on the one side and controls and displays, physical environments, structures, consoles, panels and workstations, layout and arrangement of ship spaces, maintenance workplaces, labels and signage, alarms, computer screens, material handling, valves, and other specific equipment on the other.

1.2 The criteria contained within this practice shall be applied to the design and construction of all hardware and software within a ship or maritime structure that the human crew members come in contact in any manner for operation, habitability, and maintenance purposes.

1.3 Unless otherwise stated in specific provisions of a ship or maritime structure design contract or specification, this practice is to be used to design maritime vessels, structures, equipment, systems, and subsystems to fit the full potential user population range of 5th % females to 95th % males.

1.4 This practice is divided into the following sections and subsections:

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[1] This practice is under the jurisdiction of ASTM Committee F25 on Ships and Marine Technology and is the direct responsibility of Subcommittee F25.07 on General Requirements.

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[2] A user-friendly format of this standard is available for download from ASTM's website. While the content is the same, ASTM Practice F1166 in standard published format should be considered the official version (for any legal or liability purposes).

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1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *Overall References:*

ABS Guidance Notes for the Application of Ergonomics to Marine Systems, August 2013 (Updated August 2018)

MIL-STD-1472 Department of Defense Design Criteria Standard: Human Engineering

2.2 *Alarms:*

DOT/FAA/HF-STD-001B Ahlstrom, V. (2016). Human Factors Design Standard (HFDS) Atlantic City International Airport, NJ: Federal Aviation Administration William J. Hughes Technical Center

Engineering Equipment and Materials User's Association (EEMUA) Publication # 191 Alarm Systems, a Guide to Design, Management and Procurement

International Maritime Organization (IMO) Resolution A.830(19) Code on Alarms and Indicators

2.3 *Integration of Controls, Displays, and Alarms:*

ABS (October 2003) Guidance Notes on Ergonomic Design of Navigation Bridges

2.4 *Anthropometry:*

ADULTDATA: The Handbook of Adult Anthropometrics and Strength Measurements—Data for Design Safety Institute for Occupational Ergonomics, University of Nottingham, UK, 1998

International Labor Office (ILO) International Data on Anthropometry, 1990
McDowell, M. A., Fryar, C. D., Hirsch, R., and Ogden, C. L. Anthropometric Reference Data for Children and Adults: U.S. Population, 2003-2006, Advance Data from Vital and Health Statistics No. 361, U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, July 2005
Anthropometric Survey of U.S. Army Personnel: Methods and Summary Statistics, Technical Report NATICK/TR-15./007 U.S. Army NATICK Soldier RD&E Center, 2014
Woodson, W. Human Factors Design Handbook, 1981

2.5 *Access Aids:*
ABS Guide for Means of Access to Tanks and Holds for Inspection, April 2016 (Updated March 2018)
International Maritime Organization (IMO) Guidelines for Safe Access to Tanker Bows, IMO Resolution MSC.62 (67) 1996 International Maritime Organization (IMO) International Convention on Loadlines, 1966

2.6 *Human-Computer Interface:*
Defense Information Systems Agency (DISA) Common Operating Environment (COE) User Interface Specifications (UIS) 2003
DOT/FAA/HF-STD-001B Ahlstrom, V. (2016) Human Factors Design Standard (HFDS). Atlantic City International Airport, NJ: Federal Aviation Administration William J. Hughes Technical Center
ANSI/HFES Standard No. 100–2007 American National Standard for Human Factors Engineering of Computer Workstations, Human Factors and Ergonomics Society, Inc., Santa Monica, CA, 2007

2.7 *Habitability:*
ABS (February 2016) Guide for Crew Habitability on Ships
Directive 2002/44/EC of the European Parliament and of the Council (25 June 2002) on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibration)
DNVGL-OS-A301, April 2016 DNV-GL Offshore Standard for Human Comfort
International Maritime Organization (IMO) Resolution MSC.337(91) Code on Noise Levels on Board Ships
IEC 1260:1995 Electroacoustics — Octave-band and fractional-octave-band filters
ISO 2041:1990 Vibration and shock — Vocabulary
ISO 2531:2009 Ductile iron pipes, fittings, accessories and their joints for water applications
ISO 2631-1:1997 Mechanical vibration and shock — Evaluation of human exposure to whole-body vibration
ISO 5805:1997 Mechanical vibration and shock — Human exposure — Vocabulary
ISO 8041:1990 Human response to vibration — Measuring instrumentation

2.8 *Labeling:*
ANSI Z535.2 Environmental and Facility Safety Sign Standard
ANSI Z535.3 Criteria for Safety Symbols
Globally Harmonized System of Classification and Labelling of Chemicals (GHS)
Peterson, R., Price, B., LaBrecque, J., Bass, D., and Ziemba, A., Development of Impact Injury Design Rule for High Speed Craft, Naval Surface Warfare Center, Panama City, FL, August 26, 2004

2.9 *Material Handling:*
Lifting: TLV Physical Agents, 7th edition, American Conference of Governmental Industrial Hygienists, 2005
DOT/FAA/HF-STD-001B Ahlstrom, V. (2016). Human Factors Design Standard (HFDS). Atlantic City International Airport, NJ: Federal Aviation Administration William J. Hughes Technical Center
Katrin Kroemer Elbert, Henrike Kroemer, Anne D. Kroemer Hoffman Ergonomics: How to Design for Ease and Efficiency, 3rd edition, 2018

2.10 *Maintenance:*
MIL-HDBK-454 General Guidelines for Electronic Equipment
MIL-STD-130 Department of Defense Standard Practice for Identification Marking of U.S. Military Property

2.11 *Communications:*
DOT/FAA/HF-STD-001B Ahlstrom, V. (2016). Human Factors Design Standard (HFDS). Atlantic City International Airport, NJ: Federal Aviation Administration William J. Hughes Technical Center

2.12 *Hazards and Safety:*
ANSI/ASSP Z590.3-2011 Prevention Through Design Guidelines for Addressing Occupational Hazards and Risks in Design and Redesign Processes
MIL-STD-882E Department of Defense Standard Practice, System Safety

2.13 *Small Boat and High Speed Craft Appendix:*
American Boat and Yacht Council (2014) Reboarding Means, Ladders, Handholds, Rails and Lifelines (ABYC H-41)
American Boat and Yacht Council (2019) Field of Vision from the Helm Position (ABYC H-1)
Dobbins, T., Rowley, I., and Campbell, L. (2008) High Speed Craft Human Factors Design Guide (Report Number ABCD-TR-08-01 v1.0). UK MOD Defence Equipment and Support Agency (DE&S); Directorate of Sea Systems supported by the ABCD Working Group
International Maritime Organization (2000) Adoption of the International Code of Safety for High-Speed Craft: 2000 HSC Code (MSC.97(73))
International Maritime Organization (2000) Maritime Safety Committee Circular 982: Guidelines on Ergonomic Criteria for Bridge Equipment and Layout (MSC.1-Circ. 982)
The International Organization for Standardization (2007) Ship's bridge layout and associated equipment — Requirements and guidelines: Annex A (normative): Bridge layout for high speed craft (ISO 8468, 3rd edition)
The International Organization for Standardization (2016) Small craft – Principle data (ISO 8666, 2nd edition)
The International Organization for Standardization (2019) Small craft – Field of vision from the steering position (ISO 11591, 3rd edition)
United States Coast Guard (2001) Navigation and Vessel

Inspection Circular Number 5-01
Guidance for Enhancing the Operational Safety of Domestic High Speed Vessels (COMDTPUB P16700.4)

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *accessible, adj*—an item is considered accessible when it can be operated, manipulated, inspected, serviced, removed, or replaced by the suitably clothed and equipped user with applicable body dimensions conforming to the anthropometric range and database specified by the procuring activity or, if not specified by the procuring activity, with applicable 5th to 95th percentile body dimensions as defined in Section 9.

3.1.1.1 *Discussion*—Applicable body dimensions are those dimensions that are design critical to the operation, manipulation, inspection, service, removal, or replacement task.

3.1.2 *advisory signal, n*—signal that indicates a safe or normal configuration, condition of performance, or operation of equipment or attracts attention and imparts information for routine action purposes.

3.1.3 *alarm, n*—visual or audible signal or both of a condition, or a predetermined out-of-tolerance condition, for machinery, equipment, components, or systems that require attention and response by a crewmember.

3.1.4 *alarm filtering, n*—technique by which unnecessary alarms are eliminated.

3.1.5 *alarm priority, n*—predicted assessment of the potential consequence of a condition or situation and the resulting urgency of mitigating responses required of personnel, that is, the more severe the potential consequence, the higher the alarm priority.

3.1.6 *alarm suppression, n—(1)* technique in which when a single-alarm event leads to subsequent alarm events (for example, cascading alarms), the initiating alarm is presented but the subsequent events are not (that is, are suppressed); and *(2)* technique by which alarm messages are not displayed but are available to the user upon request.

3.1.7 *analog display, n*—type of display that shows the complete range of a measured parameter on a continuous scale and by means of a pointer, or equivalent, indicating an instantaneous value of the parameter on the scale.

3.1.8 *angle of inclination, n*—angle that the stair rises measured from the deck or surface on which the stair is sitting to the underside of the stair stringers.

3.1.9 *annunciator, n—(1)* type of transilluminated display that provides written text, pictorial data, or both to a user to show status or condition of a system or equipment; and *(2)* (also called a legend light) type of transilluminated display consisting of a light source located behind a cover that contains a printed label (that is, legend).

3.1.9.1 *Discussion*—The color of the light (usually red, green, white, or blue), whether it is ON or OFF, and the printed label all provide information to the operator about the status of a piece of equipment or system.

3.1.10 *anthropometrics, n—(1)* study of the physical size, strength, and range of motion of the human body and the application of that data to the design of systems, equipment, workspaces, and tools to maximize human performance and safety in a work setting; and *(2)* measurement of human variability of body dimensions and strength as a function of gender, race, and regional origin.

3.1.11 *anti-two-block alarm, n*—alarm used to warn a crane operator of the impending collision of the traveling block and crane tip sheave.

3.1.12 *articulation index (AI), n*—technique used to measure how intelligible (that is, understandable) spoken words are that are received over communication equipment and is expressed as a percentage of speech units that are understood by a listener when heard out of context.

3.1.13 *assembly, n*—number of parts or subassemblies or any combination thereof joined together to perform a specific function and capable of disassembly.

3.1.13.1 *Discussion*—The distinction between an assembly and a subassembly is determined by the individual application. An assembly in one instance may be a subassembly in another in which it forms a portion of an assembly.

3.1.14 *assisted lifting devices, n*—items such as cranes, hoists, mobile A-frame and hydraulic jacking units, monorails, trolleys, or padeyes used by individuals to lift or move materials and equipment or both that is too heavy for direct manual lifting or carrying.

3.1.15 *audible alarm, n*—alarm comprised of tones, verbal messages, or verbal messages combined with tones and not all audible alarms are associated with visual alarms.

3.1.16 *auditory display, n*—device that provides readings, status, or condition of machinery, equipment, or system-operating parameters through the use of sound signals or spoken messages.

3.1.17 *band pass, n*—electronic filter designed to respond only to selected audio frequencies while blocking all other frequencies.

3.1.17.1 *Discussion*—Commonly used in telephones.

3.1.18 *binaural, n*—sound coming to a headset from dual channels or signal paths with a different channel or signal path presented to each headset.

3.1.19 *case, n*—part of an item of equipment that encloses and protects the equipment from its surroundings and protects the surroundings—including personnel—from the equipment.

3.1.20 *caution signal, n*—signal that indicates the existence of a condition requiring attention but not immediate action.

3.1.21 *coaming, n*—vertical steel plate extending up 50 to 76 mm (2 to 3 in.) from the deck and placed around equipment or other areas in which liquids (for example, oil, water, grey or black water, and oily water) could be spilled to contain the liquids within a confined area.

3.1.22 *color pad, n*—area on a console or panel face that is shaded a different color than the panel itself to highlight a set of controls, displays, or alarms, or combination thereof, that are related in some manner.

3.1.23 *command, n*—instructions that cause a device to perform some action.

3.1.24 *command language, n*—limited programming language used strictly for executing a series of commands (for example, Linux or any DOS shells).

3.1.25 *console, n*—group of controls and displays associated with one or more individual pieces of equipment or systems mounted together on a structure dedicated to the control and monitoring of the individual equipment or systems.

3.1.25.1 *Discussion*—Consoles may be freestanding units and include angled and vertical surfaces.

3.1.26 *continuous control, n*—continuous control is an actuator that operates at any point or value along a continuous scale (for example, engine throttle).

3.1.27 *contrast ratio, n*—ratio of the differences in luminance between the item on a video display and the background.

3.1.28 *control, n—(1)* any switch, pushbutton, knob, lever, keyboard, mouse, or other device manually manipulated by the operator/maintainer to alter or maintain the status of a particular piece of equipment or system; and *(2)* a device an operator or maintainer uses to input a signal, change the operating status of equipment or systems, or to manipulate displayed data. Examples include switches, knobs, cranks, thumbwheels, levers, keyboards, and foot pedals.

3.1.29 *cursor, n*—marker on the display screen that indicates the position where the computer expects the next input or will display the next output.

3.1.29.1 *Discussion*—The cursor may be positioned by the computer or by the user.

3.1.30 *danger signal, n*—signal that indicates the existence of a hazardous condition requiring immediate action to prevent loss of life, major equipment damage or environmental contamination, or serious loss of mission capability.

3.1.31 *dead-man switch, n*—control that automatically stops machinery or systems from operating once the control is released by the operator.

3.1.32 *dependent symbol, n*—symbols that alone do not impart any specific information to the user but require the existence of supporting data to provide useful information.

3.1.33 *detent control, n—(1)* type of discrete control, characterized by the control locking into each position setting until the operator exerts extra force to move the control out of the setting.

3.1.33.1 *Discussion*—These types of controls are preferable for machinery equipment or system operation requiring control in discrete steps or different modes.

(2) type of discrete control in which each control position setting is identified by a audible click and the control "locks" into that position setting until the operator exerts extra force to move the control out of that setting and into the next one.

3.1.34 *digital display, n*—type of display that uses numeric characters to provide an instantaneous value of a parameter.

3.1.35 *directly accessible, adj*—to be directly accessible, an object, space, component, or piece of equipment shall be in an area reachable without having to use tools or disassemble an access opening; be clear of, or protected from, obstructions, moving equipment, hot surfaces, or other obstructions that would prevent safe contact by the user; allow the user to get as close as necessary (for example, arm's reach) to perform the required tasks; be reachable by means of a permanent access; and allow all of the above by a person wearing the required protective clothing and carrying tools, spare parts, and test equipment as required.

3.1.36 *directly visible, adj*—a directly visible object (for example, control, display, hazard warning, and so forth) shall not be located behind a door or other closure cover and shall be readable from the normal user position within the provided ambient lighting and from a position that does not require the reader to stand on pipes, cable trays, structural members, or other surfaces not intended to be a regular working surface or assume awkward body postures.

3.1.37 *discrete control, n*—actuator that allows for the selection between two or more mutually exclusive operating functions or points along a scale (for example, switching a machine ON or OFF or selecting one of three pumps to run).

3.1.38 *displacement joystick, n*—joystick that moves out of the detent in the direction it is pushed.

3.1.38.1 *Discussion*—Displacement joysticks are usually spring-loaded so that they return to a neutral center (detent) position.

3.1.39 *display, n*—any gauge, light counter, printer, annunciator, sight glass, horn, siren, digital counter, cathode ray tube (CRT) screen, or any other device that provides visual or auditory information to the human operator/maintainer about the status of a piece of equipment or system.

3.1.40 *dynamic display, n*—display screen that is, or has portions within that are, updated on a regular basis, primarily alphanumeric values.

3.1.41 *emergency shutdown stations (ESDs), n*—manual controls that are located throughout a ship or maritime structure that shut down equipment, systems, or complete structures and initiate an alarm at the same time.

3.1.42 *fixed ladder, n*—ladder permanently attached to a structure, building, or equipment.

3.1.43 *foot candle (fc, lm/ft^2 or ft-c), n*—a non-SI measure of light intensity or illuminance, the amount of light striking a surface, in lumens per square foot. One foot candle is equal to approximately 10.76 lux (the corresponding SI unit).

3.1.44 *foot lambert (fl or ft-L), n*—a non-SI measure of luminance, the amount of light reflected from a surface. A foot-lambert equals $1/\pi$ candela per square foot, or 3.426 candela per square metre (the corresponding SI unit).

3.1.45 *flicker, n*—perception of rapid fluctuations in luminance levels characterized by an impression of jerky movements.

3.1.46 *function keys, n*—labeled keys that serve as keyboard shortcuts (for example, F1, F2, F3, or with the function name such as Delete or Insert) by combining in one key the actions of a sequence of individual keys.

3.1.47 *general emergency alarms, n*—alarm given in the case of an emergency involving all persons on a vessel or other maritime facility and these alarms sound throughout a vessel or maritime installation and are intended to be heard by all personnel.

3.1.47.1 *Discussion*—General emergency alarms relate to conditions of a serious nature such as announcing a fire or flooding, demanding evacuation of an area, or demanding abandonment of a vessel or installation.

3.1.48 *glare, n*—luminance or amount of light-per-unit area emitted or reflected from a surface, within a specific area of personnel's field of view, that is greater than the luminance to which the eye is adjusted compared to the remainder of the field of view.

3.1.49 *graphic label, n*—type of label used to present information through line schematics, diagrams, charts, tables, and pictures.

3.1.50 *handle or handgrab, n*—U-shaped bar attached directly to bulkheads or other structures used by a person to hold onto where handholds are required such as when passing through hatches or lightening holes or climbing vertically through deck openings.

3.1.51 *handrail, n*—vertical barrier consisting of two or more horizontal rails connected to vertical stanchions that are erected along exposed edges of floor openings, wall openings, ramps, steps, platforms, and walkways to prevent a person from falling from one elevation to another.

3.1.52 *hazard identification sign, n*—type of sign used to identify and provide information about situations that may be hazardous to personnel, equipment, or the environment; there are two types of hazards: "DANGER" and "CAUTION."

3.1.53 *hazard label, n*—type of label used to identify and provide information about situations that may be hazardous to personnel, equipment, or the environment and only two types of hazards should be allowed, that is, "DANGER" and "CAUTION," based on the following criteria.

3.1.53.1 *DANGER*—used where the hazard could result in serious injury or death to a person, serious damage to vital equipment, or a major environmental problem.

3.1.53.2 *CAUTION*—used where the hazard could result in a minor injury to a person, minor damage to the equipment, or a minor environmental problem.

3.1.54 *hierarchical menus, n*—large series of options or menus that are organized as a multilevel, branching structure in which an option in a higher-level menu is the name of another menu at the next lower level and the options in the lowest-level menus are not the names of other menus.

3.1.55 *human engineering (ergonomics), n*—scientific discipline concerned with the understanding of interactions among humans and other elements of a system and the profession that applies theory, principles, data, and methods to design to optimize human well-being and overall system performance.

3.1.56 *human machine interface (HMI), n*—means by which humans and machines/computers communicate/work with each other to control and operate systems.

3.1.57 *human systems integration (HSI), n*—systems engineering discipline that is focused on human performance, human skills and training, manpower, personnel survivability, health and safety, and quality of life at sea.

3.1.58 *hyperlinks, n*—text that provides the capability to, when selected using a pointing device or ENTER key, direct the user to another location within the window or another window.

3.1.58.1 *Discussion*—Hyperlinks are generally indicated by textual formats such as alternate text color or underlining or both.

3.1.59 *icon, n*—picture or drawing that represents an actual piece of equipment or system on the ship or maritime structure.

3.1.60 *identification label, n*—type of label used to: *(1)* identify, and be placed on, all individual equipment or components, for example, valves, gauges, junction boxes, filters, pumps, sensor, consoles, transmitters, pressure vessels, control panels, local motor controllers, fans, heaters, cabinets, lockers, and all other items used by the crew for operation, maintenance, or habitability use; *(2)* identify spaces (for example, rooms, compartments, open deck areas, buildings, tanks, voids, or any area in which the crew may enter); and *(3)* identify individual controls, displays, alarms, or groups thereof as shown in Section 8 that appear on consoles, control panels, or are individually mounted.

3.1.61 *independent symbol, n*—pictorial representation that alone provides information to personnel without requiring elaboration by supporting text.

3.1.62 *individual rung ladder, n*—fixed ladder, each rung of which is individually attached to a structure, building, or equipment rather than to ladder stringers.

3.1.63 *information label or placard, n*—type of label or placard used to present nonprocedural information of a general nature related to health, first aid, sanitation, rules, housekeeping, and general conduct.

3.1.64 *instruction label, n*—instruction label provides step-by-step instructions for accomplishing a specific task (operation or maintenance related) along with hazard and safety information related to performing the task.

3.1.65 *isometric joystick, n*—joystick that has no perceptible movement but output is a function of applied force.

3.1.66 *jitter, n*—interference in electron-gun displays (for example, CRT displays) as a result of magnetic fields from other devices such as motors and generator sets.

3.1.67 *keyboard lockout, n*—state determined by an application in which the application does not accept input from the keyboard.

3.1.68 *kickout panel, n*—part of a joiner bulkhead or wall that is marked and designed especially to be "kicked out" and used as an emergency escape exit.

3.1.69 *label, n*—term, when used alone, shall mean any type of plate, sign, placard, inscription, legend, marking, or combination of these, that is used for purposes of identification or to impart visual information or instructions to the reader.

3.1.69.1 *Discussion*—This term is used generically herein to describe all the specific types of labels described in Section 15.

3.1.70 *ladder, n*—appliance consisting of two side rails (that is, stringers) joined at regular intervals by crosspieces called rungs, or steps, on which a person steps during ascent or descent of the ladder from one elevation to another.

3.1.71 *legible, adj*—defines the state in which alphanumeric characters or other written information is presented in a form such that each character or number is recognized as being different from the other.

3.1.72 *lighted pushbutton, n*—type of annunciator in which the pushbutton lights up when it is pushed and goes off when the button is pushed again.

3.1.72.1 *Discussion*—The pushbutton serves as a control and display since the light indicates the status (that is, ON or OFF, OPEN or CLOSED, and so forth) of the controlled item.

3.1.73 *lightening hole, n*—hole (often oval in shape) cut in the steel structure of an inner-bottom plate at specific locations so as to reduce the weight of the ship without degrading its structural integrity; allow liquids that might be in a tank or hold to move freely; and provide personnel access from one tank or space to another for maintenance, repair, and construction purposes.

3.1.74 *local operating alarms, n*—alarms located within specific operating spaces close to the equipment or systems they monitor.

3.1.75 *luminance, n*—total light emitted from a video display calculated on the basis of the brightest portion or average level over the entire area of video display.

3.1.76 *maintainability, design for, n*—design decisions made directed toward achieving those combined characteristics of equipment and facilities that will enable the accomplishment of necessary maintenance quickly, safely, accurately, and effectively with minimum requirements for personnel, skills, special tools, and cost.

3.1.77 *maintenance, n*—all actions necessary for retaining material in (or restoring it to) a condition capable of a specified level of performance.

3.1.77.1 *Discussion*—Maintenance includes inspecting, servicing, removal, replacement, repair, modification, modernization, overhaul, condition determination, corrosion control, and initial provisioning of support items.

3.1.78 *manual material handling, v*—act of a person physically lifting, carrying, pushing, pulling, or holding any item or load as a part of performing any duty.

3.1.79 *may, v*—term is used in this practice to mean that the related criteria can or cannot be used at the discretion of the designer without the procuring authority or organization being notified.

3.1.80 *menu, n*—list of options from which a user makes a selection or selections.

3.1.81 *modified rhyme test (MRT), n*—another technique used to measure how intelligible spoken words are that are received over communication equipment.

3.1.82 *monaural, n*—sound coming to a headset from a single channel or signal path.

3.1.83 *multi-rotation control, n*—a control device such as a knob, crank, or handwheel which allows for adjustment over more than 360 degrees of rotation where precise settings are required over a wide range of adjustment.

3.1.84 *noise-canceling microphone, n*—design feature that reduces the masking effect of ambient noise upon speech impressed on a microphone to make the speaker's voice more intelligible.

3.1.85 *normal line of sight, n*—line drawn from the human eye to a visual object, such as a gauge or panel, which is 15° below horizontal as a result of the downward tilt of the human head under normal conditions.

3.1.86 *nose or nosing, n*—that portion of a tread projecting beyond the face of the tread immediately below.

3.1.87 *open riser, n*—air space between treads of a stairway without upright members (risers) between the treads.

3.1.88 *palettes (graphic menus), n*—set of unlabeled symbols, typically presented within small rectangles in which the symbols may be icons, patterns, characters, or drawings that represent an operation.

3.1.88.1 *Discussion*—Palettes are used widely in drawing and painting packages but are commonly found in word-processing applications as well.

3.1.89 *panel, n—(1)* any surface in which controls, displays, or alarms, or combination thereof, relating to equipment or system conditions are placed.

3.1.89.1 *Discussion*—Panels typically are flat vertical surfaces. Panels are sometimes referred to as control boards.

(2) concentration of individual controls and displays used to operate one or more pieces of equipment, usually mounted on a flat plate attached to, or located near, the equipment itself.

3.1.90 *panel and console labels, n*—labels that appear on operator consoles and panels to identify individual controls or displays or groups of controls and displays.

3.1.91 *peak clipping, v*—simple form of signal processing that limits the amplitude of signals that exceed a predetermined level to prevent the audio output from being too loud and causing listener discomfort.

3.1.92 *percentile, n*—given the range of variability of (human) bodily dimensions, anthropometric data are typically expressed as percentile statistics, such as 5th or 95th percentile and a percentile statistic defines the anthropometric point at which a percentage of a population falls above or below that value.

3.1.92.1 *Discussion*—For example, the seated eye height of a 95th percentile North American male is 853 mm (33.5 in.), so, by definition, 5 % of North American males will have a seated eye height of greater than this figure, and 95 % will have a lesser seated eye height.

3.1.93 *permanent access, n*—means of access (for example, walkway, passageway, stair, ladder, platform, clear deck area, and so forth) shall be a permanent structure (that is, not

portable) firmly secured in place or kept clear of any obstruction or both and always immediately available for use without requiring the operator to reconfigure structures.

3.1.94 *pipe marker labels, n*—labels with colored markings (for example, bands of color), text, and flow arrows placed on pipes to identify pipe content and flow direction.

3.1.95 *pixel, n*—smallest discrete element on a video screen.

3.1.96 *pointer, n*—symbol displayed on a video display that is controlled by a pointing device.

3.1.96.1 *Discussion*—Its shape may change depending on the function that is invoked or its location on the video display.

3.1.97 *pointing device, n*—non-keyboard device that allows personnel to navigate rapidly around a video display and specify and select objects for manipulation and action.

3.1.97.1 *Discussion*—Examples include a mouse, track ball, stylus and grid, light pen, and operator finger.

3.1.98 *positive fall protection, n*—device that attaches to a vertical ladder and a safety harness worn by a ladder climber that eliminates the chance for the climber to fall from the ladder.

3.1.99 *primary field of view, n*—area approximately 15° above and below the normal line of sight and 15° to the right and left of the center line of the human head (that is, a 30° cone drawn on any visual object viewed by the human eye).

3.1.100 *query, n*—process of specifying, locating, and retrieving data matching specified characteristics from a database.

3.1.101 *radio buttons (exclusive buttons or option buttons), n*—single, two-state choices, that are mutually exclusive from each other.

3.1.102 *railing, n*—single horizontal pipe or other material attached to stairs with three or less steps to a bulkhead or other structure at stairs enclosed on both sides regardless of the number of steps or to bulkheads or other structures along corridors or walkways that a person walking can hold on to for stability.

3.1.103 *readable, adv*—state in which the alphanumeric characters or other written or pictorial information is presented in such a way as to be understandable and transmits a meaningful message to the user.

3.1.104 *resolution, n*—number of individual points of color contained on a video display expressed in terms of the number of pixels on the horizontal axis and the number on the vertical axis.

3.1.105 *rise, n*—vertical distance from the top of a tread to the top of the next higher tread.

3.1.106 *riser, n*—upright member of a step that connects the back of a lower tread to near the leading edge of the next higher tread.

3.1.107 *rung, n*—ladder crosspieces of a circular or square cross section on which a person steps to climb up or down the ladder.

3.1.108 *safety cage, n*—enclosure that is fastened to the stringers of a vertical ladder so as to encircle the person climbing the ladder to protect against falls from the ladder.

3.1.109 *saturation, n*—extent to which a chromatic color differs from a gray of the same brightness.

3.1.109.1 *Discussion*—It is a measure on an arbitrary scale from 0 (gray) to 100 %.

3.1.110 *scrolling, v*—method used to move through the contents of a window or list in a dialogue box using the scroll bar or scroll arrows.

3.1.111 *shall, v*—in this practice, shall means that the use of the criteria identified is mandatory and can only be replaced or rejected by written authority from the procuring agency or organization.

3.1.112 *should, v*—in this practice, should means that the criteria identified are to be used unless there is a justifiable reason to replace the given criteria with some other and that the procuring authority or organization is so notified of the change.

3.1.113 *sight gauge, n*—tube, normally attached to the side of a tank or other vessel, that is filled with the tank's liquid, or some other indicator, to show the depth of the liquid in the tank or vessel.

3.1.114 *simple indicator, n*—light with no text or pictorial presentation but color coded to show the status of a piece of equipment or system.

3.1.115 *slip resistant, n*—the provision of adequate slip resistance to reduce the likelihood of slip for pedestrians using reasonable care on the walking surface under expected use conditions.

3.1.116 *spatial relationship, n*—placement of controls, displays, and their related equipment so that it is visually obvious to an operator or maintainer that all components of a particular system are related.

3.1.116.1 *Discussion*—Consoles and workstations shall be designed and oriented so the individual displays and controls on the consoles or workstations are arranged, as viewed by the operator facing the console or workstation, in the same spatial arrangement as the actual equipment located on the ship or maritime structure that is being controlled or monitored at the console or workstation (for example, controls and displays on the left side of a panel relate to equipment on the left side of the operator as viewed by the operator facing the panel or console).

3.1.117 *speech interference level (SIL), n*—measure of the effectiveness of noise in masking speech; it is the arithmetic mean of the same pressure levels of interfering noise in the four octave bands centered on the frequencies 500, 1000, 2000, and 4000 Hz, respectively.

3.1.117.1 *Discussion*—The unit of speech interference is the decibel (dB (A)).

3.1.118 *steps, n*—flat crosspieces of a stair on which a person steps to go up or down the stairs.

3.1.119 *stringers, n*—two vertical side rails (usually made of pipe) to which the rungs are attached on a vertical ladder or the two beams on either side of a stair to which the stair steps are attached.

3.1.120 *subassembly, n*—two or more units that form a portion of an assembly or a unit replaceable as a whole but having a part or parts that are individually replaceable.

3.1.121 *toeboard, n*—barrier placed along the edge of a walking surface to prevent personnel from placing their foot over the edge of an elevated walking surface or prevent objects from sliding or rolling over the edge onto personnel below.

3.1.122 *transilluminated display, n*—any display that is illuminated by sources within the display.

3.1.123 *tread, n*—horizontal member of a step (that is, the walking surface of a stair).

3.1.124 *tread depth, n*—horizontal distance from the front to back of a tread including the nosing when used.

3.1.125 *unit, n*—assembly or any combination of parts, subassemblies, and assemblies mounted together normally capable of independent operation in a variety of situations.

3.1.126 *user, n*—a person who works or inhabits an environment and accesses, operates or maintains a system to include equipment, computer, machinery, vessel, or other devices.

3.1.127 *vertical ladder, n*—ladder consisting of stringers and rungs that runs vertically from one deck level to another and is installed at an angle of between 75 and 90° from the horizontal.

3.1.128 *video-display unit, n*—display devices such as CRTs, flat plasma displays, liquid-crystal displays, light emitting diode (LED) displays, projectors, heads-up displays, and other display technologies.

3.1.129 *visible, adj—(1)* term visible means the operator can see the control from the normal working position without having to stand on pipes, wire ways, or structures; without assuming an awkward posture; without obstructions to the line of sight; and with ambient illumination under all operating conditions; and *(2)* state in which a display, label, sign, or any other printed or pictorially presented information can be seen from among all the other visual displays available within a user's field of view.

3.1.130 *visual alarm, n*—alarm comprised of flashing lights, lighted annunciators, rotating beacons, strobe lights, or some other form of visually presented information to the crew member.

3.1.131 *visual display, n*—type of display that visually provides information on the condition or status of a piece of equipment or system or of the environment.

3.1.132 *visually distinguishable, adj*—having colors and patterns that provide conspicuous markings for the conditions being delineated, their surroundings, and the environment in which they will be viewed by users.

3.1.132.1 *Discussion*—Bright yellow is a commonly used color for alerting users of the presence of certain walkway conditions. When properly applied and maintained, other colors can also provide effective warnings.

3.1.133 *workplace, n*—contained or otherwise defined area occupied by the human operator/maintainer to monitor, operate, maintain, repair, calibrate, or replace a piece of equipment or total system or to complete any task required as a part of the person's assigned duties.

3.1.133.1 *Discussion*—Workplaces can contain one or more consoles, panels, pieces of equipment, or individual controls and displays, or combination thereof.

4. Significance and Use

4.1 The objective of this practice is to provide ergonomic design criteria for maritime vessels and structures to ensure that maritime systems and equipment are designed in compliance with requirements for human performance, human workload, health and safety, survivability, and habitability.

4.2 *Principles of Human Behavior:*

4.2.1 There are basic principles of human behavior that control or influence how each person performs in their workplace. Some of these behaviors are culturally derived, while others are general and uniform across all cultures and geographical regions of the world. These behaviors influence a person's physical, social, and psychological approach toward the work they do and how safely they do that work. Failure to satisfy these behavioral principles in the design of a ship or maritime structure can encourage, or even coerce, maritime personnel into taking unsafe risks in their everyday activities. It is, therefore, imperative that designers of ships and maritime equipment, systems, and facilities know these principles to provide a safe and efficient workplace for maritime personnel.

4.2.2 These principles include:

4.2.2.1 If the design of the ship or maritime facility is considered to be unsafe or inefficient by the crew, it will be modified by the users, often solving the initial problem but introducing others that may be as bad, or worse, than the original.

4.2.2.2 Equipment design shall be such that it encourages safe use, that is, does not provide hardware and software that can be used in an unsafe manner.

4.2.2.3 If the equipment or system is not designed to operate as the users' cultural and stereotypical expectations lead them to think that it will operate, the chance for human error is significantly increased.

4.2.2.4 If equipment or systems are perceived by operators/maintainers to be too complex or require more effort to operate or maintain than they believe is necessary, they will always look for a "shortcut." Further, this "shortcut" may be perceived as being safe when it is not.

4.2.2.5 No amount of training, company or organizational policy, threats of retaliatory action, warning notes in a technical manual or training guide, or pleading with personnel to be safe on the job can overcome poor design that encourages, leads, or even coerces personnel into unsafe acts on the job. The most efficient way to prevent unsafe design from contributing to an accident is to eliminate the unsafe design.

4.2.2.6 Equipment users may not recognize latent hazards in a design. Therefore designers shall identify unsafe features that may not be recognized by users to minimize, or eliminate unsafe tasks, operations and acts. In addition, if hazards exist, the designer should clearly communicate known hazards inherent in processes and procedures to the users.

4.2.2.7 Designers shall consider the possibility for human error and design equipment so that incorrect use (deliberate or accidental) will result in little or no harm to the user.

4.2.2.8 Equipment operators and maintainers will be forced to infer as to what a label, instruction, or operational chart states if it is not complete, legible, readable, and positioned correctly.

4.2.2.9 Designers and engineers shall never use themselves as the standard against which a particular design is evaluated. People come in many shapes, sizes, mental capacities, and capabilities. Therefore, design for the full range of potential users, physically, mentally, and socially.

4.2.2.10 People shall be protected against themselves. Designers cannot create an unsafe piece of equipment or system and expect the users to assume full responsibility for its safe use.

4.2.2.11 Ease of equipment maintenance affects the equipment's reliability, that is, the harder it is to be maintained, the less it will be maintained.

4.2.2.12 Equipment designed to require multiple operators working together simultaneously increases the likelihood of operator errors.

4.2.2.13 Operational/maintenance procedures shall be clear, definitive, and comprehensive, otherwise, they will be misinterpreted or ignored.

4.2.2.14 Structural items such as piping, cable trays, or any other item that appears strong enough to be used by a person to hold onto or stand on, and is placed in a convenient location to use for that purpose, will eventually be used for that purpose.

4.2.2.15 Users expect consistency in the design and arrangement of their workplace. Therefore, if that workplace, or any part thereof, appears in more than one place in their work environment, it is expected to be located and look the same way at every location.

4.2.2.16 When controls and displays associated with particular pieces of equipment are placed on a console or control panel, they shall be located on that console or panel to replicate the actual location of the equipment on the ship or structure as both are viewed by the operator. Therefore, equipment that is to the operator's left as he or she faces the control station shall appear on the left of the control panel or console, and equipment to the right shall appear on the right side of the console or panel. This "spatial relationship" between the real world and the controls and displays that are associated with the equipment and systems of that world is extremely important in the design of ships and maritime structures.

4.2.3 Users develop behavioral patterns based on their cultural experiences. Designing a ship or structure that ignores or violate those culturally derived behavior patterns will inevitably increase risks of user error.

4.3 *Conflicts*—Where conflicts exist between the design criteria contained in this practice and other sources of ergonomic design criteria, this practice should prevail except where the conflicting criteria were produced by a regulatory authority

4.4 *Coverage*—The design of vessels, structures, systems, subsystems, and equipment shall use the design criteria contained herein to provide the following:

4.4.1 Safe atmospheric conditions including temperature and humidity;

4.4.2 Limits on acoustic noise and vibration that will prevent performance degradation and physiological damage;

4.4.3 Space for personnel, their equipment, and free volume for the movements and activities they are required to perform for operational and maintenance tasks under both normal and emergency conditions;

4.4.4 Physical, visual, auditory, and other communication links between individual personnel and between personnel and their equipment under both normal and emergency conditions;

4.4.5 Efficient arrangement of operation and maintenance workplaces, equipment, structural elements, controls, and displays;

4.4.6 Natural or artificial illumination at levels suitable to perform all operational and maintenance tasks under both normal and emergency conditions;

4.4.7 Safe passageways, hatches, stairs, ladders, walkways, platforms, ramps, and other provisions for ingress, egress, and passage under both normal and emergency conditions;

4.4.8 Provision for protective equipment and clothing, systems, equipment, vessels, and structures that are designed to be operated and maintained by personnel wearing the equipment and clothing;

4.4.9 Compatibility of control/display interfaces with human information processing capability;

4.4.10 Immediate, accurate, and pertinent feedback to the operator of equipment or system performance after each control movement or action taken by the operator;

4.4.11 Designs that satisfy human behavioral needs such as spatial relationships, consistency, homeostasis, and cultural and equipment expectations;

4.4.12 Provision for labels, hazard signage, instructions, and procedures that are clear, concise, and understandable;

4.4.13 Provision for fail-safe designs in those areas in which failure can disable a vital system or cause catastrophic damage to equipment, injury to personnel, or loss of mission capability;

4.4.14 Designs that minimize potential human error incidence in the operation and maintenance of the system, particularly under conditions of stress and designs that ensure that errors, having been committed, can be corrected in time (the design is error tolerant);

4.4.15 Designs that minimize training time and costs and encourage simplicity so as to reduce personnel special skills or innate abilities required to operate or maintain them;

4.4.16 Designs that minimize the adverse impact of ship motion on human performance and health and safety; and

4.4.17 Designs that provide for safe and efficient operation and maintenance by user populations from all geographical regions of the maritime world.

4.5 *Standardization*—Controls, displays, markings, coding, labeling, and arrangement schemes for equipment and panel layouts shall be uniform for those items or designs that appear more than once on the vessel or structure. Human-machine interfaces shall exhibit common design approaches based on conventions and conformance to operator and maintainer expectations.

4.6 *Off-the-Shelf Equipment*—One criterion for selecting off-the-shelf commercial or government-furnished equipment should be the degree to which the equipment conforms to the design criteria of this practice. Where off-the-shelf equipment

requires modification to interface with other equipment, the modification should be designed to comply with this practice.

4.7 *Minimize Personnel*—The design objective of the vessel or structure, equipment, systems, and subsystems shall be to reduce the number of personnel involved, especially simultaneously, in completing a particular task. Another design objective shall be to optimize ship or system manning, defined as the minimum number of personnel consistent with human performance, workload and safety requirements, reliability, affordability, and risk constraints.

4.8 *Completeness*—It is realized that no design guide or practice can cover every design requirement that might occur through the course of a ship or maritime structure's evolution. It is recognized that there will be occurrences in which a particular design requirement may have to be interpreted from the data that do exist. There may also be occasions in which design criteria may have to be acquired from a source other than this practice. When those occurrences arise, it is important that assistance be provided by trained human factors engineering (HFE) professionals familiar with this, and other, maritime-oriented design guidelines and standards and experienced in the application of these guidelines to the design of ships and maritime structures.

5. Controls

5.1 *Principles of Control Design:*

5.1.1 *Labeling*—Controls shall be labeled in compliance with the requirements described in Section 15.

5.1.2 *Feedback*—Positive indication of control activation shall be provided by means of feel (for example, snap action), an audible clicking noise, or a display.

5.1.3 *Users*—The type of control selected and the location of the motion envelope provided for control operation shall ensure that suitably clothed and equipped expected or defined user populations with applicable 5th through 95th percentile body dimensions (see Section 9, "Anthropometry") can operate them.

5.1.4 *Right versus Left-Handed Operation*—Since more operators are right handed than left handed, equipment shall be designed for right-handed operation. This is especially important for controls that require the finest degrees of setting accuracy, or the most force to operate.

5.1.5 *Multi-rotation Control*—Multi-rotation controls (such as a knob, crank or handwheel) shall be used when precision is required over a wide range of adjustment.

5.1.6 *Detent Control*—Detent controls shall be selected whenever the operational mode requires control operation in discrete steps.

5.1.7 *Simultaneous Operation of Controls*—Controls shall be placed so that simultaneous operation of two controls will not require a crossing or interchanging of hands. Controls required to be used by two operators shall be duplicated, or otherwise centered between the two operators or positioned nearest to the operator having the greatest need. If any control is required to be operated with the operator's preferred hand, such as operating a keyboard or fine setting a continuous control knob, duplicate controls shall be provided.

5.1.8 *Controls for Maintenance*—Controls used solely for maintenance or adjustment shall be covered or otherwise protected during normal operations, but within the maintainer's reach and visual envelopes when needed for maintenance.

5.1.9 *Prevention of Accidental Activation*—Controls shall be designed and located so they are not susceptible to accidental activation. Acceptable methods to reduce the likelihood of accidental activation include:

(1) Locating and orienting the control so that bumping is unlikely to cause an activation,

(2) Providing sufficient control resistance to prevent unintentional movements,

(3) Requiring complex motions for control activation, such as an interlock or rotary motion, and

(4) Restricting access to controls by isolating them or by providing a cover guard or physical barrier.

5.1.9.1 *Hidden or Internal Controls*—Hidden or internal controls shall be protected from inadvertent activation or unintentional movement. They shall also be located so the operator cannot come in contact with electrical contacts, hot pipes or other hazards.

5.1.10 *Clothing/PPE*—All controls shall be operable by personnel wearing both normal clothing and personnel protective equipment (PPE) such as boots, gloves, and hazard material clothing.

5.1.11 *Consistent Arrangement*—Functionally similar or identical controls shall be consistently arranged, and oriented from one panel, console, or workstation to another throughout the individual equipment, systems, or total ship or maritime structure.

5.2 *General Design Guidelines:*

5.2.1 *Selecting Controls*—The following guidelines described below and in Table 1 shall be used in selecting controls:

5.2.1.1 Assign controls requiring rapid or precise setting to the hands vice the feet.

5.2.1.2 Assign controls requiring large or continuous forward applications of force to the feet. Although a considerable number and variety of controls can be assigned to the hands, each foot should not have more than two controls assigned to it, and these should require only fore-aft or ankle flexion movement.

5.2.1.3 Controls shall be distributed so that no one limb is overburdened.

5.2.1.4 Select, locate, and orient controls so that their motion is compatible with the movement of the associated display element, equipment, component, vessel, or structure.

5.2.1.5 Select multi-rotation controls (for example, cranks) when precise settings are required over a wide range of adjustments with attention given to its effect on operating time.

5.2.1.6 Select discrete-adjustment (detent) controls or push-button arrays rather than continuous-adjustment controls when the controlled object is to be adjusted for discrete positions or values only. Discrete-adjustment controls are preferred when a limited number of settings are required, or when precision requirements are such that a limited number of settings can represent the entire continuum.

5.2.1.7 Continuous-adjustment controls shall be selected when precise adjustment along a continuum is needed.

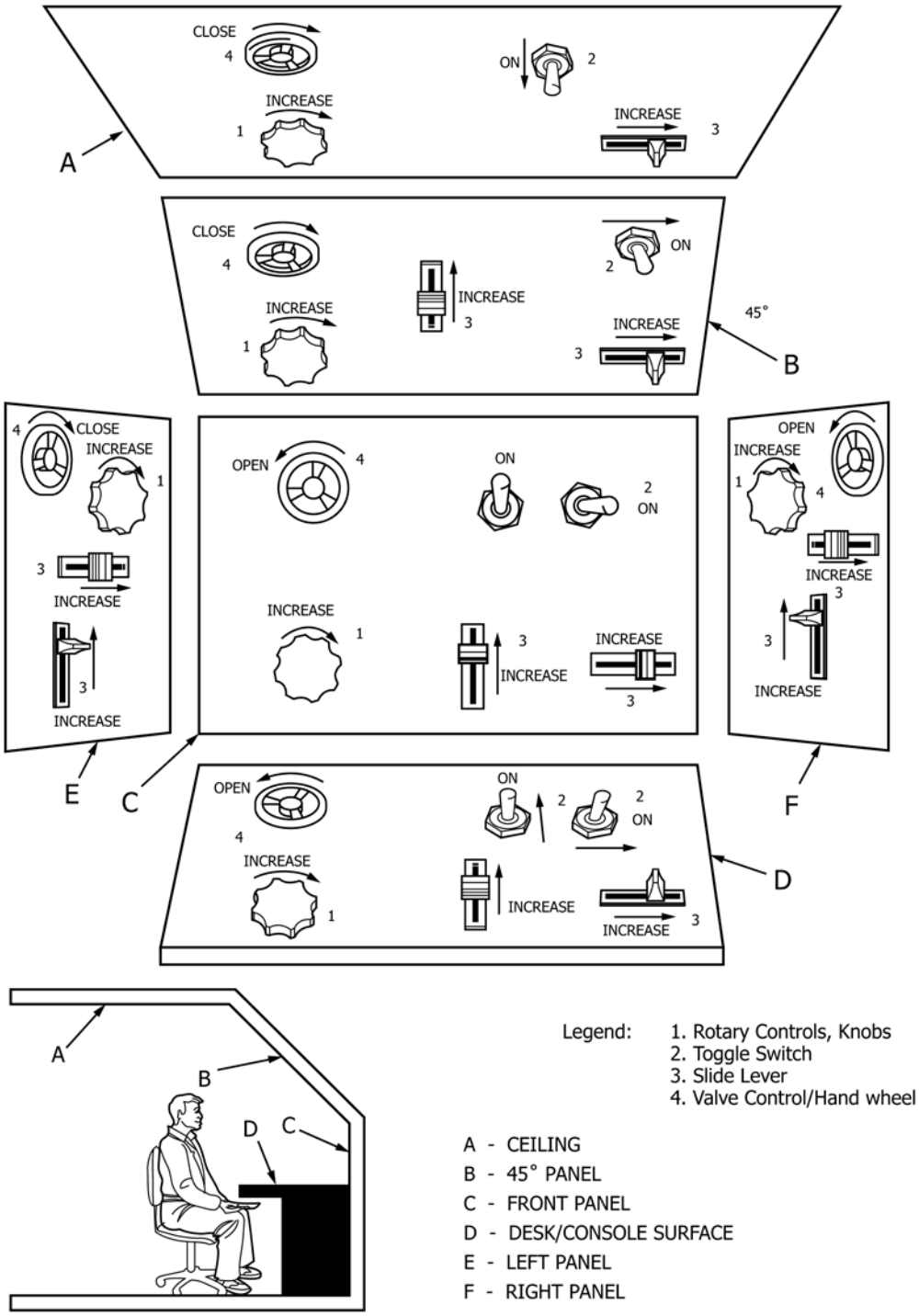


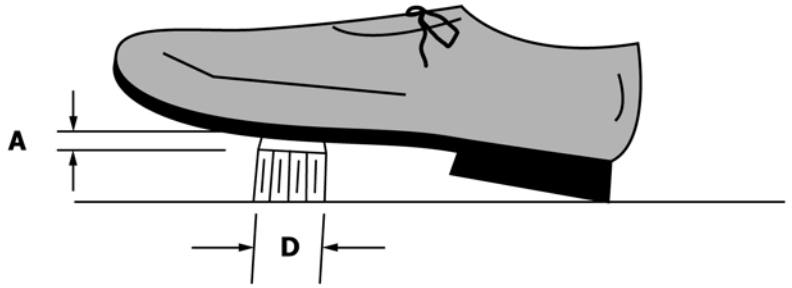
FIG. 1 Control Movement Expectations

5.2.1.8 Select controls that can be easily identified. All critical and emergency controls shall be identifiable both visually and by touch (for example, shape coding) and possibly by location. Identification information shall not hinder the manipulation of the control nor increase the likelihood of accidental activation.

5.2.1.9 Locate functionally related controls together to reduce reaching movements, aid in sequential or simultaneous operations, or economize panel space.

5.2.1.10 Multi-axis continuous controllers (for example, joysticks) should be used to provide continuous control within a two dimensional space (for example, positioning a pointer on a computer screen) or a three dimensional space (for example, operating a crane).

5.2.1.11 Ambient or internal illumination or both shall be provided so as to make all controls visible under all operational conditions.



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

FIG. 2 Foot-Operated Switches Design Requirements

5.2.1.12 Locate most important or frequently used controls in the most favorable position with respect to operator reach and grasping.

5.2.1.13 Controls operated in sequence should be arranged in that order.

5.3 *Control Movement:*

5.3.1 *Direction*—The direction of control movement shall be consistent among the same function and application and shall operate according to the cultural expectations (that is, design expectations) of the intended operators. Widely accepted movement expectations for the majority of maritime personnel worldwide are indicated in Table 2 and Fig. 1. This figure demonstrates that control movement expectations change depending on the location of the control in reference to an operator or maintainer's body position.

5.4 *Control Spacing:*

5.4.1 *Control Spacing*—Minimum separation between mechanical controls shall be as shown in Table 3.

5.4.2 *Blind Operation*—"Blind" operational controls shall be avoided, but where necessary, hand controls shall be shape coded or separated from adjacent controls by at least 127 mm (5 in.).

5.5 *Coding of Controls:*

5.5.1 *Control Coding*—Coding of controls through shape, size, color, texture, location, labeling, or other schemes to assist with the identification of a particular control or control function should be used provided the design requirements provided in 5.5.2 – 5.5.6 are met.

5.5.2 *Color Coding*—Color coding shall be used as a redundant form of information with other coding techniques. Color coding is most effective when a specific meaning can be attached to a color, and the color is used consistently with the associated meaning. Only the following colors should be used for color coding of controls: red, green, orange-yellow, and white. Blue may be used only if an additional color is absolutely necessary. If red ambient lighting could be used at any time in which the color-coded control would be operated (for example, night time on the navigational bridge), controls that would otherwise be color coded red should be coded orange-yellow with black striping. Controls that are not color coded should be black or gray.

5.5.2.1 *When Not to Color Code*—Color coding of control surfaces shall not be used when visibility of the controls is restricted or obstructed, or when illumination lighting is below 0.35 cd/m^2 (0.1 ft-L) or of some color other than white.

5.5.2.2 *Consistency*—When related controls and displays are color coded, they shall be coded the same color.

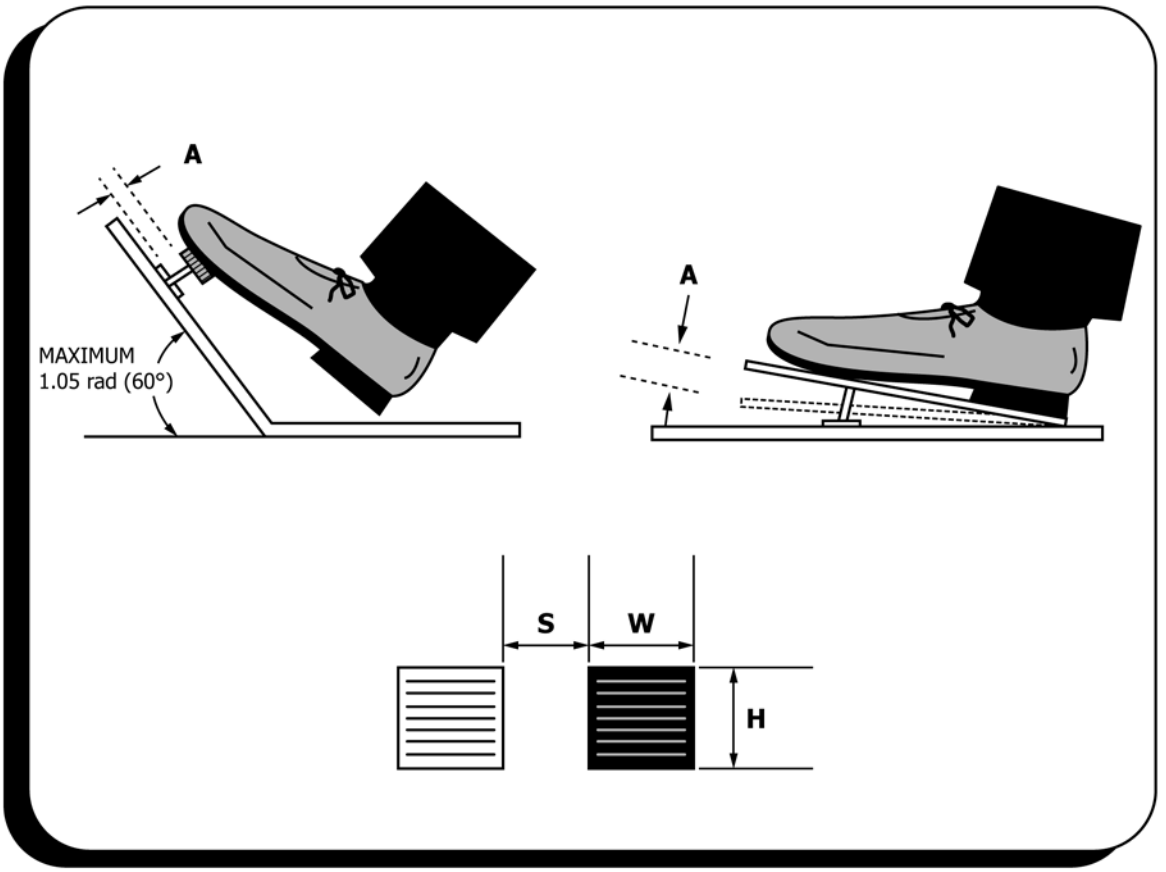
5.5.2.3 *Color Coding Under Red Lighting*—All emergency controls used under only white lighting shall be colored red. If red lighting is to be used during any portion of a mission, controls which would have been coded red shall be coded by orange-yellow and black striping. Color coding of other controls shall be kept to a minimum.

5.5.3 *Shape Coding*—Coding by shape is useful when controls should be identified without the use of vision. Shapes that suggest the purpose of the control (for example, round for a wheel, flap shape for an airplane wing flap) should be used.

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

5.5.3.2 The number of shapes to be identified by each operator based on absolute discrimination shall be not more than ten.

5.5.3.3 Shapes shall be tactually identifiable when gloves are worn.



	DIMENSIONS		DISPLACEMENT			
	H	W	A			
	Height	Width	Normal Operation	Heavy Boots	Ankle Flexion	Total Leg Movement
Minimum	25 mm (1 in)	75 mm (3 in)	13 mm (1/2 in)	25 mm (1 in)	25 mm (1 in)	25 mm (1 in)
Maximum	–	–	65 mm (2 1/2 in)	65 mm (2 1/2 in)	65 mm (2 1/2 in)	180 mm (7 in)

	RESISTANCE			
	Foot Not Resting on Pedal	Foot Resting on Pedal	Ankle Flexion Only	Total Leg Movement
Minimum	18 N (4 lb)	45 N (10 lb)	–	45 N (10 lb)
Maximum	90 N (20 lb)	90 N (20 lb)	45 N (10 lb)	800 N (180 lb)

	SEPARATION	
	S	
	One Foot Random	One Foot Sequential
Minimum	100 mm (4 in)	50 mm (2 in)
Maximum	150 mm (6 in)	100 mm (4 in)

FIG. 3 Pedal Location and Design Requirements

TABLE 1 Recommended Manual Controls

Control Function	Control Type
Small Actuation Force Controls	
2 discrete positions	Key lock Pushbutton Toggle switch Legend switch Slide switch
3 discrete positions	Pushbutton Rotary selector switch Toggle switch
4 to 24 discrete positions	Rotary selector switch
Continuous setting (linear and less than 360°)	Continuous rotary knob Joystick or lever
Continuous slewing and fine adjustment	Continuous rotary knob Crank Joystick
Large Actuation Force Controls	
2 discrete positions	Foot pushbutton Hand pushbutton Detent lever
3 to 24 discrete positions	Detent lever Rotary selector switch
Continuous setting (linear and less than 360°)	Handwheel Joystick or lever Crank Two-axis grip handle
Continuous setting (greater than 360°)	Crank Handwheel Valve Two-axis grip handle

TABLE 2 Control Movement Expectations

Direction of Control Movement	Function
Up, right, forward, clockwise, pull (push-pull type)	On
Down, left, rearward, counterclockwise, push	Off
Clockwise, right	Right
Counterclockwise, left	Left
Up, back	Raise
Down, forward	Lower
Up, rearward, pull	Retract
Down, forward, push	Extend
Forward, up, right, clockwise	Increase
Rearward, down, left, counterclockwise	Decrease
Counterclockwise (valve)	Open valve
Clockwise (valve)	Close valve

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

5.5.4 *Size Coding*—Coding by size is useful when controls are to be identified without the use of vision. If personnel are to rely on touch alone, at most three sizes of controls shall be used and knobs shall differ by at least 13 mm (0.5 in.) in diameter or by 10 mm (0.4 in.) in thickness. Size coding, as with other coding methods, should be used consistently. Controls used for performing the same function on different items of equipment shall be the same size.

5.5.5 *Texture Coding*—Three surface characteristics shall be used together to provide accurate discrimination through texture: smooth, fluted, and knurled. Different degrees of fluting or knurling should not be used together to provide discrimination.

5.5.6 *Location Coding*—Controls that are used frequently shall be located in a specific location with respect to the operator to facilitate finding them rapidly, and this location shall be common at all workstations and panels.

5.6 *Control Use and Design:*

5.6.1 *Foot-operated Controls:*

5.6.1.1 *Use*—Foot-operated controls may be used under the following conditions:

(1) Control operation requires greater force than the upper body can provide.

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

(3) A safety shutdown control is required during an operation in which the operator's hands cannot be freed to reach a safety switch.

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

5.6.1.2 *Avoidance of Use*—Foot-operated controls shall not be used under the following conditions:

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

(2) Precise control operations are required.

(3) Selection from among three or more separate controls is required.

5.6.2 *Foot-Operated Switches:*

5.6.2.1 *Use*—Foot-operated switches shall be used only where the operator is likely to have both hands occupied when switch activation may be required or when load sharing among limbs is desirable. Their uses shall be limited to noncritical or infrequent operations such as press-to-talk communication or vehicle headlight dimming.

5.6.2.2 *Operation*—Foot switches shall be positioned for operation by the toe and the ball of the foot rather than by the heel. They shall not be located so near an obstruction that the operator cannot center the ball of the foot on the switch button. When the switch may become wet and slippery, the switch-cap surface shall possess a frictional surface to minimize the possibility of the foot slipping off the switch.

5.6.2.3 *Design*—Dimensions, resistance, and displacement of foot-operated switches shall conform to the criteria in Fig. 2. Although not recommended (only one switch per foot is preferred), when one foot is required to operate more than one switch, such switches shall be at least 75 mm (3 in.) apart horizontal; 203 mm (8 in.) apart vertical.

5.6.2.4 *Feedback*—A positive indication of control activation shall be provided (for example, snap feel, audible click, associated visual, or auditory display).

TABLE 3 Minimum Spacing Between Two Controls

NOTE 1—All values are for one hand operation.

NOTE 2—Distances are measured from the edge of each control.

NOTE 3—Unless otherwise specified, all dimensions cited herein are for bare hands and should be increased for use with gloves or mittens.

	Toggle Switches	Pushbuttons[A]	Continuous Rotary Controls	Rotary Selector Switches	Discrete Thumbwheel Controls
Toggle Switches	19 mm (0.75 in.)	13 mm (0.5 in.)	19 mm (0.75 in.)	19 mm (0.75 in.)	13 mm (0.5 in.)
Pushbutton	13 mm (0.5 in.)	13 mm (0.5 in.)	13 mm (0.5 in.)	13 mm (0.5 in.)	13 mm (0.5 in.)
Continuous Rotary Controls	19 mm (0.75 in.)	13 mm (0.5 in.)	25 mm (1.0 in.)	25 mm (1.0 in.)	19 mm (0.75 in.)
Rotary Selector Switches	19 mm (0.75 in.)	13 mm (0.5 in.)	25 mm (1.0 in.)	25 mm (1.0 in.)	19 mm (0.75 in.)
Discrete Thumbwheel Controls	13 mm (0.5 in.)	13 mm (0.5 in.)	19 mm (0.75 in.)	19 mm (0.75 in.)	10 mm (0.4 in.)

[A] For pushbuttons not separated by barriers.

5.6.3 *Foot-operated Pedals:*

5.6.3.1 *Use*—Pedal controls shall be used only when the operator is likely to have both hands occupied when control operation is required or control system force is too high for manual force capability of the operator, or standardized use of pedals has created a stereotype expectancy (for example, vehicle pedal control configurations such as clutch, brake, and accelerator or aircraft rudder).

5.6.3.2 *Location*—Pedal controls shall be located so that the operator can reach them without extreme stretching or torso twisting and can reach the maximally displaced pedals within anthropometric limits and force capabilities (see Fig. 3). Pedals that may be held or shall be adjusted shall be located so the so the operator's heel can rest on the floor while articulating the ankle/foot.

5.6.3.3 *Lateral*—Lateral spacing between pedals shall conform to Fig. 4. However, the overall array shall not exceed 737 mm (29 in.) as measured from the outermost pedal centerlines.

5.6.4 *Discrete Rotary Controls:*

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

5.6.4.2 *Design Criteria*—A rotary selector switch that is not visible to the operator during normal system operation shall have no more than 12 positions. A rotary switch that is constantly visible to the operator shall have not more than 24 positions. In addition, the following design criteria shall apply:

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

(2) Mechanical detents shall be provided as the switch cannot be positioned in between nominal switch positions.

(3) A reference line shall be provided on rotary switch controls. This line shall have at least 75 % luminance contrast with the control color under all lighting conditions.

(4) Actuating torque requirements shall be compatible with control knob sizes, that is, knob dimensions of 25 mm (1 in.) or less shall not require a torque of more than 115 mN·m (1 lb·in.). Medium-sized knobs, 25 to 50 mm (1 to 2 in.), shall have a torque of less than 345 mN·m (3 lb·in.). The larger knobs, diameters of 75 mm (3 in.), shall not require an actuation torque greater than 1015 mN·m (9 lb·in.).

(5) Rotary control dimensions, switch displacement, and control separation shall conform to criteria in Figs. 5 and 6.

5.6.5 *Continuous Adjustment Rotary Controls:*

5.6.5.1 *Use*—Knobs for continuous adjustment control shall be used when low forces or precise adjustments of a continuous variable are required. A moving knob with fixed scale is preferred over a moving scale with fixed index. If positions of single revolution controls shall be distinguished, a pointer or marker shall be available on the knob.

5.6.5.2 *Knob Design*—The dimensions and resistance of knobs, and the separation between adjacent edges of knobs, shall be within the limits specified in Fig. 7.

5.6.6 *Hand Cranks:*

5.6.6.1 *Use*—Cranks shall be used for tasks requiring many rotations of a control, particularly where high rates or large forces are involved. Where cranks are used for tuning, or other processes involving numerical selection, each rotation shall correspond to a multiple of 1, 10, 100, and so forth.

5.6.6.2 *Crank Handle*—The crank grip handle shall be designed so that it turns freely around its shaft. If a crank handle could become a hazard to persons passing by, or it is critical that the handle not be inadvertently displaced by being accidentally bumped, a folding handle-type control shall be used.

5.6.6.3 *Orientation*—Cranks that must be turned rapidly shall be mounted so their turning axis are between 60° and 90° from the frontal plane as shown in Fig. 8.

5.6.6.4 *Location*—For standing operators, crank handle travel shall be between 914 and 1219 mm (36 and 48 in.) above the floor as measured to the crank handle center line.

5.6.6.5 *Design Criteria*—Dimensions, resistance, and separation between adjacent swept circular areas of cranks shall conform to the criteria of Fig. 9.

5.6.7 *Pushbuttons:*

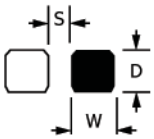
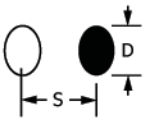
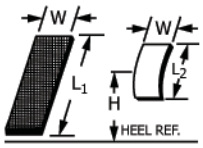
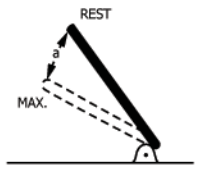
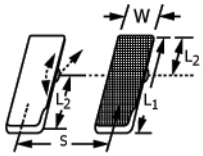
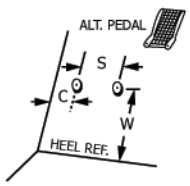
	DESIGN CRITERIA		
	DIMENSIONS	DISPLACEMENT	SEPARATION
	W = 76 mm (3 in) D = 50 mm (2 in)		S = 50 mm (2 in)
	D = 76 mm (3 in)	25 mm (1 in) Min 64 mm (2 ½ in) – 102 mm (4 in) Preferred	S = 311 mm (12 ¼ in) Min S = 470 mm (18 ½ in) Max
 	W = 50 mm (2 in) L = 260 mm (10 ¼ in) Min 311 mm (12 ¼ in) Max	30° (Shoes) 20° (Heavy Boots)	
	W = 76 mm (3 in) Min W = 152 mm (6 in) Max L = 260 mm (10 ¼ in) Min L = 311 mm (12 ¼ in) Max		S = 387 mm (15 ¼ in) Min S = 540 mm (21 ¼ in) Max
	D = 25 mm (1 in) Min H = 184 mm (7 ¼ in) Min H = 260 mm (10 ¼ in) Max C = 76 mm (3 in) Min	13 mm (½ in) Min Shoes 25 mm (1 in) Min Boots 64 mm (2 ½ in) Max	S = 76 mm (3 in) Min

FIG. 4 Lateral Spacing for Pedals

5.6.7.1 *Use*—Pushbuttons shall be used when a control or an array of controls is needed for momentary contact or for activating a locking circuit, particularly in high-frequency-of-use situations. Pushbuttons should not be used for discrete control where the function's status is determined exclusively by a position of the switch, for example, an on-off pushbutton that is pressed in and retained to turn a circuit on and pressed again to release the pushbutton and turn the circuit off.

5.6.7.2 *Shape*—The pushbutton surface shall normally be concave (indented) to fit the finger. When this is impractical, the surface shall provide a high degree of frictional resistance to prevent slipping. Large, hand or fist-operated, mushroom-shaped buttons should be used only as EMERGENCY STOP controls.

5.6.7.3 *Feedback*—A positive indication of control activation shall be provided (snap feel, audible click, or integral light).

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

5.6.7.5 *Design Criteria*—Except for use of pushbuttons in keyboards, the control dimensions, resistance, displacement, and separation between adjacent edges of finger- or hand-operated push buttons shall conform to the criteria in Fig. 10.

5.6.7.6 *Resistance*—Single-finger, 2.8 N (10 oz) to 11 N (40 oz). Thumb or palm, 2.8 N (10 oz) to 23 N (80 oz).

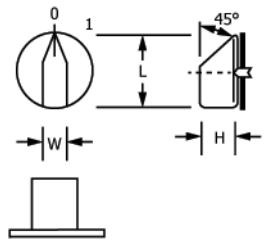
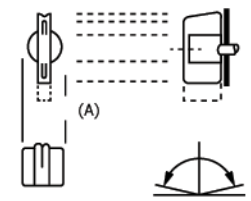
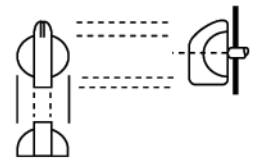
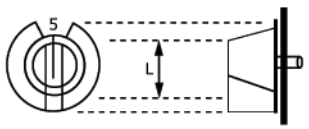
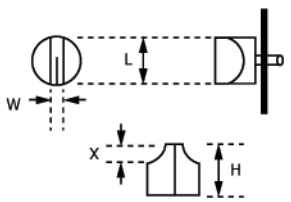
	DESIGN CRITERIA				
	DIMENSIONS			DISPLACEMENT	SEPARATION
	L = 38 mm to 100 mm (1 1/2 in to 4 in) IF GLOVES ARE WORN, ADD 13 mm (1/2 in)	W = 13 mm to 25 mm (1/2 in to 1 in)	H = 16 mm to 75 mm (5/8 in to 3 in)	MIN = 15° MIN POS'N 1D = 30° MAX = 40°; MAX FOR BLIND POSITIONING = 90°	SEE FIG. 6 FOR SIMULTANEOUS OPERATION OF ADJACENT KNOBS (TWO HANDS) ADD 25 mm (1 in), 38 mm (1 1/2 in) FOR GLOVES
	SEE ABOVE	SEE ABOVE	SEE ABOVE	SEE ABOVE	SEE ABOVE
	SEE ABOVE	SEE ABOVE	SEE ABOVE	SEE ABOVE	SEE ABOVE
	L = MIN 25 mm (1 in) OTHER SAME AS A	SEE ABOVE	SEE ABOVE	SEE ABOVE	SEE ABOVE
	L = MIN 19 mm (3/4 in)	W = MIN 6.5 mm (1 1/4 in)	Y = MIN 13 mm (1/2 in)	SEE ABOVE	25 mm (1 in)

FIG. 5 Design Criteria for Discrete Rotary Controls

5.6.7.7 *Interlocks or Barriers*—Mechanical interlocks or barriers may be used instead of the spacing required by Fig. 10.

5.6.8 *Legend Switches (Backlit Pushbuttons):*

5.6.8.1 *Use*—Backlit pushbuttons should be used to incorporate a control and its feedback display within a single device. These controls have labels on the surface of the control and use backlighting to indicate status.

5.6.8.2 *Lamp Test*—Means to test the working condition of the light bulbs in backlit pushbuttons shall be provided. Removal of light bulbs to test or inspect is not an adequate means of testing.

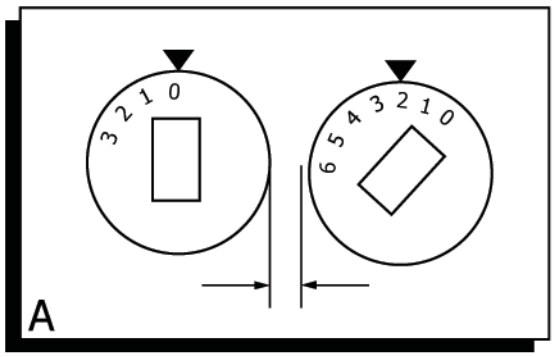
5.6.8.3 *Switch Type*—There are two basic types of legend switches with the preferred design providing a control that has a split display with one half of the display always illuminated indicating the current setting. The other option, acceptable only for noncritical control functions, toggles backlighting between on and off, and therefore can be ambiguous regarding status of equipment or the working status of light bulbs. Both types are shown in Fig. 11.

5.6.8.4 *Design Criteria*—Dimensions, resistance, displacement, and separation between adjacent edges of legend switches shall conform to the criteria in Fig. 12.

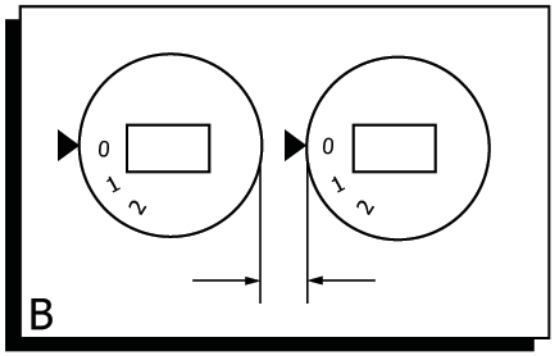
5.6.8.5 *Other Design Criteria*—Other design criteria include:

(1) Legend switches shall be provided with a detent or click for positive indication of switch activation.

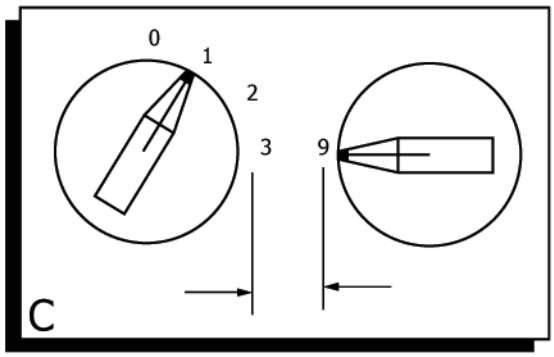
(2) The label (that is, legend) on the face of the switch shall be legible with or without internal illumination. If these controls are to be used in direct sunlight, legends and the control status shall remain readable and discernible when



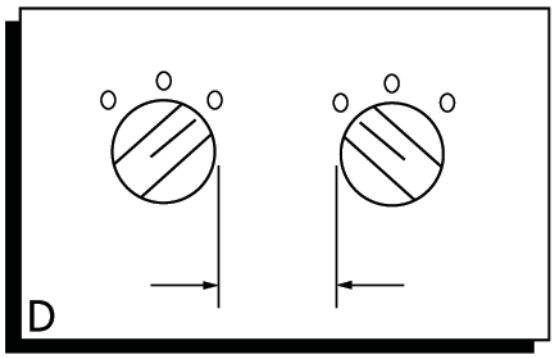
Nominal separation between moving-scale knobs requires only that there is adequate physical separation between the knob skirts to prevent knob movement interference when the zero or referencing index is at the 12-o'clock position.



Separation between moving-scale knobs that have the referencing index at the 3 or 9-o'clock position should be sufficient to ensure that there is not visual confusion regarding the knob to which the index mark refers. Minimum should be about twice the nominal character width.



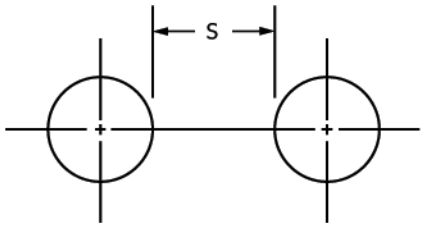
Separation between moving-pointer / fixed-scale configurations should be based on clear visual separation of the adjacent scale characters. The minimum should be at least four character widths. However, if the knob length extends the full width of the skirt and the handle is not tapered at the pointing end, there should be at least a 25 mm (1 in) separation between knobs when they are end to end.

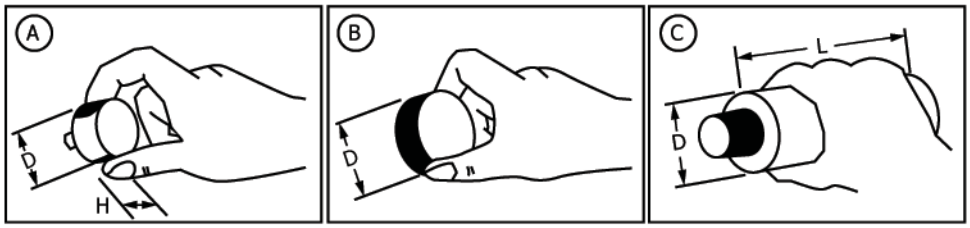


Separation between small, detented knob configurations as shown should be at least 25 mm (1 in) unless there are adjacent panel referencing marks or characters, in which case separation minimums should be established on the basis of (C) above or the 25 mm (1 in) criterion, whichever is greater,

FIG. 6 Separation Requirements for Discrete Rotary Controls

exposed to full sunlight. Internal pushbutton illumination shall be sufficient to discern the status of the display under all





	DIMENSIONS				
	A Fingertip Grasp H Height	D Diameter	B Thumb and Finger Encircled D Diameter	C Palm Grasp D Diameter	L Length
Minimum	13 mm (1/2 in)	10 mm (3/8 in)	25 mm (1 in)	38 mm (11/2 in)	75 mm (3 in)
Maximum	25 mm (1 in)	100 mm (4 in)	75 mm (3 in)	75 mm (3 in)	
	TORQUE		**SEPARATION**		
	*	**			
Minimum	-	-	25 mm (1 in)	50 mm (2 in)	
Optimum	-	-	50 mm (2 in)	125 mm (5 in)	
Maximum	32 mN·m (4 1/2 oz·in)	42 mN·m (6 oz·in)	-	-	

* - To and including 25 mm (1 in) diameter knobs.

** - Greater than 25 mm (1 in) diameter knobs.

FIG. 7 Dimension, Resistance, and Separation of Continuous Rotary Controls

conditions of ambient lighting.

(3) 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.

(4) There shall be a maximum of three lines of lettering on the legend plate.

(5) Legend switches shall be distinguishable to the operator from legend lights.

5.6.9 *Toggle Switch:*

5.6.9.1 *Use*—Toggle switches shall be used for functions that require two discrete positions or where space limitations are severe. Toggle switches with three positions shall be used only where the use of a rotary control or legend switch control are not feasible or when the toggle switch is of the spring-loaded, center position-off type. Three position toggle switches that are spring-loaded (momentary contact switch) to move to the "center-off" position from only one other position shall not be used (since a sudden release from the spring-loaded position may result in the switch handle traveling beyond the off position). Toggle switches are considered herein to be discrete position controls. Small controls that are the same size and shape as toggle switches and used for making continuous adjustments are described herein as levers.

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

5.6.9.3 *Feedback*—An indication of control activation shall be provided (snap feel, audible click, associated or integral light).

5.6.9.4 *Orientation*—Toggle switches shall be vertically oriented with OFF in the down position. Horizontal orientation and actuation of toggle switches shall be used only for compatibility with the controlled function or equipment location. For horizontal orientation ON shall be to the right. Switch orientation and toggle switch movement for ON are shown in Fig. 13.

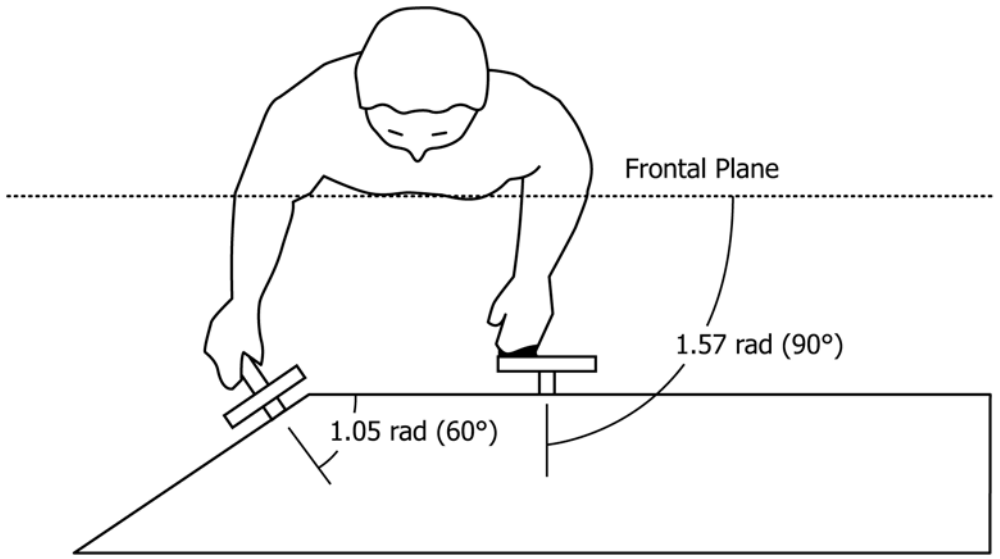


FIG. 8 Proper Mounting of Rapidly Operated Cranks

5.6.9.5 *Design Criteria*—Dimensions for various types of toggle switches are shown in Fig. 13. Resistance shall gradually increase, then drop when the switch snaps into position. The switch shall not be capable of being stopped between positions. Resistance for a small switch ranges from 2.8 N (10 oz) minimum to 4.5 N (16 oz) maximum. For large switches, the forces are 2.8 N (10 oz) minimum to 11 N (40 oz) maximum.

5.6.10 *Rocker Switches:*

5.6.10.1 *Use*—Rocker switches may be used in lieu of toggle switches for functions that require two discrete positions. Rocker switches with three positions shall be used only where the use of a rotary control, legend switch control, or other control type is not feasible and if the control is spring-loaded with the center position being OFF.

5.6.10.2 *Feedback*—An indication of control activation shall be provided (snap feel, audible click, associated or integral light).

5.6.10.3 *Orientation*—Rocker switches should be vertically oriented. Activation of the upper wing shall turn the equipment or component ON, or cause the quantity to increase, or cause the equipment or component to move forward, clockwise, to the right, or up. Horizontal orientation of rocker switches shall be used only for compatibility with the controlled function or equipment location. If rocker switches are oriented horizontally, the switch labeling shall be read horizontally.

5.6.10.4 *Color and Illumination*—Alternate colors may be used to denote the ON and OFF portions of a rocker switch. Alternate illumination of either the ON or OFF switch position may be used to provide positive recognition of current switch position. For areas in which ambient illumination will provide display luminance below 3.5 cd/m^2 (1 ft·L), the rocker switch shall be internally illuminated. Digits and letters shall appear as light or white illuminated characters on an opaque background and their dimensions shall approximate the following:

(1) Height, 4.8 mm (3⁄16 in.);

(2) Height-to-width ratio, 3:2; and

(3) Height-to-stroke width ratio, 10:1.

5.6.10.5 *Design Criteria*—Dimensions, resistance, displacement, and separation between centers of rocker switches shall conform to the criteria in Fig. 14. Resistance shall gradually increase, then drop when the switch snaps into position. The switch shall not be capable of being stopped between positions.

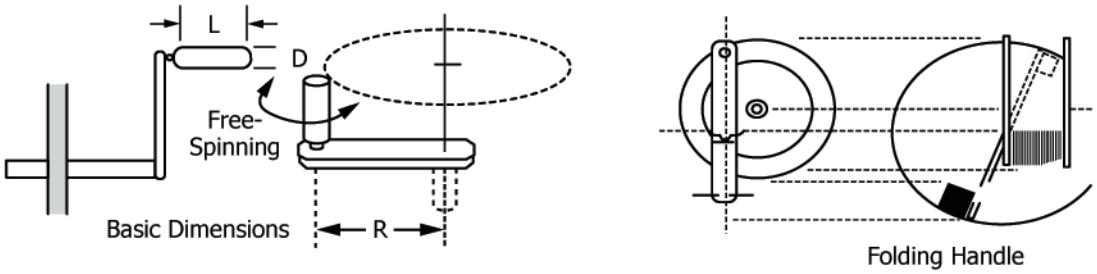
5.6.11 *Discrete Slide Switch Controls:*

5.6.11.1 *Use*—Discrete slide switch controls should be used for functions that require two discrete positions. Discrete slide switch controls should also be used for functions that require a higher number of discrete positions in which switches are arranged in a matrix to permit easy recognition of relative switch settings (for example, audio settings across frequencies), but shall not be used where misunderstanding is to be avoided.

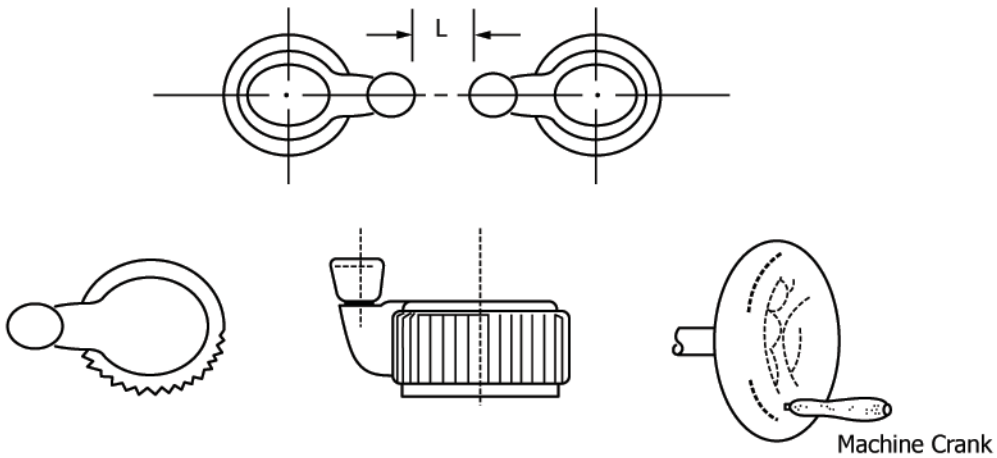
5.6.11.2 *Orientation*—Slide switches shall be vertically oriented with movement of the slide up or away from the operator turning the equipment or component on, causing a quantity to increase, or causing the equipment or component to move forward, clockwise, to the right or up. Horizontal orientation of actuation slide switches shall be used only for compatibility with the controlled function or equipment location. Movement of the slide lever to the right, shall increase the variable being controlled.

5.6.11.3 *Design Criteria*—Dimensions, resistance, and separation of slide switch controls shall conform to criteria in Fig. 15. Detents shall be provided for each control setting. Resistance shall gradually increase, then drop when the switch snaps into position. The switch shall not be capable of stopping between positions.

5.6.11.4 *Setting Indicator*—Slide switch controls involving more than two positions shall be designed to provide positive



Combined Finger/Spinner Styles (Consoles)



LOAD	SPECIFICATION	HANDLE				R, TURNING RADIUS			
		L, LENGTH		D, DIAMETER		RATE BELOW 100 RPM		RATE ABOVE 100 RPM	
		mm	in	mm	in	mm	in	mm	in
LIGHT LOADS: Less than 22 N (5 lb). (Wrist and finger movement)	MINIMUM	25	1	10	3/8	38	1 1/2	13	1/2
	PREFERRED	38	1 1/2	13	1/2	75	3	65	2 1/2
	MAXIMUM	75	3	16	5/8	125	5	115	4 1/2
HEAVY LOADS: More than 22 N (5lb). (Arm movement)	MINIMUM	75	3	25	1	190	7 1/2	125	5
	PREFERRED	95	3 3/4	25	1	–	–	–	–
	MAXIMUM	–	–	38	1 1/2	510	20	230	9

S = Separation between adjacent controls or any adjacent obstruction 75 mm (3 in) minimum

FIG. 9 Dimensions, Resistance, and Separations Required for Cranks

indication of control setting, preferably a pointer located on the left side of the slide handle.

5.6.12 *Continuous Slide Controls:*

5.6.12.1 *Use*—Slide controls should be considered when continuous control is needed (for example, engine speed, adjustment of variable lighting or sound systems) and space on the console or panel is limited. Movement of the slide lever up, forward, or to the right, should increase the variable being controlled.

5.6.12.2 *Orientation*—Slide controls should be vertically oriented with movement of the slide up or away from the operator turning the equipment or component on, causing a quantity to increase, or causing the equipment or component to move forward, clockwise, to the right or up. Horizontal orientation of actuation slide controls shall be used only for compatibility with the controlled function or equipment location. Movement of the slide lever up, forward, or to the right, should increase the variable being controlled.

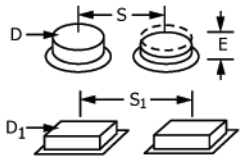
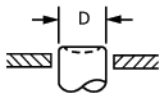
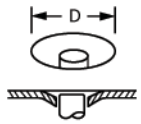
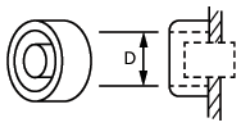
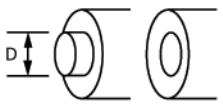
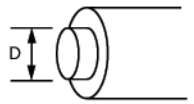
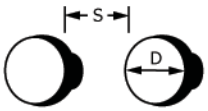
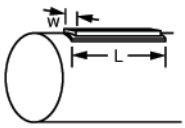
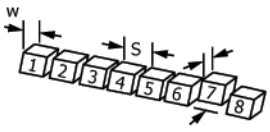
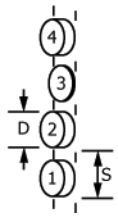
	DESIGN CRITERIA				
	DIMENSIONS			DISPLACEMENT	SEPARATION
	FINGERTIP D - MIN DIAM. OR DIMENSION (D_1) = 10 mm* (3/8 in) D-MAX = 25 mm (1 in)	THUMB OR PALM D - MIN = 19 mm (3/4 in)	– PREFERRED MIN	PREFERRED MIN S_1 -MIN = 13 mm (1/2 in) MIN = 3.2 mm (1/8 in) PREFERRED MAX = 6.5 mm (1/4 in) ADD FOR GLOVED OP'N 13 mm (1/2 in) NOTES: (1) THE DEPRESSED BUTTON (E)	S_1-MIN = 19 mm (3/4 in) WITH GLOVES 25 mm (1 in)
	D-MAX = 19 mm (3/4 in) D-MIN = 13 mm (1/2 in)	–	–	SHALL REMAIN EXPOSED BY AT LEAST 2.5 mm (.1 in) (2) SWITCHES WITH MOTION (e.g. THERMAL)	
	OPENING = 19 mm (3/4 in)	D-MIN WELL 32 mm (1 1/4 in) WITH GLOVES	PERMISSIBLE, SUBJECT TO THE APPROVAL BY THE PROCURING ACTIVITY		
	–	SAME AS ABOVE	–		
	D-MINIMUM DIAM 10 mm (3/8 in)	–	–	SAME AS ABOVE	N/A
	D-MINIMUM- 13 mm (1/2 in)	–	–	SAME AS ABOVE	N/A
	D-MIN = 25 mm (1 in)	–	–	SAME AS ABOVE	S - MIN FOR PALM OPM = 75 mm (3 in)
	W-MIN = 6.5 mm (1/4 in)	L - PREFERRED MIN = 25 mm (1 in)	–	SAME AS ABOVE	N/A
 	W OR D MIN = 10 mm (3/8 in) FOR GLOVES 13 mm (1/2 in)	–	–	x.a - MIN EXPOSURE WHEN DEPRESSED = 3.2 mm (1/8 in) x.b - MIN DEPRESSION TO ACTIVATE (PREFERRED = 5 mm (1/5 in)) NOTE: MAX DISPLACEMENT SHALL NOT EXCEED 13 mm (1/2 in)	S - CTR-CTR SPACING MIN = 19 mm (3/4 in) FOR GLOVES 25 mm (1 in)

FIG. 10 Design Criteria for Pushbuttons

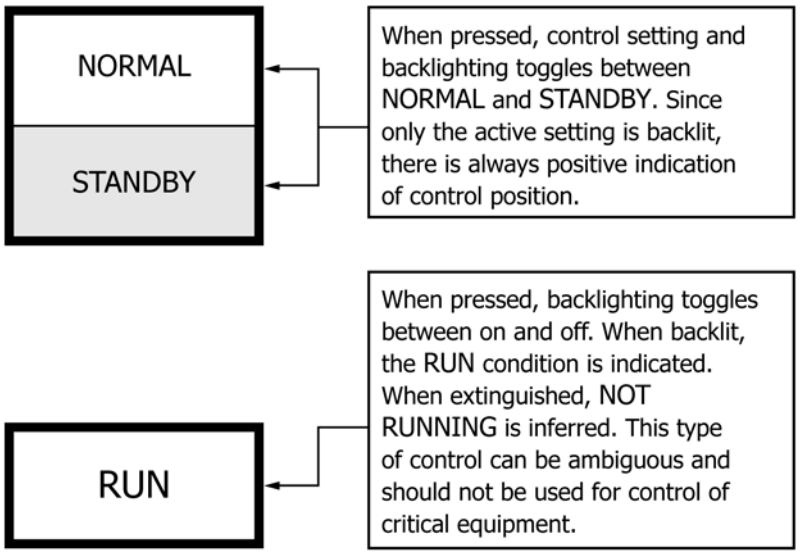
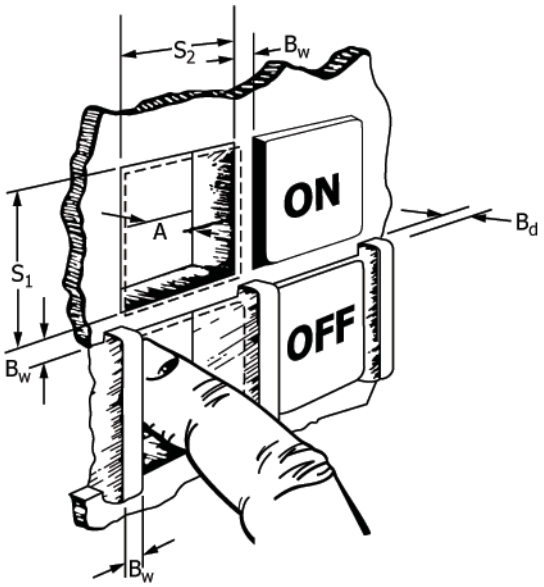


FIG. 11 Two Types of Legend Switches (Backlit Pushbuttons)



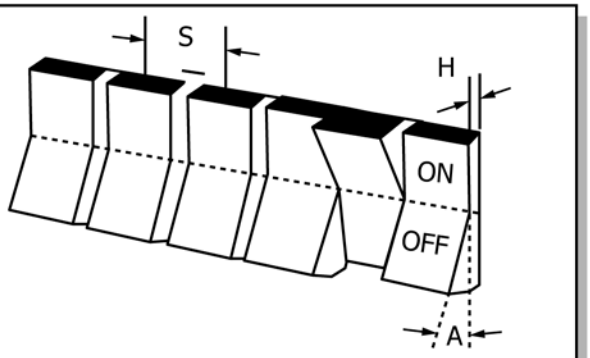
	S_1, S_2 SIZE	A DISPLACEMENT	BARRIERS		RESISTANCE
			B_w	B_d	
MINIMUM	19 mm* (3/4 in.)	3 mm** (1/8 in.)	3 mm (1/8 in.)	5 mm (3/16 in.)	Single-finger, 2.8 N*** (10 oz.) Thumb or palm, 2.8N*** (10 oz)
MAXIMUM	38 mm (1 1/2 in.)	6 mm (1/4 in.)	6 mm (1/4 in.)	6 mm (1/4 in.)	Single-finger, 11N (40 oz) Thumb or palm, 23N (80 oz)

* 15 mm (5/8 in.) where switch is not depressed below the panel.
** 5 mm (3/16 in.) for positive position switches.
*** 5.6 N (20 oz.) for use in moving vehicles. NOTE: B_w also refers to switch separation.

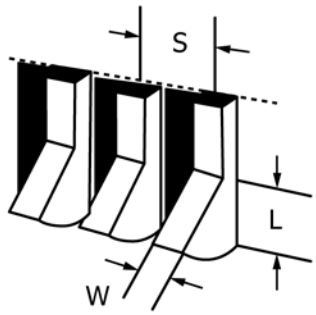
FIG. 12 Size, Displacement, and Resistance for Legend Switches

	DESIGN CRITERIA		
	DIMENSIONS		
	W-MIN DIAM = 3.3 mm (.13 in)	L-MIN LENGTH = 13 mm (1/2 in)	
	W-MIN DIAM = 4.5 mm (.18 in) MAX = 7.8 mm (.31 in)	LENGTH MIN = 13 mm (1/2 in) MAX = 50 mm (2 in)	
	W-MIN BAL DIAM =4.5 mm (.18 in) MAX = 7.8 mm (.31 in)	SAME AS ABOVE	
			W-MIN HANDLE WIDTH = 4.5 mm (.18 in)
		L-10 mm (.40 in) PREFERRED MAX = 25 mm (1 in)	W-10 mm (.40 in) PREFERRED MIN = 4.8 mm (.19 in) MAX = 18 mm (1.5 in)

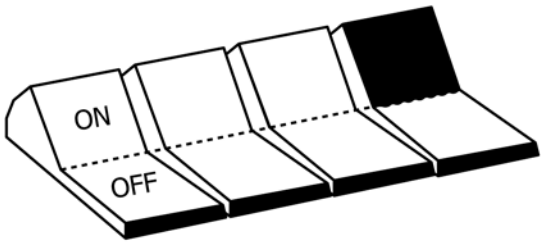
FIG. 13 Design Requirements for Various Types of Toggle Switches



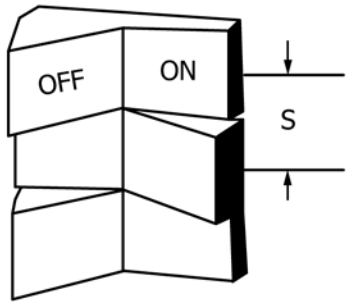
Standard Rocker Switch use as alternate two-position toggle switch to provide labeling surface, ease of color coding, and switch illumination



Narrow width, especially desirable for tactile definition with gloves.



Alternate (contrast) color for on versus off to provide conspicuous cue of switch position. Illuminated "on" desirable as second feedback cue.



	DIMENSIONS		RESISTANCE
	W - WIDTH	L - LENGTH	
MINIMUM	6 mm (1/4 in)	13 mm (1/2 in)	2.8 N (10 oz)
MAXIMUM	N/A	N/A	11 N (40 oz)

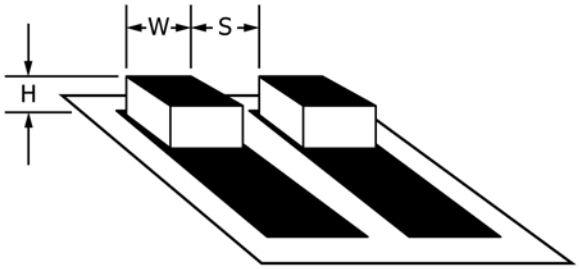
	DISPLACEMENT		SEPARATION (Center-to-Center)	
	H, HT, DEPRESSED	A, ANGLE	S (Bare Hand)	S (Gloved Hand)
MINIMUM	3 mm (1/8 in)	.52 rad (30°)	6 mm (1/4 in)	6 mm (1/4 in)

FIG. 14 Design Requirements for Rocker Switches

5.6.12.3 *Design Criteria*—Dimensions, resistance, and separation of continuous slide controls shall conform to the criteria in Fig. 16. Resistance shall be consistent over the full run of the control. The control shall be capable of stopping at any position on the scale.

5.6.12.4 *Setting Indicator*—Slide controls shall be marked with a line and a scale to show the relative setting of the control to the full range of the scale, which shall be shown on the left side of the control.

5.6.13 *Levers:*



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

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

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

FIG. 15 Dimensions, Resistance, and Separation for Discrete Slide Switch Controls

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

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

5.6.13.3 *Labeling*—All levers shall be labeled as to function and direction of motion.

5.6.13.4 *Design Criteria*—The length of levers shall be determined by the mechanical advantage needed. When the lever or grip handle is spherical, its diameter, resistance, displacement and separation shall conform to the criteria in Fig. 17. When the levers are of the slide type, dimensions and separations shall comply with Fig. 18.

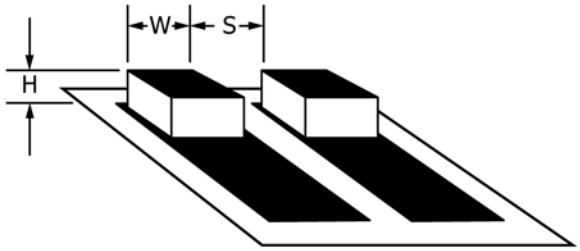
5.6.14 *Hand-Operated Displacement Joysticks:*

5.6.14.1 *Use*—Joystick controls should be used when the task requires precise or continuous control in two or more related dimensions. Their primary uses are for controlling equipment in two or three dimensions. Specific uses of displacement joysticks include: *(1)* picking data from video displays; *(2)* generating free-drawn graphics; *(3)* controlling in two to three dimensions (for example, a submerged vehicle, a crane, drill heads); *(4)* aiming sensors; and *(5)* serving as a mounting platform for a secondary control such as thumb or finger-operated switches. In rate control applications, which allow the follower (cursor or tracking symbol) to transit beyond the edge of the display, indicators shall be provided to aid the operator in bringing the follower back onto the display. If accuracy is more important than speed, a displacement joystick should be used rather than an isometric joystick. For a comparison chart, see Table 4. Displacement joysticks that are used for rate control shall be spring-loaded for return to the center when the hand is removed. In addition to the general use, hand operated displacement joysticks may be used as vehicle controllers and aiming sensors.

5.6.14.2 *Control Motion*—Movement shall not exceed 45° from the center position. Movement shall smooth in all directions, and positioning of a follower shall be attainable without noticeable backlash, cross-coupling, or need for multiple corrective movements. Control ratios, friction, and inertia shall meet the dual requirements of rapid gross positioning and precise fine positioning. Delay between control movement and confirming display response shall be minimized and shall not exceed 0.1 s.

5.6.14.3 *Design Criteria*—The hand grip length shall be in the range of 102 to 178 mm (4 to 7 in.). The grip diameter shall not exceed 50 mm (2 in.). Clearances of 100 mm (4 in.) to the side and 50 mm (2 in.) to the rear shall be provided to allow for hand movement. Joysticks shall be mounted to provide forearm support. Modular devices shall be mounted to allow actuation of the joystick without slippage, movement, or tilting of the mounting base.

5.6.15 *Hand-Operated Isometric Joysticks:*



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

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

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

FIG. 16 Dimensions, Resistance, and Separation for Continuous Slide Controls

5.6.15.1 *Use*—Also known as stiff stick, force stick, or pressure stick, isometric joystick controls may be used when the task requires precise or continuous control in two or more related dimensions. Isometric joysticks are particularly appropriate for the following applications: *(1)* tasks require precise return to center after each use; *(2)* operator feedback is primarily visual rather than tactile feedback from the control itself; and *(3)* minimal delay and tight coupling between control and input and system reaction. Isometric sticks shall ordinarily not be used in applications in which it would be necessary for the operator to maintain a constant force on the control for a long period of time or in which there is no definitive feedback when maximum control inputs have been exceeded. Joystick controls may be used when the task requires precise or continuous control in two or more related dimensions. When positioning speed is more critical than positioning accuracy, isometric joysticks shall be selected over displacement joysticks (for a comparison of the two types of joysticks, see Table 4. Isometric joysticks may also be used for various display functions such as data pickoff from a CRT. In rate control applications, which may allow the follower (cursor or tracking symbol) to transit beyond the edge of the display, indicators shall be provided to aid the operator in bringing the follower back onto the display. In addition to the general use, hand operated isometric joysticks may be used as vehicle controllers and aiming sensors. Hand-operated isometric joysticks may be used as mounting platforms for secondary controls, such as thumb- and finger-operated switches. Operation of secondary controls has greater induced error on the isometric hand grip than does displacement handgrip joysticks.

5.6.15.2 *Control Motion*—The controller has no perceptible movement, but its output is a function of force applied.

5.6.15.3 *Design Criteria*—The hand grip length shall be in the range of 110 to 180 mm (4.3 to 7.1 in.). The grip diameter shall not exceed 50 mm (2 in.). Clearances of 100 mm (4 in.) to the side and 50 mm (2 in.) to the rear shall be provided to allow for hand movement. Joysticks shall be mounted to provide forearm support. Modular devices shall be mounted to allow actuation of the joystick without slippage, movement, or tilting of the mounting base. Maximum force for full output shall not exceed 118 N (26.7 lb).

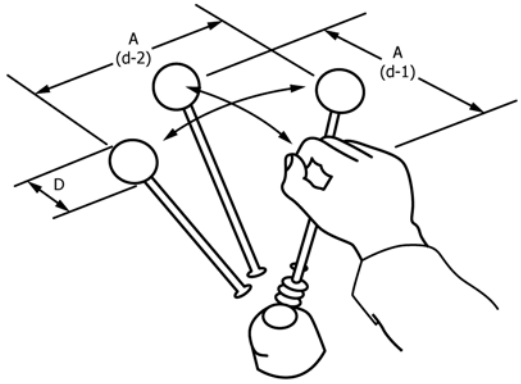
5.6.16 *Push-Pull Controls:*

5.6.16.1 *Use*—This type of control may be considered only for two-position controls (ON–OFF, OPEN–CLOSE).

5.6.16.2 *Control Motion*—Pulling a push-pull control toward the human body shall turn ON or activate the equipment or function. Pushing the push-pull control away from the human body shall turn OFF or deactivate the equipment or function.

5.6.16.3 *Design Criteria*—Handle dimensions, displacement, and clearances shall comply with Fig. 19.

5.6.16.4 *Resistance*—Force for pulling a push-pull control with fingers shall be not more than 18 N (4 lb), for pulling a T-bar with four fingers shall be not more than 45 N (10 lb).



	DIAMETER		RESISTANCE			
	D		(d-1)		(d-2)	
	Finger Grasp	Hand Grasp	One Hand	Two Hands	One Hand	Two Hands
Minimum	13 mm (0.5 in.)	38 mm (1.5 in.)	9 N (2 lb)	9 N (2 lb)	9 N (2 lb)	9 N (2 lb)
Maximum	38 mm (1.5 in.)	75 mm (3 in.)	135 N (30 lb)	220 N (50 lb)	90 N (20 lb)	135 N (30 lb)

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

FIG. 17 Dimensions, Resistance, and Separation for Levers

5.6.16.5 *Detents*—Mechanical stops at the ends of the push-pull control travel shall be incorporated into push-pull controls to provide tactile indication of the maximum travel points.

6. Displays

6.1 *Visual Displays:*

6.1.1 *General:*

6.1.1.1 Visual displays shall be used to provide the operator with an indication of equipment or system conditions by providing a positive indication of the state of the equipment such as: ready, running, not running, or "out-of-tolerance," or the current performance level of the equipment or system, or combination thereof.

6.1.1.2 The absence, or nonactivated state, of a visual display shall not be relied upon to convey status information (that is, a darkened display shall not be used to indicate that a piece of equipment is OFF) but is an acceptable indication of the absence of power (that is, POWER OFF) for an operational display but not for maintenance displays.

6.1.1.3 Where equipment status must always be available to the operator (for example, STOP/START, ON/OFF), a status indicator shall be provided for each state (for example, if the operator must always know if a piece of equipment is ON or OFF there shall be separate indicators for each condition, one of which must always be lit).

6.1.2 *Information Content*—The content of information displayed to an operator shall allow the operator to perform the intended mission, but shall be only limited to that which is necessary to perform specific actions or to make decisions.

6.1.3 *Format*—Information shall be presented to the operator in a directly usable format that shall not require transposing, computing, interpolating, or mentally translating to other units.

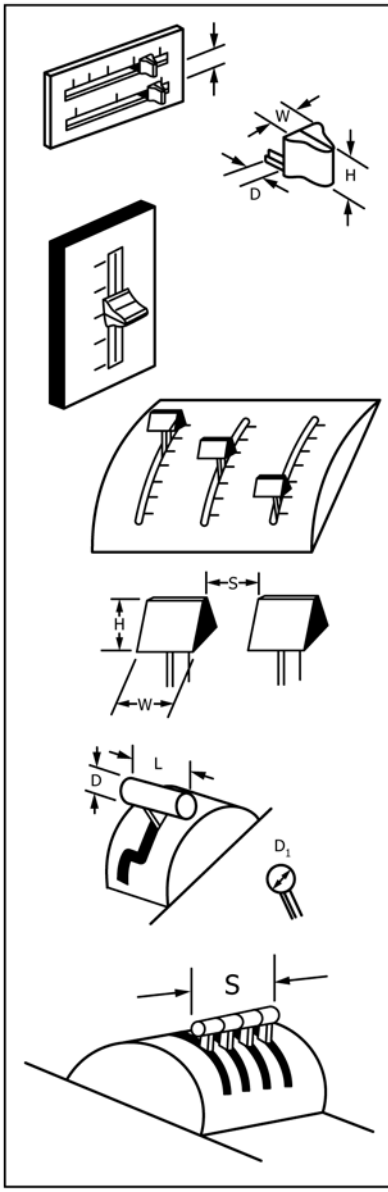
	DESIGN CRITERIA	
	DIMENSIONS	SEPARATION
	D = 13 mm (½ in) Min D = 19 mm (3/4 in) with Gloves W = 6.5 mm (¼ in) Min H= 16 mm(5/8 in) Min	S = 19 mm (3/4 in) Min S = 25 mm (1 in) with Gloves
	Cylindrical: D = 19 mm (3/4 in) Min D = 28 mm (1 1/8 in) Max	S =50 mm (2 in) Min finger clearance on all sides
	Spherical: D = 32 mm (1 ¼ in) Min L = 65 mm (2 ½ in) Min	S = 100 mm (4 in) Min S = 125 mm (5 in) Max

FIG. 18 Dimensions, Resistance, and Separation for Slide Levers

TABLE 4 Comparison of Displacement and Isometric Controls

Type of Lever or Joystick	Advantages	Disadvantages
Displacement	Positioning accuracy Less force required Less fatiguing Best for secondary switches	Slower operation Requires more operating room
Isometric	Faster Center or null position is simple to locate Requires less operating room	Provides less tactile feedback of control position

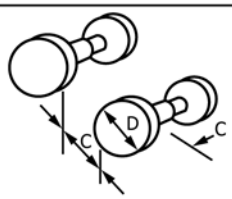
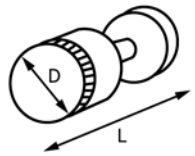
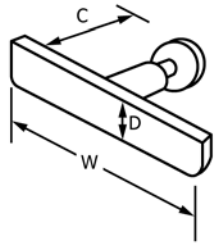
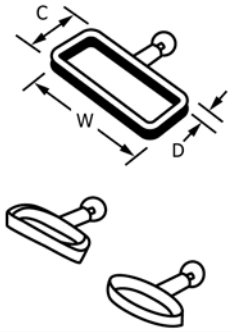
	DESIGN CRITERIA			
	CRITERIA	DIMENSIONS	DISPLACEMENT	SEPARATION
	Push-pull control, low resistance for two positions, mechanical and/or electrical systems.	D = 19 mm (3/4 in) Min C = 25 mm (1 in) Min Clearance C = 38 mm (1½ in) for gloved hand	13 mm (½ in) Min 38 mm (1½ in) for gloved hand	S = 38 mm (1½ in) Min S = 50 mm (2 in) for gloved hand
	Alternate handle: Miniature electrical panel switch only. Avoid glove use application.	D = 19 mm (3/4 in) Min L = 19 mm (3/4 in) Min	13 mm (½ in) Min	S = 25 mm (1 in) Min
	High-force push-pull for two-position mechanical system only.	W = 100 mm (4 in) D = 16 mm (5/8 in) Min D = 38 mm (1½ in) C = 38 mm (1½ in) Min Clearance C = 76 mm (3 in) for gloved hand	25 mm (1 in) Min 50 mm (2 in) Preferred	
	Same as above. Preferred where garment or cabling-snag possibility exists.	W = 100 mm (4 in) W = 125 mm (5 in) for gloved hand D = 16 mm (5/8 in) Min D = 38 mm (1½ in) C = 38 mm (1½ in)	25 mm (1 in) Min 50 mm (2 in) Preferred	S = 13 mm (½ in) Min

FIG. 19 Dimensions, Displacement, and Separation of Push-Pull Controls

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

6.1.5 *Combining Information*—Operator and maintainer information shall not be combined in a single display unless the information content and format is well suited to and time is available for both.

6.1.6 *Display Failure*—A method shall be provided to determine if a display or circuit has failed. The fact that a display has failed shall be immediately perceptible to the operator.

6.1.7 *Display Circuit Failure*—Failure of the display circuit shall not cause a failure in the equipment associated with the circuit.

6.1.8 *Unrelated Markings*—Trademarks and company names or other similar markings not related to the panel function shall not be displayed on the panel face or on the displays. If needed for maintenance purposes, such information should be placed on the side or back of the console or instrument face.

6.1.9 *Duration of Displayed Information*—For signals or displays that frequently or consistently change their outputs, the information displayed shall have a duration of sufficient length to be reliably detected under expected operator workload and operational environment.

6.1.10 *NBC Compatible*—Display characteristics (for example, clarity, legibility) shall allow viewing of displays while wearing a nuclear, biological, and chemical (NBC) or other protective mask. Displays or indicators that show the presence of NBC or other environmental contamination agents shall also show when such agent concentrations decrease to safe levels.

6.1.11 *Coding*—Coding techniques (for example, color, shape, location) used to enhance the transfer of information

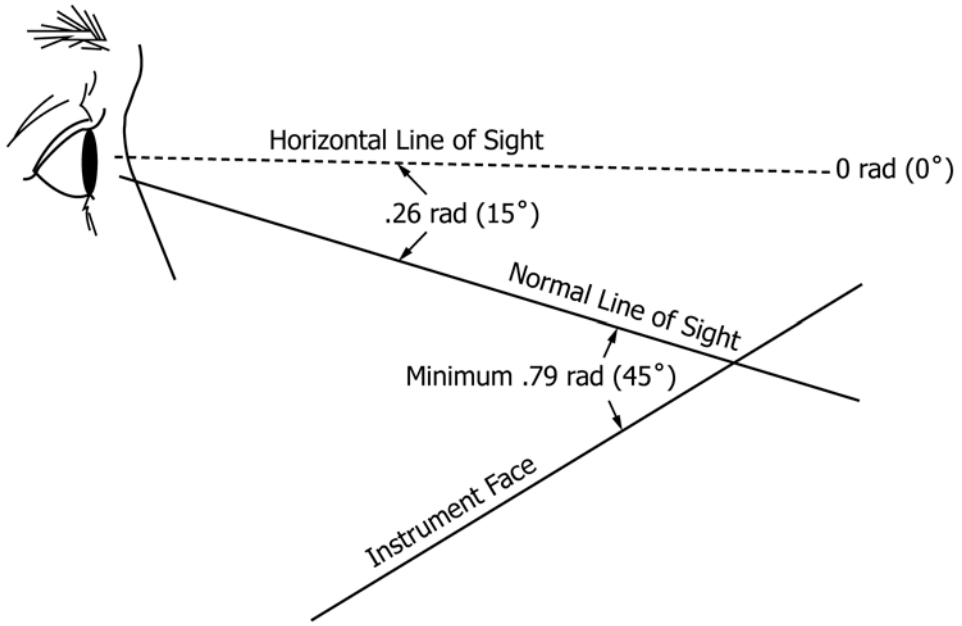


FIG. 20 Visual Lines of Sight

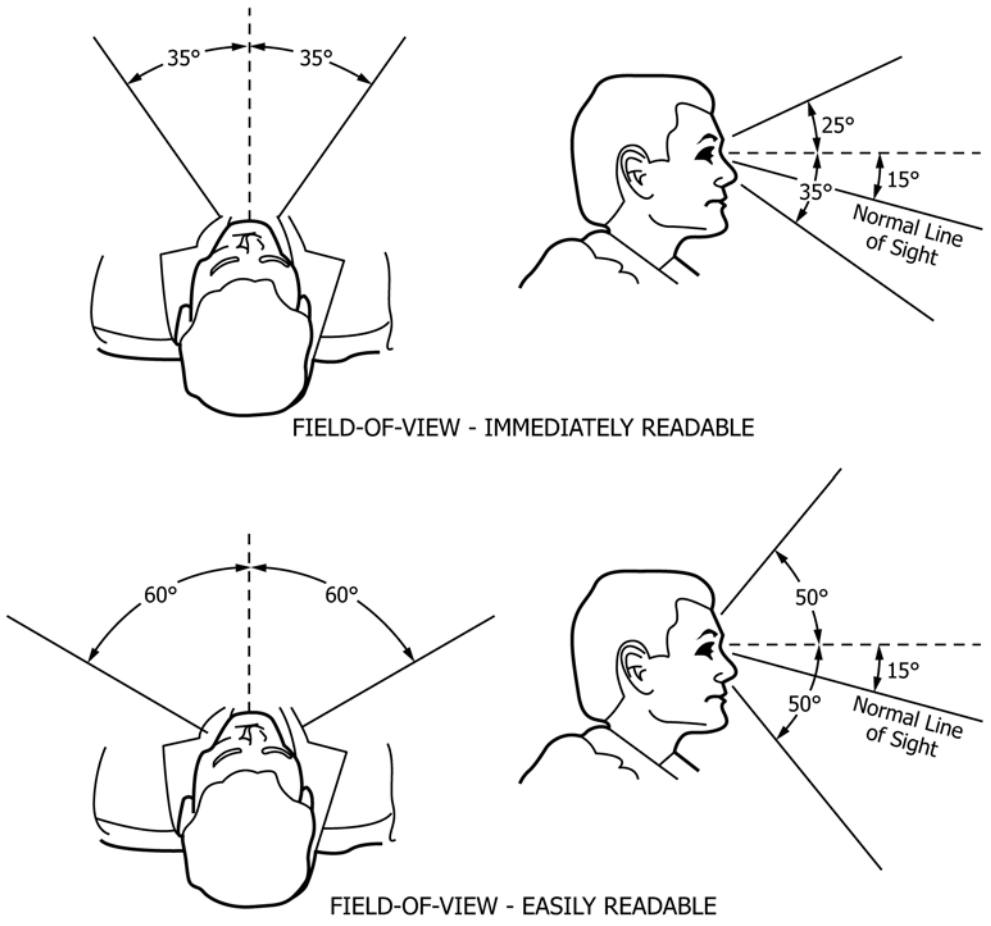
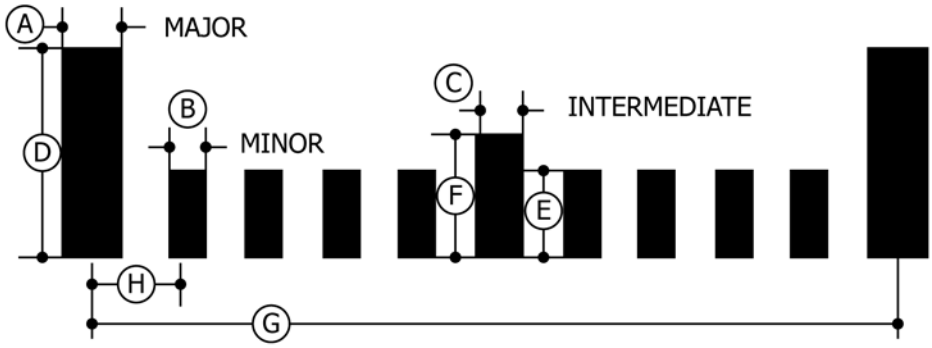


FIG. 21 Primary and Secondary Fields of View



Dimension, mm (in)	Viewing Distance 710 (28.0)	910 (35.9)	1525 (60.2)
A (Major index width)	0.89 (.035)	1.14 (.045)	1.90 (.075)
B (Minor index width)	0.64 (.025)	0.81 (.032)	1.37 (.054)
C (intermediate index width)	0.76 (.030)	0.99 (.039)	1.63 (.064)
D (Major index height)	5.59 (.221)	7.19 (.283)	12.0 (.473)
E (Minor index height)	2.54 (.100)	3.28 (.129)	5.44 (.214)
F (intermediate index width)	4.06 (.160)	5.23 (.206)	8.71 (.343)
G (Major index separation between midpoints)	17.8 (.701)	22.9 (.902)	38.0 (1.50)
H (Minor index separation between midpoints)	1.78 (.070)	2.29 (.090)	3.81 (.150)

FIG. 22 Design Criteria for Major, Intermediate, and Minor Scale Markings

from a display shall be clear, concise, and consistently applied wherever that display is used. Coding shall be appropriate for the industry, organization, and culture of the personnel who shall use the display.

6.1.12 *Legibility*—Displays shall be legible under all anticipated viewing conditions with due consideration given to ambient lighting, viewing distance, and vibration.

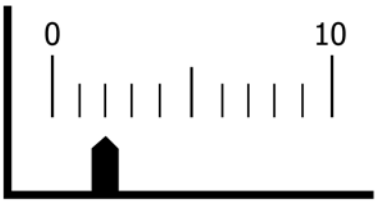
6.1.13 *Units of Measure*—Displays of quantitative information shall include units of measure.

6.1.14 *Analog Versus Digital:*

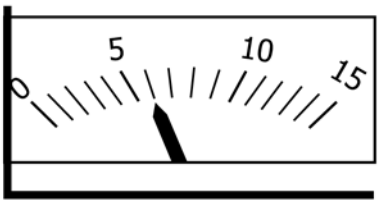
6.1.14.1 Display information should be presented in either analog or digital form. Analog displays include meters, plotters, bar charts, simple indicator lights, and legend lights. Use analog displays when trend information is required or when values need to be compared to ranges or zones.

6.1.14.2 Digital displays include digital counters and numbers displayed on a screen. Use digital displays when quick, precise readings of quantitative values are required. Do not use digital displays alone, if perception of a trend, pattern, or variation is important or where value changes occur too slowly or too rapidly to be easily detected.

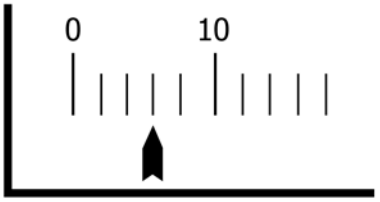
6.2 *Location, Orientation, Lighting, and Arrangement of Displays:*



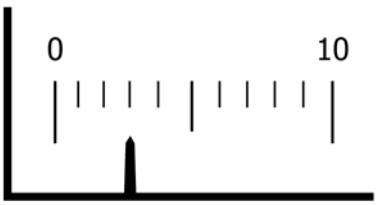
A Fixed scale moving pointer preferred: three-level marking, numbered at each major mark. Pointer adjacent to graduation marks to preclude obscuration of either marks or numbers.



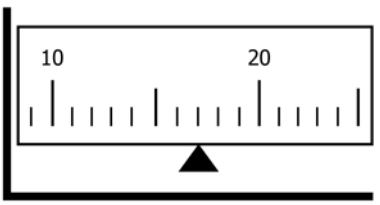
B For short, finite scale, every 5th graduation is marked; using only two-level marking.



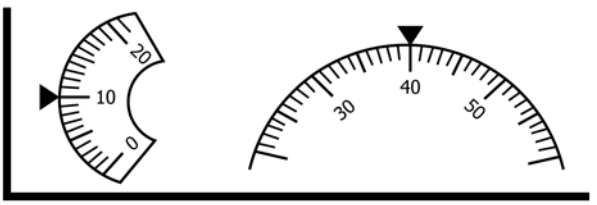
C When scale crowding makes pointer-mark association difficult, scale may be graduated in units of two, with two-level scale marking and numbering at each major marking.



D When dial face is deeply inset within instrument case and visibility of numbers is more important that scale mark-pointer association, pointer may be located inside the graduations along with numbers at major markings. Pointer width should be narrowed at point in which it passes numbers.



E Moving scale against an index mark or pointer may be used when scale length precludes the fixed scale format (i.e., graduation marks would be too close together). Open window configuration helps operator focus on significant scale area.



F When open window configuration is oriented in vertical position, numbers should appear up-right as each number passes the index mark or pointer. Total scale exposure is desirable when operator needs to refer to other portions of the scals.

FIG. 23 Scale Graduation, Pointer Position, and Scale-Numbering Alternatives

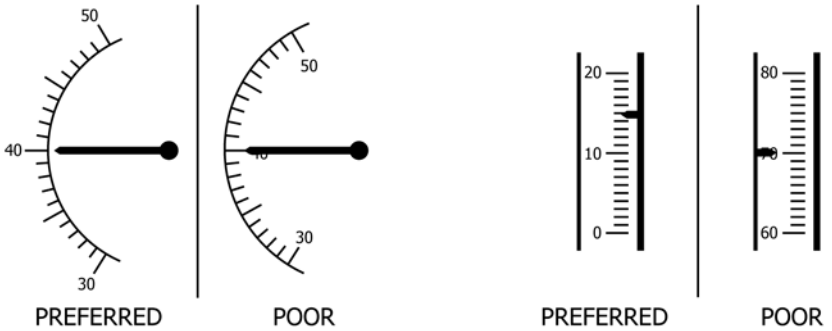


FIG. 24 Scale Number Placement

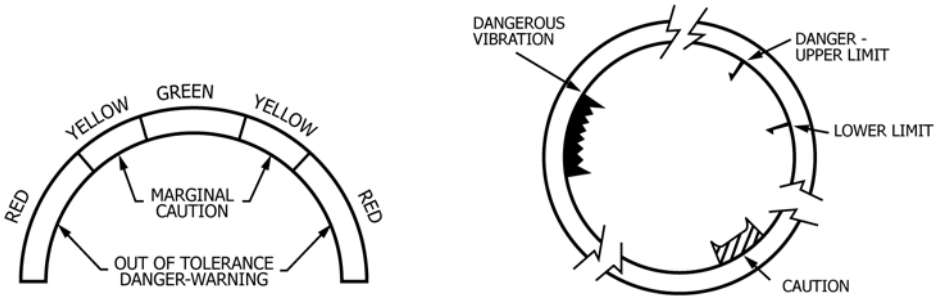
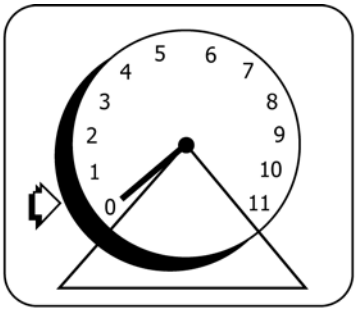
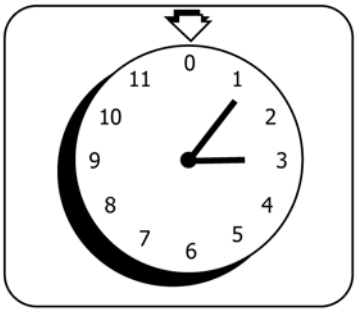


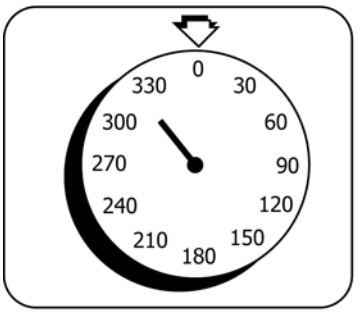
FIG. 25 Color and Shape Coding of Ranges on an Analog Display



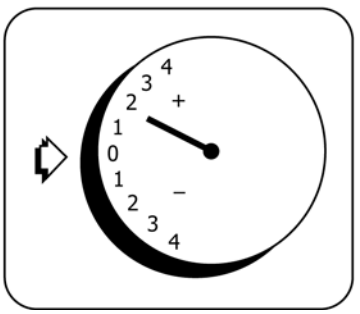
When a dial scale is of finite length, it should be numbered so that value increase is clockwise. The zero starting point should be approximately at the 7 o'clock position. There should be an obvious "break" between the two ends of the scale of at least 10° of arc.



When multirevolution pointer movement is involved, the zero reference should be at the top of the dial, and there should be no break between scale ends. No more than two pointers shall be used except for special cases, e.g., clock (with second hand).



Azimuth dial scales shall be laid out with the zero (or north) reference at the top of the dial, and scale values shall increase clockwise at least every 30° reference should be numbered.



Positive/negative dial formats shall be laid out with the zero (or "null" position) located at the 9-, 12-, or 3-o'clock position. Scale values shall increase right or left, or up or down as appropriate to provide positive/negative pointer movement relationships.

FIG. 26 Zero Position and Pointer Movement for Circular Dial Displays

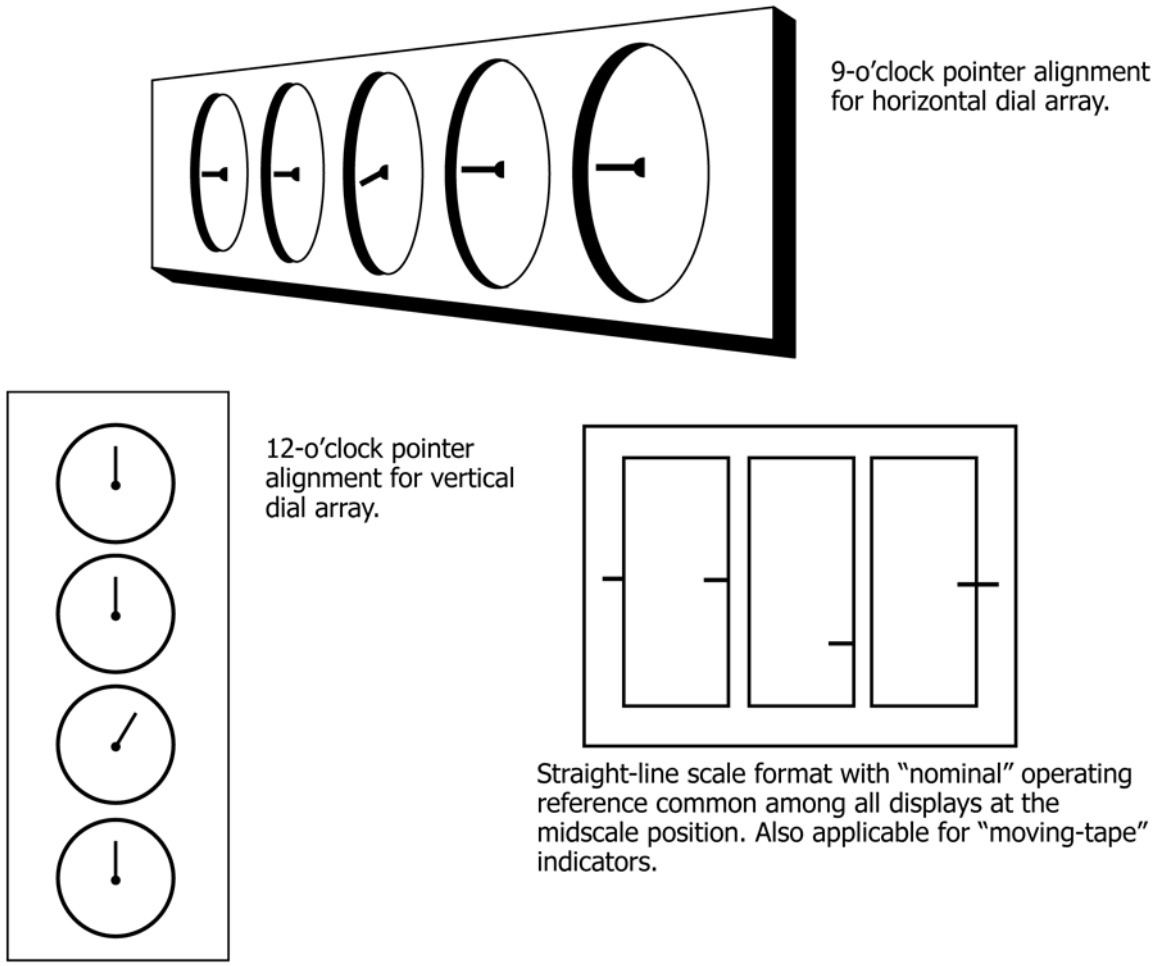


FIG. 27 Aligned Pointers for Rapid Check Readings

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

6.2.2 *Dual Gauge Arrangement*—Dual gauges providing an IN and OUT reading (for example, suction and discharge, voltage in and out, pressure in, reduced pressure out) shall be arranged so that the gauge with the IN or LOW reading is on the left (preferred) or top, and the gauge with the OUT reading is on the right (preferred) or bottom, unless the IN and OUT displays are a part of a system mimic that does not permit this arrangement. Using the reverse order from that described above shall require written approval of the procuring organization.

6.2.3 *Visual Access:*

6.2.3.1 Visual displays shall be visually accessible from the normal work position without requiring the operator to stand on equipment components, handrails, wire ways or wire way supports, pipes (bare or insulated), or any structure that is not specifically designed and provided for supporting a person's weight.

6.2.3.2 No display shall require the removal of a cover (for example, sheathing, deck plate) or any other component to be visible, unless the display is noncritical and a clearly marked quick access door is provided. The access door should be of transparent material.

6.2.3.3 Light-emitting diodes (LEDs) used on PC boards inside consoles for calibration or troubleshooting shall be visible from the maintainer's normal work position once the console doors or maintenance access openings are open.

6.2.4 *Display Orientation:*

6.2.4.1 Displays, such as thermometers and pressure gauges, that are attached directly to a pipe shall be mounted so they are read upright, or turned no more than 90° from the upright position if the upright orientation cannot be achieved.

6.2.4.2 Displays located within 305 mm (12 in.) of a walkway shall not be located lower than 457 mm (18 in.) above the deck unless the display face is protected by a non-breakable transparent material.

6.2.4.3 Armored sight gauges shall be oriented so the sight gauge is directly visible from the normal work position.

6.2.5 *Consistency*—The location, design and arrangement of displays within a system shall be consistent from application to application wherever those displays appear throughout the ship or maritime structure.

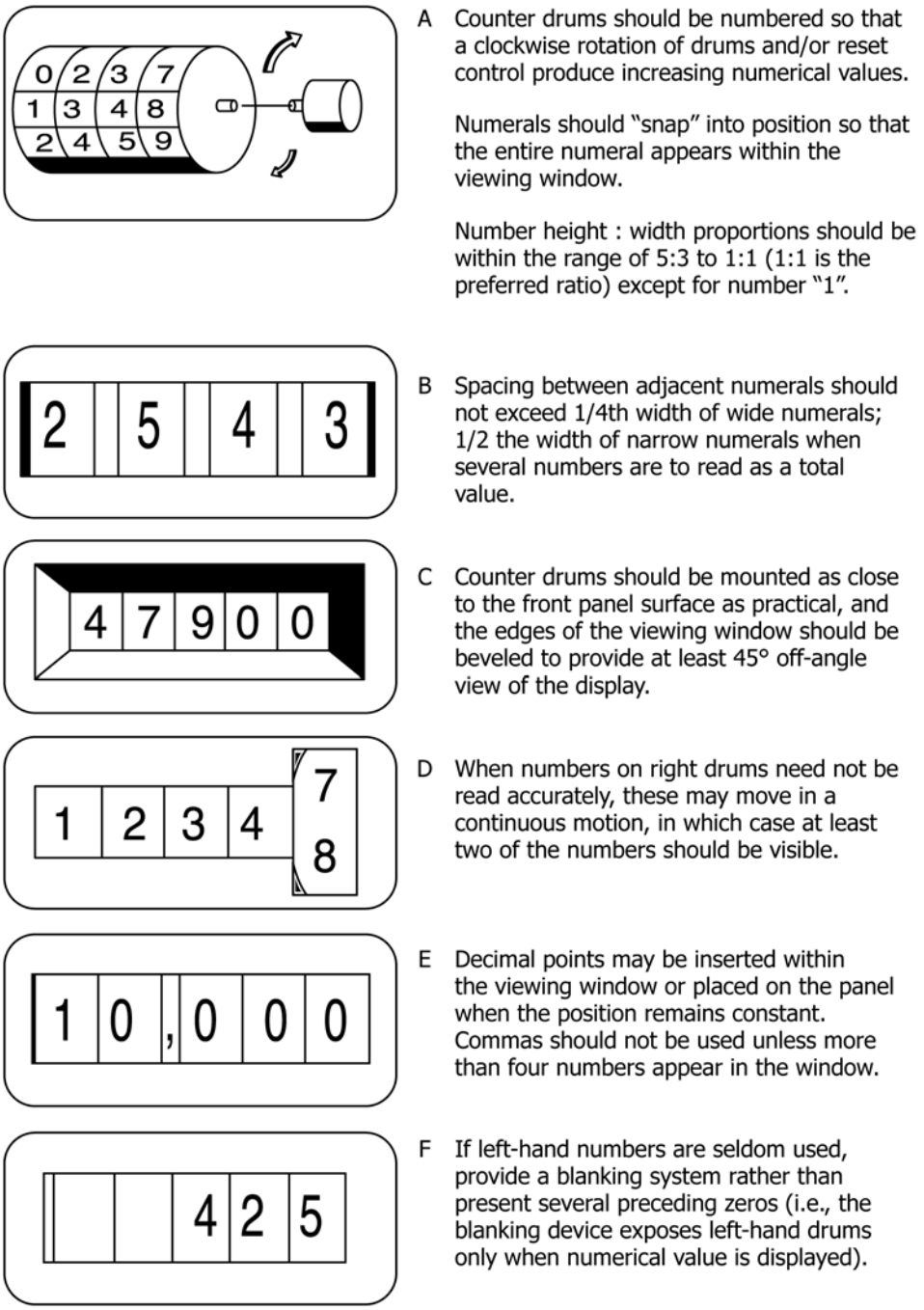


FIG. 28 Digital Display Design Requirements

6.2.6 *Grouping*—All displays necessary to support an operator activity or sequence of activities should be grouped together.

6.2.7 *Frequency of Use*—Displays used most frequently should be grouped together and placed in the primary field of view (see 6.2.17, Fig. 21).

6.2.8 *Importance*—Important or critical displays shall be located in the primary field-of-view or otherwise highlighted (see 6.2.17, Fig. 21).

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

6.2.10 *Ambient Lighting Levels*—Ambient lighting levels shall be sufficient to permit visual display viewing under all conditions of operation without the use of a flashlight or other

temporary light source. Guidance for specific lighting levels can be found in Section 14.

6.2.11 *Ambient Illumination Reflection*—Displays shall be constructed, arranged, and mounted to prevent reduction of information transfer as a result of the reflection of the ambient illumination from the display cover. Reflection of instruments and consoles in windows and other reflective surfaces shall be prevented.

6.2.12 *Sight Gauges*—Sight gauges that contain clear liquid shall be designed with a color backing, color float, or other technique to provide a distinctive color indication of the liquid level in the gauge.

6.2.13 *Vibration*—Vibration of visual displays shall not degrade user readability below the level required for mission accomplishment. The effects of excessive vibration should be countered by coupling the operator and displays to the same platform, by arranging the operator and display to minimize relative motions or enlarging the display character's or number's size, or both.

6.2.14 *Minimum Viewing Distance*—The viewing distance from the operator's eye to the face of the displays, with the exception of cathode ray tube displays, shall never be less than 330 mm (13 in.) and preferably not less than 508 mm (20 in.) and not more than 711 mm (28 in.). All displays shall be accurately read within these viewing distances.

6.2.15 *Maintenance Displays*—Displays used solely for maintenance and adjustment shall be covered or nonvisible during normal equipment operation, but shall be immediately accessible when required.

6.2.16 *Line of Sight*—A display should be perpendicular to the normal line of sight but not less than 45°, as indicated in Fig. 20. The normal line of sight is 15° below the horizontal line-of-sight.

6.2.17 *Primary and Secondary Visual Field*—Displays used most frequently, those used for obtaining precise readings, or those used in an emergency shall be placed in the primary (immediately readable) visual field in accordance with Fig. 21. Those displays used for normal operations and those not requiring accurate readings shall be located in the secondary (easily readable) field-of-view as indicated in Fig. 21. Reference displays that are used infrequently may be located in an area outside the primary and secondary field of view.

6.3 *Display Illumination:*

6.3.1 *Normal*—When maximum dark adaptation is not required, low brightness white light (preferably integral and adjustable) should be used; however, when maximum dark adaptation is required, low luminance [0.07–0.35 cd/m^2 (0.02–0.10 ft-L)] red light (greater than 620 nm) should be provided.

6.3.2 *Night Vision Device Compatibility*—When night vision devices will be worn or used by the operator(s), display illumination color shall be low-density blue-green light (incandescent filament through a high-pass filter with a 600-nm cutoff). The color selected shall provide the operator(s) with the capability to obtain required display information rapidly and accurately with unaided eye vision or by means of viewing with the night vision device. The color selected shall also provide the operator(s) with the ability to obtain required display information rapidly and accurately during any daylight condition. The lighting shall be continuously variable to the full OFF position. In the OFF position, no current shall flow through the lamps.

6.3.3 *Outdoor Panel Lighting Control*—When control or annunciator panels will be viewed by personnel out of doors at night, maximum panel illumination shall be provided when a dimming rotary control is at its extreme clockwise rotation. No current shall be provided to luminaries at extreme counter-clockwise rotation of a dimming control. Panel light levels shall be continuously variable from 0.1 cd/m^2 (0.03 fL) near OFF to 3.5 cd/m^3 (1 fL) at 50 % of clockwise rotation.

6.3.4 *Blackout Discipline*—Where operational security or survivability requires blackout discipline, the use of permanently illuminated outdoor displays shall be avoided and illumination of displays within personnel enclosures shall automatically switch off when doors to the enclosure are opened.

6.3.5 *Light Distribution Across a Panel*—Where multiple displays are grouped together, lighting shall be balanced across the instrument panel such that the mean indicator luminance of any two instruments shall not differ by more than 33 % across the range of full ON to full OFF.

6.4 *Display Types:*

6.4.1 *Transilluminated (Status) Display:*

6.4.1.1 *Use*—Transilluminated displays show the current state of equipment or systems through qualitative data provided to the operator. Transilluminated displays may be used as visual alarms that require an immediate response by the operator or as a simple indicator of current equipment or system performance. Status indicators may also be used for maintenance and adjustment functions.

6.4.1.2 *Categories*—Two categories of transilluminated displays shall be used:

(1) Simple indicator or pilot lights shall be used when an inscription on the light face is not required to convey status. However, color coding should be used. Simple indicator lights shall be used only if the design precludes the use of legend lights.

(2) Legend lights shall be used when labeling on the light face, highlighted when the light is on, conveys additional information beyond the simple indicator light. The lettering or characters or both used in legend lights shall be visible whether the light is illuminated or not except for alarm lights (that is, danger and caution) which shall be visible only when their display is lit. Legend lights shall be used to provide qualitative information, not to give commands.

6.4.1.3 *Illuminated Label Versus Illuminated Background:*

(1) An illuminated label on an opaque background shall be used:

(a) If dark adaptation of the operator's eyes is required, and

(b) Where display legibility in high ambient illumination is critical.

(2) An opaque label on an illuminated background shall be used:

(a) If the indicator is a critical alerting indicator, such as a master warning light, and

(b) If dark adaptation is not required.

6.4.1.4 *Labeling of Status Displays*—Labeling of status displays shall conform to the label requirements contained in Section 15.

6.4.1.5 *Coding*—Transilluminated displays shall be color coded if they are used for alarms, or providing equipment or system status (see 6.4.1.5*(7)*).

(1) Objective—Coding techniques should be used to facilitate discrimination between individual displays, identify specific displays, identify functionally related displays, provide an indication of relationship between displays, and identify critical information within a display.

(2) Consistency—Coding techniques shall be standardized for all display designs and shall be consistently used wherever a coding technique is used.

(3) Techniques—Displays shall be coded by color, size, location, shape, brightness, or flash coding whenever special coding is required.

(4) Size Coding—When size coding is used with displays no more than three distinct sizes shall be used and two are preferred. Each size progression should be a minimum of twice (or half) the size (in square area of the next larger [or smaller] size). Size-coded displays should be in close proximity to one another.

(5) Location Coding—Transilluminated displays that appear on more than one console, panel or individual mounting shall be located in the same or approximate location at each location and in the same relation to other displays or controls that also appear in all the locations.

(6) Brightness Coding—No more than two brightness levels shall be used to code different transilluminated displays.

(7) Color Coding—Meanings of color differ between cultures, therefore, if color codes are provided with displays, select colors that are consistent with the expectations of the expected user populations. Table 5 presents commonly used color-coding schemes in North America. Designers should identify regional and industry color meaning expectations, as well as any statutory requirements, when defining color-coding requirements.

(8) Flash Coding—Alternating the ON-OFF state of a display (that is, flashing) may be used to emphasize certain information relative to other information.

(a) No more than two flash rates shall be used and they shall differ by not less than 2 Hz. The higher flash rate shall reflect the more critical information and should be not greater than 5 Hz. nor less than 3 Hz. The slower flash rate shall be not less than 0.8 Hz for the least critical information. Flashing lights shall turn to steady red when they are acknowledged by the operator.

(b) The percentage of "ON" time should be equal to but not less than the percentage of "OFF" time. A50 % duty cycle is preferred.

(c) Characters that must be read shall not flash. Emphasis should be added by adjacent flashing symbol or flashing background.

(d) Event acknowledgment or flash suppression control shall be provided.

TABLE 5 Typical Status Display and Alarm Color Codes for North American Industry

Color	Typical Display/Alarm Color Meanings
Flashing Red	Flashing red shall be used to denote emergency conditions that require immediate operator attention. Flash rate should be between 3–5 per second.
Steady Red	Danger, hot, unsafe condition, critical parameter value is out-of-tolerance. Immediate operator action is required.
Amber[A]	Caution, test, hazard, potentially unsafe condition. Amber can be used to indicate that a condition exists that is marginal or beyond operation action, or where caution, recheck, or unexpected delay is necessary. Amber may also be used to indicate that equipment is moving from one condition to another (for example, valve is opening).
Green	Parameters normal, condition is clear or safe, no operator action required, parameter values are within tolerance. Green can also indicate that monitored equipment is operating satisfactorily or that a condition is satisfactory and it is safe to proceed.
White	White should be used to indicate system conditions that do not have right or wrong implications, such as alternative functions (for example, Pump No. 1 selected), or transitory conditions (for example, action or test in progress, function available), provided such indication does not imply success or failure of operations.
Blue	Blue may be used for an advisory light, but use of blue should be avoided whenever possible.

[A] Yellow may also be used for this purpose, and amber and yellow may both be used in a color coding scheme provided there is a distinct visual difference between the two colors, and that the definitions for the two colors are maintained throughout the ship or maritime structure.

(e) If the display is energized and the flasher device fails, the flashing device shall illuminate and burn steadily.

6.4.1.6 *Lamp Test*—When three or more simple indicator lights are used with incandescent bulbs, a master light test control shall be incorporated. With three or less lights, individual press-to-test bulb testing is allowed.

6.4.1.7 *Display Lighting Level*—When status displays are used under varying ambient illumination levels, a dimming control shall be provided. The control shall be capable of continuous variance of light level but never to full OFF.

6.4.1.8 *Feedback on Status Displays*—Changes in status displays, including those used in illuminated pushbuttons, shall display actual equipment status, not just that a control command has been initiated (that is, a lit PUMP ON light or legend switch means that the pump is running, not just that the ON control has been pushed or a VALVE CLOSED indicator shall signify that the valve is actually closed, not that the VALVE CLOSED control has been activated).

6.4.1.9 *Grouping*—Master caution, master warning, master advisory, and summation lights used to indicate the condition of an entire subsystem shall be easily discriminated from the lights which show the status of the subsystem components.

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

6.4.1.11 *Lamp Redundancy*—Meters, counters, and other displays that use incandescent bulbs to illuminate the display face may incorporate filament redundancy or dual lamps. When one filament or bulb fails, the intensity of the light shall decrease sufficiently to indicate the need for lamp replacement,

but not so much as to degrade operator performance. Lighted annunciators need not have this capability provided a lamp test button is provided.

6.4.1.12 *Lamp Removal:*

(1) Lamps shall be removable and replaceable from the front of the display panel. The procedure for lamp removal and replacement should not require the use of tools and shall be easily and rapidly accomplished. If a tool is required, special stowage for it will be provided on the panel.

(2) Lamp removal and replacement shall be possible while power is applied without causing failure of indicator circuit components or imposing personnel safety hazards.

6.4.2 *Circular and Line Gauges/Displays:*

6.4.2.1 *Use*—Analog displays such as circular and line gauges and displays shall be used when providing information about rates-of-change, trends, or deviations from a given values. They are suitable for the presentation of quantitative or qualitative information. Guidelines for analog scales are shown below.

6.4.2.2 *Types of Scale*—Types of scale indicators that may be used include:

(1) Moving pointer, fixed scale, presented in a circular, curved (arc), horizontal straight, and vertical straight presentation format, and

(2) Fixed pointer, moving scale, presented in a circular, curved (arc), horizontal straight, straight, and vertical straight presentation format.

6.4.2.3 *Scale Preferences*—Moving-pointer, fixed-scale indicators shall be used unless fixed-pointer, moving scale indicators are approved by the procuring agency. Where reading speed is important, circular scales should be used in preference to horizontal scales or vertical scales, and horizontal scales should be used in preference to vertical scales.

6.4.2.4 *Scale Orientation*—Scales should be oriented to meet the expectations of personnel.

(1) Vertical scales are appropriate with parameter such as levels, pressures, or temperatures where personnel have expectations of values rising or falling.

(2) Horizontal or arced scales are appropriate for parameters such as rudder angles, flow, revolutions per minute, or velocities/speed.

(3) Circular scales are best for parameters that have associated circular or around-the-horizon orientations like ship's heading or wind direction.

6.4.2.5 *Linear Scales*—Linear scales shall be used except where system requirements dictate nonlinearity to satisfy operator information requirements. Nonlinear scales shall be used only with the written approval of the procuring activity.

6.4.2.6 *Scale Design Units*—The units of a scale shall be specific to minimize the need for user guessing, interpolating, or performing mental calculation to read the display.

6.4.2.7 *Number of Scales Per Display*—One scale per display is preferred, but no more than two shall be used. If two scales are used, they shall have different scale ranges, scale increments, and colors so as to be visually different from each other.

6.4.2.8 *Scale Range*—The scale range shall be selected so the display pointer's normal operating position is approximately midway between the scale ends.

6.4.2.9 *Scale Markings:*

(1) A scale marker shall be included on the display for every scale unit that is to be read, unless this would result in an overcrowded display. In this case, using fewer scale markers requiring personnel to interpolate is permissible.

(2) Scales shall start and end on a major graduation mark even if this puts either or both ends beyond the usable range of the scale (for example, if the maximum voltage which can be read on an instrument is 23 V, the scale shall go at least to 25 V where there should be a major graduation mark).

(3) Display scales shall start at zero, except where this would be inappropriate for the function involved.

(a) Marking Graduations—Scale graduations shall be in increments of one, two, or five units or decimal multiples thereof. No more than three sizes of marks shall be used on any scale. The scales that require three sizes of marks include those which have numbered values in multiples of ten but are graduated in five- and ten-unit intervals.

(b) Major Markings—Except for measurements that are normally expressed in decimals, whole numbers shall be used for major graduation marks.

(c) Intermediate and Minor—The number of intermediate and minor marks between numbered scale pointers shall not exceed nine as shown in Fig. 22. Examples of the use of intermediate and minor markings are shown in Fig. 23.

(d) Scale Colors—Scale markings and numbers should be black on a white background (preferred) or dark on a light background). Any other contrast should be with the approval of the procuring agency.

6.4.2.10 *Scale Numbers*—Scale numbers should be placed so that the pointer does not obscure the scale numbers. See Fig. 23 and Fig. 25. For small round dial displays where placing the numbers outside of the scale markers would result in crowding of the markers, the markers can be placed on the perimeter of the instrument face and the numbers inside. The numbers should be large enough to be readable when the pointer is over them.

6.4.2.11 *Pointers*—Indicators with scales should have pointers that are relatively wide at the pivot, tapering gradually to a fine tip, arrowhead, or teardrop that is the same width as the smallest graduation mark.

6.4.2.12 *Pointer to Scale Marks Relationship*—Pointers shall meet, but not overlap, the shortest scale-graduation mark. The tips shall never be more than 1.5 mm (1⁄16 in.) from the scale graduations. The tips shall be equal in width to the minor scale graduations.

6.4.2.13 *Luminance Contrast*—Luminance contrast of at least 75 % shall be provided between the scale face, the markings, and the pointer.

6.4.2.14 *Pointer Color*—Pointers shall be the same color as the numbers and scale divisions.

6.4.2.15 *Pointers Per Dial*—With the exception of clocks and watches, there shall not be more than two pointers on a single dial.

6.4.2.16 *Calibration Information*—Provision shall be made for placing calibration information on instruments without degrading dial legibility.

6.4.2.17 *Coding*—When operating conditions always fall within a limited range of the total scale, these ranges shall be made readily identifiable by means of pattern, color, or shape coding applied to the face of the instrument. Use of red color coding shall be limited to critical situations. Operating zones may be shape coded when the indicator must be viewed in very low-light-level work environments, 0.07 to 0.7 cd/m^2 (0.02 to 0.2 ft·L) or where the illuminant color will cause difficulty in discrimination of colors. See Fig. 25.

6.4.2.18 *Moving Scale-Fixed Pointer Display*—Moving scale fixed pointer displays shall not be used except only with the approval of the procuring agency. If such scales are used, they shall comply with the following design criteria:

(1) Numbered scales shall increase clockwise, from left to right, or from bottom to top, depending on scale layout (circumferential or linear in a horizontal or vertical axis).

(2) Numbers on fixed scales shall appear vertical (upright) to the observer.

6.4.2.19 *Circular Displays*—Circular displays are best for parameters that have associated circular or round-the-horizon orientations like ship's heading or wind direction or where the parameter shown is not more suited to a straight display.

(1) Scale Reading Pointer Movement—To display values ranging from negative through zero to positive, and consistently, locate the zero point at the 9 or 12 o'clock position. Positive values shall increase when the pointer moves clockwise (to the right), and negative values shall increase when the pointer moves counterclockwise (to the left).

(2) Zero Position and Pointer Movement—When positive and negative values are displayed around a zero point, the magnitude of positive values shall increase with movement of the pointer up or to the right, and the magnitude of negative values shall increase with movement of the pointer down or to the left. The position of the zero value on a numbered scale and the relative pointer movement shall conform to criteria in Fig. 26.

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

(4) Aligned Pointers for Check Reading—When a stable value exists for given operating conditions in a group of circular scale indicators, they 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 in accordance with Fig. 27. If a matrix of indicators is needed, preference shall be given to the 9 o'clock position.

6.4.3 *Digital Displays:*

6.4.3.1 *Use*—Use and design criteria for digital displays include:

(1) Numbers shall change by snap action rather than by continuous movement.

(2) If numbers should be read in consecutive order, they shall not change faster than two per second.

(3) Counter drums shall be numbered so that a clockwise rotation of the drums or reset control, or both, produces an increase in the numerical value of the counter, as depicted in Fig. 28.

(4) Counters shall be oriented to be read from left to right or as appropriate for personnel's normal cultural reading practices.

(5) Digital displays shall be mounted as close as possible to the mounting surface.

(6) Digital displays should be dark numbers on a light background.

(7) Design criteria for digital displays are shown in Table 6 and in Fig. 28 a height:width ratio of at least 5:3 shall be provided for letters and numbers (except for "i," "j," and "l" [one]) which may be reduced to 5:1. The preferred height-:width ratio of 1:1 should be provided for letters and numbers (except for "i," "j," and "l" [one]) which should be reduced to 5:1.

6.4.4 *CRT Displays:*

6.4.4.1 *Signal Size*—When a target of complex shape is to be distinguished from a non-target shape that is also complex, the target signal shall subtend not less than 6 mrad (20 min) of visual angle and shall subtend not less than ten lines or resolution elements.

6.4.4.2 *Viewing Distance*—A 406-mm (16-in.) viewing distance shall be provided. When periods of scope observation will be short, or when dim signals must be detected, the viewing distance may be reduced to 254 mm (10 in.). Design shall permit the observer to view the scope from as close as desired. Displays that must be placed at viewing distances greater than 406 mm (16 in.) as a result of other considerations shall be appropriately modified in aspects such as display size, symbol size, brightness ranges, line-pair spacing, and resolution.

6.4.4.3 *Ambient Illuminance:*

(1) The ambient illuminance in the CRT area shall be appropriate for other visual functions (setting controls, reading instruments, maintenance) but shall not degrade the visibility of signals on the CRT display. When a CRT display is used in variable ambient illuminance, controls shall be provided to dim

TABLE 6 Character Sizes for Digital Displays[A]

Viewing Distance	Height	Width	Stroke Width	Minimum Separation between Numerals
Normal illumination above 3.4 cd/m^2 (1 ft-L)				
710 mm (28 in.)	3.8 mm (0.15 in.)	3.8 mm (0.15 in.)	0.94 mm (0.04 in.)	0.64 mm (0.02 in.)
910 mm (36 in.)	4.8 mm (0.19 in.)	4.8 mm (0.19 in.)	1.2 mm (0.05 in.)	0.81 mm (0.03 in.)
1525 mm (60 in.)	7.9 mm (0.31 in.)	7.9 mm (0.31 in.)	1.3 mm (0.05 in.)	1.3 mm (0.05 in.)
Low illumination below 3.4 cd/m^2 (1 ft-L)				
710 mm (28 in.)	5.6 mm (0.22 in.)	5.6 mm (0.22 in.)	0.94 mm (0.04 in.)	0.94 mm (0.04 in.)
910 mm (36 in.)	7.1 mm (0.28 in.)	7.1 mm (0.28 in.)	1.2 mm (0.05 in.)	1.2 mm (0.05 in.)
1525 mm (60 in.)	13.0 mm (0.51 in.)	13.0 mm (0.51 in.)	2.1 mm (0.08 in.)	2.1 mm (0.08 in.)

[A] For reading closer than 710 mm (28.0 in.), characters should be at least 3 mm (0.118 in.) high.

all light sources, including illuminated panels, indicators, and switches in the immediate area. Automatic adjustment of CRT brightness may be used if the CRT brightness is automatically adjusted as a function of ambient illuminance and the range of automatic adjustment is adequate for the full range of ambient illuminance.

(2) If the ambient illumination in the vicinity of the CRT is 540 lux (50 ft-c) or greater, dark characters and symbols on a light background should be used rather than light characters a dark background.

6.4.4.4 *Contrast Control*—A control shall be provided to vary the luminous symbol/dark background dark symbol/luminous background contrast ratio. Contrast between light characters and a dark screen background shall be not less than 6:1 (10:1 preferred); contrast between dark characters on a light screen background shall be not less than 1:6 (1:10 preferred).

6.4.4.5 *Adjacent Surfaces*—Surfaces adjacent to the scope shall have a dull matte finish.

6.4.4.6 *Pictorial/Graphic Situational Data*—Pictorial or situational data such as plan position indicator data shall be presented as luminous symbols against a dark background.

6.4.4.7 *Installation*—The face of a CRT display shall be flush with the surface of the panel in which it is installed.

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

6.4.4.9 *Lamp Replacement*—When replaceable incandescent lamps are used as the illuminant source for integral lighting of panel assemblies on the CRT, lamps shall be accessible without disconnecting the panel(s). A sufficient number of lamps shall be provided so that failure of one lamp will not cause any part of the display to be unreadable.

6.4.4.10 *Panel Marking Brightness Control*—Brightness of illuminated markings and trans-illuminated controls on the CRT shall be compatible with the ambient environment and operating conditions (for example, dark adaptation requirements). Brightness control (dimming) by the operator shall be provided where applicable to control/maintain appropriate visibility and operator dark adaptation level.

6.4.5 *Large-Screen Displays:*

6.4.5.1 *Use*—Large-screen displays shall only be used when the conditions allow satisfactory observational geometry to ensure that all critical operators have direct visual access in terms of viewing distance, angle, and lack of interference from intervening objects, personnel, or ambient lighting.

6.4.5.2 *Mounting Height*—Large-screen displays, such as status boards in Combat Information Center (CIC) rooms, which are mounted vertically, shall be no lower than 457 mm (18 in.) (preferred), 305 mm (12 in.) absolute, above the deck, or no higher than 1981 mm (78 in.) above the deck.

6.4.5.3 *Viewing Distance*—The display shall not be closer to any observer than one half the display width or height, whichever is greater.

6.4.5.4 *Design Criteria*—Large-screen displays shall be designed as follows:

(1) The height of letters and numerals should be not less than 5.8 mrad (20 min) of visual angle, and shall be not less than 2.9 mrad (10 min) of visual angle from the longest anticipated viewing distance.

(2) Character width should be approximately 0.9 of the height (except for "i," "j," "l," and the numeral "1").

(3) Dark characters should be displayed on a light background unless the background appears to flicker.

(4) If the display includes color-coded objects, the background shall be a neutral color such as gray.

(5) If characters are formed from dot matrices, the matrix shall be not less than 10 by 14 dots.

6.4.6 *Light-Emitting Diodes (LED):*

6.4.6.1 *Use*—LEDs may be used for transilluminated displays, including legend and simple indicator lights, and for matrix (alphanumeric) displays, but only if the display is bright enough to be readable in the environment of intended use.

6.4.6.2 *Design Requirements*—The design standard for LEDs will be the same as the requirements for the transilluminated displays (6.4.1).

6.4.6.3 *Light Intensity Control*—The dimming of LEDs shall be compatible with the dimming of incandescent lamps.

6.4.6.4 *Color Coding*—LED color coding requirements shall conform to 6.4.1.5*(7)* with the exception that red alphanumeric displays and red bar segments for vertical, horizontal, and circular meters may be used with approval from the procuring activity. However, red LEDs shall not be located in the proximity of emergency red lights.

6.4.7 *Dot Matrix/Segmented Display:*

6.4.7.1 *Use*—Dot matrix, 14-segment, and 16-segment displays may be used for applications involving interactive computer systems, instruments, navigation, and communication equipment, where the presentation of alphanumeric, vector-graphic, symbolic, or real-time information is required. The use of seven-segment displays are discouraged, and shall only be used for applications requiring numeric information.

6.4.7.2 *Design Criteria*—The design criteria below shall be applied to those displays (LED, CRT, gas discharge, liquid crystal, and incandescent) used for presentation of alphanumeric and symbolic information.

(1) Alphanumeric and symbolic characters shall not subtend less than 4.7 mrad (16 min) of visual angle.

(2) Alphanumeric characters shall be uppercase.

(3) Monochromatic displays shall use the following colors in order of preference: green (555 nm), yellow (575 nm), orange (585 nm), and red (660 nm). Blue emitters shall not be used.

(4) Dimming controls shall be provided where applicable to maintain appropriate legibility and operator dark adaptation level.

(5) Red LED/segmented displays shall not be grouped with or located adjacent to red warning lights.

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

6.4.8 *Electroluminescent Displays:*

6.4.8.1 *Use*—Electroluminescent displays may be used wherever system requirements dictate the use of transilluminated displays provided they comply with 6.4.1. In addition, they may replace existing mechanical instrumentation and they may also be used where sudden lamp failure could result in catastrophic consequences.

6.4.8.2 *Design Requirements*—The height of alphanumeric characters and geometric and pictorial symbols shall not subtend less than 4.5 mrad (15 min) of visual angle. Alphanumerical characters shall be composed of uppercase letters. All other design requirements shall comply with those for transilluminated displays in 6.4.1.

6.4.9 *Liquid Crystal Displays (LCDs):*

6.4.9.1 *Use*—LCDs are best used with low ambient illumination backlighting and adjustable viewing angles by the user are available.

6.4.9.2 *Image Contrast*—The image should be light characters on a dark background for reflective LCDs and dark characters on a light background for transmissive (that is, backlit) LCDs.

6.4.10 *Mimic Displays:*

6.4.10.1 *Use*—Mimic displays shall be used to integrate qualitative and quantitative information about relationships between objects in symbolic or pictographic form in order to enhance the operator's ability to conceptualize relationships. Mimic displays shall present information about: *(1)* the relative position and separation of objects, *(2)* functional or actual configuration of equipment and systems, and *(3)* current operational status of equipment or systems.

6.4.10.2 *Spatial Relationship*—Mimic displays shall be displayed to the user so that all equipment and systems are directly spatially related to the operator in the real world as they are shown on the display, for example, equipment and systems on the user's left in the real world shall be shown on the left side of the panel, things to the user's right in the real world shall be shown on the right side of the display.

6.4.10.3 *Design Criteria*—Design criteria for controls, displays, labeling, and control/display integration used in a mimic display shall comply with those criteria defined in this section and Sections 5, 7, 8, 10, and 15.

6.5 *Audible Displays:*

6.5.1 *General*—Three basic forms of information displays using sound include:

6.5.1.1 Voice communications (aided and unaided).

6.5.1.2 Alarm and warning signals (denoting off-normal or emergency situations).

6.5.1.3 General auditory display of information (to present simple status information such as to indicate completion of a time interval or to orient operator attention).

6.5.1.4 Guidance for the design of the audible portion of alarm systems is presented in Section 7. Guidelines for design of general auditory displays are presented below.

6.5.2 *Use*—Audible displays shall be provided when:

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

6.5.2.2 Information will not need to be referred to at a later time.

6.5.2.3 It is important to orient an operator to a location (for example, to direct visual attention to a radar display).

6.5.2.4 Vision is poor (for example, smoke-filled spaces, in holds and tanks).

6.5.2.5 The visual display mode is restricted by overburdening; ambient light variability or limitation; operator mobility; degradation of vision by vibration, or other environmental considerations; or anticipated operator inattention.

6.5.2.6 The criticality of transmission response makes supplementary or redundant transmission of critical data desirable.

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

6.5.2.8 Custom or usage has created anticipation of an audio display on the part of the operator.

6.5.2.9 It is necessary to present information independent of visual orientation.

6.5.3 *False Alarms or Interference*—The design of audible display devices and circuits shall preclude false alarms or interference from other electronic sources.

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

6.5.5 *Circuit Test*—All audible displays shall be equipped with circuit test devices or other means of operability test.

6.5.6 *Use with Several Visual Displays*—One audible signal may be used in conjunction with up to three visual displays provided that immediate discrimination between visual displays is not critical to personnel safety or system performance.

6.5.7 *Preference for Auditory Displays*—Audible presentation is preferred over visual presentation for:

6.5.7.1 Signals of acoustic origin,

6.5.7.2 Warning signals to call attention to imminent or potential danger,

6.5.7.3 Situations when many displays are visually presented,

6.5.7.4 Presenting information independently of head orientation,

6.5.7.5 Situations when darkness limits vision or makes seeing impossible, and

6.5.7.6 When signals must be distinguished from noise, especially periodic signals in noise.

6.5.8 *Signal Characteristics*—The intensity, duration, and source location of the signal shall be compatible with the acoustical environment of the intended receiver as well as the requirements of other personnel in the signal area. Signals shall be intermittent, allowing the user sufficient time to respond. Signals shall be automatically terminated by the operator response action or by manual control.

6.5.9 *Signal Type*—The optimum type of audio signal shall be presented in accordance with Table 7. Audio signals shall not interfere with other sound sources, including verbal communication.

6.5.10 *Signal Meaning*—Each audio signal shall be clearly distinct from the others and have only one specific meaning or required operator response.

TABLE 7 Functional Evaluation of Types of Audio Signals

Function	Type of Signal		
	Tones (Periodic)	Complex Sounds (Non-periodic)	Speech
Quantitative indication	POOR Maximum of five to six tones absolutely recognizable.	POOR Interpolation between signals inaccurate.	GOOD Minimum time and error in obtaining exact value in terms compatible with response.
Qualitative indication	POOR-TO-FAIR Difficult to judge approximate value and direction of deviation from null setting unless presented in close temporal sequence.	POOR Difficult to judge approximate deviation from desired value.	GOOD Information concerning displacement, direction, and rate presented in form compatible with required response.
Status indication	GOOD Start and stop timing. Continuous information where rate of change of input is low.	GOOD Especially suitable for irregularly occurring signals (for example, alarm signals).	POOR Inefficient; more easily masked; problem of repeatability.
Tracking	FAIR Null position easily monitored: problem of signal-response compatibility.	POOR Required qualitative indications difficult to provide.	GOOD Meaning intrinsic in signal.
General	FAIR Good for automatic communication of limited information. Meaning must be learned. Easily generated.	POOR Some sounds available with common meaning (for example, fire bell). Easily generated.	GOOD Most effective for rapid (but not automatic) communication of complex, multidimensional information. Meaning intrinsic in signal and context when standardized. Minimum of new learning required.

6.5.11 *Number of Coded Signals*—The number of coded signals should be limited to five. Where more than five coded signals are needed, use a two-phase signal.

6.5.12 *Location of Signal Source*—Signal sound source should propagate from the immediate vicinity of where operator or maintainer action (for example, examine a display or operate a control) is performed.

6.5.13 *Speech Supplements*—When speech supplements are used, the length of the initial alerting and the actual message shall not interfere with other auditory inputs including interpersonal voice communication unless the message is critical.

6.5.14 *Silent Operations at Night*—In equipment designed for silent operation at night, the sound level at the ear under an earphone shall not be greater than 60 dB(A).

6.5.15 *Manual Overrides*—Noncritical audio signals should be capable of being turned off at the discretion of the user. Where this capability is provided, a visual indication that the signal has been turned off shall be provided to the user.

6.5.16 *Supportive Function*—Audio signals used in conjunction with visual displays shall be supplementary to the visual signals and shall be used to alert and direct the user's attention to the appropriate visual display.

7. Alarms

7.1 *General Alarm Requirements:*

7.1.1 *Purpose*—Alarms shall be designed to:

7.1.1.1 Notify the crew that an out-of-tolerance condition exists.

7.1.1.2 Inform the user of the nature of the problem and its priority.

7.1.1.3 Confirm that the user's response corrected the problem.

7.1.2 *Overall Design Strategy*—An overall design strategy and philosophy should be prepared before any alarm design effort is initiated that sets a formal set of principles and policies for all alarms to be placed on a ship or other maritime facility. Each alarm proposed for use should then require a formal justification and a formal defined operator response. The basic principles should be set for each ship or maritime facility but should contain at least the following:

7.1.2.1 Eliminate all duplicate alarms.

7.1.2.2 No alarming of normal or expected events or expected deviations.

7.1.2.3 No alarming of operator actions.

7.1.2.4 Provide no more than one pre-alarm for each trip cause (that is, do not use a cascading alarm design).

7.1.2.5 Prioritize all alarms with no more than three priority levels, and allow only 5 to 10 % of all alarms to be in the "high-priority" category, 15 to 20 % to be in the "medium-priority" category, and 70 to 80 % be in the "low-priority" category.

7.1.2.6 Do not be overly aggressive in setting alarm trip points (that is, do not set trip points so near the actual performance limits so that the slightest deviation from the "normal operational value" will set off an alarm.

7.1.2.7 Maintain a tight control on changing alarm set points once the system and equipment have become operational.

7.1.2.8 Define what will be an "alert" message (that is, a message that provides the operator with a notice of a change in operations but which requires no immediate action by the operator) and what will be an "alarm" message (that is, an out-of-tolerance that does requires some operator response).

7.1.2.9 Maintain an aggressive program to eliminate "false" alarms.

7.1.2.10 Rely on system design rather than alarms to protect the crewmembers from injury or the ship or structure from damage.

7.1.2.11 Design alarm controls and displays in compliance with this section and Sections 5 and 6.

7.1.2.12 Danger and caution signals shall be immediately and easily discernible from each other and shall be consistently applied for all alarms.

7.1.2.13 All processed alarm information, whether visual or auditory, shall be presented in the most simple and understandable format possible.

7.1.3 *Types of Alarms*—The three types of alarms to be used on ships or maritime structures are:

7.1.3.1 Visual alarms alone (for example, flashing lights, rotating beacons, lighted annunciators on panels) shall be used on consoles or panels to attract attention and inform personnel of out-of-tolerance conditions. In addition, visual alarms shall be used as a supplement in high noise areas to alert crewmembers that an audible alarm has been activated.

7.1.3.2 Audible alarms alone may be used when the sound is unique and understood by the crewmembers to mean a specific out-of-tolerance condition, or when the purpose of the alarm is to serve as a general alert that requires a person to then check a visual display to find the exact nature of the alarmed condition (for example, a local alarm at a panel, console or workstation).

7.1.3.3 Audible alarms (for example, tones, verbal messages, combination of tones and verbal messages) accompanied by visual alarms (for example, rotating beacons, strobe lights, flashing lights, lit annunciators) shall be used in high noise areas, in any other circumstance where the operator may not be able to see, or be aware of, just a visual alarm alone.

7.1.4 *Alarm Response Requirement*—Each alarm shall prompt personnel action. Where multiple alarm conditions prompt the same action, there shall only be one alarm. If there is no action required, then that function shall not be conveyed by means of an alarm, but through a status indication.

7.1.5 *Alarm Acknowledge Requirement*—Alarms shall require personnel acknowledgment after alarm onset. An acknowledged control shall be provided, either as a separate control or integrated into each visual alarm display. The control shall terminate a flashing visual alarm and allow the alarm to remain illuminated until the alarm condition is cleared. The control shall also mute the audible signal (if one is provided) or a separate auditory silence control can be provided. The acknowledge control shall be located near the controls and displays associated with the alarm, or in a standardized location on all consoles, panels, and workstations.

7.1.6 *Alarm Rates*—The alarm system should create a presentation rate of alarms as follows:

7.1.6.1 Preferred rate of less than 6 per hour and a preferred peak rate of 60 per hour.[3]

7.1.6.2 Maximum allowable rate of 60 per hour and a maximum allowable peak rate of 600 per hour.[3]

7.1.7 *Set Points*—The limits or set points for initiating the alarm signals shall:

7.1.7.1 Not occur so frequently as to be considered a nuisance by personnel, and

7.1.7.2 Provide personnel adequate time to respond to the alarmed condition before it gets beyond the capability of the crew to correct the problem.

7.1.8 *False Alarms*—A means shall be provided to prevent normal operating conditions from causing false alarms. These methods may include the provision of time delays or allowance for transient signals.

7.1.9 *Simultaneous Alarms*—When two or more incidents or malfunctions occur simultaneously, the one with the higher priority shall be presented first. After presentation of the highest priority message, remaining alarms shall be presented in descending order of priority. Further, if a second alarm occurs in the same equipment or system before an earlier malfunction has been corrected, both the visual and audible alarms shall operate again.

7.1.10 *Alarm Priorities:*

7.1.10.1 Alarms shall be automatically organized and presented to the user in prioritized form. Prioritization shall be accomplished using a maximum of three levels.

7.1.10.2 A message priority system shall be established so that a more critical message shall override the presentation of any message with a lower priority.

7.1.10.3 Priority can be conveyed with either visual or auditory coding methods.

7.1.10.4 Prioritization shall be based on a combination of:

(1) Relative severity of the consequences of not responding to the condition or situation,

(2) Time required for the operator/maintainer to act, and

(3) The tasks required of the operator to respond to the alarm.

7.1.11 *Alarm Integration*—In the event of a complete system failure, a single summary alarm (for example, "Diesel Generator Set B Failure") may indicate the failure rather than requiring personnel to integrate the information presented by numerous component level alarms (for example, "Low Bus Voltage," "Stator Trouble," or "Lube Oil Pressure Low").

7.1.12 *Master Silence Control*—If a master silence control is provided it shall only silence active audible signals. It shall not block audible signals at the onset of subsequent alarms. The master silence control shall not affect the visual portion of the alarm.

7.1.13 *Subsequent Alarms*—Each subsequent alarm onset shall activate visual and audible signals such as a flashing visual indicator and audible alerting signal. This shall occur regardless of the condition of any other active alarms (for example, acknowledged, not acknowledged, cleared, active, or reset). If a single alarm has multiple inputs, any new alarm condition shall reactivate that alarm.

7.1.14 *Repetitive Alarms/Controls*—Repetitively appearing groups of alarms shall have the same arrangement and relative location on different panels and consoles. Placement of all alarm controls (for example, silence, acknowledge, reset, clear) that appear in more than one location shall be consistent between panels and consoles.

7.1.15 *Alarm Test*—For control consoles or panels, a means shall be provided to test the flashing and auditory signals associated with alarms without disrupting the normal operation of the alarm system.

7.1.16 *Temporary Disconnection of Alarms*—Alarm circuits may be temporarily disabled or left ON (for example, for maintenance) if such action is coordinated with appropriate personnel (for example, operations centers, the bridge engine control room) and is clearly indicated at all locations where such information may be required. These locations include the specific piece of equipment, the local control panel or console, the central control room, and work permits control center. Permanent alarms (for example, fixed lights or tiles, as opposed

[3] These rates shall exist for no more than 10 min.

TABLE 8 Guidelines for Color Coding of Visual Alarms

Color	Meaning	Explanation	Typical Applications
Flashing Red	Danger Serious damage to vessel or structure, serious injury or loss of life to crewman, major pollution	Requires immediate operator attention—danger situation	Over pressure, high temperature, impending loss of propulsion, high water level, low levels of critical liquids, over filling of tanks
Red	Danger Emergency condition acknowledged but has not yet been corrected	Warning of dangerous situation that requires immediate action.	Stop of essential machinery, (for example, lubricating oil pump for the propulsion engine or motor, failure of pressure in the lubricating system for the propulsion machine, and so forth) Temperature and pressure values (water, oil, etc) at critical levels Activation of a safety system
Yellow[A]	Caution Condition beyond operational limits exists but does not require immediate operator action	Notice of an out-of-tolerance condition that must be corrected but does not demand immediate attention by the operator.	Temperature and pressure values which differ from the normal levels, but not by critical amount Battery discharging but not yet at a critically low level
Blue	Instruction/test/information lost, (specific meaning assigned according to the case considered)	Blue may be given specific meaning that is not covered by red, yellow, or white but blue should be avoided whenever possible for alarm use.	Built-in-test (BIT) signal lost Non-essential equipment not working Electrical heating circuit for idle electrical machines not working
White	Neutral	Any meaning; may be used whenever doubt exists about the application of the colors red, yellow, and blue often used for confirmation.	Earth insulation indicators Synchronizing lamps Telephone calls Appliances automatically controlled

[A] Amber is not the same as yellow and can in fact be used as another color if needed. However, it is important to ensure that the two are easily distinguishable.

to computer-driven displays) shall be provided with a means to indicate their status (for example, by tag out or sticker indicating that the alarm is disabled).

7.1.17 *Navigation Bridge Alarms:*

7.1.17.1 Alarms on the navigation bridge should be limited to those that are critical to safety of the vessel or maritime structure. Visual alarms and indicators should not interfere with night vision.

7.1.17.2 Alarms on the bridge that are displayed in mimic arrangements on a panel (for example, fire doors, smoke alarm locations) shall be designed so that the mimic lines are visible both in day and night lighting conditions.

7.1.17.3 Alarm panels located on the bridge shall be arranged and located so the individual alarmed items are located within the panel to be spatially related to the actual ship layout as viewed by the operator on the bridge.

7.1.18 *Loss of Redundant Backup*—When part of a redundant system, piece of equipment, module or component becomes inoperable, an alarm signaling the loss of that redundancy shall be provided immediately even if the system, equipment, module or component is functioning normally. The visual alarm shall be continuously displayed until the redundant system, equipment, module or component has been restored.

7.1.19 *Alarms for Computer Displays*—Alarms contained within computer displays shall provide printed summary messages for each alarm which are both displayed on the screens and contained electronically for data log purposes. These messages are in addition to the standard visual or auditory alarms, or both (see Section 13 for Human-Computer Interface requirements).

7.1.20 *Alarm Filtering*—Alarm filtering shall only be used for alarms that have no current operational significance.

7.1.21 *Suppression*—Alarm suppression may be used where cascading alarms can occur as long as it does not interfere with the completion of users' tasks, and users can retrieve the suppressed alarm information with no more than two discrete steps.

7.2 *Visual Alarms:*

7.2.1 *Types of Visual Alarms*—Visual alarms shall be in the form of:

7.2.1.1 Flashing or rotating lights used in conjunction with audible alarms in spaces with loud noise.

7.2.1.2 Simple indicators that shall be used on panels, consoles or other workstations to call the operator's attention to an out-of-tolerance condition displayed at that site. Indicators shall be a minimum of 25 mm (1.0 in.) in diameter but should be used only if other design considerations preclude the use of annunciators.

7.2.1.3 Annunciators that shall be used in preference to simple indicators, and when used as alarms, should only provide qualitative information and not give commands.

7.2.2 *Flash Rate*—Visual alarms shall flash at onset. Flash rates shall be three to five flashes per second with approximately equal on and off time. The flashing display shall change to a steady state upon alarm acknowledgment. The steady state shall remain activated, either individually or in a summarized fashion, until the alarm condition is corrected.

7.2.3 *Alarms and Normal Operations*—Under normal operating conditions, no visual alarms shall be illuminated. Exceptions include provisions for alarms associated with equipment under repair or receiving servicing. When this is the case, alarms shall be tagged otherwise marked to indicate the status of the display and equipment. Alarms that are illuminated as a general case shall undergo review to determine if that alarm should be reclassified as a status indicator and if so, removed and relocated.

7.2.4 *Priority Coding*—A method for coding the visual alarms for the various priority levels shall be employed.

Acceptable methods for priority coding include color, position, shape, size, flash rate, or symbols.

7.2.5 *Flasher Failure*—If a panel or console visual alarm flasher fails, then at the onset of an alarm condition the alarm light shall illuminate and burn steadily, rather than not illuminate.

7.2.6 *Contrast Detection*—There shall be sufficient contrast between flashing and fully illuminated alarms, and between illuminated and non-illuminated alarms, so that personnel can reliably discriminate each state.

7.2.7 *Text Visibility and Legibility*—The text on visual annunciator alarms shall be readable whether or not the alarm is illuminated.

7.2.8 *Text Wording*—If text is displayed on visual alarms, wording shall be in accordance with the labeling requirements contained in Section 15. Text shall be all capital letters. Abbreviations and acronyms shall comply with Section 15 and have consistent usage throughout the vessel or other maritime installation. Personnel shall be able to read all the text associated with visual alarms from the position at the panel or console where the alarms acknowledgment control is located.

7.2.9 *Color Coding*—Visual alarms shall be color coded in compliance with Table 8. This color-coding scheme shall be consistent throughout the vessel or other maritime facility.

7.2.10 *Visual/Auditory Alarms:*

7.2.10.1 Visual alarms (for example, rotating beacons, strobe lights, flashing lights) shall be used in conjunction with general auditory alarms in spaces with ambient noise limits in excess of 85 dB(A), where a high degree of ambient illumination could prevent the detection of just a visual alarm, or under other circumstances where the audible alarms alone might not be discernible.

7.2.10.2 When visual alarms are used in conjunction with audible alarms, the visual alarms shall comply with the following:

(1) Be clearly visible in all parts of the space in which they are used,

(2) Be color coded in compliance with Table 8,

(3) Flash as long as the audible alarm is activated and continue to steady illumination until the alarm condition is cleared, and

(4) Use a single flash rate pattern for all alarm lights throughout the ship or maritime structure.

7.2.11 *Visual Alarm Panels*—Visual alarm panels displaying alarms for fire, gas, or other emergencies that can spread throughout the ship or maritime structure, or that display remote alarm station activation, shall be designed as follows:

7.2.11.1 The individual alarm indicators shall be placed within the overall alarm panel so they are spatially related to the actual location of the alarm sensors within the ship or structure as the panel is viewed by the operator.

7.2.11.2 The panel should be marked by zones corresponding to the fire or gas tight boundaries within the ship or structure.

7.2.11.3 Each visual alarm shall be provided a text label identifying the location of the emergency.

7.2.11.4 Alarm indicators should be coded (for example, color) to assist the operator in identifying the type or hazard level of the emergency (for example, red for fire or fire suppressant release, amber for smoke).

7.2.11.5 The use of a mimic outline of the ship or structure on the panel should be included.

7.2.11.6 If the visual alarm panels are a part of a computer control system the operator shall be capable of retrieving the alarm screens with no more than two key presses.

7.2.11.7 The panels should be designed and arranged so it is obvious which equipment is affected by each alarm, or at least which portions of the ship or structure are affected.

7.2.11.8 An audible alarm shall accompany the display of a visual alarm. It shall be silenced with the acknowledgment of the visual alarm by the operator. The audible alarm shall comply with the requirements of this section.

7.2.12 *Supplemental Alarm Information*—Supplemental visual alarm information shall be provided to the operator whenever an alarm sounds. This information will allow the operator to determine all containment control capabilities (for example, fire stations, damage control stations, deluge sprinklers, fire suppression systems including portable fire extinguishers, vent fans and other damage control equipment). This information may be presented in printed form or by means of computer display or other visual format.

7.2.13 *Alarm/Display Integration*—Where visual alarm indicators are mounted with controls or displays, or both, on consoles, panels, or workstations they shall be arranged in accordance with the requirements contained in Section 8.

7.3 *Audible Alarms:*

7.3.1 *Audible Alarm for Emergency Response*—Audible alarms, rather than visual alarms, shall be the primary mode used to alert personnel to major ship/structure wide general emergencies (for example, muster, report to fire party, presence of toxic gases such as H_2S, report to lifeboat station). Audible alarm signals shall not be used to indicate normal conditions.

7.3.2 *Content*—Audible alarms shall be stand-alone tones, or tones used with verbal messages. Audible alarms with verbal messages shall consist of an initial alerting signal to attract attention and a brief, standardized verbal message to first identify the specific hazardous condition and then describe the required action on the part of the listener to that condition.

TABLE 9 General Recommendations for Sound Loudness and Frequency

Conditions	Recommendations
If the distance to the listener is great	Use increased loudness and low frequencies
If the sound is to be heard around obstacles and pass through partitions	Use low frequencies
If background noise is present	Select frequencies lower than those of the background noise. Use several tones differing by an octave
To demand personnel attention	Modulate the signal to give intermittent “beeps” or modulate the frequency to make pitch rise and fall at rate of 1 to 3 Hertz.
To distinguish between different alarms	Use different sound waveforms, with pulse frequency between 0.5 to 2.0 Hertz. Consistently use the same waveform for the same function or purpose. Use no more than three or four different forms.

TABLE 10 Guidelines for Selecting Audible Alarm Sounds

Device	Loudness	Frequency	Attention Demanding Ability	Noise-penetration Ability
Foghorn	Very high	Very low	Good	Poor in ambient backgrounds with low-frequency noise; good in ambient backgrounds with high frequency noise
Horn	High	Low to high	Good	Good
Whistle	High	Low to high	Good if intermittent	Good if frequency is properly chosen
Siren	High	Low to high	Very good if pitch is rising and falling frequently	Very good with rising and falling frequency
Bell	Medium	Medium to high	Good	Good in low-frequency noise
Buzzer	Low to medium	Low to medium	Good	Fair if spectrum is suited to background noise
Warble	High	Low to high	Very good	Good
Wail	High	Medium to high	Very good	Good
High-low	High	Medium to high	Very good	Very good with high and low frequency alternating

7.3.3 *Sound Character*—The selection of loudness, frequency, and use of sound waveforms shall be in accordance with the guidelines shown in Table 9.

7.3.3.1 Using the same type of signal, but in two different forms, (for example, a continuous bell versus an intermittent bell), to identify two different emergencies (for example, H_2S present versus ship on fire), or to solicit two different responses from an alarm listener (for example, don PPE equipment versus abandon ship) shall not be used.

7.3.3.2 Completely separate and very distinct tones shall be used for all of the ship/structure wide general audible alarms. As an example, one alarm could be a siren, another could be a high-low warbling tone, and a third could be a "yelping" sound (these are all terms defining a specific wave form and frequency offered by a commercial alarm manufacturer). In selecting auditory signals for use as alarms it is preferable to pick tones which carry a preestablished cultural association with the tones in other emergency conditions. As an example, a siren is the long established sound for fire and police vehicles in the United States and as a result a siren could be selected for the fire alarm on a ship or other maritime structure manned by American crew. Likewise, creating new meanings for well-established cultural sounds shall not be done.

7.3.4 *Number of Distinct Tones for Alarms:*

7.3.4.1 Electronically generated sounds can be produced in many different tones, but the number of distinct audible alarms (in terms of the auditory characteristics of each) should not exceed seven for ship/structure wide alarms.

7.3.4.2 The upper limit of seven different tones may be used for local alarms but none of these should be the same sound as used for the ship/structure wide general alarms.

7.3.5 *Number of Distinct Tones for Relative Identification*—The maximum number of audio signals that can be used for relative identification shall not exceed twelve.

7.3.6 *Single Audio Signal*—A single auditory signal used in conjunction with multiple displays shall be used only if immediate identification of the appropriate visual display is not critical to personnel safety or system performance.

7.3.7 *Differing Signals:*

7.3.7.1 Differentiating audible signals that require different user responses shall be accomplished by varying frequency, modulation, pitch, beats or harmonics.

7.3.7.2 Audio signals used as alarms shall be clearly and easily distinguishable from routine signals and noises generated during normal operations.

7.3.8 *Selection of Sounds*—Sounds such as a whistle, siren, bell, klaxon, horn, warble tones, wails, high-low oscillating and a large assortment of other electronically generated alarm sounds can be used to provide distinct audible alarms. General guidance for the selection of sounds is given in Table 10.

7.3.9 *Audible Alarm at Console/Panel:*

7.3.9.1 When an audible alarm is used at a console, panel or other operator workstation to supplement the visual alarms the supplement audible alarm should be a siren (when used in conjunction with the flashing red light) for dangerous situations, and a horn (used in conjunction with the yellow or amber light) for a caution situation.

7.3.9.2 The audible alarm shall be silenced when the visual alarm is acknowledged.

7.3.10 *Headsets*—Operators who normally wear headsets covering both ears shall have the audible alarms presented in their headsets as well as in the work area.

7.3.11 *Sound Loudness*—Sound loudness criteria for alarms are as follows:

7.3.11.1 Audible alarm sound loudness shall be at least 75 dB(A) at a distance of 1000 mm (40 in.) from the source and at sleeping positions in cabins.

7.3.11.2 A signal-to-noise ratio of at least 20 dB(A) shall be provided in at least one octave band between 500 and 3000 Hz preferred, 200 and 5000 Hertz allowed, measured within 305 mm (12 in.) of the responder's ear.

7.3.11.3 When signals must travel over 300 m (985 ft), frequencies below 1000 Hz should be used.

7.3.11.4 Frequencies below 500 Hz should be used if signals must bend around obstacles or through partitions.

7.3.11.5 Frequencies between 1500 to 3000 Hz should not be used for alarms that require localization.

7.3.11.6 Audible alarm signal sound levels in a space shall not exceed 120 dB(A).

7.3.11.7 For large spaces, more than one audible alarm may be required to ensure the sound level can be heard throughout the space.

7.3.11.8 For spaces of unusually high noise levels, a beacon, strobe light, or similar device, installed in a location visible from all parts of the space shall supplement the audible signal. Red light beacons should only be used for fire alarms, unless this conflicts with appropriate statutory, regulatory, or class requirements.

7.3.11.9 Alarms shall not generate a startling reaction. In the first 0.2 s of a signal, avoid having abruptly rising waveforms,

square topped waveforms, or maximum sound level, and limit the sound level rise to less than 30 dB(A) in the first 0.5 s.

7.3.12 *Control of Loudness*—The loudness of an audible alarm signal shall be designed to be adjustable. The control mechanism shall be restricted and administratively controlled to prevent reducing the volume to an inaudible level or increasing it to an unacceptably high level.

7.3.13 *Detection Level of Alarm*—Each audible signal shall be detectable in all locations where personnel may be when their response to the condition is required. For example, signals to be detected by control room personnel shall be readily detectable anywhere in the control room. General emergency alarms (for example, emergency or evacuation) shall be detectable throughout the vessel or maritime installation (for example, in hull, topsides, and accommodations).

7.3.14 *Automatic Reset*—An automatic reset function should be provided whether the audible signal is designed to terminate automatically, manually, or both. It should be controlled by a sensing mechanism that recycles the alarm system to a specified condition (for example, alarm active or inactive) as a function of time or the state of the signaling system so that the alarm can sound again if the condition reoccurs.

7.3.15 *Manual Reset*—If an automatic reset function is not provided, a control should be provided to reset the system manually after alarms have been cleared.

7.3.16 *Cleared Alarms*—Cleared alarms should be accompanied by a dedicated, distinctive, audible signal of finite duration.

7.3.17 *Priority Coding of Alarm Signals*—Coding methods for audible alarm signals include pulse, duration, and frequency. Intensity should not be used as a coding method. If pulse coding is used, the number of levels should not exceed three. If duration is used, the number of levels should not exceed three. If frequency coding is used, the number of levels should not exceed four.

7.3.18 *Caution Signal Design*—Audible signals to denote a CAUTION notice shall be noticeably different from audible alarms identifying a DANGER situation. Audible caution signals shall be provided with manual reset and volume controls.

7.3.19 *Location of Alarm Signal Generators*—Equipment for generating audible signals should be positioned in a location and with an orientation that will maximize perception of the signal. The equipment should not be located where personnel may be immediately nearby unless precautions have been taken to ensure that the activation of audible signals will not startle them. The equipment generating audible signals should be located and arranged to remain operable during incidents such as flooding or fire.

7.3.20 *Public Address Systems:*

7.3.20.1 Public address system used in conjunction with the alarm system shall not become distorted through reverberation or interference.

7.3.20.2 Public address announcements shall be audible over the alarm. Announcements shall be at least 10 dB(A) above the alarm signal.

7.4 *Voice Messages:*

7.4.1 *Content*—Voice messages should be incorporated into all ship or structure general alarms. The messages shall identify both what the hazard is that caused the alarm, and what specifically is required of the personnel for this alarm (for example, go to lifeboat, report to muster station, don respirators for H_2S protection, report to emergency stations), rather than simply the nature of the emergency. In selecting words to be used in the verbal messages, priority shall be given to intelligibility, appropriateness, and conciseness, in that order. Voice signals shall be brief and a standardized message.

7.4.2 *Type of Voice*—The voice used in recording verbal messages may be male or female (male is preferred) and shall be distinctive, mature, without a dialect and from the country or region of the user. Verbal messages shall be presented in a formal, impersonal manner.

7.4.3 *Voice Intensity*—Guidance for verbal message intensity is as follows:

7.4.3.1 Verbal message intensity for critical functions shall be at least 20 dB(A) above ambient noise levels at the typical operating positions of the intended receivers, but should not exceed 90 dB(A).

7.4.3.2 The message should capture personnel's attention but should not cause irritation or a startle reaction.

7.4.3.3 Voice message intensity, if adjustable, should be controlled by administrative procedures and not by an openly available local control.

7.4.4 *Alarm Message Structure*—The structure of the alarm tone and message shall be as follows:

7.4.4.1 The voice signal shall be preceded by a non-speech (sound) alerting signal lasting from 1.0 to 2.0 s.

7.4.4.2 The voice message shall start with an alerting statement spoken two times (for example, "ATTENTION–ATTENTION").

7.4.4.3 The voice message shall then make the hazard identification and action required statement (for example, "FIRE–FIRE, GO TO YOUR EMERGENCY STATION" or "GO TO YOUR MUSTER STATION," which is repeated twice).

7.4.4.4 A 2-s pause shall follow the voice announcement and the cycle is then repeated. Total cycle time shall take between 11 and 14 s.

7.4.4.5 This sequence shall be repeated until the alarm is acknowledged, at which time both the tone and the voice message shall be terminated. If there has been a visual alarm operated with the auditory alarm the light shall stop flashing but remain lit until the alarm condition has been cleared.

7.4.5 *Words to Avoid:*

7.4.5.1 Words that rhyme with other words or that sound similar to other words should be avoided if the other words might be used in the same context in the same message. The use of vowels (a, e, i, o, u) is preferable to consonants as vowels are typically of lower frequencies, have a longer intonation and can be more readily distinguished than consonants pairs such as s-t, th-f, h-, c-h that are intoned more quickly and at a higher frequency.

7.4.5.2 Slang, jargon and colloquial words shall not be used.

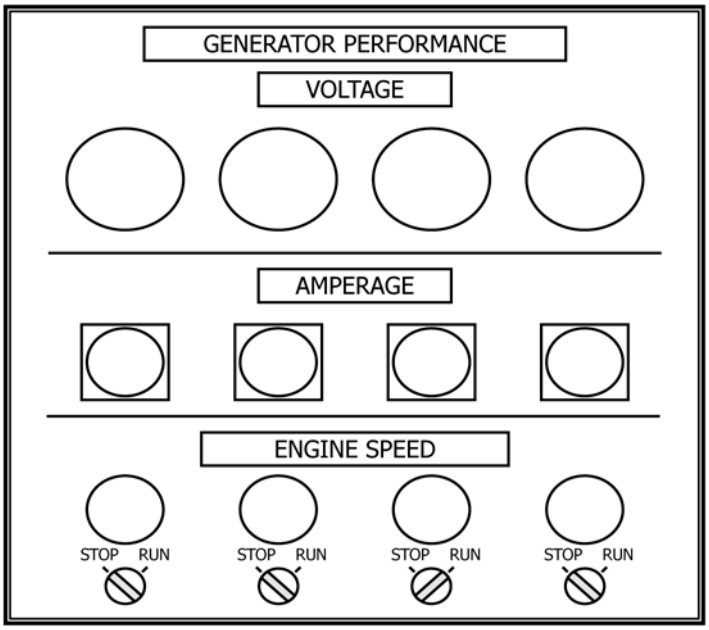


FIG. 29 Grouping Controls and Displays by Common Function

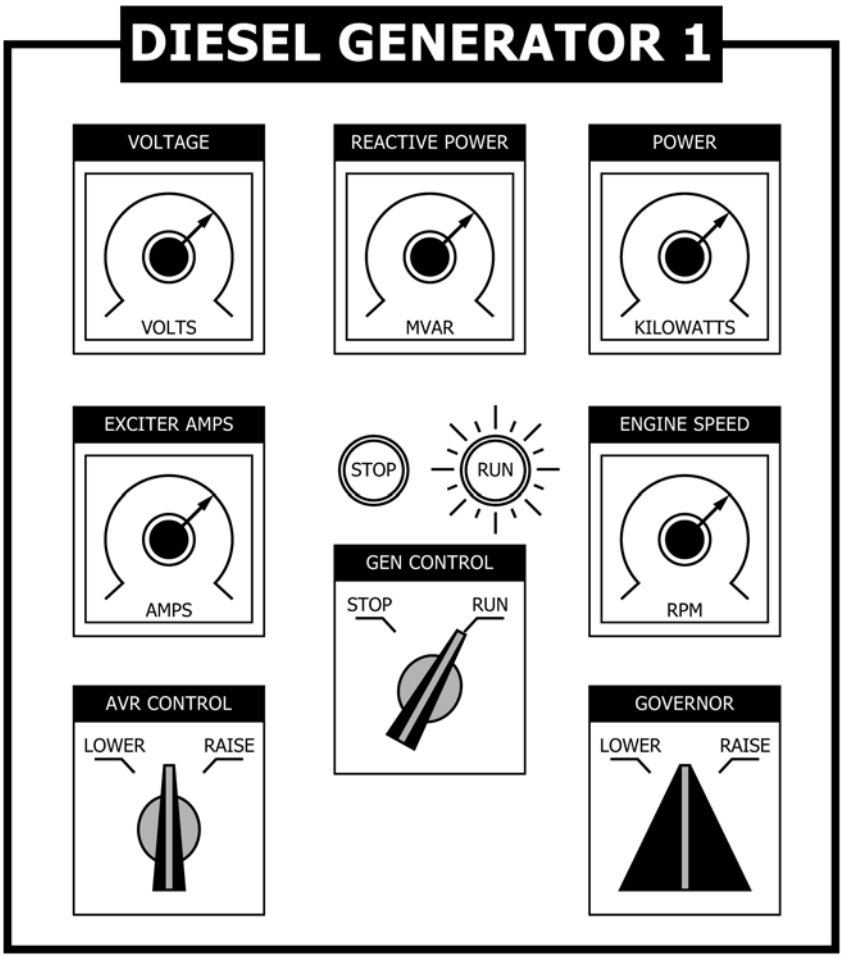


FIG. 30 Grouping Controls and Displays by Individual Equipment

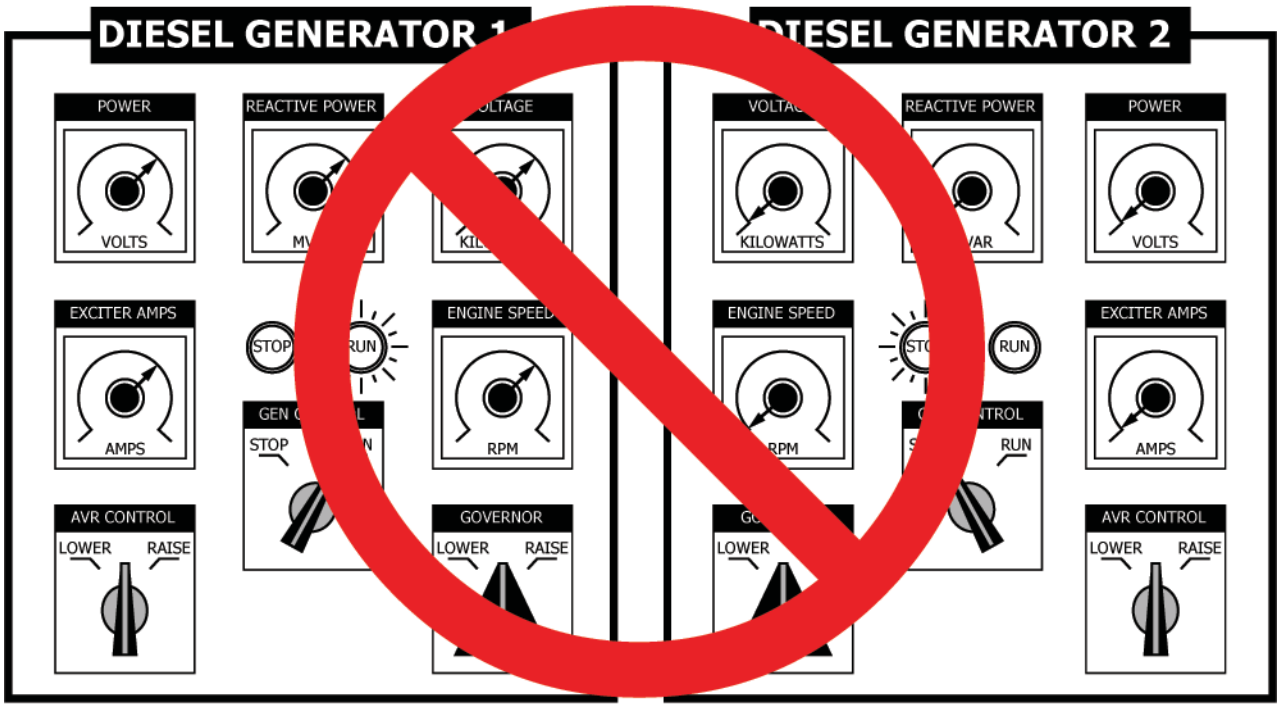


FIG. 31 Mirror-Imaged Arrangement of Individual Equipment Control and Display Groupings (Not Recommended)

7.4.5.3 Alphabet letters should not be used but should be replaced with the phonetic alphabet (for example, “Alpha” not A, “Bravo” not B, “Charlie” not C, and on through the rest of the alphabet).

7.5 *Alarm Initiation Stations:*

7.5.1 *Location*—Alarm initiation stations shall be located at or near exits, doorways, control stations, and evacuation/escape routes.

7.5.2 *Design*—Alarm initiation points located throughout a ship or maritime structure shall comply with the following design requirements:

7.5.2.1 They shall be simple to use requiring no more than two discrete steps.

7.5.2.2 They shall be identical in their design and operation throughout the ship or maritime structure.

7.5.2.3 They shall be uniquely designed so they cannot be confused with any other control, and they shall be separated from all other controls used in normal operations.

7.5.2.4 They shall be clearly identified using labeling and color coding in accordance with the requirements for DANGER signs contained in Section 15.

7.5.2.5 They shall be designed so it is visually obvious how the control works and if they have been activated. Further, their mode of operation shall be in compliance with the operator’s cultural expectation for operation of emergency controls (for example, pushbuttons in the United States).

7.5.2.6 Station identification numbers and emergency contact numbers shall be displayed. For standing operations these shall be located at the standing eye height of the 5th % female of the user population plus 178 mm (7 in.).

7.5.2.7 Emergency telephone numbers shall be short (for example, four digits or less) and easy to remember.

7.5.2.8 Where alarm initiation stations possess a telephone, a sound insulated booth shall be provided at the initiation station if the sound level exceeds 65 dB(A).

7.5.2.9 For standing operations, the controls shall be mounted between 1016 and 1397 mm (40 and 55 in.) above deck level.

7.5.2.10 They shall be designed to avoid accidental activation.

7.5.2.11 They shall be sized to their expected mode of operation (for example, operators wearing heavy gloves or mittens).

7.6 *Alarm Requirements by IMO:*

7.6.1 *General Requirements*—Ships subject to the International Convention for the Safety of Life at Sea (SOLAS) should follow the alarm guidelines contained in IMO Assembly Resolution A.1021(86), Code on Alerts and Indicators, 2009.

8. Integration of Controls, Displays, and Alarms

8.1 *Principles of Design:*

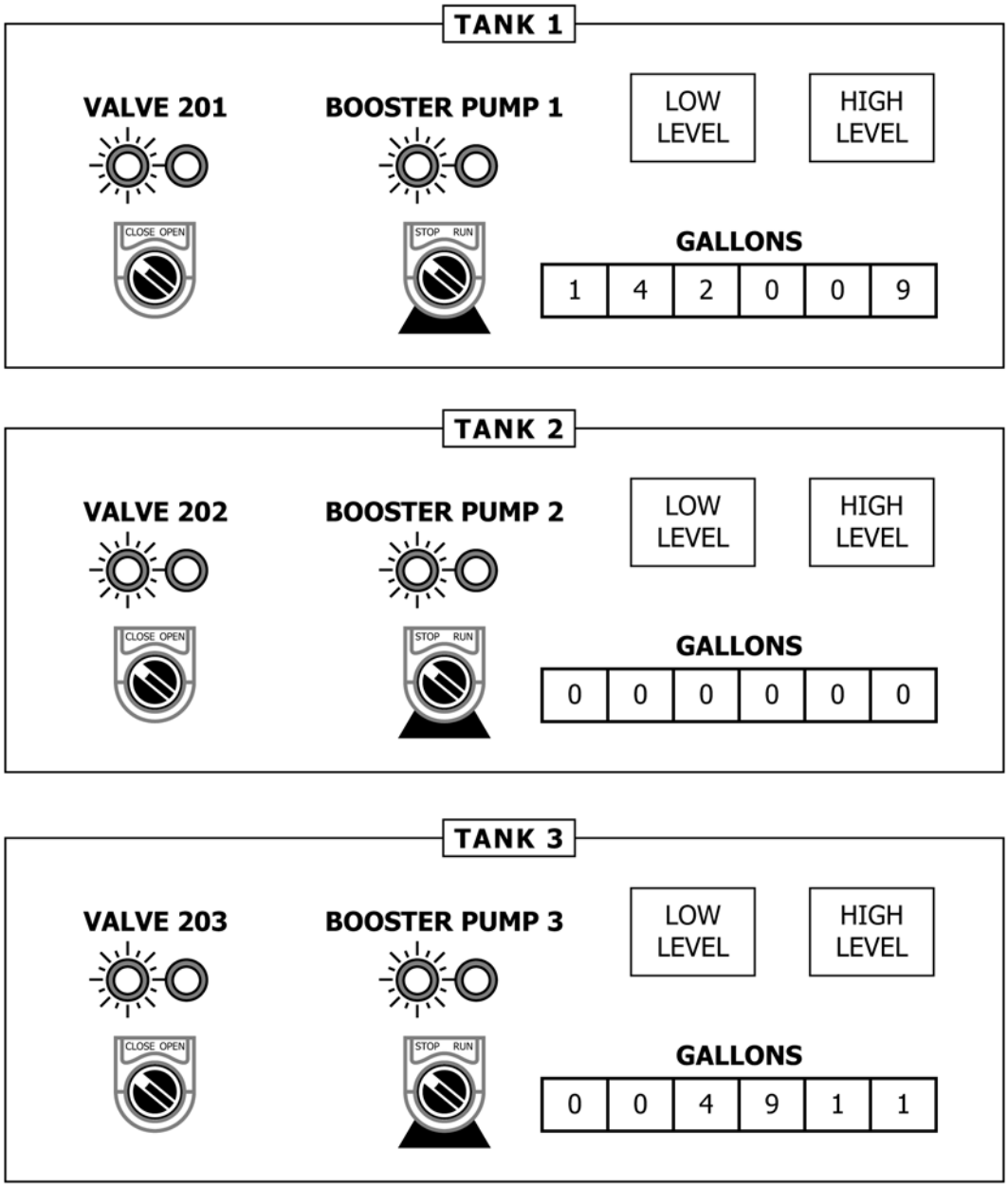


FIG. 32 Grouping Controls and Displays by Common Equipment

8.1.1 *Control/Display Relationship*—The relationship of a control with its associated display shall be apparent and unambiguous to personnel. Controls should be located under, or to the right of, their associated displays.

8.1.2 *Control/Display Equipment Relationship:*

8.1.2.1 Where controls and displays are provided for local operation of a specific piece of equipment, they should be located above or immediately adjacent to that equipment. For example, a board of gauges associated with a pump or filter would be located next to the pump or filter to ensure that it is visually obvious that all of the components are functionally related.

8.1.2.2 Where a deliberate choice is made to place the controls and displays remote from the equipment, the controls and displays shall be mounted in such a manner that the relationship of the location of the controls and displays matches the actual arrangement of the associated equipment.

8.1.3 *Control/ Display/Alarm Relationship*—On consoles or panels where there is a control, display and alarm provided for a particular function, the three components shall be arranged with the alarm on top (or to the left), the display immediately under (or to the right) of the alarm, and the control under (or to the right) of the display.

8.1.4 *Display/Alarm Relationships:*

8.1.4.1 The relationship between a display and its associated alarm indicator shall be immediately apparent and unambiguous to personnel. Alarms that are provided individually with a specific display shall be placed directly above (preferred) or to the left (acceptable), of the display.

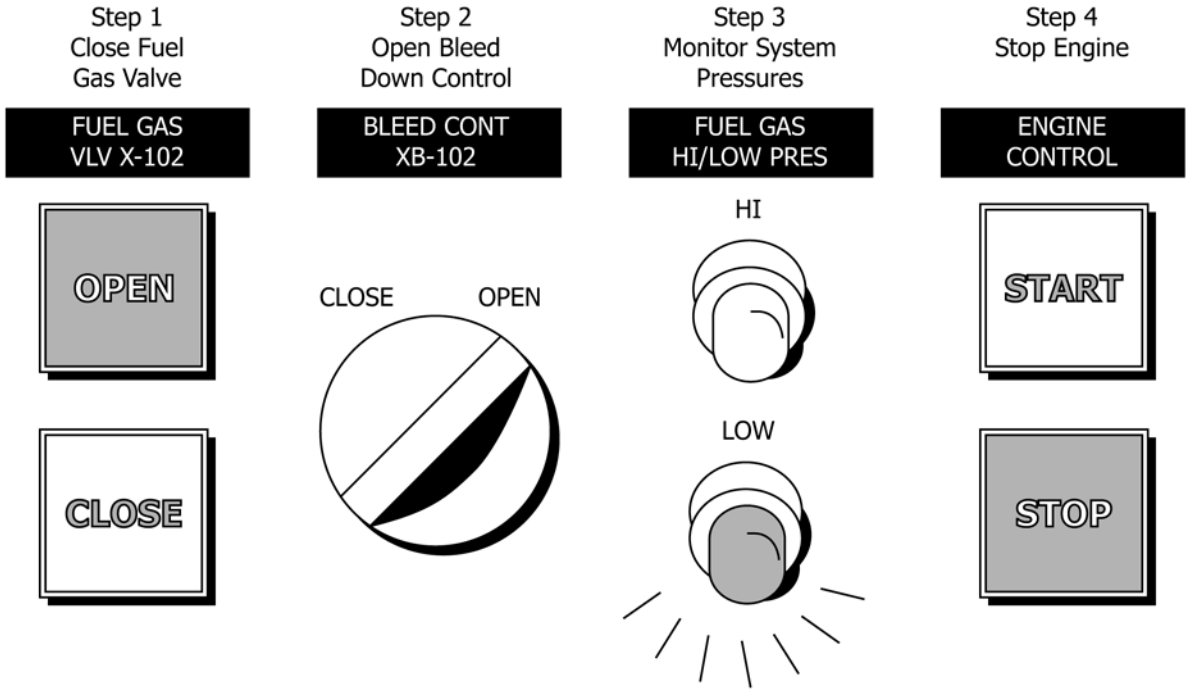


FIG. 33 Grouping Controls and Displays by Sequence of Use

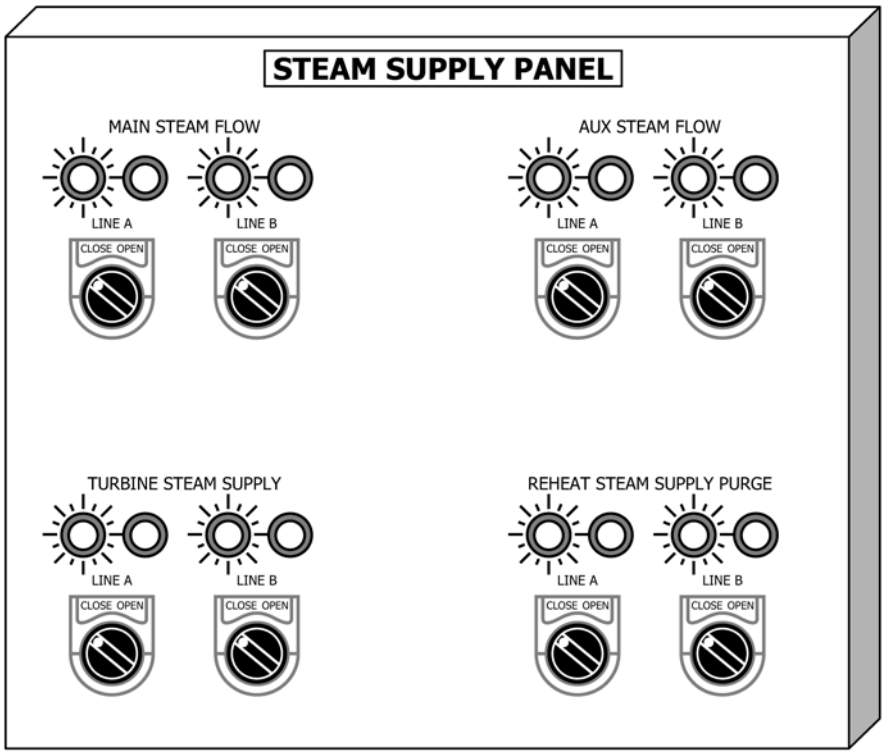


FIG. 34 Grouping with Physical Separation

8.1.4.2 Alarms that are ganged together should be located at the top of a console or panel, and arranged so there is a direct spatial relationship between the alarms and their associated displays placed elsewhere on the console or panel.

8.1.5 *Control/Display Movement Relationship:*

8.1.5.1 The response of a display to a control movement shall be consistent, predictable, and based on the personnel's movement expectations (see Section 5).

8.1.5.2 Combining more than one control into one control device shall not create any conflicts between control movement

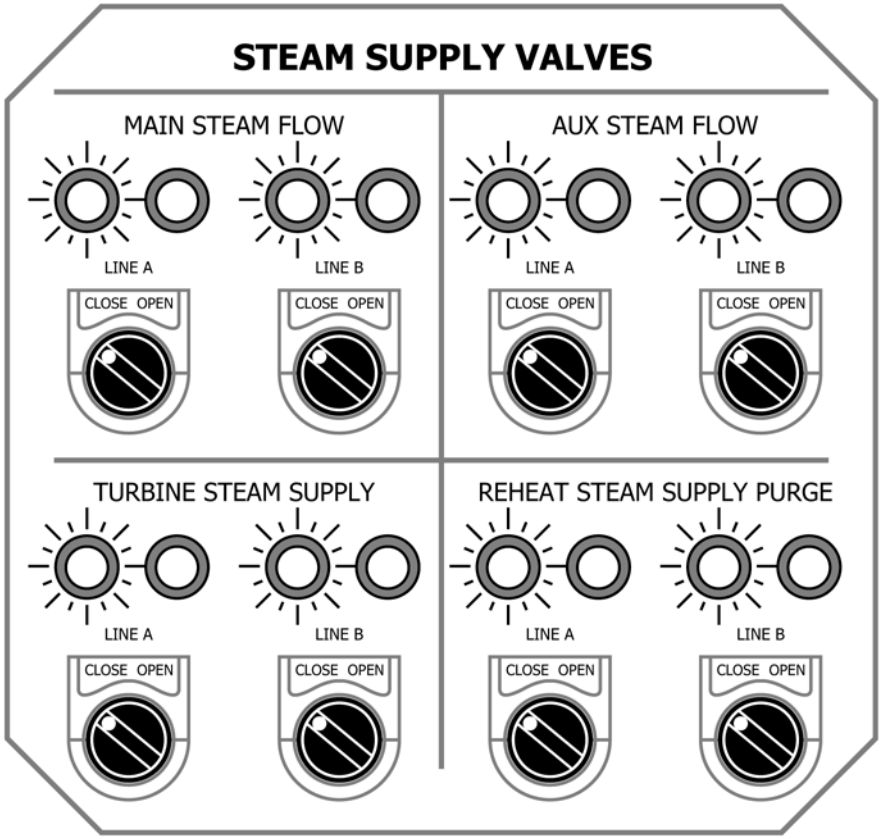


FIG. 35 Grouping with Boundary Lines and Borders

and the movement of the vessel or maritime facility (for example, a right movement of a control can create both a right turn and a right roll).

8.1.6 *Segregation of Groups of Controls and Displays*—Groups of controls and displays shall be physically and visually segregated (for example, a group of controls and displays associated with Generator Set A are adjacent to, but physically and visibly separated from Generator Set B).

8.1.7 *Labeling*—Console and panel labels shall be used to identify individual or groups of controls, displays, or alarms. Identification labels shall be provided for each control, display, and alarm as described in Section 15 and 8.5.4 – 8.5.5.

8.1.8 *Color Coding*—Color coding of controls shall be consistent with the requirements described in Section 5. Color coding of displays and alarms shall comply with the requirements described in Section 6 and 7, respectively.

8.1.9 *Feedback*—Feedback on equipment/system response to a control action shall be within the times shown in Table 30. Feedback can be provided through direct visual observation of equipment or by an associated display.

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

8.1.11 *Vertical and Horizontal Arrays*—If a horizontal row of displays must be associated with a vertical column of controls, or vice versa, the farthest left item in the horizontal array shall correspond to the top item in the vertical array. However, this type of arrangement shall be used only with the approval of the procuring organization.

8.1.12 *Simultaneous Access:*

8.1.12.1 If more than one crew member must have simultaneous access to a particular group of controls and displays they must be arranged and placed in a location such that more than one person can use them at a time.

8.1.12.2 A visual display that must be monitored concurrently with the manipulation of a related control shall be located so that the appropriate operators are not required to observe a display beyond the visual angles for secondary fields of view shown in Fig. 21.

8.1.13 *Consistency in Control, Display, Alarm Layouts*—Where controls, displays, and alarms used on identical equipment or systems installed in different locations in the same compartment, or in different compartments, the same arrangement and layout shall be used at each installation.

8.1.14 *Differentiate between Displays and Controls*—Where displays and controls that appear similar (for example, lighted annunciator and lit pushbutton) are integrated into a panel, console or workstation one of them shall be visually coded (for example, size, color, shape) so it is visually obvious to the

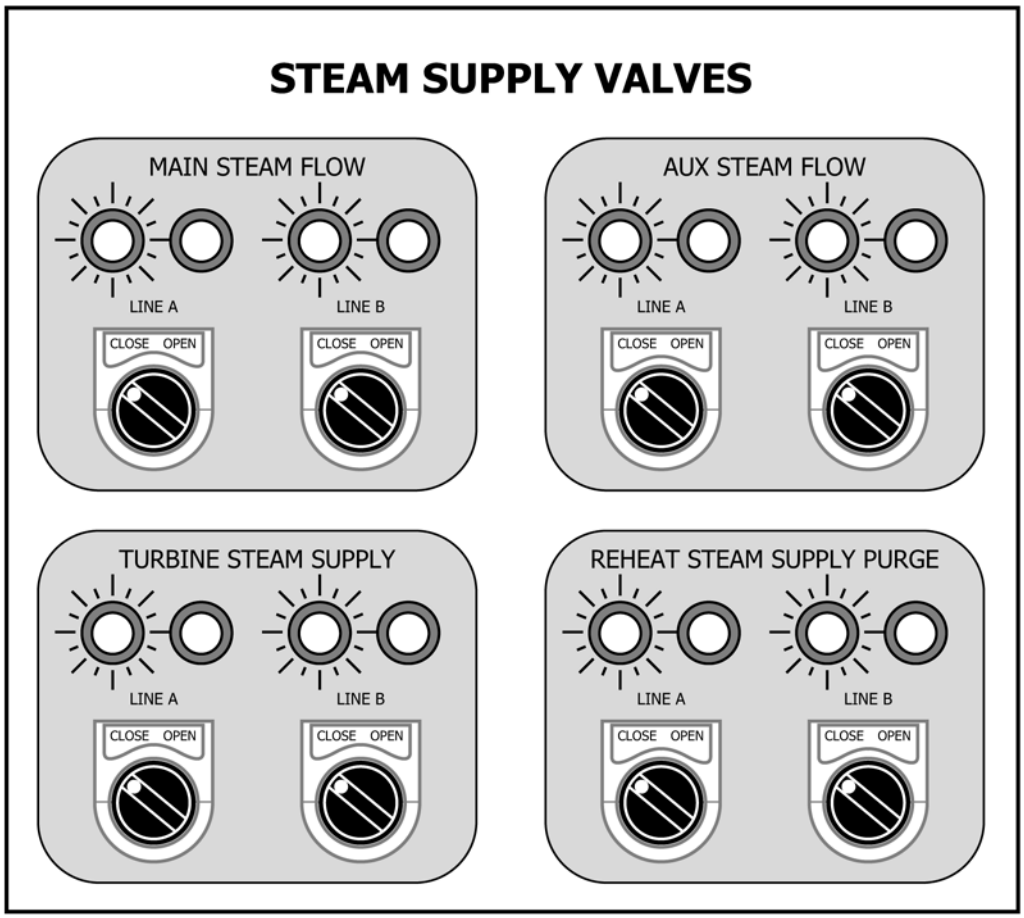


FIG. 36 Grouping with Colored and Shaded Pads

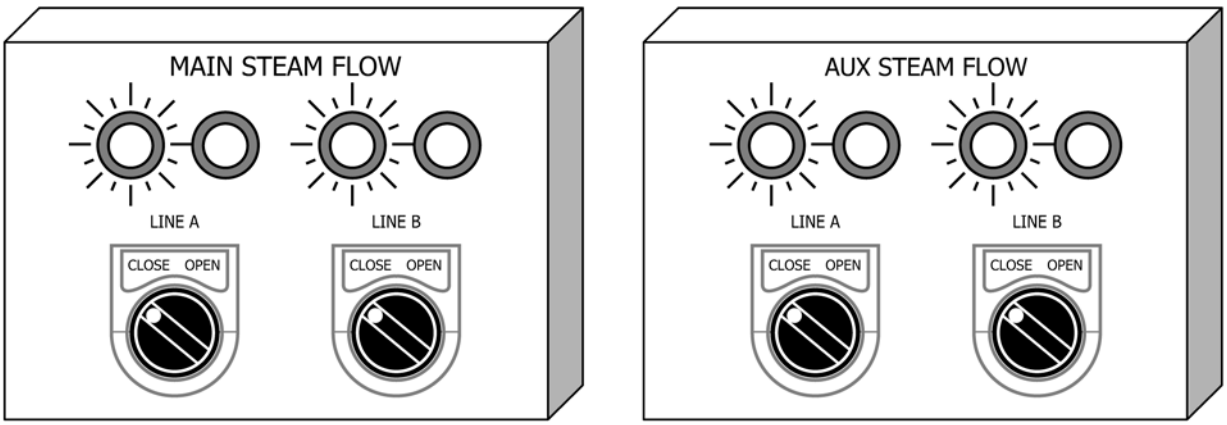


FIG. 37 Grouping with Subpanels

operator that one is a control (that is, can be pushed) and the other is a display only (that is, it is only a light).

8.2 *Grouping Relationships–Principles of Arrangement:*

8.2.1 *General Requirements*—Arranging controls and displays on a console or panel shall be accomplished using one of the two methods described below:

8.2.1.1 *General Location*—The more important or the most frequently used controls and their displays shall have the most favorable location (for example, located in the center of a console or panel) with respect to ease of reaching, grasping, and seeing. Functionally related controls and displays should be located together.

8.2.1.2 *Specific Arrangement*—Once assigned a general location, items shall be arranged within that area using one of several techniques described below.

8.2.2 *Functional Grouping*—Items having the same or common function may be grouped as demonstrated in Fig. 29 where all displays and controls associated with the common

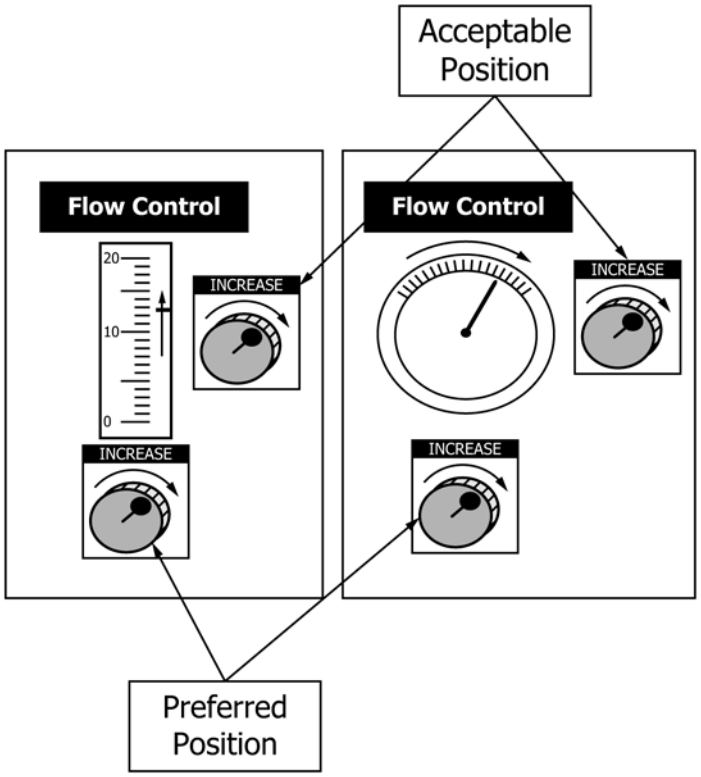


FIG. 38 Position of Individual Controls and Associated Displays for Right-handed Operator

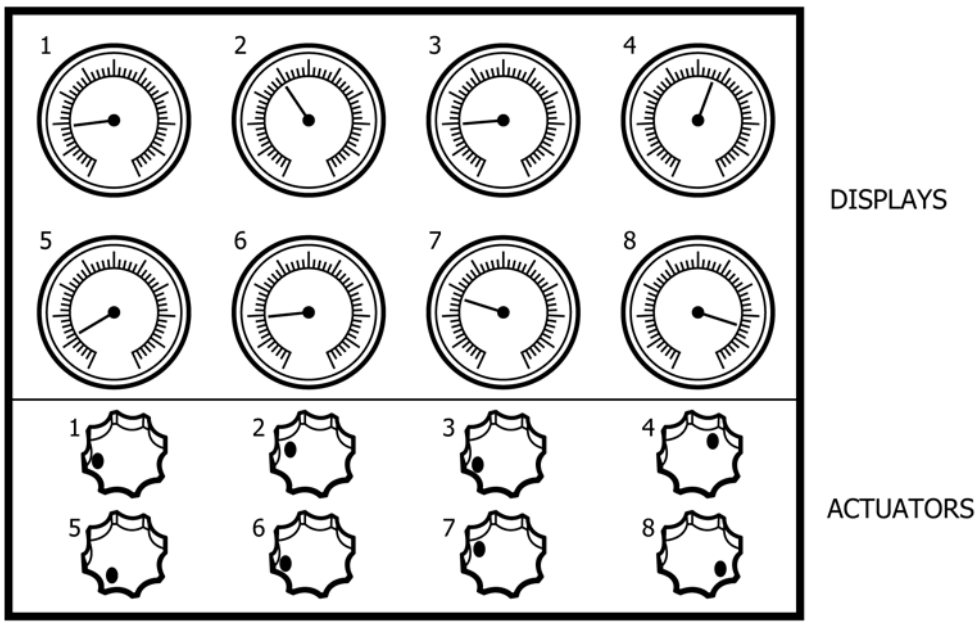


FIG. 39 Arrangement of Multiple Rows of Controls and Displays

functions of generator voltage, amperage, engine speed, and stop/run control for four generators are grouped together.

8.2.3 *Individual Equipment Grouping*—Items may be grouped by individual pieces of equipment as shown in Fig. 30 in which all controls, displays, and alarms for a particular piece of equipment are grouped together.

8.2.4 *Mirror-Imaged Arrangements*—Where multiple individual equipment groupings are provided, they shall not appear

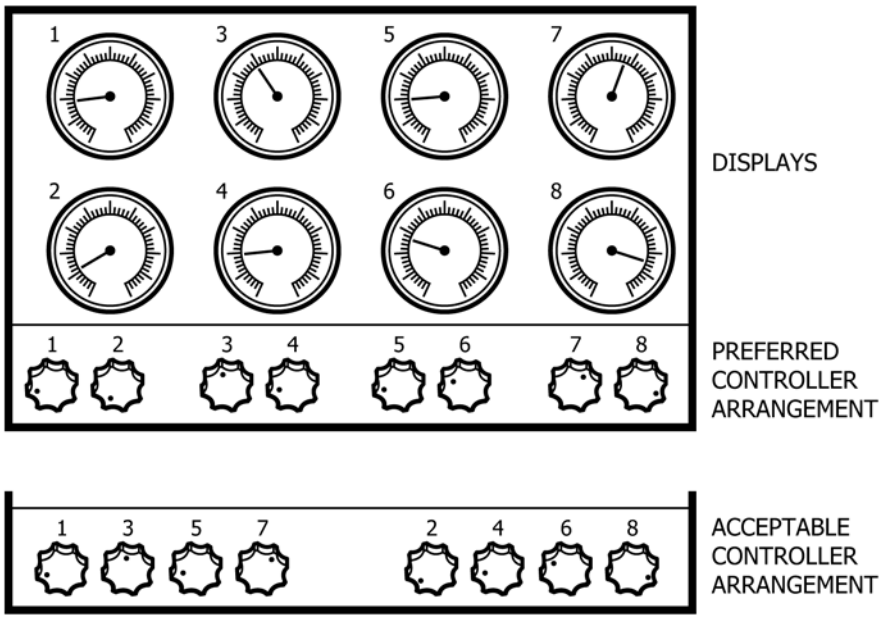


FIG. 40 Arrangement of Multiple Rows of Displays and a Single Row of Controls

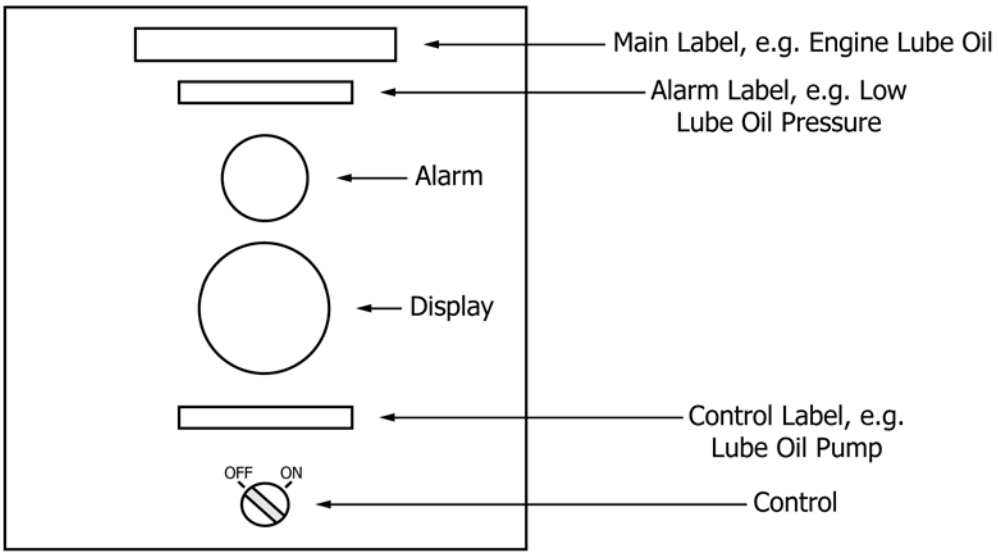


FIG. 41 Positional Relationship Between Alarm, Display, and Control

in a mirror-imaged arrangement as shown in Fig. 31 unless specifically approved by the procuring organization.

8.2.5 *Common Equipment Grouping*—Controls and displays may be grouped by common equipment such as all controls or displays associated with each piece of common equipment that appears on the ship or maritime structure as shown in Fig. 32.

8.2.6 *Sequence Grouping*—Items may be grouped by their sequence of use as shown in Fig. 33.

8.2.6.1 When sequential operations follow a fixed pattern, controls and their respective displays, shall be arranged to facilitate operation (such as in a fixed left-to-right and top-to-bottom arrangement).

8.2.6.2 When using the sequence of use principle, care must be taken that the arrangement avoids having to cycle through " a particular control (for example, OPEN/CLOSE) on a regular basis.

8.3 *Separating Groupings:*

8.3.1 *General Requirements*—The general principle of separating groupings is to ensure that there is a visually obvious relationship among groupings of controls, displays, and equipment. Once a grouping is established based on a chosen relationship, this grouping shall be segregated from other groupings through one or more of the following methods.

8.3.2 *Physical Separation*—Groups may be physically or visually separated as shown in Fig. 34. To be considered physically or visually separated, groups should be at least 25 mm (1.0 in.) apart. Where space is limited on a panel or console, keeping groups separated horizontally is preferred over keeping them separated vertically.

8.3.3 *Boundary Lines and Border Separations*—Groups may be separated by boundary lines and borders as shown in Fig. 35.

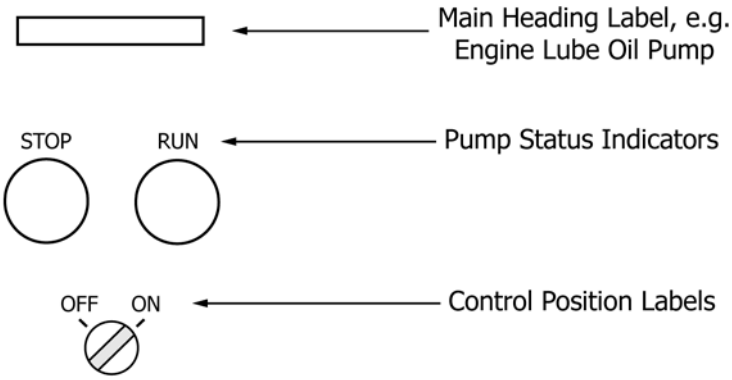


FIG. 42 Positional Relationship Between Control Pointer and Status Indicator

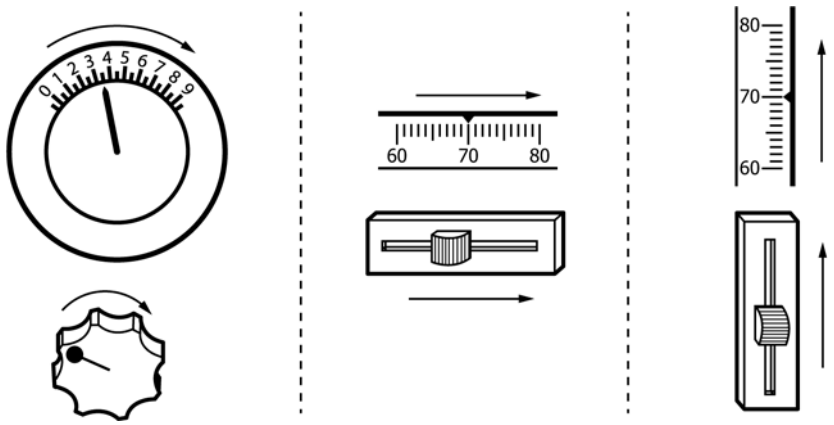


FIG. 43 Control and Display Movement Relationship

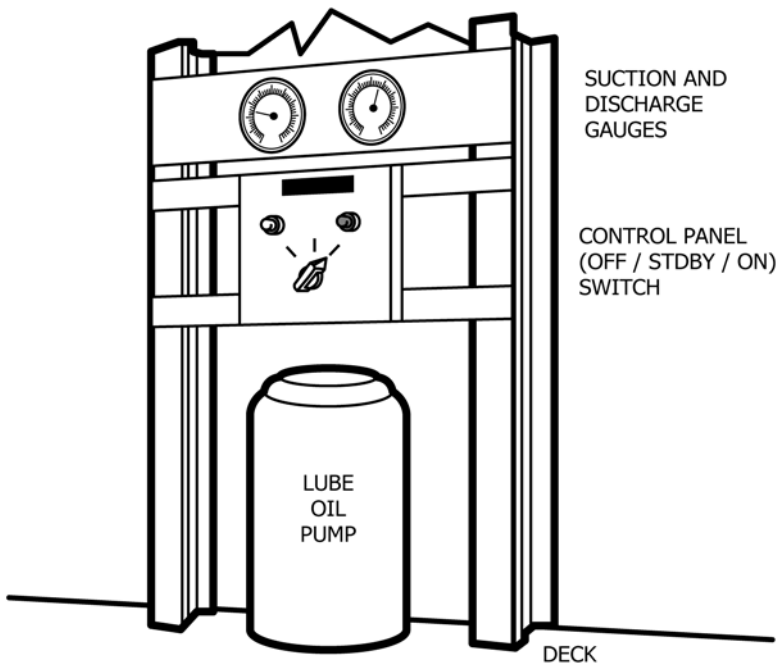
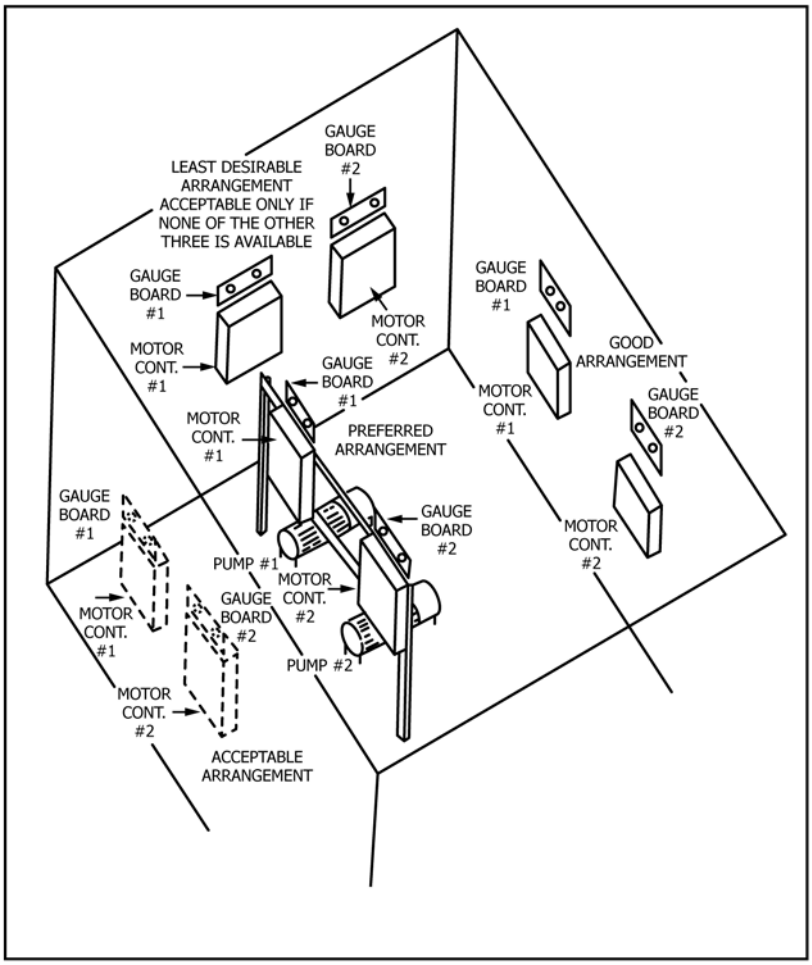


FIG. 44 Spatial Relationship Between Controls, Displays, and Equipment

8.3.3.1 *Border/Boundary Line Color Coding*—Noncritical functional groups should be outlined with a 1.5-mm (1⁄16-in.) black border (#27038 from FED-STD-595). Those functional groups associated with emergency or critical operations should



Note the “Preferred,” “Good,” “Acceptable,” and “Least Desirable” locations.

FIG. 45 Spatial Relationships Between Equipment and Control Panels

be outlined with a 5-mm (3⁄16-in.) red border (#21136 from FED-STD-595). If red ambient lighting is used, an orange-yellow (#23538) and black striped border should be used to outline the emergency or critical operations, or both. This color coding scheme should be used only if the panel or console face is a light color, for example, white, grey.

8.3.4 *Colored Pads*—Groups may be separated by colored or shaded pads as shown in Fig. 36.

8.3.4.1 *Color Pad Coding*—The colored or shaded pads should be color-coded with colors darker than the panel background such as light pastels or a darker shade of grey above that which colors the panel or console faces. Where color coded pads appear at different sites on the ship or maritime structure for the same or similar functional groups, they shall be the same color wherever they appear. Colors selected should be compatible with the functional system they are representing (for example, light blue for potable water, green for sea water, orange for fuel) and shall match the colors used for pipe markings if systems on the panel or console face are a part of the pipe color coding program.

8.3.5 *Subpanel Groupings*—Groups may be separated by the use of subpanels mounted to a background plate as shown in Fig. 37.

8.4 *Position Relationships of Displays and Alarms:*

8.4.1 *Position to Relationship:*

8.4.1.1 Display arrangement should provide viewing from left to right, top bottom. This arrangement however, shall take into consideration the cultural expectations of the intended operators and maintainers, (for example, there are cultures that read right to left).

8.4.1.2 Displays that are functionally or otherwise related to each other shall be positioned in a consistent manner to each other. As an example, dual displays providing IN and OUT type information (for example, suction and discharge pressure, voltage in and out) shall be arranged as shown below unless the IN and OUT displays are a part of a mimic display that does not permit these locations.

IN:	On the left (preferred), or top
OUT:	On the right (preferred), or bottom

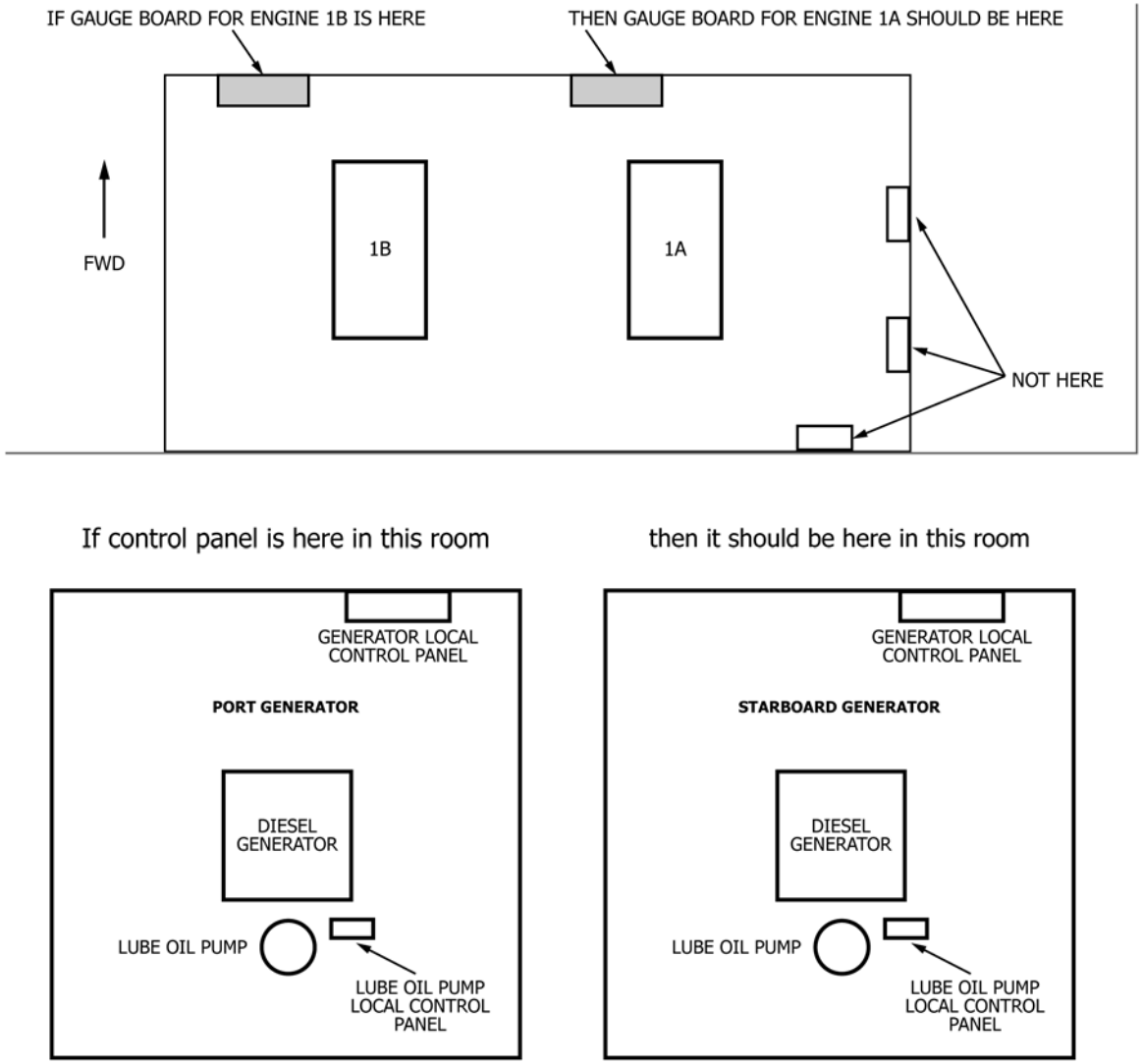


FIG. 46 Spatial Relationships for Redundant Controls and Displays

8.4.1.3 Lighted annunciators used as alarms to identify two critical positions of a measured parameter (for example, high and low temperature, high and low pressure, high and low flow rate) shall be located so that the high alarm annunciator is directly above or to the right of the low alarm annunciator.

8.4.1.4 Lighted annunciators or backlit pushbuttons for ON and OFF, START and STOP, or OPEN and CLOSE should be located as follows. The arrangement of these types of displays should also consider cultural expectations.

ON:	On the top (preferred), or right
OFF:	On the bottom (preferred), or left
START:	On the top (preferred), or right
STOP:	On the bottom (preferred), or left
OPEN:	On the top (preferred), or right
CLOSE:	On the bottom (preferred), or left

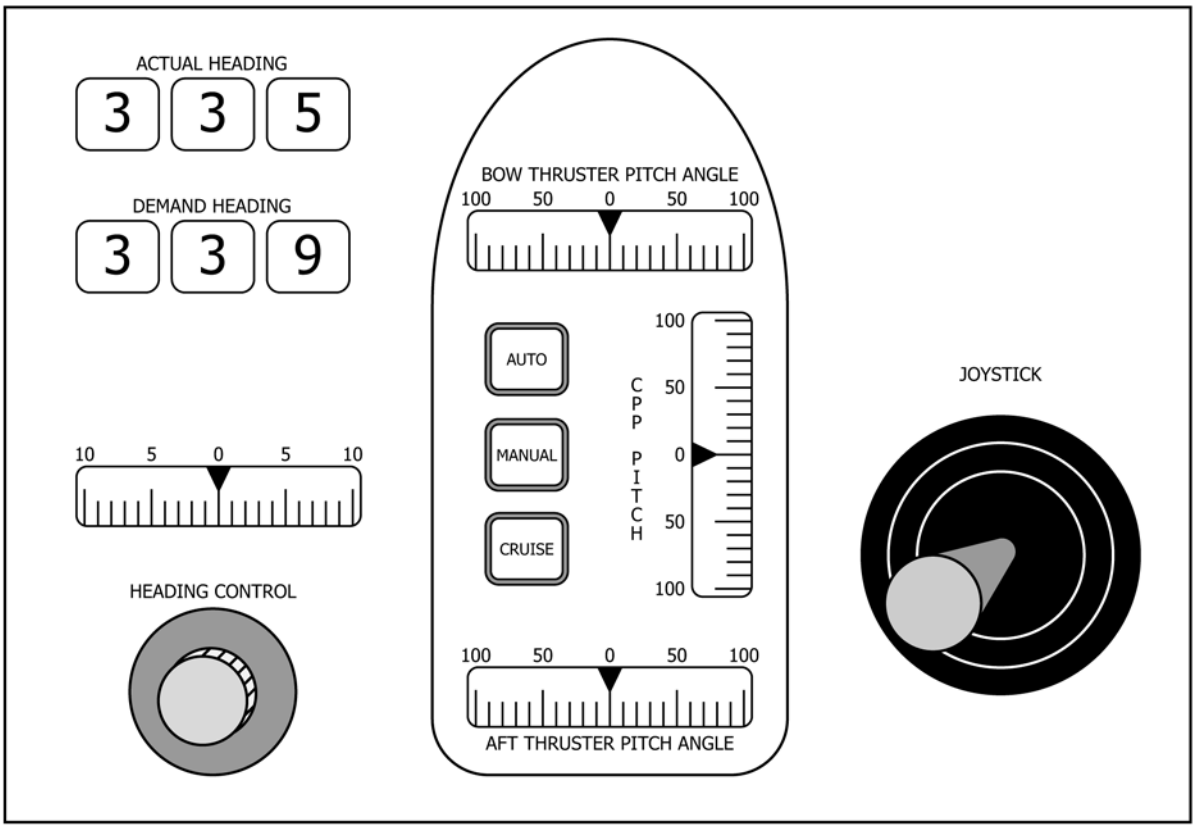
8.5 *Position Relationships of Controls to Associated Displays and Alarms:*

8.5.1 *General Requirements*—The positioning of controls associated with displays and visual alarms shall ensure that neither the control itself nor the hand normally used for operating the control, blocks the view of the display or visual alarm, as shown in Fig. 38.

8.5.2 *Alarm Matrix*—For control panels, groups of visual alarms should be organized as a matrix. When a matrix is used, it shall be located on a panel above the related controls and displays that are required for corrective or diagnostic action in response to the alarm. Further, the location of each visual alarm within the matrix shall be spatially related to the display or control, or both, required for corrective or diagnostic action as they are arranged on the panel. The number of individual alarms in a matrix should not exceed 50.

8.5.3 *Multiple Rows of Displays or Alarms*—For multiple rows of displays or visual alarms where corresponding controls cannot be located directly under each display or visual alarm, or adjacent to the displays or visual alarms, then they shall be placed as shown in Fig. 39 or Fig. 40.

8.5.4 *Between Alarm, Display, and Control*—The positional relationship between individual controls, displays, and alarms shall place the alarm at the top, display below the alarm and the control at the bottom as shown in Fig. 41. An alternative



Forward and aft thruster displays are shown within profile of ship where thrusters are actually located.

FIG. 47 Panel Layout That Replicates Location of Equipment in Remote Space

arrangement would be horizontal with the alarm on the left, display in the center, and control to the right.

8.5.5 *Between Control Pointer and Status Indicator*—The positional relationship between controls and status indicators, for example, between a rotary pump control and the pump operating status indicators shall be such that the control pointer is aimed at the status indicators related to the status control pointer position (see Fig. 42).

8.6 *Control and Display Movement Relationships:*

8.6.1 *General Requirements*—The response of a display to a control movement shall be consistent, predictable and based on the control movement expectations of the personnel who will use the equipment (see Section 5).

8.6.2 *Control/Display Movement Relationship*—The direction of movement of a display shall be the same as the direction of movement of the control, as shown in Fig. 43, "Control and Display Movement Relationship." Clockwise movement of a rotary control or movement of a linear control forward, up, or to the right, shall produce a clockwise movement of the pointer in a circular display. Movement up or to the right for horizontal and vertical displays shall cause an increase in the magnitude of the display reading.

8.6.3 *Control/Display Response Speeds*—For continuous-adjustment controls, such as knobs, and if speed of adjustment is more important than accuracy, the control/display ratio should be low (high gain). If accuracy is more important than speed, a high control/display ratio (low gain) is preferred. If both speed and accuracy are important, the ratio must be optimized for the specific task.

8.7 *Spatial Relationship between Controls, Displays, and Equipment:*

8.7.1 *Local Control, Display, and Equipment Spatial Relationships*—Where local control of equipment is provided (for example, local control panels, simple ON/OFF switch), controls or displays associated with a specific piece of equipment (for example, controls and pressure gauges for a pump) should be mounted directly above, or adjacent to, the equipment so that it is visually obvious that all of the components are related. (See Fig. 44, "Spatial Relationship between Controls, Displays and Equipment.")

8.7.2 *Spatial Relationships between Equipment Panels*—When local controls, displays, or alarms, or combination thereof, are provided at the equipment (for example, in a panel mounted on the bulkhead or a support stanchion) they shall be located and oriented so as to be spatially related to the equipment each is associated with as viewed by the operator facing the and control, displays, and alarms. See Fig. 45 for examples.

8.7.3 *Spatial Relationships for Redundant Controls*—Controls, displays, and alarms that are provided for similar or identical systems, or individual pieces of equipment, that appear in the same, or separate spaces, shall be located and oriented in the same spatial relationship at each location as shown in Fig. 46.

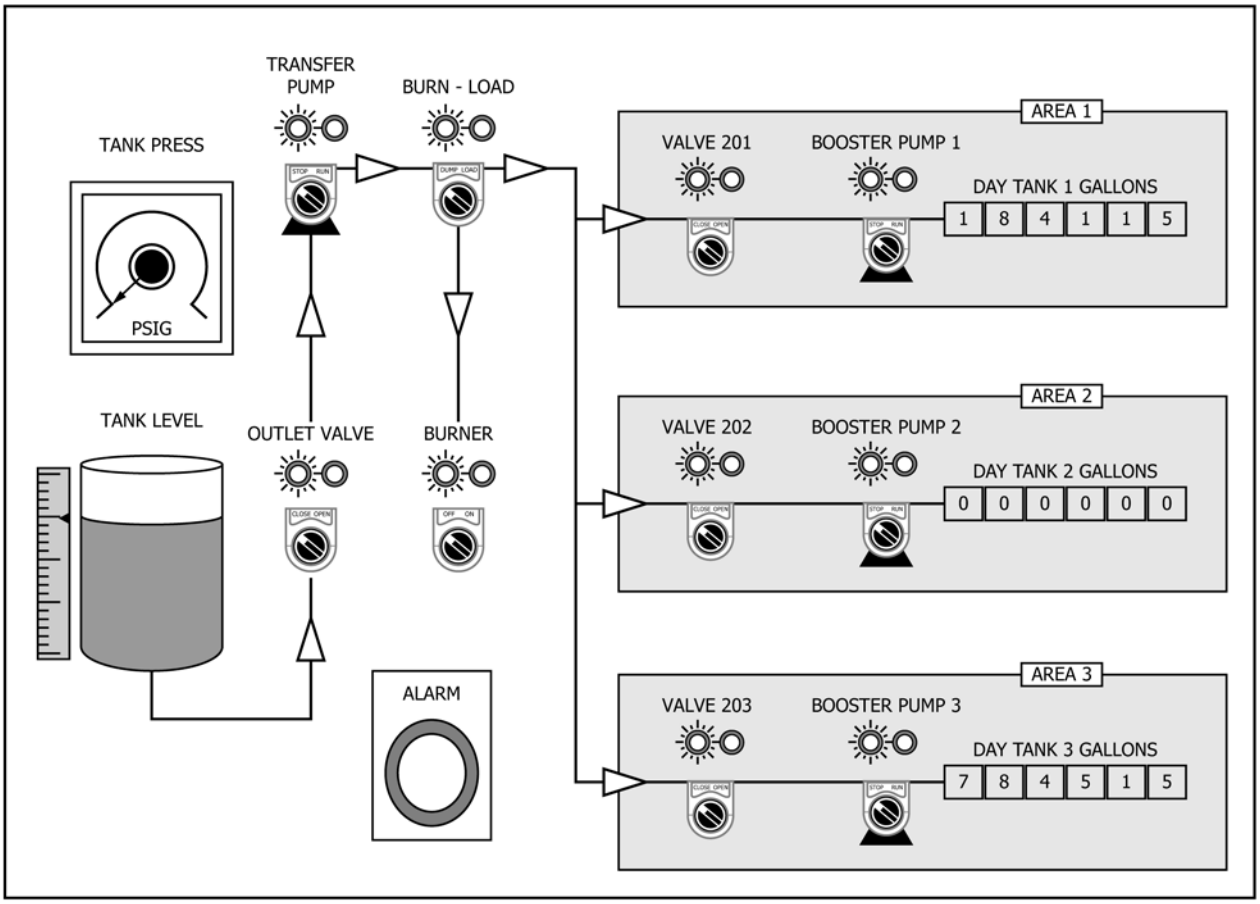


FIG. 48 Mimic of Physical Equipment Functional Layout

8.7.4 *Spatial Relationships from at Remote Locations*—Where a deliberate choice is made to place the controls and displays remotely from the equipment (that is, on a control panel or console away the area where the equipment is actually located) then the controls and displays shall be mounted so that the relationship of the location of the controls and displays matches the arrangement of the equipment to which they belong. (See Fig. 47.)

8.8 *Alternative Approach to Grouping Design:*

8.8.1 *Mimic Format*—An alternative to integrating controls, displays, and alarms through one of the grouping techniques is to mimic the system or equipment, either with a mimic of the physical equipment functional layout (Fig. 48, "Mimic of Physical Equipment Functional Layout") or with a mimic of the functional groups irrespective of the equipment layouts (Fig. 49, "Mimic of Functional Groups Irrespective of Equipment Layout").

8.9 *Special Requirements for Control and Display Integration on Bridges:*

8.9.1 *General Requirements*—Special requirements for control/display integration unique to the navigational bridge are defined in Section 6, Part 8 of the ABS "Guidance Notes on Ergonomic Design of Navigational Bridges."

9. Anthropometry

9.1 *General Design Requirements:*

9.1.1 *Data Limitations:*

9.1.1.1 The anthropometric data presented herein represent nude, or minimally clothed, body measurements taken from erect standing or seated postures. However, in the actual operating environment, personnel often wear heavy clothing, helmets, boots, load-carrying equipment, personnel protective equipment (PPE), and other worn or carried items. All of these can add bulk and restrict mobility of the wearer.

9.1.1.2 In addition, humans seldom sit or stand erect (that is, they have postural slump) and this factor could, in conjunction with body covering, effect overall anthropometric sizing of the human being so that it should be incorporated in the equipment design. To aid in that effort non-specific clothing and posture slumping data are provided in Table 11 that should be used in cooperation with the basic anthropometric data contained in the following figures and tables in this chapter to establish the final anthropometric design criteria.

9.1.1.3 Due to the difficulty in accurately measuring the human body it is to be expected that there will be some variability [as much as ±12 mm (0.5 in.)] between different sources of anthropometric data for the same body measurement.

9.1.2 *Design Range*—All systems, equipment, individual components, workspaces, control rooms, accommodations, or any other part of a vessel or maritime facility, including vendor-supplied hardware and software, shall be designed to fit the 5th % female to the 95th % male of the expected user population.

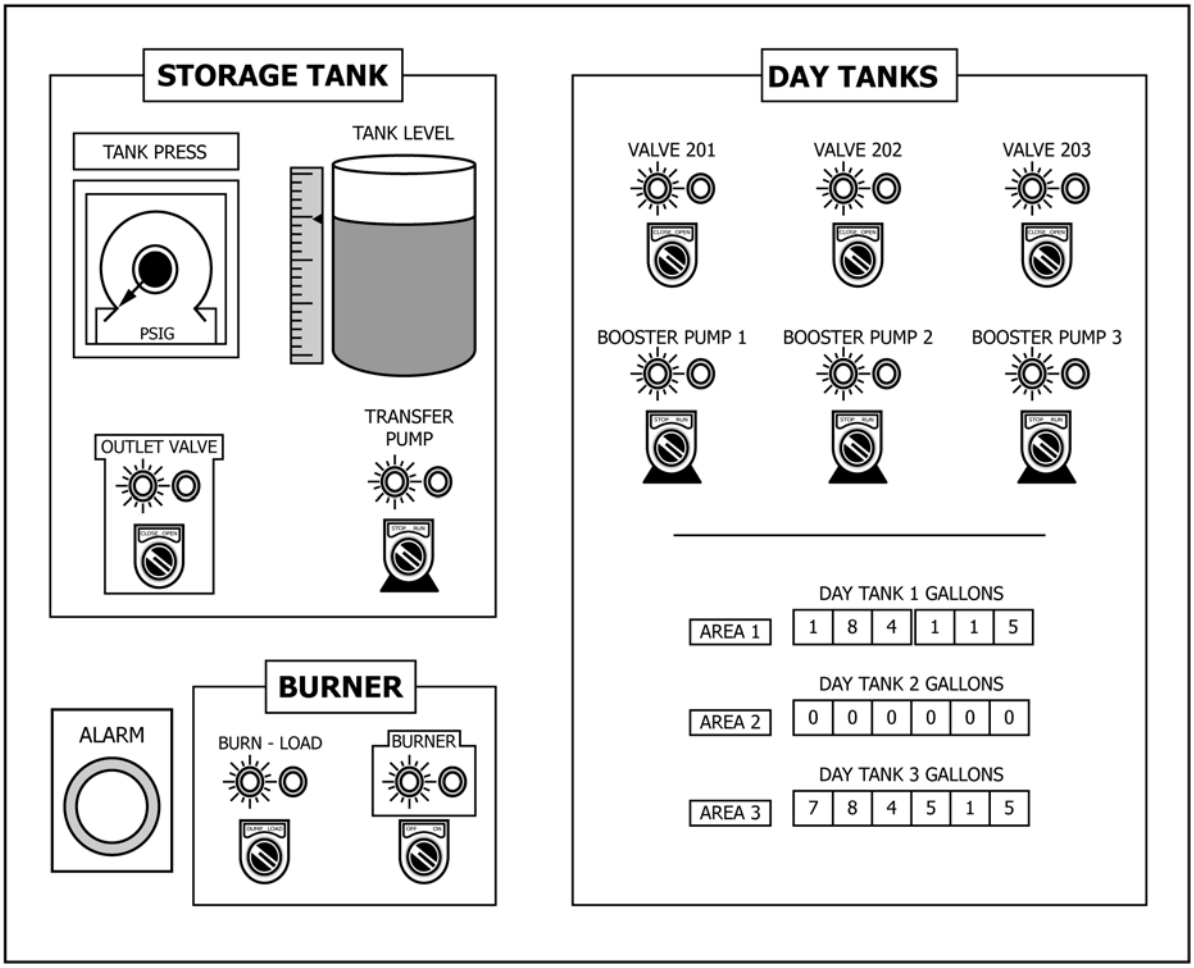


FIG. 49 Mimic of Functional Groups Irrespective of Equipment Layout

TABLE 11 Clothing and Postural Effects

Description	Effect
Effect of footwear in standing height measures	+25 mm (1 in.)
Effect of clothing in sitting height measures	+5 mm (0.2 in.)
Effect of clothing in breadth	+15 mm (0.6 in.)
Effect of clothing in foot length	+30 mm (1.2 in.)
Effect of hard hat in stature	+75 mm (3.0 in.)
Effect of gloves on hand length/breadth	+7 mm (0.3 in.)
Effect of postural slump in standing height	–20 mm (0.8 in.)
Effect of postural slump in sitting height	–45 mm (1.8 in.)

9.1.3 *Special User Populations*—Where equipment will be used, inclusively or exclusively, by selected or specialized segments of user populations or population ranges other than the 5th to 95th percentiles, appropriate available anthropometric data on these special populations shall be used for design and sizing criteria.

9.1.4 *Anthropometric Design Principle*—When selecting anthropometric data to be used in determining a design, only those data that directly drive design limits shall be used. As an example, if the design task was to set an overhead clearance in a walkway, the stature height of the 95th % male would be used since that represents the controlling design limit (i.e., the worst case anthropometric dimension affecting overhead clearance). In contrast, if a reach dimension were required, the anthropometric data for the 5th % female would set the design limit since it reflects the worst case in terms of a maximum reach.

9.2 *Static Anthropometric Data:*

9.2.1 *Static Body Dimensions—North American*—Body dimensions for North American 5th and 95th % male and female populations are shown in Fig. 50, "Standing Body Dimensions;" Fig. 51, "Seated Dimensions;" Fig. 52, "Depth and Breath Dimensions;" Fig. 53, "Hand and Foot Dimensions;" Fig. 54, "Gloved Hand Dimensions;" and Fig. 55, "Head Dimensions." S.I. dimensions are shown on the top, inch-pound units are in parentheses.

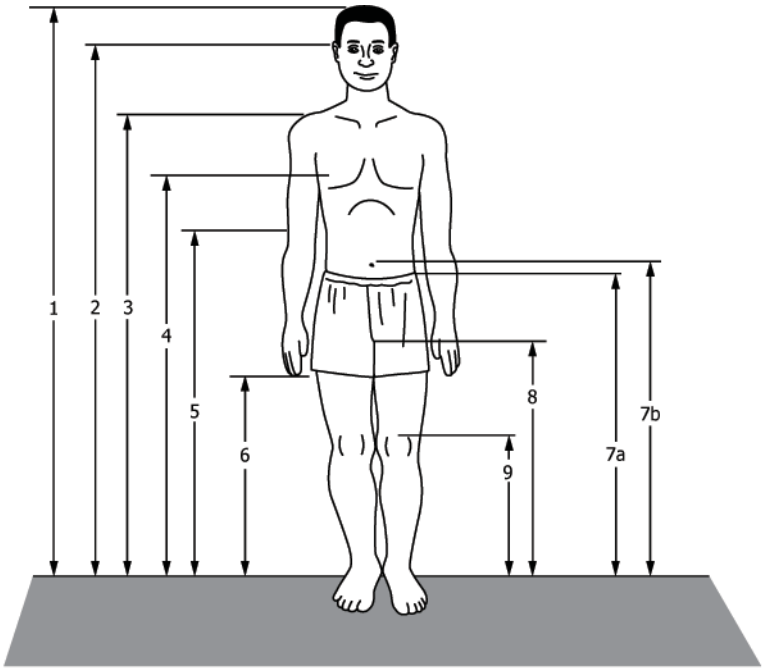
9.2.2 *Example of How to Use Anthropometric Tables:*

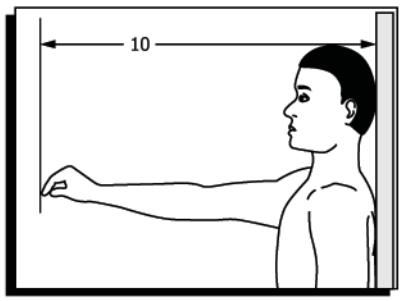
9.2.2.1 *Design Issue*—Set the overhead clearance required for a walkway on a Japanese crewed ship.

(1) Identify the population to serve as the base for selecting the design criteria. In this case the ship has been identified as being crewed by Japanese.

(2) Select the percentage of the expected population to be accommodated. Without being told otherwise one must anticipate that men and women might be in the crew and therefore the design must accommodate the 5th % female to the 95th % male.

(3) Select the "worst case" condition for the particular design concern, that is, overhead clearance. In this case this

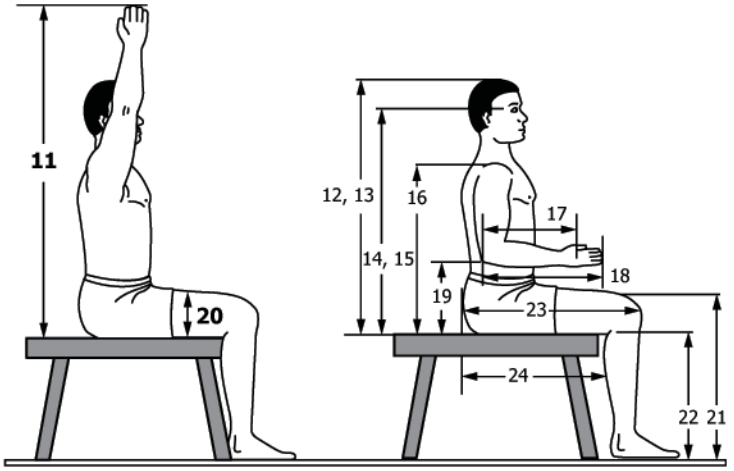




Right shoulder is extended as far forward as possible while keeping the back of the left shoulder firmly against the back.

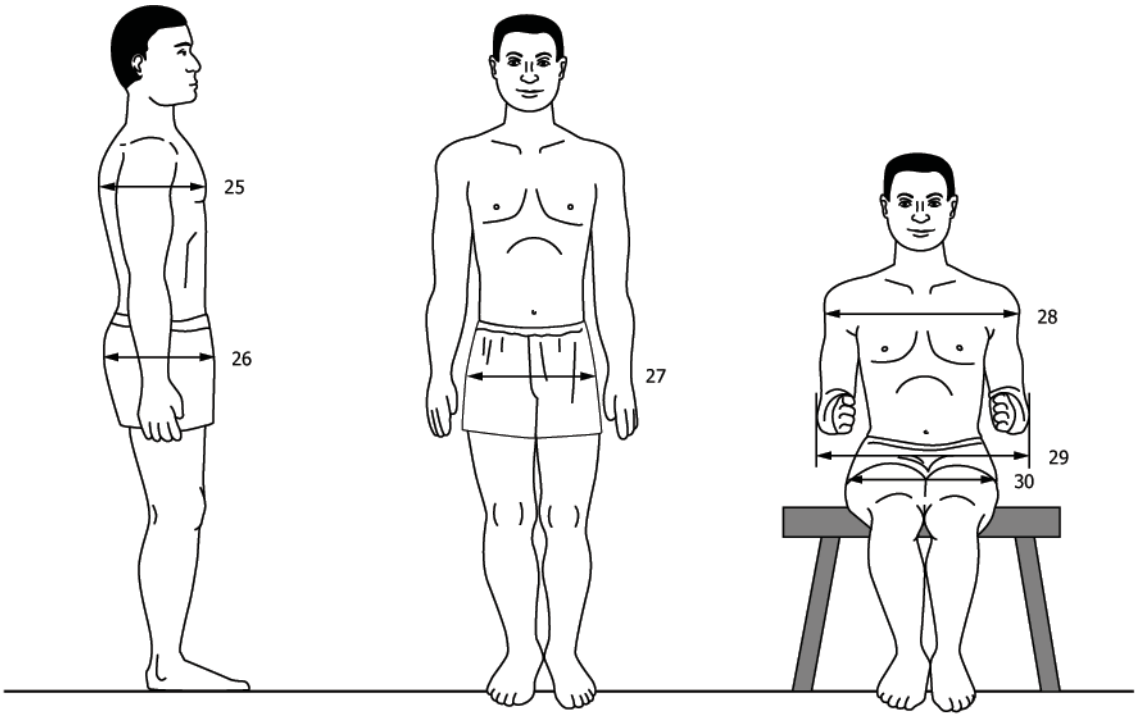
	5th Percentile, mm (in)			95th Percentile, mm (in)		
	Male	Arctic Male	Female	Male	Arctic Male	Female
1 STATURE	1645 (64.8)	1732 (68.2)	1512 (59.5)	876 (73.9)	1941 (76.4)	1742 (68.6)
2 EYE HEIGHT (STANDING)	1528 (60.2)	1577 (62.1)	1406 (55.4)	1758 (69.2)	1768 (69.6)	1628 (64.1)
3 SHOULDER (ACROMIALE) HEIGHT	1354 (53.3)	1384 (54.5)	1226 (48.3)	1565 (61.6)	1585 (62.4)	1445 (56.9)
4 CHEST (NIPPLE) HEIGHT	1175 (46.3)		1080 (42.3)	1365 (53.7)		1260 (49.6)
5 ELBOW (RADIALE) HEIGHT	1026 (40.3)		949 (37.4)	1194 (47.0)		1108 (43.6)
6 FINGERTIP (DACTYLION) HEIGHT	591 (23.3)		551 (21.7)	724 (28.5)		670 (26.5)
7a WAIST (ILIOCRISTALE) HEIGHT	953 (37.5)		911 (35.9)	1159 (45.6)		1071 (42.2)
7b WAIST (OMPHALION) HEIGHT	977 (38.5)		903 (35.6)	1143 (45.0)		1065 (41.9)
8 CROTCH HEIGHT	738 (29.0)	706 (27.8)	665 (26.2)	898 (35.4)	831 (32.7)	818 (32.2)
9 KNEE (MID-PATELLA) HEIGHT	462 (18.1)	498 (19.6)	424 (16.7)	554 (21.7)	594 (23.4)	515 (20.3)
10 FUNCTIONAL REACH, EXTENDED	842 (33.1)	815 (32.0)	746 (29.4)	975 (37.1)		876 (34.5)

FIG. 50 Standing Body Dimensions



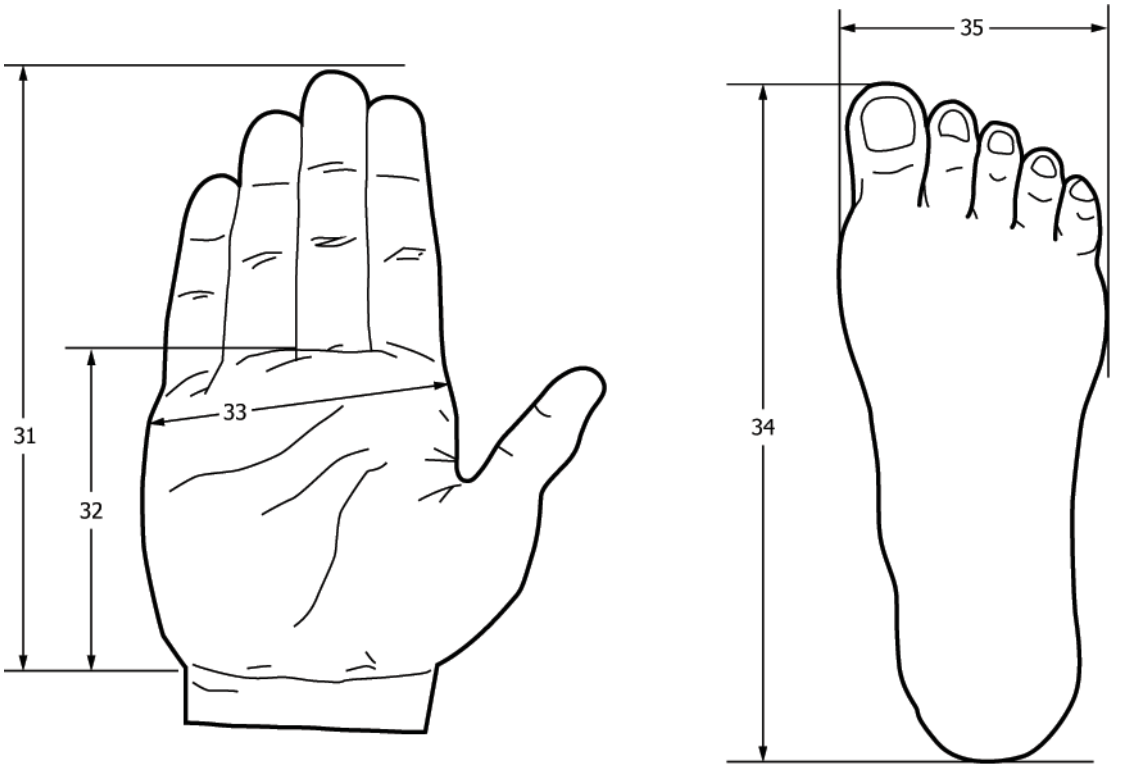
	5th Percentile, mm (in)			95th Percentile, mm (in)		
	Male	Arctic Male	Female	Male	Arctic Male	Female
11 VERTICAL ARM REACH, SITTING	1286 **(50.6)**		1233 **(48.5)**	1532 **(60.3)**		1418 **(55.8)**
12 SITTING HEIGHT, ERECT	862 **(34.0)**	897 **(35.3)**	802 **(31.6)**	983 **(38.7)**	1019 **(40.1)**	920 **(36.2)**
13 SITTING HEIGHT, RELAXED	818 **(32.1)**		789 **(31.1)**	948 **(33.3)**		897 **(35.3)**
14 EYE HEIGHT SITTING, ERECT	729 **(28.7)**	757 **(29.0)**	685 **(27.0)**	852 **(33.5)**	864 **(34.0)**	794 **(31.3)**
15 EYE HEIGHT SITTING, RELAXED	700 **(27.6)**		662 **(26.1)**	825 **(32.5)**		779 **(30.7)**
16 SHOULDER HEIGHT, SITTING	558 **(22.0)**		521 **(20.4)**	663 **(26.1)**		629 **(24.8)**
17 ELBOW-GRIP LENGTH	332 **(13.1)**		300 **(11.8)**	391 **(15.4)**		358 **(14.1)**
18 ELBOW-FINGERTIP LENGTH	444 **(17.5)**		406 **(16.0)**	524 **(20.6)**		483 **(19.0)**
19 ELBOW REST HEIGHT	184 **(7.2)**	170 **(6.7)**	176 **(6.9)**	286 **(11.3)**	279 **(11.0)**	269 **(10.6)**
20 THIGH CLEARANCE HEIGHT	137 **(5.4)**	180 **(7.1)**	104 **(4.1)**	190 **(7.5)**	211 **(8.3)**	180 **(7.1)**
21 KNEE HEIGHT, SITTING	500 **(19.7)**	566 **(22.3)**	474 **(18.7)**	606 **(23.9)**	645 **(25.4)**	560 **(22.0)**
22 POPLITEAL HEIGHT	405 **(15.9)**	400 **(15.8)**	351 **(13.8)**	500 **(19.7)**	455 **(17.9)**	441 **(17.4)**
23 BUTTOCK-KNEE LENGTH	552 **(21.7)**	602 **(23.7)**	520 **(20.9)**	660 **(26.8)**	683 **(26.9)**	630 **(24.8)**
24 BUTTOCK-POPLITEAL LENGTH	456 **(18.0)**	439 **(17.3)**	435 **(17.1)**	546 **(21.5)**		528 **(20.8)**

FIG. 51 Seated Body Dimensions



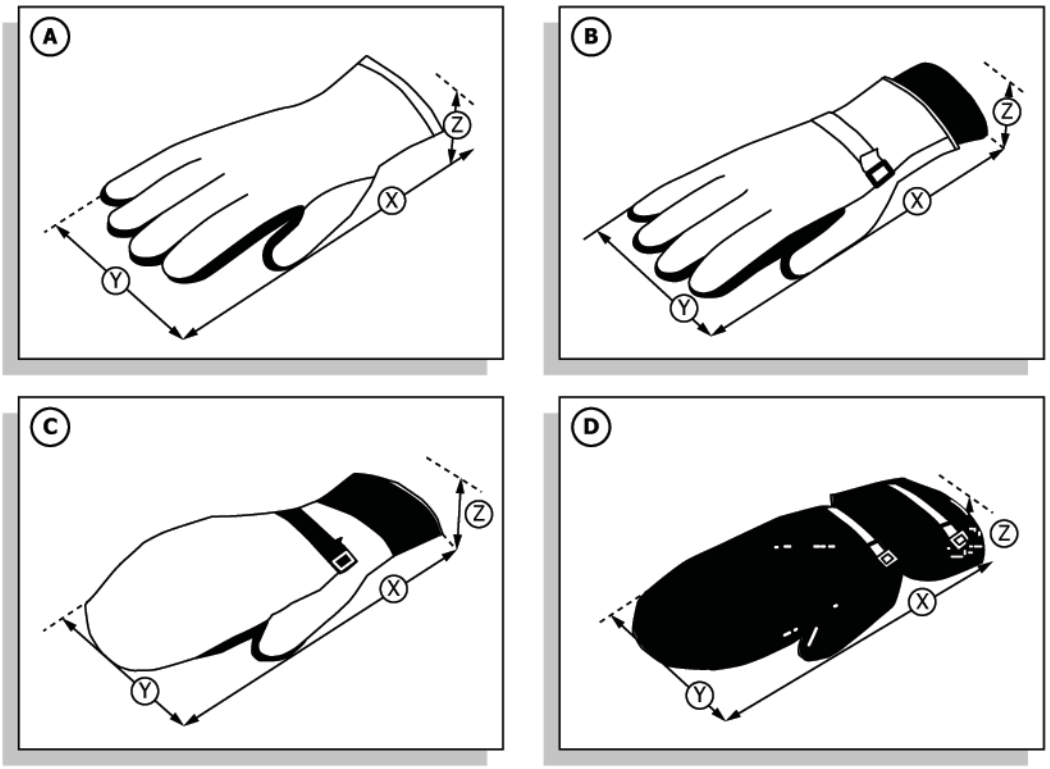
	5th Percentile, mm (in)			95th Percentile, mm (in)		
	Male	Cold Weather	Female	Male	Cold Weather	Female
25 CHEST DEPTH	204 **(8.0)**	302 **(11.9)**	209 **(8.2)**	280 **(11.0)**	333 **(13.1)**	278 **(10.9)**
26 BUTTOCK DEPTH	212 **(8.3)**		184 **(7.2)**	286 **(11.3)**		265 **(10.4)**
27 HIP BREADTH, STANDING	305 **(12.0)**	399 **(15.7)**	308 **(12.1)**	383 **(15.1)**	478 **(18.8)**	388 **(15.3)**
28 SHOULDER BREADTH	418 **(16.5)**	480 **(18.9)**	382 **(15.0)**	535 **(21.1)**	599 **(23.6)**	472 **(18.6)**
29 FOREARM-FOREARM BREADTH	477 **(18.8)**		415 **(16.3)**	621 **(24.4)**		528 **(20.8)**
30 HIP BREADTH, SITTING	338 **(13.3)**	414 **(16.3)**	310 **(12.2)**	466 **(18.3)**	518 **(20.4)**	413 **(16.3)**

FIG. 52 Depth and Breadth Dimensions



	5th Percentile, mm (in.)			95th Percentile, mm (in.)		
	Male	Cold Weather	Female	Male	Cold Weather	Female
31 HAND LENGTH	175 **(6.9)**	211 **(8.3)**	165 **(6.5)**	211 **(8.3)**	246 **(9.7)**	201 **(7.9)**
32 PALM LENGTH	96 **(3.8)**	104 **(4.1)**	90 **(3.5)**	117 **(4.6)**	124 **(4.9)**	108 **(4.3)**
33 HAND BREADTH	82 **(3.2)**	127 **(5.0)**	69 **(2.7)**	9.8 **(3.9)**	122 **(4.8)**	86 **(3.4)**
34 FOOT LENGTH	246 **(9.7)**		222 **(8.7)**	292 **(11.5)**		265 **(10.4)**
35 FOOT BREADTH	90 **(3.5)**	122 **(4.0)**	80 **(3.1)**	110 **(4.3)**	135 **(5.3)**	98 **(3.9)**

FIG. 53 Hand and Foot Dimensions



Hand Position mm (in)	A Anticontact Glove, mm (in)			B Wet-Cold Glove, mm (in)			C Wet-Cold Glove, mm (in)			D Arctic Glove, mm (in)		
	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
Extended Flat	267 **(10.5)**	119 **(4.8)**	64 **(2.5)**	272 **(10.7)**	145 **(5.7)**	76 **(3.0)**	361 **(14.2)**	152 **(6.0)**	81 **(3.2)**	422 **(16.6)**	137 **(5.4)**	91 **(3.6)**
Closed Fist	178 **(7.0)**	127 **(5.0)**	84 **(3.3)**	185 **(7.3)**	147 **(5.8)**	94 **(3.7)**	292 **(11.5)**	147 **(5.8)**	97 **(3.8)**	363 **(14.3)**	132 **(5.2)**	137 **(5.4)**
Grasping Handles												
6 (1/4) diameter	178 **(7.0)**	127 **(5.0)**	89 **(3.5)**	185 **(7.3)**	140 **(5.5)**	102 **(4.0)**	274 **(10.8)**	145 **(5.7)**	107 **(4.2)**	358 **(14.0)**	140 **(5.5)**	114 **(4.5)**
25 (1) diameter	178 **(7.0)**	127 **(5.0)**	89 **(3.5)**	185 **(7.3)**	135 **(5.3)**	102 **(4.0)**	274 **(10.8)**	132 **(5.2)**	114 **(4.5)**	358 **(14.0)**	132 **(5.2)**	114 **(4.5)**
50 (2) diameter	190 **(7.5)**	114 **(4.5)**	107 **(4.2)**	203 **(8.0)**	119 **(4.7)**	102 **(4.0)**	305 **(12.0)**	132 **(5.2)**	119 **(4.7)**	381 **(15.0)**	137 **(5.4)**	127 **(5.0)**
Grasping Knob												
6 (1/4) diameter	200 **(7.4)**	97 **(3.8)**	109 **(4.3)**	229 **(9.0)**	117 **(4.6)**	102 **(4.0)**	292 **(11.5)**	127 **(5.0)**	107 **(4.2)**	394 **(15.5)**	122 **(4.8)**	114 **(4.5)**
25 (1) diameter	229 **(9.0)**	89 **(3.5)**	102 **(4.0)**	229 **(9.0)**	114 **(4.5)**	102 **(4.0)**	305 **(12.0)**	127 **(5.0)**	107 **(4.2)**	394 **(15.5)**	122 **(4.8)**	122 **(4.8)**
50 (2) diameter	241 **(9.5)**	94 **(3.7)**	94 **(3.7)**	234 **(9.2)**	11.4 **(4.5)**	107 **(4.2)**	318 **(12.5)**	119 **(4.7)**	112 **(4.4)**	406 **(16.0)**	119 **(4.7)**	122 **(4.8)**

FIG. 54 Gloved Hand Dimensions

Head Breadth

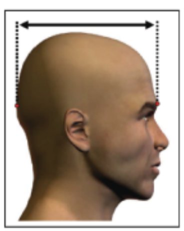
The maximum horizontal breadth of the head above the plane of attachment of the ears is measured with a spreading caliper. For female participants with braids or cornrows, the measurement includes the styled hair.

	5th Percentile	95th Percentile
Female	140.0 mm (5.51 in)	156.0 mm (6.14 in)
Male	146.0 mm (5.75 in)	163.0 mm (6.42 in)

Head Circumference

The maximum circumference of the head above the attachment of the ears is measured with a tape passing just above the ridges of the eyebrows and around the back of the head. For female participants with braids or cornrows, the measurement includes the styled hair.

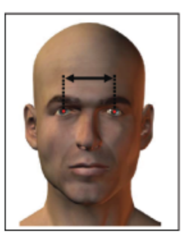
	5th Percentile	95th Percentile
Female	532.0 mm (20.94 in)	597.0 mm (23.50 in)
Male	548.0 mm (21.57 in)	601.0 mm (23.66 in)



Head Length

The distance from the glabella landmark to the opisthocranion landmark is measured with a spreading caliper. For female participants with braids or cornrows, the measurement includes the styled hair.

	5th Percentile	95th Percentile
Female	178.0 mm (7.01 in)	202.0 mm (7.95 in)
Male	188.0 mm (7.40 in)	211.0 mm (8.31 in)



Interpupillary Breadth

The distance between the two pupils is measured with a pupillometer.

	5th Percentile	95th Percentile
Female	55.5 mm (2.19 in)	67.5 mm (2.66 in)
Male	58.5 mm (2.30 in)	70.0 mm (2.76 in)

Data obtained from 2012 Anthropometric Survey of U.S. Army Personnel: Methods and Summary Statistics, Technical Report NATICK/TR-15/007, U.S. Army NATICK Soldier RD&E Center. Published December 2014.

FIG. 55 Head Dimensions

will be the 95th % male because the most clearance needed will be for the taller males.

(4) Check Table 12 to find that the height of the 95th % Japanese male is 1781 mm (70.1 in.).

(5) From Table 11, add a clothing allowance, which for this situation is limited to footwear, 25 mm (1.0 in.) and hard hat, 75 mm (3.0 in.).

(6) Allow for the dynamics of walking (that is, the gait of the human body while walking). There is no value published for this dimension but experience indicates that an additional 50 mm (2.0 in.) should be adequate.

(7) To this point, the absolute minimum overhead clearance height has been established, and it would be acceptable if overhead clearance were absolutely restricted. However, a safety factor (again a matter of judgment, not from any table) of at least 50 mm (2.0 in.) would be a good added design feature here.

(8) Adding all of the contributing dimensions together gives an overhead clearance of 1981 mm (78 in.) required for overhead clearance on this vessel for its anticipated user population.

9.2.3 *Static Body Dimensions—International Regions*—Design data contained in the other chapters of this practice are appropriate for use by the 5th % female to the 95th % male maritime personnel from North America. In addition, every effort has been made to have the design criteria also apply to maritime personnel from around the world. Where that occurs, it is so identified in this document. As a further effort to make this an international design standard, anthropometric data are included in this chapter from selected geographic regions around the globe. If the design being accomplished is for personnel from those regions, their data can be used directly from this document. However, it is the ultimate responsibility of the user of this practice to acquire and use anthropometric data particular to the specific user population for which the particular ship or other maritime facility is being designed. The breakdown of the geographic regions for which some anthropometric data are available is shown in Table 13.

9.2.4 *Standing Heights*—Standing heights for 5th and 95th % males and females from twenty geographic regions around the world are shown in Table 12.

TABLE 12 Standing Height Dimensions—International Population

Region	Male		Female		Min	Max
	5 %	95 %	5 %	95 %		
Northern Europe	1710 mm (67.3 in.)	1910 mm (75.2 in.)	1580 mm (62.2 in.)	1791 mm (70.5 in.)	1580 mm (62.2 in.)	1910 mm (75.2 in.)
North America	1644 mm (64.7 in.)	1876 mm (73.9 in.)	1510 mm (59.5 in.)	1742 mm (68.6 in.)	1510 mm (59.5 in.)	1876 mm (73.9 in.)
Australia	1661 mm (65.4 in.)	1890 mm (74.4 in.)	1560 mm (61.4 in.)	1770 mm (69.7 in.)	1560 mm (61.4 in.)	1890 mm (74.4 in.)
France	1661 mm (65.4 in.)	1890 mm (74.4 in.)	1530 mm (60.2 in.)	1740 mm (68.5 in.)	1530 mm (60.2 in.)	1860 mm (74.4 in.)
Central Europe	1669 mm (65.7 in.)	1860 mm (73.2 in.)	1550 mm (61.0 in.)	1750 mm (68.9 in.)	1550 mm (61.0 in.)	1860 mm (73.2 in.)
Eastern Europe	1661 mm (65.4 in.)	1849 mm (72.8 in.)	1539 mm (60.6 in.)	1720 mm (67.7 in.)	1539 mm (60.6 in.)	1849 mm (72.8 in.)
Latin America	1651 mm (65.0 in.)	1849 mm (72.8 in.)	1519 mm (59.8 in.)	1720 mm (67.7 in.)	1519 mm (59.8 in.)	1849 mm (72.8 in.)
Iberian Peninsula	1580 mm (62.2 in.)	1829 mm (72.0 in.)	1509 mm (59.4 in.)	1699 mm (66.9 in.)	1509 mm (59.4 in.)	1829 mm (72.0 in.)
Southeastern Europe	1687 mm (66.4 in.)	1829 mm (72.0 in.)	1529 mm (60.2 in.)	1720 mm (67.7 in.)	1529 mm (60.2 in.)	1829 mm (72.0 in.)
Japan	1593 mm (62.7 in.)	1781 mm (70.1 in.)	1474 mm (58.0 in.)	1641 mm (64.6 in.)	1474 mm (58.0 in.)	1781 mm (70.1 in.)
North Asia	1560 mm (61.4 in.)	1821 mm (71.7 in.)	1501 mm (59.1 in.)	1669 mm (65.7 in.)	1501 mm (59.1 in.)	1821 mm (71.7 in.)
North Africa	1580 mm (62.2 in.)	1811 mm (71.3 in.)	1501 mm (59.1 in.)	1720 mm (67.7 in.)	1501 mm (59.1 in.)	1811 mm (71.3 in.)
Near East	1621 mm (63.8 in.)	1801 mm (70.9 in.)	1539 mm (60.6 in.)	1699 mm (66.9 in.)	1539 mm (60.6 in.)	1801 mm (70.9 in.)
West Africa	1560 mm (61.4 in.)	1791 mm (70.5 in.)	1440 mm (56.7 in.)	1621 mm (63.8 in.)	1440 mm (56.7 in.)	1791 mm (70.5 in.)
Southeastern Africa	1590 mm (62.6 in.)	1781 mm (70.1 in.)	1481 mm (58.3 in.)	1662 mm (65.4 in.)	1481 mm (58.3 in.)	1781 mm (70.1 in.)
North India	1580 mm (62.2 in.)	1770 mm (69.7 in.)	1450 mm (57.1 in.)	1631 mm (64.2 in.)	1450 mm (57.1 in.)	1770 mm (69.7 in.)
South India	1529 mm (60.2 in.)	1720 mm (67.7 in.)	1389 mm (54.7 in.)	1600 mm (63.0 in.)	1389 mm (54.7 in.)	1720 mm (67.7 in.)
Southeast Asia	1529 mm (60.2 in.)	1720 mm (67.7 in.)	1440 mm (56.7 in.)	1620 mm (63.8 in.)	1440 mm (56.7 in.)	1720 mm (67.7 in.)
Latin America	1519 mm (59.8 in.)	1709 mm (67.3 in.)	1389 mm (54.7 in.)	1560 mm (61.4 in.)	1389 mm (54.7 in.)	1709 mm (67.3 in.)
South China	1610 mm (63.4 in.)	1709 mm (67.3 in.)	1430 mm (56.3 in.)	1590 mm (62.6 in.)	1430 mm (56.3 in.)	1709 mm (67.3 in.)

9.2.5 *Seated Eye Heights*—Seated eye heights for 5th and 95th % males and females from twenty geographic regions around the world are shown in Table 14.

9.2.6 *Forward Functional*—Forward functional reach for 5th and 95th % males and females from twenty geographic regions around the world are shown in Table 15.

9.2.7 *Male Anthropometric Data*—Anthropometric data for males from four geographic regions of the world are shown in Table 16.

9.2.8 *Female Anthropometric Data*—Female anthropometric data from four geographical regions of the world are shown in Table 17.

9.2.9 *Adult Weight Data*—Weight data for 5th and 95th percentile American adult females and males are shown in Table 18.

TABLE 13 International Geographical Regions for which Anthropometric Data are Available

Geographic Region	Countries included in the Geographic Region
Northern Europe	Denmark, Finland, Germany, Iceland, Netherlands, Norway, Sweden
North America	United States, Canada
Australia	Australia, New Zealand (European Population)
France	France
Central Europe	Austria, Belgium, Eastern Germany, Czech Republic, Slovakia, Switzerland, United Kingdom, Luxembourg
Eastern Europe	Poland, Russian Federation
Latin America	Argentina, Belize, Brazil, Chile, Costa Rica, Guyana, Surinam, Uruguay, Caribbean Island States (European and Negroid populations)
Iberian Peninsula	Portugal, Spain
Southeastern Europe	Bulgaria, Greece, Hungary, Italy, Israel, Malta, Romania, Yugoslavia
Japan	North Korea, South Korea, Japan
North Asia	China (Northern), Mongolia, Russian Federation (Asian part)
North Africa	Algeria, Chad, Egypt, Ethiopia, Libya, Mali, Morocco, Niger, Sudan, Tunisia
Near East	Afghanistan, Bahrain, Iraq, Iran, Jordan, Kuwait, Lebanon, Oman, Yemen, Saudi Arabia, Syria, Turkey, UA Emirates
West Africa	Benin, Cameroon, Congo, Guinea, Gabon, Ghana, Liberia, Nigeria, Sierra Leone, Zaire
Southeastern Africa	Kenya, Malawi, Madagascar, Mozambique, Rwanda, Somalia, South Africa, Uganda, Tanzania, Zambia, Zimbabwe
North India	Bangladesh, India (Northern), Nepal, Pakistan
South India	India (Southern), Maldives, Sri Lanka
Southeast Asia	Brunei, Indonesia, Laos, Malaysia, Philippines, Singapore, Thailand, Vietnam
Latin America (Indian Population)	Bolivia, Columbia, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Peru, Paraguay, Venezuela
South China	China (Southern), Hong Kong, Macao, Taiwan

TABLE 14 Seated Eye Height Dimensions—International Population

Region	Male		Female		Min	Max
	5 %	95 %	5 %	95 %		
Northern Europe	770 mm (30.3 in.)	871 mm (34.3 in.)	711 mm (28.0 in.)	818 mm (32.3 in.)	711 mm (28.0 in.)	871 mm (34.3 in.)
North America	733 mm (28.9 in.)	853 mm (33.6 in.)	677 mm (26.7 in.)	794 mm (31.3 in.)	677 mm (26.7 in.)	853 mm (33.6 in.)
Australia	760 mm (29.9 in.)	861 mm (33.9 in.)	711 mm (28.0 in.)	810 mm (31.9 in.)	711 mm (28.0 in.)	861 mm (33.9 in.)
France	749 mm (29.5 in.)	851 mm (33.5 in.)	691 mm (27.2 in.)	780 mm (30.7 in.)	691 mm (27.2 in.)	851 mm (33.5 in.)
Central Europe	749 mm (29.1 in.)	871 mm (33.5 in.)	710 mm (27.6 in.)	820 mm (31.9 in.)	701 mm (27.6 in.)	851 mm (33.5 in.)
Eastern Europe	729 mm (28.7 in.)	851 mm (33.5 in.)	671 mm (26.4 in.)	790 mm (31.1 in.)	671 mm (26.4 in.)	861 mm (33.5 in.)
Latin America	749 mm (29.5 in.)	871 mm (34.3 in.)	710 mm (27.6 in.)	820 mm (32.3 in.)	701 mm (27.6 in.)	871 mm (34.3 in.)
Iberian Peninsula	719 mm (28.3 in.)	851 mm (33.5 in.)	681 mm (26.8 in.)	810 mm (31.9 in.)	681 mm (26.8 in.)	851 mm (33.5 in.)
Southeastern Europe	739 mm (29.1 in.)	841 mm (33.1 in.)	681 mm (26.8 in.)	780 mm (30.7 in.)	681 mm (26.8 in.)	841 mm (33.1 in.)
Japan	726 mm (28.6 in.)	832 mm (32.8 in.)	679 mm (26.7 in.)	764 mm (30.1 in.)	679 mm (26.7 in.)	832 mm (32.8 in.)
North Asia	739 mm (29.1 in.)	851 mm (33.5 in.)	701 mm (27.6 in.)	790 mm (31.1 in.)	701 mm (27.6 in.)	851 mm (33.5 in.)
North Africa	701 mm (27.6 in.)	820 mm (32.3 in.)	681 mm (26.8 in.)	810 mm (31.9 in.)	681 mm (26.8 in.)	820 mm (32.3 in.)
Near East	729 mm (28.7 in.)	820 mm (32.3 in.)	711 mm (28.0 in.)	790 mm (31.1 in.)	711 mm (28.0 in.)	820 mm (32.3 in.)
West Africa	650 mm (25.6 in.)	780 mm (30.7 in.)	620 mm (24.4 in.)	620 mm (24.4 in.)	620 mm (24.4 in.)	780 mm (30.7 in.)
Southeastern Africa	706 mm (27.8 in.)	790 mm (31.1 in.)	681 mm (26.8 in.)	780 mm (30.7 in.)	681 mm (26.8 in.)	790 mm (31.1 in.)
North India	711 mm (28.0 in.)	800 mm (31.5 in.)	650 mm (25.6 in.)	729 mm (28.7 in.)	650 mm (25.6 in.)	800 mm (31.5 in.)
South India	660 mm (26.0 in.)	739 mm (29.1 in.)	620 mm (24.4 in.)	719 mm (28.3 in.)	620 mm (24.4 in.)	739 mm (29.1 in.)
Southeast Asia	681 mm (26.8 in.)	780 mm (30.7 in.)	660 mm (26.0 in.)	739 mm (29.1 in.)	660 mm (26.0 in.)	780 mm (30.7 in.)

TABLE 14 *Continued*

Region	Male		Female		Min	Max
	5 %	95 %	5 %	95 %		
Latin America	709 mm (28.3 in.)	800 mm (31.5 in.)	660 mm (26.0 in.)	739 mm (29.1 in.)	660 mm (26.0 in.)	800 mm (31.5 in.)
South China	691 mm (27.2 in.)	790 mm (31.1 in.)	650 mm (25.6 in.)	739 mm (29.1 in.)	650 mm (25.6 in.)	790 mm (31.1 in.)

TABLE 15 Forward Functional Reach Dimensions—International Population

Region	Male		Female		Min	Max
	5 %	95 %	5 %	95 %		
Northern Europe	820 mm (32.3 in.)	930 mm (36.6 in.)	740 mm (29.1 in.)	870 mm (34.3 in.)	740 mm (29.1 in.)	930 mm (36.6 in.)
North America	842 mm (33.1 in.)	975 mm (38.4 in.)	746 mm (29.4 in.)	876 mm (34.5 in.)	746 mm (29.4 in.)	975 mm (38.4 in.)
Australia	800 mm (31.5 in.)	920 mm (36.2 in.)	740 mm (29.1 in.)	860 mm (33.9 in.)	740 mm (29.1 in.)	920 mm (36.2 in.)
France	800 mm (31.5 in.)	910 mm (35.8 in.)	730 mm (28.7 in.)	830 mm (32.7 in.)	730 mm (28.7 in.)	910 mm (35.8 in.)
Central Europe	800 mm (31.5 in.)	890 mm (35.0 in.)	740 mm (29.1 in.)	840 mm (33.0 in.)	740 mm (29.1 in.)	890 mm (35.0 in.)
Eastern Europe	800 mm (31.5 in.)	890 mm (35.0 in.)	740 mm (29.1 in.)	820 mm (32.3 in.)	740 mm (29.1 in.)	890 mm (35.0 in.)
Latin America	790 mm (31.1 in.)	890 mm (35.0 in.)	710 mm (28.0 in.)	830 mm (32.7 in.)	710 mm (28.0 in.)	890 mm (35.0 in.)
Iberian Peninsula	760 mm (29.9 in.)	880 mm (34.6 in.)	720 mm (28.3 in.)	820 mm (32.3 in.)	720 mm (28.3 in.)	880 mm (34.6 in.)
Southeastern Europe	790 mm (31.1 in.)	880 mm (34.6 in.)	740 mm (29.1 in.)	830 mm (32.7 in.)	740 mm (29.1 in.)	880 mm (34.6 in.)
Japan	758 mm (29.8 in.)	882 mm (34.7 in.)	696 mm (27.4 in.)	810 mm (31.9 in.)	696 mm (27.4 in.)	882 mm (34.7 in.)
North Asia	780 mm (30.7 in.)	900 mm (35.4 in.)	720 mm (28.3 in.)	850 mm (33.5 in.)	720 mm (28.3 in.)	900 mm (35.4 in.)
North Africa	800 mm (31.5 in.)	920 mm (36.2 in.)	750 mm (29.5 in.)	870 mm (34.3 in.)	750 mm (29.5 in.)	920 mm (36.2 in.)
Near East	780 mm (30.7 in.)	860 mm (33.9 in.)	740 mm (29.1 in.)	815 mm (32.1 in.)	740 mm (29.1 in.)	860 mm (33.9 in.)
West Africa	790 mm (31.1 in.)	900 mm (35.4 in.)	720 mm (28.3 in.)	820 mm (32.3 in.)	720 mm (28.3 in.)	900 mm (35.4 in.)
Southeastern Africa	810 mm (31.9 in.)	950 mm (37.4 in.)	740 mm (29.1 in.)	860 mm (33.9 in.)	740 mm (29.1 in.)	950 mm (37.4 in.)
North India	760 mm (29.9 in.)	850 mm (33.5 in.)	700 mm (27.6 in.)	780 mm (30.7 in.)	700 mm (27.6 in.)	850 mm (33.5 in.)
South India	730 mm (28.7 in.)	840 mm (33.1 in.)	670 mm (26.4 in.)	770 mm (30.3 in.)	670 mm (26.4 in.)	840 mm (33.1 in.)
Southeast Asia	730 mm (28.7 in.)	820 mm (32.3 in.)	690 mm (27.2 in.)	780 mm (30.7 in.)	690 mm (27.2 in.)	820 mm (32.3 in.)
Latin America	730 mm (28.7 in.)	820 mm (32.3 in.)	670 mm (26.4 in.)	750 mm (29.5 in.)	670 mm (26.4 in.)	820 mm (32.3 in.)
South China	760 mm (29.9 in.)	840 mm (33.1 in.)	690 mm (27.2 in.)	760 mm (29.9 in.)	690 mm (27.2 in.)	840 mm (33.1 in.)

TABLE 16 Male Anthropometric Data from Four Regions of the World

Males (mm and inches)	North America (US)			Japan			Southeast Asia[A]			Europe[B]		
	5 %	50 %	95 %	5 %	50 %	95 %	5 %	50 %	95 %	5 %	50 %	95 %
Stature (floor to top of head)	1644 (64.7)	1760 (69.3)	1876 (73.9)	1593 (62.7)	187 (66.4)	1728 1 (70.1)	1530 (60.2)	1630 (64.2)	1720 (67.7)	1604 (63.1)	1728 (68.0)	1847 (72.7)
Seated Stature (buttocks to top of head)	862 (33.9)	923 (36.3)	984 (38.7)	855 (33.7)	913 (35.9)	970 (38.2)	790 (31.1)	840 (33.1)	900 (35.4)	836 (32.9)	894 (35.2)	959 (37.8)
Shoulder Breadth	424 (16.7)	483 (19.0)	544 (21.4)	413 (16.3)	448 (17.6)	484 (19.1)	380 (15.0)	410 (16.1)	430 (16.9)	420 (16.5)	456 (18.0)	496 (19.5)
Standing Eye Height	1529 (60.2)	1643 (64.7)	1758 (69.2)	1474 (58.0)	1568 (61.7)	1661 (65.4)				1509[C] (59.5)	1613[C] (63.4)	1720[C] (67.7[C])
Seated Eye Height (buttocks to eye)	733 (28.9)	793 (31.2)	853 (33.6)	726 (28.6)	775 (30.5)	832 (32.8)	680 (26.8)	730 (28.7)	780 (30.7)	740[D] (29.1[D])	796[D] (31.3[D])	851[D] (33.5[D])
Back of Knee Height (approximate max seat height)	404 (15.9)	450 (17.7)	496 (19.5)	369 (14.5)	408 (16.1)	447 (17.6)	380 (15.0)	415 (16.3)	445 (17.5)	425 (16.7)	473 (18.6)	521 (20.5)
Forward Functional Reach (back of shoulder to fingertips)	842 (33.1)	909 (35.8)	975 (38.4)	758 (29.8)	820 (32.3)	882 (34.7)	730 (28.7)	780 (30.7)	820 (32.3)	711[D] (28.0[D])	771[D] (30.4[D])	827[D] (32.6[D])

TABLE 16 *Continued*

Males (mm and inches)	North America (US)			Japan			Southeast Asia[A]			Europe[B]		
	5 %	50 %	95 %	5 %	50 %	95 %	5 %	50 %	95 %	5 %	50 %	95 %
Standing Overhead Reach (floor to tip of extended middle finger)	2067 (81.4)	2237 (88.1)	2407 (94.8)	1959 (77.1)	2121 (83.5)	2282 (89.8)						
Arm Length (fingertip to shoulder)	737 (29.0)	796 (31.3)	856 (33.7)	682 (26.9)	735 (28.9)	71827 (31.0)				711 (28.0)	771 (30.4)	827 (32.6)
Hip Breadth Standing	312 (12.3)	345 (13.6)	394 (15.5)	299 (11.8)	328 (12.9)	357 (14.1)				310[C] (12.2)	344[C] (13.5)	368[C] (14.5[C])

[A] Represented by Brunei, Indonesia, Laos, Malaysia, Philippines, Singapore, Thailand, and Vietnam. Source: *International Data on Anthropometry*. International Labor Organization, 1990. The data in this source date to the middle 1960s and may be out of date. For males, regional growth in the area since that time is approximately 29 mm in stature, or an increase of about 2 %. Given this, users of the Southeast Asia data for males may consider scaling stature, leg length, and reach dimensions by a factor of 1.02. The data contained in the above table are true to the source document.
[B] Represented by data from Sweden, Germany, Italy, and France. Source: *ADULTDATA: The Handbook of Adult Anthropometric and Strength Measurements—Data for Design Safety*. Institute for Occupational Ergonomics, University of Nottingham, UK. 1998.
[C] German population data.
[D] French population data.

TABLE 17 Female Anthropometric Data from Four Regions of the World

Females (mm and inches)	North America (US)			Japan			Southeast Asia[A]			Europe[B]		
	5 %	50 %	95 %	5 %	50 %	95 %	5 %	50 %	95 %	5 %	50 %	95 %
Stature (floor to top of head)	1512 (59.5)	1627 (64.1)	1742 (68.6)	1474 (58.0)	1558 (61.3)	1742 1 (64.6)	1500 (56.7)	150 (60.2)	1500 (63.8)	1500 (59.1)	1610 (63.4)	1710 (67.3)
Seated Stature (buttocks to top of head)	802 (31.6)	861 (33.9)	920 (36.2)	793 (31.2)	848 (33.4)	902 (35.5)	750 (29.5)	800 (31.5)	850 (33.5)	794 (31.3)	852 (33.5)	904 (35.6)
Shoulder Breadth	381 (15.0)	424 (16.7)	467 (18.4)	376 (14.8)	409 (16.1)	441 (17.4)	340 (13.4)	380 (15.0)	410 (16.1)	366 (14.4)	401 (15.8)	447 (17.6)
Standing Eye Height	1406 (55.4)	1517 (59.7)	1628 (64.1)	1370 (53.9)	1448 (57.0)	1527 (60.1)				1402[C] (55.1[C])	1502[C] (59.1[C])	1596[C] (62.8[C])
Seated Eye Height (buttocks to eye)	677 (26.7)	735 (28.9)	794 (31.3)	679 (26.7)	721 (28.4)	764 (30.1)	660 (26.0)	700 (27.6)	740 (29.1)	703[D] (27.7[D])	751[D] (29.6[D])	801[D] (31.5[D])
Back of Knee Height (approximate max seat height)	354 (13.9)	400 (15.7)	446 (17.6)	331 (13.0)	362 (14.3)	393 (15.5)	365 (14.4)	385 (15.2)	405 (15.9)	380 (15.0)	431 (17.0)7	481 (18.9)
Forward Functional Reach (back of shoulder to fingertips)	746 (29.4)	811 (31.9)	876 (34.5)	696 (27.4)	753 (29.6)	810 (31.9)	690 (27.2)	730 (28.7)	780 (30.7)	652[D] (25.7[D])	704[D] (27.7[D])	761[D] (30.0[D])
Standing Overhead Reach (floor to tip of extended middle finger)	1890 (74.4)	2057 (81.0)	2225 (87.6)	1796 (70.7)	1935 (76.2)	2075 (81.7)						
Arm Length (fingertip to shoulder)	649 (25.6)	718 (28.3)	788 (31.0)	613 (24.1)	660 (26.0)	706 (27.8)				652 (25.7)	704 (27.7)	761 (30.0)
Hip Breadth (Standing)	307 (12.1)	404 (15.9)	400 (15.7)	291 (11.5)	316 (12.4)	342 (13.5)				314[C] (12.4[C])	358[C] (14.1[C])	405[C] (15.9[C])

[A] Represented by Brunei, Indonesia, Laos, Malaysia, Philippines, Singapore, Thailand, and Vietnam. Source: *International Data on Anthropometry*. International Labor Organization, 1990. For females, regional growth since these data has been approximately 69 mm in stature, or an increase of about 4.5 %. Given this, users of the Southeast Asia data may consider scaling stature, leg length, and reach dimensions by a factor of 1.045 for females. The data contained in the above table are true to the source document.
[B] Represented by data from Sweden, Germany, Italy, and France. Source: *ADULTDATA: The Handbook of Adult Anthropometric and Strength Measurements—Data for Design Safety*. Institute for Occupational Ergonomics, University of Nottingham, UK. 1998.
[C] German population data.
[D] French population data.

TABLE 18 Weights for American Adult Females and Males[A]

	5th Percentile, kg (lb)	95th Percentile, kg (lb)
Female	50.1 (110.5)	116.5 (256.8)
Male	62.0 (136.7)	124.9 (275.4)

[A] Data obtained from Anthropometric Reference Data for Children and Adults: U.S. Population, 1999–2002. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics. July 7, 2005.

10. Workplace Arrangements

10.1 *Basic Principles of Workplace Design:*

10.1.1 *General Requirement*—Workspace shall be provided to perform all operational and maintenance tasks by the 5th % female to the 95th % male, or for whatever specific range and type of user population is specified by the procuring organization (see Section 9) while wearing the appropriate (for example, winter or PPE) clothing and using the required tools. In establishing the workspace, consideration shall be given to the number of personnel required to perform the work and the body positions required to do the work.

10.1.2 *Kick Space*—All cabinets, consoles, and work surfaces that require an operator to stand close to their front surfaces shall contain a kick space at the base at least 100 mm (4 in.) deep and 100 mm (4 in.) high.

10.1.3 *Guards*—Guards shall be provided around all exposed rotating equipment, as well as other hazardous situations

(for example, hot or cold points, exposed electrical wiring, crushing points). Removal of guards shall not be possible without special tools. Quick-release fasteners shall not be used. Removal of guards shall stop the operation of the equipment which cannot start again until the guard is replaced. Guards should be accessible from at least two sides (that is, a guard over a rotating shaft should be accessible from either side of the shaft).

10.1.4 *Flushing, Draining, Venting*—Flushing, draining, and venting facilities shall be provided to discharge in a manner that does not place the contents of the pipe onto walking surfaces or into work areas where personnel could be hit by the discharge or become a hazard. All valves shall be installed in accordance with Section 12.

10.1.5 *Skid Layout*—Pumps, compressors, turbines, or other pieces of equipment that are mounted on skids or other packages, then placed in the vessel or structure as a unit, should be placed at the periphery of the skid for ease of access for maintenance.

10.1.6 *Even Walking Surfaces*—Elevation changes in workplace walkways due to changes in grating levels shall be avoided except where necessary to reduce risks from other hazards, such as at fire doors, watertight doors, etc. Adjoining walkway surfaces shall be made flush and fair, whenever possible and for new construction and existing facilities to the extent practicable.

10.1.6.1 Changes in levels up to 6 mm (¼ in.) may be vertical and without edge treatment. (See Fig. 56.)

10.1.6.2 Changes in levels between 6 and 12 mm (¼ and ½ in.) shall be beveled with a slope no greater than 1:2 (rise:run).

10.1.6.3 Except where necessary to reduce risks from other hazards, such as at fire doors, watertight doors, etc., changes in levels greater than 12 mm (½ in.) shall be transitioned by means of a ramp or stairway that complies with the appropriate sections of this standard.

10.1.7 *Slip Resistant Walking Surface*—Walking surfaces shall be shown to be slip resistant by testing to a recognized industry standard. The methodology and criterion of this standard must be appropriate for use for the expected environmental conditions and use of the walking surface.

10.1.8 *Control/Display Accessibility*—All controls and displays shall be reachable and readable from the normal work body postures or positions without having to assume awkward or uncomfortable postures.

10.1.9 *Eliminate Crew Interference with Each Other*—The workplace shall be designed to eliminate interference among crewmembers during operation or maintenance. Multiple, simultaneous tasks should be avoided unless the design has been specifically created to allow such tasks without interfering with each other.

10.1.10 *Pull Space Requirements*—Pull spaces provided for maintenance or repair (for example, areas needed for the pulling of tube bundles from heat exchangers or condensers) shall be kept clear of all piping, cable trays, panels, and any other obstructions. In addition, the pull space shall provide room for the personnel performing the tasks, tools required, lifting or support equipment, and transport devices (if used) to move the item from the area.

10.2 *Seated Workstation:*

10.2.1 *Window Placement*—Seated workstations requiring vision through windows shall be designed with the window's lower edge no higher than 1016 mm (40 in.) above the floor on which the chair sits.

10.2.2 *Desk Dimensions*—Dimensions for a seated desk-type workstation are provided in Fig. 57, "Seated Workspace Dimensions" and Table 19, "Seated Workspace Dimensions."

10.2.3 *Casters*—All chairs shall have five casters.

10.2.4 *Computer Workstation*—Dimensions for a seated computer workstation are provided in Fig. 58, "Seated Computer Workstation Dimensions," and Table 20, "Seated Computer Workstation Dimensions."

10.2.5 *Sitting at Tables*—For people sitting at tables or other non-desk types of workstations, the dimensions shown in Fig. 59, "Dimensions for Single or Multiple Personnel at a Table or Other Duty Station not Requiring a Desk," shall be provided. Table height, knee clearance and other dimensions shall be the same as in Fig. 57 and Table 19 or Fig. 58 and Table 20 for computer workstations.

10.2.6 *Stool Seating*—Stools may be used for temporary seating, especially where the operator frequently moves from a sitting to standing posture. Stool heights should range from 711 to 813 mm (28 to 32 in.) from the floor to the top of the seat.

10.2.7 *Seating at CRT Workstations*—Seating dimensions for stool or chair seating at CRT-type displays or similar workstations are shown in Fig. 60, "Seating at CRT-Type Workstations."

10.2.8 *Seated Overhead Reach*—Where overhead reach is required for a seated person to operate a control the maximum extended reach shall be 1321 mm (52 in.) above the seated surface for males and 1245 mm (49 in.) for females. Maximum overhead reach for gripping reach (for example, grasping a knob or turning a handle) shall be 1270 mm (50 in.) above the seated surface for males and 1168 mm (46 in.) for females. These dimensions are appropriate for most of the maritime populations but shall be reduced by 50–76 mm (2–3 in.) for personnel from Southeast Asia, China, West Africa, Japan, and India.

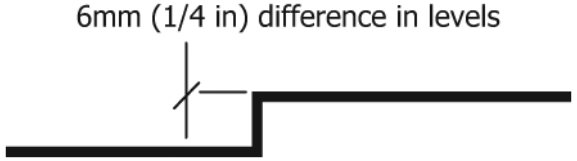


FIG. 56 Changes in Levels up to a Maximum of 6 mm (¼ in.)

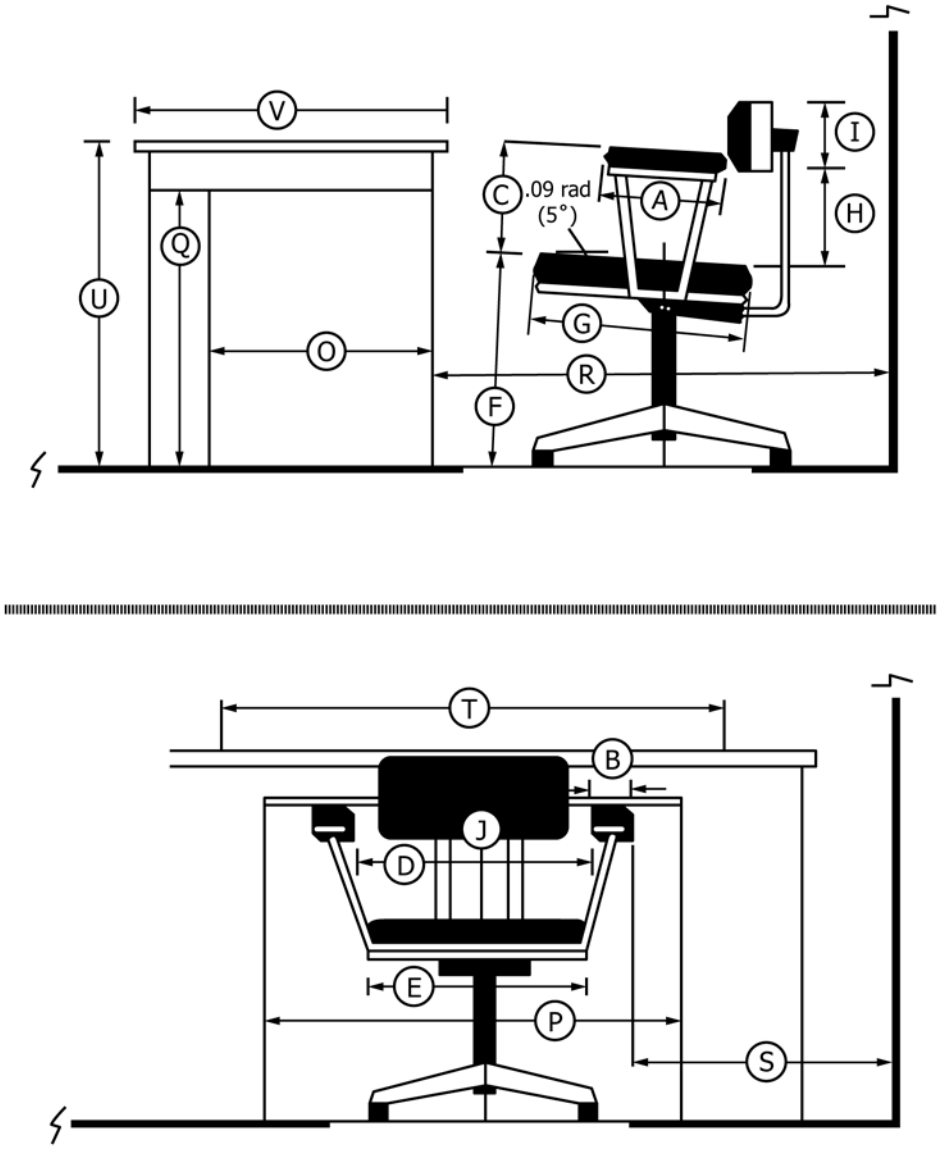


FIG. 57 Seated Workspace Dimensions

10.2.9 *Clearance Behind Seated Workstations*—Clearance behind a seated workstation to allow a person to walk shall be as shown in Fig. 61.

10.2.10 *Control Mounting Heights*—Mounting heights for controls mounted on a vertical surface to be used by a seated operator shall be as shown in Fig. 62, "Control Mounting Height for Seated Personnel."

10.2.11 *Display Mounting Height*—Mounting heights for displays on a vertical flat surface such as a panel or bulkhead for use by a seated person shall be as shown in Fig. 63, "Display Mounting Height for Seated Personnel."

10.3 *Standing Workstation:*

10.3.1 *Window Placement:*

10.3.1.1 Workstations requiring vision outside through windows shall be designed so the lower edge of the window is no more than 1.32 m (52 in.) and the upper edge no less than 1.85 m (74 in.) above the deck, except for forward bridge windows which shall be no less than 1.98 m (79 in.) above the deck. Where reflection from window glass could be a problem, the window shall be angled from the vertical, top-out, and bottom-in 15°, but in no case shall the angle be less than 8° or more than 25°.

10.3.1.2 These dimensions are appropriate for maritime populations worldwide except that the bottom edge height should be reduced by 50 mm (2 in.) for the 5th % male and female crewmembers from regions with smaller populations.

10.3.2 *Overhead Reach*—Where overhead reach is required for a standing person to operate a control, the maximum extended reach, and the maximum gripping reach shall be as shown in Table 21, "Maximum Overhead Extended and Gripping Reach." These dimensions are appropriate for 5th to 95th % males and females from the regions shown in Table 21. Dimensions for other maritime populations not shown in Table

TABLE 19 Seated Workspace Dimensions[A]

		Dimensions	Fixed/Min mm	Fixed/Min in.	Adjust
Armrest	A	Length	254	10	
	B	Width	50	2	
	C	Height	216	8.5	191 mm (7.5 in.) to 279 mm (11 in.)
	D	Separation	457	18	
Seat pan	E	Width	406	16	
	F	Height	381	15	Seat height shall be adjustable from the minimum height up 127 mm (5 in.)—in increments of no more than 25 mm (1 in.)
	G	Depth	406	16	
		Angle from horizontal			0–10° (5° preferred)
		Pan – backrest angle			90–100°
Backrest	H	Space	152	6	Full backrest with no space between seat pan and bottom of backrest is preferred.
	I	Height	380	15	Backrest height shall be adjustable unless it is solid from seat pan to minimum height shown. Adjustments should be in increments no greater than 75 mm (1 in.).
	J	Width	406	16	462 mm (18 in.) preferred
		Dimensions	Minimum		Preferred
Workspace	O	Kneehole depth (at knee height)	381	15	
		Kneehole depth (at deck level)	597	23.5	
	P	Kneehole width	508	20	610 mm (24 in.) preferred
	o	Kneehole height	635	25	
	R	Desk to wall	813	32	
	S	Chair to wall	381	15	
	T	Desk width	1372	54	
		Writing surface width	610	24	
	U	Height of work surface	737	29	762 mm (30 in.)
	V	Desk depth	762	30	914 mm (36 in.)
		Writing surface depth	305	12	406 mm (16 in.)

[A] These dimensions are for 5th % female to 95th % male North American populations and may have to be adjusted for other international user populations.

21 shall be used for vessels and facilities likely to be crewed by these other populations.

10.3.3 *Control Mounting*—Controls mounted on a vertical surface such as a bulkhead or panel for use by a standing person shall be mounted as shown in Fig. 64.

10.3.4 *Display Mounting*—Displays mounted on a vertical surface such as a bulkhead or panel for use by a standing person shall be mounted as shown in Fig. 65, "Display Height Mounting Height for Standing Personnel."

10.4 *Kneeling Workstation:*

10.4.1 *Control Mounting Height*—Mounting heights for controls that must be reached and operated from a kneeling position are shown in Fig. 66, "Control Mounting Heights for a Kneeling Person."

10.4.2 *Display Mounting*—Mounting heights for displays mounted on a vertical surface such as a bulkhead or panel for use by a kneeling person are shown in Fig. 67, Height "Display Mounting Heights for Kneeling Personnel."

10.4.3 *Working Area Required for Kneeling Worker*—The clear area required for a kneeling worker at a task site shall be as shown in Fig. 68, "Required Dimensions for Kneeling Worker." Task requiring access to flanges with tools shall be a minimum of 27 in. off the deck.

10.5 *Squatting Workstation:*

10.5.1 *Control Mounting Height*—Mounting heights for controls mounted on a vertical surface such as a bulkhead or panel for use by a person in a squatting position are shown in Fig. 69, "Control Mounting Heights for Squatting Personnel."

10.5.2 *Display Mounting Height*—Mounting heights for displays on a vertical flat surface such as a panel or bulkhead for use by a squatting person are shown in Fig. 70, "Display Mounting Heights for Squatting Personnel."

10.5.3 *Working Area Required for Squatting Person*—The clear working area required for a person squatting at a work site shall be as shown in Fig. 71, "Required Dimensions for a Squatting Worker." Task requiring access to flanges with tools shall be a minimum of 27 in. off the deck.

10.6 *Shelving:*

10.6.1 *Shelf Dimensions with Full Access*—Shelf dimensions and workplace clearances for use of shelves that provide full access to the user (such as in an office or warehouse) shall be as shown in Fig. 72, "Workplace Dimensions for Shelves with Full Access."

10.6.2 *Top Shelf Foot Supports*—If shelves in storerooms are mounted higher than 1956 mm (77 in.), they shall be equipped with foot supports to stand on designed to support a 113-kg (250-lb) load. If lower shelves are used as a foot support, they shall be designed to support whatever may be placed on the shelves plus the 113-kg (250-lb) load.

10.6.3 *Shelf Dimensions Above a Cabinet*—Shelf dimensions and workplace clearances for shelves that are located above a cabinet shall be as shown in Fig. 73, "Workplace Dimensions Above for Shelves Located Above a Cabinet."

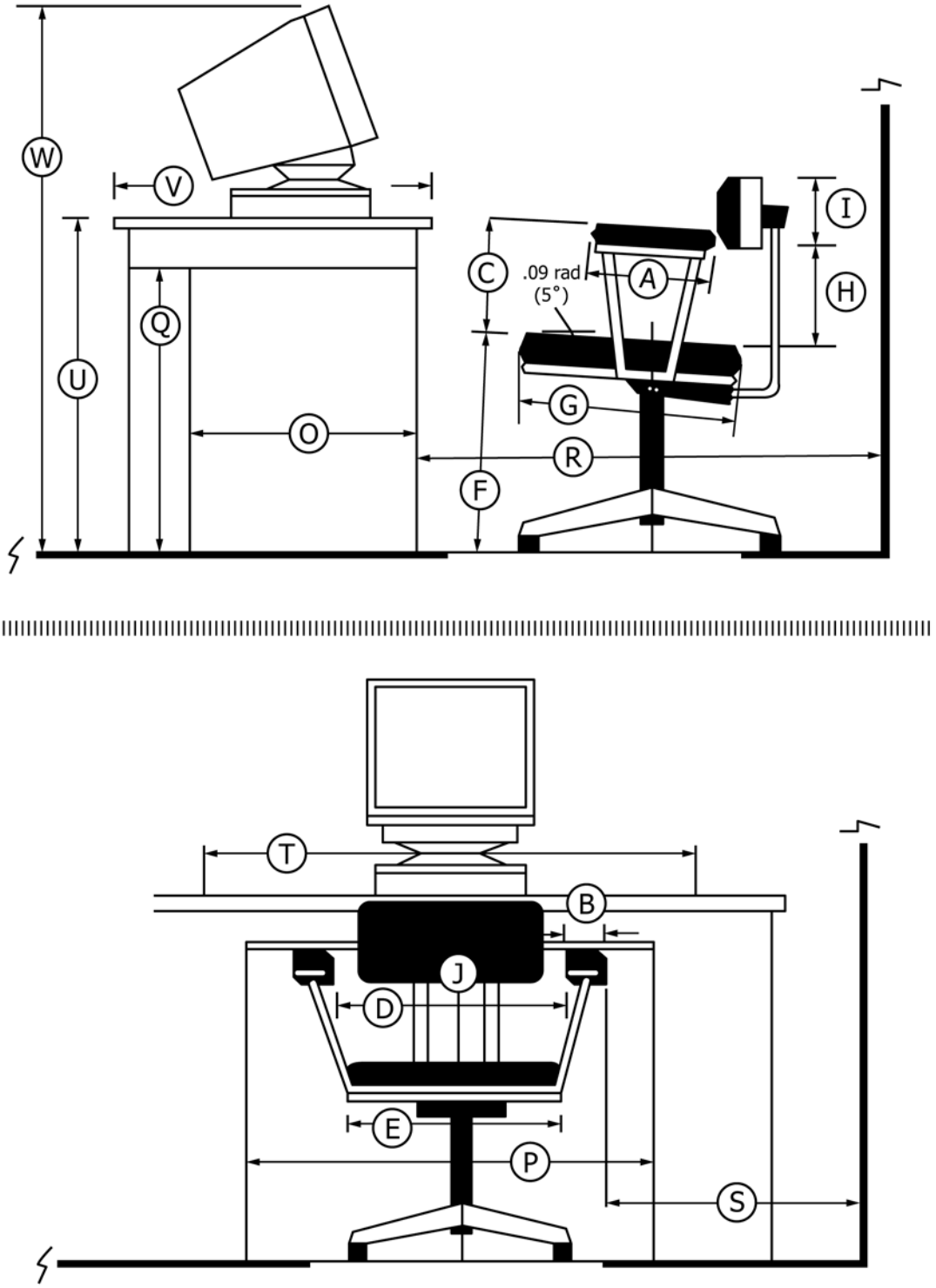


FIG. 58 Seated Computer Workstation Dimensions

10.6.4 *Shelf Dimensions Requiring Vision Over the Top*—Dimensions for shelves that require vision over the top shall be as shown in Fig. 74, "Workplace Dimensions for Shelves Requiring Vision Over the Top."

10.6.5 *Access to Lower Shelves*—Clearance required in front of lower shelves in order to place items on them shall be as shown in Fig. 75, "Front Clearance Requirement for Lower Shelves."

10.7 *Status Boards and File Cabinets:*

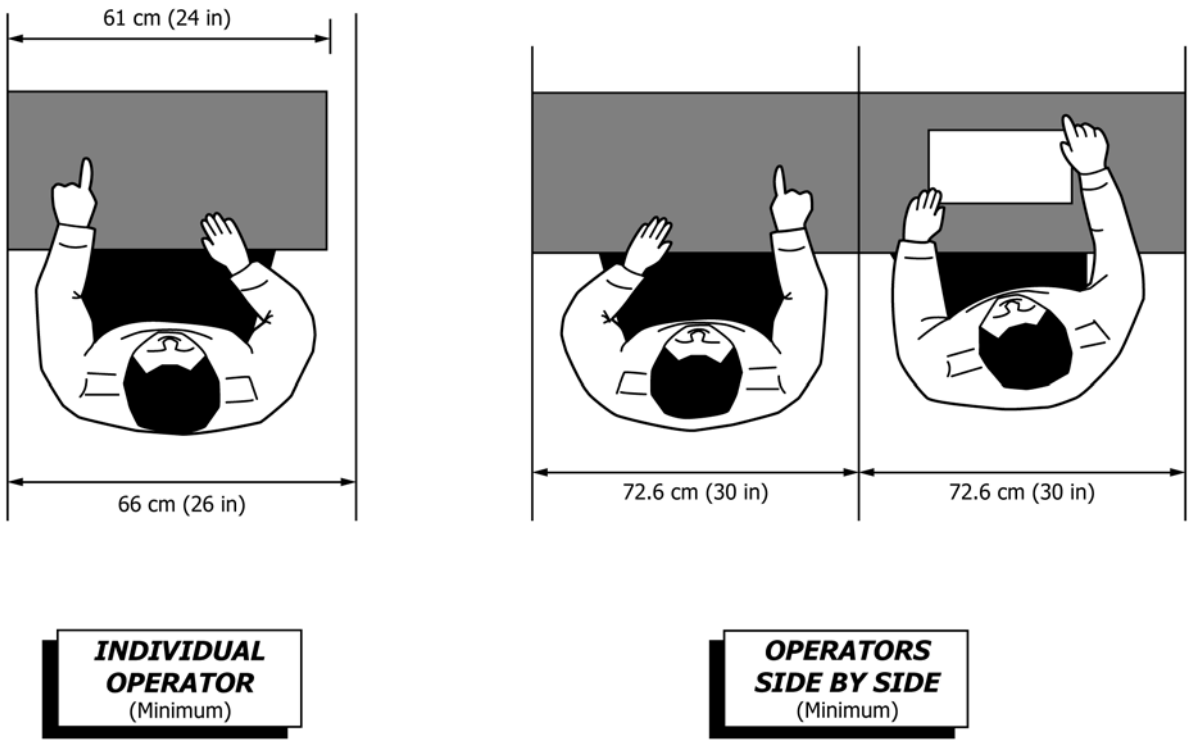
10.7.1 *Mounting Height of Status Boards*—Mounting height of status boards shall be as shown in Fig. 76, "Mounting Height of Status Boards."

10.7.2 *Filing*—Clearance in front of filing cabinets shall be as shown in Fig. 77, Cabinets "Clearance in Front of Filing Cabinets." Filing cabinets should be oriented so the drawers open fore and aft.

TABLE 20 Seated Computer Workstation Dimensions[A]

		Dimensions	Fixed/Min		Adjust
			mm	in.	
Armrest	A	Length	254	10	
	B	Width	50	2	
	C	Height	216	8.5	191 mm (7.5 in.) to 279 mm (11 in.)
	D	Separation	457	18	
Seat pan	E	Width	406	16	
	F	Height	381	15	Seat height shall be adjustable from the minimum height up 127 mm (5 in.)—in increments of no more than 25 mm (1 in.)
	G	Depth	381	15	Up to 432 mm (17 in.)
		Angle from horizontal			0–10° (5° preferred)
		Pan – backrest angle			90–100°
Backrest	H	Space	152	6	Full backrest with no space between seat pan and bottom of backrest is preferred.
	I	Height	380	15	Backrest height shall be adjustable unless it is solid from seat pan to minimum height shown. Adjustments should be in increments no greater than 75 mm (1 in.).
	J	Width	406	16	462 mm (18 in.) preferred
		Dimensions	Minimum		Preferred
Workspace	O	Kneehole depth (at knee height)	381	15	
		Kneehole depth (at deck level)	597	23.5	
	P	Kneehole width	508	20	610 mm (24 in.)
	Q	Kneehole height	635	25	
	R	Desk to wall	813	32	
	S	Chair to wall	381	15	
	T	Desk width	1372	54	
		Work surface width	610	24	
	U	Height of work surface keyboard (adjustable)			610 mm (24 in.) – 711 mm (28 in.) Independent adjustable keyboard support surface
		Height of work surface keyboard (fixed)	762	30	Fixed keyboard support surface, for example, desk top
	V	Desk depth	762	30	914 mm (36 in.)
		Work surface depth	610	24	762 mm (30 in.)

[A] These dimensions are for 5th % female to 95th % male North American populations and may have to be adjusted for other international user populations.



NOTE 1—These dimensions are appropriate for maritime populations worldwide.

FIG. 59 Dimensions for Single or Multiple Personnel at a Table or Other Duty Station Not Requiring a Desk

10.8 *Workbenches:*

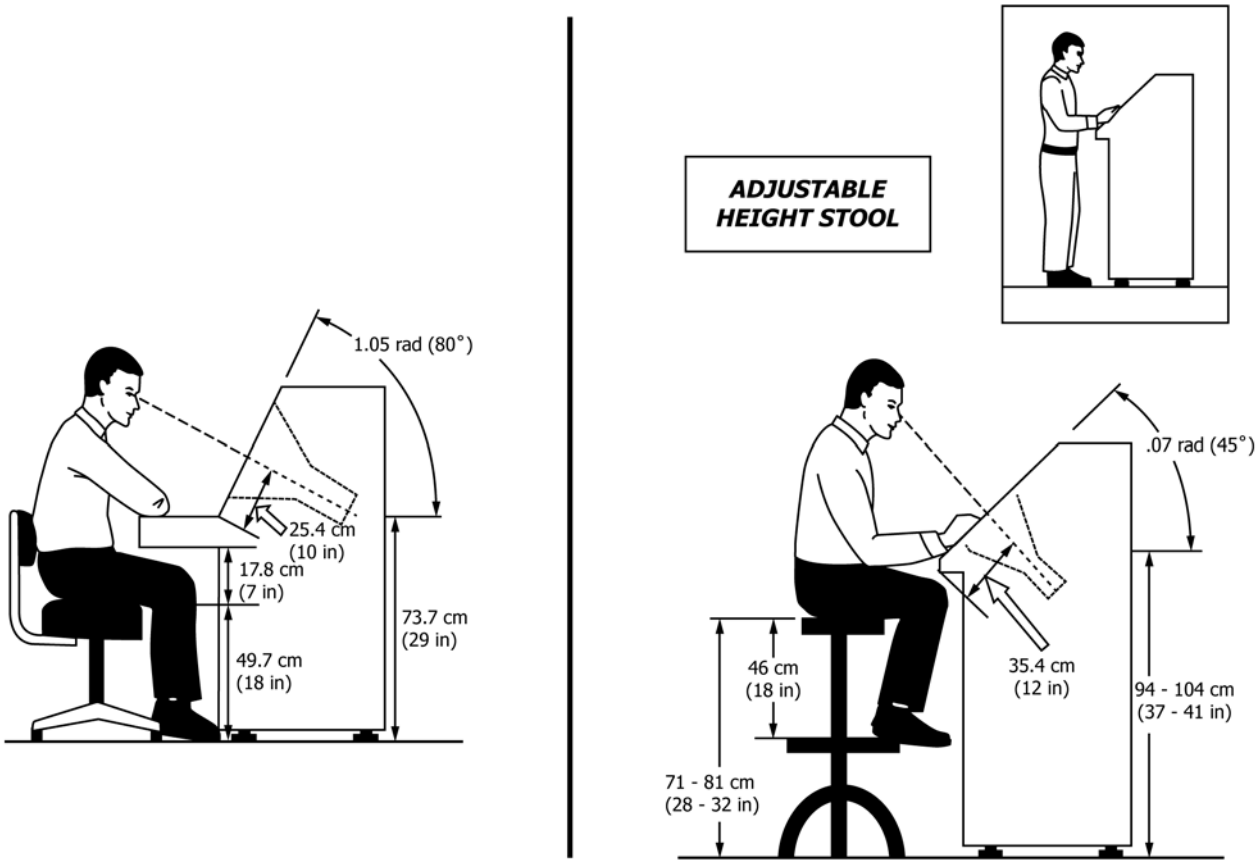
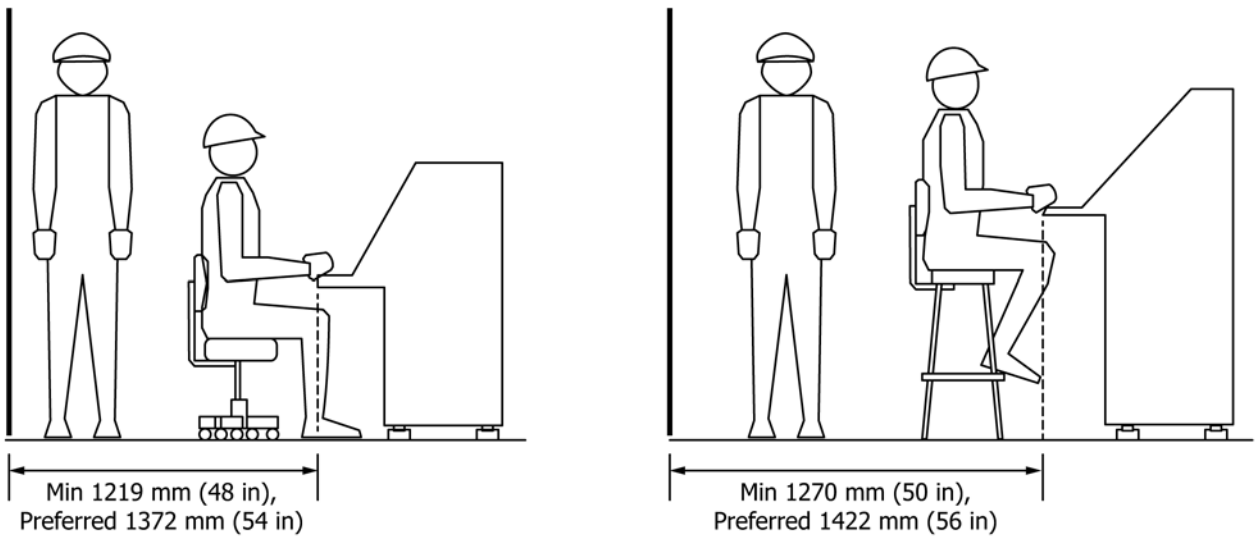


FIG. 60 Seating at CRT-Type Workstations

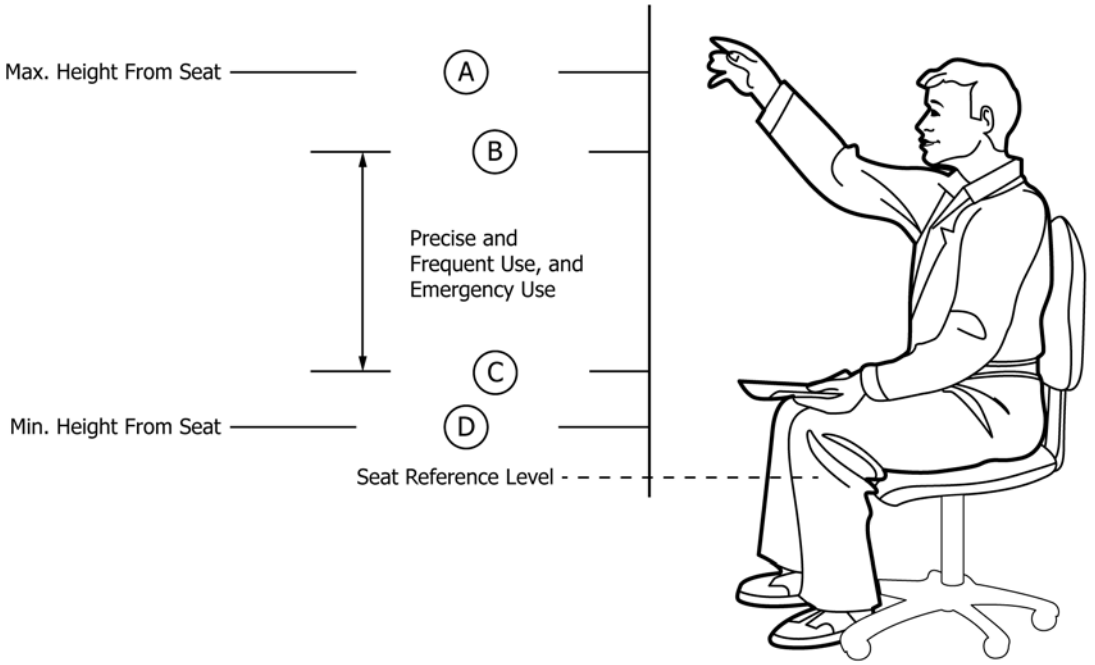


NOTE 1—These dimensions are appropriate for maritime populations worldwide.

FIG. 61 Clearance Behind a Seated Workstation

10.8.1 *Seated Workbench Dimensions*—Seated workbenches shall be 762 mm (30 in.) above the deck and a maximum of 685 mm (27 in.) wide, with 610 mm (24 in.) preferred. A minimum clear passing lane of 610 mm (24 in.) [762 mm (30 in.) preferred] shall be provided behind the seated operator. A minimum 1219 mm (48 in.) [preferred 1372 mm (54 in.)] of clear working area, measured from the edge of the workbench to the nearest obstacle behind the seated operator shall also be provided.

10.8.2 *Standing Workbench Dimensions*—Standing workbench dimensions and clearance around workbenches shall be designed as shown in Fig. 78, "Work Bench Dimensions."



Dimension	North America	Latin America	Northern Europe	West Africa	Southeast Asia
Maximum Height, (A)	1067 mm **(42 in)**	1041 mm **(41 in)**	1093 mm **(43 in)**	1015 mm **(40 in)**	1040 mm **(41 in)**
Preferred Max. Height, (B)**	860 mm **(32 in)**	813 mm **(32 in)**	890 mm **(34 in)**	813 mm **(31 in)**	813 mm **(31 in)**
Preferred Min. Height, (C)**	203 mm **(8 in)**	200 mm **(8 in)**	229 mm **(9 in)**	180 mm **(7 in)**	180 mm **(7 in)**
Minimum Height, (D)	150 mm **(6 in)**	150 mm **(6 in)**	200 mm **(7 in)**	150 mm **(6 in)**	150 mm **(6 in)**

** Preferred dimensions are for those controls that require precise, frequent, or emergency use.

NOTE 1—These dimensions are for 5th % females through 95th % males within the regions shown.

FIG. 62 Control Mounting Height for Seated Personnel

10.8.3 *Orientation*—Workbenches in vessels or structures that experience movement due to sea conditions should be oriented so the user faces fore or aft while standing at the bench.

10.8.4 *Location*—Workbenches shall not be located within 3 ft of rotating shafts, hot or cold piping, or any other hazard that a crewmember could come in contact with due to unexpected ship motion or other circumstance unless the hazard is guarded.

10.9 *Vertical Strainers and Filters:*

10.9.1 *Access:*

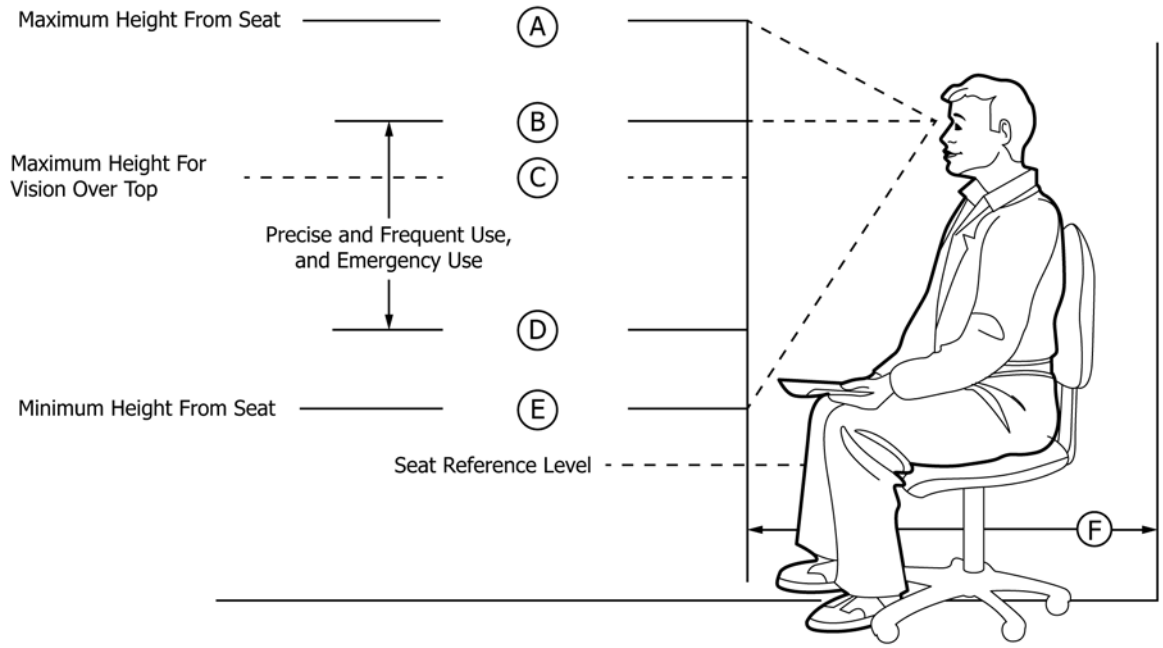
10.9.1.1 Vertical strainers and filters shall be located so that personnel do not have to stand on valve handles, piping, wire tray supports, or other surfaces not intended to be a permanent standing surface to remove the strainer or filter vessel cover, or remove or clean filter elements. The cover, its fasteners, and the filter elements shall be physically and visually accessible without the person having to reach over or around piping, other equipment, cable trays or any obstacle in order to reach the cover or filter elements.

10.9.1.2 Filters and strainers that contain elements that have to be removed for cleaning or replacement should provide a horizontal clearance around the unit of at least 508 mm (20 in.).

10.9.1.3 If elevated work platforms are provided to meet this requirement, they shall comply with the design requirements contained in Section 11.

10.9.2 *Top Height*—The top of the filter (that is, the point where the filter lid and body are joined and which the filter element must clear when being removed) shall be between 965 and 1016 mm (38 and 40 in.) above the operator's standing surface.

10.9.3 *Lid Orientation*—Filters or strainers with hinged lids or covers shall be oriented so the lid folds away from the operator's work position, not toward the operator. When the cover is removed or swung aside, full access to the elements



Dimension	North America	Latin America	Northern Europe	West Africa	Southeast Asia
Maximum Height, (A)	1118 mm **(44 in)**	1105 mm **(43.5 in)**	1118 mm **(44 in)**	1092 mm **(43 in)**	1080 mm **(42.5 in)**
Preferred Maximum Height, (B)**	900 mm **(35 in)**	864 mm **(34 in)**	889 mm **(35 in)**	864 mm **(34 in)**	851 mm **(33.5 in)**
Max Height For Vision Over Top, (C)	686 mm **(27 in)**	660 mm **(26 in)**	686 mm **(27 in)**	660 mm **(26 in)**	648 mm **(25.5 in)**
Preferred Minimum Height, (D)**	356 mm **(14 in)**	343 mm **(13.5 in)**	356 mm **(14 in)**	330 mm **(13 in)**	330 mm **(13 in)**
Minimum Height, (E)	152 mm **(6 in)**	152 mm **(6 in)**	152 mm **(6 in)**	152 mm **(6 in)**	152 mm **(6 in)**
Min. Workspace Depth, (F)	1067 mm **(42 in)**	1041 mm **(41 in)**	1105 mm **(43.5 in)**	1016 mm **(40 in)**	1016 mm **(40 in)**

** Preferred dimensions are for those displays that require precise, frequent, or emergency reading.

NOTE 1—These dimensions are appropriate for the 5th % female to the 95th % male for the regions shown.

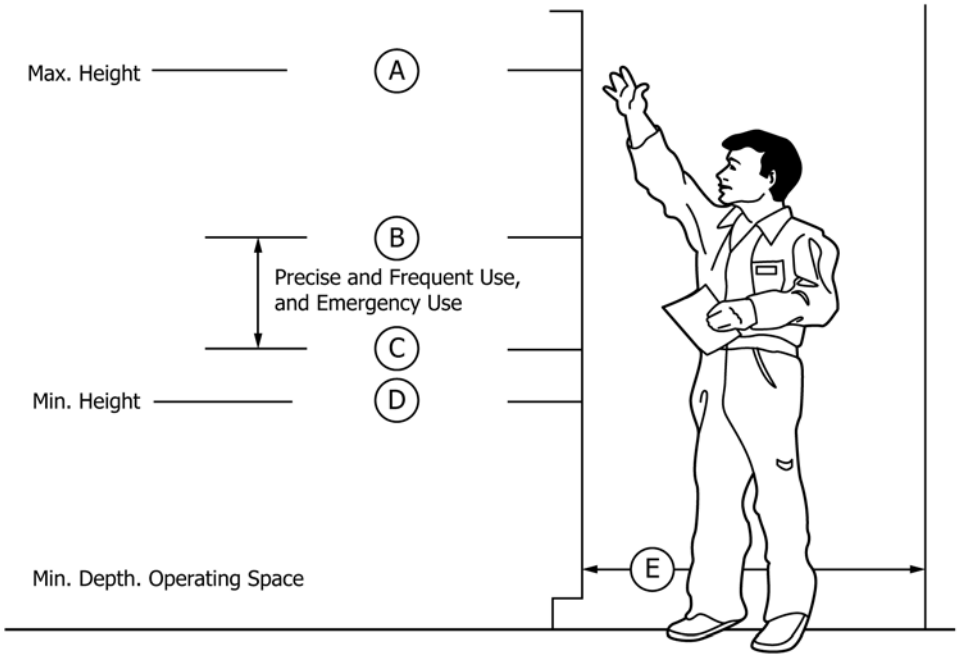
FIG. 63 Display Mounting Height for Seated Personnel

TABLE 21 Maximum Overhead Extended and Gripping Reach

Region	Max Extended Reach		Max Gripping Reach	
	Males	Females	Males	Females
Eastern Europe, Australia, North America, Northern Europe	2057 mm (81 in.)	1956 mm (77 in.)	1981 mm (78 in.)	1880 mm (74 in.)
Japan, China, Southeast Asia	1981 mm (78 in.)	1829 mm (72 in.)	1905 mm (75 in.)	1752 mm (69 in.)

inside shall be provided. The cover shall not interfere with removing the vessel contents, block access to replacement items, or obstruct placement of used items outside the strainer or filter. The open cover shall not interfere with access to items that must be viewed or reached during maintenance.

10.9.4 *Lid Operation*—Lids weighing in excess 13.6 kg (30 lb) should be provided with lifting aids to assist in moving the cover between the OPEN and CLOSED positions. Covers in the open position shall be provided with stops or retainers to prevent the cover from swinging or falling onto personnel.



Dimension	North America	Latin America	Northern Europe	West Africa	Southeast Asia
Maximum Height, (A)	1880 mm **(74 in)**	1854 mm **(73 in)**	1930 mm **(76 in)**	1803 mm **(71 in)**	1778 mm **(70 in)**
Preferred Max. Height, (B)**	1397 mm **(55 in)**	1372 mm **(54 in)**	1422 mm **(56 in)**	1372 mm **(54 in)**	1270 mm **(50 in)**
Preferred Min. Height, (C)**	864 mm **(34 in)**	864 mm **(34 in)**	914 mm **(36 in)**	838 mm **(33 in)**	762 mm **(30 in)**
Minimum Height, (D)	762 mm **(30 in)**	762 mm **(30 in)**	813 mm **(32 in)**	737 mm **(29 in)**	711 mm **(28 in)**
Preferred Min. Depth*, (E)	1067 mm **(42 in)**	1016 mm **(40 in)**	1067 mm **(42 in)**	1016 mm **(40 in)**	940 mm **(37 in)**
Minimum Depth, (E)	940 mm **(37 in)**	914 mm **(36 in)**	940 mm **(37 in)**	864 mm **(34 in)**	762 mm **(30 in)**

** Preferred dimensions are for those controls that require precise, frequent, or emergency use.

NOTE 1—The dimensions listed accommodate 5th % females through 95th % males within the given populations.

FIG. 64 Control Mounting Height for Standing Personnel

Where a chainfall or other similar lifting aid is used to open the lid, it is preferred they be left permanently attached to the lid rather than be installed each time the filter or strainer is cleaned.

10.10 *Reach Limitations at Workstations:*

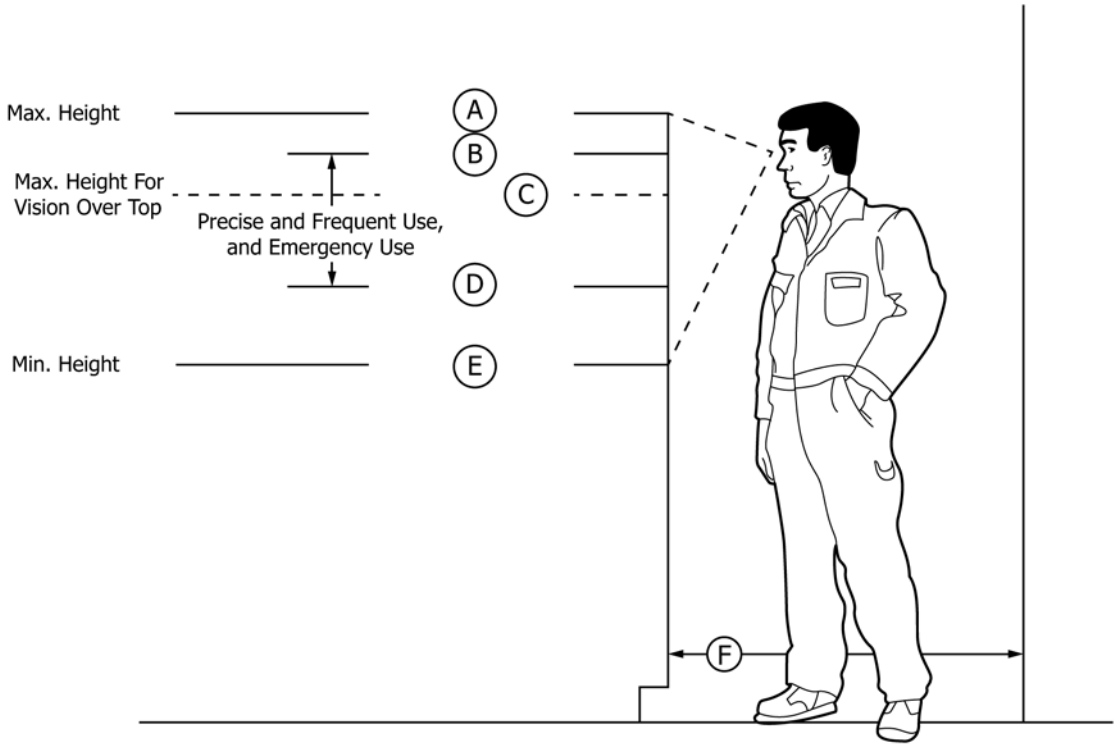
10.10.1 *Forward Reach*—Maximum effective forward reach (that is, able to grasp and turn/push/pull) shall be 610 mm (24 in.) from the front of the operator's body. For additional guidance on lateral reach envelopes for seated postures at various heights above the seated surface, refer to Human Factors Design Handbook, pp. 743–756.

10.10.2 *Forward Reach to Lift or Produce Torque*—Jobs requiring the operator to lift more than 3 kg (7 lb), or produce torque (for example, turning a wrench), should be kept within 305 mm (12 in.) of the front of the operator's body.

10.10.3 *Safe Distances for Reach Over an Obstacle or Barrier:*

10.10.3.1 Maximum horizontal reach limits over a barrier to perform light work is dependent on the task height above the standing surface and the barrier height. The relationship between these three elements for maximum reach is shown in Fig. 79, "Safe Reach Distances Over an Obstacle or Barrier."

10.10.3.2 If a hazard (hot surface, electrical contact, and so forth) exists within these reach envelopes, it must be guarded, removed, or moved beyond the maximum reach dimensions shown in Fig. 79.



Dimension	North America	Latin America	Northern Europe	West Africa	Southeast Asia
Maximum Height, (A)	1778 mm **(70 in)**	1740 mm **(68.5 in)**	1816 mm **(71.5 in)**	1727 mm **(68 in)**	1702 mm **(67 in)**
Preferred Maximum Height, (B)**	1651 mm **(65 in)**	1613 mm **(63.5 in)**	1689 mm **(66.5 in)**	1600 mm **(63 in)**	1575 mm **(62 in)**
Maximum Height For Vision Over Top, (C)	1397 mm **(55 in)**	1359 mm **(53.5 in)**	1435 mm **(56.5 in)**	1346 mm **(53 in)**	1321 mm **(52.5 in)**
Preferred Minimum Height, (D)**	1270 mm **(50 in)**	1232 mm **(48.5 in)**	1295 mm **(51 in)**	1219 mm **(48 in)**	1194 mm **(47 in)**
Minimum Height, (E)	1040 mm **(41 in)**	1016 mm **(40 in)**	1080 mm **(42.5 in)**	978 mm **(38.5 in)**	965 mm **(38 in)**
Minimum Depth, (F)	940 mm **(37 in)**	889 mm **(35 in)**	940 mm **(37 in)**	889 mm **(35 in)**	864 mm **(34 in)**

** Preferred dimensions are for those displays that require precise, frequent, or emergency reading.

NOTE 1—These dimensions are for the 5th % female to 95th % male populations from the regions listed.

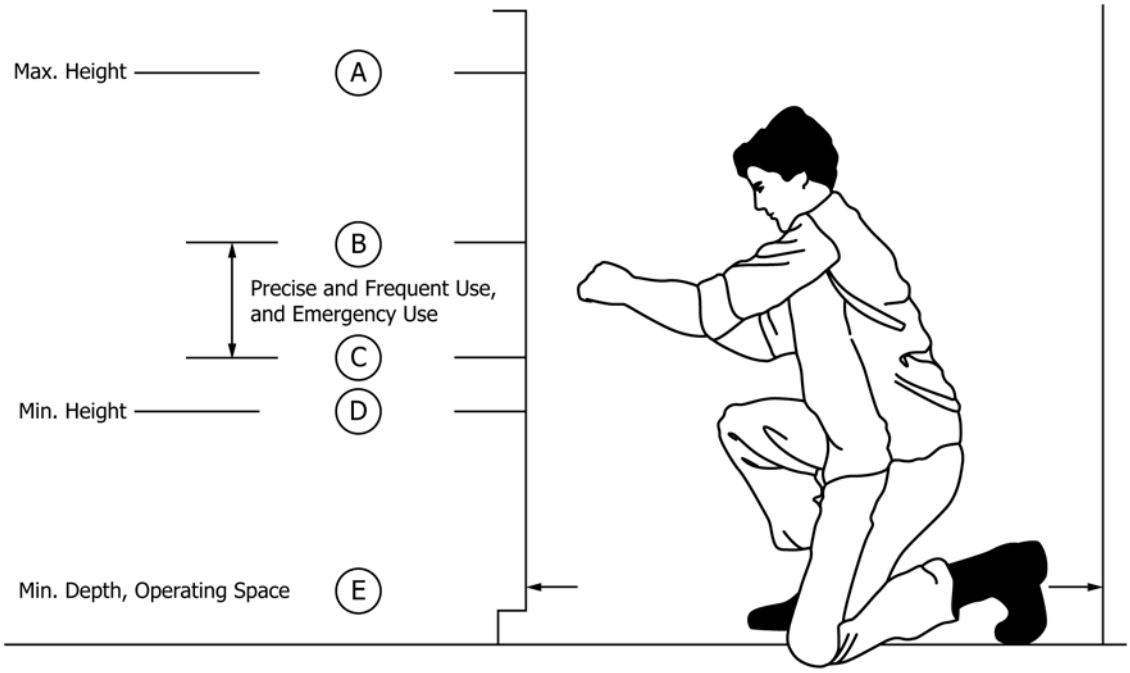
FIG. 65 Display Mounting Height for Standing Personnel

10.11 *Safety Eyewash Fountains and Showers:*

10.11.1 *Location*—Safety showers and eyewash fountains shall be located within 10 m (33 ft) of the source of contamination. The person in need of the fountain or shower shall not have to travel up or down stairs or change walking surface elevations at any point of travel between the point of contamination and the shower or fountain. The person shall not have to step over any obstacle, such as chemical spill containment rails, pipes, wireways on or above the walking surface.

10.11.2 *Clearances*—A minimum clearance of 305 mm (12 in.), with 381 mm (15 in.) preferred, shall be provided on either side of an eyewash fountain/safety shower as measured from the eyewash/shower centerline.

10.11.3 *Labeling*—A sign, prepared in accordance with the IMO standards and the guidance from Section 15, shall be placed in the immediate vicinity of the shower or fountain so as to be visible by any person approaching the shower or fountain from any direction. It is preferred that the sign be



Dimension	North America	Latin America	Northern Europe	West Africa	Southeast Asia
Maximum Height, (A)	1450 mm **(57 in)**	1425 mm **(56 in)**	1473 mm **(58 in)**	1372 mm **(54 in)**	1346 mm **(53 in)**
Preferred Max. Height, (B)**	1090 mm **(43 in)**	1080 mm **(42.5 in)**	1118 mm **(44 in)**	1054 mm **(41.5 in)**	1016 mm **(40 in)**
Preferred Min. Height, (C)**	540 mm **(21 in)**	508 mm **(20 in)**	559 mm **(22 in)**	508 mm **(20 in)**	483 mm **(19 in)**
Minimum Height, (D)	457 mm **(18 in)**	457 mm **(18 in)**	917 mm **(19 in)**	432 mm **(17 in)**	432 mm **(17 in)**
Minimum. Depth*, (E)	1070 mm **(42 in)**	1041 mm **(41 in)**	1070 mm **(42 in)**	918 mm **(39 in)**	965 mm **(38 in)**

** Preferred dimensions are for those controls that require precise, frequent, or emergency use.

NOTE 1—The dimensions listed accommodate 5th % females through 95th % males for the given populations.

FIG. 66 Control Mounting Height for a Kneeling Person

suspended from the overhead but other mounting techniques and locations for the sign may be approved by the procuring organization.

10.11.4 *Alarms*—Alarms shall be provided in control stations to alert personnel that safety eye wash fountains or showers have been engaged. Alarm characteristics shall comply with guidance in Section 7.

10.12 *Pedestal-Mounted Controls and Displays:*

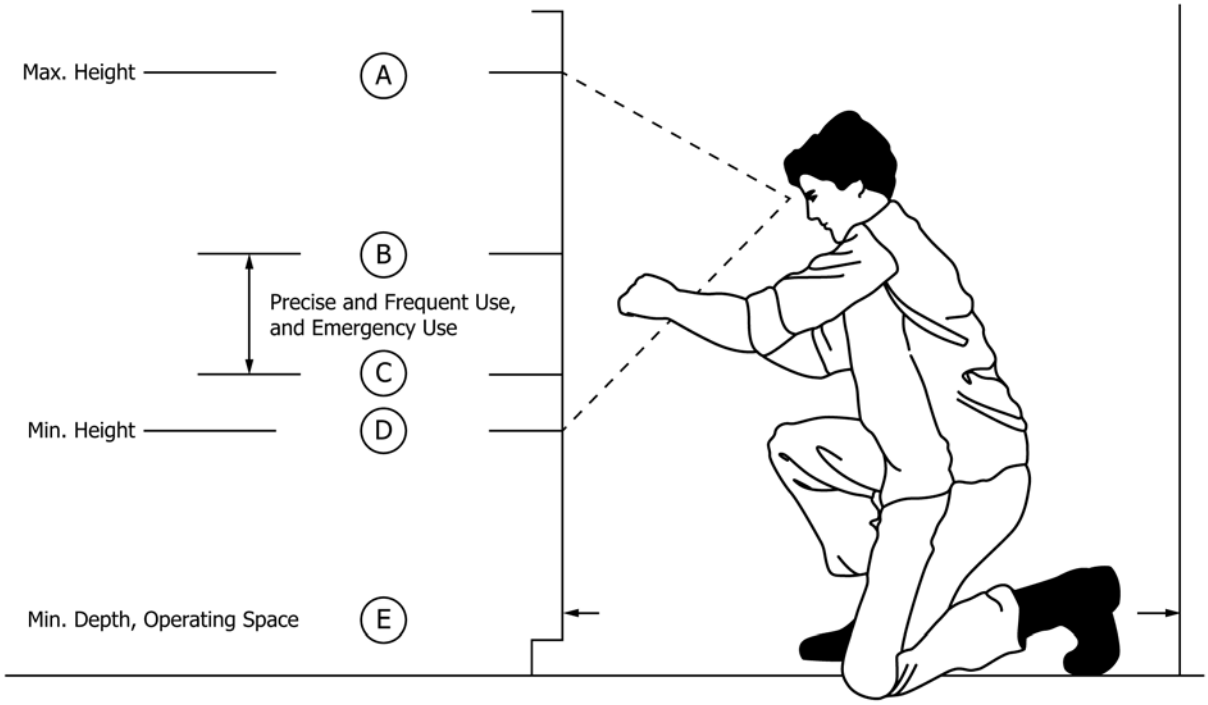
10.12.1 *Mounting Height*—Controls/displays mounted on pedestals (such as for deck equipment operation) shall be mounted so the controls and displays are facing up toward the operator and the control handle or display face is 1041 mm (41 in.) above the operator's standing surface.

10.12.2 *Orientation*—Each deck-mounted pedestal shall be oriented to provide a direct spatial relationship between the controls/displays on the pedestal control/display box and the equipment which is being controlled or monitored at the pedestal control/display box as the operator faces the control/display box.

10.12.3 *Lifeboat Controls*—All lifeboat controls should be located so the operator can visually follow the lifeboat from the control pedestal through its full route of travel from its stowed position to touchdown in the water.

10.13 *Hand Cranks and Pumps:*

10.13.1 *Location Installation:*



Dimension	North America	Latin America	Northern Europe	West Africa	Southeast Asia
Maximum Height, (A)	1450 mm **(57 in)**	1422 mm **(56 in)**	1473 mm **(58 in)**	1410 mm **(55.5 in)**	1397 mm **(55 in)**
Preferred Max Height, (B)**	1320 mm **(52 in)**	1295 mm **(51 in)**	1346 mm **(58 in)**	1270 mm **(50 in)**	1270 mm **(50 in)**
Preferred Min. Height, (C)**	950 mm **(37 in)**	927 mm **(36.5 in)**	965 mm **(38 in)**	914 mm **(36 in)**	914 mm **(36 in)**
Minimum Height, (D)	711 mm **(28 in)**	686 mm **(27 in)**	724 mm **(28.5 in)**	686 mm **(27 in)**	663 mm **(26.5 in)**
Minimum Depth, (E)	1150 mm **(45 in)**	1067 mm **(42 in)**	1150 mm **(45 in)**	1041 mm **(41 in)**	1041 mm **(41 in)**

** Preferred dimensions are for those displays that require precise, frequent, or emergency reading.

NOTE 1—These dimensions are for the 5th % female to 95th % male populations from the regions listed.

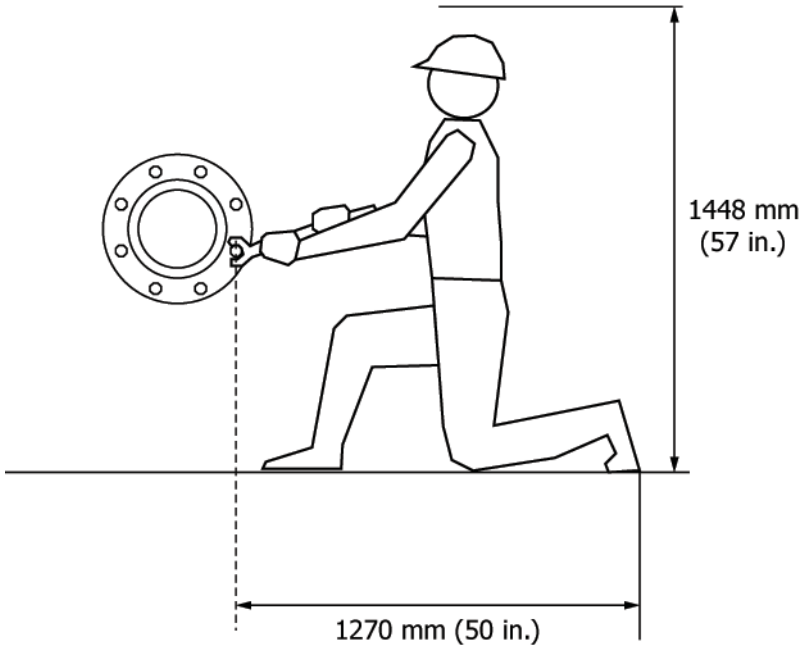
FIG. 67 Display Mounting Height for Kneeling Personnel

10.13.1.1 Hand cranks and pumps shall be installed so the lowest point of travel for the handle is no lower than 635 mm (25 in.) or no higher than 1168 mm (46 in.) above the level on which the pump operator is standing. Where both dimensions cannot be met, the maximum height shall be the controlling dimension.

10.13.1.2 Grating or other permanent footing shall be provided in front of hand pumps.

10.13.2 *Two Person Operation*—Where a hand pump is capable of, or required to be operated by two people simultaneously, sufficient room shall be provided for both operators to work (see 10.13.3). Hand pumps should be located so that the pump face is parallel with the operator's body (that is, the pump handle is perpendicular with the operator body).

10.13.3 *Clearance*—Clearance shall be provided around the pump to permit the operator's body to move during the cranking operation. For operation of pumps with handles perpendicular to the operator, a minimum clearance of 813 mm (32 in.) wide by 610 mm (24 in.) deep (measured from the end of the handle closest to the operator) shall be provided. For operation of pumps with handles parallel to the operator, a minimum clearance of 762 mm (30 in.) wide by 635 mm (25 in.) deep (measured from the handle at its closest position from the operator to the nearest obstruction) shall be provided.



NOTE 1—These dimensions are appropriate for maritime personnel worldwide but may be reduced for the smaller worker populations.

FIG. 68 Required Dimensions for a Kneeling Worker

10.14 *Bulkhead-Mounted Equipment:*

10.14.1 *Mounting Height in Passageways*—Equipment (for example, electrical panels, electrical outlet plugs, pneumatic quick disconnects) mounted on a passageway bulkhead, or on any vertical structure bordering a walkway, shall be located only in the areas shown in Fig. 80, "Mounting Heights for Bulkhead-Mounted Equipment in Passageways." Items should be mounted in the upper area, above 1956 mm (77 in.), if they have no controls or displays that require visual or reach access.

10.14.2 *Bulkhead-Mounted Electrical Fixtures*—Mounting heights for common electrical fixtures mounted to a bulkhead are shown in Fig. 81, "Mounting Heights for Common Electrical Fixtures."

10.15 *Equipment Racks, Cabinets, and Individual Equipment Spacing:*

10.15.1 *Lateral Spacing for Standing Operations:*

10.15.1.1 The minimum lateral workspace for equipment racks having drawers or removable equipment shall be as follows (measured from the drawers or equipment in the extended position):

(1) For racks having drawers or removable equipment weighing less than 20 kg (44 lb): 460 mm (18 in.) on one side and 100 mm (4 in.) on the other side.

(2) For racks having drawers or removable items weighing more than 20 kg (44 lb): 457 mm (18 in.) on both sides. Racks or equipment weighing in excess of 20 kg (44 lb) should be designed to rotate within the rack or equipment supports to permit in place maintenance or repair, or to permit partial equipment removal to lighten the load required to be handled when the rack or equipment is removed. If racks or equipment cannot be reduced below the 20-kg (44-lb) limit, then lifting shall be accomplished in accordance with weight lifting requirements contained in Section 16.

(3) For individual equipment (for example, cold food and drink dispensers in the galley) that are mounted side-by-side, or any equipment that requires side access for maintenance or repair, the minimum separation between equipment, or between equipment and the nearest obstacle shall be as follows:

(a) 203 mm (8 in.) for hand and arm access only.

(b) 203 mm (8 in.) plus any additional width required to use a tool or pull a part from the equipment.

10.15.2 *Frontal Space between Rows of Racks or Cabinets for Standing Operations:*

10.15.2.1 The minimum space between the two rows of racks or cabinets facing each other shall be as follows:

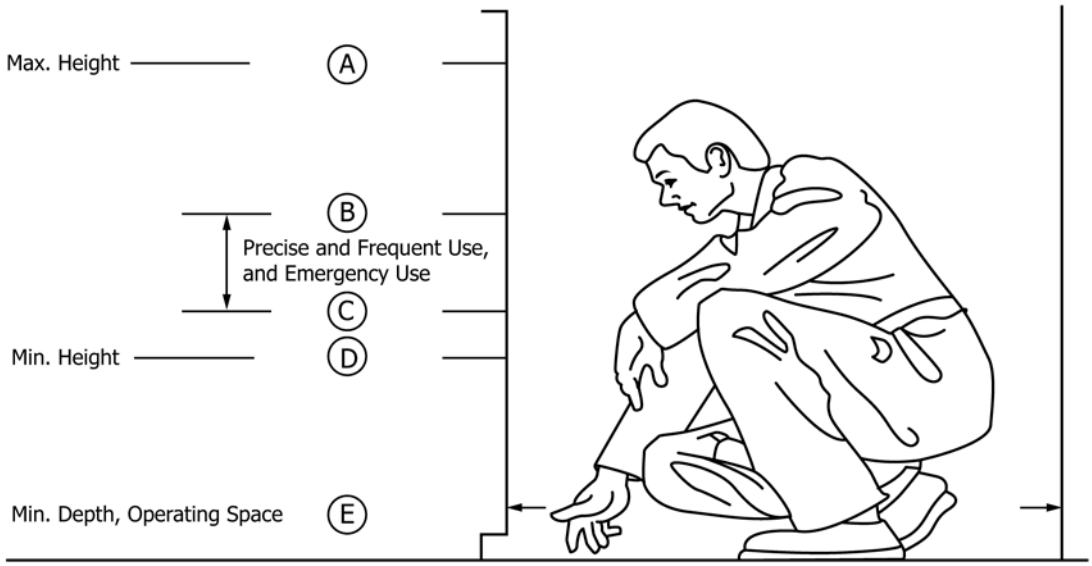
(1) 203 mm (8 in.) greater than the depth of the deepest drawer or cabinet shelf item being removed from the cabinet provided there is room enough for a person to stand at the side of the rack or item being removed from the shelf to complete all tasks associated with the removal of the drawer or item.

(2) 610 mm (24 in.) plus the depth of the deepest drawer or shelf width in the cabinet if the drawer or item must be removed by a person standing in front of the drawer or cabinet.

10.15.3 *Lateral and Frontal Spacing for Kneeling or Squatting Positions*—The minimum lateral workspace equipment for racks having drawers or removable equipment that are accessed from a kneeling or squatting position shall be the same as defined in 10.15.1. Clear frontal space shall be as shown in Fig. 68 or Fig. 71 for kneeling or squatting postures.

10.16 *Consoles and Control Panels:*

10.16.1 *Spatial Relationships*—Controls and displays on a local console or control panel shall be designed, arranged, located, and oriented in accordance with the requirements contained in Section 5, "Controls," through Section 8, "Integration of Controls, Displays and Alarms." Controls and displays shall be located and oriented so they provide a direct



Dimension	North America	Latin America	Northern Europe	West Africa	Southeast Asia
Maximum Height, (A)	1250 mm **(49 in)**	1219 mm **(48 in)**	1270 mm **(50 in)**	1194 mm **(49 in)**	1194 mm **(47 in)**
Preferred Max. Height, (B)**	813 mm **(32 in)**	813 mm **(32 in)**	864 mm **(34 in)**	800 mm **(31.5 in)**	787 mm **(31 in)**
Preferred Min. Height, (C)**	400 mm **(16 in)**	400 mm **(16 in)**	432 mm **(17 in)**	381 mm **(15 in)**	381 mm **(15 in)**
Minimum Height, (D)	360 mm **(14 in)**	360 mm **(14 in)**	381 mm **(15 in)**	343 mm **(13.5 in)**	330 mm **(13 in)**
Minimum Depth, (E)	915 mm **(36 in)**	889 mm **(35 in)**	915 mm **(36 in)**	864 mm **(34 in)**	813 mm **(32 in)**

** Preferred dimensions are for those controls that require precise, frequent, or emergency use.

NOTE 1—The dimensions listed accommodate 5th % females through 95th % males within the given population.

FIG. 69 Control Mounting Height for Squatting Personnel

spatial relationship to the actual ship or structure's equipment as viewed by the operator at the console or panel. See Fig. 82.

10.16.2 *Local Control Panels*—Local control panels that appear at multiple copies of the same piece of equipment or system (for example, three sewage treatment pumps each mounted on its own skid or all together on a single skid, or two diesel generators housed in separate rooms) shall have their local control panels arranged, located, and oriented in the same manner at each piece of equipment.

10.16.3 *Consoles Oriented Athwartships Displaying Relationship Fore/Aft Equipment*—When a console is oriented athwartships on a vessel to control or monitor equipment or systems that are physically arranged fore and aft on the vessel (for example, piping and pumps on a tanker), the preferred control and display arrangement on the console is shown in Fig. 83, "Spatial of Fore and Aft Equipment to Controls and Displays on a Console Located Athwartships."

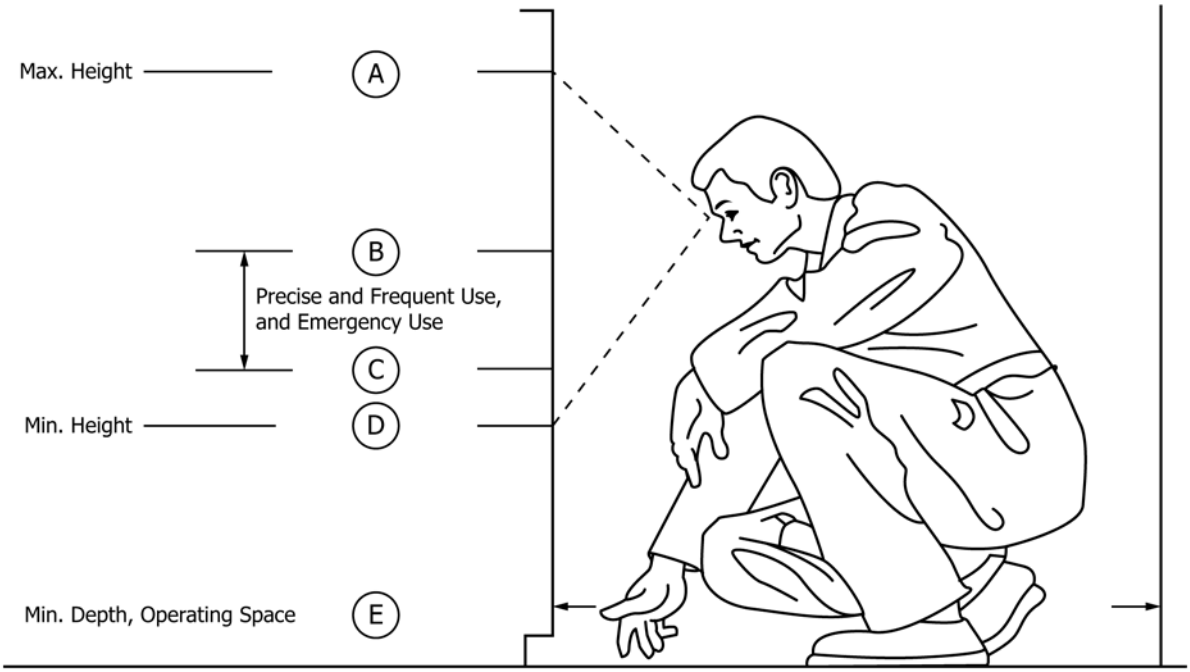
10.16.3.1 Controls and displays positioned on the right side of the console should be for equipment located forward. Correspondingly, those on the left side of the console are for equipment located aft.

10.16.3.2 Controls and displays positioned at the top of the console should be for equipment on the port side. Correspondingly, those at the bottom of the console are for equipment located on the starboard side.

10.16.3.3 This arrangement may also be used for panels and consoles oriented where personnel face port.

10.16.3.4 The same rules apply to vertical control panels.

10.16.4 *Consoles/Control Panels on Equipment Skids*—Consoles or control panels provided on equipment packages,



Dimension	North America	Latin America	Northern Europe	West Africa	Southeast Asia
Maximum Height, (A)	1250 mm **(49 in)**	1207 mm **(47.5 in)**	1270 mm **(50 in)**	1207 mm **(47.5 in)**	1194 mm **(47 in)**
Preferred Max Height, (B)**	1020 mm **(40 in)**	991 mm **(39 in)**	1054 mm **(41.5 in)**	953 mm **(37.5 in)**	940 mm **(37 in)**
Preferred Min. Height, (C)**	635 mm **(25 in)**	610 mm **(24 in)**	673 mm **(26.5 in)**	597 mm **(23.5 in)**	597 mm **(23.5 in)**
Minimum Height, (D)	508 mm **(20 in)**	483 mm **(19 in)**	533 mm **(21 in)**	470 mm **(18.5 in)**	457 mm **(18 in)**
Minimum Depth, (E)	1050 mm **(41 in)**	991 mm **(39 in)**	1067 mm **(42 in)**	965 mm **(38 in)**	965 mm **(38 in)**

** Preferred dimensions are for those displays that require precise, frequent, or emergency reading.

NOTE 1—These dimensions are for the 5th % female to 95th % male populations from the regions listed.

FIG. 70 Display Mounting Heights for Squatting Personnel

including skid-mounted packages acquired from vendors or fabrication yards, shall be located and oriented so personnel face the equipment. Each control or display shall be located on the console or panel so they are spatially related to the equipment as viewed by the operator facing the console or panel.

10.16.5 *Seated Single Operator Console:*

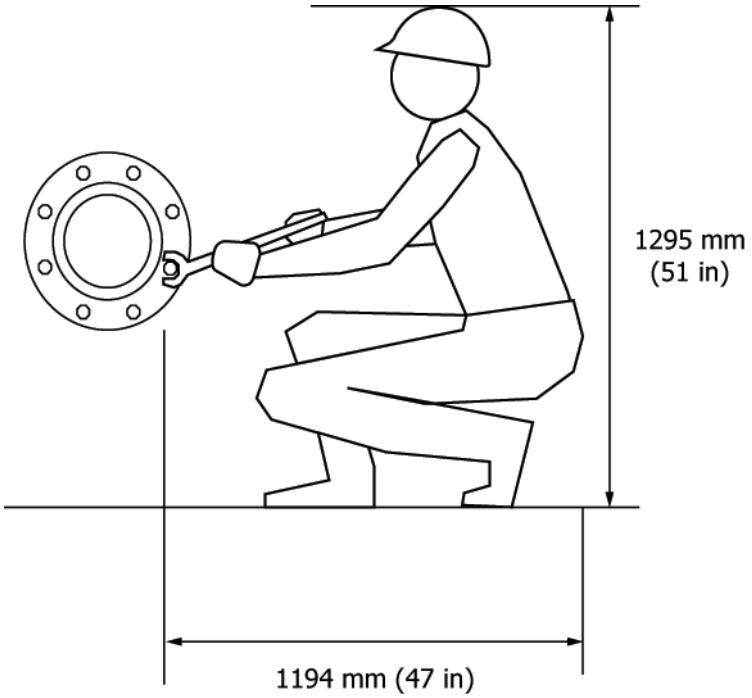
10.16.5.1 Dimensions for a seated single operator console with or without vision over the top are shown in Fig. 84, "Seated Single Operator Console Dimensions." Console width should be a maximum of 1118 mm (44 in.). Frequently used controls (that is, those used at least once per shift or watch) shall be within a radius of 406 mm (16 in.). Infrequently used controls (that is, those used less than once per shift or watch) shall be within a radius of 711 mm (28 in.).

10.16.5.2 The dimensions shown are based on North American males so that adjustment shall be made to these dimensions for other user populations.

10.16.6 *Visual Viewing Distance*—The preferred viewing distance from the operator's eyes to the console or panel displays is 635 mm (25 in.), 635 mm (28 in.) maximum. Viewing distance to displays shall not be less than 330 mm (13 in.) and, preferably, never less than 406 mm (16 in.) for short viewing periods (that is, less than 10 min).

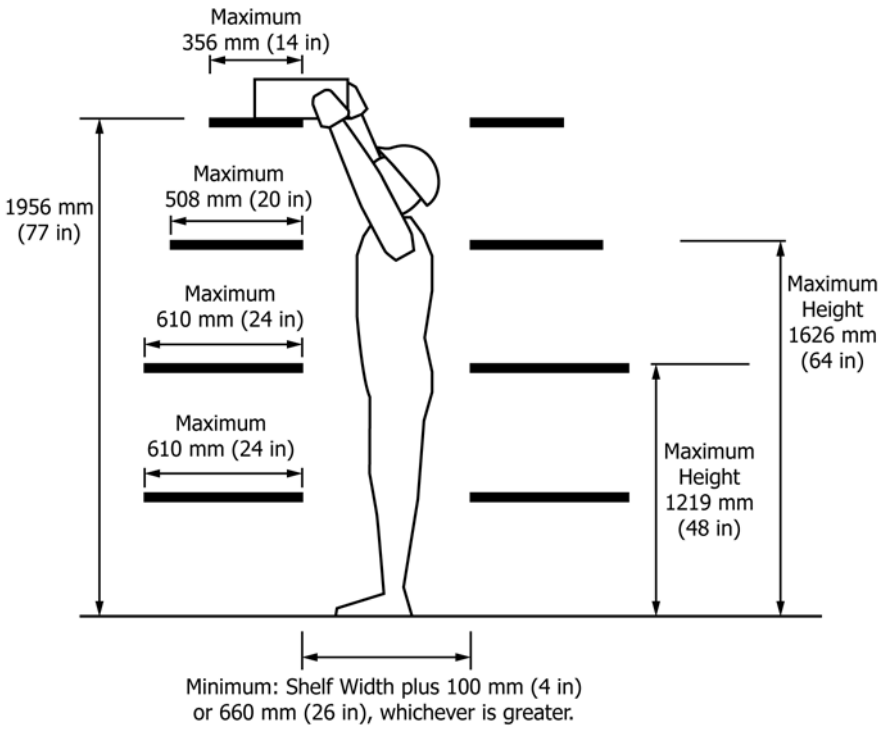
10.16.7 *Extra-Wide Consoles:*

10.16.7.1 Seated consoles shall be 1120 mm (44 in.) or less in width, and standing consoles shall be 1525 mm (60 in.) or less in width. There may, however, be conditions in which it is preferred to have wider consoles. Acceptable alternatives include:



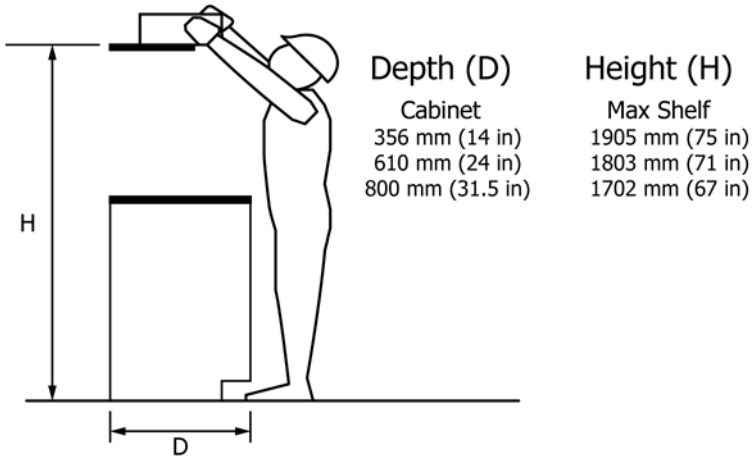
NOTE 1—These dimensions are appropriate for maritime personnel worldwide but may be reduced for the smaller worker populations.

FIG. 71 Required Dimensions for a Squatting Worker



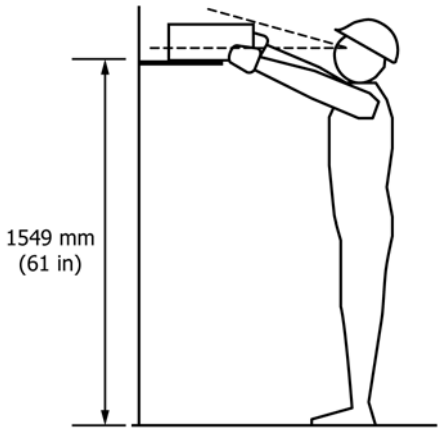
NOTE 1—These dimensions are appropriate for North American and Northern European 5th to 95th % males. To accommodate all males from maritime populations the maximum height should be reduced to 1854 mm (73 in.), and for all females the height should be reduced to 1730 mm (68 in.). The second shelf up from the deck should be lowered to a maximum height of 1107 mm (44 in.) and the third shelf up from the deck should be lowered to a maximum height of 1477 mm (58 in.).

FIG. 72 Workplace Dimensions for Shelves with Full Access



NOTE 1—These dimensions are for 5th to 95th % males from North America and Northern Europe. To accommodate 5th to 95th % males and females from all maritime populations the height numbers must be reduced by 178 mm (7 in.).

FIG. 73 Workplace Dimensions for Shelves Located Above a Cabinet



NOTE 1—This dimension is for 5th to 95th % males in North America and Northern Europe. To fit all males from maritime countries, lower this number to 1448 mm (57 in.) and to accommodate all females from maritime countries reduce the height to 1321 mm (52 in.).

FIG. 74 Workplace Dimensions for Shelves Requiring Vision Over the Top

(1) Wraparound—A seated wraparound console is shown in Fig. 85, "Wraparound Seated Console" with an 1120-mm (44-in.) center span and 610-mm (24-in.) wings. A standing console shall be similar but with a 1525-mm (60-in.) center span and 915-mm (36-in.) wings. Additional dimensions shall be as shown in Fig. 84, "Seated Console Dimensions."

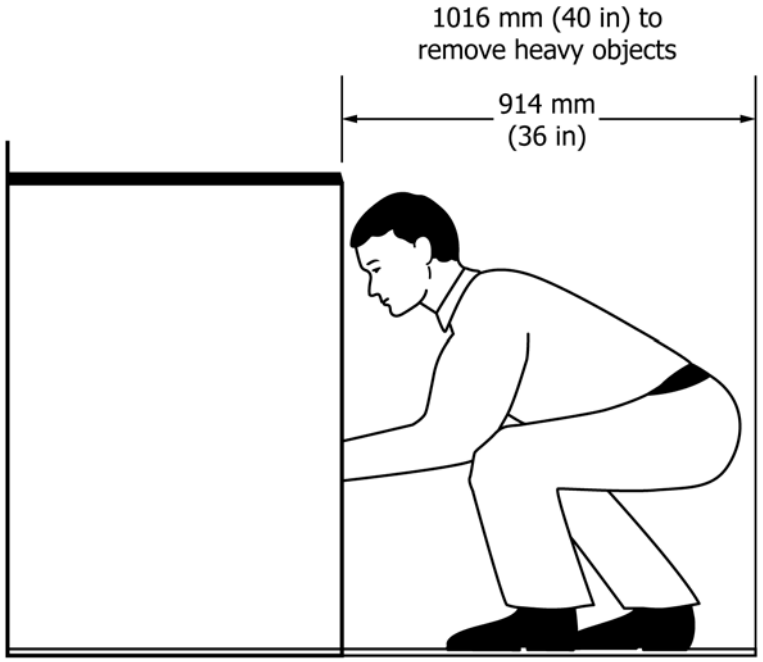
(2) Extra-Width—A console may be configured as an extra-width seated console, as shown in Fig. 86, "Special-Width Console." With the extra-wide console, frequently used controls (that is, those used more than once a shift) shall be within a distance of 457 mm (18 in.) from the console's centerline and the less frequently used controls (that is, those used less than once a shift) should be located within a distance of 800 mm (31.5 in.) from the console's centerline. These dimensions assume a single-person workstation. All other dimensions shall be as shown in Fig. 84, "Console Dimensions."

10.16.7.2 The dimensions shown are based on North American males and shall be adjusted for other user populations by using the international anthropometric data shown in Section 9.

10.16.8 *Extra Height Multi-tiered Consoles*—For standing and seated consoles where vision over the top is not required, the console height may be increased provided the angled upper tier is used only for displays and the displays remain within the field of view as shown in Fig. 87, "Multi-tiered Standing Console" and Fig. 88, "Multi-tiered Seated Console." The dimensions shown in both figures are for North American males and shall be adjusted for other user populations by adjusting to the international anthropometric data found in Section 9.

10.16.9 *Desktop Console*—Dimensions for desktop consoles for standing personnel are shown in Fig. 89, "Dimensions for Desktop Standing Console." Although it is preferred that desktop standing consoles be 1219 mm (48 in.) or less in width, consoles of greater width may be allowed for specific applications, such as for navigation bridge or propulsion control consoles. In those instances, the console layouts shall separate control and display groups into segments no greater than 1219 mm (48 in.) in width on the console face. Dimensions shown in Fig. 89 are for North American males and shall be adjusted for other user populations.

10.16.10 *Cargo and Ballast Control Consoles:*



NOTE 1—These dimensions will accommodate all maritime populations worldwide but may be reduced for smaller populations.

FIG. 75 Front Clearance Requirement for Lower Shelves

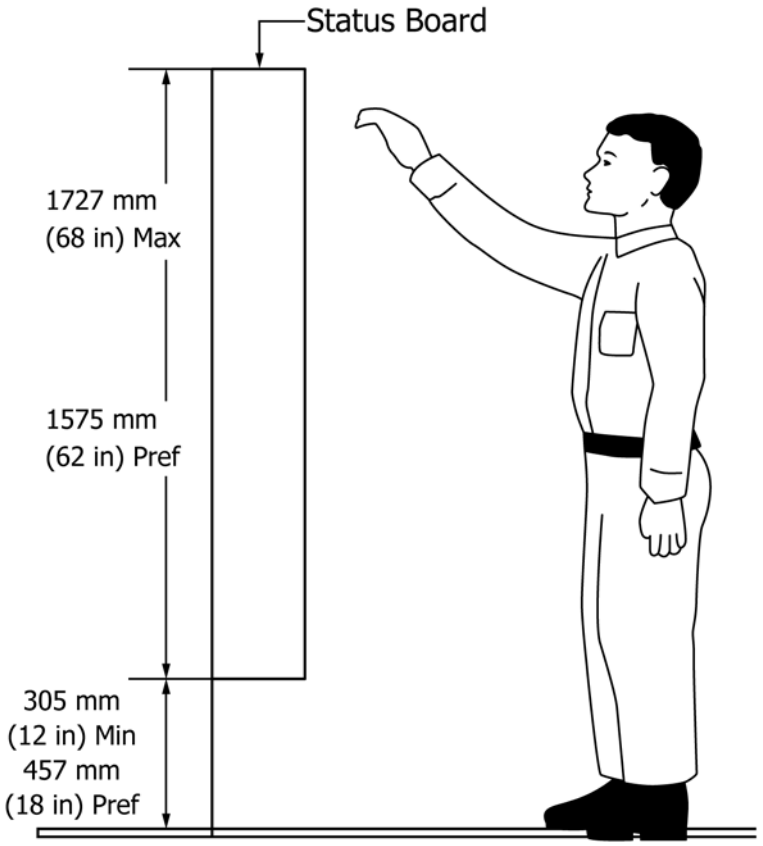


FIG. 76 Mounting Height of Status Boards

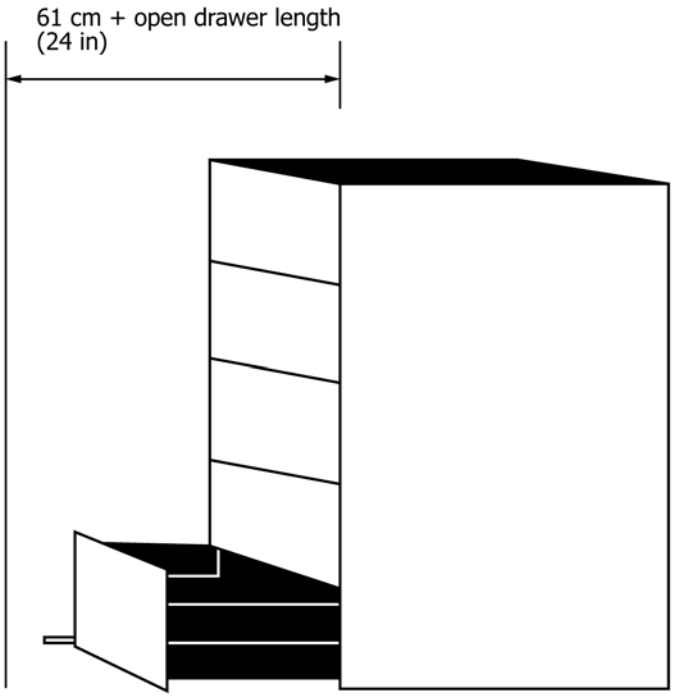


FIG. 77 Clearance in Front of Filing Cabinets

10.16.10.1 Cargo and ballast transfer controls and displays on the console shall be arranged so their orientation is spatially related to the actual tanks, valves, pumps, liquid level gauges, and other equipment installed in the systems located on the vessel or maritime installation. In the case of vessels, control panels and consoles shall be installed so personnel face forward or port.

10.16.10.2 On multi-tier consoles that use a combination of mimics, controls, and their associated displays, or visual alarms, or combination thereof (for example, cargo transfer console on tankers), the layout of the bottom portion of the console and the upper tier shall maintain the same relationship as shown in Fig. 90. The top or upper area of the console face shall represent the port side of the vessel and the bottom or lower area of the console face should represent the starboard side of the vessel.

10.16.11 *Other Consoles Orientation*—Consoles associated with the control of propulsion engines, navigation (including chart tables, radar, electronic chart displays) and steering shall be installed so personnel face forward in the direction the vessel travels. This shall be done regardless of whether personnel have visual contact with the outside of the vessel.

10.16.12 *Auxiliary Machinery Consoles*—Consoles associated with auxiliary machinery, such as vessel service generators, pumps, mooring winches, or thrusters, shall be oriented to maintain a spatial relationship between the console controls, displays, and the actual equipment they control or monitor. If there is more than one piece of identical machinery located in separate spaces, such as identical thrusters located in a forward and aft thruster room, the console for each piece of equipment shall be located and oriented the same in each space.

10.16.13 *Labeling*—Consoles, control panels, and workstations shall be labeled in compliance with the requirements of Section 15.

10.17 *Bridge Design:*

10.17.1 *Bridge-Specific Design Requirements*—In addition to the requirements contained throughout this practice that shall be applied to the design of a ship's bridge, other design guidance notes specific to the bridge area are contained in the ABS "Guidance Notes on Ergonomic Design of Navigation Bridges" and should be followed in the design of a ship's bridge.

11. Access Aids: Stairs, Handrails, Railings, Vertical Ladders, Ramps, Walkways, Doors, Lightening Holes, Hatches, Kick-Out Panels, Passageways and Walkways, and Work Platforms

11.1 *Stairs, Ladders, and Ramps:*

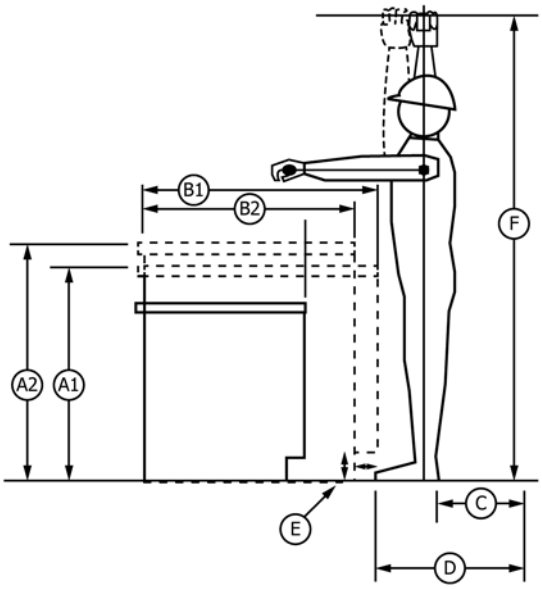
11.1.1 *General Requirements*—Stairs, vertical ladders, or ramps shall be provided whenever personnel must change elevation abruptly by more than 305 mm (12 in.).

11.1.2 *Operational / Maintenance Requirements*—Requirements for operational/maintenance access shall be determined as follows:

11.1.2.1 Stairs should be used for changing from one walking or working surface to another if any of the following conditions exist:

(1) Operational/maintenance activities require regular travel between levels or decks by personnel.

(2) Access is required to elevated work platforms (for example, mezzanines) daily, or at least once a shift.



		Height above floor			Max Depth	
Standard bench (Standing)	**A1**	914 mm	36 in	**B1**	1016 mm	40 in
Example: Work bench in machinery shop for maintenance of valves.						
Tall Bench	**A2**	1016 mm	40 in	**B2**	914 mm	36 in
Example: Work bench for fine detail inspection or maintenance.						
		Minimum			**Preferred**	
Passing width behind body	**C**	381 mm	15 in		635 mm	25 in
Working Space	**D**	813 mm	32 in		914 mm	36 in
Foot Space (square)	**E**	102 mm	4 in			
Overhead Clearance	**F**	1981 mm	78 in		2134 mm	84 in

FIG. 78 Workbench Dimensions

(3) Quick escape may be needed from elevated work areas or platforms.

(4) Employees could be hand carrying tools, equipment, or spare parts regardless of the frequency of this activity.

11.1.2.2 Ramps should be used for changing from one walking or working surface to another when the following conditions exist:

(1) When the change in vertical elevation is less than 610 mm (24 in.) in height.

(2) When it is necessary to move people, vehicles, or materials by means of a single technique rather than through individual vehicle ramps and personnel stairs.

(3) When a ramp would allow more efficient egress along an emergency access/egress route, so long as the angle of inclination is 8° or less.

(4) When a person is hand-carrying bulky loads or loads weighing more than 13.6 kg (30 lb).

11.1.2.3 Vertical ladders should be used when space is unavailable for stairs or a ramp.

11.1.3 *Selection of Vertical Access Device*—The final selection of the vertical access device (that is, stair, vertical ladder or ramp) to be used to move from one walking or working surface to another shall be based on the purpose, frequency of use, and height of the vertical access change required. See Table 22, "Selection of Access Type" for related guidance on angle of inclination. Inclined stairs (that is, vertical access devices with angles between 50 and 75º) should not be used. The maximum angle of inclination of stairs should not exceed that prescribed by applicable requirements.

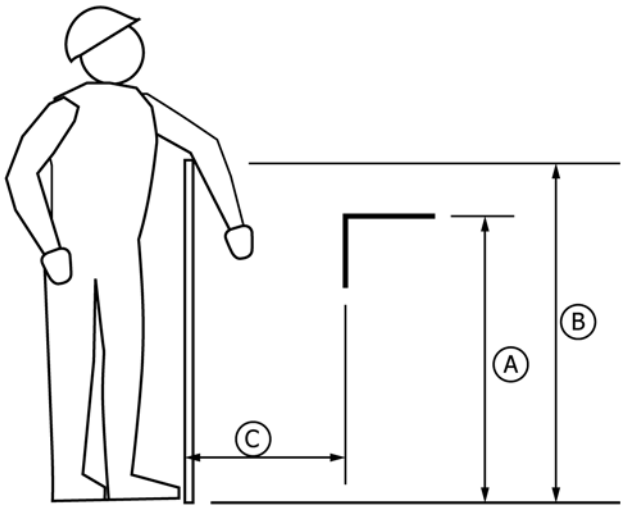
11.1.4 *Emergency Use Requirements:*

11.1.4.1 Stairs shall be the primary means of emergency egress from spaces. However, in areas where two means of egress are required, a vertical ladder may be used as the secondary egress means.

11.1.4.2 A vertical ladder leading to a deck scuttle is not to be used as a means of emergency egress except on vessels less than 19.8 m (65 ft) in length, or as not more than one of the means of egress from any crew accommodations space or work space.

11.1.4.3 Each ladder used as a means of emergency egress shall be designed in accordance with the requirements outlined in 11.4 and Fig. 95.

11.2 *Stairs:*



	Height of Barrier (B) mm (in)							
	2405 (94.7)	2200 (86.8)	2004 (78.9)	1806 (71.1)	1605 (63.2)	1405 (55.2)	1204 (47.4)	1003 (39.5)
Height of Task Above The Floor (A) mm (in)	**Maximum Horizontal Reach Distance from Barrier (C) mm (in)**							
2405 (94.7)		10 (3.9)	10 (3.9)	10 (3.9)	10 (3.9)	10 (3.9)	10 (3.9)	10 (3.9)
2200 (86.8)		251 (9.9)	351 (13.8)	401 (15.8)	500 (19.7)	500 (19.7)	602 (23.7)	602 (23.7)
2004 (78.9)			351 (13.8)	500 (19.7)	602 (23.7)	701 (27.7)	902 (35.5)	1102 (43.4)
1806 (71.1)				602 (23.7)	902 (35.5)	902 (35.5)	1003 (39.5)	1103 (43.4)
1605 (63.2)				500 (19.7)	902 (35.5)	902 (35.5)	1003 (39.5)	1303 (51.3)
1405 (55.3)				10 (3.9)	803 (31.6)	902 (35.5)	1003 (39.5)	1303 (51.3)
1204 (47.4)					500 (19.7)	902 (35.5)	1003 (39.5)	1405 (55.2)
1003 (39.5)					300 (11.8)	902 (35.5)	1003 (39.5)	1405 (55.3)
800 (31.6)						600 (23.7)	902 (35.5)	1303 (51.3)
603 (3.7)							500 (19.7)	1200 (47.4)
400 (15.8)							300 (11.8)	1200 (47.2)
200 (7.8)							700 (27.6)	1100 (43.7)

FIG. 79 Safe Reach Distances Over an Obstacle or Barrier

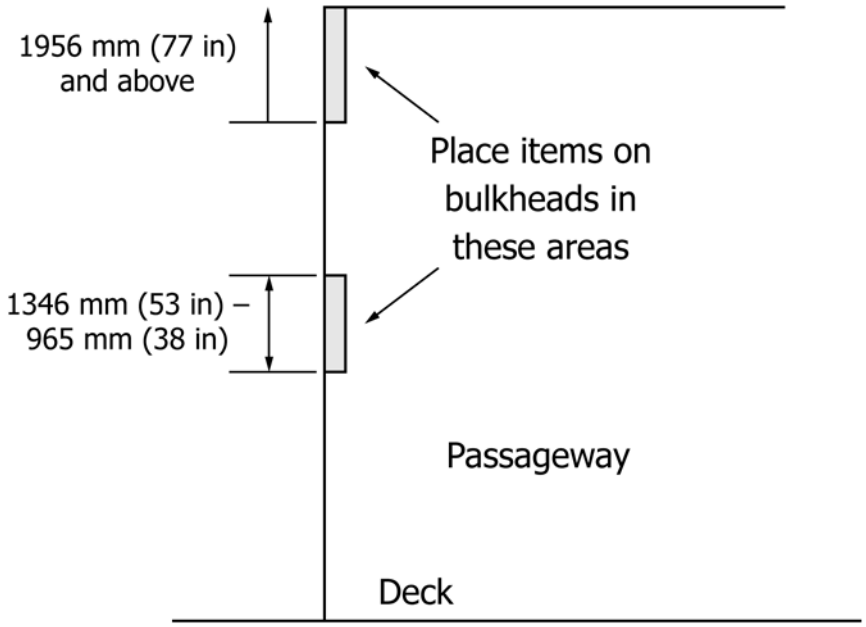


FIG. 80 Mounting Heights for Bulkhead-Mounted Equipment in Passageways

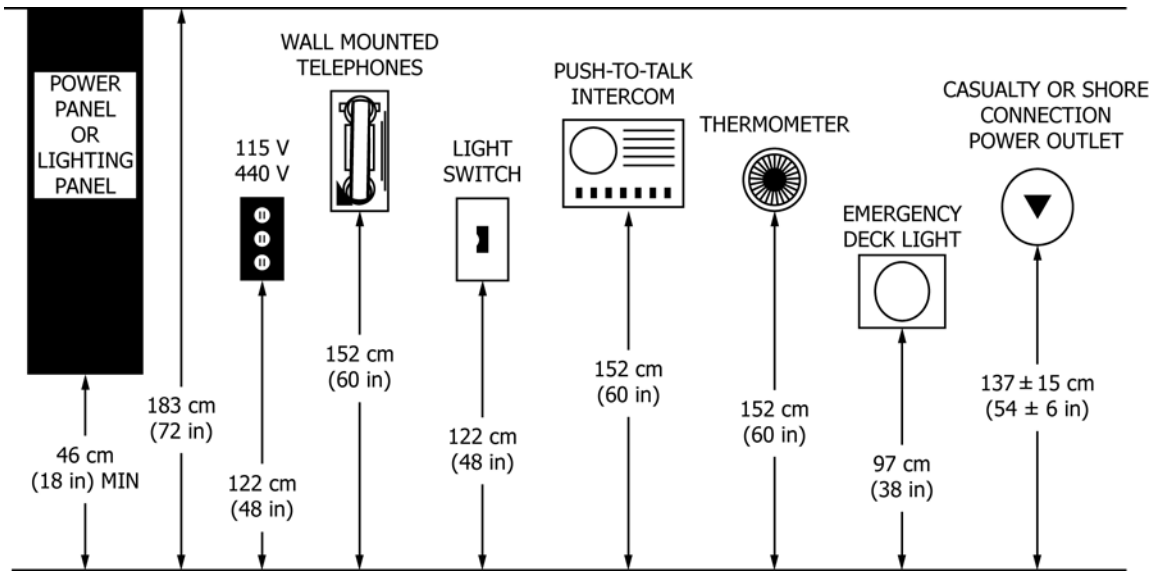


FIG. 81 Mounting Heights for Common Electrical Fixtures

11.2.1 *Angle of Inclination*—The angle of inclination shall be determined by the vertical change in height. Angles between 35 and 45° are acceptable but a stair angle of 38° is preferred. Angles over 48° should not be used. Any deviation from these design requirements shall first be approved by the procuring organization.

11.2.2 *Design Load*—Stairways shall be built to carry five times the normal anticipated live load, but less than a 544-kg (1000-lb) moving concentrated load.

11.2.3 *Stair Dimensions*—Stair tread and riser dimensions may vary depending on the angle of inclination but all other stair dimensions shall be consistent regardless of angle of inclination and shall be within the range shown in Fig. 91 and Table 23.

11.2.3.1 *Design Consistency*—For any given run of stairs, all riser heights and tread depths should be the same including the top and bottom step, however variation shall be limited to 5 mm (3⁄16 in.) between adjacent steps and 10 mm (3⁄8 in.) across the stair run. Riser heights and tread depths can change from one stair run to another but effort should be made to make all stair runs uniform in design throughout the vessel or structure.

11.2.3.2 *Coloring of Leading Edge of Tread*—The leading edge of each tread shall be colored with a strip at least 38 mm (1½ in.) in width made with a nonslip, skid-resistant material. Further, the front edge of each tread shall be also colored with the same color so that it is visually distinguishable from the rest of the tread or deck below the tread or both.

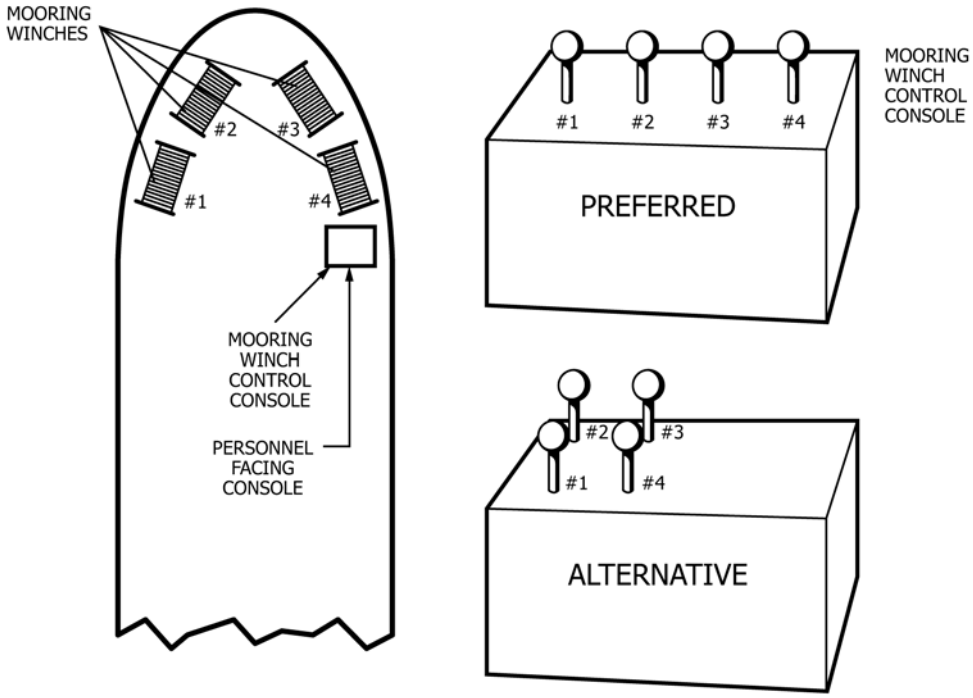


FIG. 82 Direct Spatial Relationships Between Controls and Equipment

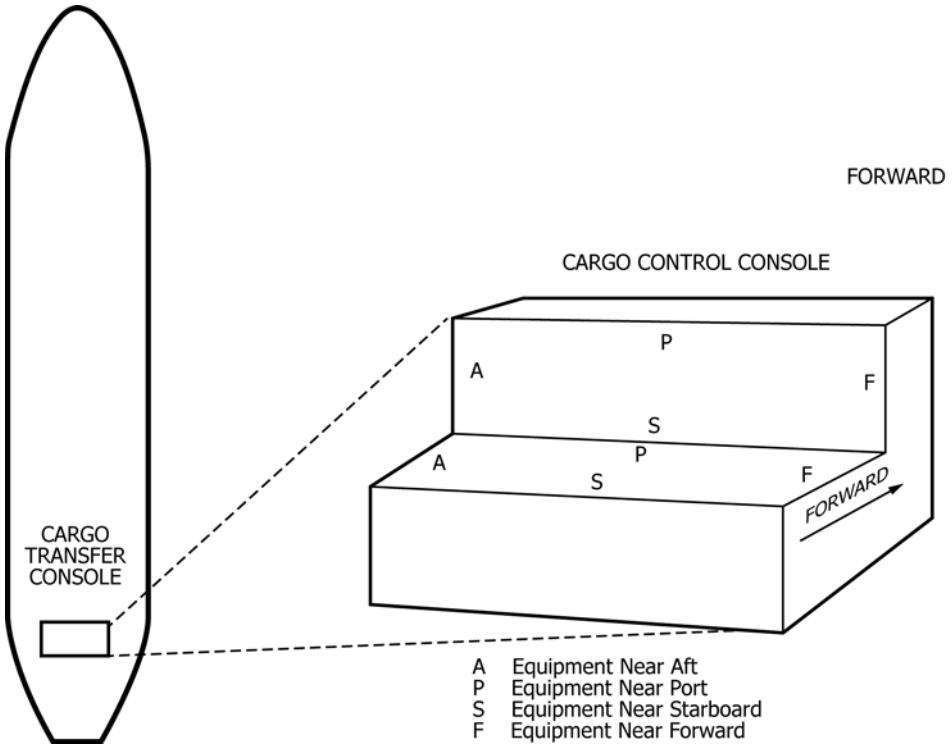
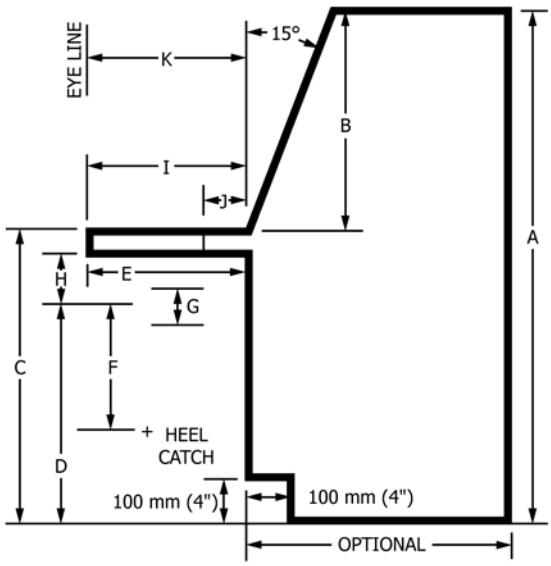


FIG. 83 Spatial Relationship of Fore and Aft Equipment to Controls and Displays on a Console Located Athwartships

11.2.4 *Tread Material*—The surface of treads on exterior stairs shall be constructed of open steel grating or shall be covered with flat plate treated with nonskid material. Treads shall be slip resistant under expected environmental conditions and use. Interior stair treads that are not slip resistant when wet shall be maintained dry during periods of pedestrian use.

11.2.5 *Top Tread*—The top tread shall be flush with the walking surface to which the stair is attached. If there is



A[1]	Minimum total console height from standing surface		
B[1]	Suggested vertical dimension of panel, including sills		
C[1]	Writing surface: shelf height from standing surface		
D[1]	Seat height from standing surface at midpoint of "G"		
E[2]	Minimum knee clearance	460 mm	(18")
F[2,3]	Foot support to sitting surface	460 mm	(18")
G[2]	Seat adjustability	150 mm	(6")
H[2]	Minimum thigh clearance at midpoint of "G"	190 mm	(7.5")
I	Writing surface depth including shelf	400 mm	(16")
J	Minimum shelf depth	100 mm	(4")
K	Eye line-to-console front distance	400 mm	(16")

[1] For A through D, see below.
[2] Not applicable to console Types 4 and 5 of table below.
[3] Since this dimension must not be exceeded, a heel catch must be added to the chair if "D" exceeds 400 mm (18").
NOTE: A shelf thickness of 25 mm (1") is assumed. For other shelf thicknesses, suitable adjustments should be made.

Type of Console	Maximum Total Console Height from Standing Surface A		Suggested Vertical Dimension of Panel (Including Sills) B		Writing Surface: Shelf Height from Standing Surface C		Seat Height from Standing Surface at Midpoint of G D		Maximum Console Width (not shown)	
	m	(in)	mm	(in)	mm	(in)	mm	(in)	mm	(in)
1. Sit (with vision over top†)	1.170	(46.0)	520	(20.5)	650	(25.5)	435	(17.0)	1120	(44.0)
	1.335	(52.5)	520	(20.5)	810	(32.0)	595	(23.5)	1120	(44.0)
	1.435	(56.5)	520	(20.5)	910	(36.0)	695	(27.5)	1120	(44.0)
2. Sit (without vision over top)	1.310	(51.5)	660	(26.0)	650	(25.5)	435	(17.0)	1120	(44.0)
	1.470	(58.0)	660	(26.0)	810	(32.0)	595	(23.5)	1120	(44.0)
3. Sit-stand (with standing vision over top)	1.570	(62.0)	660	(26.0)	910	(36.0)	695	(27.5)	1120	(44.0)
	1.535	(60.5)	620	(24.5)	910	(36.0)	695	(27.5)	1120	(44.0)
4. Stand (with vision over top)	1.535	(60.5)	620	(24.5)	910	(36.0)	NA	NA	1524	(60.0)
5. Stand (without vision over top)	1.830	(72.0)	910	(36.0)	910	(36.0)	NA	NA	1524	(60.0)

†The Range in "A" is provided to allow latitude in the volume of the lower part of the console; not relationship to "C" and "D."

FIG. 84 Seated Single-Operator Console Dimensions

coaming at the top of the stair the top tread shall be flush with the top of the coaming and shall extend to the coaming.

11.2.6 *Open Riser*—Risers shall be open unless screens or plate backing behind the stairs is required to protect personnel or equipment under the stairs.

11.2.7 *Stair Orientation*—Stairs running fore and aft in a ship are preferable but athwartship stairs are allowed.

11.2.8 *Stair Width*—The width of stairs shall comply with the dimensions shown in Table 24.

11.2.9 *Overhead Clearance*—An overhead clearance of 2032 mm (80 in.) minimum, 2134 mm (84 in.) preferred, shall be provided. The clearance is measured perpendicular from the top of any stair tread to any obstacle overhead of the stairs (see Fig. 91).

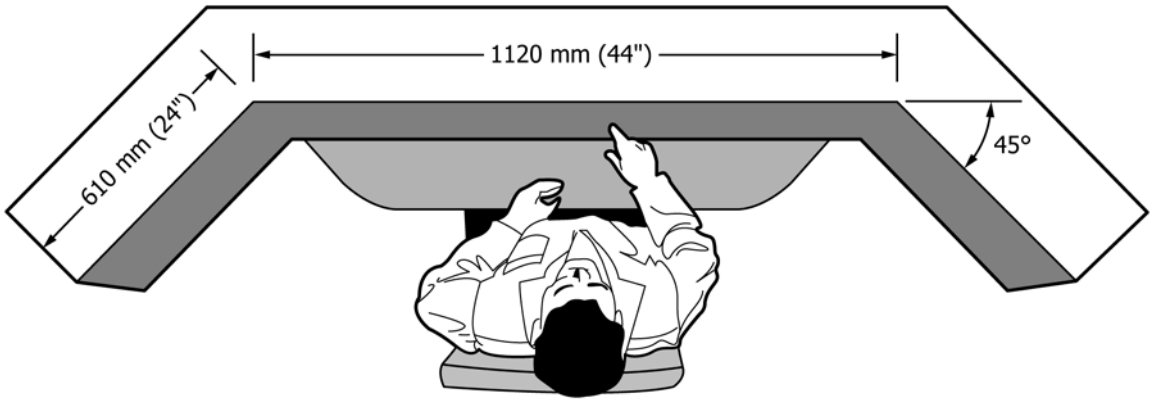
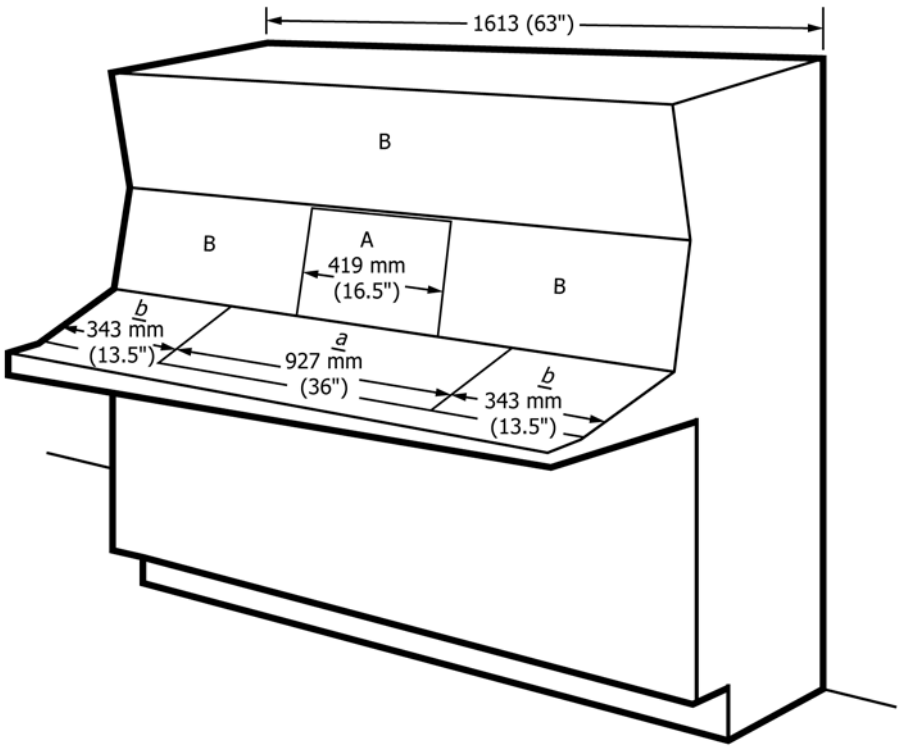


FIG. 85 Wraparound Seated Console



PRIMARY

A	Displays	Precise and frequent use and emergency use.
a	Controls	

SECONDARY

B	Displays	Normal and infrequent use.
b	Controls	

FIG. 86 Special Width Console

11.2.10 *Stair Landing:*

11.2.10.1 The bottom and top landing area of a stairway shall provide a clear space at least as long as the stair is wide, but in no case shall it be less than 914 mm (36 in.), with a preferred length of 1118 mm (44 in.).

11.2.10.2 Top and bottom landings that connect to outwardly swinging doors shall be at least 1524 mm (60 in.) long.

11.2.10.3 A landing shall be provided at each deck level serviced by the stair or at a maximum of 3.65 m (12 ft) of vertical travel for stairs with a vertical rise of 6.1 m (20 ft) or

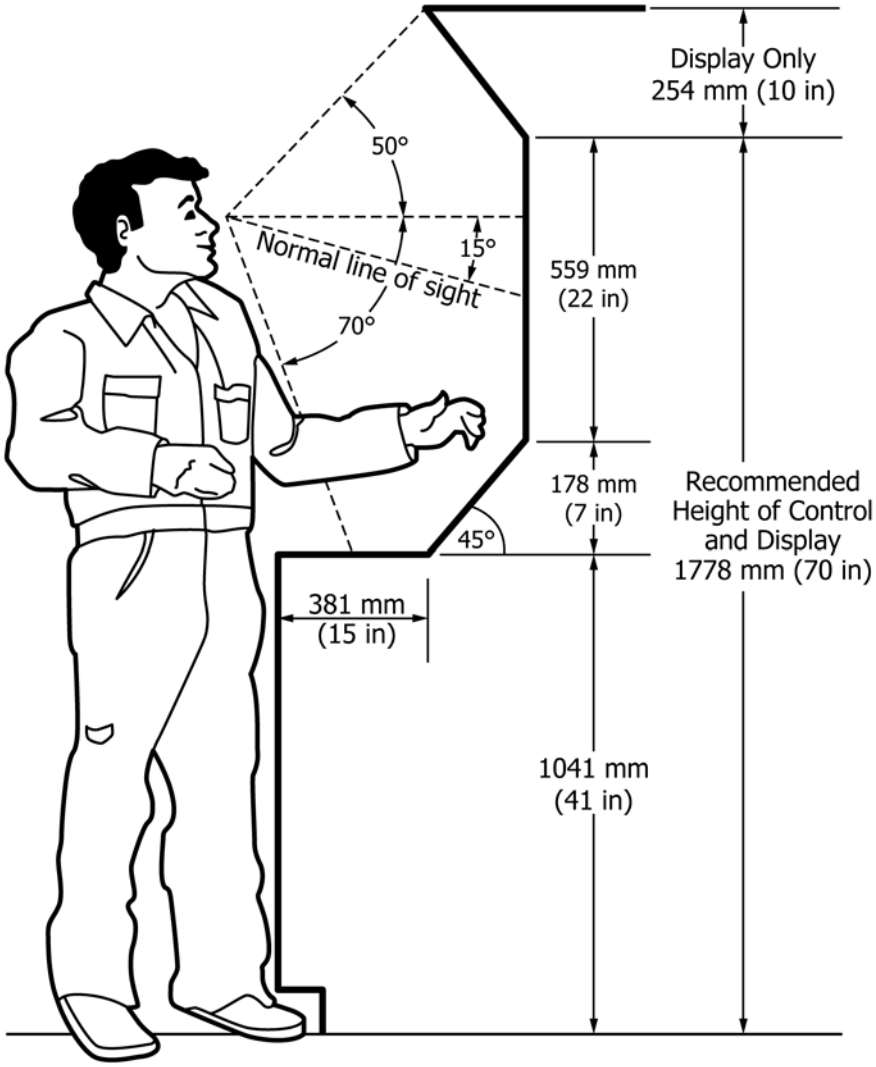


FIG. 87 Multi-tiered Standing Console

more. Note that SOLAS and the IMO International Code for Fire Safety Systems, Ch. 13, 2.2.3, limit the vertical rise between landings to 3.5 m (11.5 ft). An intermediate landing should also be provided for stairs with a vertical rise of between 4.57 m (15 ft) and 6.1 m (20 ft). The intermediate landing shall be the same size as the bottom and top landing and shall be provided with handrails as described in 11.2.11.1. Where stairs change directions, it is recommended that intermediate landings along paths for evacuating personnel stretchers be at least 1778 mm (70 in.) in length and 2900 mm (114 in.) wide to accommodate rotating the stretcher.

11.2.10.4 Landings, including those associated with stairs, located just outside a door, shall be at the same level as the floor is on the other side of the door.

11.2.11 *Stair Railings and Handrails:*

(1) Stairs with three or less steps shall be provided with a railing designed as the top rail on a handrail. Stairs with more than three steps shall be provided with handrails as detailed in Table 25, "Handrail Arrangements." Railings to assist people in going up or down the stairs shall be installed on the bulkhead side(s) of stairs. A two-tier handrail to maintain balance and prevent falls from stairs shall be installed on the open sides of stairs.

(2) Square handrails shall be avoided and used only with the permission of the procuring organization.

(3) Handrails shall have nonslip surfaces.

11.2.11.1 *Stair Handrail Dimensions:*

(1) Handrails should be constructed with a circular cross section of no less than 32 mm (1¼ in.) and no more than 51 mm (2 in.) with a preferred nominal diameter of 38 mm (1.5 in.). The height of the top handrail shall be between 914 and 991 mm (36 to 39 in.) 850 mm and 1015 mm (33.5 to 40 in.), with 940 mm (37 in.) preferred, measured perpendicular from the centerline (TOP?) of the handrail to the surface of the tread nearest the nose (see Fig. 91, "Stair Dimensions").

(2) Two-tier handrails shall be two equally spaced courses with the vertical height to the top of the top rail the same as shown above.

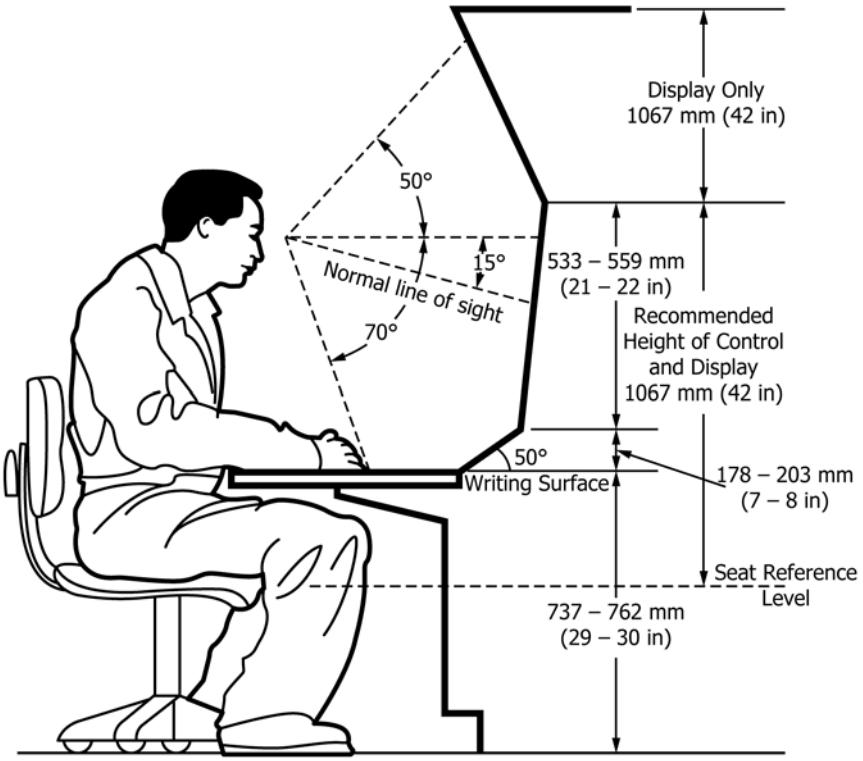


FIG. 88 Multi-tiered Seated Console

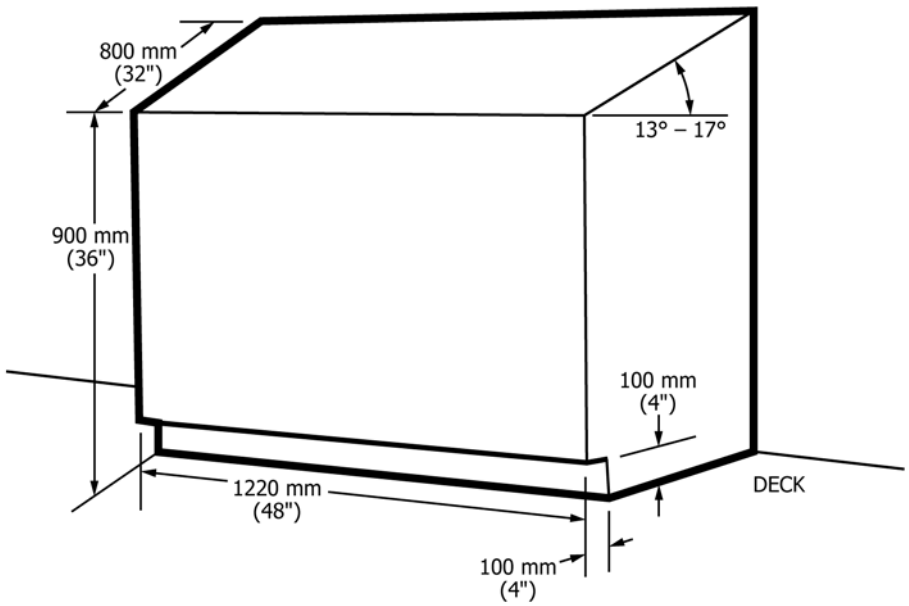


FIG. 89 Dimensions for Desktop Standing Console

(3) A minimum clearance of 75 mm (3 in.) shall be provided between the back of the handrail and the bulkhead or any other obstruction behind the rail.

11.2.11.2 *Stair Railing Dimensions*—Railings shall have the same dimensions and mounting heights above the stairs as for the top rail on handrails.

11.2.11.3 *Retractable Handrails*—For those locations where stairs are required to come up from a deck below and pass through an open horizontal hatch and eventually connect to a vertical stanchion on the deck just above the hatch, the use of chains, ropes, or wire to serve as temporary handrails should not be used. This also applies to walkways to a flight deck where permanent handrails are not allowed to protrude above deck. Instead, regular stair handrails should be designed to allow the handrails to be retracted, removed or stowed below the hatch opening or flight deck level until needed, and then easily and quickly installed to provide a rigid and sturdy solid handrail.

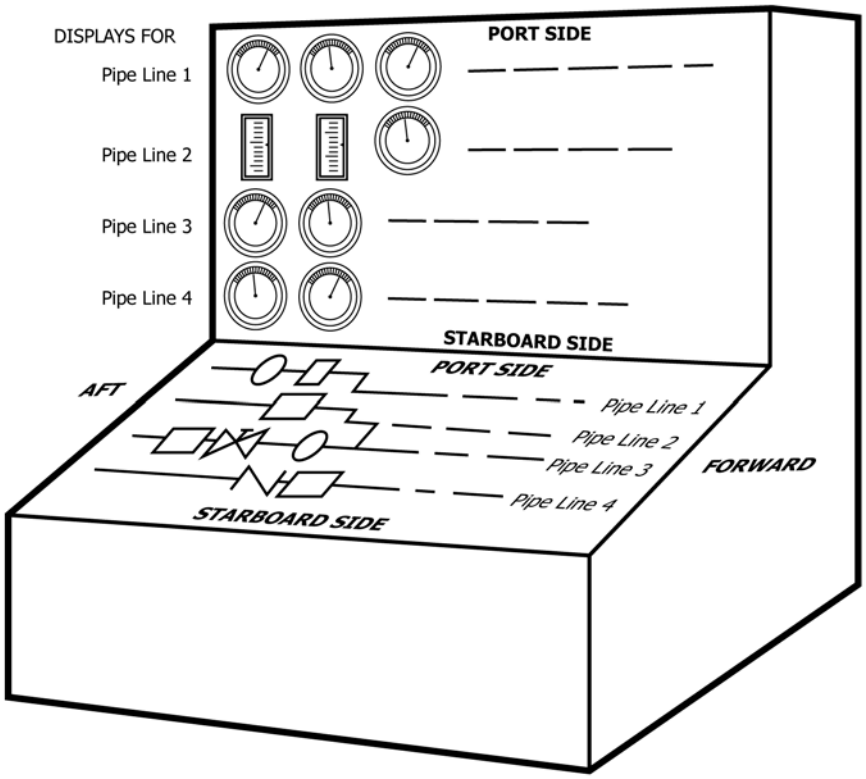


FIG. 90 Cargo and Ballast Transfer Consoles

TABLE 22 Selection of Access Type

Type	Angle of Inclination (in Degrees)	Preferred Angles of Inclination (in Degrees)
Stairs	35°–45°	38°
Inclined Stairs	50°–75°	Do Not Use
Vertical Ladders	75°–90°	90°
Ramps for Personnel	7°–15°	7°–8°
Ramps for Passengers	3°–7°	3°
Ramps for Materials Handling	4°–7°	4°

11.2.12 *Individual Stair Steps*—Individual steps comprised of tread surfaces only may be attached directly to a structure to change vertical elevations where a stair or vertical ladder is not practical. All dimensions for such steps shall comply with the stair treads described in 11.2.3, Fig. 91.

11.2.13 *Spiral Stairs:*

11.2.13.1 Spiral stairs should not be permitted, except on tanks or other round structures with a diameter greater than 2.44 m (8 ft), and where a straight run stair design is not possible.

11.2.13.2 The stairs should ascend in a clockwise direction to allow the stair handrail to be on the right-hand side during descent. The handrail shall be designed in compliance with the requirements of 11.2.11.1.

11.2.14 *Removable Stairs*—Stairs shall be pinned at the top and bottom for easy removal in locations where removal of stairs would enhance ease of equipment removal for maintenance or replacement. Stairs that are required as a means of egress in emergencies shall not be removable, but rather permanently installed.

11.3 *Ramps:*

11.3.1 *General Design Requirements*—Ramps intended for pedestrian traffic are best used with changes in vertical elevations of less than 610 mm (24 in.), but may be used for other heights provided the angles of inclination shown in Table 26 are followed.

11.3.2 *Ramp Width*—Ramps used for pedestrian traffic shall provide a minimum clear width of walking surface of at least 914 mm (36 in.) with 1219 mm (48 in.) or more preferred.

11.3.3 *Handrails and Railings:*

11.3.3.1 Handrails, in accordance with the requirements of 11.13, "Handrails," shall be provided on any open side of a ramp provided the vertical distance from the ramp to the nearest adjacent surface below the ramp is 610 mm (24 in.) or more, or when the ramp angle of inclination is greater than 5°.

11.3.3.2 The handrails shall be designed in accordance with the requirements of 11.11.2 and Fig. 109.

11.3.3.3 Railings, in accordance with the requirements for stairs of 11.2.11.1 and 11.2.11.2, shall be provided for ramps with angles greater than 5° that have enclosed sides.

11.3.4 *Landings*—Ramps shall have level landings at the top and bottom of each ramp and intermediate landings with recommended ramp shapes and dimensions for pedestrian traffic shown in Figs. 92-94.

11.3.5 *Non-skid:*

11.3.5.1 Pedestrian ramps with an angle of inclination greater than 5° shall have nonskid surfaces. Ramps inclined greater than 10° should have cleats spaced at 356 mm (14 in.) preferred, 406 mm (16 in.) maximum apart. Cleats shall extend the full width of the ramp and at right angles to the direction of travel.

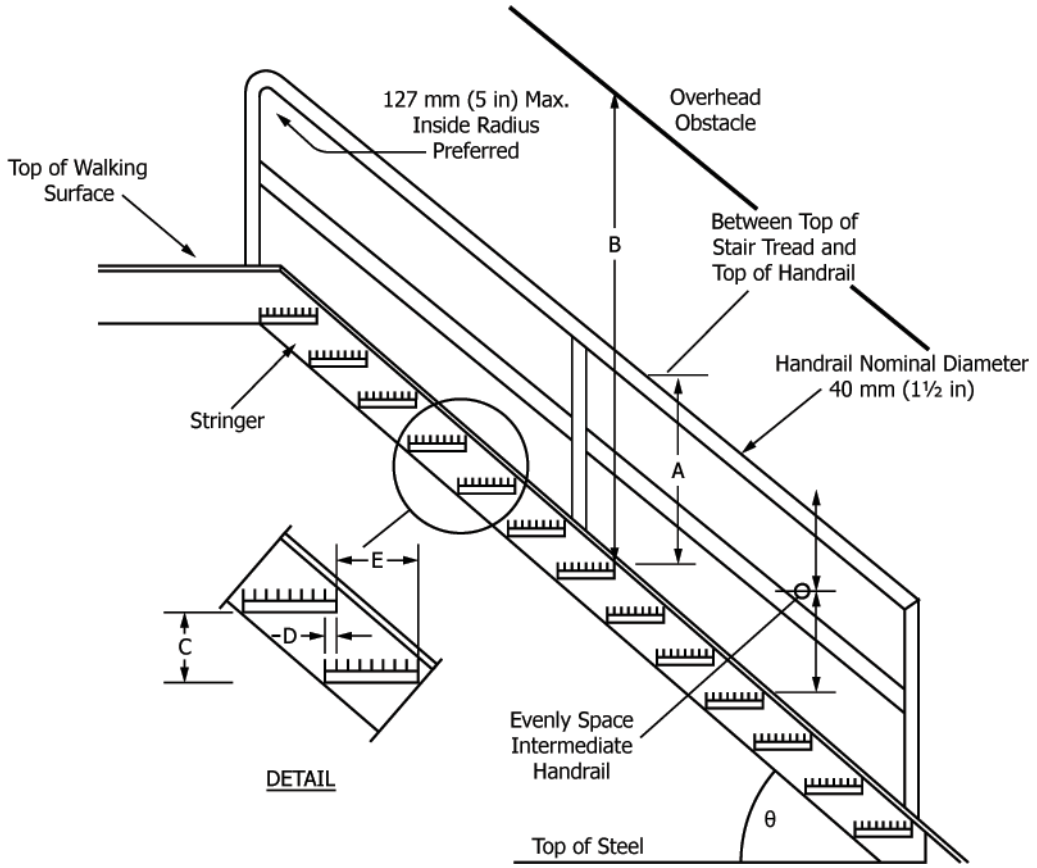


FIG. 91 Stair Dimensions

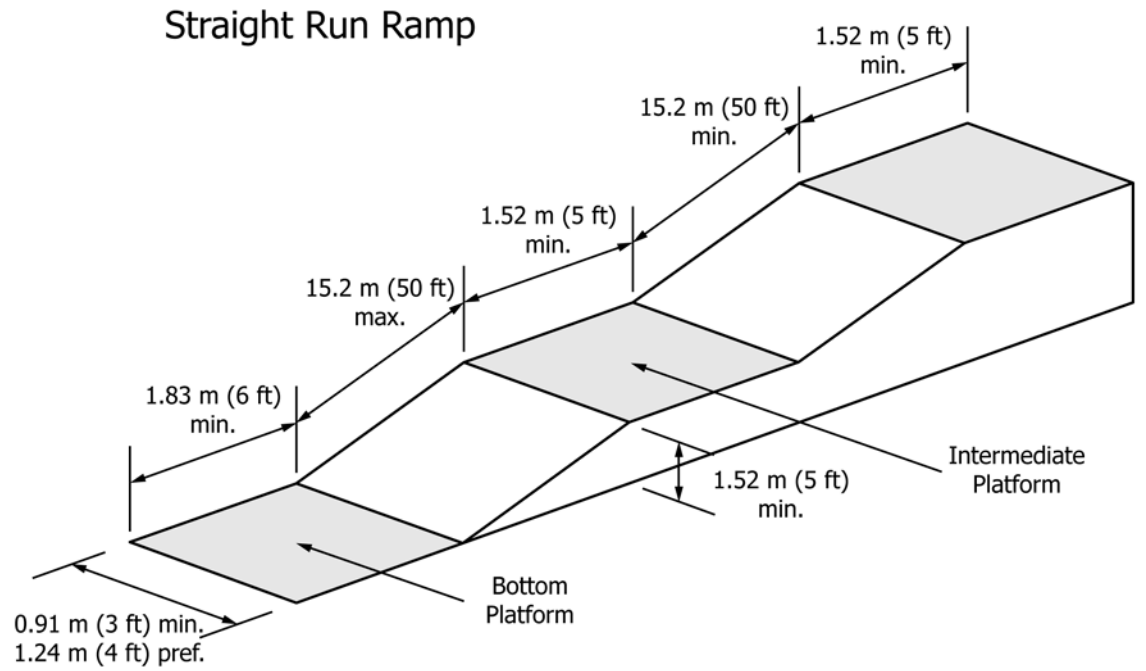


FIG. 92 Straight Run Ramp Dimensions

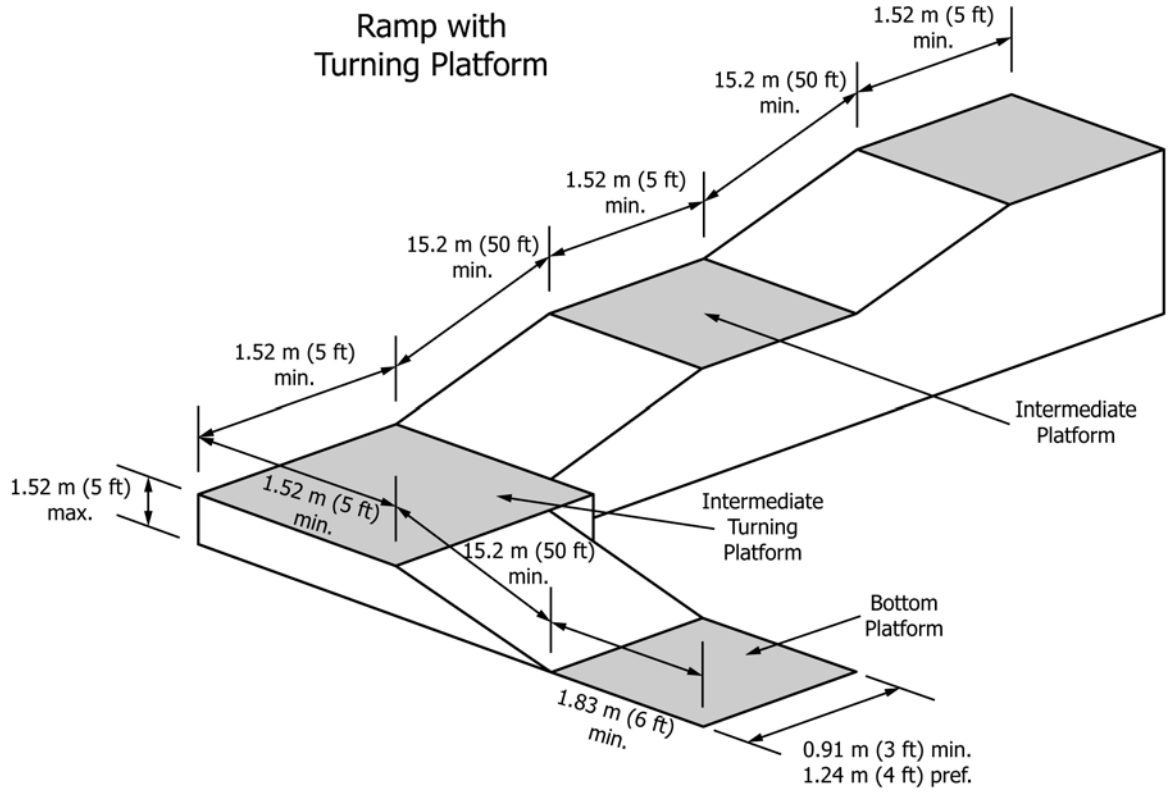


FIG. 93 Ramp with Turning Platform

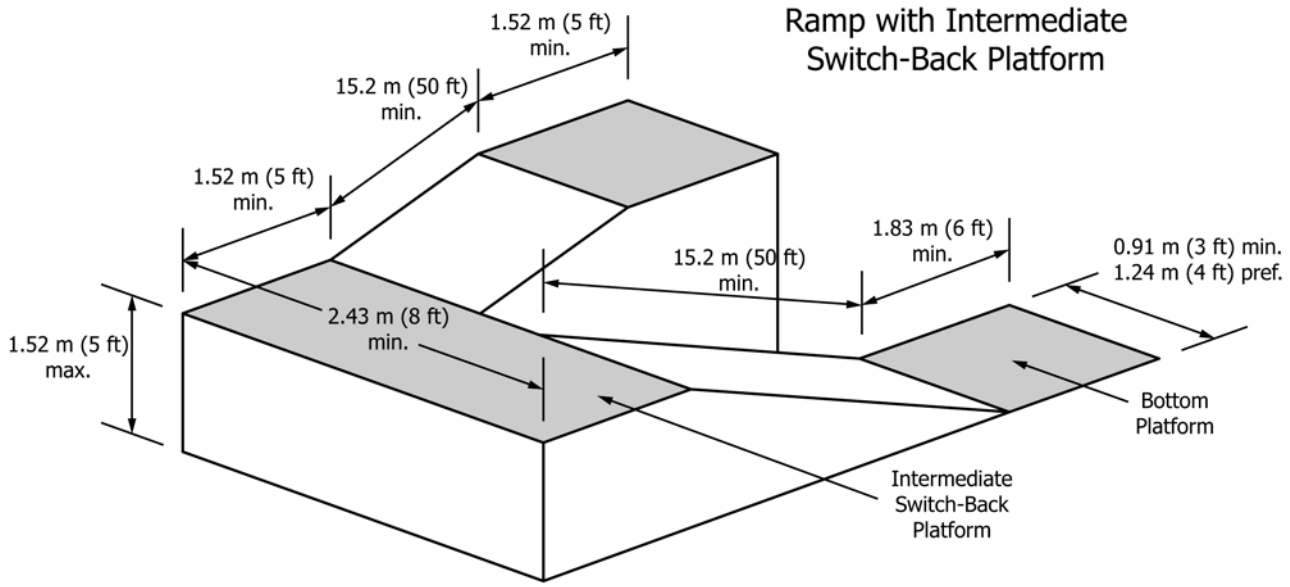
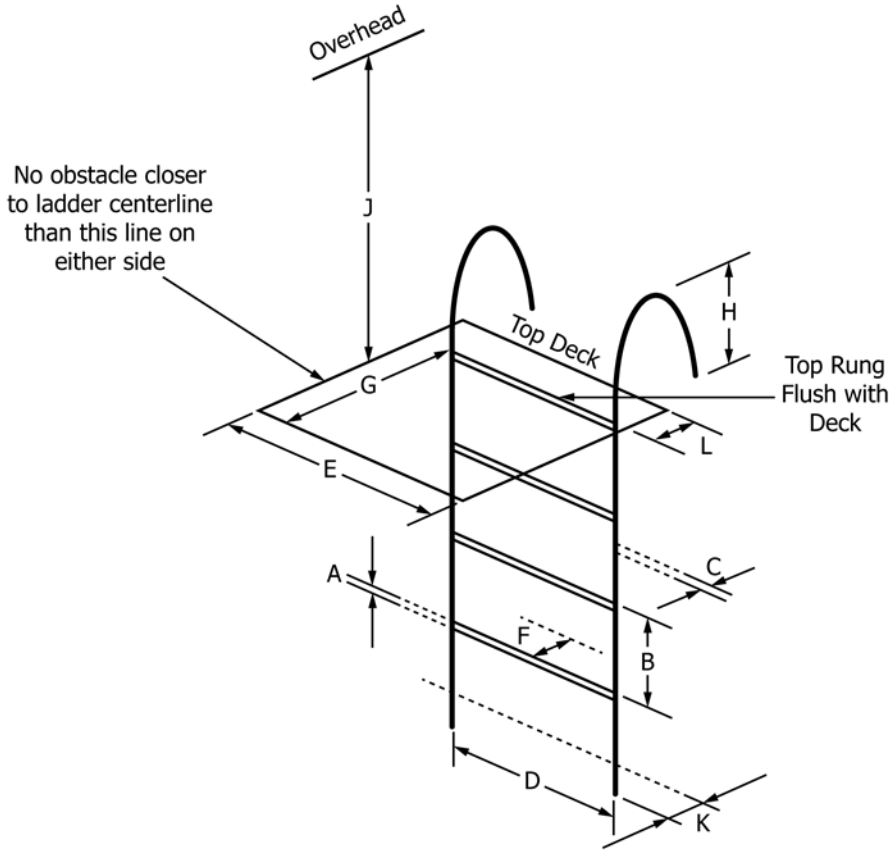


FIG. 94 Ramp with Switchback Turning Platform

11.3.5.2 Ramp walking surfaces shall be slip resistant under expected environmental conditions and use. Interior ramps that are not slip resistant when wet shall be maintained dry during periods of pedestrian use.



Dimension	Minimum mm (in)	Maximum mm (in)	Recommended mm (in)
A. Rung Thickness	25 mm **(1.0 in)**	25 mm **(1.0 in)**	25 mm **(1.0 in)**
B. Rung Spacing	279 mm **(11 in)**	305 mm **(12 in)**	
C. Stringer Diameter	40 mm **(1.5 in)**	51 mm **(2 in)**	40 mm **(1.5 in)**
D. Rung Length	406 mm **(16 in)**		457 mm **(18 in)**
E. Climbing Clearance Width	762 mm **(30 in)**		
F. Clearance Depth in Back of Ladder	178 mm **(7 in)**		203 mm **(8 in)**
G. Clearance Depth on Climbing Side	762 mm **(30 in)**		
H. Height of Stringer Above Landing	1067 mm **(42 in)**		
J. Overhead Clearance	2032 mm **(80 in)**		2134 mm **(84 in)**
K. Clearance Behind Stringer	102 mm **(4 in)**		
L. Step Across Width	64 mm **(2.5 in)**	203 mm **(8 in)**	

FIG. 95 Vertical Ladder Dimensions

TABLE 23 Stair Dimensions

Description	Minimum	Maximum	Preferred
Angle of Inclination	30°	50°	38°
Handrail Height (A)	914 mm (36 in.)	991 mm (39 in.)	940 mm (37 in.)
Overhead Clearance (B)	2032 mm (80 in.)		2134 mm (84 in.)
Riser Height (C)	178 mm (7 in.)	230 mm (9 in.)	203 mm (8 in.)
Nosing (D)	25 mm (1 in.)	25 mm (1 in.)	25 mm (1 in.)
Effective Tread Depth (E)	203 mm (8 in.)	254 mm (10 in.)	254 mm (10 in.)

TABLE 24 Stair Widths

Description	Minimum	Preferred
One-way stairs in seldom used space or for maintenance access	559 mm (22 in.)	610 mm (24 in.)
One-way stairs for carrying tools, spare parts, bulky loads	710 mm (28 in.)	864 mm (34 in.)
Secondary one-way stair or two persons passing facing each other	965 (38 in.)	1067 mm (42 in.)
Primary two-way stair—two persons passing side-by-side, stretcher access, path of major egress, primary escape path	1219 mm (48 in.)	1370 mm (54 in.)

TABLE 25 Handrail Arrangements

Application	Handrail
1118 mm (44 in.) or wider with bulkhead on both sides	Single tier railing on both sides
Less than 1118 mm (44 in.) wide with bulkhead on both sides.	Single tier railing on one side—preferably on the right side descending as a minimum.
1118 mm (44 in.) or wider, one side exposed, one with bulkhead	Two tier handrail on exposed side, single tier railing on bulkhead side
Less than 1118 mm (44 in.), one side exposed, one with bulkhead.	Two tier handrail on exposed side, single tier railing on bulkhead side
All widths, both exposed	Two tier handrails on both sides
Stairs wider than 2235 mm (88 in.)	One single-tier center railing as well as outside rails—the type depending on whether the outsides are exposed or enclosed

TABLE 26 Recommended Ramp Angle Inclinations

Ramp Use	Recommended Incline in Degrees
Vehicle Traffic Only	20° (Maximum)
Pedestrian Traffic Without Materials Handling	8° (Preferred)–15° (Maximum)
Pedestrian Traffic With Materials Handling	4° (Preferred)–7° (Maximum)

11.3.6 *Mixed Traffic*—When a ramp is required for both pedestrian and vehicle traffic, the vehicle-bearing surface shall be located in the center of the ramp, with the pedestrian surface next to the handrails. (A vehicle ramp with an adjacent pedestrian stairway is preferred for this situation.)

11.4 *Vertical Ladders:*

11.4.1 *General Design Requirements*—General design requirements for vertical ladders shall include:

11.4.1.1 Vertical ladders shall be attached to a permanent structure and shall not be attached to removable or movable objects.

11.4.1.2 A barrier shall be placed on the backside of ladders so that they may not be inadvertently climbed on the wrong side.

11.4.1.3 The maximum distance from the ladder's centerline to any object that must be reached by personnel from the ladder shall not exceed 965 mm (38 in.).

11.4.1.4 If a work task requires the use of two hands, a vertical ladder is not appropriate and the work site should be provided with a work platform that provides a flat and stable standing surface.

11.4.1.5 The angle of inclination for a vertical ladder shall be between 75 and 90° from the horizontal with 90° preferred.

11.4.1.6 Vertical ladders shall not be used as the primary mode of emergency egress but may be used for secondary access and emergency egress, maintenance access to platforms or other accesses that are used infrequently.

11.4.1.7 Vertical ladders used to access tank openings, pressure vessel manways, or any other opening equipped with a cover, or to provide access to a site that requires the worker to use two hands, shall be equipped with a work platform, or allow the worker to secure himself to the ladder or other tie-off point, so the worker can use both hands to complete the tasks.

11.4.1.8 Vertical ladders shall be oriented so that a person faces the structure, equipment or building while climbing the ladder.

11.4.2 *Rungs:*

11.4.2.1 Ladder rungs shall be circular pipes with a nominal diameter of 25 mm (1 in.) or square tubing with a flat stepping surface of 25 mm (1 in.) in width. Rungs shall be corrugated, knurled, dimpled, coated with skid-resistance material, or otherwise treated to minimize slipping.

11.4.2.2 Vertical spacing between the centerline of rungs shall be between 279 mm (11 in.) and 305 mm (12 in.), depending on what is required to provide equal spacing between rungs over the full length of the ladder run from the bottom landing to the top rung.

11.4.2.3 Where multiple runs of ladders are provided to cover the vertical distance, the same rung spacing shall be used in each run.

11.4.2.4 Rungs shall be a minimum of 406 mm (16 in.) in width, with 457 mm (18 in.) preferred. (See Fig. 95.)

11.4.2.5 Rung spacing may be adjusted from any one vertical ladder to another to get equal rung spacing for a particular ladder run, but effort shall be made to maintain consistent rung spacing throughout the ship or maritime facility.

11.4.3 *Top Rung*—The top rung on a vertical ladder used to access a deck, work platform, building roof, or top of a tank by stepping through the ladder to a walking or standing surface, or any rung on the ladder used to side step to an intermediate platform, shall be located to be flush with the top walking surface or side-step platform. (See Fig. 95.)

11.4.4 *Stringers:*

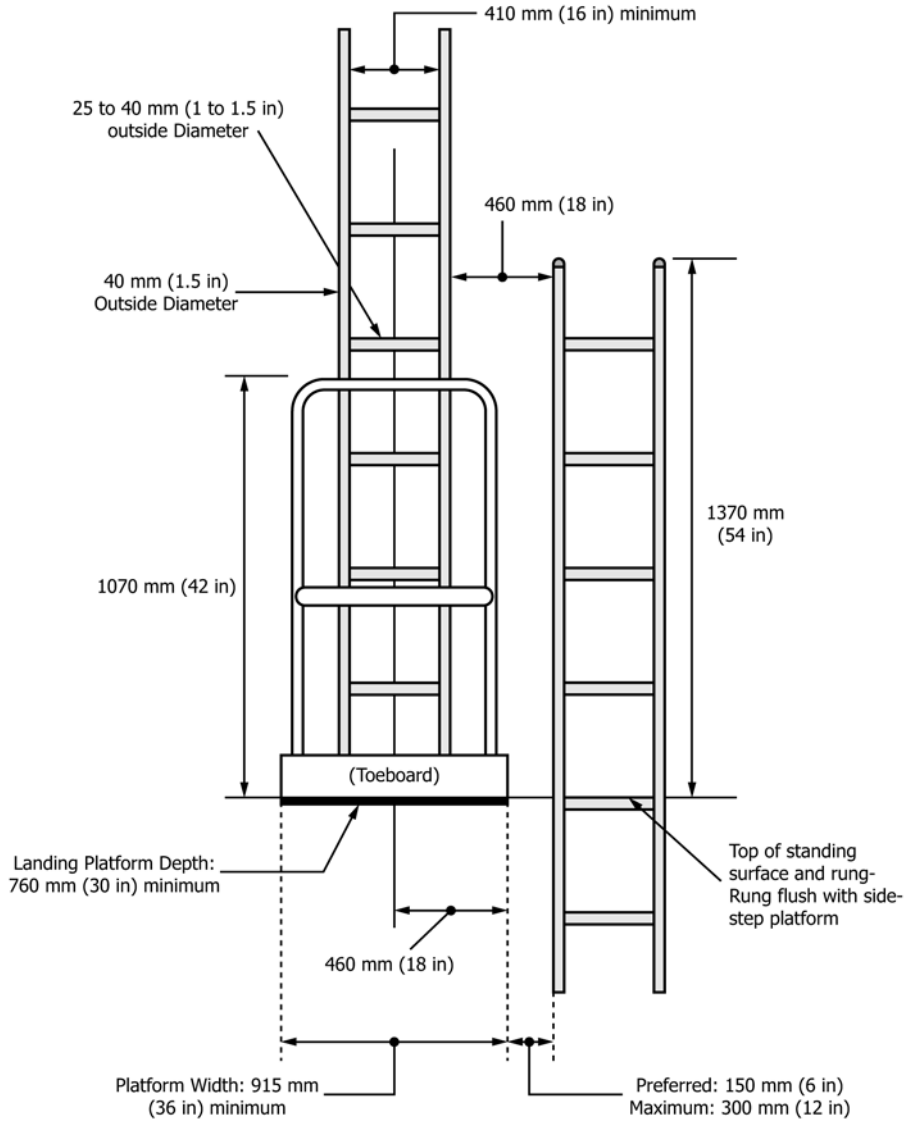


FIG. 96 Dimensions for a Vertical Ladder Arrangement

11.4.4.1 Ladder stringers shall be provided on both sides of the ladder over the full length and should be constructed of pipes with a preferable diameter of 40 mm (1.5 in.).

11.4.4.2 Ladder stringers shall be a minimum of 406 mm (16 in.) apart, with 457 mm (18 in.) preferred, apart, measured from the inside of the stringers.

11.4.4.3 Flat bar should not be used for stringers.

11.4.4.4 For multiple runs of vertical ladders, the stringers should extend 1372 mm (54 in.) above landings or intermediate platforms. (See Fig. 95.)

11.4.5 *Height*—Continuous ladders shall not exceed 9.14 m (30 ft) in height. Where the vertical height exceeds 9.14 m (30 ft), intermediate landings and separate multiple ladder runs of equal length shall be provided.

11.4.6 *Self-Closing Gate:*

11.4.6.1 At each vertical ladder that requires a step-through mount/dismount, a self-closing gate that covers the full width of the opening between the ladder stringers shall be installed at the top of the ladder. The gate shall be installed at a height of 965 mm (38 in.) to 1041 mm (41 in.) (measured to the top of the gate) above the landing or walking surface. The gate shall open away from the person climbing the ladder.

11.4.6.2 Chains or wire rope should not be used in lieu of a self-closing gate.

11.4.6.3 Safety gates shall be able to resist the weight of a 91 kg (200 lb) person in both the vertical and horizontal direction.

11.4.6.4 Where ladders provide access to small platforms that do not provide sufficient space for the self-closing gate to swing horizontally, manually operated gates that open and close by means of a vertical swing may be used.

11.4.7 *Intermediate Platforms*—Platforms used to access a vertical ladder shall provide a minimum clear standing area of 762 mm (30 in.) in front of the ladder with at least 457 mm (18 in.) of width on each side of the ladder centerline. (See Fig. 96, "Dimensions for a Vertical Ladder Arrangement.")

11.4.7.1 *Intermediate Platforms—Toeboards*—Intermediate platforms shall be provided with handrails and toeboards on all

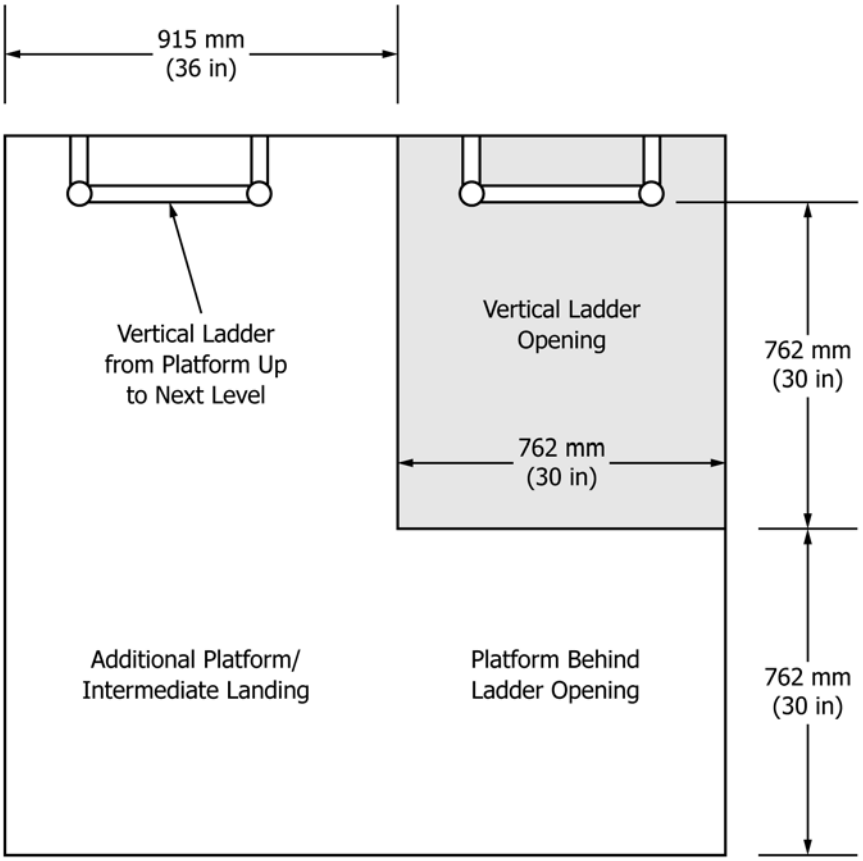


FIG. 97 Platform/landing Dimensions for Vertical Ladder Penetration

sides not used to access the vertical ladder, as shown in Fig. 96, "Dimensions for a Vertical Ladder Arrangement."

11.4.7.2 *Separation Between Ladder and Platform*—The distance from the edge of the ladder stringer to the side step platform being accessed shall be no more than 305 mm (12 in.) with a preferred distance of 152 mm (6 in.). There shall be a rung on the vertical ladder at the same height as the standing surface of the intermediate platform. (See Fig. 96, "Dimensions for a Vertical Ladder Arrangement.").

11.4.7.3 *Separation Between Two Ladders*—The horizontal separation between two vertical ladders using an intermediate platform shall not be greater than 457 mm (18 in.), measured from stringer to stringer. (See Fig. 96, "Dimensions for a Vertical Ladder Arrangement.")

11.4.7.4 *Ladder Penetrating Platform or Landing:*

(1) Where a ladder penetrates through an intermediate platform or landing the dimensions of the opening and platform or landing shall be as shown in Fig. 97, "Platform/landing Dimensions for Vertical Ladder Penetration."

(2) If the intermediate platform is used as the base for another vertical ladder to go up from the intermediate platform, an additional platform with a width of at least 915 mm (36 in.) and depth of 1524 mm (60 in.) shall be added to the side of the platform provided for the ladder coming up to the platform. (See "Additional Platform/intermediate Landing" in Fig. 97.)

11.5 *Vertical Ladders with Safety Cages:*

11.5.1 *General Requirements:*

11.5.1.1 Safety cages shall be installed on vertical ladders where the vertical height exceeds 4.57 m (15 ft). The cage shall begin 2.13 m (7 ft) above the standing surface and extend 1067 mm (42 in.) above the upper deck. (See Fig. 98, "Caged Ladder Dimensions.")

11.5.1.2 Cages used on vertical ladders equipped with intermediate landings shall extend 1372 mm (54 in.) above the intermediate landing with the cage open on the side facing the landing.

11.5.2 *Cage Design*—Cage shape and size shall be as shown in Fig. 99, "Cage Shape and Size" for the top, middle, and bottom portions of the cage.

11.6 *Vertical Ladders with Positive Fall Protection Devices:*

11.6.1 *General Requirements*—All vertical ladders in excess of 6.1 m (20 ft) in height, or where a climber could fall overboard, onto equipment or other decks, shall be equipped with positive fall protection. Safety rails or cables secured to personnel wearing a safety harness are examples of positive fall protection devices. Cages alone are not positive fall protection devices.

11.6.2 *Dimensions*—Vertical ladders equipped with positive fall protection devices shall be shaped and sized in accordance with the dimensions shown in Fig. 100, "Ladder and Climber Safety Device Dimensions."

11.6.3 *Device Types*—Of the three types of climber safety devices (flat bar, notched rail, and cable), the 6-mm (¼-in.) by 50-mm (2-in.) flat bar is preferred although the others are

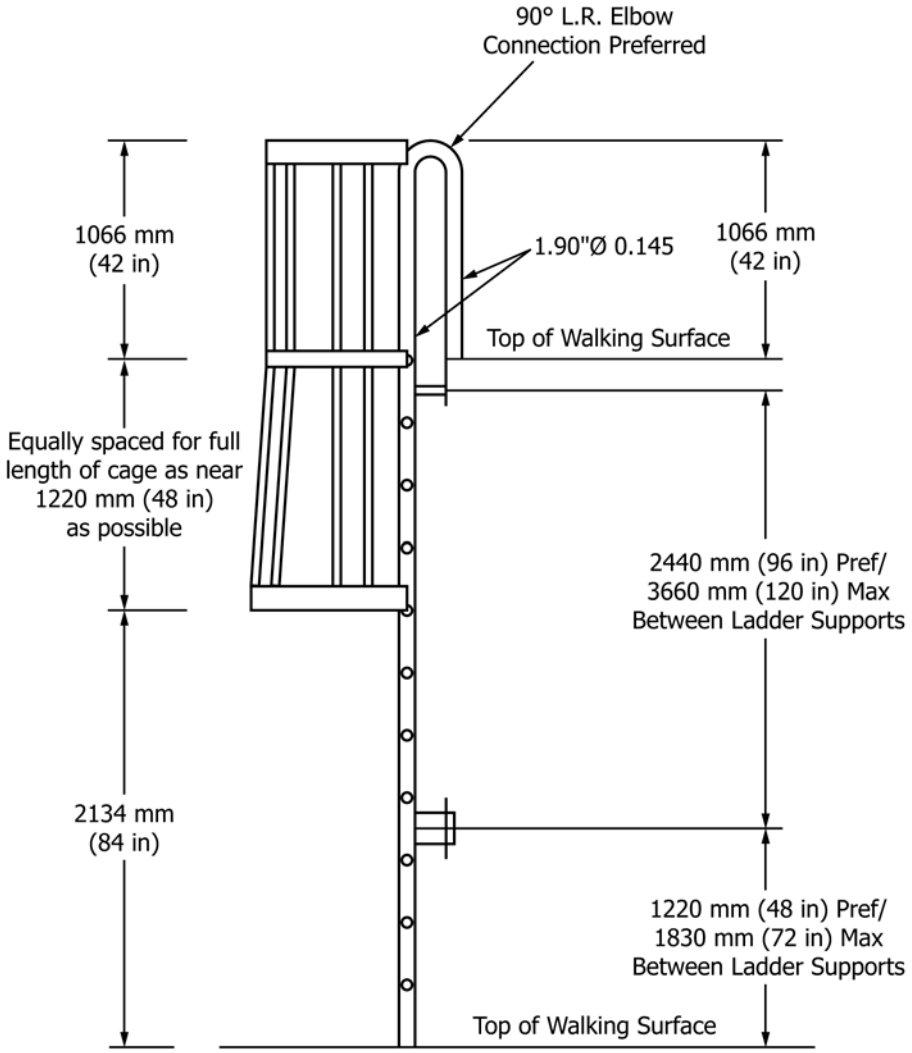


FIG. 98 Caged Ladder Dimensions

acceptable. Two safety slides, which fit over the bar and hook to the climber's safety harness, shall be provided for each climber safety device. Stowage for the harness(es) and safety slides should be provided adjacent to the vertical ladder.

11.7 *Special Ladder Requirements:*

11.7.1 *Design Requirements*—Avoid placing ladders within 1829 mm (72 in.) from the edge of a deck, as measured from the ladder centerline laterally in either direction or from the ladder centerline away from the front of the ladder. A fall protection device must be provided for any vertical ladder that is (*a*) located within 1829 mm (72 in.) of the edge of a deck level; (*b*) higher than 610 mm (24 in.) above an adjacent surface level; and (*c*) has a potential fall height from the ladder to a lower deck level of greater than 6.1 m (20 ft), or overboard from any height. The fall protection may be in the form of a climber safety rail or special treatment of railing or cages as shown in Figs. 101 and 102, "Extended Railing for Ladder Fall Protection," front and side views and Figs. 103 and 104, "Extended Railing and Cage for Ladder Fall Protection," front and side views.

11.8 *Handle/Hand Grab:*

11.8.1 *General Requirements*—Handles or hand grabs shall be installed at locations where vertical ladder stringers cannot be provided (for example, where a ladder opens through a hatch or deck opening or where a worker transitions from a ladder to an intermediate platform. (See Fig. 105, "Handles or Hand Grabs for Use as Ladder Extensions" and Fig. 106, "Handle for Transition from a Ladder to an Intermediate Platform.") Handles and hand grabs shall be a minimum of 16 mm (0.625 in.) in diameter and a maximum of 25 mm (1.0 in.). A clearance of at least 100 mm (4.0 in.) shall be provided between the back of the handle and the surface to which it is attached.

11.9 *Individual Rung Ladders:*

11.9.1 *General Requirements*—Individual rungs may be attached directly to a bulkhead, tank, or steel structure and used as a vertical ladder provided that the change in vertical height is 3.66 m (12 ft) or less and that all applicable dimensional requirements can be achieved for vertical ladder rungs as described in 11.4.2. Circular rungs are preferred. Each rung

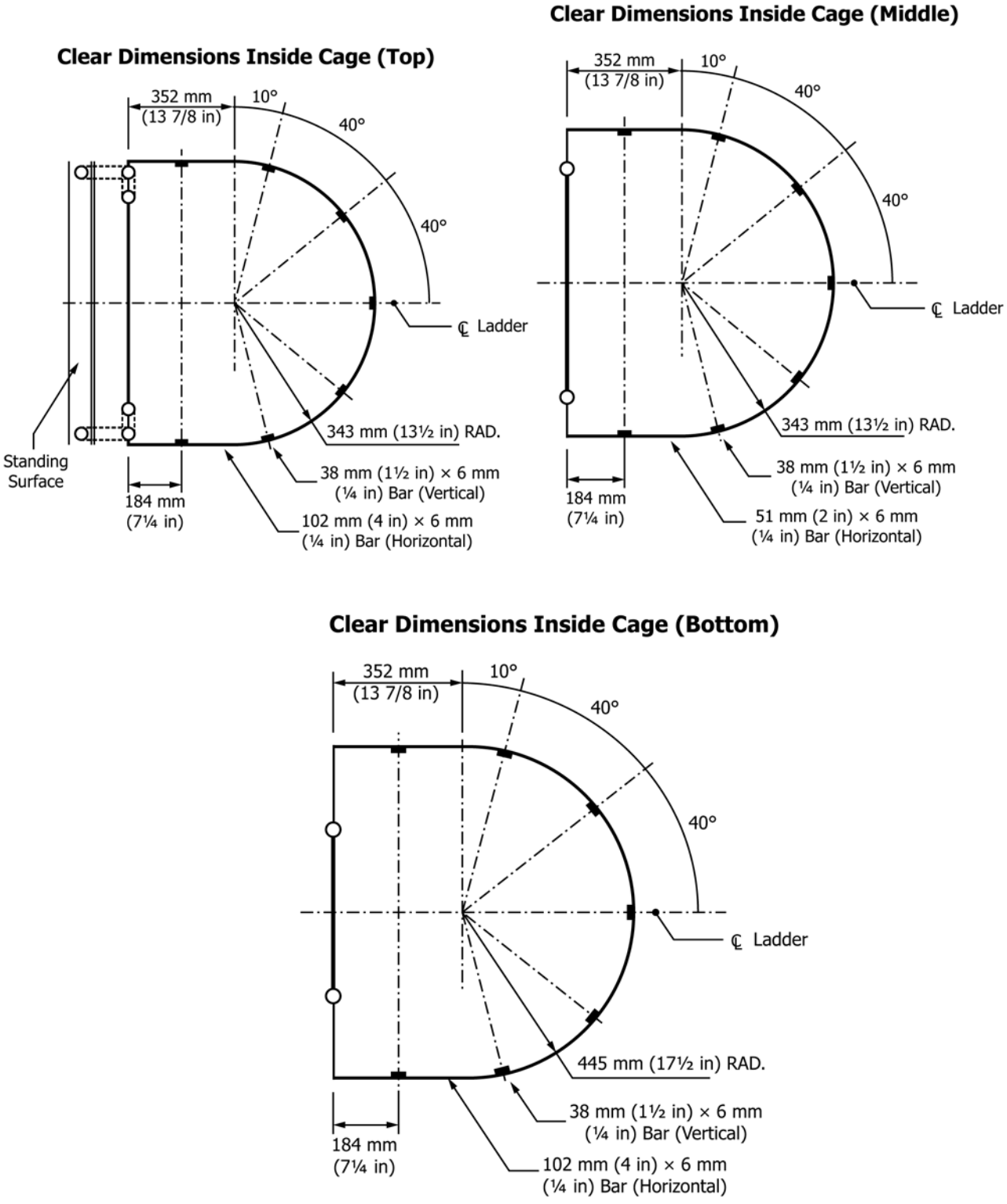


FIG. 99 Cage Shape and Size

should be attached to the structure in a manner that fully supports a climber and any design loads (see Fig. 107). Rungs shall be a minimum of at least 25 mm (1.0 in.) in diameter.

11.10 *D-ring Ladders:*

11.10.1 *Dimensions*—D-ring ladders may be installed in spaces where it is not feasible to place a regular bulkhead mounted ladder or stair but they shall be avoided for any other use and used only with the approval of the procuring organization. When used they shall comply with the dimensions shown in Fig. 108.

11.11 *Handrails:*

11.11.1 *General Requirement:*

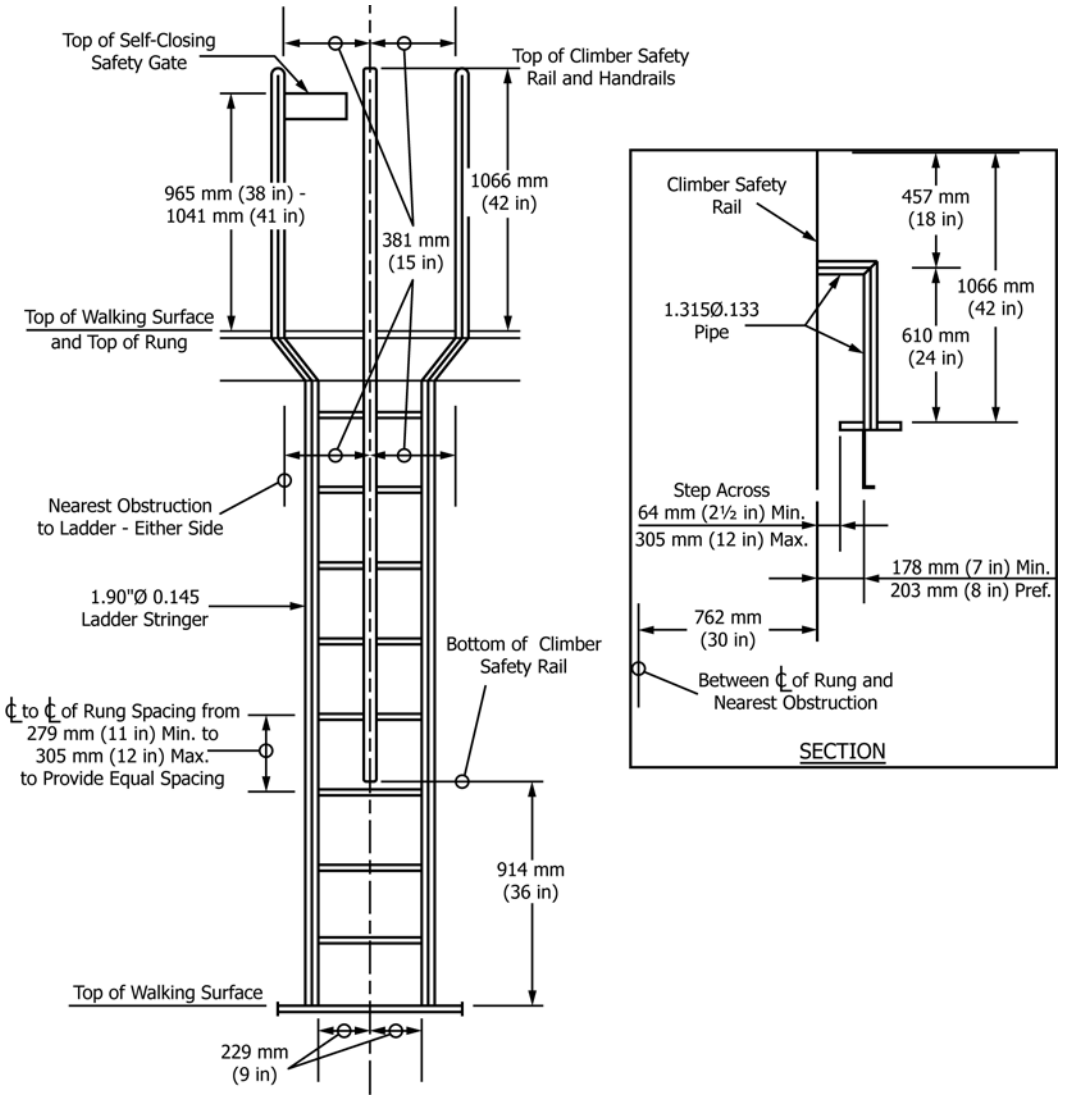


FIG. 100 Ladder and Climber Safety Device Dimensions

11.11.1.1 Handrails shall be provided at the open side of any standing or walking surface when that surface is 610 mm (24 in.) higher than the adjacent surface. Open sides are those with 76 mm (3 in.) or more gap between the surface edge and the nearest solid structure, equipment or wall.

11.11.1.2 Floor or deck openings 305 mm (12 in.) or greater that are left open or unattended shall have handrails installed around the openings as long as the opening exists.

11.11.1.3 Openings in vertical walls or bulkheads greater than 762 mm (30 in.) high by 457 mm (18 in.) wide shall have a handrail or equivalent barrier if a fall through the opening to a level of 610 mm (24 in.) or more is possible.

11.11.1.4 Regardless of height, open-sided decks, walkways, platforms, or ramps above or adjacent to dangerous equipment, valves, piping, or other hazards shall be guarded with a standard handrail.

11.11.1.5 Handrails shall withstand a side loading of at least 200 lb applied at any point and in any direction against the top rail.

11.11.1.6 Handrails should be made of 38-mm (1½-in.) NPS Schedule 40 steel pipe.

11.11.1.7 Square handrails should not be used.

11.11.2 *Fixed Handrail Dimensions*—Handrails shall be 1067 mm (42 in.) high measured from the walking surface to the centerline of the top rail. One intermediate rail shall be located 457 mm (18 in.) below the top rail as measured from centerline of the top rail to centerline of the intermediate rail. A 102-mm (4-in.) toeboard located 6 mm (¼ in.) above the walking surface shall also be included (see Fig. 109).

11.11.3 *Outside Clearance*—The distance between the centerline of the handrail and the outside edge of the walkway, platform or deck shall not exceed 64 mm (2.5 in.).

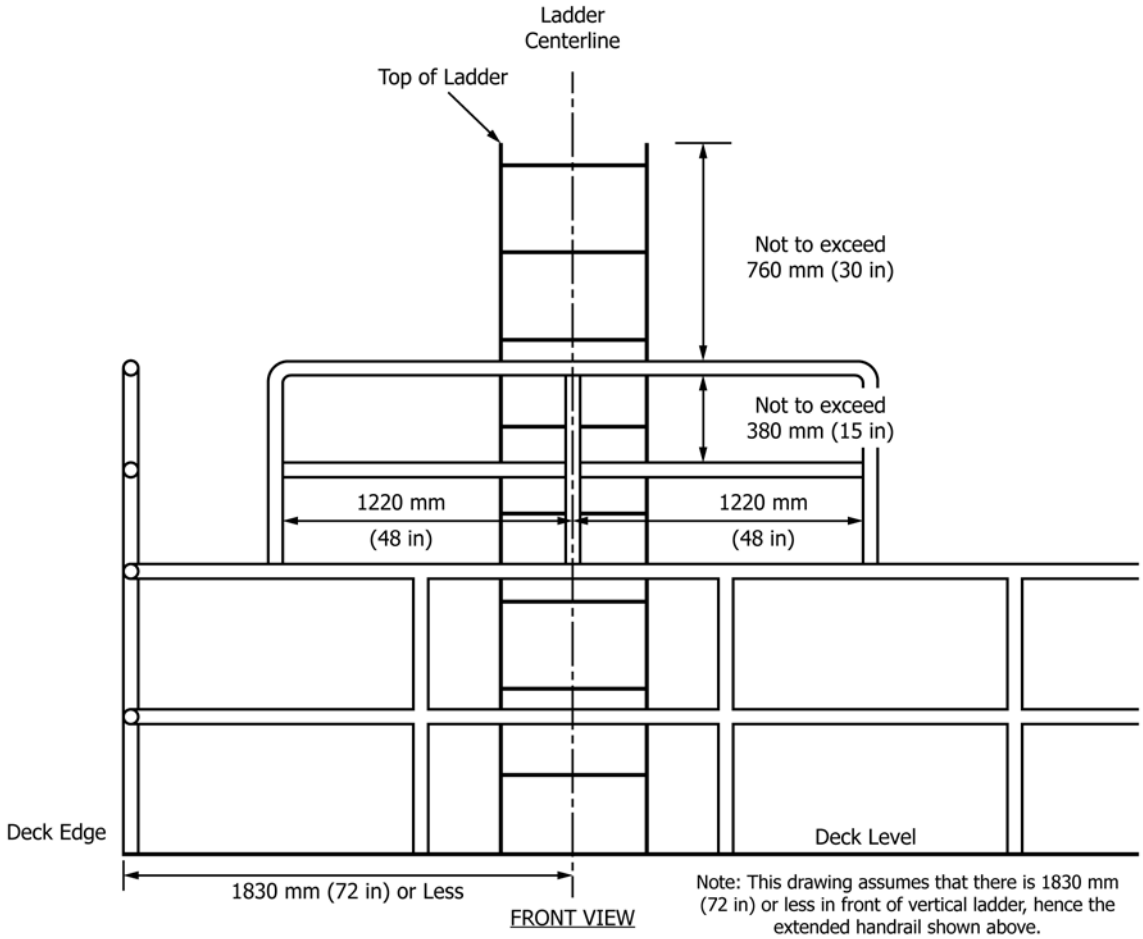


FIG. 101 Extended Railing for Ladder Fall Protection (Front View)

11.11.4 *Removable Handrails*—Handrails that can be temporarily removed for operational or maintenance purposes shall have dimensions as shown in Fig. 110, "Handrail Dimensions for Removable Handrails."

11.11.5 *Inside Clearance*—Handrails shall be installed so the inside of the handrails shall be even with the outside edge of the platform, walkway, or deck grating.

11.11.6 *Special Handrail Design Dimensions:*

11.11.6.1 Handrails installed at special locations for special circumstances that require extra personnel protection between the intermediate rail and the toeboard shall be constructed as shown in Fig. 111, "Special Handrail Design Dimensions." These handrails should be installed at locations where a person could be washed overboard or slide on ice and fall overboard.

11.11.6.2 The top of the handrail shall be 1067 mm (42 in.) high measured from the walking surface to the top of the top rail.

11.11.6.3 The first intermediate rail shall be 394 mm (15.5 in.) below the top rail as measured from the top of the first rail to the top of the intermediate rail.

11.11.6.4 The second intermediate rail shall be 203 mm (8 in.) below the top intermediate rail measured from the top of each of the rails.

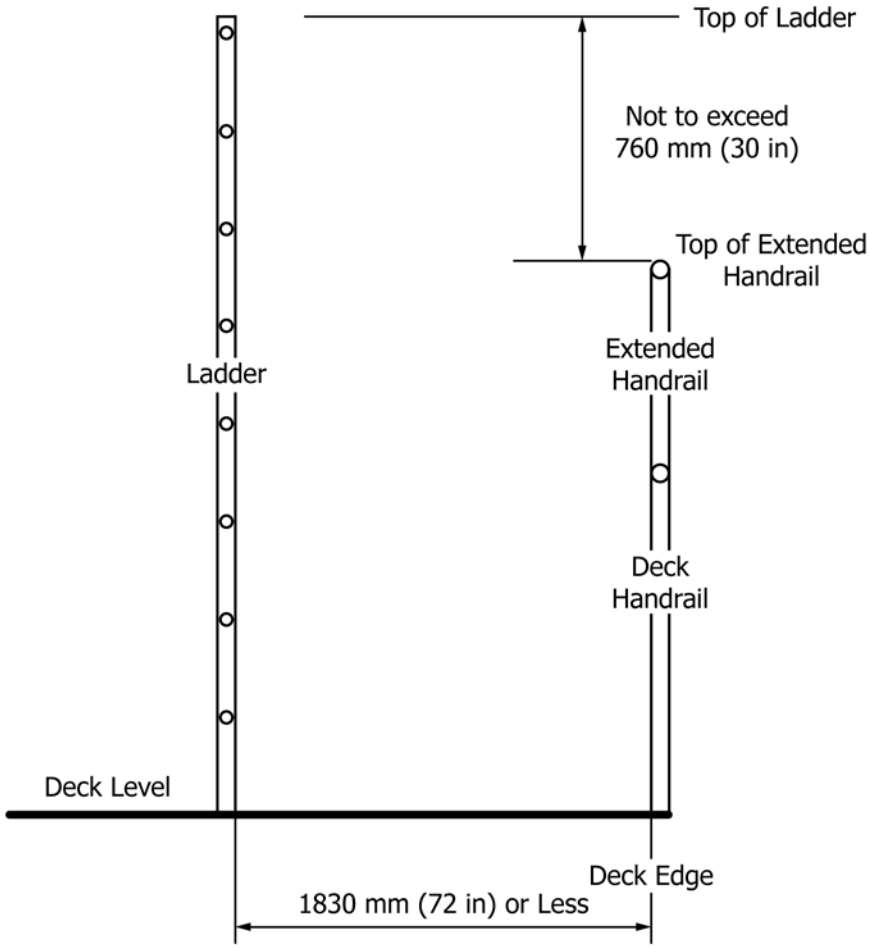
11.11.6.5 The 100-mm (4-in.) toeboard shall be installed 6 mm (¼ in.) above the walking surface.

11.11.7 *Special Between-Handrail Protection*—If it is possible that material could be placed in an area on a walkway to such a height that the toeboard would not prevent its passing through the handrails and falling to a lower deck level, then between-rail protection by means of expanded metal screen, netting, or other material shall be added between the rails to a height equal to that of the expected stacked material.

11.11.8 *Maximum Rail Opening Unprotected*—The maximum unprotected opening between adjacent handrails shall be no greater than 152 mm (6 in.).

11.11.9 *Transition Handrails*—Whenever a worker is required to move up or down from one walking surface to another, handrails shall be provided to protect that person during transition from the one surface to the other. The transition handrail shall be connected between the top and bottom handrails in a manner that provides height of at least 940 mm (37 in.) minimum and 991 mm (39 in.) maximum above each step level as the person moves from one level to the other (see Fig. 112, "Transition Handrail Dimensions").

11.11.10 *International Convention on Loadlines*—For locations requiring handrails or guardrails in accordance with the International Convention on Loadlines, the handrail or guardrail shall be three tiers. The height of the top tier should be at least 1000 mm (39.5 in.) from the deck. A lesser height may be considered in cases where this height would interfere with the



SIDE VIEW

FIG. 102 Extended Railing for Ladder Fall Protection (Side View)

normal operation of the vessel.. The opening below the lowest course of the guardrail should not exceed 229 mm (9 in.). The intermediate course should not be more than 381 mm (15 in.) from the other two courses. For additional details concerning the protection of crew, refer to Regulations 25, 26, and 27 of the International Convention on Loadlines. Where any conflicts exist, statutory requirements take precedence over these design standards although the design standards contained herein are more ergonomically correct.

11.12 *Walkways, Passageways and Alternate Means of Personnel Movement:*

11.12.1 *Walkways and Passageways:*

11.12.1.1 Minimum walkway and passageway widths for various applications are provided in Table 27, "Walkway and Passageway Dimensions." Walkways and passageways shall have a clearance of 2032 mm (80 in.) minimum and, 2134 mm (84 in.) preferred above the walking surface for the full length and width of the walkway or passageway. Elevated walkways that are 610 mm (24 in.) or higher above the adjacent surface shall be provided with handrails and toeboards as described in 11.11.2.

Minimum walkway and passageway widths for various applications are provided in , "Walkway and Passageway Dimensions." Walkways and passageways shall have clearance above the walking surface of 2032 mm (80 in.) minimum, 2134 mm (84 in.) preferred, for the full length and width of the walkway or passageway. Elevated walkways that are 610 mm (24 in.) or higher above the adjacent surface shall be provided with handrails and toeboards as described in .

11.12.1.2 Walkways, passageways, decks and all other walking surfaces shall be slip resistant under expected environmental conditions and use. Interior walkways that are not slip resistant when wet shall be maintained dry during periods of pedestrian use.

11.12.2 *Additional Personnel Movement-related Design Features*—Dimensions for additional alternative personnel movement features beyond those described in 11.12.1 are shown in Fig. 113, "Additional Personnel Movement-Related Design Features" and Table 28, "Dimensions for Additional Personnel Movement-Related Features." The preferred dimensions should be used unless the minimum dimensions are approved by the procuring organization. The dimensions are

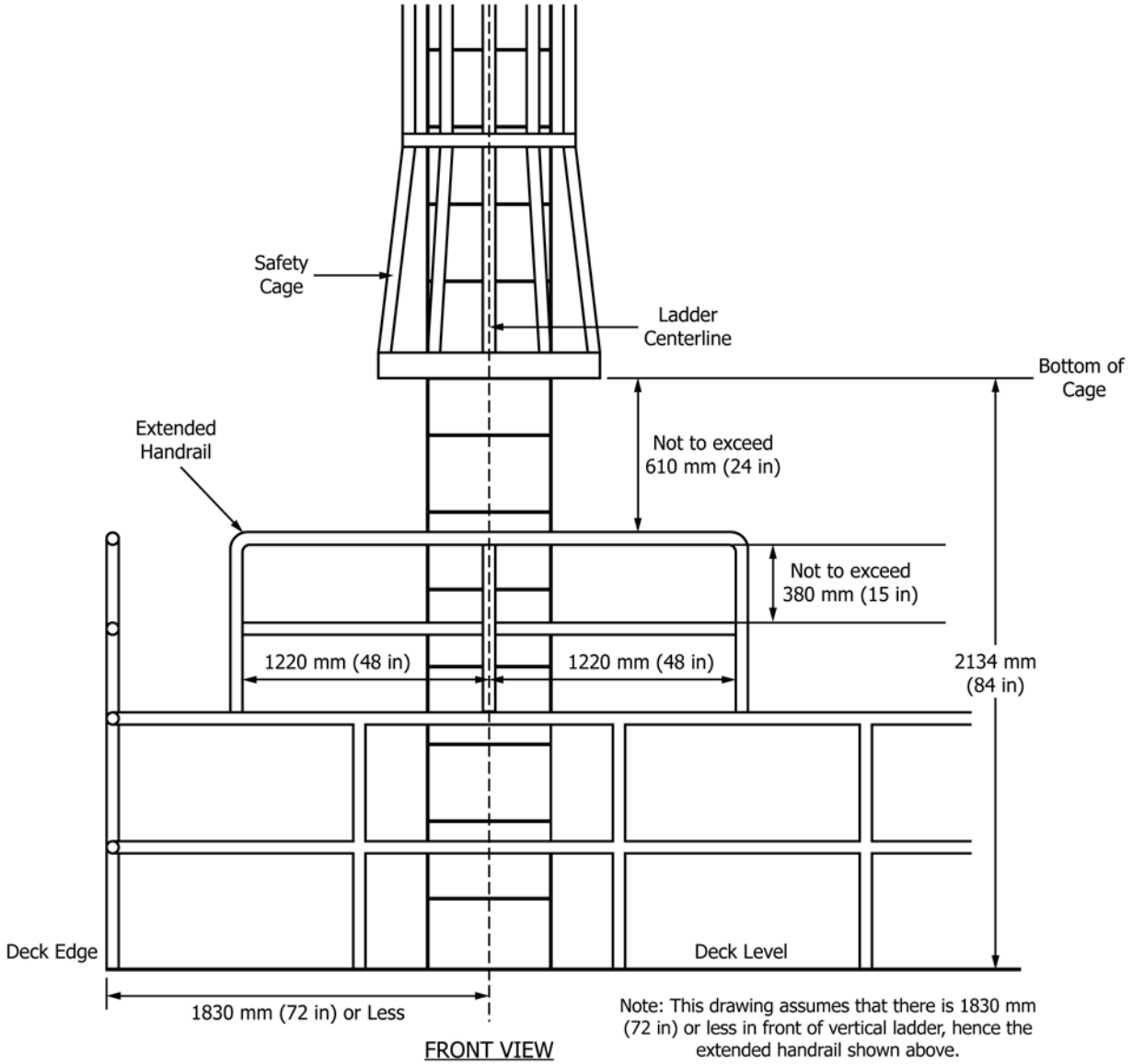


FIG. 103 Extended Railing and Cage for Ladder Fall Protection (Front View)

for North American males so adjustments should be made for other user populations.

11.12.3 *Bulkhead-Mounted Items*—No items should be mounted on the walls or bulkheads of these passageways that could reduce the effective width of the passageways as shown in Table 28.

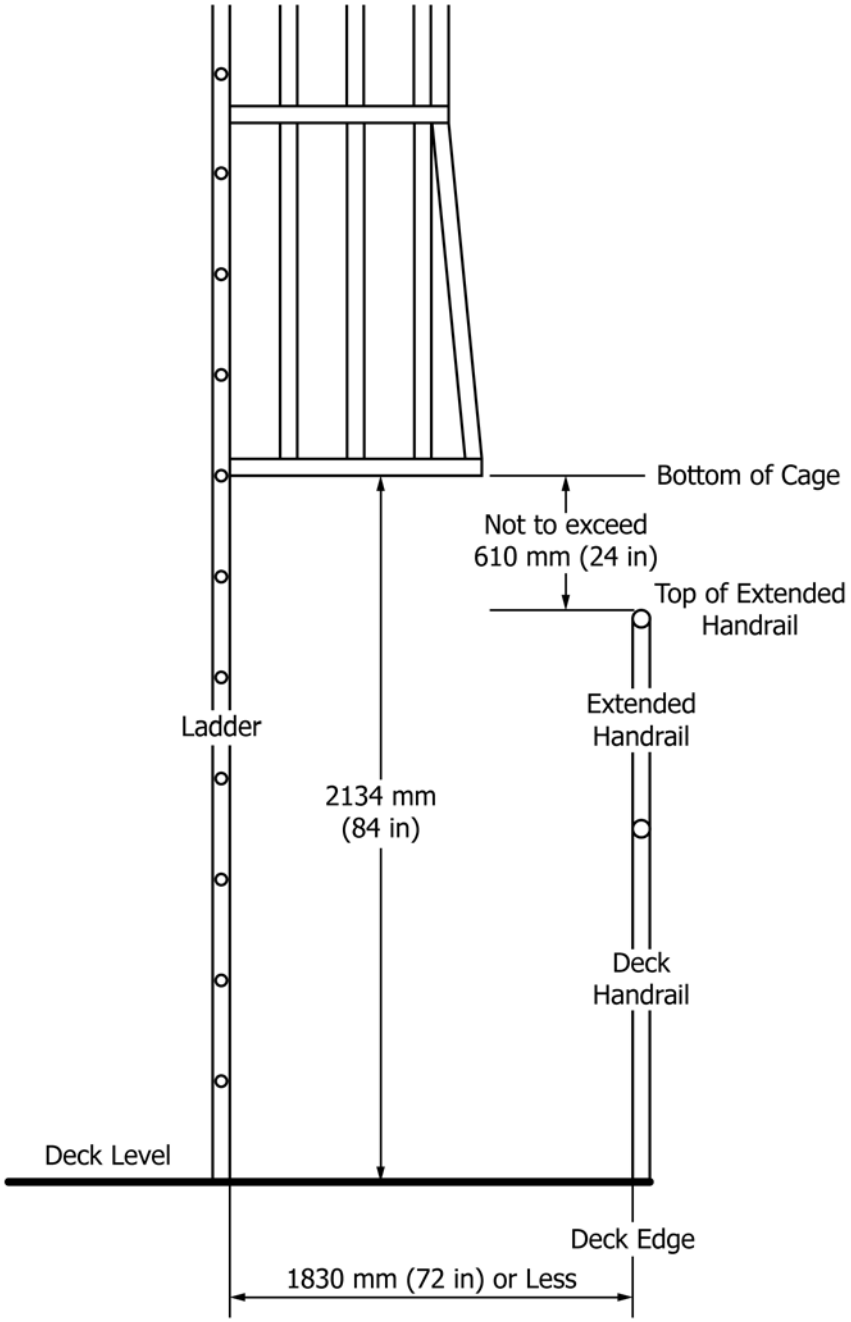
11.12.4 *Items with Raised Foundations*—T-bitts and other deck-mounted equipment with raised foundations should be recessed into the walkway or deck grating whenever clear walkway widths would be less than 914 mm (36 in.) with the raised foundations exposed.

11.12.5 *Access Walkway to Tanker Bows*—Tankers, including oil tankers, chemical tankers, and gas carriers shall be provided with a means to enable personnel to gain safe access to the bow in severe weather conditions. The International Convention for the Safety of Life at Sea refers to IMO Resolution MSC.62 (67), Guidelines for Safe Access to Tanker Bows, for details. Access should be by means of either a walkway on the deck or a permanently constructed gangway at or above the level of the superstructure deck or the first tier of a deckhouse and be in accordance with the following:

11.12.5.1 The access shall not be less than 1016 mm (40 in.) in width situated on or as near as practicable to the centerline of the vessel and located so as not to interfere with access across working areas of the deck.

11.12.5.2 The access shall be fitted at each side throughout its length with a toeboard and guardrails supported by stanchions. Such rails shall consist of no less than three courses, the lowest being not more than 229 mm (9 in.) and the uppermost being at least 1016 mm (40 in.) above the gangway or walkway and no intermediate opening more than 381 mm (15 in.) in height. Stanchions should be at intervals of not more than 1524 mm (60 in.).

11.12.5.3 The access shall be constructed of fire resistant, nonslip material and have a level surface.



SIDE VIEW

FIG. 104 Extended Railing and Cage for Ladder Fall Protection (Side View)

11.12.5.4 The access shall be provided with openings in the handrails and with ladders, where appropriate, to and from the deck. Openings shall not be more than 40 m (131 ft) apart.

11.12.5.5 If the exposed length of the access exceeds 70 m (230 ft), it should have shelters of substantial construction at intervals not to exceed 45 m (148 ft). Every shelter should be capable of accommodating at least one person and be constructed to provide weather protection on the forward, port, and starboard sides.

11.12.5.6 If the access is obstructed by permanently installed pipes or other fittings, means for passage over such obstruction shall be provided.

11.13 *Elevated Work Platforms:*

11.13.1 *General Requirements*—Work platforms shall be provided at locations where personnel must perform tasks that cannot be easily accomplished by reaching from an existing

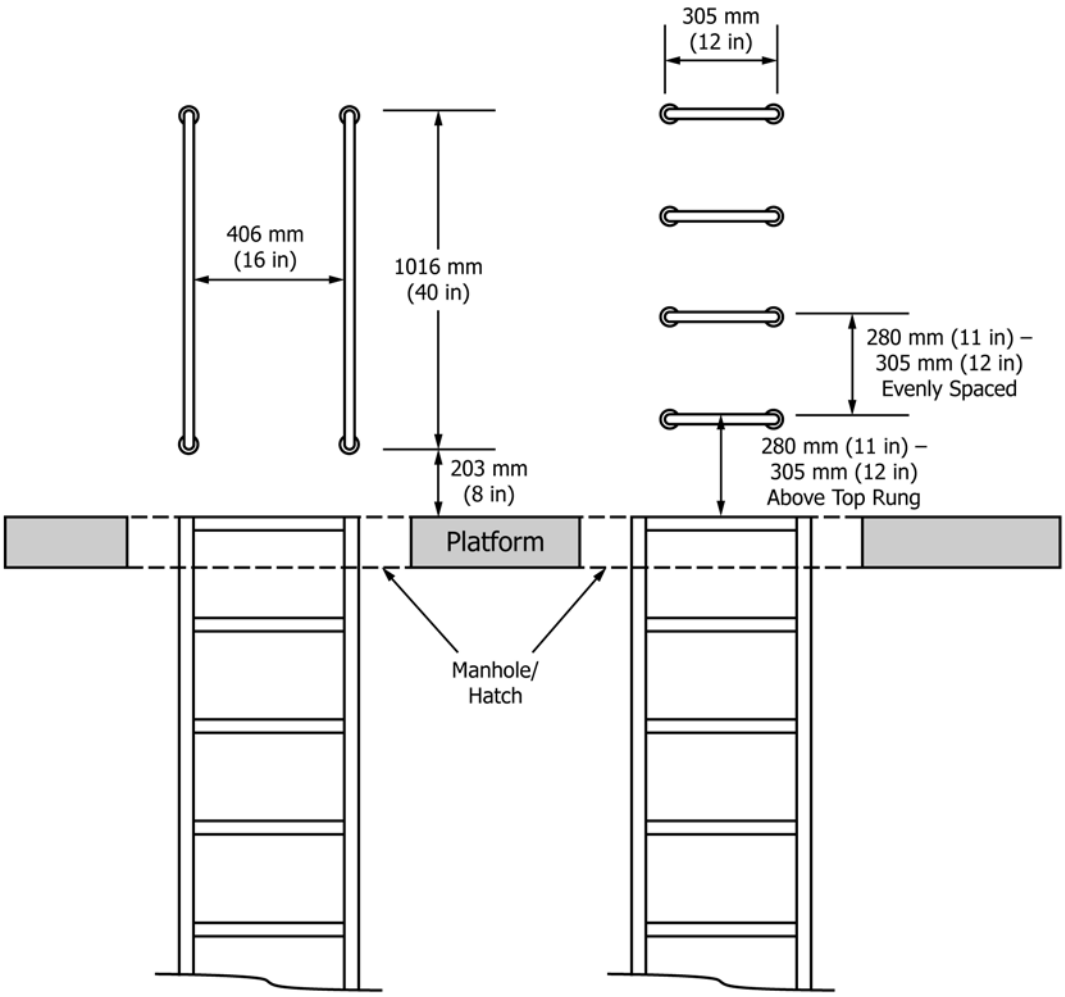


FIG. 105 Handles or Hand Grabs for Use as Ladder Extensions

standing surface. Platforms shall be of sufficient size to accommodate the task and allow for placement of any required spare parts and tools.

11.13.2 *Dimensions*—Platforms shall be no less than 762 mm (30 in.) wide and 915 mm (36 in.) deep, except for platforms used exclusively for standing which may be no less than 381 mm (15 in.) wide and 457 mm (18 in.) in depth.

11.13.3 *Handrails*—Handrails for platforms shall be provided at the exposed side of any work platform surface that is 610 mm (24 in.) or higher above the adjacent surface and where a person could fall from the platform to the lower surface. Handrails shall comply with the design contained in 11.11.2.

11.13.4 *Work Height Above the Platform:*

11.13.4.1 For lifting or producing maximum torque the standing surface of the platform shall be at a height between 985 mm (38 in.) to 1270 mm (50 in.) below the height of the work task.

11.13.4.2 For light tasks the maximum extended reach shall be no more than 1905 mm (75 in.) above the work platform standing surface.

11.13.4.3 Work platforms shall be located at a height so the worker can perform the required tasks without having to assume an awkward or unsafe posture. As a guide to establishing the platform height in regard to task height for tasks other than those listed above, check dimensions for display and control heights and workplace dimensions in Section 10 or use the dimensions shown in Section 9.

11.14 *Hatches, Manways, Lightening Holes, Inspection Ports, and Kick-Out Panels:*

11.14.1 *General Design Requirements*—Hatches, open manways, inspection ports, lightening holes and other openings provided for manual access in a ship or maritime structure that require a step to assist in the movement through the opening shall comply with the design criteria shown in Fig. 114, "Dimensions for Access Openings Installed in a Vertical Orientation Requiring a Step to Reach the Opening." Dimensions for openings directly accessible without a step are shown in Fig. 115, "Dimensions for Rectangular, Square and Round Openings in Vertical and Horizontal Orientations" and Fig. 116, "Dimensions for Lightening Holes."

11.14.2 *Access to Vertical Escape Hatches*—Hatches mounted in vertical walls for escape purposes shall be sized and located as shown in Fig. 117, "Access to Vertical Escape Hatches."

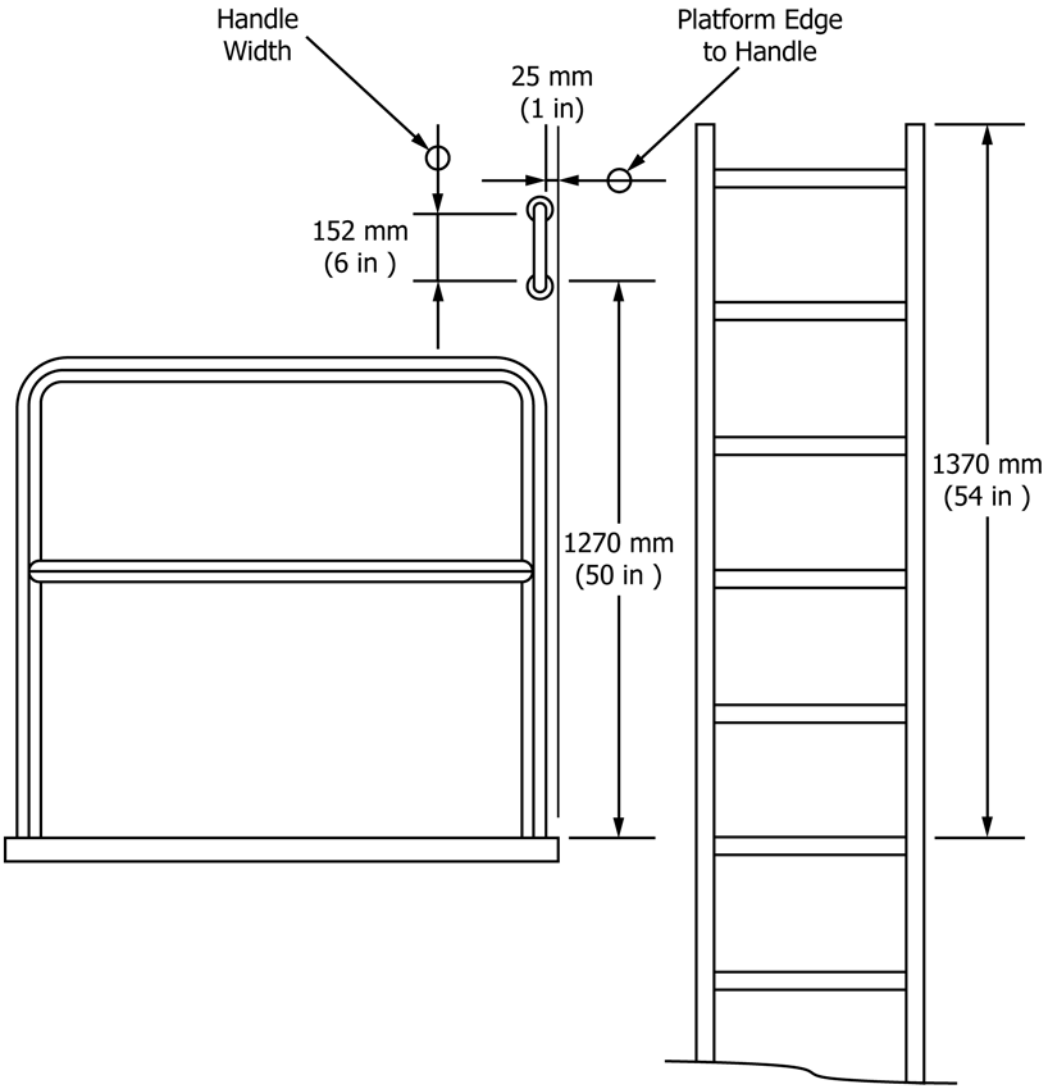


FIG. 106 Handle for Transition from a Ladder to an Intermediate Platform

11.14.3 *Access by Means of Overhead Hatch*—When an overhead hatch is reached by means of a ladder, the edge of the hatch opening shall be no more than 203 mm (8 in.) from the face of the ladder rung (see Fig. 118, "Access to Overhead Hatch").

11.14.4 *Access Through a Raised Hatch*—Access into liquid cargo hold by means of a raised hatch shall be accomplished as shown in Fig. 119, "Access into a Cargo Hold Through a Raised Hatch."

11.14.5 *Kick-Out Panels:*

11.14.5.1 Emergency escape kick-out hatches shall be provided in spaces where it is impractical or impossible to provide a second door or hatch for emergency escape.

11.14.5.2 The kick-out panels shall be clearly marked on both sides, and shall not be covered by furniture, cabinets, equipment, or any other item that could prevent direct and unobstructed access to the panel. Kick-out panels shall be sized and located to accommodate the 5th to 95th percentile person easily, but in no case shall they be smaller than 737 mm (29 in.) wide and 1016 mm (40 in.) high.

11.14.6 *Hatch Unlocking Force*—When a handle is used for unlocking a hatch, the force required for unlocking shall be less than 220-N (50-lb) force for opening and closing and shall be operable by a suitably equipped and clothed user with 5th percentile arm and hand strength. The force of gravity shall be used, where possible, for ease of opening.

11.14.7 *Hatch Locking Mechanism*—Hatches shall have a locking mechanism such that the hatch is locked in the open position as soon as the hatch opens 1.57 rad (90°). The latching mechanism shall require a deliberate effort by a crew member to override before the hatch can be closed. Further, the locking mechanism shall be designed so that the hatch cannot close inadvertently during severe ship motion or wear on the locking mechanism.

11.14.8 *Operation*—Hatches shall open with a single motion of the hand or foot.

11.14.9 *Heavy Hatches:*

11.14.9.1 Hatch or manway covers installed on vertical bulkheads that are accessible only from a ladder or ladder rungs attached to the bulkhead shall be equipped with two

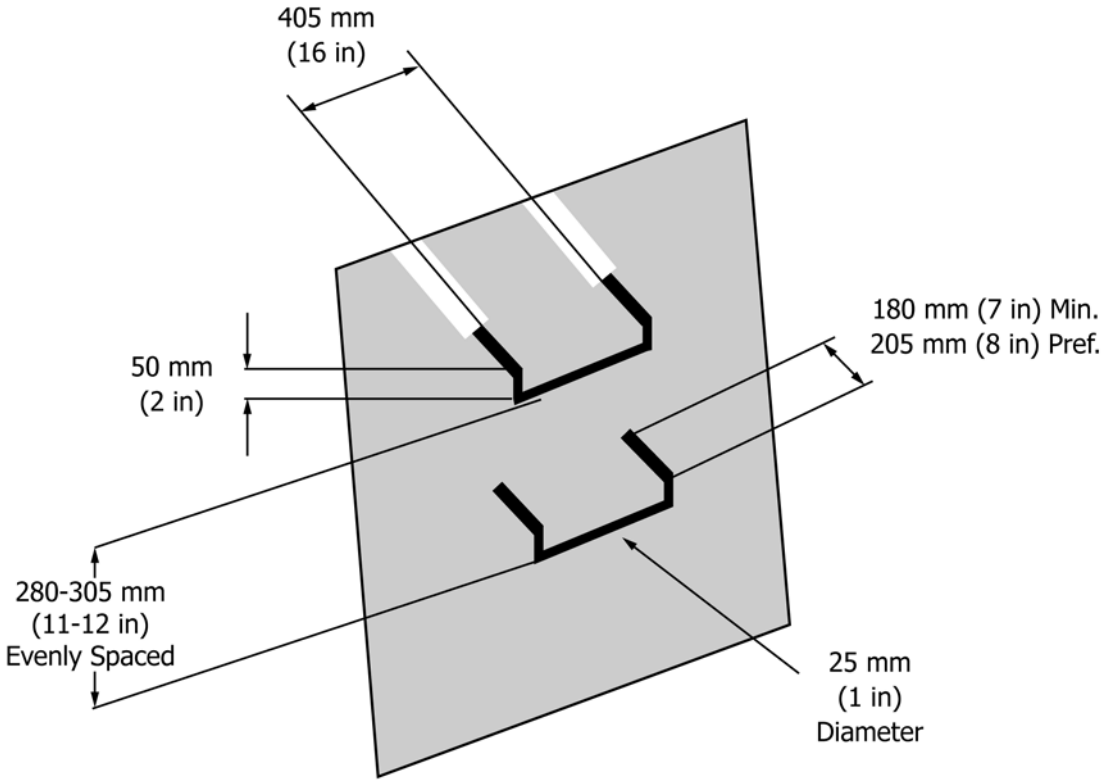


FIG. 107 Recommended Design Criteria for Individual Rung Ladders

handles (running parallel to the standing surface and spaced to occupy two-thirds of the hatch or manway height) or hinges that will support the manway or hatch when it is open. If handles are provided padeyes or other means of support to lift and hold the hatch or manway cover during its removal or replacement shall be provided.

11.14.9.2 The same handle or hinge installation shall be provided on any hatch or manway cover that weights more than 20 kg (45 lb) and is accessible from a deck or other permanent standing surface.

11.14.10 *Labeling*—Every removable manway or hatch shall have a label listing its weight. The labels shall be black on white for all manways and hatches weighing less than 13.6 kg (30 lb) and black on yellow for all hatches or manways heavier than 13.6 kg (30 lb.).

11.14.11 *Number of Access Hatches in a Vessel or Tank*—The number of access hatches/manways in a vessel or tank shall be based on the vessel or tank in accordance with the following schedule:

11.14.11.1 Vessels/tanks less than 10 m (33 ft) long may have only one access opening.

11.14.11.2 Vessels/tanks less than 19 m (63 ft) long shall have at least two access openings.

11.14.11.3 Vessels/tanks longer than 19 m (63 ft) shall have at least three access openings.

11.14.12 *Angle of Access Hatch or Manway in Tanks or Pressure Vessels*—Access hatches or manways provided in pressure vessels or tanks mounted horizontal to the deck should be installed so the hatch or manway angles down 30° from the horizontal.

11.14.13 *HVAC Clean-out Doors/Hatches*—Inspection doors or clean-out access hatches shall be provided every 3 to 4 m (10 to 13 ft) of running length for ducts up to 305 mm (12 in.) in Access diameter. For ducts greater in size the doors or hatches shall be greater. The size of the openings will depend on the tasks required to complete the cleaning.

11.15 *Doors and Arches:*

11.15.1 *Sliding or Vertical Opening Doors:*

11.15.1.1 External sliding or vertical doors are recommended for large vehicles, pieces of equipment, or cargo that must be moved into or out of a compartment or down large passageways. Separate hinged doors sized 762 mm (30 in.) by 1829 mm (72 in.) should be inserted into the sliding or vertical doors for pedestrian traffic use.

11.15.1.2 Vertical or sliding doors shall not be the only exit from an area. There must always be another way to escape.

11.15.1.3 Controls for opening and closing the sliding or vertical doors shall be located on both sides of the door and mounted in compliance with the requirements of Section 5.

11.15.2 *Door Location*—Location of doors shall be as shown in Fig. 120, “Door Placement.”

11.15.3 *Clearance Around Door Sweeps*—Fixed equipment shall not be mounted on bulkheads or other structures within 102 mm (4 in.) minimum, 152 mm (6 in.) preferred, of the sweep area of doors being fully opened.

11.15.4 *Doorways And Arches*—For doorways or arches leading outside the ship to be used by two persons simultaneously, the opening shall be not less than 1397 mm (55 in.) wide minimum, 1524 mm (60 in.) preferred.

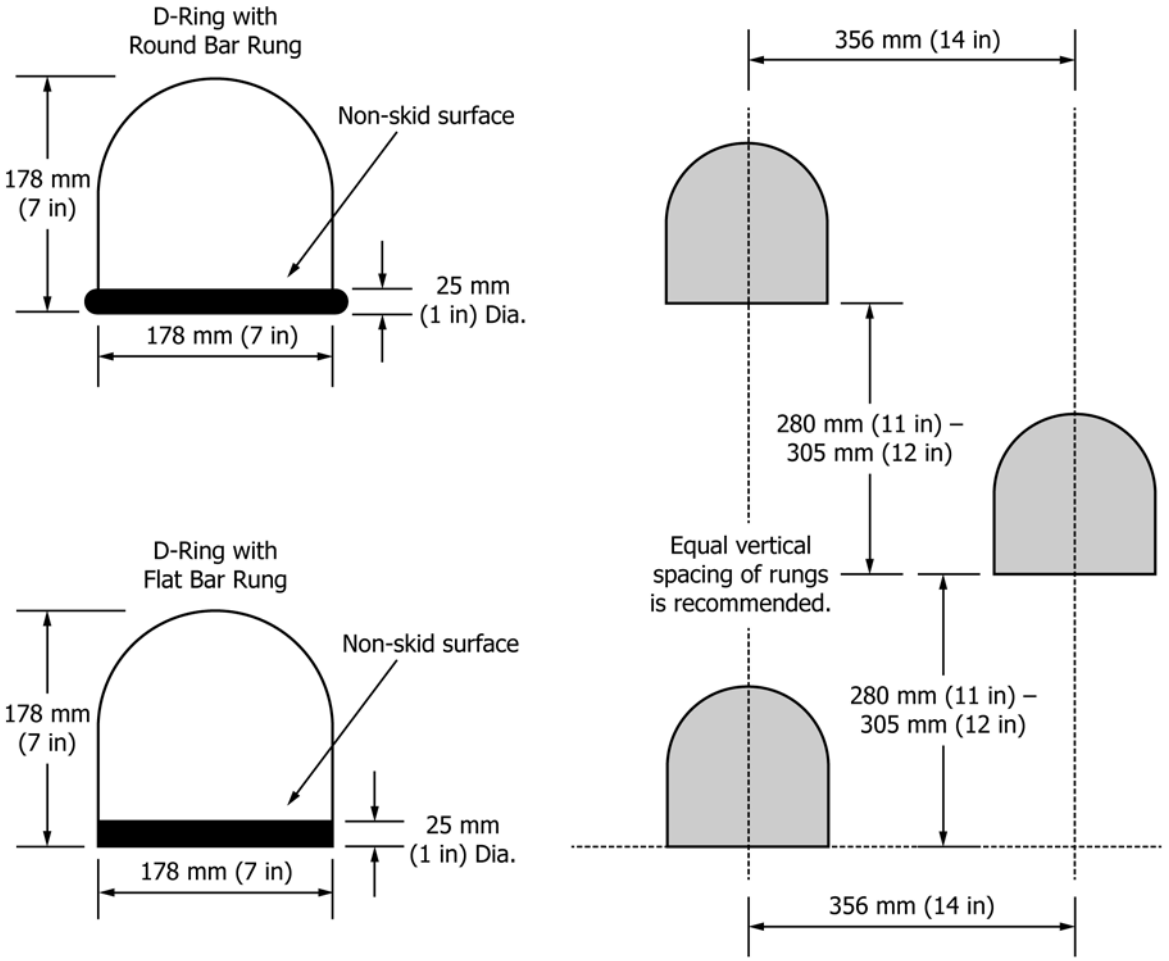


FIG. 108 Dimensions for D-ring Ladders

11.15.5 *Swinging Doors*—Swinging doors intended for two-way traffic should be used in pairs, with the doors separated by a center door post. They should be hinged at the center post and should have openings or windows for visual access to oncoming traffic.

11.15.6 *Airlock Doors*—Doors used for airlocks shall be provided with a local alarm if the doors remain open beyond a set time period.

11.15.7 *Labeling*—Emergency doors, hatches, and kick-out panels shall be clearly marked on both sides. and they shall be capable of being opened within three seconds.

11.15.8 *Door Opening Requirements:*

11.15.8.1 If normal traffic density and exiting personnel traffic in emergency conditions are expected to be low, hinged doors should open inward rather than outward into a corridor.

11.15.8.2 If exiting traffic volume is expected to be high doors shall have a see-through window and should open outward into a corridor to facilitate emergency exiting.

11.15.8.3 Doors in room corners shall be hinged on the corner side.

11.15.9 *Stores and Cargo Movement Doors*—Doors at the load-unload stations for vertical package conveyors, dumbwaiters, and elevators shall open 2.09 rad (120°). Control stations for elevators, package conveyors, and dumbwaiters shall be located on the side of the door opposite the hinges, or above the door opening, and shall be placed so that the operator has an unobstructed view into the trunk when the doors are open. For double-door elevators, the controls shall be located so that the operator has direct access to the emergency shutoff button with the doors open, yet allows the operator to see into the trunk with the doors open. Control stations shall be mounted so that no control is less than 1016 mm (40 in.), or more than 1524 mm (60 in.) above the deck (for control stations located beside the door) and no higher than 1930 mm (76 in.) for stations placed above the door.

11.16 *Permanent Means of Access (PMA):*

11.16.1 *Design Details*—Design criteria for stairs, ladders, walkways, ramps, and other structures required by SOLAS Reg. II-1/3-6 to provide safe, permanently installed accesses within oil tanker and bulk cargo carrier holds for vessel inspection are found in the ABS publication “Guide for Means of Access to Tanks and Holds for Inspection.”

12. Valve Placement, Orientation, and Location

12.1 *General Design Requirements:*

12.1.1 *Standing on Pipes, Cable Trays, Handrails, etc.*—Valve handles shall be located so the operator or maintainer does not have to stand on nearby pipes, cable trays, handrails, equipment, or any object not meant specifically to be used as a

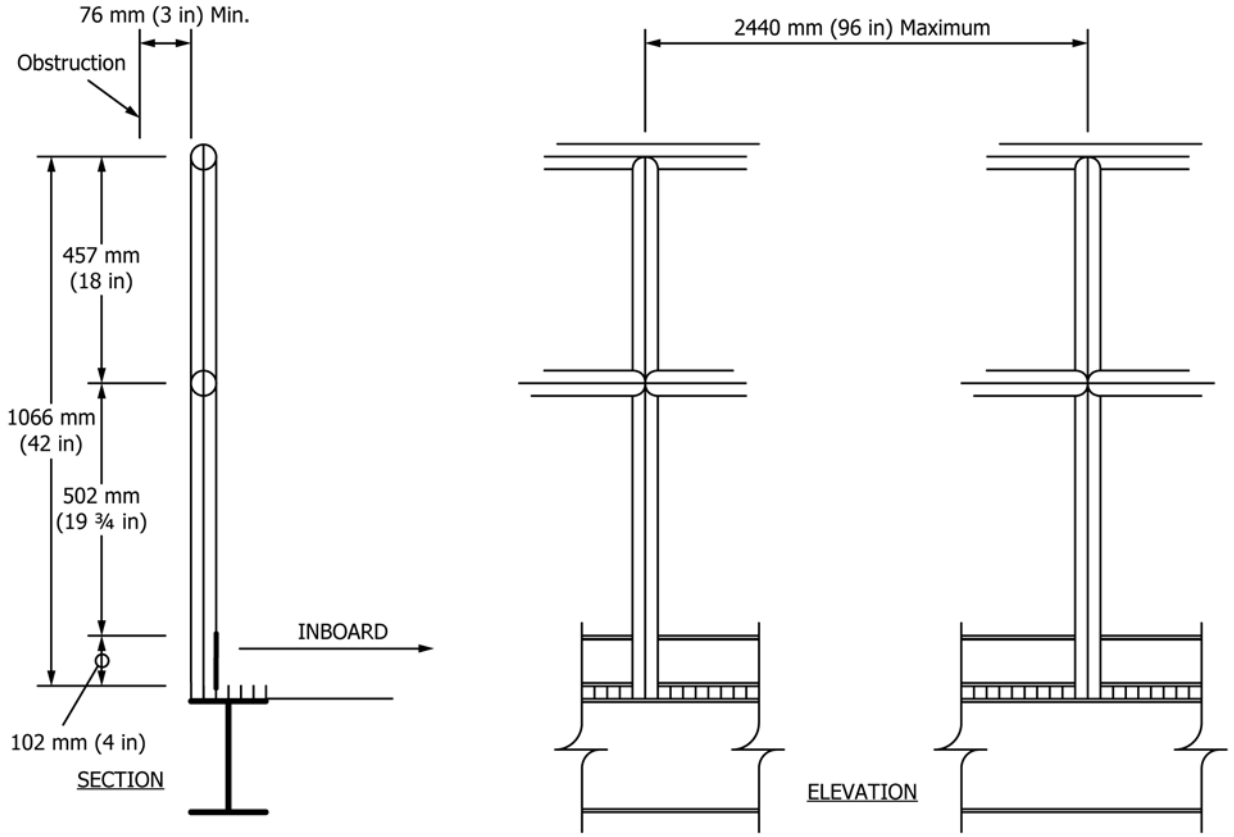
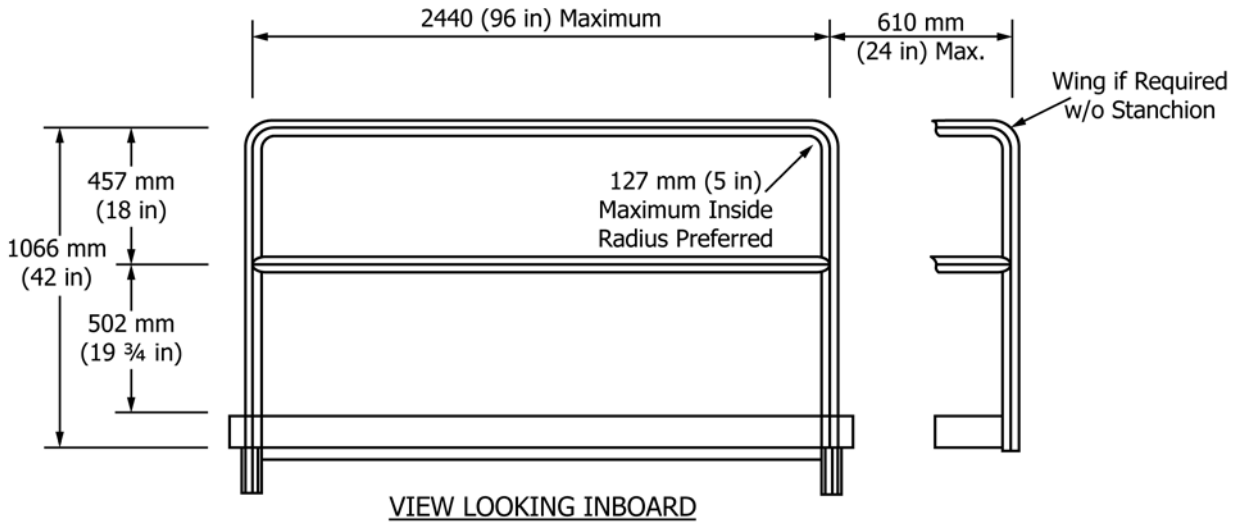


FIG. 109 Fixed Handrail Design



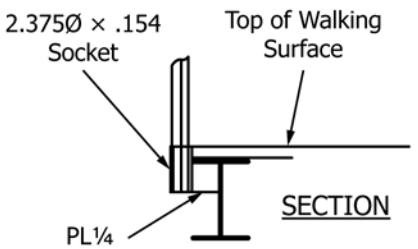


FIG. 110 Removable Handrail Dimensions

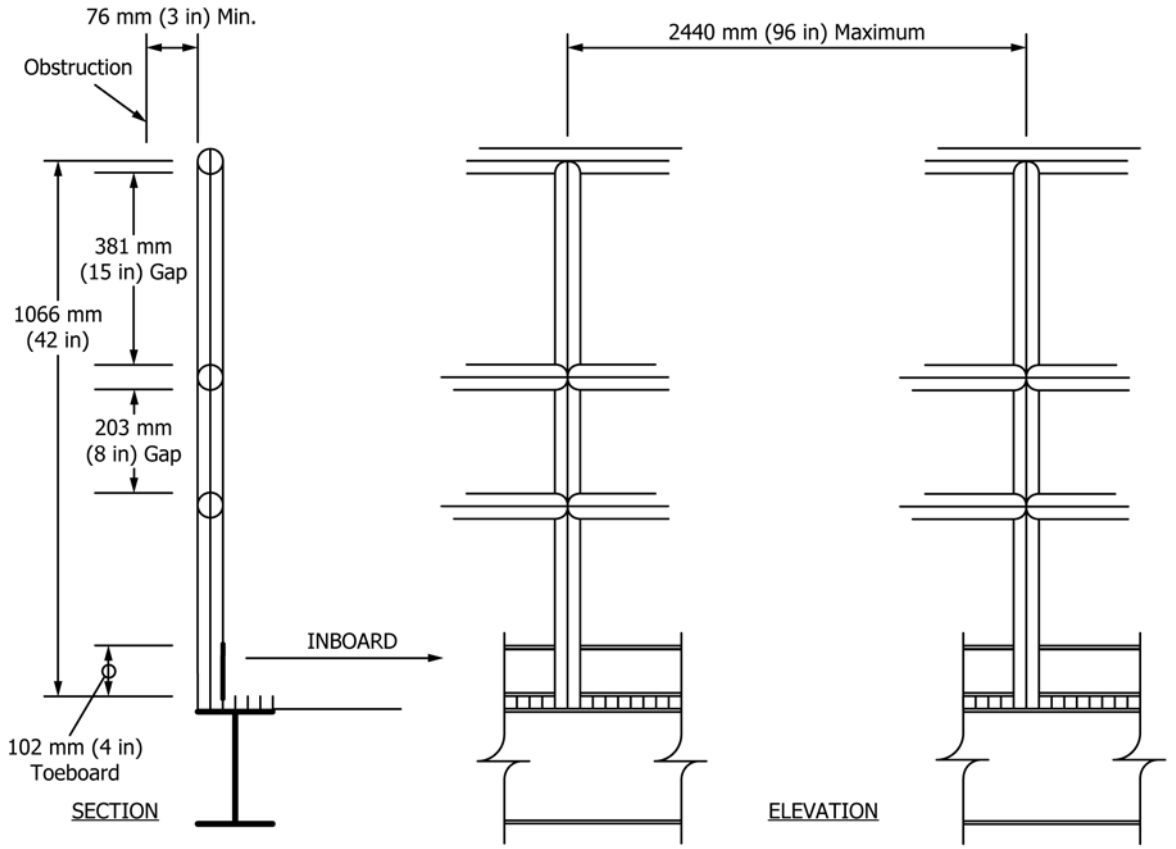


FIG. 111 Special Handrail Design Dimensions

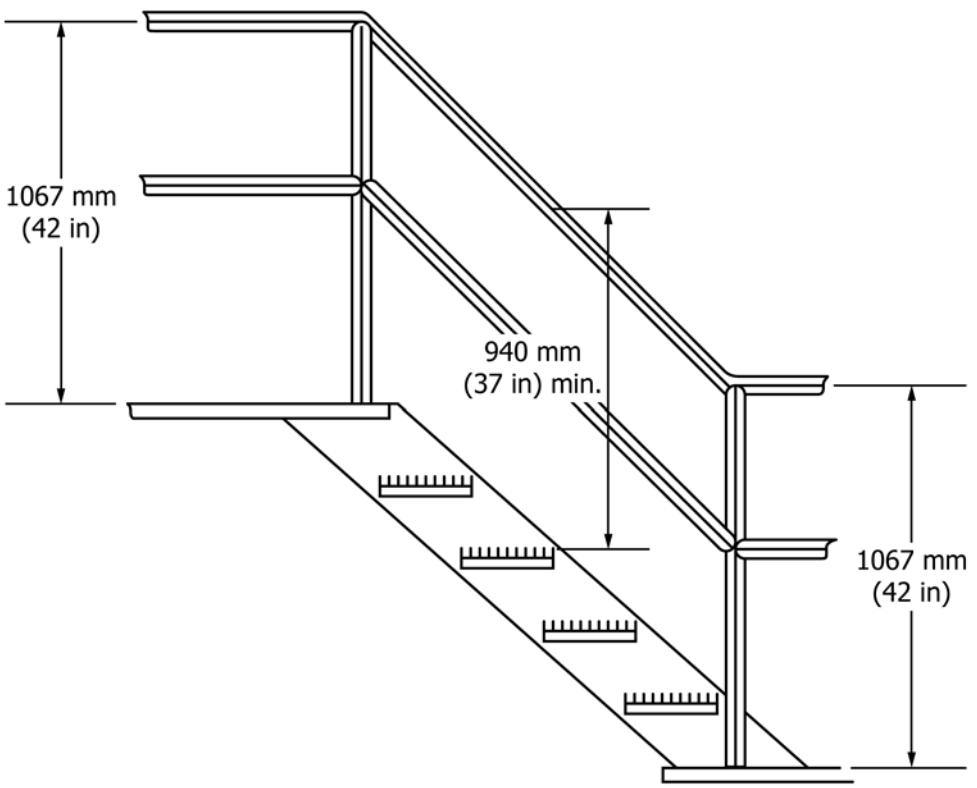


FIG. 112 Transition Handrail Dimensions

TABLE 27 Walkway and Passageway Dimensions

Application	Minimum Dimension	Maximum Dimension
One person walking sideways in restricted area (for example, machinery space)	330 mm (13 in.)	381 mm (15 in.)
One person walking sideways in restricted area in bulky clothing	406 mm (16 in.)	457 mm (18 in.)
One person traveling forward in area with limited access	508 mm (20 in.)	610 mm (24 in.)
One person in unrestricted area, where two persons could pass. One person carrying bulky loads.	710 mm (28 in.)	813 mm (32 in.)
Two persons passing face-to-face	813 mm (32 in.)	864 mm (34 in.)
Two persons passing, one sideways	864 mm (34 in.)	914 mm (36 in.)
Normal two-way traffic or any means of egress that leads to an entrance or exit	965 mm (38 in.)	1067 mm (42 in.)
Corridor or passageway which serves as a required exit	1118 mm (44 in.)	1370 mm (54 in.)
Route that serves as an emergency exit from manned spaces	1219 mm (48 in.)	1370 mm (54 in.)

standing surface for the operation, maintenance, repair, or replacement of any valve.

12.1.2 *Clearance Around Valve Handwheel or Handle*—A minimum of 76-mm (3-in.) clearance shall be provided between the outside rim of a valve handwheel or the end of a valve lever and any obstacle located throughout the handwheel or lever's field of travel.

12.1.3 *Emergency Valve Access*—Valves used for emergency operations should not be located below deck gratings or behind covers. If it is absolutely necessary to locate emergency valves below grating, an extender rod shall be provided to place the operating handle or handwheel above grating level. If located behind a cover, (for example, to meet a regulatory requirement) the cover shall be capable of being opened without requiring any tools or the removal of any securing fasteners. The cover shall be clearly labeled to identify the valve (see Section 15).

12.1.4 *Valve Operators and Indicators:*

12.1.4.1 Valve handles shall close with a right-hand (clockwise) motion of the handwheel or lever when facing the end of the valve stem. Valves shall be provided with a means to determine valve position. Valve position indicators should be installed so the indicator is directly visible to the operator or maintainer from the normal body position required to open or close the valve.

12.1.4.2 For valves that cannot be located within the operator or maintainer's reach limits given in the following subsections, they should be operated by mechanical extenders rather than chain operators. For valves fitted for remote control, an independent indicator showing whether the valve is open or closed shall be provided on or adjacent to the control.

12.1.5 *Labeling*—Labels shall be used to identify manual valves in accordance with the requirements in Section 15.

12.1.6 *Motorized Valve Adjustment Access*—Motorized valves with internal adjustable pots shall be mounted so the door to the internal compartment opens toward the operator/maintainer.

12.1.7 *Maximum Operating Force:*

12.1.7.1 The maximum force required to initially crack open a manual valve shall be set on the basis of the expected operator population, valve actuator height and orientation with respect to the operator, valve lever or handwheel design and size, operating environment, and frequency and criticality of the valve operation, but in no case shall exceed 450 N (100 lb) for all population sizes.

12.1.7.2 As an indication of torque requirements however, Fig. 121, shows torque limits for two valve handwheel orientations for three sizes of handwheels.

12.1.8 *Locate Heavy Valves for Easy Removal:*

12.1.8.1 All valves that must be lifted for repair, replacement, or maintenance, and weigh more than the limits defined in Section 16, shall be located for ease of lifting and use of lifting aids as described in 16.5.

12.1.8.2 There shall be sufficient clearance above each valve to attach the lifting device and pull the valve, or valve operating mechanism, or complete all maintenance tasks in place without removing the valve.

12.2 *Valve Criticality and Location:*

12.2.1 *Valve Criticality*—Valves should be rated by criticality to help ensure that critical valves are located to provide for rapid and effective identification and operation. The following three categories should be used:

12.2.1.1 *Category 1*—Valves critical for safety or operations. These valves are also used frequently (at least once in a six month period) for routine operation and maintenance.

12.2.1.2 *Category 2*—Valves not critical for operations but required for routine operation and maintenance.

12.2.1.3 *Category 3*—Valves not critical for operations or routine maintenance and are infrequently used for particular tasks like commissioning, start-up, shutdown, or rarely performed maintenance tasks.

12.2.2 *Category 1 Valves*—Category 1 valves shall include those essential to normal or emergency operations where rapid and unencumbered access is essential. Permanent access shall be provided at deck level or by means of a permanent standing elevated surface. If such access is not practical, access by stair is acceptable.

12.2.2.1 *Category 1 Criteria*—Category 1 valves should meet any of the following criteria:

(1) Valves that are essential for operations.

(2) Valves that are essential for personnel safety, vessel or structure protection, cargo protection, and pollution prevention.

(3) Valves which have a high likelihood of failure.

(4) Valves where the consequence of failure or lack of quick access would be serious (for example, damage to personnel, property, productivity, or the environment).

(5) Valves where an expected operational or maintenance frequency, or both, is greater than once in a 6 month period.

(6) Valves with handwheels or handles greater than 610 mm (24 in.) in diameter or length.

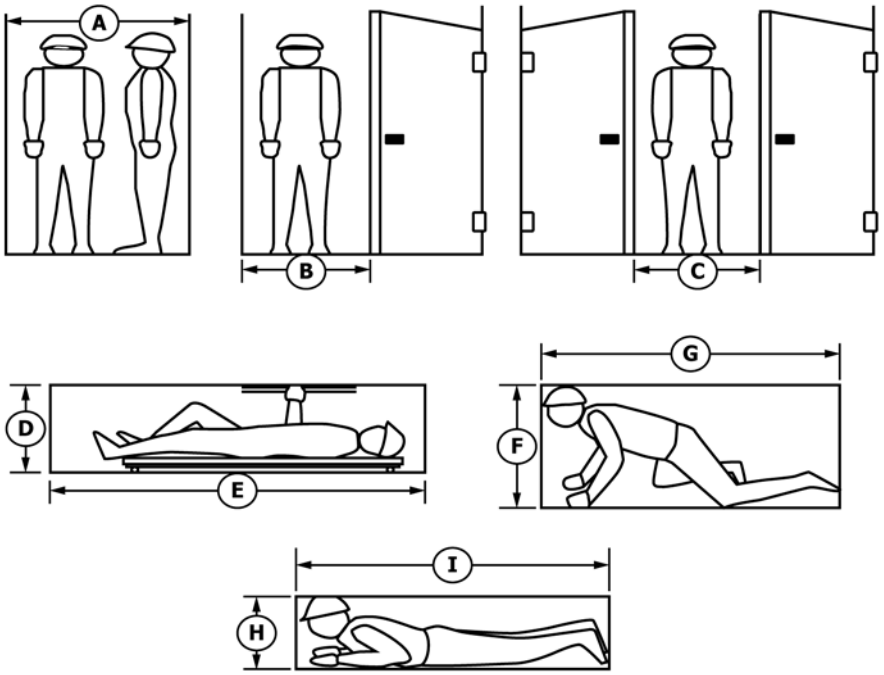


FIG. 113 Additional Personnel Movement-Related Design Features

TABLE 28 Dimensions for Additional Personnel Movement-Related Features

	Minimum		Preferred		Cold Weather	
	mm	in.	mm	in.	mm	in.
PASSAGEWAY						
A. Two personnel passing—one sideways	864	34	914	36	1040	41
Passageways With One Door						
B. Width Clear of Door	635	25	710	28	813	32
Passageway With Two Doors						
C. Width Clear of Doors	635	25	710	28	813	32
Supine work space (Lying on Back):						
D. Height						
Visual Inspection	355	14	405	16	483	19
Reach	560	22	610	24	660	26
E. Length	1880	74	1880	74	1980	78
Crawling space:						
F. Height	785	31	915	36	965	38
G. Length	1525	60	1760	70	1760	70
Prone work or crawl space:						
H. Height	430	17	510	20	610	24
I. Length	2870	113	2870	113	2870	113

12.2.2.2 *Category 1 Examples*—Examples of valves typically included in Category 1 are:

(1) Control valves, their bypasses and isolation valves.

(2) Relief valves and depressuring valves.

(3) Trip and anti-surge control valves.

(4) Emergency shutdown valves.

(5) Liquid cargo transfer valves (especially for hydrocarbons and chemicals).

12.2.3 *Category 2 Valves*—Category 2 valves are those that are not critical for normal or emergency operations but are used during routine maintenance activities. These valves should be located with permanent access at deck level, or access by means of stairs. However, with written permission of the procuring agency, alternative means of access including vertical ladders with a purpose-built standing surface, or use of other auxiliary equipment to gain access (for example, mobile platforms, personnel lift, or scaffolding, or combination thereof), for maintenance purposes may also be used as long as drawings indicate the planned access means, and clearances, and space is provided in the design to accommodate personnel, tools, parts, and the access equipment.

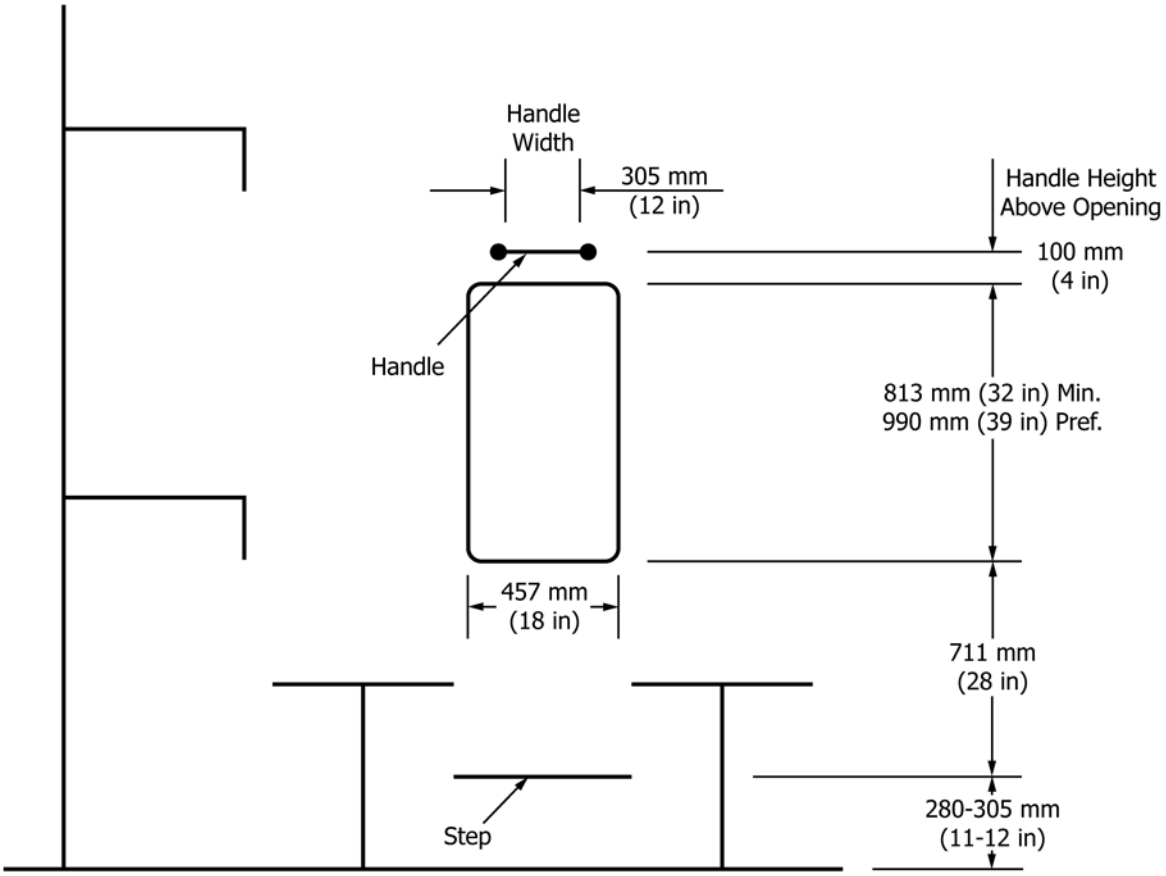
12.2.3.1 *Category 2 Criteria:*

(1) Category 2 valves do not require immediate and unencumbered access as do the Category 1 valves but they shall be accessible without having to remove bulkhead panels or other similar obstructions.

(2) Category 2 valves shall also be valves with an expected operating/maintenance frequency of less than once per six months.

12.2.3.2 *Category 2 Examples*—Examples of valves typically found in Category 2 are:

(1) Sewage treatment valves.



NOTE 1—A rectangular opening is shown in the figure but the same dimensions are appropriate (with the exception of the opening height and width) regardless of the opening shape (that is, rectangular, square, round, oval).

FIG. 114 Dimensions for Rectangular Access Openings Installed in a Vertical Orientation Requiring a Step to Reach the Opening

(2) Condensate drain valves.
(3) Service oil valves.
(4) Potable water valves.
(5) Ship service air valves.
(6) Hydraulic service valves.
(7) Defrost gas valves.
(8) Manual valves for normal startup/shutdown operation.
(9) Valves where quick action is not required.
(10) Drain and vent valves 25 mm (1 in.) or less in size with flange or cap end.

12.2.4 *Category 3 Valves*—Category 3 valves are normally non-operating valves that are used in particular circumstances on an infrequent basis.

12.2.4.1 *Category 3 Criteria*—Permanent accessibility is desirable for such valves, but it is not mandatory. No specific location requirements are imposed. The use of auxiliary equipment to gain access, (for example, mobile platforms, personnel lift, or scaffolding, or combination thereof) is permissible, however, access requirements and equipment type should be indicated on drawings, and clearances and space shall be allowed for personnel, tools, parts, and access equipment in the design.

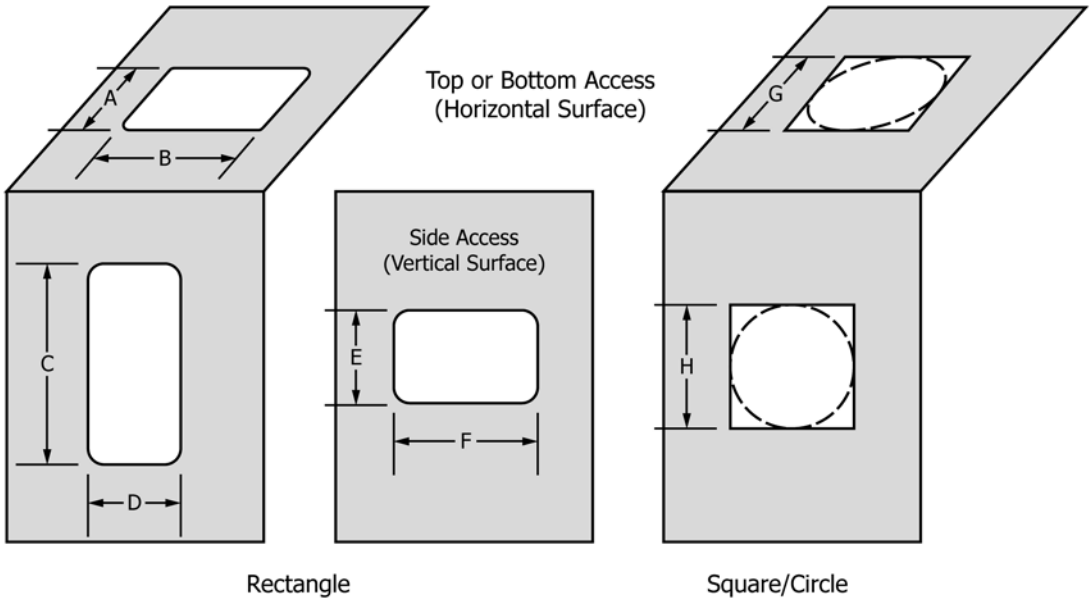
12.2.4.2 *Category 3 Examples*—Examples of valves included in Category 3 are:

(1) Valves used in drydock only.
(2) Valves used in initial vessel or structure commissioning.
(3) Valves used for decommissioning.
(4) Valves used only during start-ups after extended shutdowns.
(5) Valves used during extended shutdowns.
(6) Valves used to isolate pressure vessels, tanks, etc. for inspections.
(7) Tie-in valves used for tie-in purpose only (hot-tap valves).
(8) Valves for pressure test.

12.3 *Valve-Mounting Heights and Orientations: Handwheel Operated:*

12.3.1 *152 mm (6 in.) or Less Handwheels*—Handwheels of less than 152 mm (6 in.) in diameter shall be designed and oriented for one-hand operation, while handwheels of greater than 152 mm (6 in.) diameter shall be designed and oriented for two-hand operation.

12.3.2 *Mounting Height by Stem Orientation*—Valve handwheels, including Category 1 valves, shall be located as shown in Fig. 122, "Mounting Heights for Handwheel Valves With Vertical Valve Stems," Fig. 123, "Mounting Heights for Handwheel Valves With Horizontal Stems" and Fig. 124,



Hatch Shape	Rectangle		Square		Circle	
Clothing	**Light**	**Bulky**	**Light**	**Bulky**	**Light**	**Bulky**
Top Entry (Horizontal Surface)	A. 356 mm **(14 in)** B. 559 mm **(22 in)**	A. 457 mm **(18 in)** B. 660 mm **(26 in)**	G. 584 mm **(23 in)**	G. 685 mm **(27 in)**	G. 686 mm **(27 in)**	G. 813 mm **(32 in)**
Side Entry (Vertical Surface)	***Vertical Opening*** C. 813 mm **(32 in)** D. 457 mm **(18 in)** ***Horizontal Opening*** E. 406 mm **(16 in)** F. 610 mm **(24 in)**	***Vertical Opening*** C. 990 mm **(39 in)** D. 559 mm **(22 in)** ***Horizontal Opening*** E. 533 mm **(21 in)** F. 711 mm **(28 in)**	H. 660 mm **(26 in)**	H. 787 mm **(31 in)**	H. 686 mm **(27 in)**	H. 813 mm **(32 in)**

FIG. 115 Dimensions for Rectangular, Square and Round Openings in Vertical and Horizontal Orientations

"Mounting Heights for Handwheel Valves With Angled Stems." (See Note at bottom of figures for exceptions to these dimensions).

12.3.2.1 *Preferred Choice Location*—Preferred choice locations should be used for all Category 1 valves as well as the Category 2 valves that:

(1) Are associated with critical systems such as firefighting, damage control, propulsion, process flow and steering.

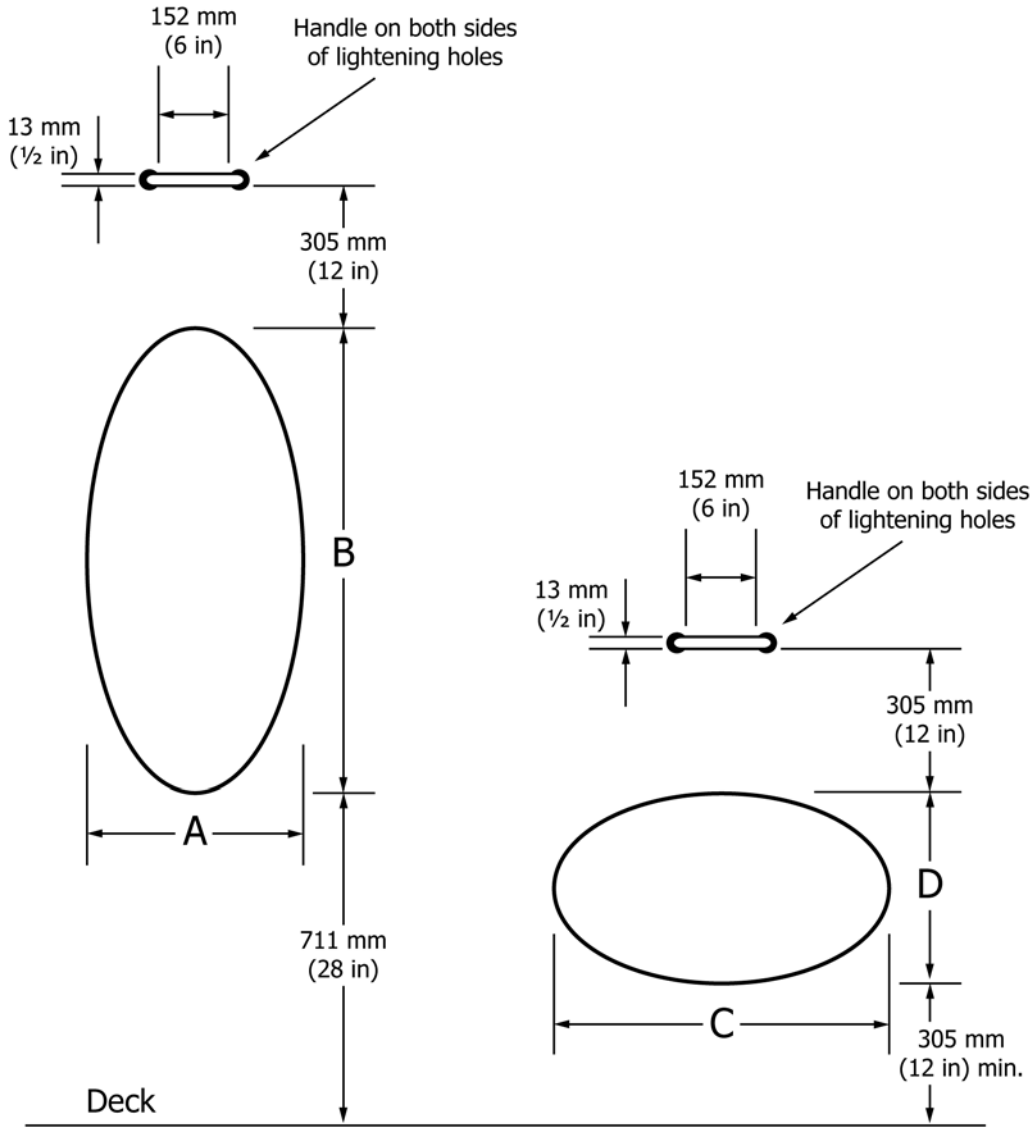
(2) Are operated more than once in a six month period.

(3) Possess handwheels or levers greater that 406 mm (16 in.) in diameter or length.

(4) Have operational time constraints, especially in an emergency manual mode.

12.3.2.2 *Acceptable Choice Location*—Acceptable choice locations should be allocated to any Category 1 valves that could not be placed in a Preferred location. Acceptable locations are also appropriate locations for the remaining Category 2 and all Category 3 valves.

12.3.3 *Handwheel Diameter*—Valve handwheels should not be larger than 610 mm (24 in.) in diameter for populations in the majority of maritime countries but reduced to 508 mm (20



Dimension	Minimum mm (in)	Preferred mm (in)
A. Vertical Oval Width	457 mm **(18 in)**	559 mm **(22 in)**
B. Vertical Oval Height	813 mm **(32 in)**	991 mm **(39 in)**
C. Horizontal Oval Width	660 mm **(26 in)**	762 mm **(30 in)**
D. Horizontal Oval Height	432 mm **(17 in)**	533 mm **(21 in)**

FIG. 116 Dimensions for Lightening Holes

in.) maximum, 457 mm (18 in.) preferred, for populations in Southeast Asia, West Africa, South China, South India, and Japan.

12.3.4 *Handwheel Surfaces*—Handwheel grasping surfaces shall have knurling, indentations, or other configurations to maximize the grip on the wheel surface.

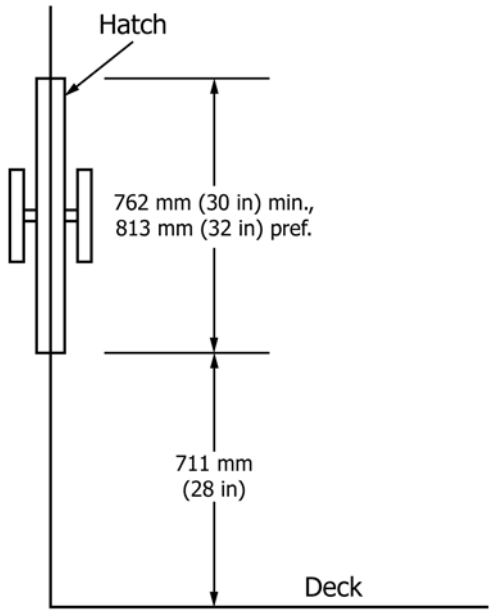


FIG. 117 Access to Vertical Escape Hatches

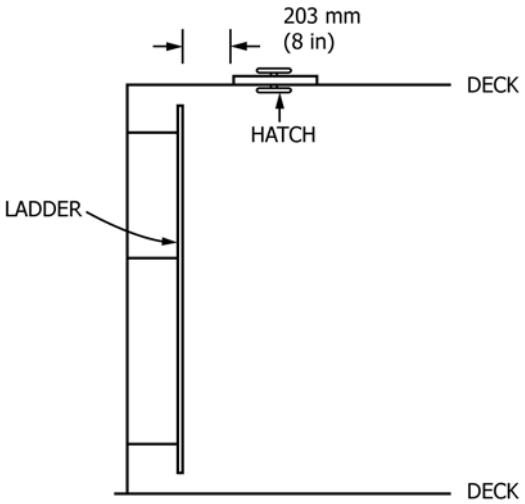


FIG. 118 Access to Overhead Hatch

12.3.5 *Valve Handle*—The number of rotations required to go from fully open to closed (or closed to open) shall be limited to the smallest number possible.

12.4 *Valve-Mounting Heights and Orientations: Lever-Operated Valves:*

12.4.1 *Mounting Heights for Vertical Stem Orientation:*

12.4.1.1 Valves oriented with the stem in the vertical position should be used when the valve lever can be located between 762 mm (30 in.) and 1270 mm (50 in.) above the standing surface as shown in Fig. 125, "Mounting Heights for Lever-Operated Valves With Vertical Stems." (See the note at the bottom of Fig. 125 for the exception to these dimensions.)

12.4.1.2 The handle on all vertical stem valves shall not rotate into a walkways or working areas so as to become a tripping or knee knocker hazard.

12.4.2 *Mounting Heights for Horizontal Stem Orientation*—Valves oriented with the stem in a horizontal position are preferred when the lever is located between 152 mm (6 in.) and 762 mm (30 in.), or more than 1270 mm (50 in.) above the standing surface, as shown in Fig. 126, "Mounting Heights for Lever-Operated Valves With Horizontal Stem." The maximum height above the standing surface to the lever tip should not exceed 1905 mm (75 in.). (See Fig. 126 for exceptions to these dimensions.)

12.4.3 *Handle Length*—Valve lever handles shall be as long as necessary to produce the necessary torque to crack open and turn the valve. However, handle lengths normally range from 356 mm (14 in.) to 914 mm (36 in.) in length.

12.4.4 *Handle Design*—Valve lever handles may be of any shape (circular is preferred) but shall have a circular grasping surface for the final 178 mm (7 in.) of its length. The grasping surface should be between 13 mm (0.5 in.) and 25 mm (1.0 in.) in diameter and should have a nonslip surface.

12.5 *Alternative Valve Orientations:*

12.5.1 *Valves in the Overhead:*

12.5.1.1 Valves located in the overhead with the handwheel or handle rotating in a plane parallel to the walking surface shall be avoided. When it is necessary to locate valves above an operator or maintainer's head with the valve handwheel or lever oriented parallel to the standing surface, the following design criteria shall be applied:

(1) The handwheel or lever should be at least 1956 mm (77 in.) above the deck or other walking surface.

(2) The handwheel or lever shall be no more than 508 mm (20 in.) in diameter or length.

(3) The maximum operating force shall be less than 15 N. m (20 ft-lb).

12.5.1.2 These dimensions are appropriate for the majority of the maritime population but will have to be reduced to approximately 1803 mm (71 in.) for 5th % males from such areas as Southeast Asia, West Africa, and South India, and to 1727 mm (68 in.) for 5th % females from areas like Southeast Asia, West Africa, South China, and South India. If these heights are used it must be verified that a minimum of 50 mm (2 in.) of headroom exists under all valve handwheels or handles for the intended user population.

12.5.2 *Valves in Walkways*—Valve handwheels or levers shall not protrude into dedicated walkways or work areas below the overhead height stated in 12.5.1.

12.5.3 *Valves Only Accessible from One Side*—When access to a lever-operated valve is available from one side only, the valve shall be mounted such that the lever moves to and from the accessible side where the operator or maintainer will be positioned as shown in Fig. 127, "Direction of Travel for Valve Levers Accessible from One Side Only."

12.5.4 *Valves at the Standing Surface*—If a valve is located at the standing surface, so as to require stooping or squatting to operate the valve, the preferred valve position in relation to an operator's or maintainer's body position is shown in Fig. 128, "Physical Reach from a Stooping or Squatting Position." No Category 1 valves should be placed to required operation by a squatting or kneeling operator.

12.5.5 *Valves Below the Standing Surface:*

12.5.5.1 Valves located below the operator or maintainer's standing surface, either horizontal- or vertical-oriented valves,

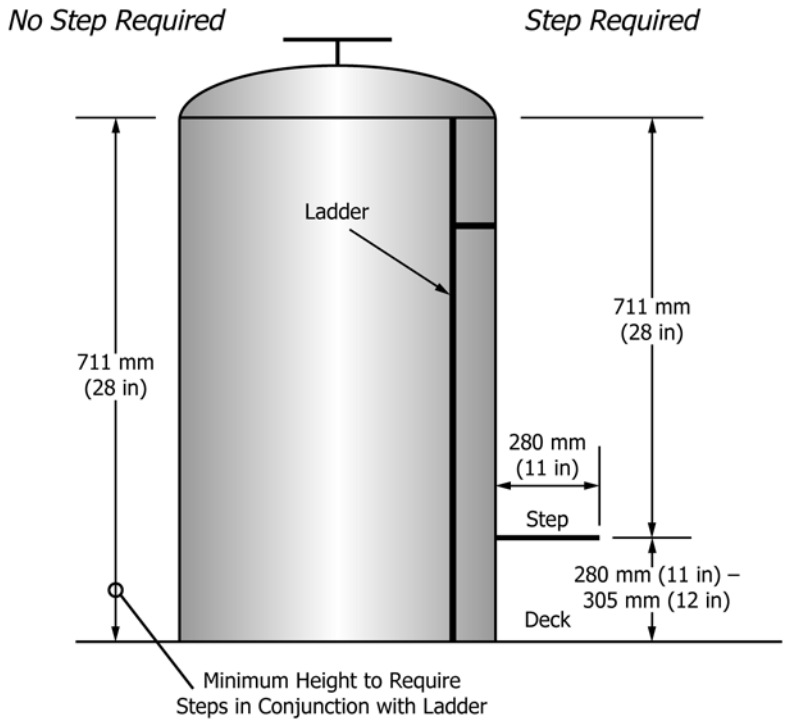
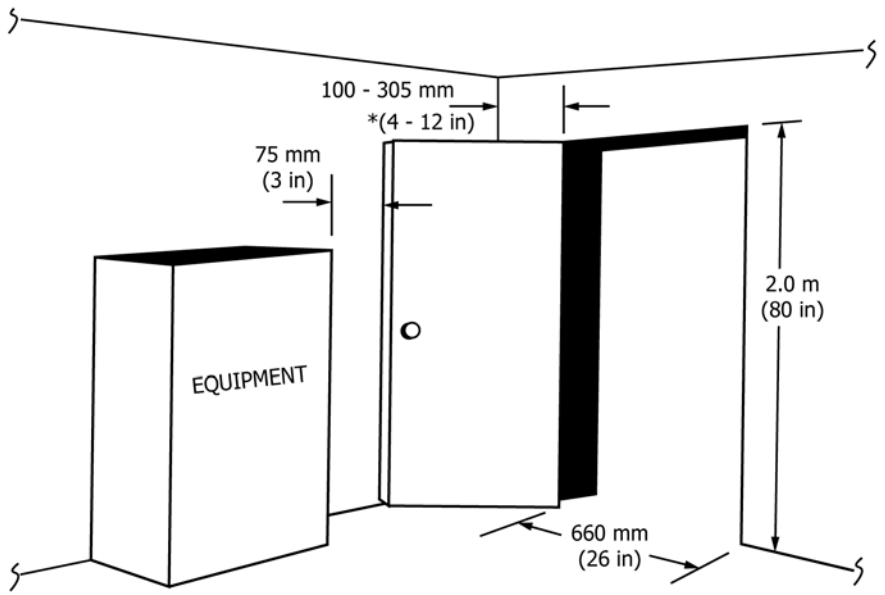


FIG. 119 Access into a Cargo Hold Through a Raised Hatch



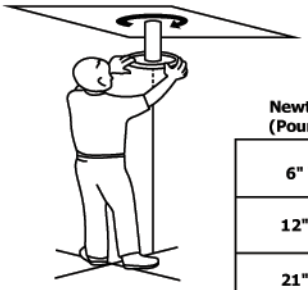
IF THE DOOR OPENS ON TO A PASSAGEWAY WHICH INTERSECTS ANOTHER PASSAGEWAY, OR IF THE PASSAGEWAY TURNS A CORNER AT THE DOOR, THE DOOR SHOULD BE AT LEAST 1.5 m (60 in) FROM THE CORNER.

FIG. 120 Door Placement

should be installed as shown in Fig. 129, "Mounting Position For Valve Levers and Handwheels Below Standing Surface."

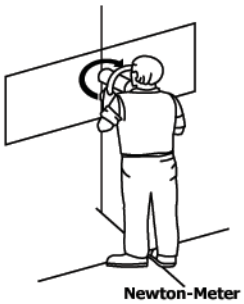
12.5.5.2 No Category 1 valve should be located so the valve handwheel or level is below deck level.

12.5.6 *Deck Opening Sizes*—Deck opening sizes to reach and operate levers or handwheels located below the standing surface should be as shown in Table 29, "Access Opening and



VALVE HANDWHEEL HORIZONTAL (2 Hand Torque)

Newton-Meter (Pounds/Feet)	WAIST HIGH	CHEST HIGH	OVERHEAD
6" Wheel	16.3 (12)	16.3 (12)	13.6 (10)
12" Wheel	48 (35.4)	45.6 (33.6)	29.3 (21.6)
21" Wheel	69.1 (51)	65.1 (48)	44.7 (33)



VALVE HANDWHEEL VERTICAL (2 Hand Torque)

Newton-Meter (Pounds/Feet)	KNEE HIGH	WAIST HIGH	CHEST HIGH	OVERHEAD
6" Wheel	15.3 (11.3)	15.2 (11.2)	14.8 (10.9)	12.3 (9.1)
12" Wheel	48.8 (36)	36.3 (26.8)	43.1 (31.8)	34.2 (25.2)
21" Wheel	86.2 (63.6)	70 (51.6)	74.8 (55.2)	62.6 (46.2)

NOTE 1—These values are appropriate for 5th % to 95th % male and female maritime personnel worldwide.

FIG. 121 Desirable Upper Limits for Handwheel Torque

Mounting Depth Dimensions for Levers and Handwheels Mounted Below the Standing Surface."

12.5.7 *Valves Accessible from Ladders*—Valves that require operation from a ladder should be avoided.

12.5.7.1 Where valves must be operated from a ladder, they shall be limited to those that can be operated with one hand, that is, valves with handwheels less than 152 mm (6 in.) in diameter and lever valves. It is preferred that the valve handle not turn parallel to the operator's body but if this is necessary the ladder shall be positioned so the valve handle is not more than 457 mm (18 in.) distance forward of the ladder.

12.5.7.2 For valve handles that turn perpendicular to the ladder they should be no further from the operator than 1219-mm (48-in.) distance as measured from the far side of the ladder to the valve stem. Both dimensions are shown in Fig. 130, "Orientation and Reach from Ladder Parallel to Valves," Fig. 131, "Orientation and Reach from Ladder Perpendicular to Valves" and Fig. 132, "Operating Valves from a Ladder" gives additional requirements for placement of valves with relationship to ladders.

12.5.7.3 The valve orientation, direction of valve operation, and distances shown are applicable to both lever and handwheel-operated valves (see the note in each of the three figures for exceptions to the above dimensions).

12.5.7.4 Category 1 valves should not be located to require operation from a ladder.

12.6 *Valve Manifolds:*

12.6.1 *Manifold Orientation:*

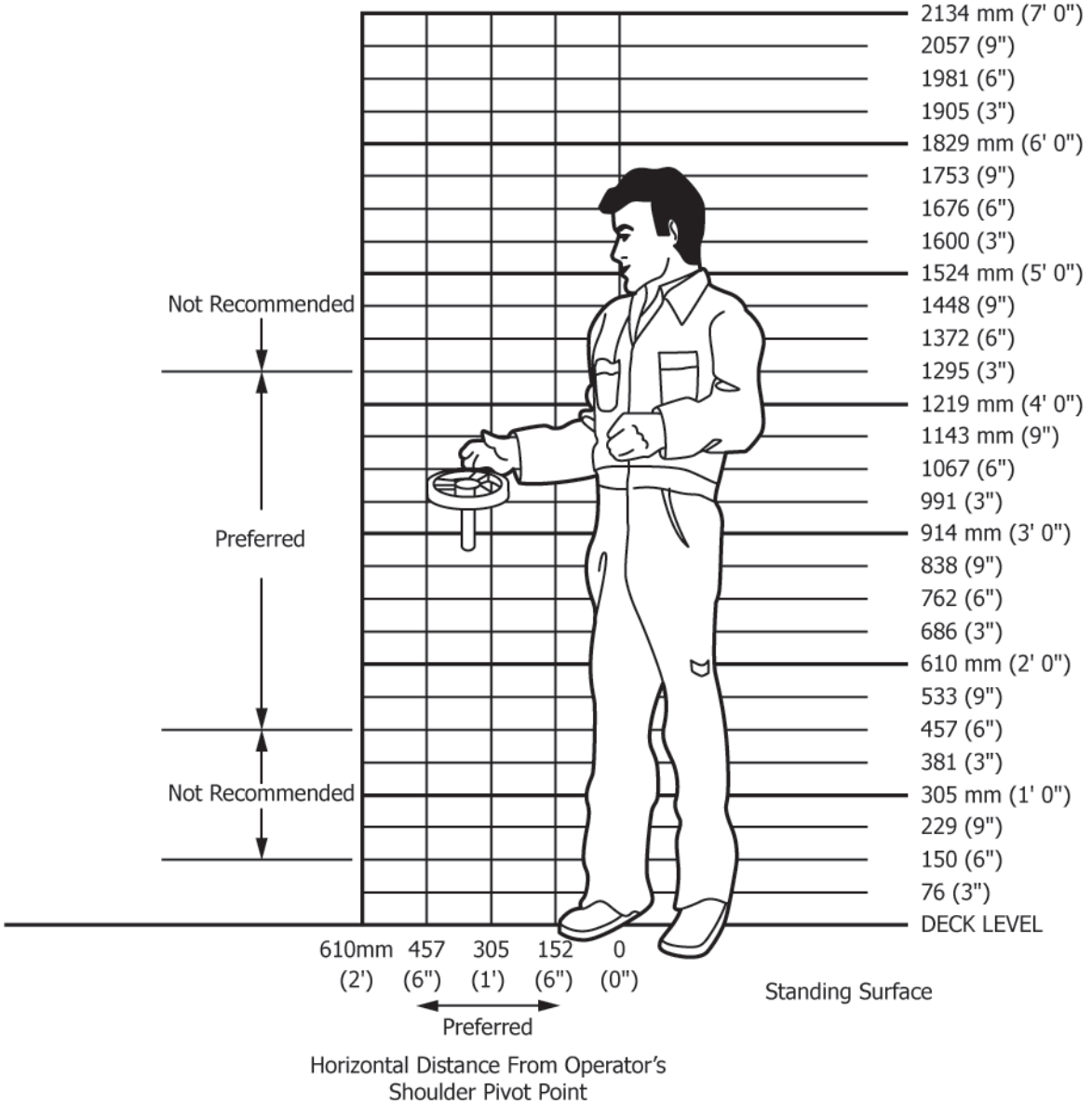
12.6.1.1 Where valves are mounted together to create a valve manifold (for example, fuel oil transfer or cargo oil transfer), the valve handles should be arranged such that as the operator faces the valve manifold, the location of the tank or pump with which the valve is associated replicates, or has direct spatial relationship with, the location of the associated item as shown in Fig. 133, "Valve Manifold for Tanks Located Athwartship" and Fig. 134, "Valve Manifold for Tanks Located Fore and Aft."

12.6.1.2 The overall vertical orientation and horizontal location of the manifold valves should provide a direct spatial relationship between the valves in the manifold and the equipment (for example, tank, pump, exchanger, and so forth) associated with the valves. See Fig. 135, "Valve Manifold for Fill, High Suction, and Low Suction."

13. Human-Computer Interface (HCI)

13.1 *General Design Requirements:*

13.1.1 *General Principles*—Critical to the usability and effectiveness of computer systems is the design of interfaces that promote maximum human performance and error reduction while considering operating environment (for example, high stress) and information (data received/transmitted) transfer requirements. The basic design principles of computer interfaces also applicable to HCI hardware and software are as follows:



NOTE 1—These dimensions are appropriate for 5th % to 95th % male and female maritime personnel worldwide except that the top level limit for the "Preferred" choice location should be reduced by 100 mm (4 in.) to accommodate male and female populations from such geographic regions as West Africa, Southeast Asia, Southern China, India, and Japan.

FIG. 122 Mounting Heights for Handwheel Valves With Vertical Stems

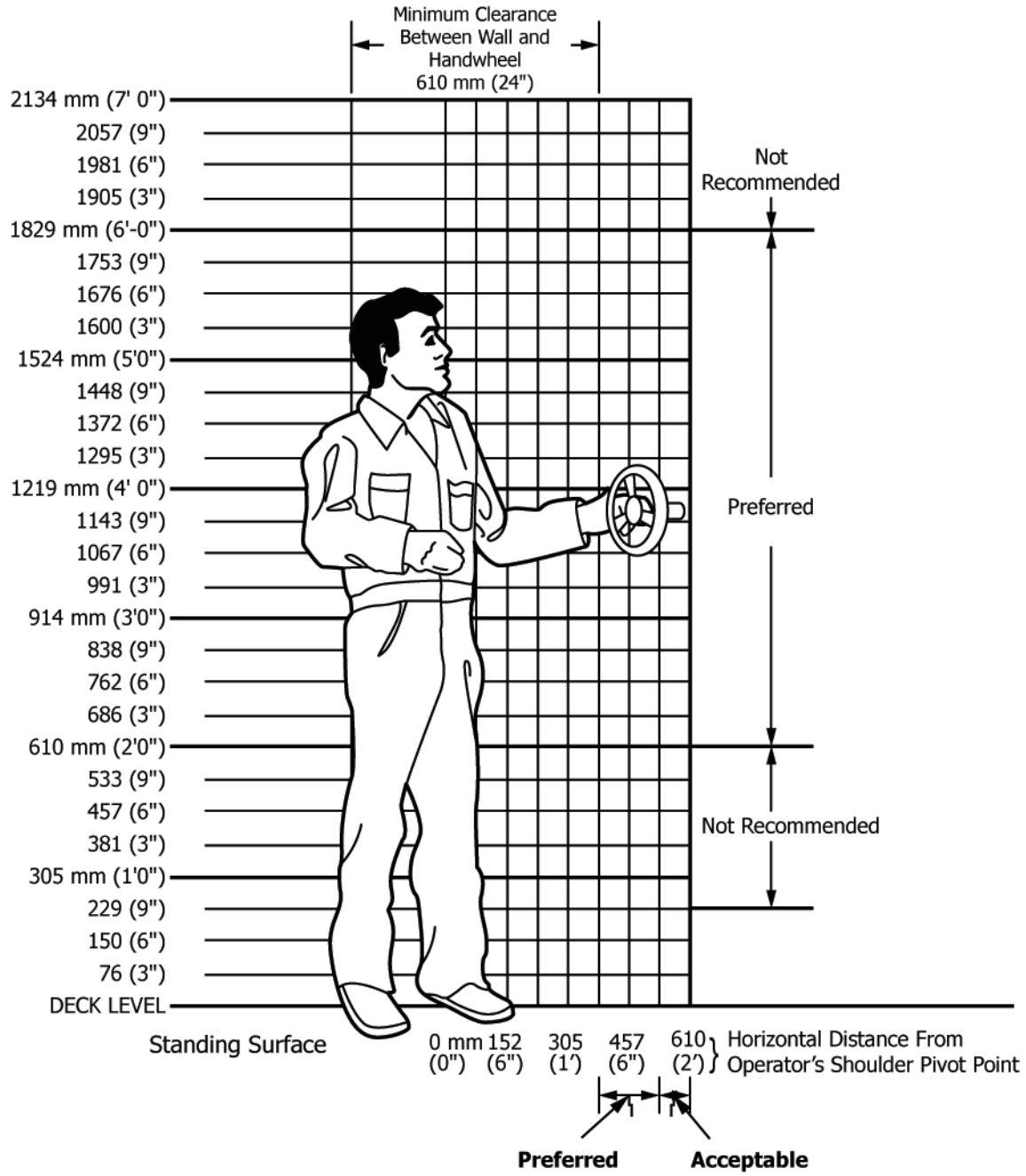
13.1.1.1 *Simplicity*—All aspects of design shall promote presenting the user with essential information required to conduct operational tasks in an organized, uncluttered, and uncomplicated manner. Additionally, the dynamic interaction shall be simplified, for example navigation and data entry tasks shall not require unnecessary actions in order to accomplish the mission.

13.1.1.2 *Consistency*—As a means to achieve an intuitive design based on user expectations, consistency in information displayed and system behavior is essential throughout the interface design both within the bounds of the system designed as well as consistency with design and practices external to the system.

13.1.1.3 *Intuitive*—Design of interfaces shall be based upon established standard procedures or expectations of users in order to maintain acceptable performance and limit human errors. The goal for effective interface design is for the user to be able to anticipate system responses and operate/navigate a system with minimal training.

13.1.1.4 *Task-Oriented*—Design of interfaces shall provide all of the functionality and information required for the operator to perform tasks based on formal analyses of system functions and tasks. Critical to providing task-oriented design is limiting the interaction (both user supplied actions to the system and information fed to the user) to information essential for the specified task.

13.1.2 *Navigation*—The ability to efficiently navigate through functions of an interface shall be provided. The following features shall be provided to promote usable navigation:



NOTE 1—These dimensions are appropriate for 5th % female to 95 % male maritime personnel worldwide except that the top limit should be set at 1753 mm (69 in.) for 5th% males and 1676 mm (66 in.) for 5th % females from such regions as West Africa, Southeast Asia, China, Southern India, and Japan.

FIG. 123 Mounting Heights for Handwheel Valves With Horizontal Stems

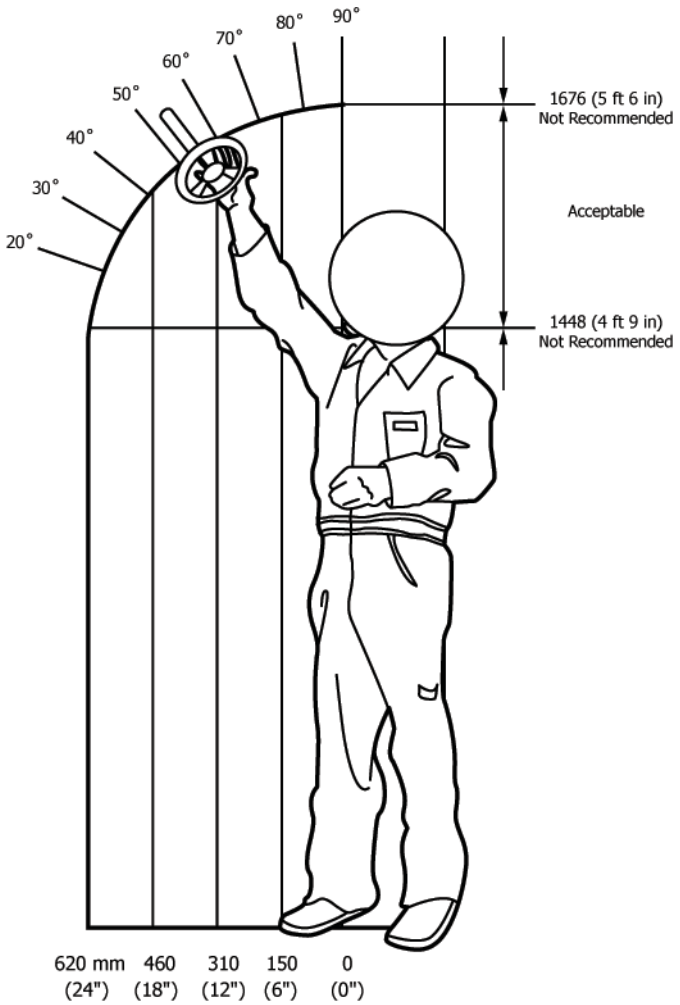
13.1.2.1 Provide current location of the user within an interface at all times.

13.1.2.2 Provide the ability to return to the main window, or HOME screen from all locations within an interface.

13.1.2.3 Limit the "depth" of the interface to three windows or screens that must be retraced in order to return to a HOME screen.

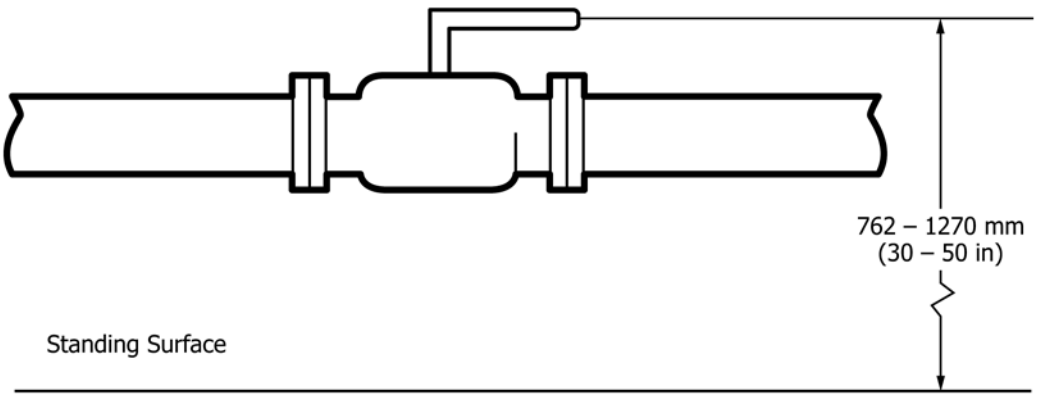
13.1.2.4 Navigational aids shall be provided that allow the user to use a tree or organizational chart to reach a particular "location" or sub-location directly without unnecessary steps.

13.1.3 *Consistency with Physical/Manual Interfaces*—Considering that computer interfaces are often electronic representations of physical/manual interfaces with equipment, such as control panels and associated indicators, the designs of



NOTE 1—These dimensions are for 5th% to 95th% North American males. To cover smaller populations, the angled valves should start at 1448 mm (57 in.) and reach a maximum overhead height of 1676 mm (66 in.) for 5th % females and start at 1600 mm (63 in.) and reach a maximum of 1829 mm (72 in.) for 5th % males for such regions as West Africa, Japan, Southeast Asia, South China, and India.

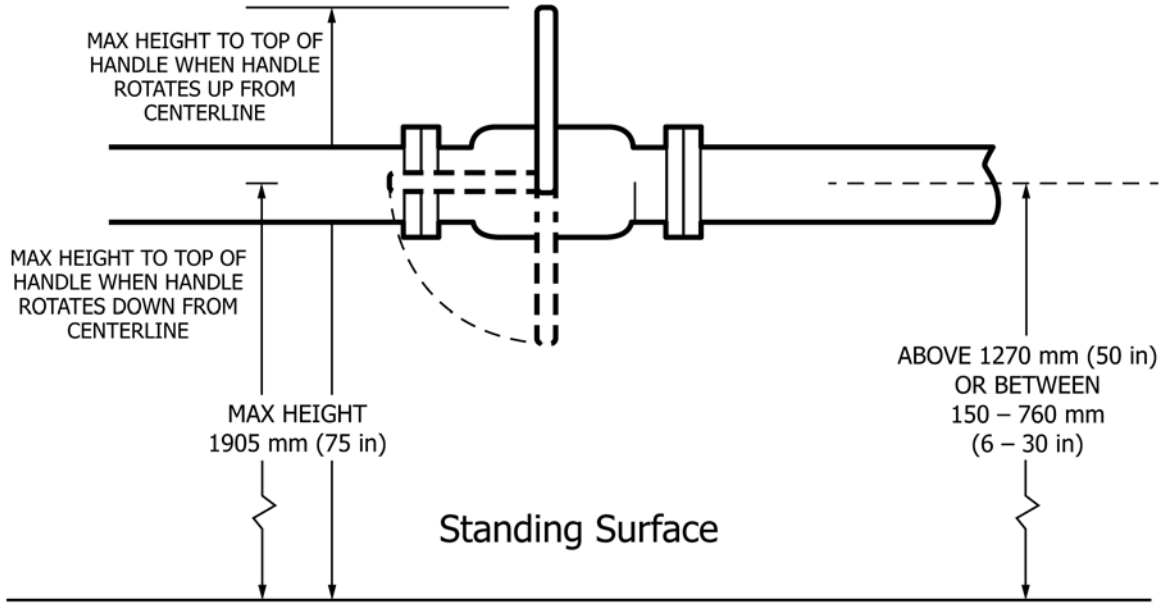
FIG. 124 Mounting Heights for Handwheel Valves With Angled Stems



NOTE 1—These dimensions are appropriate for the 5th % female to the 95th % male maritime personnel worldwide except that the maximum height dimension should be reduced to 1143 mm (45 in.) to accommodate 5th % females from geographic locations such as West Africa, Southeast Asia, China, parts of Latin America, India, and Japan.

FIG. 125 Mounting Heights for Lever-Operated Valves With Vertical Stems

computer interfaces shall also comply with the Human Engineering design criteria in Sections 5 through 8 on Controls, Displays, and Alarms and the Integration therein, in addition to the criteria defined in this chapter.



NOTE 1—These dimensions are drawn from North American males, and therefore are appropriate for Other regions such as Northern Europe, Australia, UK, and Central Europe. These dimensions should be reduced to 1803 mm (71 in.) for 5th % males in areas such as West Africa, Southeast Asia, and South India, and 1727 mm (68 in.) for 5th % females in West Africa, Southeast Asia, South China, South India and Japan. To accommodate the same international population of 5th % females, the horizontal stem valves should be used above 1143 mm (45 in.) above the standing surface, vice 1270 mm (50 in.) as shown.

FIG. 126 Mounting Heights for Lever-Operated Valves With Horizontal Stems

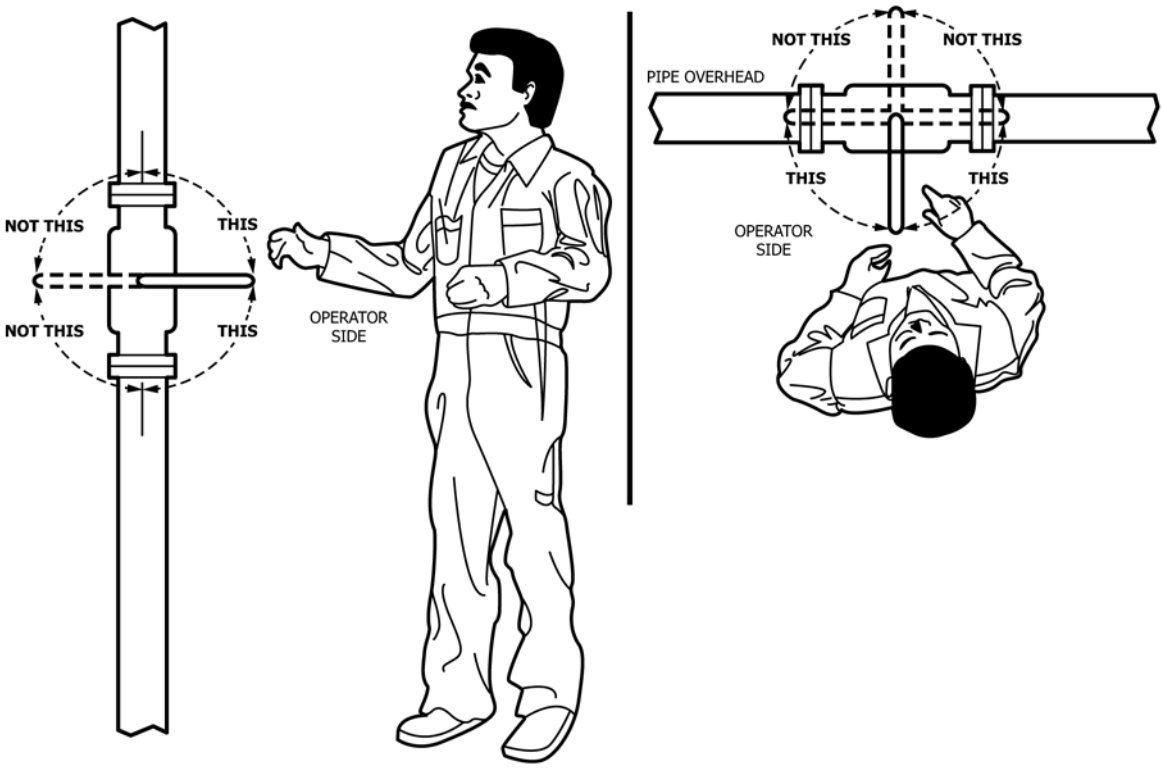
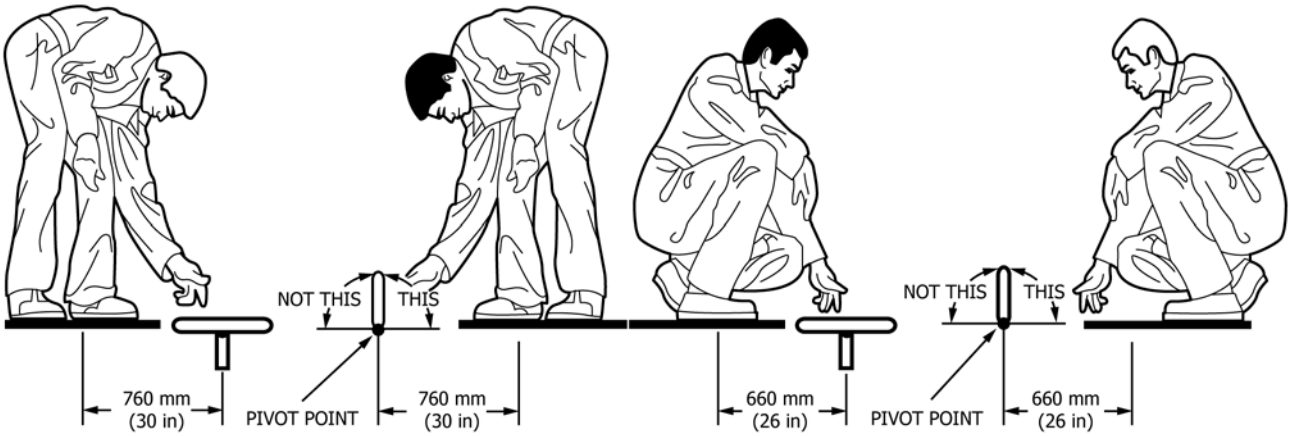


FIG. 127 Direction of Travel for Valve Levers Accessible From One Side Only

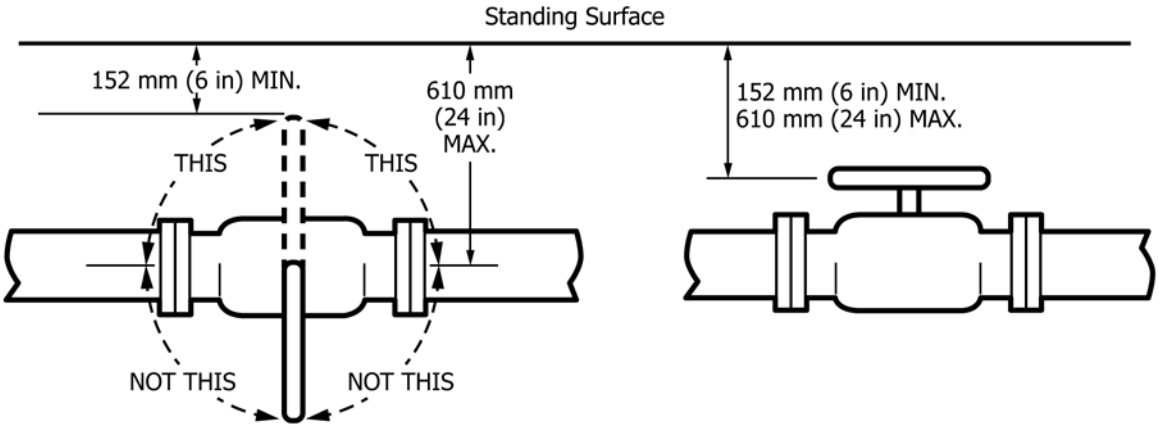
13.1.4 *Standard Procedures*—Users shall be provided standard procedures for similar, logically related transactions based upon an analysis of operator or maintainer tasks.

13.1.5 *Computer Response*—Every input by a user shall consistently produce some perceptible response output from the computer.



NOTE 1—These dimensions are appropriate for 5th % to 95th % maritime populations worldwide but should be reduced 102 mm (4 in.) for stooping postures and 76 mm (3 in.) for squatting postures to accommodate the 5th % males, and 127 mm (5 in.) for the stooping posture and 102 mm (4 in.) for the kneeling posture for the 5th % females in such regions as Southeast Asia, South China, India, Near East, and Japan.

FIG. 128 Physical Reach from a Stooping or Squatting Position



NOTE 1—These dimensions are appropriate for all maritime personnel except that the maximum reach below the standing surface should be reduced from 610 mm (24 in.) to 508 mm (20 in.) to accommodate the 5th % males and females in Southeast Asia, Near East, South China India, and Japan.

FIG. 129 Mounting Position for Valve Levers and Handwheels Below Standing Surface

TABLE 29 Access Opening and Mounting Depth Dimensions for Levers and Handwheels Mounted Below the Standing Surface

Valve Handle (Diameter or Length)	Depth Below Deck	Deck Opening Size
Handwheel		
127 mm (5 in.) or less	152–254 mm (6–10 in.)	178 mm (7 in.)
	Greater than 254 mm (10 in.)	216 mm (8.5 in.)
127 mm (5 in.) or more	152 mm (6 in.) to 457 mm (18 in.)	The diameter of the handwheel plus 152 mm (6 in.) with a minimum of 356 mm (14 in.)
Lever		
Any Lever Length	Any Depth up to 457 mm (18 in.)	254 mm (10 in.)

13.1.6 *Screen Design and Content*—The design of the video-display screen layout including display partitioning, paging, scrolling, and inter-frame considerations should be based upon an analysis of operator or maintainer tasks.

13.1.7 *Coding*—Coding should be used to enhance the transfer of information to personnel. Coding should be consistent and meaningful.

13.1.8 *Input Devices*—Computer input and entry devices should be appropriate for the intended task and should be compatible with the environment. For example, on moving platforms, the use of rolling input and entry devices, such as a mouse, should be avoided.

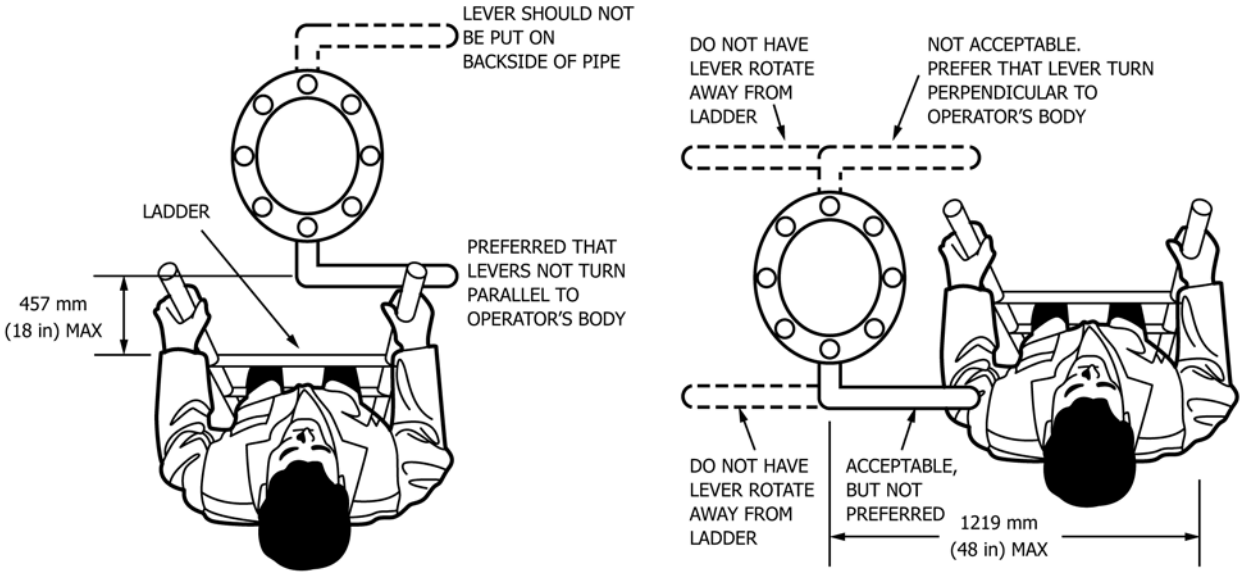
13.1.9 *System Status*—Users shall be provided information at all times on system status regarding operational modes, availability, and loads, either automatically or by request.

13.1.10 *On-Line Help*—Users shall be provided on-line, context-sensitive help. Definitions of allowable options, system capabilities, procedures, and ranges of values shall be displayable at the user's request.

13.2 *System Operations:*

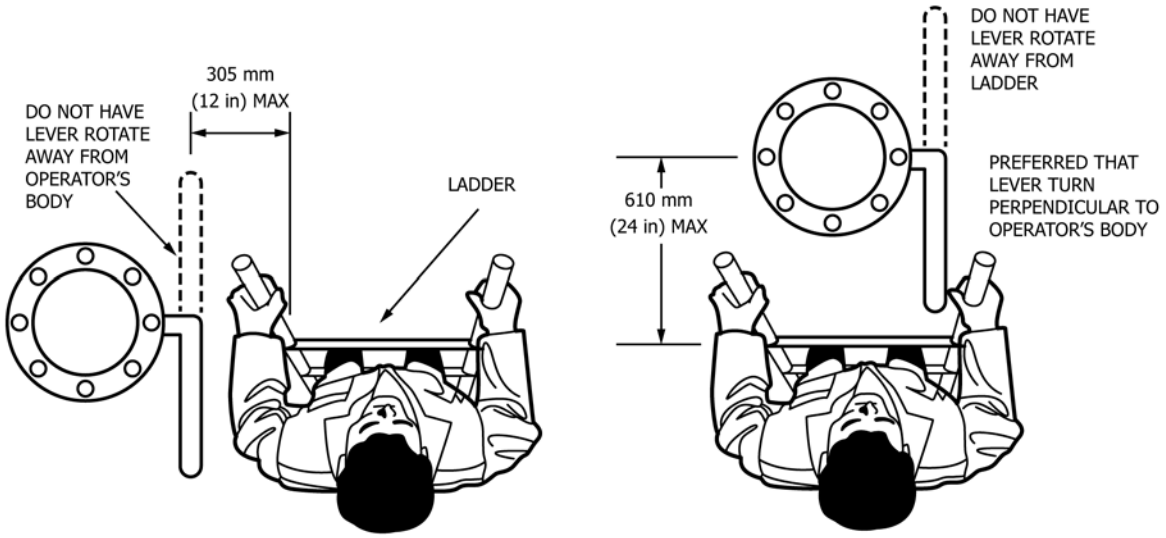
13.2.1 *Log-On Procedures*—In applications in which users must log-on to the system, log-on shall be a separate procedure that must be completed before a user is required to select among any operational options.

13.2.1.1 *Automatic Log-On Display*—Appropriate prompts for log-on shall be automatically displayed on the user's terminal with no special action required other than turning on the terminal.



NOTE 1—The maximum distance from the lever shown on the right should be reduced from 1219 mm (48 in.) to 1016 mm (40 in.) to accommodate 5th % females from geographic locations such as West Africa, Southeast Asia, and Latin America.

FIG. 130 Orientation and Reach from Ladder Parallel to Valves



NOTE 1—The maximum distance from the center of the valve shown on the right should be reduced from 610 mm (24 in.) to 533 mm (21 in.) to accommodate 5th % males and females from geographic locations such as West Africa, Southeast Asia, China, India, and parts of Latin America.

FIG. 131 Orientation and Reach from Ladder Perpendicular to Valves

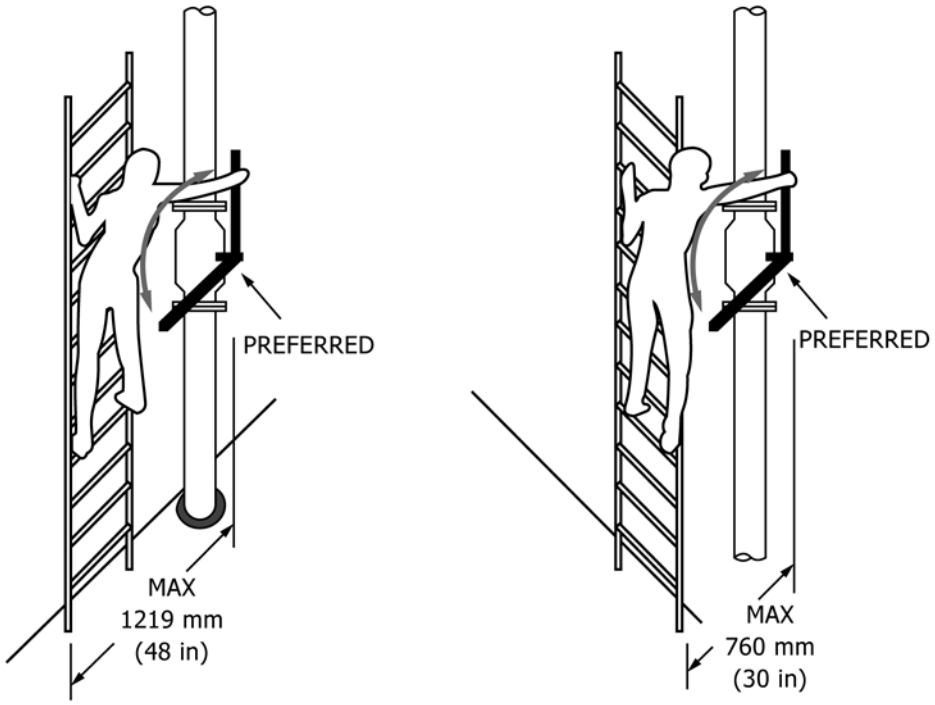
13.2.1.2 *Log-On Feedback*—Users shall be provided feedback relevant to the log-on procedure that indicates the status of the inputs.

13.2.1.3 *Log-On Delay*—If a user cannot log-on to a system, a prompt shall be provided to explain the reason for this inability. Log-on processes shall require minimum input from the user consistent with the requirements prohibiting illegal entry.

13.2.2 *Log-Off Procedures*—When a user signals for log-off, the system shall check pending transactions to determine if data loss seems probable. If so, the computer shall prompt for confirmation before the log-off command is executed.

13.2.3 *Computer Failure*—In the event of partial hardware/software failure, the program shall allow for orderly shutdown and establishment of a checkpoint so restoration can be accomplished without loss of computing performed to date.

13.2.4 *Interaction*—Where two or more users must have simultaneous read access to the computer program or data processing results from multiple personnel equipment interfaces, the operation by one person shall not interfere with the operations of another person unless mission survival may be contingent upon the preemption. Provisions shall be made so that the preempted user can resume operations at the point of interference without information loss.



NOTE 1—The maximum distance from the center of the valve shown on the left should be reduced from 1219 mm (48 in.) to 1016 mm (40 in.) and the distance on the right should be reduced from 762 mm (30 in.) to 660 (26 in.) to accommodate 5th % males and females from such geographic locations as West Africa, Southeast Asia, India, Latin America, and Japan.

FIG. 132 Operating Valves from a Ladder

13.3 *Computer Displays:*

13.3.1 *Design Criteria*—Following are design criteria for selecting or manipulating video displays used as a computer interface. Although the criteria provide enough data to provide a safe and usable system, additional detailed information can be found in Section 6, "Displays" and ANSI/HFES 100-2007 Human Factors Engineering of Computer Workstations..

13.3.2 *Luminance*—A display luminance of 80 to 160 cd/m^2 (22.9 to 45.7 ft-L) is the preferred average luminance level for a text-filled video display. The minimal acceptable luminance level for a text-filled video display is 45 cd/m^2 (12.9 ft-L). Display luminance should be consistent across video displays. A control shall be provided to vary the luminous symbol/dark background or dark symbol/luminous background contrast ratio.

13.3.2.1 *Peak Display Luminance*—Peak luminance of a video display should be at least 35 cd/m^2 (10 ft-L) in moderate levels of ambient lighting and approximately 100 cd/m^2 (35 ft-L) in high levels of ambient lighting. When video-display units may be used in direct sunlight (for example, navigation bridge or drillers' shack), liquid-crystal displays provide for better readability. Sun shields in combination with high luminance outdoor-type displays should also be used. Additionally, care should be taken in locating the video-display units to minimize the incidence of sunlight.

13.3.3 *Contrast Ratio (Brightness Contrast)*—Contrast ratios for color combinations should be between 6:1 and 10:1 with a preferred ratio of 10:1. These ratios are based on preferred background luminance levels between 15 and 20 cd/m^2 (4.3 to 5.7 ft-L). The contrast ratio for monochromatic displays should be approximately 3:1 and provide adjustable luminance levels and contrast ratios over the stated ranges.

13.3.4 *Refresh Rate*—CRT displays shall be refreshed at a rate of at least 65 Hz, preferably more than 100 Hz, to avoid the perception of flicker on monitors for photosensitive users.

13.3.5 *Monochromatic Color Combinations*—The optimum combination for monochrome video displays is a black image on a white background. Where this is not achieved, white, green, or amber images on a dark background are also acceptable.

13.3.5.1 *Color Uniformity*—Color rendition throughout the display should be uniform.

13.3.6 *Resolution and Display Size*—Video display resolution and display size shall be sufficient for the level of detail required for the visual tasks performed. Resolution shall be sufficient to support character sizes outlined in 13.8.2 of this chapter.

13.3.6.1 *Display Aspect Ratios*—Display aspect ratios (width-height ratios) of 5:7 or 2:3 are recommended for readability of text.

13.3.7 *Flat Panel Image Formation Time*—Flat panel displays should have an image formation time of less than 55 ms.

13.3.8 *Flicker*—The image and its background on the video display should be free of apparent flicker under all lighting conditions, including florescent lighting.

13.3.9 *Jitter*—Cathode Ray Tube-type video displays and other sensitive components should be located away from sources of strong magnetic fields, such as motors and generator sets. Deviations in the location of a displayed element shall be

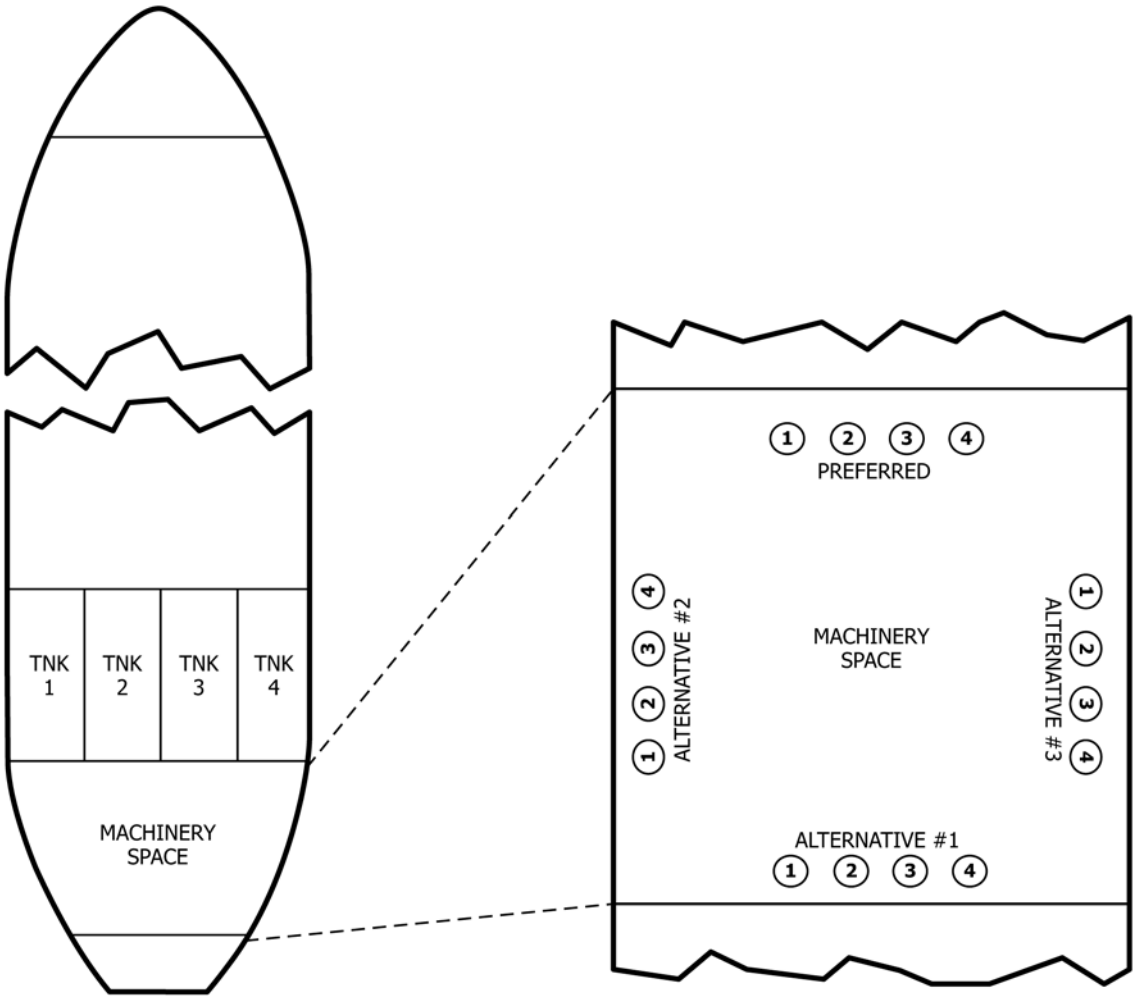


FIG. 133 Valve Manifold for Tanks Located Athwartship

equal to or less than 0.0002 mm per millimetre of viewing distance over the period of a second.

13.3.10 *Glare*—Video displays, including flat panel displays, should be positioned so that sources of light (for example, area lighting, spot lighting, indicator lamps, etc.) or bright objects are not reflected in the viewing screen.

13.4 *Display Content:*

13.4.1 *Standardization*—The content of displays within a system shall be presented in a consistent, standardized manner.

13.4.2 *Information Density*—Information density shall be held to a minimum in displays used for critical task sequences. A minimum of one-character space shall be left blank vertically above and below critical information, with a minimum of two character spaces left blank horizontally before and after.

13.4.2.1 *Crowded Displays*—When a display contains too much data for presentation in a single frame, the data shall be partitioned into separately displayable pages.

13.4.2.2 *Related Data*—When partitioning displays into multiple pages, functionally related data items shall be displayed together on one page.

13.4.2.3 *Page Labeling*—In a multi-page display, each page shall be labeled to show its relation to the others.

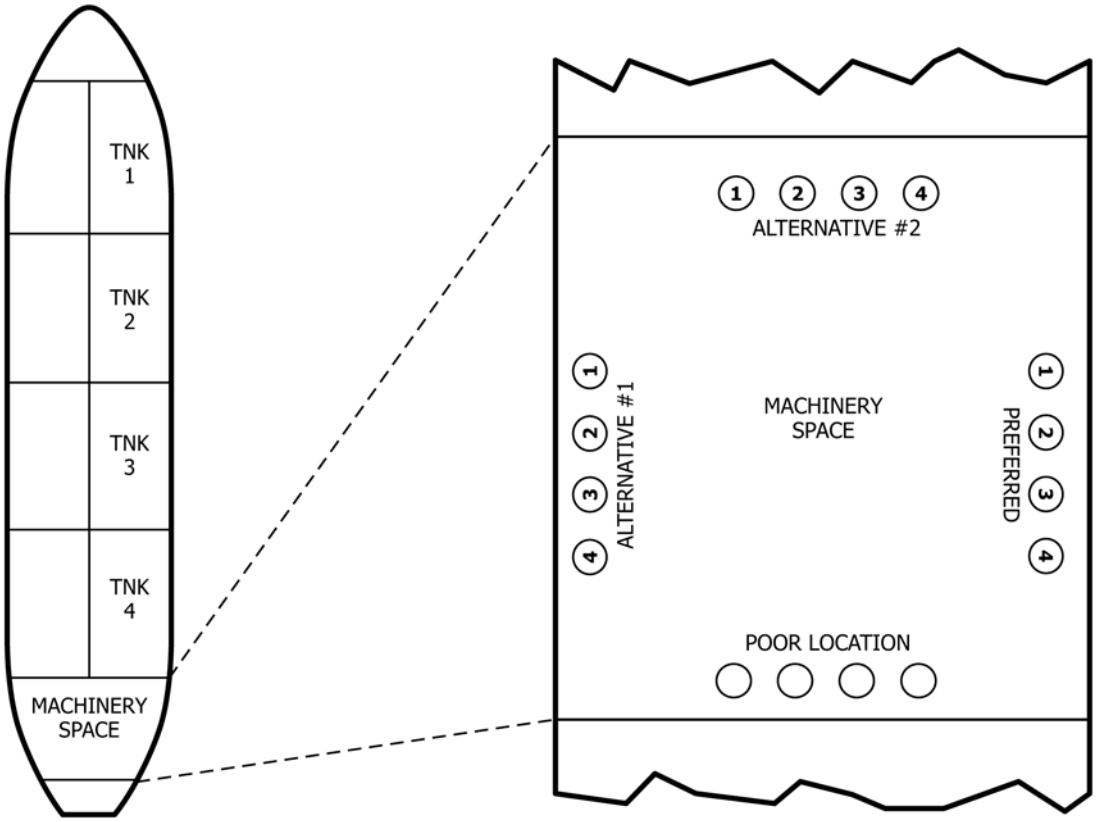
13.4.3 *Data Display Consistency*—Data display word choice, format, and style shall be consistent with the requirements for data entry and control.

13.4.3.1 *Data Display Context*—The user shall not have to rely on memory to interpret new data; each data display shall provide needed context, including recapitulating prior data from prior displays as necessary.

13.5 *Display Coding:*

13.5.1 *Use*—Coding shall be used to differentiate between items of information and to call the user's attention to changes in the state of the system. Coding shall be used for critical information, unusual values, changed items, items to be changed, high priority messages, special areas of the display, errors in entry, criticality of command entry, and targets. Consistent, meaningful codes shall be used. Coding shall not reduce legibility or increase transmission time. See also Section 6, "Displays."

13.5.2 *Flash Coding*—Flash coding shall be used to call the user's attention to mission critical events only. No more than 2 flash rates shall be used. Where one rate is used, the rate shall be 3–5 flashes per second. Where two rates are used, the



NOTE 1—In Fig. 134, the starboard-facing orientation of the valve manifold is preferred over the port-facing orientation to allow the ordering of the tank numbers to read from left to right. This preference principle is different from that for a mimic control console (such as a ballast control console) where the required console orientation is facing forward or to port with the forward-most items located on the right hand side of the console.

FIG. 134 Valve Manifold for Tanks Located Fore and Aft

second rate shall be not greater than 2 per second. The display should have a 50 % on- and 50 % off-cycle.

13.5.3 *Brightness Coding*—Brightness intensity coding shall be employed only to differentiate between an item of information and adjacent information. No more than two levels of brightness shall be used. Each level shall be separated from the nearest other level by not less than a 2:1 ratio.

13.5.4 *Pattern and Location*—Pattern and location coding shall be used to reduce user search time by restricting the area to be searched to prescribed segments.

13.5.5 *Underlining/Bold*—Bold text styles may be used to indicate unusual values, errors in entry, changed items, or items to be changed. Underlining, however, should only be used for hyperlinks.

13.5.6 *Symbols*—Symbol coding may be used to enhance information assimilation from data displays. Symbols shall be analogs of the event or system element they represent or be in consistent general use and well known to the expected users. Where size difference between symbols is used, the major dimensions of the larger shall be at least 150 % of the major dimension of the smaller with a maximum of three size levels permitted. Additional guidance on symbols is provided in 13.9.20 and Section 15, "Labeling."

13.5.6.1 *Special Symbols*—When special symbols are used to signal critical conditions, they shall be used for only that purpose. See also Section 15, "Labeling" for special symbols.

13.5.6.2 *Symbols as Word Markers*—When a special symbol is used to mark a word, the symbol shall be separated from the beginning of the word by one space.

13.5.7 *Color Coding*—Color coding may be used to differentiate between classes of information in complex, dense, or critical displays and shall follow the following criteria:

(1) Information shall not be coded solely by color if the data must be accessed from monochromatic as well as color terminals or printed in hardcopy versions.

(2) Color-filled symbols shall be used instead of color outlined symbols.

(3) Color-coding schemes should not vary between different displays or the screens of any single display.

(4) No more than six colors should be used when the meaning of a color is to be remembered as part of a coding scheme, or if rapid visual search tasks based on color discrimination are required.

13.5.7.1 *Selecting Colors*—The color-coding schemes used on a video display should be in accordance with Control Color Coding information in Section 5, "Controls" and Table 5, "Typical Display and Alarm Color Codes for North American Industry." Other colors may be used to present other types of information provided that contrast ratios meet the requirements of 13.3.3, and the following guidance to allow for ease of reading:

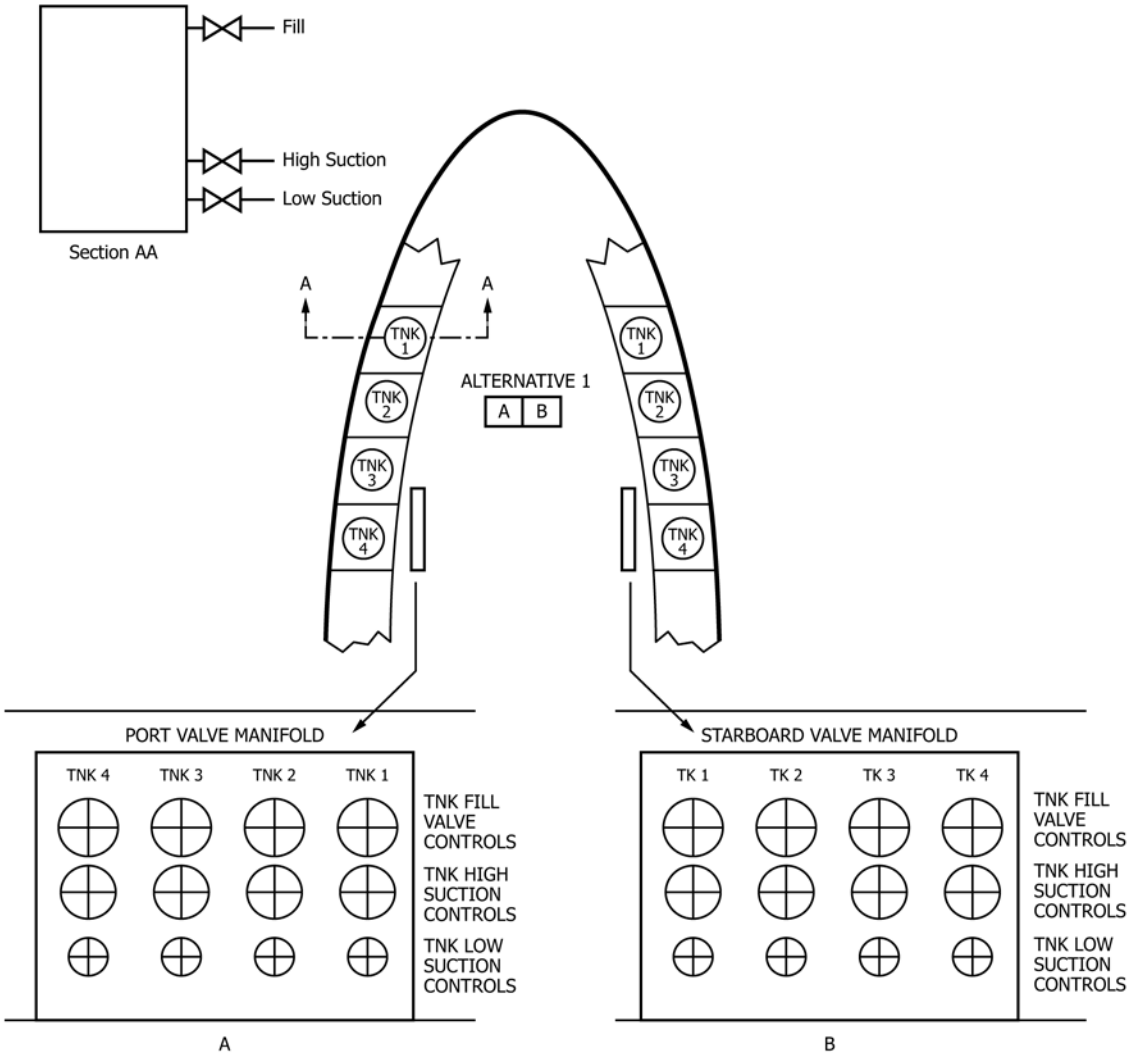


FIG. 135 Valve Manifold for Fill, High-Suction, and Low-Suction Valves

(1) Orange should be used only if clearly visually different from red, yellow, and white.

(2) Magenta, blue, blue-violet, and violet should be avoided.

(3) For a darker background, dark blue is not suitable for text, thin lines, or high-resolution information. On light backgrounds, dark blue may be confused as black.

(4) Saturated blue and saturated red contrasts should be avoided (red-on-blue background and blue-on-red background).

(5) Where personnel may have difficulty discriminating colors (that is, color deficient vision), color coding should be supplemented by other forms of coding.

13.5.7.2 It is recommended to use established color codes for piping system labeling (see Section 15, "Labeling") on computer interfaces and other items in order to provide consistency between parts of the video display and physical items.

13.5.8 *Shape Coding*—The designer should use shape categories (for example, circles, triangles, and squares) to code related objects and to support the user's ability to search, identify, and discriminate between various categories of displayed data. When shape coding is used, the codes selected shall be based on established standards, conventional meanings or shapes that suggest the purpose of the control (for example, round for a wheel, flap shape for an airplane wing flap). The number of shapes to be identified by each operator based on absolute discrimination shall be not more than ten. The designer should ensure that screen resolution is adequate for shape coding.

13.5.9 *Brightness Inversion*—When a capability for brightness inversion is available (so-called "reverse video," where dark characters on a bright background can be changed under computer control to bright on dark or vice versa), it may be used for highlighting critical items that require user attention. When used for alerting purposes, brightness inversion shall be reserved consistently for that purpose and not be used for general highlighting.

13.5.10 *Line Coding*—Meaningful differences between lines appearing in graphic displays, such as flow paths, should be depicted using various line types (for example, solid, dashed, dotted, and various widths). Line types should be

limited to three and line widths should also be limited to three. Line coding should be used sparingly.

13.6 *Dynamic Displays:*

13.6.1 *Changing Values*—Changing alphanumeric values that the operator must reliably read shall not be updated more than once per second. Changing values that the viewer uses to identify rate of change or to read gross values shall not be updated faster than five times per second, or slower than two per second, when the display is to be considered as real time.

13.6.2 *Update Rate Control*—The rate of update shall be controllable by the user and shall be determined by the use to be made of the information.

13.6.3 *Display Freeze*—A display freeze mode shall be provided to allow close scrutiny of any selected frame that is updated or advanced automatically by the system. For frozen display frames, an option shall be provided to allow resumption at the point of stoppage or at the current real-time point.

13.6.4 *Freeze Feedback*—An appropriate label or indication shall be provided to remind the operator when the display is in the freeze mode.

13.7 *Display Format:*

13.7.1 *Consistency*—Display formats shall be consistent within a system.

13.7.1.1 When appropriate for users, the same format shall be used for input and output.

13.7.1.2 Data entry formats shall match the source document formats.

13.7.1.3 Essential data, text, and formats shall be under computer, not user, control.

13.7.2 *Data Criticality*—Only data essential to the user's needs shall be displayed. Prioritize pertinent data to minimize clutter.

13.7.3 *Usability*—Data presented to the user shall be in a readily usable and readable form that the user does not have to transpose, compute, interpolate, or mentally translate into other units, number bases, or languages.

13.7.4 *Order and Sequence*—When data fields have a naturally occurring order (such as chronological), such order shall be reflected in the format organization of the fields.

13.7.4.1 *Grouped by Importance*—Where some displayed data items are of significant importance or require immediate user response, those items shall be grouped at the top and left of the display.

13.7.4.2 *Grouped by Function*—Where sets of data are associated with particular questions or related to particular functions, each set may be grouped together to help illustrate those functional relationships.

13.7.4.3 *Grouped by Frequency*—Where some data items are used more frequently than others, those items may be grouped at the top of the display.

13.7.5 *Data Separation*—Separation of groups of information shall be accomplished by blanks, spacing, lines, color coding, or other means consistent with the application. (See 8.2.)

13.7.6 *Recurring Data Fields*—Recurring data fields within a system shall have consistent names and shall have consistent relative positions within displays.

13.7.7 *Extended Alphanumerics*—When five or more alphanumeric characters within natural organization are displayed, the characters shall be grouped in blocks of three or four characters within each group separated by a minimum of one blank space or other separating character such as a hyphen or slash. When a code consists of both letters and digits, common character types shall be grouped for ease of location.

13.7.8 *Comparative Data Fields*—Data fields to be compared on a character-by-character basis shall be positioned one above the other.

13.7.9 *Labels and Titles*—Each display shall be labeled with a title or label that is unique within the system. To make the display as meaningful as possible and to reduce user memory requirements, every field or column heading shall be labeled.

13.7.9.1 *Display Title*—Every display shall begin with a title or header at the top, describing briefly the contents or purpose of the display. There shall be at least one blank line between the title and the body of the display.

13.7.9.2 *Command Entry, Prompts, Messages at Bottom*—The last several lines at the bottom of every display shall be reserved for status and error messages, prompts, and command entry. Messages that are critical or that require operator acknowledgment should appear in their own dialogue boxes.

13.7.10 *Data Group Labels*—Each individual data group or message shall contain a descriptive title, phrase, word, or similar device to designate the content of the group or message. Labels shall perform the following:

13.7.10.1 Be located in a consistent fashion adjacent to the data group or message they describe. The relationship of the label to the group, field, or message being described shall be unambiguous.

13.7.10.2 Be highlighted or otherwise accentuated to facilitate operator scanning and recognition. The technique used to accentuate labels shall be different from, and easily distinguished from, that used to highlight or code emergency or critical messages.

13.7.10.3 Be unique and meaningful to distinguish them from data, error messages, or other alphanumerics.

13.7.10.4 Reflect the question or decision being posed to the user, when presenting a list of user options.

13.7.11 *Page Numbering*—Each page of a multiple-page display shall be labeled to identify the currently displayed page and the total number of pages, for example, "Page 2 of 5."

13.7.12 *Frame Identification*—Every display frame shall have a unique identification to provide a reference for use in requesting the display of that frame. The frame identification shall be an alphanumeric code or an abbreviation which is prominently displayed in a consistent location. It shall be short enough (three to seven characters) and meaningful enough to be learned and remembered easily.

13.7.13 *Tabular Data Use*—Tabular data displays shall be used to present row-column data.

13.7.13.1 *Tabular Formats*—Location of recurring data shall be similar among all tabular data displayed and common throughout the system.

13.7.13.2 *Tabular Data Arrangement*—Tabular data shall be displayed in rows and columns. If the data in the rows have order, the order shall increase from left to right. If the data in

the columns have order, the order shall increase from top to bottom. Alphanumeric data shall be left justified; numeric data shall be right justified with decimal points, if any, aligned vertically.

13.7.13.3 *Tabular Data Titles*—When tabular data are divided into classifications, the classification titles shall be displayed and sub-classification shall be identified. When tabular data extend over more than one page vertically, the columns shall be titled identically on each page.

13.7.13.4 *Horizontal Tables*—Tabular displays shall not extend over more than one page horizontally.

13.7.14 *Lists*—Items in lists shall be arranged in a recognizable order, such as chronological, alphabetical, sequential, functional, or importance.

13.7.14.1 *List Lines*—Each item in a list shall start on a new line.

13.7.14.2 *Vertical Extension*—Where lists extend over more than one display page, the last line of one page shall be the first line of the succeeding page.

13.7.14.3 *Multi-line Items*—Where a single item in a two separate word list continues for more than one line, such items shall be marked in some way (for example, blank line, indentation) so that the continuation of the item is obvious.

13.7.14.4 *List Numerals*—When listed items will be numbered, Arabic numerals shall be used rather than Roman numerals.

13.7.14.5 *List Labels*—Rows and columns shall be labeled distinctively to guide data entry.

13.7.14.6 *Vertical Ordering*—Where items in a list are displayed in multiple columns, items shall be ordered vertically within each column.

13.7.14.7 *Hierarchical Structure*—Where lists are long and must extend beyond more than one displayed page, a hierarchic structure shall be used to permit the logical partitioning into related shorter lists.

13.7.15 *Numeric Punctuation*—Long numeric fields shall not be punctuated with spaces, commas, or slashes. Conventional punctuation schemes shall be used if in common usage. Where none exist, a space shall be used after every third or fourth digit. Leading zeros shall not be used in numerical data except where needed for clarity.

13.7.16 *Numeric Justification*—Users shall be allowed to make numeric entries in tables without concern for justification; the computer shall right justify integers or else justify with respect to a decimal point if present.

13.7.16.1 *Labeling Units*—In tabular display, the units of displayed data shall be consistently included in the column labels.

13.7.16.2 *Column Spacing*—Column spacing within a table from one table to another shall be uniform and consistent.

13.7.16.3 *Column Separation*—A column separation of at least three spaces shall be maintained.

13.7.16.4 *Row Separation*—In dense tables with many rows, a blank line shall be inserted after a group of rows at regular intervals. No more than five lines shall be displayed without a blank line being inserted.

13.8 *Textual Data Displays:*

13.8.1 *Use*—Information, such as abstracts or reports, that cannot be presented in any other format, may be presented in text format.

13.8.2 *Character Formats*—Textual data formats for electronic displays shall conform to the following criteria:

13.8.2.1 The minimum font size used on video screens shall be 9 point.

13.8.2.2 The default font size shall be 12 point.

13.8.2.3 Shall be consistent with visual angle in 6.4.

13.8.2.4 When characters are formed using a dot matrix, the matrix should be at least 7 dots wide and 9 dots high.

13.8.2.5 Capital letters shall be used for the first letter of every word (“Title Case”) for titles, headings and short phrases with the exception of abbreviations and acronyms which shall be all capitals. For sentences, standard capitalization rules shall apply. In the case of labels used within graphical representations of equipment or control panels on electronic displays (for example, mimics or control representations), capitalization rules for “identification” labels as described in Section 15, “Labeling” shall apply. Dot matrix and segmented displays shall use all capitals.

13.8.3 *Brevity*—Short simple sentences shall be used and shall be displayed in normal upper/lower case font.

13.8.4 *Abbreviations and Acronyms*—Information shall be displayed in plain concise text. Abbreviations and acronyms shall conform to Section 15, “Labeling.” Abbreviations shall be distinctive to avoid confusion. Words shall have only one consistent abbreviation. No punctuation shall be used in abbreviations. Definitions of all abbreviations, mnemonics, and codes shall be provided at the user’s request.

13.8.5 *Print Layout*—Users shall have the option of displaying text as it will be printed, including underlining, boldface, subscript, superscript, special characters, special symbols, and different styles and sizes of type. Where display of all possible features (for example, special fonts) is impractical, format codes shall be highlighted and displayed within the text to mark the text that will be affected by the code.

13.9 *Graphic Displays:*

13.9.1 *Use*—Graphic data displays may be used to present assessment of trend information, spatially structured data, time critical information, or relatively imprecise information.

13.9.2 *Recurring Data*—See 13.7.6.

13.9.3 *Refresh Rates*—Graphic displays that require user visual integration of changing patterns shall be updated at the maximum refresh rate of the display device consistent with the user’s information handling rates.

13.9.4 *Line Format*—Graphic lines shall be no less than ¼ pt. Graphic lines should contain a minimum of 50 resolution elements per inch, which will give the user a sense of continuity.

13.9.5 *Trend Lines*—When trend lines are to be compared, multiple lines shall be used on a single graph.

13.9.6 *Pointing*—Where graphic data entry involves frequent pointing on a display surface, the user interface shall provide display control and sequence control by pointing to minimize shifts from one entry device to another. For example, in drawing a flow chart, a user shall be able to link elements or

points directly by pointing at them or drawing lines between rather than by separately keyed entries.

13.9.7 *Distinctive Cursor*—The current cursor position on a graphic display shall be indicated by displaying some distinctive cursor symbol at that point, for example, a plus sign, representing abbreviated crosshairs whose intersection can mark a position with reasonable precision.

13.9.8 *Precise Positioning*—Where data entry requires exact placement of graphic elements, users shall be provided the capability for expansion of the critical display area (for example, zooming and panning) to make the positioning task easier and more precise.

13.9.9 *Selecting Graphic Elements*—Users shall be provided some means for designating and selecting displayed graphic elements for manipulation such as by pointing where a pointing device is provided for line-drawing purposes.

13.9.9.1 *Selecting from Displayed Attributes*—During graphic data entry, users shall be allowed to specify attributes for displayed elements (for example, text font, plotting symbol, line type) by selecting from displayed samples illustrating the available options.

13.9.9.2 *Display Current Attributes*—During graphic data entry/editing, the selected attributes that will affect current actions shall be displayed for ready reference as a reminder of current selections in effect.

13.9.10 *Easy Storage and Retrieval*—An easy and convenient means shall be provided for saving and retrieving graphic displays for their possible reuse. The user shall be allowed to designate filenames of his or her choice for the stored graphic data.

13.9.11 *Automatic Data Registration*—The computer shall provide automatic registration or alignment of computer-generated graphic data, so that variable data are shown properly with respect to fixed background or data map at any display scale.

13.9.12 *Graphic Formats*—Where graphic data must be plotted in predefined standard formats (for example, target areas on maps, flight plans), templates or skeletal displays shall be provided for those formats to aid data entry.

13.9.13 *Derivation of Graphical Data*—When graphic data can be derived from data already available in the computer, machine aids for that purpose shall be provided.

13.9.14 *Drawing Lines*—When line drawing is required, users shall be provided with aids for drawing straight line segments. When line segments must join or intersect, computer aids shall be provided to aid in such connection.

13.9.14.1 *Drawing Figures*—When a user must draw figures, computer aids shall be provided for that purpose (for example, templates, tracing techniques, stored forms).

13.9.14.2 *Drawing with Numeric Coordinates*—When lines or figures must be drawn to represent numeric coordinates, computer aids should include templates for entering the coordinates, and if necessary, selecting the appropriate units for those coordinates.

13.9.15 *Resizing*—When editing graphic data, users shall be provided with the capability to change the size (scale) of any selected element on the display, rather than delete and recreate the element in a different size.

13.9.16 *Highlighting Data*—When a user's attention must be directed to a portion of a graphic display showing critical or abnormal data, that feature shall be highlighted with some distinctive means of data coding.

13.9.17 *Reference Index*—When a user must compare graphic data to some significant level or critical value, a reference index or baseline shall be included in the display.

13.9.18 *Annotation of Data*—When precise reading of a graphic display may be required, the capability shall be provided to supplement the graphic representation with the actual numeric values.

13.9.19 *Label Orientation*—The labels on dynamic graphic displays shall remain with the top of the label up when the displayed image rotates.

13.9.20 *Pictorial Symbols*—Pictorial symbols (for example, icons, pictograms) shall look like the objects, features, or processes they represent and shall consist of a graphic image and an identifying label. When images are used to identify controls, status indicators, or other programmatic elements, the meaning assigned to those images shall be consistent throughout an application and across related applications.

13.9.21 *Display of Scale*—When a map or other graphic display has been expanded from its normal presentation, an indicator of the scale expansion shall be provided.

13.9.21.1 *Consistent Scaling*—When users must compare graphic data across a series of charts, the same scale shall be used for each chart.

13.9.21.2 *Single Scale*—Where graphs are presented, only a single scale shall be shown in each axis, rather than including different scales for different curves in the graph. If interpolation must be made or where accuracy of reading graphic data is required, computer aids shall be provided the user.

13.9.22 *Grids*—When grid lines are displayed, they shall be unobtrusive and shall not obscure data elements. Grid lines shall be displayed or suppressed at the option of the user.

13.9.23 *Graphic Comparison*—Where users must evaluate the difference between two sets of data, that difference shall be plotted directly as a curve in its own right, rather than requiring users to compare visually the curves that represent the original data sets.

13.9.24 *Bar Graphs*—Bar graphs shall be used for comparing a single measure across a set of several entities or for a variable sampled at discrete intervals.

13.9.24.1 *Bar Spacing*—Adjacent bars shall be spaced closely enough, normally not more than one bar width, so that a direct visual comparison can be made without eye movement.

13.9.24.2 *Histograms*—Histograms (bar graphs without spaces between the bars) shall be used where bar graphs are required and where a great many intervals must be plotted.

13.9.25 *Maps*—Map displays shall be large enough to permit the simultaneous presentation and visual integration required by users. When more than one map will be displayed, all maps should have the same orientation, usually with north at the top. When important for task performance and to the extent possible, other displays, such as dialog boxes and windows, should not obscure a map display.

13.9.26 *Mimics*—Mimics displayed shall contain the minimum amount of detail required to yield a meaningful pictorial

representation. Mimics shall follow the design criteria outlined in Section 6, "Displays."

13.10 *Audio Displays:*

13.10.1 *Use*—Audio displays (signals), used as part of the user-computer interface, have applications where:

13.10.1.1 The common mode of visual display is restricted by overburdening or user mobility needs and it is desirable to cue, alert, or warn the user.

13.10.1.2 The user shall be provided feedback after control actuation, data entry, or completion of timing cycles and sequences.

13.10.2 *Audio Supportive Function*—Audio signals used in conjunction with visual displays shall be supplementary to the visual signals and shall be used to alert and direct the user's attention to the appropriate visual display.

13.10.3 *Signal Characteristics*—The intensity, duration, and source location of the signal shall be compatible with the acoustical environment of the intended receiver as well as the requirements of other personnel in the signal area. Signals shall be intermittent, allowing the user sufficient time to respond. Signals shall be automatically terminated by operator response action or by manual control.

13.10.4 *Additional Criteria*—Additional criteria for audible displays can be found in Section 6, "Displays," use of audio signals for the purposes of alarms used in machine and computer interfaces can be found in Section 7, "Alarms" and the integration thereof in Section 8, "Integration of Controls, Displays, and Alarms."

13.11 *Data Entry:*

13.11.1 *General Requirements*—Data entry functions shall be designed to establish consistency of data entry transactions, minimize input actions and memory load on the user, ensure compatibility of data entry with data display, and provide flexibility of user control of data entry.

13.11.2 *User Pacing*—Data entry shall be paced by the user, depending on the user's application, criticality of the operation and attention span, rather than by the system.

13.11.3 *Positive Feedback*—The system shall provide a positive feedback to the user of the acceptance or rejection of a data entry.

13.11.4 *Processing Delay*—Where system overload or other system conditions will result in a processing delay, the system shall acknowledge the data entry and provide an indication of the delay to the user.

13.11.5 *Explicit Action*—Data entry shall require an explicit completion action, such as the depression of an ENTER/RETURN key or "OK" button.

13.11.6 *Validation*—Data entries shall be validated by the system for correct format, legal value, or range of values. Where repetitive entry of data sets is required, data validation for each set shall be completed before another transaction can begin.

13.11.7 *Available Data*—The user shall not be required to enter data already available to the software.

13.11.8 *Input Units*—Data shall be entered in units that are familiar to the user.

13.11.9 *Buffer*—When selected data are cut or copied from a text file, tabular file, or graphics file, or combination thereof, and placed in a temporary editing buffer, the data should be placed in the buffer automatically, with the only specific action required by the user being the cut or copy action.

13.11.10 *Presentation Mode*—Display mode rather than line mode shall be used for text editing.

13.11.11 *Display Window*—ROLL and SCROLL commands shall refer to the display window not the text/data, that is, the display window shall appear to the user to be an aperture moving over stationary text.

13.11.12 *Data Deletion*—Data deletion or cancellation shall require an explicit action, such as the depression of a DELETE key. Permanent deletion (in absence of an "undo" function) of more than one character shall not be allowed without an affirmative response to an "Are you sure?" type of query.

13.11.13 *Data Change*—Where a user requests change (or deletion) of a data item that is not currently being displayed, the option of displaying the old value before confirming the change shall be presented.

13.11.14 *Single Data Entry Method*—Data entry methods and data displays shall not require the user to shift between entry methods.

13.11.15 *Data Entry Display*—Where data entry on an electronic display is permitted only in prescribed areas, a clear visual definition of the entry fields shall be provided.

13.11.16 *Data Editing*—Easy-to-use, special editing commands, such as MOVE, COPY, and DELETE, for adding, inserting, or deleting text/program segments shall be provided.

13.11.16.1 *Text Edit Commands*—In text editing, the special commands shall be based on sentences, paragraphs, or higher-order segments.

13.11.16.2 *Program Edit Commands*—In program editing, the special commands shall be used on lines or subprograms. Program lines shall reflect a numbering scheme for ease in editing and error correction. When possible, line-by-line syntax checking shall be under user control.

13.11.16.3 *Tab Controls*—For editing programs or tabular data, cursor tab controls or other provisions for establishing and moving readily from field to field shall be provided.

13.11.16.4 *Editing Commands*—Where editing commands are made by keying onto the display, the editing commands shall be readily distinguishable from the displayed textual material.

13.11.16.5 *Highlighted Text*—Where text has been specified to become the subject of control entries (for example, it has been selected for underlining, bolding, moving, copying, or deleting), the affected segment of text shall be highlighted to indicate its boundaries.

13.11.17 *String Search*—The capability shall be provided to allow the user to specify a string of text (words, phases, or numbers) and request the computer to advance (or back up) the cursor automatically to the next occurrence of that string.

13.11.18 *Automatic Line Break*—An automatic line break (carriage return) shall be provided when the text reaches the right margin for entry/editing of unformatted text. User override of this feature shall be provided.

13.11.19 *Format Control*—An easy means shall be provided for users to specify required format control features during text entry/editing, for example, to specify margins, tab settings, and line spacing.

13.11.19.1 *Pre-Defined Formats*—When text formats must follow predefined standards, the required format shall be provided automatically. Where text formats are a user option, a convenient means shall be provided to allow the user to specify and store for future use the formats that have been generated for particular applications.

13.11.20 *Frequently Used Text*—The capability shall be provided to label and store frequently used text segments (for example, signature blocks, organizational names, call signs, coordinates) and later to recall (copy into current text) stored segments identified by their assigned labels.

13.11.21 *Control Annotations*—Where special formatting features are indicated in the text by use of special codes or annotation, the insertion of the special annotation shall not disturb the spacing of the displayed text and shall not disturb formatting of graphs and tables or alignment of rows and columns.

13.11.22 *Printing Options*—In printing text, users shall be allowed to select among available output formats (for example, line spacing, character size, margin size, heading, and footing) and to specify the pages of a document to be printed.

13.11.23 *Text Length*—Except for extended text, the length of individual data items shall be minimized.

13.11.24 *Justification*—When entering tabular data, the user shall not be required to right- or left-justify tabular data entries. The system shall automatically justify columnar data with respect to decimal point, left margin, and right margin.

13.11.25 *Minimization of Keying*—The amount of keying required shall be minimized by using numbered lists and abbreviations.

13.11.25.1 *Minimization of SHIFT Keying*—The use of key-shifting functions shall be minimized during data entry transactions.

13.12 *Interactive Control:*

13.12.1 *Response Time—General*—System response times shall be consistent with operational requirements. Required user response times shall be compatible with required system response time. Required user response times shall be within the limits imposed by total user tasking expected in the operational environment.

13.12.1.1 *System Response Time—Specific*—Maximum system response times for real-time systems (for example, fire-control systems, command and control systems) shall not exceed the values of Table 30, "System Response Time Limits." Non-real-time systems may permit relaxed response times. If computer response time will exceed 15 s, the user shall be given a message indicating that the system is responding.

13.12.1.2 *Response Time-Induced Keyboard Lockout*—If computer processing time requires delay of concurrent user inputs and no keyboard buffer is available, keyboard lockout shall occur until the computer can accept the next transaction. An alert shall be displayed to indicate to the user that lockout has occurred.

13.12.1.3 *Keyboard Restoration*—When the computer is ready to continue, following response time-induced keyboard lockout, a signal to so indicate shall be presented, for example, the cursor changes back to normal shape.

13.12.1.4 *Interrupt Keyboard Lockout*—When keyboard lockout has occurred, the user shall be provided with a capability to abort a transaction that has resulted in an extended lockout. Such capability shall act like an UNDO command that stops ongoing processing and does not RESET the computer thereby losing prior processing.

13.12.2 *Simplicity*—Control/display relationships shall be straightforward and explicit. Control actions shall be simple and direct.

13.12.3 *Accidental Actuation*—Provision shall be made to prevent accidental actuation of potentially destructive control actions, including the possibility of accidental erasure or memory dump.

13.12.3.1 *Undo Capability*—The system shall provide the capability to allow users to "undo" the action most recently made.

13.12.4 *Compatibility with User Skill*—Controls shall be compatible with the lowest anticipated user skill levels.

TABLE 30 System Response Time Limits

System Interpretation	Response Time Definition	Maximum Acceptable Response Time(s)
Key response	Key depression until positive response; for example "click"	0.1
Key print	Key depression until appearance of character	0.2
Page turn	End of request until first few lines are visible	1.0
Page scan	End of request until text begins to scroll	0.5
XY entry	From selection of field until visual verification	0.2
Function	From selection of command until response	2.0
Pointing	From input of point to display point	0.2
Sketching	From input of point to display of line	0.2
Local update	Change to image using local database; for example, new menu list from display buffer	0.5
Host update	Change where data is at host in readily accessible form; for example, a scale change of existing image	2.0
File update	Image update requires an access to a host file	10.0
Inquiry (simple)	From command until display of a commonly used message	2.0
Inquiry (complex)	Response message requires seldom-used calculations in graphic form	10.0
Error feedback	From entry of input until error message appears	2.0

13.12.5 *Availability of Information*—Information necessary to select or enter a specific control action shall be available to the user when selection of that control action is appropriate.

13.12.6 *Concurrent Display*—Control actions to be selected from a discrete set of alternatives shall have those alternatives displayed before the time of selection. The current value of any parameter or variable with which the user is interacting shall be displayed. User control inputs shall result in a positive feedback response displayed to indicate performance of requested actions.

13.12.7 *Hierarchical Process*—When hierarchical levels are used to control a process or sequence, the number of levels shall be minimized. Display and input formats shall be similar within levels and the system shall indicate the current positions within the sequence at all times.

13.12.8 *Memorization Requirements*—The requirement to learn mnemonics, codes, special or long sequences, or special instructions shall be minimized.

13.12.9 *Dialogue Type*—The choice of dialogue type (for example, form filling, menus, command language) for interactive control shall be compatible with user characteristics and task requirements.

13.12.10 *Numbering System*—When numeric data are displayed or required for control input, such data shall be in the decimal, rather than binary, octal, hexadecimal, or other number system.

13.12.11 *Data Manipulation*—The user shall be able to manipulate data without concern for internal storage and retrieval mechanisms of the system.

13.12.12 *Processing Constraints*—The sequence of transaction selection shall generally be dictated by user choices and not by internal computer-processing constraints.

13.12.13 *Feedback for Correct Input*—Control feedback responses to correct user input shall consist of changes in state or value of those elements of the displays that are being controlled in an expected and logically natural form. An acknowledgement message shall be used only in those cases in which the more conventional mechanism is not appropriate or feedback response time must exceed 1 s.

13.12.13.1 *Feedback for Erroneous Input*—Where control input errors are detected by the system, error messages shall be available, and error recovery procedures shall be provided.

13.12.14 *Control Input Data Display*—The presence and location of control input data entered by the user shall be clearly and appropriately indicated. Data displayed shall not mislead the user with regard to nomenclature, units of measure, sequence of task steps, or time phasing.

13.12.15 *Originator Identification*—Except for broadcast communication systems, the transmitter of each message in inter-user communications shall be identified—automatically, if possible.

13.13 *Graphic Controls:*

13.13.1 *Use*—Graphic interaction as a dialogue may be considered for use by casual users to provide graphic aids as a supplement to other types of interactive control.

13.13.2 *Iconic Menus*—When system users have different linguistic backgrounds, graphic menus may be used which display icons to represent the control options. Where the system is intended for use by foreign personnel, icon design shall be consistent with applicable cultural and ethnic variables to ensure comprehension and to avoid potential offense.

13.13.3 *Supplemental Verbal Labels*—Where icons are used to represent control actions in menus, verbal labels shall be displayed with each icon to help assure that its intended meaning will be understood.

13.13.4 *Icon Controls*—Designers shall make the selectable area of an icon large enough to reduce the risk of error and increase the user's ease in selecting the icon. The selectable area or hotspot outside of the area of the icon shall be at least 4 mm (0.15 in.). Users should be able to move icons using similar methods available for moving windows.

13.13.4.1 *Icon Locations*—Icons shall be positioned at least 10 mm (0.39 in.) apart from each other, measured from perimeter to perimeter. Designers should display fewer than 20 icons simultaneously on the same screen. Icons should be grouped according to similar shapes and colors that depict a common relationship.

13.13.5 *Palettes*—Palettes allow the user to select an action or attribute from a group of icons fixed in a window and can be fixed or floating. Floating palettes should be used when the attributes on the palette are utilized frequently at specific times and infrequently at others.

13.13.5.1 *Palette Locations*—Fixed palettes should be permanently placed in an application environment when the attributes on the palette will be accessed frequently. Fixed palettes should be placed on the left side of the application window or along the top of the window under the title bar.

13.13.6 *Pushbuttons*—All pushbuttons in a window should have the same size and shape. A pushbutton shall have a consistent text or graphic label that should describe the results of pressing the button and reflect the action that will be taken by the application rather than the user. Default pushbuttons shall be clearly distinguishable from the other pushbuttons using visual features such as highlighting or appearing three dimensional. See Fig. 136, "Default Push Button" for an illustration.

13.13.6.1 *Pushbutton Appearance*—The states of a pushbutton shall be distinguishable by the user through appearance as shown in Fig. 137, "Pushbutton States."

13.13.7 *Radio Buttons*—Radio buttons shall be used if it is required that one and only one of a set of mutually exclusive options be selected. An individual radio button shall always be part of a mutually exclusive group of two or more radio buttons. A radio button that is active shall cause all of the other radio buttons in its group to be inactive. A user shall be able to select a radio button using a pointing device by moving the pointer onto the radio button and clicking the appropriate device button or using a keyboard by using the arrow keys to locate the pointer and select using the ENTER key.

FIG. 136 Default Pushbutton

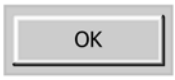
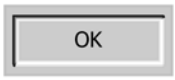
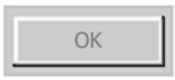
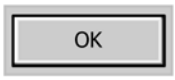
Command Button Appearance	Button State
	Normal Appearance
	Pressed Appearance
	Unavailable Appearance
	Selectable Appearance

FIG. 137 Pushbutton States

13.13.7.1 *Radio Button Appearance*—Labels shall be provided for each set of radio buttons. A box should be drawn around a group of radio buttons to visually separate the group from other interface features. When a particular option is not available, it should be displayed as subdued or grayed-out in relation to the brightness of the available options. An example illustration is shown in Fig. 138, "Radio Buttons."

13.13.8 *Check Boxes*—Check boxes shall have two states, selected and unselected. Check boxes shall be provided if a user must be able to select any number, including all or none, of a set of options. Users shall be able to toggle selected and unselected states on a check box using either a pointing device or the keyboard.

13.13.8.1 *Check Box Appearance*—Labels shall be provided for each set of check boxes and the style and orientation should remain consistent for groups of check boxes within an application and across related applications. Check boxes shall be arranged in logical order so that the most frequently used boxes are at the top or at the left, depending on how the boxes are oriented. See Fig. 139, "Check Boxes."

13.13.9 *Sliders*—Sliders are appropriate and should be used when users must set a value within a fixed range and the precise value is less important than relative position. Users shall be able to change the setting of a slider by moving the pointer onto the marker and dragging it. Additional design guidance with examples of slide switch controls can be found in Fig. 140, "Slider Control" and Section 5, "Controls."

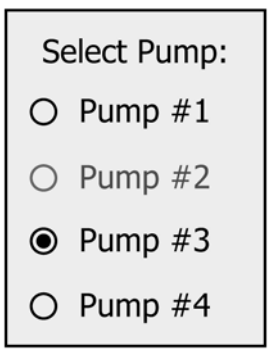


FIG. 138 Radio Buttons

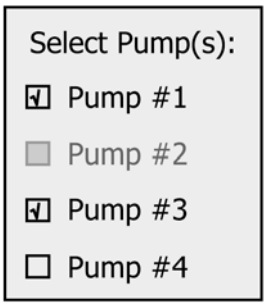


FIG. 139 Check Boxes

13.13.9.1 *Slider Components*—Slider designs shall contain the following components:

(1) A slider shall have a movable marker that indicates the current setting and a line or rectangular area along which it moves.

(2) A slider shall have a label or title that indicates the purpose of the slider.

(3) When appropriate, the slider should provide a numerical readout of the current setting.

13.14 *Windows:*

13.14.1 *Use*—When there is a need to view several different types of data simultaneously, the user shall be able to display and select separate windows on a single display screen.

13.14.1.1 *Window Operations*—The user shall have the capability to perform the following operations on open windows: move, resize, hide (or minimize), activate, deactivate, scroll, and zoom. Users should be able to perform the following operations on objects in a window:

(1) Select an object with the pointing device.

(2) Select an object using the keyboard.

(3) Move an object to another location in the same window.

(4) Move an object to a different window.

(5) Copy an object for placement at a different location within the same window.

(6) Copy an object for placement in a different window.

(7) Paste an object previously copied from this or another window.

(8) Undo/redo the last action.

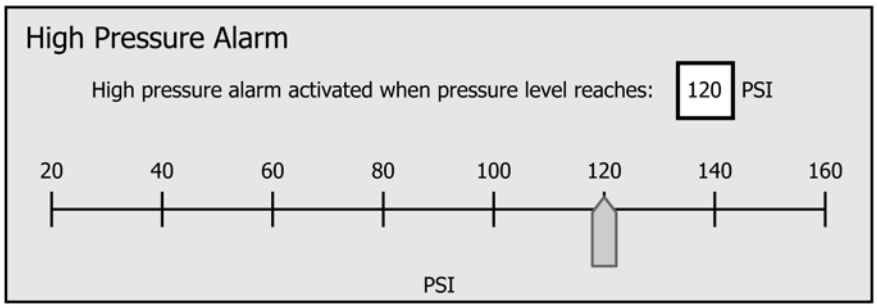


FIG. 140 Slider Control

13.14.1.2 *Presentation*—Windows shall be initially presented in the form that is most appropriate for the user's tasks.

13.14.1.3 *Window Manipulation*—Window controls (that is, menus and buttons) should be provided to allow users to adjust windows for personal needs, when such manipulation will not adversely affect human performance. The amount of manipulation of windows required for using the HCI, such as resizing, moving, and so forth shall be minimized.

13.14.1.4 *Window Controls*—Window controls shall be available through both the pointing device and the keyboard.

13.14.1.5 *Window Alerts*—The system shall alert the user to critical information that becomes available in a hidden or inactive window.

13.14.2 *Primary and Secondary Windows*—An application shall use one or more primary windows for the performance of primary operational task(s) and secondary windows to present supplementary or supporting data related to primary task(s). Secondary windows may include message windows or windows for short-term interactions related to subtask or functional control and message windows for presenting messages to users.

13.14.2.1 *Initial Primary Window*—Every application with a user interface shall initially display a primary window. A primary window shall be displayed as soon as the application starts, without leaving the screen blank.

13.14.2.2 *Secondary Window Use*—The usage of secondary windows should be limited. The default size of a secondary window shall be as small as possible to convey the needed information.

13.14.3 *Window Location*—The initial placement of a window should be based on the importance of the information in that window and information in other visible windows that should not be obscured. When a window is first displayed, input focus shall be placed on a default object, which the user is most likely to access.

13.14.3.1 *Message Window Location*—Caution and warning windows and other message windows shall be front most on the display.

13.14.4 *Multiple Windows*—When multiple windows are open simultaneously, the user shall have the capability to tile, layer, or sequentially view the windows easily. Tiling shall automatically size all open windows equally and position them side-by-side vertically, horizontally, or in a tiled pattern within the available virtual display area. Cascading (or layering) shall automatically lay windows on top of each other such that the title bar of each window is visible and the top window is active.

13.14.5 *Window Navigation*—Navigation between windows shall reflect an obvious logic based on task requirements, which should be easy for users to understand. Windows should be designed to facilitate easy access between related windows or related pages within a window.

13.14.6 *Window Shifting*—The user shall have several easy means to shift among all open windows. Default methods of shifting among open windows will be clicking a mouse button and using function keys.

13.14.6.1 *Open Window Access*—The control system shall maintain a list of all open windows and their statuses (including any that are hidden) and shall provide a user interface to this list. Users shall be able to identify, access, and control all open windows easily from this list, upon request.

13.14.6.2 *Navigation Aids*—For HCIs with multiple windows, the HCI should include a "map" of the available windows to facilitate HCI navigation. This display should depict the relationships of significant windows to each other and the corresponding hierarchical structure of the information space. Cues should be provided to help the user retain a sense of location within the hierarchical information structure.

13.14.6.3 *Hyperlinks*—Window design shall avoid the use of hypertext links for HCI navigation.

13.14.7 *Window Organization*—The interface objects (that is, window elements, including controls and menus), shall have consistent appearance across all applications. Information in windows should be organized in some recognizable, logical, and consistent form to facilitate scanning and assimilation. Where applicable, the organization and appearance of the contents of windows shall meet requirements in Section 8.

13.14.7.1 *Information Grouping*—Information in a window should be grouped according to principles obvious to the user (for example, by mission, task, system function, or sequence), based upon the user's requirements in performance of the ongoing task.

13.14.7.2 *Graphics Alignment*—Related graphics in a window shall be aligned unless position is intended to indicate a spatial or functional relationship.

13.14.7.3 *Appropriate Window Content*—Function- or task-related elements shall be located together in one window or on one page within the same window, if the window includes multiple pages. Windows should be designed so that users do not need to:

(1) Switch back and forth between windows or pages when performing a task, or

(2) Remember information from one window or page while looking at another.

13.14.7.4 *Customized Windows*—When used for multiple tasks, the HCI should provide the user with the ability to customize window content.

13.14.8 *Title Bar*—All windows shall contain a title bar at the top of the window, which provides a title and access to all of the controls available to the open window. The titles of subordinate (secondary) windows shall correlate with the menu selection items from the main window menu.

13.14.9 *Status Bar*—The status bar shall be located at the bottom of a window, just inside the window frame.

13.14.10 *Tool Bars*—Toolbars shall be used for frequently utilized features and commands. Users shall be allowed to specify which toolbars, if any, they wish to display.

13.14.11 *Control Consistency*—Window controls, such as "open" and "close" shall operate consistently on all windows.

13.14.11.1 *Open Window*—Users shall be able to open a window with a single action. The action that opens a window shall automatically make that window active.

13.14.11.2 *Close Window*—Users shall be able to close a window with a single action. Closing a window shall remove it from the screen and cease all processing in that window. A pop-up window shall appear to request user confirmation of a closing action when closing a window that contains unsaved data or ongoing processes. The user shall have the option to cancel the close action, to complete/halt any ongoing processing or to save data.

13.14.11.3 *Closing Primary/Secondary Windows*—When a primary window is closed by the user, all associated subordinate (secondary) windows and message windows shall also close. Closing a secondary window shall not affect the primary (parent) window.

13.14.12 *Active Windows*—There shall be no more than one active window. When a window is made active, all other windows shall be made inactive. Only the active window shall have the input focus and shall be capable of accepting the keyboard input. The frame of the active window shall be highlighted to indicate that it is active, or shade inactive windows for the same effect. Users shall be able to activate and assign input focus to any open window by using either a pointing device or the keyboard.

13.14.12.1 *Inactive Windows*—Operations such as background processing shall continue to occur in inactive windows. Inactive windows may continue to be displayed on the screen but may be obscured by other windows. When a window becomes inactive, it shall lose input focus. Selections in that window shall be deselected and the title bar shall become inoperative.

13.14.12.2 *Window Overlap*—When two or more windows are located in the same part of the display (that is, overlap), the window that was most recently active shall be shown in front of the other windows and the overlapped portions of the other window(s) shall not be shown. An obscured window shall become fully visible when it is made active.

13.14.13 *Moving Windows*—Where applicable, window movement capability shall be provided so the user can move windows to different areas of the display. For windows that can be moved, the user may drag the window by the title bar at any point where window controls (that is, buttons and menus) are not located. The user shall not be able to move a window to a nonretrievable position.

13.14.13.1 *Multiple Screens*—If multiple display screens are used, users shall be able to move a window between screens by dragging the window from one screen to another.

13.14.14 *Window Sizing*—The user shall be allowed to change the size of windows to any value between the minimum and the maximum defined. Users shall be able to change the horizontal and vertical dimensions of a window independently or together. The contents of a window shall remain visible during the resizing.

13.14.14.1 *Initial/Default Sizing*—The default size for a window should be large enough to present all relevant information for the task, not obscure important information, not cause crowding or visual confusion, and minimize the need for scrolling. The size of the initial presentation of a window shall be consistent with its contents (for example, the amount of information to be displayed, number of menus, data fields, and so forth).

13.14.14.2 *Window Sizing Effects*—Resizing a window shall not result in the textual information being resized to scale. When resized, the graphics in the window shall remain the same size, while the scope of the graphics being shown shall change. The relative position of the data and the controls within the borders of a window shall not change when a window is resized.

13.14.14.3 *Minimum Window Size*—The minimum window size shall be tall enough to display the title bar, classification bar, status bar, menu bar, and border. It shall be wide enough to display the window title, border, and any window controls. The default height of windows containing textual information and windows used for scanning data shall be large enough to display at least four lines of text. The default width for a window containing textual information shall be large enough to display 50 to 80 characters.

13.14.14.4 *Maximum Window Size*—The maximum window size shall not exceed the display area of a single VDU. When a window is maximized, it shall be relocated to a fixed position on the VDU. The entire title bar and application area shall be visible in the maximized state.

13.14.14.5 *Minimize/Maximize Control*—A user shall be able to minimize the window by moving the pointer onto the "Minimize" control in the title bar and clicking the appropriate button or by selecting "Minimize" from the window menu or using either a pointing device or the keyboard.

13.14.15 *Scrolling*—Scroll bars shall be used to view textual or graphic information when it exceeds the available display area in the window and shall not be used, or disabled if all information can be viewed simultaneously. Windows shall be designed to preclude scrolling more than two pages. Vertical (top-to-bottom scrolling is preferred over horizontal (left-to-right) scrolling which is not recommended.

13.14.15.1 *Scroll Bar Location*—If used, a horizontal scroll bar shall appear at the bottom of the window and a vertical scrollbar shall appear on the right side of the window.

13.14.15.2 *Scroll Bar Characteristics*—The position of the slider on a scroll bar shall be proportional to the position of the information displayed in the application area in relation to the overall document. When data are organized into pages, the scroll bar shall include features that allow users to step forward or backward through the information at the rate of one page at a time.

13.14.16 *Zooming*—Zooming shall be available to change the scale of textual and graphic information when it exceeds the available display area in the window. Zoom functions shall be provided for changing scale both continuously and in discrete steps.

13.14.16.1 *Zooming Aids*—For windows displaying portions of a larger graphic, thumbnails or distorted views can be presented to facilitate user recognition of location.

13.14.17 *Window Menus*—Menu bars shall only be used in primary windows. There shall be no more than one menu bar in a given window. The menu bar shall be located at the very top of the application area and extend the full width of the window.

13.14.18 *Window Toolbars*—Toolbars shall be displayed in a horizontal row or vertical column. When the same toolbars are used in different windows, they should be placed consistently in the same location.

13.14.19 *Message Windows*—Message windows shall contain a title, a message, and one or more push buttons. They should also contain information and options for user interaction. If it is necessary to view information in other windows while viewing a message box, the message window shall be movable.

13.14.19.1 *Message Window Size*—Users shall not be able to minimize or resize message windows.

13.14.19.2 *Message Confirmation*—Destructive actions shall be preceded by a user confirmation (at least one extra step) in a message window.

13.14.19.3 *Default Buttons*—In message windows, the default button shall be a non-destructive button, such that it would be activated if an operator presses ENTER. The default button shall be visually highlighted, such as by adding an extra border around it. See Fig. 137.

13.14.19.4 *Button Locations*—The control buttons used to input a command from a message window shall be located consistently at the bottom of the message window as shown in Fig. 141, “Message Window Design.” The default button shall be consistently located on the left side of the message window. The button with the opposing action shall be located on the right side. Any additional control buttons shall be located between the default and opposing action buttons.

13.15 *Menus:*

13.15.1 *Use*—Menus shall be used for selecting values and choosing from a set of related options. Menu selection interactive control shall be used for tasks that involve little or no entry of arbitrary data and where users may have relatively little training. It shall also be used when a command set is so large that users are not likely to be able to commit all of the commands to memory.

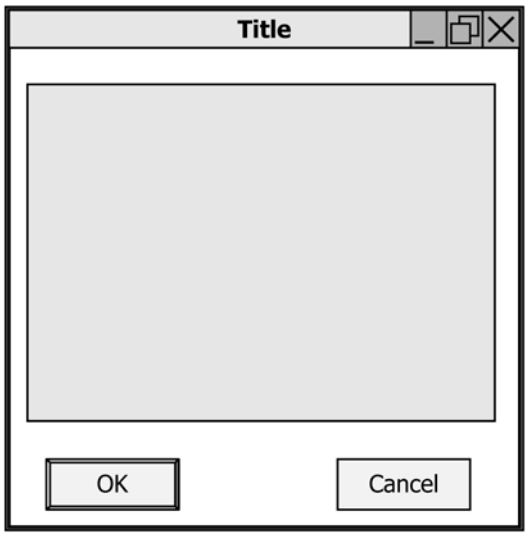


FIG. 141 Message Window Design

13.15.1.1 The following types of windows with associated guidance on use should be considered based upon the tasks required by the user:

(1) System Menu—Each system should provide a system menu that includes options to end a session, print selections, review system status, define user preferences, manage alerts, change a password, access peripherals, and perform file management.

(2) Pull-Down Menus—Pull-down menus have limited applicability in data entry but may be useful for such activities as retrieving files. The advantage of pull-down menus over pop-up menus is that pull-down menus always have a visual cue in the form of a menu. Pull-down menus should be used rather than pop-up menus if the position of the cursor on the screen is not important for information or option retrieval.

(3) Hierarchical Menus—Hierarchical menus should be used when there are more than ten options and the options can be organized in a branching structure. Hierarchical menus should be organized and labeled to guide the user within the hierarchical structure.

(4) Pop-Up Menus—A pop-up menu resembles a pull-down menu, but it is not associated with the top level menus listed in the menu bar. Pop-up menus can be very useful in data entry. They can present to a user the permissible entries for a field, thus eliminating the need for the user to remember the entries, preventing invalid entries, and eliminating potential typing errors.

(5) Graphic Menus—Graphic menus (palettes) are a set of unlabeled symbols, typically presented within small rectangles. Symbols may be icons, patterns, characters, or drawings that represent an operation that may be selected using a pointing device. Graphic menus can be used to select a symbol or tool and as such, a reminder should be displayed to indicate the mode that has been activated.

13.15.2 *Item Selection*—Where design constraints do not permit pointing devices, a standard window shall be provided for the user to key the selected option code. If menu selection is accomplished by pointing, dual actions should be provided. The first action should designate the selected option. This

should be followed by a separate action to enter the selection for processing. A menu option should be highlighted when the pointer is on the menu option.

13.15.3 *Titles*—Each page of options (menu) shall have a title that clarifies the purpose of that menu.

13.15.4 *Sequences*—A menu shall not consist of a long list of multi-page options, but shall be logically segmented to allow several sequential selections among a few alternatives.

13.15.5 *Active Option Presentation*—The system shall present only menu selections for actions that are currently available.

13.15.6 *Format Consistency*—Menus shall be presented in a consistent format throughout the system and shall be available at all times.

13.15.7 *Option Sequence*—Menu selections shall be listed in a logical order, or, if no logical order exists, in the order of frequency of use.

13.15.8 *Simple Menus*—When the number of selections can fit on one page in two columns, a simple menu shall be used. If the selection options exceed two columns, hierarchical menus may be used. A scrolling menu should be used for more than 10 options if the options cannot be organized into a branching structure.

13.15.9 *Option Presentation*—Selection codes and associated descriptors shall be presented on single lines.

13.15.10 *Direct Function Call*—If several levels of hierarchical menus are provided, a direct function call capability shall be provided such that the experienced user does not have to step through multiple menu levels.

13.15.11 *Consistency with Command Language*—When menu selection is used to train in the use of a command language, the wording and order shall be consistent with the command language.

13.15.12 *Option Coding*—When selections are indicated by coded entry, the code associated with each option shall be included on the display in some consistent manner.

13.15.13 *Keyed Codes*—If menu selections must be made by keyed codes, the options shall be coded by the first several letters of their displayed labels rather than by more arbitrary numeric codes. In defining the codes, however, they should not duplicate any other user function codes.

13.15.14 *Position in Structure*—When menu traversal can be accomplished by clearly defined hierarchical paths, the user shall be given some indication of the displayed menu's current position in the overall or relevant structure, such as by having an optional display of "path" information. A menu tree showing the menu hierarchy shall be included in the user manual or on-line HELP.

13.15.15 *Back Menu*—When using hierarchical menus, the user shall be able to return to the next higher level by using single key action until the initial, top-level menu or display is reached.

13.15.16 *Return to Top Level*—A function shall be provided to directly recall the initial, top-level menu, or display without stepping through the menu or display hierarchy.

13.16 *Forms:*

13.16.1 *Use*—Form-filling interactive control may be used when some flexibility in data to be entered is needed and where the users will have moderate training.

13.16.2 *Grouping*—Displayed forms shall be arranged such that related items are grouped together. Additional information on grouping of information can be found in Section 8.

13.16.3 *Format/Content Consistency*—The format and content of displayed forms shall be perceptually related to that of paper forms, if paper forms are used to guide data entry. A standard input form shall be used. The displayed form shall require a response for every data entry field; advance through a field (that is, leave blank) for which no entry is desired will require an explicit action such as TAB or ENTER keystrokes.

13.16.4 *Distinctive Fields*—Fields or groups of fields shall be separated by lines or other delineation cues. Required fields shall be distinguished from optional fields.

13.16.4.1 *Field Labels*—Field labels shall be distinctively presented such that they can be distinguished from data entry. Labels for data entry fields shall incorporate additional cueing of data format where the entry is made up of multiple inputs, for example engineering units or DATE (M/D/Y): __/__/__. Descriptive wording shall be used when labeling data fields; use of arbitrary codes shall be avoided.

13.16.4.2 *Cursor Position*—A displayed cursor shall be positioned by the system at the first data entry field when the form is displayed. The cursor may be advanced by a TAB key or other cursor positioning device to the next data entry field when the user has completed entry of the current field.

13.16.4.3 *Entry Length*—The maximum acceptable length for variable length fields shall be indicated.

13.16.4.4 *Overwriting*—Data entry by overwriting a set of characters in a field (such as a default) shall not be used.

13.16.4.5 *Underscores*—When an item length is variable, the user shall not have to remove unused underscores.

13.16.4.6 *Dimensional Units*—When a consistent dimensional unit is used in a given entry field, the dimensional unit shall be provided by the computer. When the dimensional unit varies for a given field, it shall be provided, or selected, by the user.

13.16.5 *Omissions*—When required data entries have not been inputted, the omission shall be indicated to the user and either immediate or delayed input of the missing items shall be allowed. For delayed entry, the user shall be required to enter a special symbol in the field to indicate that the missing item is delayed, not overlooked.

13.16.6 *Protected Areas*—Non-entry (protected) areas of the display shall be designated and made inaccessible to the user by means of the cursor.

13.16.7 *Flexible Data Entry*—When multiple data items are entered as a single transaction, the user shall be allowed to re-enter, change, or cancel any item before taking a final ENTER action.

13.16.8 *Logical Order*—Where no source document or external information is involved, forms shall be designed so that data items are ordered in a logical sequence for input.

13.16.9 *Control Entry*—Form filling shall be considered as an aid for composing complex control entries. For example, for

a print request, a displayed form should help a user invoke the various format controls that are available.

13.16.9.1 *Function Keys*—Fixed function key interactive control may be used for tasks requiring only a limited number of control inputs or in conjunction with other dialogue types.

13.16.10 *Message Forms*—Where formats conform to a defined standard or are predictable in other ways, prestored forms shall be provided to aid users in message preparation.

13.17 *Alarms:*

13.17.1 *General*—Alarms provided through computer and machine interfaces shall adhere to design criteria regarding strategies, prioritization, display (including visual and audible alarms), control and management documented in Sections 6 – 8 of this practice. Additional criteria necessary for alarms represented through computer interfaces follow.

13.17.2 *Display Types*—Displaying alarms through machine and computer interfaces shall use the following types (or a combination thereof) depending on the application:

13.17.2.1 *Spatially Dedicated Alarm Tiles*—This display indicates a single, critical alarm message which appears in the same position on the display screen used for alarms that require continuous monitoring. These shall be used sparingly as they require constant designated screen space (status always displayed whether alarm or no alarm).

13.17.2.2 *Alarm Message Lists*—This display presents a textual list of the active alarms and supporting information in a single window. A similar window shall be used to depict cleared alarms (an alarm log).

13.17.2.3 *Alarms Integrated Into Other Displays*—Displays are coded to indicate the presence of an alarm condition based on the format of the display, and access is given to additional information on request.

13.17.3 *Access to Detailed Information*—Alarm indication displays shall support rapid access to the detailed alarm information from the location of the alarm messages.

13.17.4 *Printed Alarm Messages*—If alarms will be printed on paper, the format of printed alarm lists shall be consistent with that of displays.

13.17.5 *Simultaneous Display*—For alarm lists, sufficient display area shall be provided for simultaneous viewing of the maximum number of high-priority alarms that are anticipated.

13.17.6 *Notice of Hidden Alarms*—The alarm system shall display a notification if the user is not viewing the display screen where unacknowledged alarm messages appear including the priority and the location of the alarm.

13.17.7 *Combining Alarms*—Alarms shall not be combined if the resulting alarm imposes additional workload on the operator. If alarms are combined, the system shall allow users to access the individual alarm information.

13.17.8 *Alarm Contents*—Alarm messages presented in tiles or lists shall be standardized and contain the following information:

13.17.8.1 Alarm description,

13.17.8.2 Alarm priority,

13.17.8.3 Required actions,

13.17.8.4 Time cleared,

13.17.8.5 Alarm source,

13.17.8.6 Setpoint/parameter values,

13.17.8.7 Time stamp, and

13.17.8.8 Time for response.

13.17.9 *Alarm Color*—Alarms shall be color-coded in accordance with the requirements described in Table 5.

13.17.10 *Alarm Organization*—Each watchstation shall only list alarms relevant to that watchstation.

13.17.11 *Alarm List Sorting*—An alarm list shall provide the option of sorting alarms into the operationally relevant categories. The “Prioritized List” shall be the default.

13.17.11.1 *Prioritized List*—The “Prioritized List” shall display alarms with the highest priority listed first. Multiple alarms of the same priority shall be sorted by time (most recent at the top), then by functional group.

13.17.11.2 *Time Sequential List*—The “Time Sequential List” shall display alarms in a time sequential format, with the most recent alarms at the top of the list. Multiple alarms with the same initiation time shall be sorted by priority, then by functional group.

13.17.11.3 *Functional List*—The “Functional List” shall display alarms organized by function (for example, mission area, system, and so forth). Further sorting within a group shall be by priority, then initiation time.

13.17.12 *User-Selectable Configurations*—Active user-selectable operational configurations on alarm systems shall be indicated (and distinguished from system designed alarms) at all times and shall not interfere with existing alarms and set-points.

13.18 *Language:*

13.18.1 *Command Language*—Command language interactive control may be used for tasks involving a wide range of user inputs and where user familiarity with the system can take advantage of the flexibility and speed of the control technique.

13.18.1.1 *User Viewpoint*—A command language shall reflect the user’s point of view such that the commands are logically related to the user’s conception of what is being done.

13.18.1.2 *Command Distinctiveness*—Commands shall be distinctive from one another.

13.18.2 *Punctuation*—The command language shall contain a minimum of punctuation or other special characters.

13.18.3 *Command Entry*—The user shall be permitted to enter the full command name or an abbreviation for any command of more than five characters.

13.18.3.1 *Standardization*—All commands and their abbreviations, if any, shall be standardized and consistent with 13.8 and Section 15.

13.18.4 *Display Location*—Commands shall be entered and displayed in a standard location on the display.

13.18.5 *Command Prompts*—The user shall be able to request prompts, as necessary, to determine required parameters in a command entry.

13.18.6 *Complexity*—The command language shall be programmed in layers of complexity such that the basic layer will allow the inexperienced user to control a transaction. As this person’s skill increases, the command language shall allow skipping from basic to more advanced layers to meet the user’s current needs.

13.18.7 *Macro Commands*—The programming shall not accept a user designated macro name that is the same as an existing command name.

13.18.8 *Standard Command Editing*—Users shall be allowed to edit erroneous command entries with the same techniques that are used to edit data entries since consistent editing techniques will speed learning and reduce errors.

13.18.9 *Destructive Commands*—Where a command entry may have disruptive consequences, the user shall be required to review and confirm a displayed interpretation of the command before it is executed.

13.18.10 *Questions and Answers*—Question-and-answer dialogues shall be considered for routine data entry tasks in which data items are known and their ordering can be constrained, users will have little or no training, and the computer is expected to have medium response speed.

13.18.10.1 *Question Separation*—Each question shall be displayed separately in question-and-answer dialogues; users shall not be required to answer several questions at once.

13.18.10.2 *Auto-fill Prior Answers*—When a series of computer-posed questions are interrelated, answers to previous questions shall be displayed when those will provide context to help a user answer the current questions.

13.18.10.3 *Source Document Consistency*—When questions prompt entry of data from a source document, the question sequence shall match the data sequence in the source document.

13.18.11 *Query Language*—Query language dialogue shall be used for tasks emphasizing unpredictable information retrieval (as in many analysis and planning tasks), with moderately trained users.

13.18.11.1 *Organization of Data*—Query languages shall reflect a data structure or organization perceived by users to be natural. For example, if a user supposes that all data about a particular topic are stored in one place, then the query language shall permit such data to be retrieved by a single query, even though actual computer storage might carry the various data in different files.

13.18.11.2 *Representation of Data*—A single representation of the data organization for use in query formulation shall be established, for example, if different queries will access different databases over different routes, the user shall not necessarily need to know this.

13.18.11.3 *Task-Oriented Wording*—The wording of a query shall simply specify what data are requested; a user shall not have to tell the computer how to find the data.

13.18.11.4 *Logic to Link Queries*—The query language shall be designed to include logic elements that permit users to link (for example, "and," "or") sequential queries as a single entry.

13.18.11.5 *Retrieval Confirmation*—If a query will result in a large-scale data retrieval, the user shall be required to confirm the transaction or else take further action to narrow the query before processing.

13.19 *Feedback:*

13.19.1 *Use*—Feedback shall be provided which presents status information, confirmation, and verification throughout the interaction.

13.19.2 *Standby*—When system functioning requires the user to standby, WORKING, BUSY, or WAIT messages shall be displayed until user interaction is again possible. Where the delay is likely to exceed 15 s, the user shall be informed. For delays exceeding 60 s, a countdown display shall show delay time remaining.

13.19.3 *Process Outcome*—When a control process or sequence is completed or aborted by the system, positive indication shall be presented to the user concerning the outcome of the process and the requirements for subsequent user action.

13.19.4 *Input Confirmation*—Confirmation shall not cause displayed data removal.

13.19.5 *Current Modes*—When multiple modes of operation exist, a means shall be provided to remind the user of the current mode.

13.19.6 *Highlighted Selection*—When a displayed message or datum is selected as an option or input to the system, the subject item shall be highlighted to indicate acknowledgment by the system.

13.19.7 *Input Rejection*—If the system rejects a user input, feedback shall be provided to indicate the reason for rejection and the required corrective action. Feedback shall be self explanatory.

13.19.8 *Feedback Messages*—Users shall not be required to translate feedback messages by use of reference system or code sheets. Abbreviations shall not be used unless necessary.

13.19.9 *Time Delay Warning*—The system shall give warning information when a command is invoked that will be time-consuming or expensive to process.

13.20 *Prompts:*

13.20.1 *Use*—Prompts and help instructions shall be used to explain commands, error messages, system capabilities, display formats, procedures, and sequences and to provide data. Prompting shall conform to the following:

13.20.1.1 When operating in special modes, the system shall display the mode designation and file(s) being processed.

13.20.1.2 Before processing any user requests that would result in extensive or final changes to existing data, the system shall require user confirmation.

13.20.1.3 When missing data are detected, the system shall prompt the user.

13.20.1.4 When data entries or changes will be nullified by an abort action, the user shall be requested to confirm the abort.

13.20.1.5 Neither humor nor admonishment shall be used in structuring messages; the dialog shall be strictly factual and informative for the user.

13.20.1.6 Error messages shall appear as close as possible to the user entry that caused the message.

13.20.1.7 If a user repeats an entry error, the second error message shall be revised to include a noticeable change so that the user may be certain that the computer has processed the attempted correction.

13.20.2 *Standard Display*—Prompting messages shall be displayed in a standardized area of the displays.

13.20.3 *Explicit Prompts*—Prompts and help instructions for system-controlled dialogue shall be explicit, and the user

shall not be required to memorize lengthy sequences or refer to secondary written procedural references.

13.20.4 *Prompt Clarity*—Prompts shall be clear and understandable. They shall not require reference to coding schemes or conventions which may be unfamiliar to occasional users.

13.20.5 *Definitions*—A dictionary of abbreviations and codes shall be available on-line. Definitions of allowable options and ranges of values shall be displayable at the user's request.

13.20.6 *Consistent Terminology*—On-line documentation, off-line documentation, and help instructions shall use consistent terminology.

13.20.7 *Confirmation*—User acceptance of stored data or defaults shall be possible by a single confirming keystroke.

13.21 *Defaults:*

13.21.1 *Use*—Default values shall be used to reduce user workload. Currently defined default values shall be displayed automatically in their appropriate data fields with the initiation of a data entry transaction and the user shall indicate acceptance of the default.

13.21.2 *User Selection*—The user shall have the option of generating default values based on operational experience if the systems designer cannot predefine appropriate values.

13.21.3 *Default Substitution*—The user shall be able to replace any default value during a given transaction without changing the default definition.

13.21.4 *Sequential Defaults*—Where a series of default values have been defined for a data entry sequence, the user shall be allowed to default all entries or to default until the next required entry. The experienced user may not wish to accept each default value for each data field individually.

13.22 *Error Management/Data Protection:*

13.22.1 *Error Correction*—Where users are required to make entries into a system, an easy means shall be provided for correcting erroneous entries. The system shall permit correction of individual errors without requiring reentry of correctly entered commands or data elements.

13.22.2 *Error Detection*—A capability shall be provided to facilitate detection and correction of errors after keying in but before entering into the system. While it is desirable that errors be detected early, error checking shall occur at logical data entry breaks, for example, at the end of data fields rather than character by character to avoid disrupting the user.

13.22.3 *Internal Software Checks*—User errors shall be minimized by use of internal software checks of user entries for validity of item, sequence of entry, completeness of entry, and range of value.

13.22.4 *Critical Entries*—The system shall require the user to acknowledge critical entries before their being implemented by the system. An explicitly labeled CONFIRM function key, different from the ENTER key, shall be provided for user confirmation of control and data entries that have been questioned by the computer.

13.22.5 *Error Message Content*—Error message shall be constructive and neutral in tone, avoiding phrases that suggest a judgment of the user's behavior. The error messages shall reflect the user's view, not that of the programmer. Error messages shall be appropriate to the user's level of training, be as specific as possible to the user's particular application, and describe a way to remedy, recover, or escape from the error situation.

13.22.6 *Error Recovery*—The user shall be able to stop the control process at any point in a sequence as a result of indicated error or as an option. The user shall be able to return easily to previous levels in multistep processes to nullify an error or to effect a desired change.

13.22.7 *Diagnostic Information*—Error messages shall explicitly provide as much diagnostic information and remedial direction as can be inferred reliably from the error condition. Where clear inference is not possible, probable helpful inference(s) may be offered.

13.22.8 *Entry Correction and Confirmation*—When the user enters correction of an error, such corrections shall be implemented by an explicit action by the user (for example, actuation of an ENTER key). All error corrections by the user shall be acknowledged by the systems either by indicating a correct entry has been made or by another error message.

13.22.9 *Spelling Errors*—Spelling and other common errors shall not produce valid system commands or initiate transactions different from those intended. It is preferred that the system shall recognize common misspellings of commands and execute the commands as if spelling had been correct. Computer-corrected commands, values, and spellings shall be displayed and highlighted for user confirmation.

13.22.10 *Errors in Stacked Commands*—To prompt for corrections of an error in stacked commands, the system shall display the stacked sequence with the error highlighted. Where possible, a procedure shall be provided to correct the error and salvage the stack.

13.22.11 *Display of Erroneous Entries*—A computer-detected error, as well as the error message, shall be continuously display until the error is corrected.

13.22.12 *File Management*—An easy means shall be provided for saving and retrieving data. The user shall be prompted to save the file contents when exiting a file. Information from a file that has been modified and stored with the "save" action should be retrievable with a single action. The system should provide the capability to automatically save a file at frequent intervals during the editing process.

13.23 *Data Security:*

13.23.1 *General*—Data shall be protected from unauthorized use, potential loss from equipment failure, and user errors.

13.23.2 *Automated Measures*—Automated measures shall be provided to minimize data loss from intruders in a system or from errors by legitimate users.

13.23.2.1 *Warning of Threats*—Computer logic shall be provided that will generate messages or alarm signals or both to warn users of attempted intrusion by unauthorized users.

13.23.3 *Segregating Real/Simulated Data*—When simulated data and system functions are provided (perhaps for user training), real data shall be protected and real system use shall be clearly distinguished from all simulated operations.

13.23.3.1 *Display of Simulated Data*—In applications in which either real or simulated data can be displayed, a clear indication of simulated data shall be included as part of the classification label.

13.23.4 *Security Classification Display*—When displayed data are classified for security purposes, a prominent indication of security classification level shall be labeled in each display.

13.23.5 *User Identification*—User identification procedures shall be as simple as possible, consistent with adequate data protection. Examples include biometrics, personal identification verification card, token, passwords, etc. Personal information, such as the password or identifier shall not be echoed on the display.

13.23.5.1 *Password Choice*—When passwords are required, users shall be allowed to choose their own passwords since a password chosen by a user will generally be easier for that individual to remember. Guidelines for password selection shall be given so that users will not choose easily guessable ones.

13.23.5.2 *Changing Passwords*—Users shall be allowed to change passwords whenever they choose; all passwords shall be changed at regular periodic intervals.

13.24 *Help:*

13.24.1 *General*—In addition to explicit error management aids, (labels, prompts, and advisory messages) and implicit aids (cuing), users shall be able to obtain further online guidance by requesting HELP. Following the output of a simple error message, users shall be permitted to request a more detailed discussion at levels of increasing detail.

13.24.2 *HELP Request*—A single, standard action (single keystroke or click or a pointing device) that is always available shall be provided to request HELP.

13.24.3 *HELP Content*—Online HELP should include the following components:

13.24.3.1 Memory aids,

13.24.3.2 Basic information likely to be of use only to novices,

13.24.3.3 Material selected from written documentation,

13.24.3.4 Explanations that go beyond written documentation,

13.24.3.5 Information that might seem obvious but may not be to all users, and

13.24.3.6 Step-by-step instructions on how to perform the most common tasks.

13.24.4 *Multi-level HELP*—When an initial HELP display provides only summary information, more detailed explanations shall be provided in response to repeated user requests for HELP.

13.24.5 *Browse/HELP*—Users shall be permitted to browse and search through on-line HELP search displays, just as they would through a printed manual, to gain familiarity with system functions and operating procedures.

13.24.6 *HELP Access*—Users should be able to access HELP from within an application, (that is, without leaving the application), and return to where they were before requesting HELP. Users should also be able to alternate between the two.

13.24.7 *Appropriate HELP*—HELP information content (wording and level of detail) and format shall be appropriate to the experience and training of the system users.

13.25 *Software:*

13.25.1 *General*—The design of a computer program shall provide adequate information and respond within required time limits with sufficient detail and precision to ensure mission accomplishment while minimizing physical and mental stress on the users.

13.25.2 *Information and System Response*—The information displayed to the user, such as symbols, display codes, prompts, alerts, and alarms shall be limited to that which is necessary to perform specific actions or to make decisions.

13.25.3 *Computer Failure*—In the event of computer failure, the program shall allow for orderly shutdown and establishment of a checkpoint so restoration can be accomplished without loss of computing performed to date.

13.25.4 *Task Complexity*—Software shall minimize user task complexity. Control inputs shall be simplified to the extent possible, particularly for tasks requiring real-time responses, and shall permit logical task sequences with a minimum number of control manipulations to achieve task completion.

13.25.5 *Interaction*—Where two or more users must have simultaneous read access to the computer program or data-processing results from multiple personnel equipment interfaces, the operation by one person shall not interfere with the operations of another person unless mission survival may be contingent upon the preemption. Provisions shall be made so that the preempted user can resume operations at the point of interference without information loss.

13.26 *Data Transmission/Messaging:*

13.26.1 *Functional Integration*—Data transmission functions shall be integrated with other information-handling functions within a system. A user shall be able to transmit data using the same computer system and procedures used for general entry, display, and other processing of data.

13.26.2 *Consistent Procedures*—Procedures for preparing, sending, and receiving data and messages shall be consistent from one transaction to another and consistent with procedures for other information-handling tasks.

13.26.3 *Message Formats*—When messages must conform to a defined format, a preformatted message form including standard information, such as headers and distribution lists shall be available to users. If no requirement exists, users should be able to compose and transmit messages as unformatted text or with a format of their own design.

13.26.4 *Interruption*—Users shall be allowed to interrupt message preparation, review, or disposition and then resume any of those tasks from the point of interruption.

13.26.5 *Incorporate Existing Files*—Users shall be allowed to incorporate, or "attach" an existing data file in a message or to combine several files into a single message for transmission and to combine stored data with new data when preparing messages for transmission. It shall not be necessary to re-enter any data already entered for other purposes.

13.26.6 *User Initiation*—Data transmission should be initiated by an explicit user action (for example, a SEND command).

13.26.7 *Transmission Notification*—Users shall be notified if a message could not be transmitted. When possible, notification of failure to transmit a message should include an explanation of the failure.

13.26.8 *Address Entry Prompt*—When users must specify the address for messages, prompting shall be provided to guide the user in the process.

13.26.8.1 *Address Directory*—Users should be able to select addresses from a directory for automatic entry in address fields. Users should be able to search for addresses in a directory by specifying a complete or partial name or other address information.

13.26.9 *Incoming Message Control*—Users should be able to specify "filters" based on message source, priority, type, or content that will control the notification of incoming messages. Users should be able to choose the device (files, display, printer) that will receive messages.

13.26.9.1 *Incoming Message Notification*—While using the system, users should be notified when they receive a new message. Notification of the arrival of an electronic message should not interfere with ongoing system use.

13.26.10 *Data Preservation*—The arrival of a message in a format incompatible with that of the system shall not result in the loss of the message or of any ongoing transaction. When the format of a data transmission is incompatible with the system receiving it (for example, incompatible with system decoding or with the available devices), the intended recipient should be notified.

13.27 *Input Devices:*

13.27.1 *Device Selection*—Selection of an input device shall be based upon an analysis of the tasks required by the operator/maintainer. Additional guidance on input devices can be found in Section 5, "Controls" and selection for nonkeyboard applications is shown in Table 31.

13.27.2 *Keyboard Use*—Arrangements of push buttons in the form of keyboards shall be used when alphabetic, numeric, or special function information is to be entered into a system.

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

(1) Numeric Keyboard—The configuration of a keyboard used to enter solely numeric information shall be a 3 × 3 + 1 matrix with the zero digit entered on the bottom row and arranged using the standard calculator format: "789 456 123 0." If the keyboard will be used primarily for communications, it shall use the "telephone" arrangement, that is, with the numerals 1, 2, and 3 in the top row.

(2) Alphanumeric Keyboard—QWERTY keyboards, rather than alphabetical order keyboards, with the numeric keyboard located to the right of the standard keyboard should be provided unless special requirements exist for some other type of key arrangement.

(3) Dimensions, Resistance, Displacement, and Separation—The control dimensions, resistance, displacement, and separation between adjacent edges of the pushbuttons which form keyboards shall conform to the criteria in Section 5, "Controls," Table 32, "Keyboard Push-button Characteristics" and ANSI/HFS Standard No. 100-1988, Human Factors Engineering of Visual Display Terminal Workstations. For a given keyboard, these criteria shall be uniform for all individual keys.

13.27.2.2 *Timely Display*—Keyed inputs, except security items such as passwords, shall be echoed on the display within 0.1 s.

13.27.2.3 *Feedback*—The actuation of a key shall be accompanied by either tactile or auditory feedback or both. If only one, tactile is preferred. Auditory feedback shall be adjustable with the ability to be turned off. Additionally, feedback shall be provided to inform the operator whether the intended key was pressed, and whether the next operation may be initiated.

13.27.2.4 *Numeric Keypads*—Keyboards used in systems requiring substantial numeric input shall be equipped with a numeric keypad.

13.27.2.5 *Multiple Keyboards*—Systems containing more than one keyboard shall maintain the same configuration for alphanumeric, numeric, and special function keys throughout the system.

13.27.2.6 *On-Screen Keyboards*—Graphical representations of keyboards that appear on video displays using pointing devices or touch screens shall be designed in accordance with 13.27.2.1.

13.27.3 *Fixed Function Keys*—Fixed-function, or dedicated, keys (for example, ENTER) shall be used for time-critical, error-critical, frequently used control inputs or those that must be continuously available. Once a key has been assigned a given function, it shall not be reassigned to a different function for a given user.

13.27.3.1 *Fixed Function Key Standardization*—Fixed function keys shall be common throughout the system.

13.27.3.2 *Fixed Function Key Availability*—Fixed function keys shall be selected to control functions that are continuously available; lockout of fixed function keys shall be avoided.

13.27.3.3 *Non-Active Keys*—Non-active fixed function keys shall be replaced by a blank key on the keyboard.

13.27.3.4 *Function Key Grouping*—Fixed function keys shall be logically grouped and shall be placed in distinctive locations on the keyboard.

13.27.3.5 *Function Key Actuation*—A fixed function key shall require only a single actuation to accomplish its function.

13.27.3.6 *Function Key Feedback*—When fixed function key activation does not result in an immediately observable natural response, the user shall be given an indication of system acknowledgement.

13.27.3.7 *Function Key Labels*—Key assignments shall be displayed at all times, preferably through direct marking. Where abbreviations are necessary, they shall be in accordance with Section 15.

13.27.3.8 *Prolonged Key Depression*—Prolonged depression of function keys shall not result in a repeat of the function except for the DELETE, arrow, and backspace keys.

TABLE 31 Advantages and Disadvantages of Nonkeyboard Input Devices

Device	Advantages	Disadvantages
Touchscreen	No separate input device Fast	Low resolution Finger can block view Fingerprints on screen Tires arm
Trackball (and Joystick)	Can be used comfortably with minimum fatigue Does not cover parts of the screen in use Expansion or concentration Ball control is an efficient use of space	Slower than the light pen and other “point-to-devices” for simple input and option selections Must be attached, but not to the display Unless there is a large joystick, an inadequate control to display ratio will result for positional control The displacement of the stick controls both the direction and the speed of cursor movement Trackball and joystick controllers are difficult to use for accurate free-hand graphic input Difficult to integrate the activate switch with the trackball
Grid and Stylus	Good for graphic entry Can be designed to be used on horizontal surface Multipurpose input device Minimal difficulty going from graphic input if character is built into the system, and the tablet is used for the input Spatial correspondence between displays and control movement	Extra space required on work surface Displacement of visual feedback from motor activity may cause coordination problems Entering hand printed characters to be recognized by the system is very slow (fewer than 40 characters/min) compared with typewriter entry (averaging 200 recognition characters/min)
Mouse	Relatively fast Has low error rates for large targets Allows user to concentrate attention on VDU screen	Requires additional flat work surface Difficult to use for free-hand graphic input High error rates with small targets Lost time when mouse held backwards or sideways Some training needed Wheel (ball) slipping sometimes a problem
Lightpen	Fast for simple input Good for tracking moving objects Minimal perceptual motor skills needed Efficient for successful multiple selection User does not have to scan to find a cursor somewhere on the screen May be adaptable to bar coding	May not feel natural to user, like a real pen or pencil does Requires some fine motor control May lack precision because of the aperture distance from the CRT screen surface, and parallax Contact with the computer may be lost unintentionally Frequently requires simultaneous button depression may cause slippage and inaccuracy Must be attached to terminal, which may be inconvenient Glare problem if pen tilted to reduce arm fatigue Fatiguing if pen is held perpendicular to work surface If pointing to dark area, may require user to flash the screen to find pen One-to-one input only (zero order control) May be cumbersome to use with alternate, incompatible entry methods, like the keyboard Tends to be used for purposes other than originally intended, such as for key depression Tends to be fragile Hand may obstruct a portion of screen when in use Care must be taken to provide adequate “activate” area around choice point Cannot be used on gas plasma panel
Speech Recognition	Does not require hands Does not require user to shift gaze Useful for low light conditions Allows simultaneous activation of more than one control mode Could be used in lieu of a translator, allowing natural, conversational version of different languages to control complicated systems	Entry can be slow Must use specified vocabulary Some systems must be individualized to specific user If individual’s voice changes (for example, become stressed) system may not respond May require headset Speaker-dependent systems require template loading time

TABLE 32 Keyboard Push-button Characteristics

	Diameter/Square, mm (in.)		Resistance, N (oz)		
	Bare-Handed	Arctic Mittens	Numeric	Alphanumeric	Dual Function
Minimum	10 (0.385)	19 (0.75)	1 (3.5)	0.25 (0.9)	0.25 (0.9)
Maximum	19 (0.75)		4 (14)	1.5 (5.3)	1.5 (5.3)
Preferred	13 (0.5)	19 (0.75)			
				Displacement, mm (in.)	
Minimum			0.76 (0.03)	1.3 (0.05)	0.76 (0.03)
Maximum			4.8 (0.19)	6.4 (0.25)	4.8 (0.19)
Preferred			6.4 (0.25)	6.4 (0.25)	6.4 (0.25)

13.27.4 *Variable Action (Soft) Key*—Variable action keys may be used for programmable menu selection and entry of control functions. Operational sequences using variable action keys shall be minimized with respect to the number of key functions required.

13.27.4.1 *Variable Key Status*—When the function of an action key varies, the status of the key shall be displayed.

13.27.4.2 *Inactive Key Alert*—When keys with labeled default functions are reprogrammed or turned off, a visual warning shall alert the user that the standard action is not currently accessible by means of that key.

13.27.4.3 *Variable Key Relabeling*—Provision shall be made for easily relabeling variable action keys. Labels for variable function keys, located along the perimeter of a display, may be generated on the display face.

13.27.4.4 *SHIFT-ed Variable Keys*—Variable function keys shall not be shifted character keys that require the depression of a shift key before each actuation of the variable key.

13.27.4.5 *Variable Key Restoration*—Where the functions assigned to a set of function keys change as a result of user selection, the user shall be given an easy means to return to the initial, base-level functions. For example, in cockpit design, where multifunction keys may be used for various purposes such as navigation or weapons control, the aircrew should be able to take a single action to restore those keys quickly to their basic flight control functions.

13.27.4.6 *Overlays*—Mechanical overlays, such as coverings over the keyboard or transparent sheet placed over the display, shall be avoided.

13.27.5 *Touchscreen Use*—Touchscreen control may be used to provide an overlaying control function to a data display device such as CRTs, dot matrix/segmented plays, electroluminescent displays, programmable indicators, or other display devices in which direct visual reference access and optimum direct control access are desired. Touchscreens are appropriate for interactions involving the selection of devices or targets on position displays (for example, radars), arrangement diagrams, piping diagrams, discrete-function controls, or opening/closing valves. A touch screen should not be used if personnel will be entering large amounts of data.

13.27.5.1 *Confirmation of Critical Tasks*—Where a touchscreen control is used for a critical task, system response shall require confirming an additional, confirmatory action to ensure that the control actuation is, in fact, intended. If this is impractical, multiple touch actuation shall be incorporated.

13.27.5.2 *Repeat Function Delay*—An initial delay of 500 to 750 ms should be provided when a repeat delay is provided. All repeat functions should display the fact that a repeat request has been initiated.

13.27.5.3 *Touchscreen Luminance*—When used, touchscreen displays shall have sufficient luminance transmission to allow the display with touch screen installed to be clearly readable in the intended environment and meet the display luminance requirements herein.

13.27.5.4 *Touchscreen Parallax and Glare*—Touch-interactive devices should be selected and mounted to minimize parallax problems and minimize specular glare.

13.27.5.5 *Positive Indication*—A positive indication of touchscreen activation shall be provided to acknowledge the system response to the control action. This can include the display of a pointing device, such as a crosshair. Plotting or map displays should allow the pointing device to follow finger movements across the display.

13.27.5.6 *Dimensions and Separation*—Targets (for example, keys) on a touchscreen should be regular, symmetrical, and equilateral in shape. The dimensions and separation of responsible areas of the touch screen shall conform to S_1, S_2, and B_w of Fig. 12.

13.27.5.7 *Touchscreen Sensitivity*—The sensitivity of the touchscreen should be sufficiently high that no resistance or displacement is required to activate the touch screen. Contact with the touch screen should be adequate to activate the control or input function.

13.27.5.8 *Touchscreen Response Time*—System display response time in terms of feedback relating to personnel's commands or actions should be displayed within 0.25 s.

13.27.5.9 *Impact on Visual Display*—Characteristics of touch-interactive devices shall not degrade visual display quality in a manner that impairs operator performance and shall provide sufficient spatial resolution for anticipated task performance.

13.27.6 *Pointing Devices*—The pointing device selected for an application should be the one that most appropriately meets the application requirements and is most cost effective. When present, a pointing device shall be capable of the following:

(1) Moving a pointer on the screen,

(2) Selecting objects on which the pointer is placed, and

(3) Drop and drag operations.

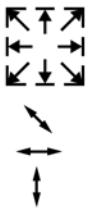
13.27.6.1 *Pointer Appearance*—An arrow pointing up and to the left should be the general-purpose pointer. This and other examples of pointer shapes associated with specific functions are illustrated in Table 33, "Pointer Shapes and Associated Functions." If an application provides any of these functions, it shall change the pointer to the associated shape whenever that function is invoked. An application shall redefine the shape of a pointer only when the pointer is inside an application window (including the border). A pointer should have a "hotspot," that is an active point that indicates the precise location where an operation will occur. The screen location of a hotspot shall not change if the pointer changes from one shape to another.

13.27.6.2 *Movement of the Pointer*—An operator should be able to move the pointer on the screen by moving all or part of the pointing device. The pointer should move in the same direction that the pointing device moves. Personnel should be able to move the pointer anywhere on the video display and shall not move beyond the outer boundaries of the screen, nor shall it disappear from sight. A pointer should not move on the video display unless an operator or maintainer moves the pointing device.

13.27.6.3 *Movement Ratio*—The ratio of movement of the pointing device to the movement of the pointer should default to approximately 1:1 and be adjustable by the user.

13.27.6.4 *Pointing Device Activation*—One or more buttons should be provided on pointing devices to allow the manipulation of objects on the screen so personnel can perform the

TABLE 33 Pointer Shapes and Associated Functions

Shape	Name	Function	Hotspot
	Arrow	**Pointing.** Used in most window areas for object selection.	The point of the arrow.
	I-beam	**Pointing.** Used in text areas to position the text cursor and perform actions on text. The I-beam pointer is hidden during the time between any keyboard action and pointer movement (that is, when text entry is occurring at the location of the text cursor).	On the vertical bar of the I-beam about one-third from the top.
	Watch (or hourglass)	**Working.** Indicates that an operation is being performed in a window area. When the working pointer is displayed, all pointing device and keyboard actions are ignored in the area.	Not applicable
	Caution sign	**Caution.** Indicates that action is expected in another window area before input can be made in the current area and that the pointer has no effect in the area. When the caution pointer is displayed, all pointing device and keyboard actions are ignored in the area.	Not applicable
	Resize pointer	**Resize.** Indicates positions for area resize, with the direction of the arrow in the pointer indicating the direction of increasing size. The horizontal and vertical resize pointers indicate resize in either the horizontal or vertical direction. The diagonal resize pointers indicate resize in both the horizontal and vertical directions simultaneously. The resize pointer appears when the pointer is on the frame border.	On the corner or line at the position pointed to by the arrow.
	Move arrows	**Moving.** Indicates a move operation in progress or a resize operation before the resize direction has been determined. During a resize operation, the four-directional arrow pointer indicates a direction for resizing and changes to the appropriate resize arrow when the pointer is on the frame border.	The intersection of the arrows.
	Sight or cross	**Sighting.** Used to make fine position selections (for example, to select a location on a map display).	The intersection of the lines.

actions listed in Table 34, “Pointing Device Button Actions.” This selection or activation process should be invoked by pressing a button on the pointing device. If the device has only one button, that button should provide the “select” function. If the device has two buttons, the left one should provide the “select” function and the right button should provide a “menu” function. A system shall provide users the ability to reverse the left-right operation of the buttons.

13.27.7 *Joysticks*—Joysticks are appropriate to use if precise input functions are required. They are most useful when used to control direct pointing, rather than discrete controls such as cursor control keys. A discrete mechanism shall be provided to allow the user to activate and deactivate the joystick. Hand-Operated Displacement Joysticks and Hand-Operated Isometric Joysticks are described in detail in 5.6.14 and 5.6.15 of this practice, respectively, and other applications

TABLE 34 Pointing Device Button Actions

Action	Response
Press	Depress a button and hold it down
Release	Release a button that has been depressed
Click	Press and release a button without moving the pointing device
Double Click	Press and release a button twice in rapid succession without moving the pointing device
Drag	Depress a button and move the device while holding the button down
Move	Move the pointing device without pressing any buttons

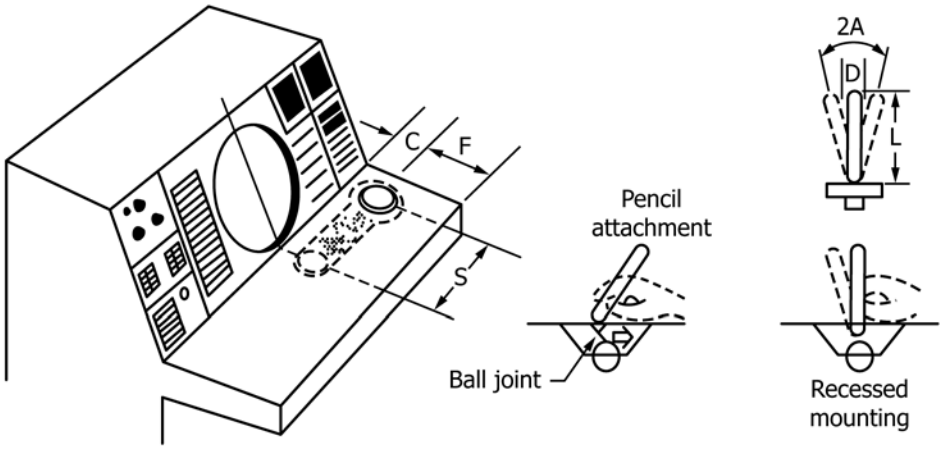
of joysticks used for interaction with computer interfaces are described in the following.

13.27.7.1 *Finger-Operated Displacement Joysticks Use*—Finger-operated displacement joysticks are useful for free-drawn graphics. In this application, they are not usually spring-loaded to return to center. It is desirable that they have sufficient friction to remain in their last position when the hand is removed.

13.27.7.2 *Specifications*—The dimensions, resistance, and clearance of finger-operated displacement joysticks shall not exceed the maximum or minimum values given in Fig. 141.

13.27.7.3 *Mounting*—The joystick shall be mounted in a way that provides forearm or wrist support. If the joystick is a separate modular device, the module shall be mounted so that the joystick can be manipulated without slippage, movement, or tilting of its base.

13.27.7.4 *Movement*—Movement shall not exceed 45° from the center position. Movement shall be smooth in all directions, and positioning of a follower shall be attainable without noticeable backlash, cross-coupling, or need for multiple corrective movements. Control ratios, friction, and inertia shall meet the dual requirements of rapid gross positioning and precise fine positioning. Recessed mounting or pencil attachments may be used as indicated in Fig. 142, "Finger-Operated Displacement Joystick Specifications" to provide greater precision of control. If the joystick is to be used for generating



	D diameter	L length	Resistance	A Displacement	S display clearance to stick clearance	C around stick	F stick clearance to shelf front
Minimum	6.5 mm (0.25 in)	75 mm (3.0 in)	3.3 N (12.0 oz)	--	0	†	120 mm (4.75 in)
Maximum	16 mm (0.6 in)	150 mm (6.0 in)	8.9 N (32 oz)	45°	400 mm (15.75 in)	--	250 mm (9.9 in)

FIG. 142 Finger-Operated Displacement Joystick Specifications

free-drawn graphics, the CRT shall have a refresh rate sufficiently high to give the appearance of a continuous track when the follower is moved. Delay between control movement and the confirming visual indicator response shall be minimized and shall not exceed 0.1 s.

13.27.8 *Thumb Tip and Fingertip-Operated Displacement Joysticks*—Thumb tip and fingertip-operated displacement joysticks may be mounted on a handgrip, which can serve as a steady rest to damp vibration or increase precision. If they are so mounted, the handgrip shall not itself also function as a joystick. Thumb tip and fingertip-operated displacement joysticks shall be mounted in a way that provides wrist or hand support. Console-mounted joysticks shall be mounted as shown in Fig. 142. Movement shall not exceed 45° from the center position. If the joystick is a separate modular device, the module shall be mounted so that the joystick can be manipulated without slippage, movement, or tilting of its base.

13.27.8.1 *Thumb Tip and Fingertip-Operated Isometric Joysticks*—Thumb tip- and fingertip-operated isometric joysticks shall be mounted in a way that provides wrist or hand support. They may be mounted on a handgrip that serves as a steady rest to damp vibrations or to increase precision. If they are so mounted, the handgrip itself shall not function simultaneously as a joystick controller. Console-mounted joysticks shall be mounted as shown in Fig. 142, "Finger-Operated Displacement Joystick Specifications." If the joystick is a separate modular device, the module shall be mounted so that the joystick can be manipulated without slippage, movement, or tilting of its base.

13.27.9 *Trackball*—Track ball controls rotate freely in all directions. Therefore, they are suitable for applications such as generating precise X and Y output values, data pickoff and accumulative travel, however, they do not provide for automatic return to a point of origin, so the interfacing system must provide this. Track ball controls should be used only as position controls, that is, applications in which a movement of the ball produces a proportional movement of a follower on a display. In any application that would allow the ball to drive the pointer on the display off the edge of the display, indicators shall be provided to advise the operator how to bring the follower back onto the display. Ball controls shall be used only as position controls (that is, a given movement of a ball makes a proportional movement of the pointer on the display).

13.27.9.1 *Trackball Design Criteria*—Design and operation considerations for track balls are as follows:

(1) If a track ball will be used to make precise or continuous adjustments, a wrist or arm support or both should be provided.

(2) A track ball should be capable of rotation in any direction so as to generate any combination of X and Y output values. When moved in either the X or Y direction alone, the control should exhibit no apparent cross-coupling (for example, movement of the follower in the orthogonal direction).

(3) There should be no backlash apparent to the operator.

(4) Control ratios and dynamic features should meet the dual requirements of rapid gross positioning and smooth, precise fine positioning.

13.27.9.2 *Trackball Dimensions*—Dimensions, resistance, and clearances shall conform to the criteria in Fig. 143, "Trackball Dimensions, Resistance and Clearance." The smaller diameter ball controls shall be used only where space availability is very limited and when there is no need for precision. Preferred mounting is on a shelf or desk top.

13.27.9.3 *Trackball Actuation*—A discrete mechanism shall be provided to allow the user to actuate/deactuate the device.

13.27.10 *Grid and Stylus Devices*—These provisions cover various techniques that use some means of establishing an *x* and *y* grid and a stylus for designating specific points on that grid for control purposes (time-shared *x* and *y* potential grids and a voltage-sensitive stylus).

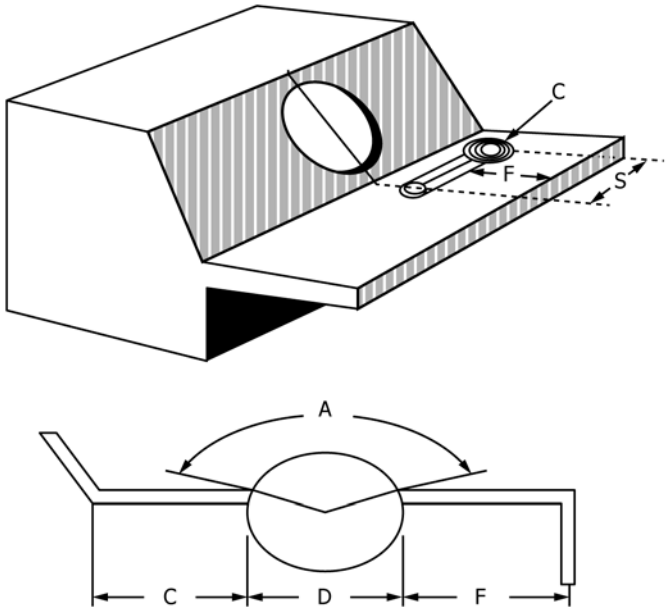
13.27.10.1 *Application*—Grid and stylus devices may be used for data pickoff from a CRT, entry of points on a display, generation of free-drawn graphics, and smaller control applications. The grid may be on a transparent medium allowing stylus placement directly over corresponding points on the display or it may be displaced from the display in a convenient position for stylus manipulation. In either case, a follower (bug, mark, hook, and so forth) shall be presented on the display at the coordinate values selected by the stylus. Devices of this type shall be used only for zero order control functions (that is, displacement of the stylus from the reference position causes a proportional displacement of the follower).

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

13.27.10.3 *Dimensions and Mounting*—Transparent grids that are used as display overlays shall conform to the size of the display. Grids that are displaced from the display shall approximate the display size and shall be mounted below the display in an orientation to preserve directional relationships to the maximum extent (a vertical plane passing through the north/south axis on the grid shall pass through or be parallel to the north/south axis on the display).

13.27.11 *Mouse Use*—When used the mouse shall be used on a flat surface to generate *x* and *y* coordinate values that control the position of the follower on the associated display. It may be used for data pickoff or for entry of coordinate values. It shall be used for zero order control only (generation of *x* and *y* outputs by the controller results in proportional displacement of the pointer). It shall not be used for generation of free-drawn graphics. Where vessel or maritime installation motion may result in unintended movement of the mouse, then other pointing devices, such as a track ball, should be used.

13.27.11.1 *Dynamic Characteristics*—The design of the controller and placement of the maneuvering surface shall be such as to allow the operator to consistently orient the controller to within 6175 mrad (10°) of the correct orientation without visual reference to the controller. [That is, for example, when the operator grasps the controller in what seems to be the



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

FIG. 143 Trackball Dimensions, Resistance, and Clearance

correct orientation and moves it rectilinearly along what is assumed to be straight up the y axis, then the direction of movement of the follower on the CRT shall be between 175 and 6110 mrad (10 and 350°).] The controller shall be easily movable in any direction without a change of hand grasp and shall result in smooth movement of the follower in the same direction 6175 mrad (10°). The controller shall be operable with either the left or right hand. A complete excursion of the controller from side to side of the maneuvering area shall move the follower from side to side on the display regardless of scale setting or offset unless expanded movement is selected for an automatic sequencing mode of operation. In any application that would allow the controller to drive the follower off the edge of the display, indicators shall be provided to assist the operator in bringing the follower back onto the display.

13.27.11.2 *Dimensions*—The mouse shall have no sharp edges but shall be shaped roughly as a rectangular solid, with limiting dimensions as given in Table 35.

TABLE 35 Limiting Dimensions for Mouse

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

13.27.12 *Light Pen*—A simple light pen may be used as a track-oriented readout device. That is, it may be positioned on the display screen to detect the presence of a computer-generated track by sensing its refresh pattern; the display system will then present a pointer (hook) on the designed track. With suitable additional circuitry, a pointer can be made to track the movement of the light pen across the surface, thus allowing it to function as a two-axis controller capable of serving the same purposes as the grid and stylus devices (see 13.27.10).

13.27.12.1 *Dynamic Characteristics*—When used as a two-axis controller, light-pen dynamic characteristics shall conform to 13.27.10.2.

13.27.12.2 *Light Pen Dimensions and Mounting*—The light pen shall be 120 to 180 mm (4.7 to 7.1 in.) long with a diameter of 7 to 20 mm (0.3 to 0.8 in.). A convenient clip shall be provided at the lower right side of the CRT to hold the light pen when it is not in use.

13.27.12.3 *Light Pen Actuation*—Light pens shall be equipped with a discrete actuating/de-actuating mechanism.

For most applications, a push-tip switch, requiring 0.5 to 1.4 N (2 to 4 oz) of force to actuate, is preferred.

13.27.12.4 *Light Pen Feedback*—Two forms of feedback shall be provided to the user when using a light pen:

(1) Position of the light pen, preferably in the form of displayed cursor (for example, illuminated circle, crosshair) or highlighting projecting from the light pen onto the screen. The feedback shall be large enough to be seen under the point of the light pen.

(2) Feedback that the light pen has actuated and the input has been received by the system that informs the user that the system is recognizing the presence of the light pen.

13.27.13 *Speech Recognition Use*—Speech recognition devices may be used as controls when the user's hands are occupied, when regular or frequent mobility is required, or when the user's visual attention is fully occupied. Speech recognition devices are used when: *(1)* the consequences of recognition errors are low; *(2)* identifying and correcting errors should be easy; *(3)* use is expected to be infrequent; and *(4)* the device can be readily inhibited when speech recognition is not desired. Speech recognition devices should not be used for tasks that involve describing the position or manipulation of objects. Speech recognition devices should be used only where satisfactory performance can be obtained. This may preclude environments that produce stress in the user, are noisy, or have high g-loading. The devices should adapt to the operator, instead of vice versa. Speech recognition devices should require minimal training.

13.27.13.1 *Input Vocabulary*—Input vocabulary shall be minimized, consistent with system needs, and selected to provide phonetically distinct elements to eliminate misinterpretation.

13.27.13.2 *Inter-word Delays*—Speech recognition devices shall not require interword delays or exaggeration in speech.

13.27.13.3 *Voice Prompting*—Voice prompting from the computer should be provided where there is an advantage to freeing the user from reading a display. Lack of user response to the prompt shall result in a repetition of the prompt.

13.27.13.4 *Correction Capability*—A capability should be provided to reject unintended and involuntary sounds (for example, sneezes, coughs, throat clearing, and noncommand words).

13.27.13.5 *Alternative Input Device*—Speech recognition devices shall not be used as the sole control device; an alternative control device shall be provided in case of speech recognition device degradation or failure.

13.27.14 *Input Device Interchangeability/Redundancy*—If more than one input device is present, a user should be able to control computer interaction with all of them. For example, a keyboard should be capable of executing navigation and selection operations when used in conjunction with a mouse, light pen, or other input devices.

13.28 *Cursors:*

13.28.1 *Control*—Systems using cursors shall provide cursor control capability consistent with user speed and accuracy requirements. Additionally, the user should be able to adjust the sensitivity of the cursor movement to be compatible with the required task.

13.28.2 *Display*—Cursor display properties shall incorporate the following:

13.28.2.1 A movable cursor within the display shall have a distinctive visual attribute.

13.28.2.2 A cursor shall not obscure or distract from the reading of other displayed entities.

13.28.2.3 When fine positioning accuracy is required, as in some forms of graphic and image-processing applications, the displayed cursor shall include an appropriate point designation feature (such as crosshairs).

13.28.2.4 Cursors should blink at a rate of approximately 3 Hertz.

13.28.3 *Home Position*—The home position for the cursor shall be consistent across similar types of displays.

13.28.4 *Explicit Actuation*—A separate, explicit action, distinct from cursor position, shall be required for the actual entry (for example, enabling, actuation) of a designated position. For most graphics data entry, pointing shall be a dual action, with the first action positioning the cursor at a desired position and the second action confirming that position to the computer. An exception may be a design allowing "freehand" drawing of continuous lines where the computer must store and display a series of cursor positions as they are entered by the user.

13.28.5 *Consistent Positioning*—Where cursor positioning is incremental by discrete steps, the step size of cursor movement shall be consistent horizontally (that is, in both right and left directions) and vertically (in both up and down directions).

13.28.6 *Keyboard Cursor Control*—When position designation is required in a task emphasizing keyed data entry, cursor control shall be by some device integral to the keyboard. If cursor movement is accomplished by depressing keys, the keys shall be located on the main keyboard.

13.28.7 *Movement Relationships*—The response of a cursor to control movements shall be consistent, predictable, and compatible with the user's expectations. For cursor control by key action, a key labeled with a left-pointing arrow shall move the cursor leftward on the display; for cursor control by joystick, leftward movement of the control shall result in leftward movement of the cursor.

13.28.8 *Head and Foot of File*—The means shall be provided to readily move the cursor to the head or the foot (end) of the file.

13.28.9 *Cursor as a Status Indicator*—If there is no application status indicator, changing the shape of the cursor from the normal shape should be used to indicate the current status when an operation in progress takes more than 2 or 3 s to complete and the user cannot continue working in that application until the operation finishes.

13.29 *Printing:*

13.29.1 *Printer Use*—The user shall have the capability to obtain a paper copy of the exact contents of the alphanumeric or digital graphic display in those systems where:

13.29.1.1 Mass storage is restricted.

13.29.1.2 Mass stored data can be lost by power interruption.

13.29.1.3 Visual record keeping is required or desirable.

13.29.2 *Print Display*—The user shall be able to print information as displayed on a screen by simple request (for example, PRINT-SCREEN) without having to take series of other actions first, such as calling for the display to be filed, specifying a filename, then calling for a print of that named file.

13.29.3 *Print Page(s)*—The user shall have the capability to request printing of a single page, or sequence of pages, by specifying the page numbers. Request sequence shall provide status of destination printer. Feedback shall be provided to the user if the print request was denied with appropriate actions required to correct error (for example, "Printer empty, please add paper").

13.29.4 *Minimum Contrast*—A minimum luminance contrast of 3:1 shall be provided between the printed material and the background on which it is printed.

13.29.5 *Print Legibility*—The print shall be free from character line miss-registration, character tilt, and smear.

13.29.6 *Controls and Feedback*—Printers shall conform to the rules in this standard with respect to:

13.29.6.1 The controls and displays used to start, stop, and adjust the machine and its critical operating elements.

13.29.6.2 Giving a positive indication of the remaining supply of materials such as paper and ink.

13.29.6.3 Operations performed by the user, such as inserting, adjusting, removing, replenishing, and replacing supplies and materials without requiring disassembly or special tools.

13.29.6.4 Operations performed on site by a technician, such as adjustments and replacements not ordinarily performed by the user.

14. Habitability

14.1 *Noise:*

14.1.1 *Maximum Levels*—The maximum permissible noise levels for specific spaces within a vessel or maritime installation should not exceed those indicated in Table 36.

14.1.2 *Maximum Exposure and Protection*—Maximum permissible daily and occasional noise exposure limits are shown in Fig. 144 and discussed below:

14.1.2.1 *Zone A, Maximum Exposure With Protection*—No personnel even wearing hearing protectors shall be exposed to levels exceeding 120 dB(A) or to an $L_{eq}(24)$ (24-h equivalent continuous sound level) exceeding 105 dB(A).

14.1.2.2 *Zone B, Occasional Exposure*—Only occasional exposure should be allowed and both ear muffs and ear plugs shall be used unless the exposure duration is restricted to not more than 10 min when only ear muffs or plugs are required.

14.1.2.3 *Zone C, Occasional Exposure*—Only occasional exposures shall be allowed and ear muffs or plugs shall be required.

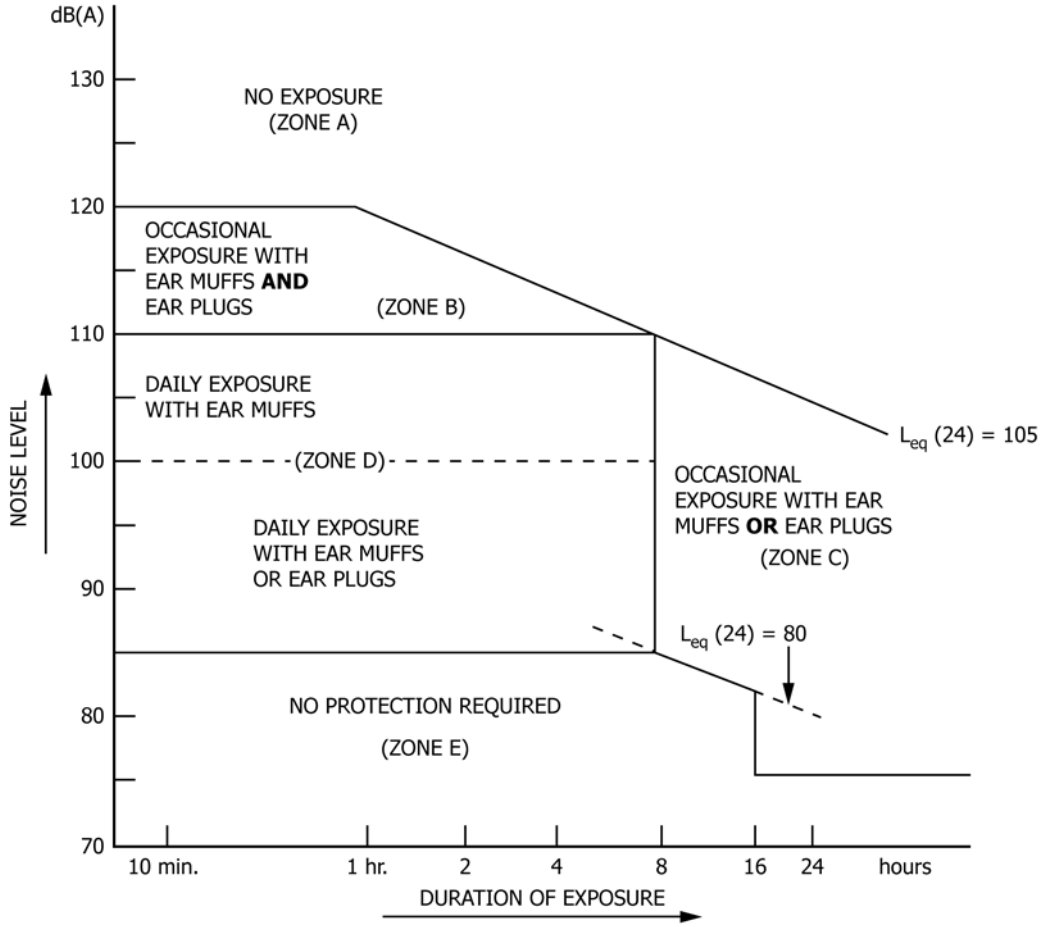
14.1.2.4 *Zone D, Daily Exposure*—If personnel routinely work with daily exposure in spaces with noise levels within Zone D, hearing protectors shall be worn.

14.1.2.5 *Zone E, Maximum Exposure Without Protection*—For exposures of less than 8 h, personnel without hearing protection shall not be exposed to noise levels exceeding 84 dB(A). When personnel remain for more than 8 h in spaces with a high noise level, an $L_{eq}(24)$ of 80 dB(A) shall not to be exceeded. Consequently, for at least a third of each 24 h, the

TABLE 36 Maximum Permissible Noise Levels

NOTE 1—All spaces with noise in excess of 84 dB(A) require the use of hearing protection as described in FIG 142 "Permissible Noise Exposure Limits." For measurement techniques, refer to IMO Resolution MSC.337(91) Code on Noise Levels on Board Ships.

Space	Noise Limit dB(A) Maximum	Noise Limit dB(A) Preferred
Work Spaces	90	84
Machinery space (continuously manned)	110	95
Machinery space (not continuously manned)	75	65
Machinery control rooms	84	75
Workshops	95	84
Non-specified spaces	70	65
Control Rooms and Offices	95	80
Open Deck Areas (Cargo Handling)	100	84
Fan Rooms		
Navigation Spaces	65	55
Navigation bridge and chartroom	70	60
Listening post, including bridge wings and windows	60	55
Radio rooms	65	55
Radar room/areas	75	60
Ship's Offices		
Accommodation Spaces	60	50
Cabins	60	45
Hospitals, dental, first aid centers	65	55
Mess rooms	65	50
Indoor recreation rooms	84	75
Open deck recreation areas	65	55
Offices	75	65
Gym		
Service Areas	75	65
Galleys	84	70
Serving lines, pantries, storerooms	84	75
Laundries		
Normally unoccupied spaces	90	84
Spaces not specified		



NOTE 1—Figure and description adapted from IMO Assembly Resolution A.468 (XII).

FIG. 144 Permissible Noise Exposure Limits

personnel shall be subject to an environment with a noise level not exceeding 75 dB(A).

14.1.2.6 As an alternative to Fig. 144, the personal exposure to a 24-h equivalent continuous sound level shall be no greater than 80 dB(A). Each individual's daily exposure duration in spaces requiring the use of hearing protectors shall not exceed 4 h continuously or 8 h in total.

14.1.3 *Hearing Protection Attenuation*—The use of earplugs, earmuffs, or both is based on the noise level and length of exposure. Hearing protectors selected for use should provide at least the noise attenuation at the ear as shown in Table 37.

14.1.4 *High Noise Area*—Any area in which noise levels exceed 84 dB(A) shall be classified as a "High Noise Area." Consideration shall be made to reduce personnel exposure to high noise by relocating controls, displays and workstations from "High Noise Areas" by implementing remote monitoring of equipment in separate, acoustically isolated spaces.

TABLE 37 Recommended Noise Attenuation from Hearing Protectors

Hearing Protection	Minimum Attenuation
Ear plugs	20 dB(A)
Ear muffs	30 dB(A)
Ear plugs and ear muffs	35 dB(A)

14.1.5 *Warning Sign*—A DANGER hazard sign shall be posted at each entrance into every "High Noise Area." The sign shall be in compliance with the requirements for hazard warning signs defined in Section 15 and shall describe the level of protection required based on 14.1.2 and Fig. 144.

14.1.6 *Portable Equipment Noise*—If hand tools in the workshop, or other portable or localized equipment produce noise levels that exceed 84 dB(A), a warning sign shall be posted at the work site or on the equipment identifying the hazard and requiring the use of hearing protectors at that site or with that equipment. The warning sign shall comply with the DANGER label requirements for hazard warnings as described in Section 15.

14.2 *Indoor Climate:*

14.2.1 *Design Requirement*—Indoor climate requirements shall be provided only for "manned spaces." A space is considered "manned" if it is occupied continuously for more than 20 min.

14.2.2 *Temperature*—The Heating, Ventilation, and Air Conditioning (HVAC) system shall be capable of providing a preset room temperature of 22 ± 1°C (71.5 ± 2°F). The preferred design shall be that the HVAC system shall be capable of sustaining an adjustable range of air temperature between 18°C (64°F) and 26.5°C (80°F) inclusive in all

manned spaces. Temperatures shall be maintained by a temperature controller. For the preferred design each manned space shall have its own individual thermostat for temperature regulation and dehumidification purpose.

14.2.2.1 *Vertical Temperature Gradient*—The difference in temperature at 100 mm (4 in.) above the deck and 1702 mm (67 in.) above the deck shall be maintained within 5.5°C (10°F) maximum and 3°C (6°F) preferred.

14.2.2.2 *Berthing Horizontal Temperature Gradient*—In berthing areas, the difference between the inside bulkhead surface temperature adjacent to the berthing and the average air temperature within the space shall be less than 10°C (18°F).

14.2.3 *Relative Humidity*—The HVAC system shall be capable of providing and maintaining a relative humidity within a range from 30 % percent minimum to 70 % percent maximum with 40 to 45 % preferred.

14.2.4 *Temperature/Humidity Design Goal*—The temperature/humidity design goal should be 21°C (70°F) and 45 %.

14.2.5 *Air Velocity*—Air velocities shall be as follows:

14.2.5.1 Air velocities shall not exceed 30 m (100 ft) per minute (0.5 m/s or 1.7 ft/s) at any measured position in the space. An exception would be in work locations where spot cooling of personnel is provided. In these cases, air should move past personnel at a velocity of less than 60 m (200 ft) per minute. In areas in which manuals or other loose papers are used, the air velocity should be preferably 20 m (65 ft) per minute (0.33 m/s or 1.1 ft/s) but no more than 30 m (100 ft) per minute.

14.2.5.2 For small spaces [for example, enclosed volume of 4.25 m^3 (150 ft^3) or less per person] a minimum of 0.85 m^3 (30 ft^3) of ventilation air per minute per person should be provided with approximately two thirds of the volume being outside air. For larger enclosures, the air supply per person should be in accordance with the curves shown in Fig. 145. The rate of air exchange for enclosed spaces should be at least six complete changes per hour. Care should be taken to provide outside air from a location away from process equipment, hazardous areas, exhausts, contamination sources, sea spray or sources of odor.

14.2.5.3 Engine room ventilation should comply with ISO 8861, Engine Room Ventilation in Diesel Engine Ships—Design Requirements and Basis of Calculations, and ISO 8862, Air Conditioning and Ventilation of Machinery Control—Rooms on Board Ships—Design Conditions and Basis of Calculations.

14.2.6 *Air Intakes*—Intakes for ventilation systems shall be located to minimize the introduction of contaminated air from such sources as exhaust pipes, galley exhaust vents, and paint locker exhausts into room ventilation intake openings or into the air intakes for the engine, reduction gear, or other moving machinery.

14.3 *Lighting:*

14.3.1 *General Design Requirements*—Lighting shall be designed and located to avoid glare from working and display surfaces as viewed from the normal working position. The maximum luminance ratio between any two different sources of luminance light within an operator or maintainer's field of view shall not exceed 5:1. To reduce glare, nonreflective or matte-finished surfaces shall be provided on consoles, panels, and other work surfaces. Placement of smooth, highly polished surfaces within 60° of a person's normal visual field shall be avoided.

14.3.2 *Location*—Avoid placing lights where persons climbing stairs or ladders look directly into the light. Other requirements include:

14.3.2.1 Avoid placing light fixtures in locations that are difficult to reach for bulb replacement or other maintenance.

14.3.2.2 Light fixtures mounted on ship or structure buildings or exposed sides shall be located so as not to shine into the eyes of operators of ship or structure mounted cranes or approaching aircraft or helicopters.

14.3.3 *Bulb Changing Fall Protection*—Stanchions or poles supporting light fixtures that are located at the edge of a vessel or maritime structure shall have anchor points welded on each side of the stanchion or pole so a person wearing a safety harness can be secured to at least one of the anchor points on the stanchion or pole at all times when climbing to and from the fixture.

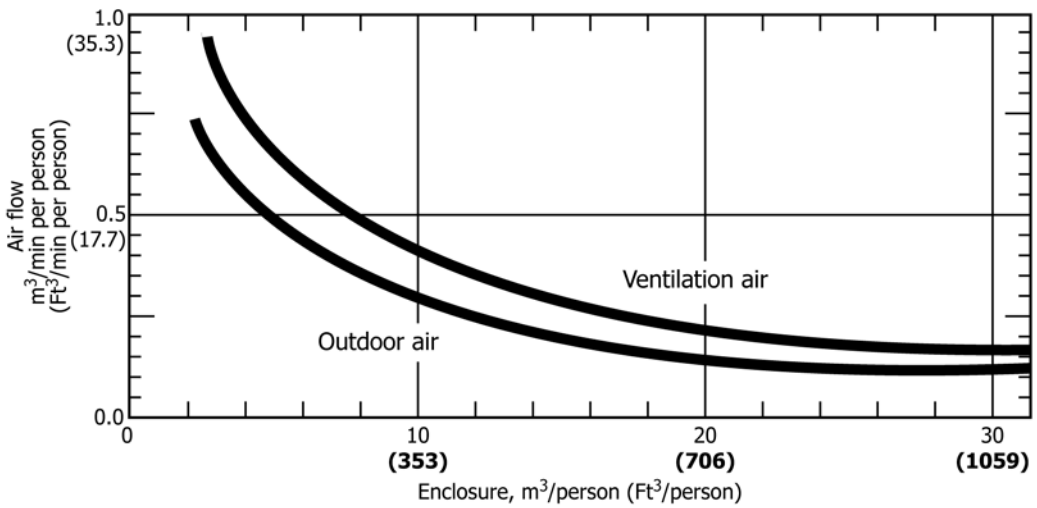


FIG. 145 Large-Enclosure Ventilation Requirements

14.3.4 *Dark Adaptation:*

14.3.4.1 When night vision is required for extended periods of time, low-level white lighting (with the capability to dim to zero) is preferred to low-level red lighting. Red lighting should not be used in areas where color recognition is required.

14.3.4.2 Where compatibility with night vision devices is required, the spectral output of all light emitting from or illuminating a display should not be greater than 600 nm in wavelength. The lighting shall be continuously variable to the full OFF position.

14.3.5 *Lighting Levels*—Lighting levels shall be provided as shown in Table 38, "Lighting Levels for Ships and Maritime Structures."

14.3.6 *Brightness Ratio*—The brightness ratio between the lightest and darkest areas or between a task area (for example, computer screen) and its surroundings (for example, bulkhead behind the screen) should be no greater than specified in Table 39, "Maximum Brightness Ratios."

14.3.7 *Wall Surface Reflectance*—Wall surface areas in working and living areas should be covered with non-saturated light colors such as tints, pastels, whites, and light shades of gray to increase the reflectance of space lights. Preferred surface reflectance values for spaces such as offices, control rooms, and maintenance areas are shown in Fig. 146.

TABLE 38 Lighting Levels for Ships and Maritime Structures

Work Area or Type of Task	Illumination Level		Work Area or Type of Task	Illumination Level	
	Preferred Lux (Ft-c)	Minimum Lux (Ft-c)		Preferred Lux (Ft-c)	Minimum Lux (Ft-c)
Assembly (Bench Work)			Muster Station		200 (18)
Course Work Detail	540 (50)	325 (30)	Medical Space		
Medium Work Detail	810 (75)	540 (50)	Waiting Area	755 (70)	540 (50)
Precise Work Detail	3230 (300)	2155 (200)	Exam/Treatment Room	1075 (100)	810 (75)
Bakery	540 (50)	325 (30)	Missile Facilities		
Battery Room	300 (28)	200 (18)	General Inspection	540 (50)	325 (30)
Bridge		325 30)	Repair and Service	1075 (100)	540 (50)
Business Machine Operation	1075 (100)	540 (50)	Storage Areas	215 (20)	215 (20)
Cargo Handling (Weather Decks)		150 (14)	Offices		
Chart Room			General	755 (70)	540 (30)
General Lighting		150 (14)	Computer Workstation	540 (50)	300 (28)
On Chart Table	1075 (100)	810 (75)	Ordinary Visual Tasks	540 (50)	325 (30)
Control Rooms			Paint Room		
General Lighting	540 (50)		General		325 (30)
Computer Work	300 (28)		Color Matching		2155 (200)
Consoles (front)	540 (50)	325 (30)	Pump Room	340 (32)	225 (20)
Consoles (rear)	325 (30)	110 (10)	Purifier Room (Water or Oil)	500 (46)	
Compressor/Pump/Generator	300 (28)	200 (18)	Passageways (walkways)	215 (20)	150 (14)
Crane Cab	540 (50)	400 (37)	Pump Rows, Valves	200 (18)	
Electrical Equip Testing	540 (50)	325 (30)	Radar Room		200 (18)
Elevators	325 (30)	215 (20)	Radio Room		540 (50)
Emergency Lighting	55 (5)	30 (3)	Reading		
Emergency Generator Room	340 (32)		Large Print	325 (30)	110 (10)
Escape Trunks		30 (3)	News Print	540 (50)	325 (30)
Fan Room		150 (14)	Small Type/Prolong Reading	755 (70)	540 (50)
Fire Pump Room	300 (28)	200 (18)	Recreation Rooms		300 (28)
Food Storage			Repair Rooms		
Non-refrigerated		200 (18)	General Lighting	540 (30)	325 (30)
Refrigerated		100 (9)	Instrument Repair	2155 (200)	1075 (100)
Galley	755 (70)	540 (50)	Sanitary Spaces		
Gyro Room		200 (18)	General		325 (30)
HVAC Room	300 (28)	200 (18)	Sinks and Mirrors		540 (50)
Instrument Shop	540 (50)	325 (30)	Toilets		150 (14)
Laundry			Service Areas (General)	215 (20)	110 (10)
General		540 (50)	Shaft Alley	215 (20)	110 (10)
Hand Pressing		1395 (150)	Snack and Coffee Bar		500 (46)
Lay Down Areas		200 (18)			
Laboratory	540 (50)	360 (33)	Stairs and Ladders	215 (20)	110 (10)
Library		540 (50)	Ship Stores		
Loading/Off-loading Area		150 (14)	General Warehouse	110 (10)	55 (5)
Lounges		300 (28)	Large Parts	200 (18)	
Manifold Area		100 (9)	Small Parts	300 (28)	
Machinery Room		200 (18)	Fine Parts	540 (50)	
Machine Shop			Steering Gear Room	540 (50)	300 (28)
General Lighting	540 (50)	325 (30)	Switchboards	540 (50)	325 (30)
Fine Bench Work	1075 (100)	745 (80)	Tanks	215 (20)	215 (20)
Maintenance Platform		200 (18)	Welding/Mechanical Shop	500 (46)	
Machinery Room		150 (14)	Windlass Room		100 (9)
Mess Room (Cafeteria)		300 (28)	Work and Repair Areas	700 (65)	

TABLE 39 Maximum Brightness Ratios

NOTE 1—Adopted from DOT/FAA/CT-96/1—Human Factors Design Guide.

Comparison	Environmental Classification		
	A	B	C
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	**
Between tasks and more remote lighter surfaces	1 to 10	1 to 20	**
Between luminaries and adjacent surfaces	20 to 1	**	**
Between the immediate work area and the rest of the environment	40 to 1	**	**

Legend:
A = Interior areas in which reflectances of entire space can be controlled for optimum visual conditions.
B = Areas in which reflectances of nearby work can be controlled, but there is only limited control over remote surroundings.
C = Areas (indoor and outdoor) in which it is completely impractical to control reflectances and difficult to alter environmental conditions.
** = Brightness ratio control is not practical.

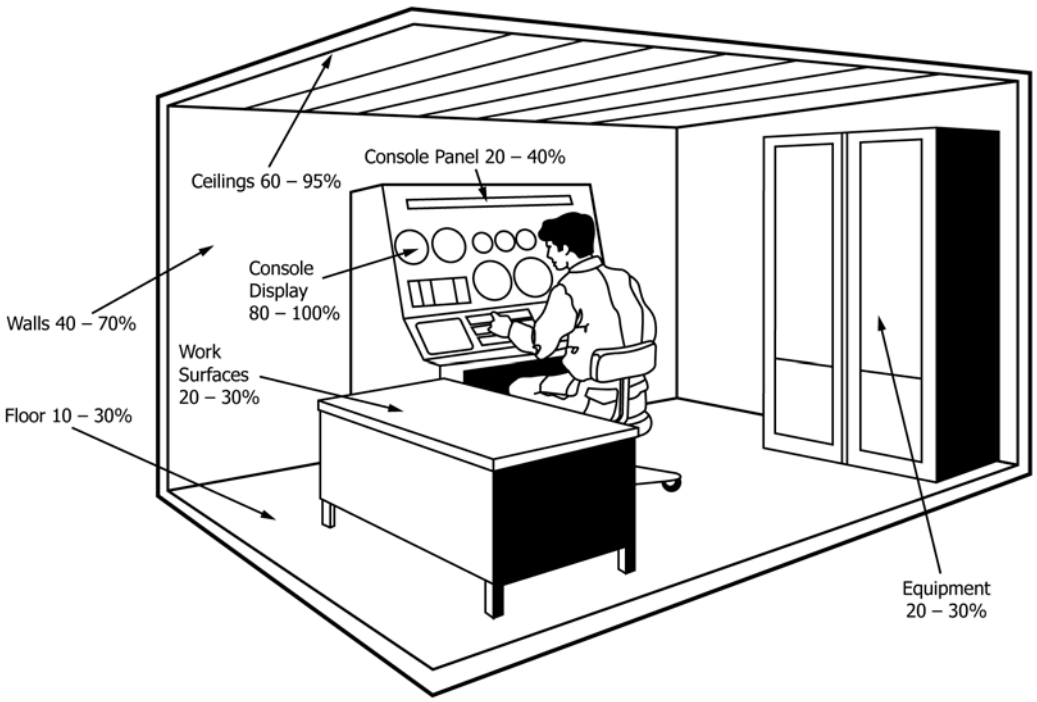


FIG. 146 Surface Reflectance Values

TABLE 40 Operational Environment Types

Type	Description of Environment	Applicable Paragraph
I	Exposure can be of any duration. The environment may contain some underlying vibration, but is predominantly characterized by repeated shocks or transient vibrations (for example, wave impacts of high speed boats).	14.4.2
II	Exposure can be of any duration. The environment is characterized as predominantly sinusoidal in nature, where occasional shocks or transient vibrations are present.	14.4.3
III	Exposure is limited in duration (less than 8 hours). The environment is characterized as predominantly sinusoidal in nature, with no shocks or transient vibrations present.	14.4.4
IV	Exposure is continuous (greater than 8 hours). The environment is characterized as predominantly sinusoidal in nature, with no shocks or transient vibrations present.	14.4.5

14.3.8 *Other Lighting Requirement*—For further criteria on lighting, refer to the ABS Guide for Crew Habitability on Ships and the ABS Guide for Crew Habitability on Offshore Installations.

14.3.9 *Emergency Lighting:*

14.3.9.1 Emergency lighting shall be provided for use when the power supply to the normal lighting is not available or fails and shall be powered from a source independent of that supplying the normal lighting.

14.3.9.2 Emergency lighting requirements exist in statutory, class, and other regulatory documents including ABS Rules for Building and Classing Steel Vessels (SVR 4-8-2/5.5), the IMO Convention for the Safety of Life at Sea (SOLAS), and the Mobile Offshore Drilling Unit (MODU) Code. As a result, the

design requirement for emergency lighting shown in 14.3.5 and Table 38 shall be used if not in conflict with any of the other documents listed above.

14.4 *Whole-body Vibration and Shock:*

14.4.1 *Applicability:*

14.4.1.1 The anticipated operational environment and exposure duration is required for the appropriate analysis method and threshold of whole-body vibration and shock. Table 40, "Operational Environment Types" defines each operational environment type and identifies the applicable paragraph to follow when determining operational limits.

14.4.1.2 In addition to the health and injury limits associated with Type I-IV environments, considerations should be made for the potential impact of craft motion on human comfort (14.4.6); human perception (14.4.7); and motion sickness (14.4.8).

14.4.2 *Repeated Shock:*

14.4.2.1 A minimum of 30 min of "worst case" accelerations should be measured when assessing repeated shock. The data must be collected and processed in accordance with the steps and formulas detailed in ISO 2631-1 (1997), Part 5.

14.4.2.2 For operational environments where impacts are less than or equal to 4 Gs, and for a general population (military or civilian), the resulting Equivalent Daily Static Compressive Stress (S_{ed}) or Spinal Stress Dose should not exceed 0.5 MPa for a low probability of adverse health effects at a lifetime exposure. If the resulting Sed exceeds 0.8 MPa, there is a high probability of adverse health effects.

14.4.2.3 For operational environments where impacts routinely exceed 4 Gs (for example, high-speed craft), and given a military-only population, the S_{ed} value should be normalized over an 8-h period and should not exceed an $S_{ed}(8)$ value of 4.7 MPa, with a 3.9 MPa limit preferred, for a low probability of adverse health effects at a lifetime exposure in accordance with Peterson et al (2004).

14.4.3 *Whole-Body Vibration with Occasional Shock:*

14.4.3.1 For operational environments that subject humans to occasional shocks or transient vibrations (Type II), the weighted frequency root mean square (RMS) and crest factor for the dominant vibration source must first be defined. If the crest factor is less than or equal to 9, RMS vibration levels in any manned space shall not fall within the zone labeled "Health Risks are LIKELY" as depicted in Fig. 147, "Health Guidance Zones for Limited Exposures," preferably within the "Minimal Risk to Health" area of the chart. If the weighted accelerations fall with the "Caution Zone," a warning to occupants shall be provided indicating the potential health risk.

14.4.3.2 If the crest factor exceeds 9, calculate the Fourth Power Vibration Dose (VDV) using the mathematical formulas detailed in ISO 2631-1 (1997), Part 1, Paragraph 6.3.2 which should not exceed a daily exposure limit value of 21 $m/s^{1.75}$ in accordance with Directive 2002/44/EC.

14.4.4 *Limited Whole-Body Vibration*—For operational environments with limited exposure duration that do not include occasional shocks or transient vibrations (Type III), data must be processed in accordance with calculations detailed in ISO

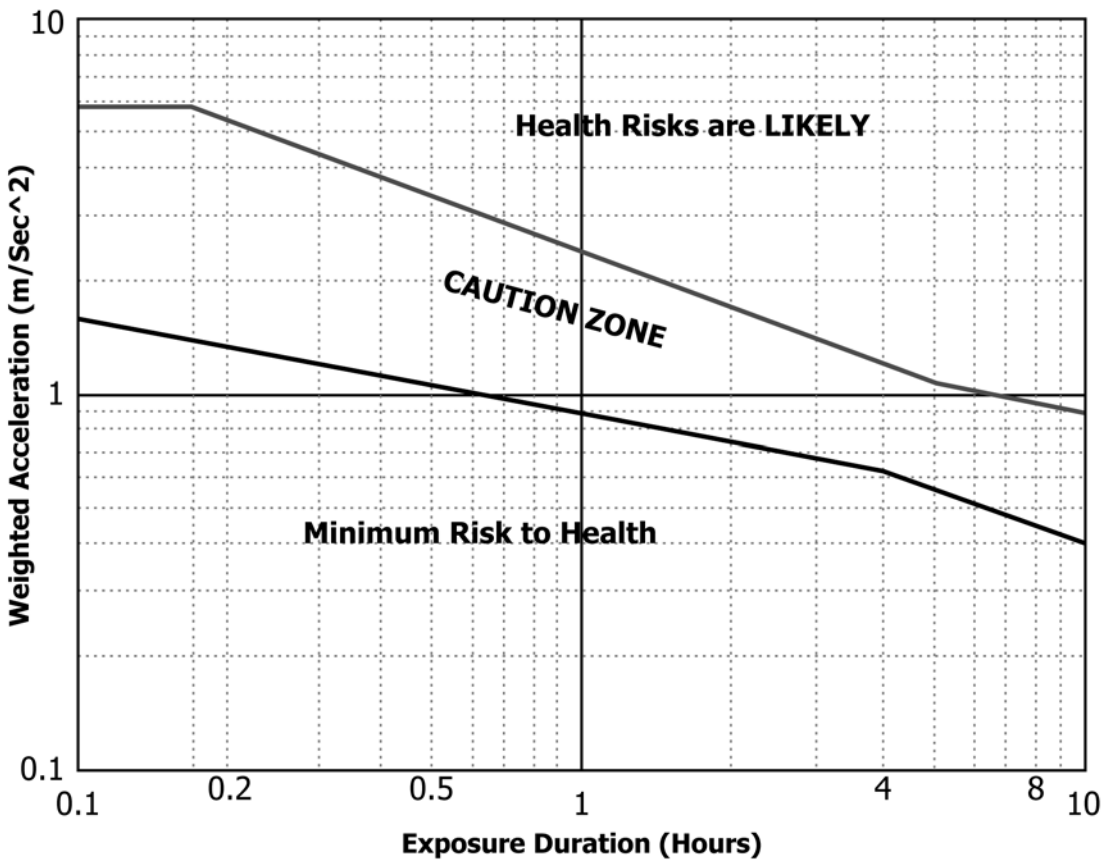


FIG. 147 Health Guidance Zones for Limited Exposures

2631-1 (1997), Part 1, Paragraph 6.1. The resulting frequency weighted, RMS vibration levels in any manned space shall not fall within the zone labeled "Health Risks are LIKELY" as shown in Fig. 147, preferably within the "Minimal Risk to Health" area of the figure. If the weighted accelerations fall with the "Caution Zone," a warning to occupants must be provided indicating the potential health risk.

14.4.5 *Continuous Whole-Body Vibration*—For continuous operational environments that do not include occasional shocks or transient vibrations (Type IV), the frequency weighted, RMS levels in any manned space shall not exceed 0.4 m/s^2, 0.315 m/s^2 preferred, in the frequency range of 0.5 to 80 Hz. This requirement applies to vibrations observed in each primary direction (*x*, *y*, and *z*) relative to the human. Data must be processed in accordance with calculations detailed in ISO 2631-1 (1997), Part 1, Paragraph 6.1.

14.4.6 *Comfort*—To determine the appropriate acceleration limits related to human comfort, the frequency weighted RMS must be calculated using frequency weighting as detailed in ISO 2631-1 (1997), Part 1, Paragraphs 6.5 and 8. For Type III and IV environments, the frequency weighted RMS accelerations levels, combined for all three axes, should not exceed 0.315 m/s^2. Comfort levels have not been defined for Type I and II environments.

14.4.7 *Perception*—To minimize the human perception of vibration, the frequency weighted RMS acceleration levels combined for all three axes should be below 0.015 m/s^2.

14.4.8 *Motion Sickness*—To maintain a motion sickness rate of less than 10 % sick, the motion sickness dose value (MSDV) must be less than 0.3 $m/s^{1.5}$ determined by the method provided in ISO 2631-1, Part 1, Paragraph 9 and Annex D. This method only applies to limited duration exposures and does not account for adaptation that occurs for longer duration exposures.

14.4.9 *Measuring Accelerations:*

14.4.9.1 For Type I environments, triaxial accelerations must be measured on the occupant at the lower lumbar (L4) or as close as possible to the interface of the human and predominant impact source (for example, seat cushion).

14.4.9.2 For Type II-IV environments, triaxial accelerations must be measured at the interface between the human and the predominant vibration source. For standing occupants, this is the deck. For seated occupants, measurements must be taken at the seat cushion, preferably including measurements at the seat back and foot rest. For additional detail on instrumentation, refer to ISO 2631-1 (1997), Part 1, Section 5.

14.4.9.3 For assessing potential for comfort, perception, and motion sickness, accelerations may be collected from a central location within inhabited spaces.

15. Labeling

15.1 *Design Criteria of Labels:*

15.1.1 *General Requirements*—Labels can be printed directly on, or adjacent to, the object, or they can be printed on a plate that is attached to the object or adjacent to the object. Marking is nonverbal information, such as colors, symbols, or demarcations which identify or describe an object. Markings can appear directly on or adjacent to the object, or they can be printed on a card or plate that is attached to the object or adjacent to the object. The location, orientation, organization, format, layout, and coding of all labels and markings shall be standardized across all equipment items throughout the vessel or maritime structure.

15.1.2 *Application*—Labels, legends, placards, signs, markings, or a combination of these shall be provided whenever personnel must identify items (except where it is obvious to the observer what an item is and what he or she is to do with it), interpret, follow procedures or avoid hazards, and should comply with accepted national or international standards.

15.1.3 *Orientation*—Labels and information thereon shall be written in the normal orientation for the language and culture of the proposed user population (for example, oriented horizontally and read from left to right for North America or European maritime personnel). Vertical orientation shall be used only if that is the cultural preference for the intended user population, or when there is insufficient space for the preferred horizontal orientation and the label is not critical for personnel safety or performance. When used, vertical labels shall read from top to bottom, except on pipe markings which shall be read in the direction of flow.

15.1.4 *Location*—Labels shall be placed directly above, or to the right, of displays and controls. Labels shall not be placed on components that turn where the label could be placed in an unreadable position. Labels shall not be located where a control or an operator's normal hand, arm position, or portable repair equipment will obscure the label. Labels shall be located so as not to obscure any other information needed by the operator. Mounting labels on bulkheads or other ship structures to identify equipment, valves, or machinery should be avoided.

15.1.5 *Uppercase versus Lowercase Letters*—Use capital letters for all identification and component labels, pipe markers, short instructions (that is, two sentences or less) and text on alarm lights. Uppercase and lowercase should be used for extended messages (for example, instructional, informational or hazard labels) or where it is necessary to provide punctuation. Label case for use in electronic displays (for example, computers) is defined in Section 13.

15.1.6 *Redundant Labeling*—Redundant labeling/marking should be used for installations such as pipes that take several turns and are viewed from several planes, or motors that can be viewed from two sides.

15.1.7 *Curved Surfaced Labels*—Curved labels shall be avoided except when wrapped around a pipe or large curved surface. Attached tags may be used where adequate flat surfaces are not available for mounting labels.

15.1.8 *Technical References*—Requiring a reader to reference another source as a part of a label or sign shall be avoided especially if the referenced material is required to avoid a hazardous situation. References to other documents or sources of information may be used only to direct the user to supplemental information which is not a required action to avoid the hazard.

15.1.9 *Character/Background Color*—Where the ambient illumination will be above 10 lux (0.9 ft-c), identification labels, instruction labels, information labels, and graphic labels (all labels other than hazard labels) shall be provided with

black characters on a light background. Background should be matte and nonreflective to avoid glare which makes the sign difficult to read. Where dark adaptation lighting (low level white or red) is required, the displayed letters or numerals shall be visible without interfering with night vision requirements. Markings should be white on a dark background.

15.1.10 *Characters and Numerals*—Characters and numerals shall be designed as follows:

15.1.10.1 Characters shall be a simple block-type font, such as Alternate Gothic #2, News or Trade Gothic, or Futura or Spartan medium. All numerals shall be Arabic.

15.1.10.2 All capital letters shall be used for identification labels, headings and subheadings, signal words such as "danger," "caution," "attention," "notice," legends, and short message labels. Capital and lowercase letters shall be used for extended sentence messages in which it is necessary to use punctuation.

15.1.10.3 Numerals should be Arabic (not Roman Numerals). The use of the number "1" in combination with the letters "L" or "I" and the number "0" with the letters "O" or "Q" should be avoided.

15.1.10.4 Alphanumeric characters should have a width of ⅗ to ⅘ of the height except for single stroke characters (for example, I, 1) which should be between 1/10 and ⅕ of the height.

15.1.10.5 The width of numerals shall preferably be ⅗ of the height, except for "4," which shall be ⅘ of the height and "1" which shall be ⅕ of the height.

15.1.10.6 Where conditions indicate the use of wider characters, as on a curved surface, the basic height-to-width ratio may be increased to 1:1.

15.1.10.7 For black characters on a white (or light) background, the stroke width shall be 1/6 to 1/7 of the height.

15.1.10.8 For general and panel design, with the luminance normally above 3.5 cd/m^2 (1 ft-L), for labels of all types, minimum character height shall conform to the following values for various expected viewing distances:

Distance, mm (in.)	Minimum Height, mm (in.) [pt]
Less than 500 (19.7)	2.3 (0.09) [6]
500–1000 (19.7–39.4)	4.7 (0.18) [12]
1000–2000 (39.4–78.7)	9.4 (0.37) [26]
2000–4000 (78.7–157.5)	19 (0.75) [54]
4000–8000 (157.4–315.5)	38 (1.50) [108]

15.1.10.9 The minimum space between characters shall be one stroke width.

15.1.10.10 Separation between words shall be the width of three characters (±½ width). The minimum space between words shall be the width of one character.

15.1.10.11 The minimum space between lines shall be ½-character height, but in no case shall the separation between the tallest characters on a lower line be less than one stroke width from a character above that projects below the line.

15.1.11 *Material*—Labels, signs, or graphics should be made from materials, and manufactured by a process, that will be suitable for all expected conditions in the operating environment. The use of brass or stamped/etched metals filled with colored enamel text should be avoided. The material should also be compatible with the surface on which it is attached and be resistant to ultraviolet (UV) damage, if exposed to sunlight.

15.1.12 *Preinstalled Labels:*

15.1.12.1 Items that have labels installed before the item is located in the vessel or structure shall be placed so the labels are visible and legible after the item is in place.

15.1.12.2 Each control, control setting, and display on every console or panel shall be provided with an identification labeled as shall any individual control or display mounted on a pole, desk, or other structure.

15.1.13 *Irrelevant Information*—Trade names, company logos, or other information not directly required by the users shall not appear on the face of a display or control, nor be included in any label nor be the subject of any label.

15.1.14 *Label Groups*—Placement of more than three labels in a group shall be avoided. However, if more than one label is required to be mounted in the same location, the labels shall be grouped by label type and organized as follows:

15.1.14.1 Hazard labels shall be mounted in the most prominent location.

15.1.14.2 Instruction labels shall be mounted in the next most prominent location.

15.1.14.3 Information labels and graphic plates shall be mounted in the next most prominent location.

15.1.14.4 Graphic labels that are referenced by other types of labels shall be mounted adjacent to the referencing label.

15.1.15 *Consistency*—All labels of the same type shall be consistent in format and presentation of information throughout the ship or maritime structure.

15.1.16 *Subheadings*—Headings and subheadings shall be used to identify groups of related information. They shall be of larger character size than the text of the label with the main heading or label title the largest and subheadings of smaller size.

15.1.17 *Integrated Safety Information*—Safety and hazard information that is integrated with other information (for example, an instruction) on labels other than hazard labels, shall be designed such that the safety and hazard information is clearly, and distinctly, different visually from the other information is easily identified by the user, and complies with other applicable standards.

15.1.18 *Surface Color Contrast*—Label background color shall contrast with the color of the surface to which it will be attached.

15.2 *Abbreviations:*

15.2.1 *General*—Labels and signs shall use abbreviations familiar to personnel. Full words shall be used wherever possible. Abbreviating a word or word group shall be used only if:

15.2.1.1 There is insufficient space available at the location where the label is to be affixed for the design of a spelled out label; or

15.2.1.2 The abbreviation is more commonly known and understood by the user population than the spelled out word or word group (for example, AFFF rather than aqueous film-forming foam).

15.2.2 *Creating an Abbreviation*—If the need for an abbreviation has been justified and a standard abbreviation does not exist in commercial or military standards, then the following rules shall be applied to develop the abbreviation.

15.2.2.1 When abbreviating single words:

(1) Determine the number of characters required in the abbreviated term.

(2) Choose the first letter and last consonant of the word to be abbreviated as the first and last letter of the abbreviation. For example, "Multiplexer" would be "M—R."

(3) Fill the remaining spaces with the consonants in the order in which they appear in the word. Avoid the use of double consonants in the abbreviation.

(4) If there are insufficient consonants, use the first vowel in the order in which it appears in the word. For example, an eight character abbreviation for "Multiplexer" would be "MULTPLXR."

15.2.2.2 When abbreviating two-word groups:

(1) Determine the number of characters required in the abbreviated term.

(2) Take half of the characters from the first word and the other half from the second word, using the above abbreviation methodology for single words. If an odd number of total characters are needed, take the odd character from the longer word.

15.2.2.3 When abbreviating three-word groups:

(1) Form an abbreviation for each of the three words as if they were individual words or create a three-letter acronym, using the first letter of each of the three words.

15.2.3 *Punctuation*—Periods or other punctuation shall not be used after abbreviations.

15.2.4 *Standardization*—Abbreviations shall be standardized and used consistently on all labels.

15.2.5 *Familiarity*—Words and abbreviations shall be chosen on the basis of familiarity by the intended population.

15.3 *Symbols:*

15.3.1 *Symbol Types*—Two types of symbols shall be used:

15.3.1.1 Dependent symbols are those that alone do not impart any specific information to the user (for example, %, +, −), but require the existence of supporting data to provide meaningful information (for example, 10 %, +5 psi, 3 lb). Dependent symbols shall be used only where they have an accepted meaning to all potential users.

15.3.1.2 Independent symbols are symbols that alone provide information to the user and normally are associated with hazard or emergency situations. Independent symbols shall not be used alone to identify a hazardous situation but shall always be accompanied by text describing the hazard. Independent symbols can be used alone for non-hazardous identification purposes (for example, the cross on a first aid box). Examples of independent symbols suitable for shipboard use are shown in Fig. 148.

15.3.2 *Symbol Sources*—Independent symbols and internationally recognized symbols, such as those Sources of International Maritime Organization (IMO), should be used. Flag Administrations or regulatory bodies may also require the use of particular symbols to convey information. Sources of internationally accepted graphic symbols for hazard identification signs and placards include:

15.3.2.1 IMO Resolution A.830 (19)—Code on alarms.

15.3.2.2 British Standard 5499—Graphical symbols and signs.

15.3.2.3 IMO Resolution A.760 (18)—Symbols related to life-saving appliances and arrangements.

15.3.2.4 IMO Resolution A.654 (16)—Graphical symbols for fire control plans.

15.3.2.5 International Maritime Dangerous Goods Code (IMDG Code).

15.3.2.6 American National Standards Institute Z535.3, Criteria for Safety Symbols.

15.3.2.7 Marine Safety Committee Circular 451 (MSC/Circ.451)—Guidance concerning the location of fire control plans for the assistance of shoreside fire-fighting personnel.

15.3.2.8 International Labor Organization—Accident prevention aboard ship at sea and in port.

15.3.2.9 Globally Harmonized System of Labeling of Chemicals

15.4 *Component Labels on Consoles and Panels:*

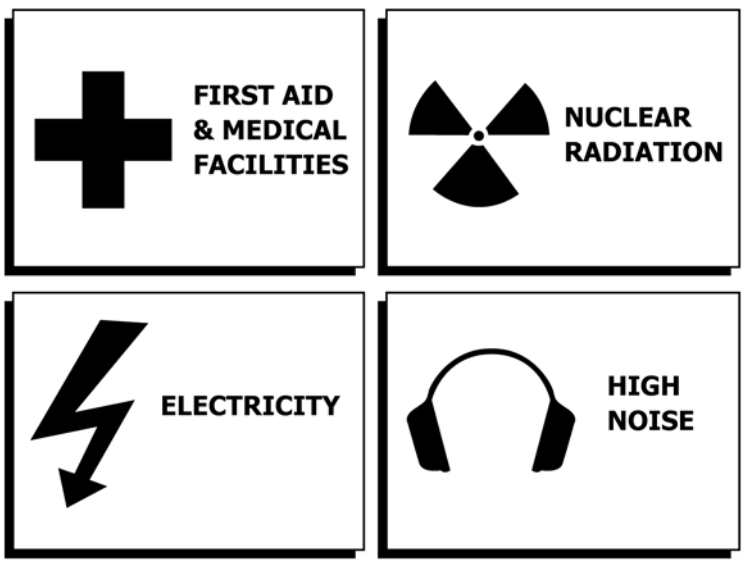


FIG. 148 Independent Symbols

15.4.1 *General*—Labels shall be used to identify individual controls, displays, or groups of controls and displays on consoles and panels. Each control and display, including their positions, shall be labeled in accordance with the following:

15.4.1.1 Each control, control setting, and display on every console or panel shall be labeled.

15.4.1.2 The character size of labels should follow the guidelines shown in Fig. 149. Character sizes greater than the minimum are acceptable, if applied consistently to all levels of labeling.

15.4.1.3 As shown in Fig. 149, labels should be above their respective controls and displays they identify. The relative placement of labels to their respective controls and displays shall be consistent. In limited circumstances, when placement above a control or display may result in an unreadable label hidden by its control or display, labels may be placed below the control or display, provided any confusion with other components or labels is minimized.

15.4.1.4 Similar names for different controls and displays should not be allowed.

15.4.1.5 Labels shall be all capitals in accordance with the requirements of 3.1.60 (definition for identification labels) and 15.1.5, and shown in Fig. 149.

15.4.2 *Content*—The content of labels shall be determined by using the following guidelines:

15.4.2.1 *Describe Function*—Control and display labels shall indicate the function of the device rather than the technical name for the device. For example:

(1) VOLTAGE rather than VOLTMETER.

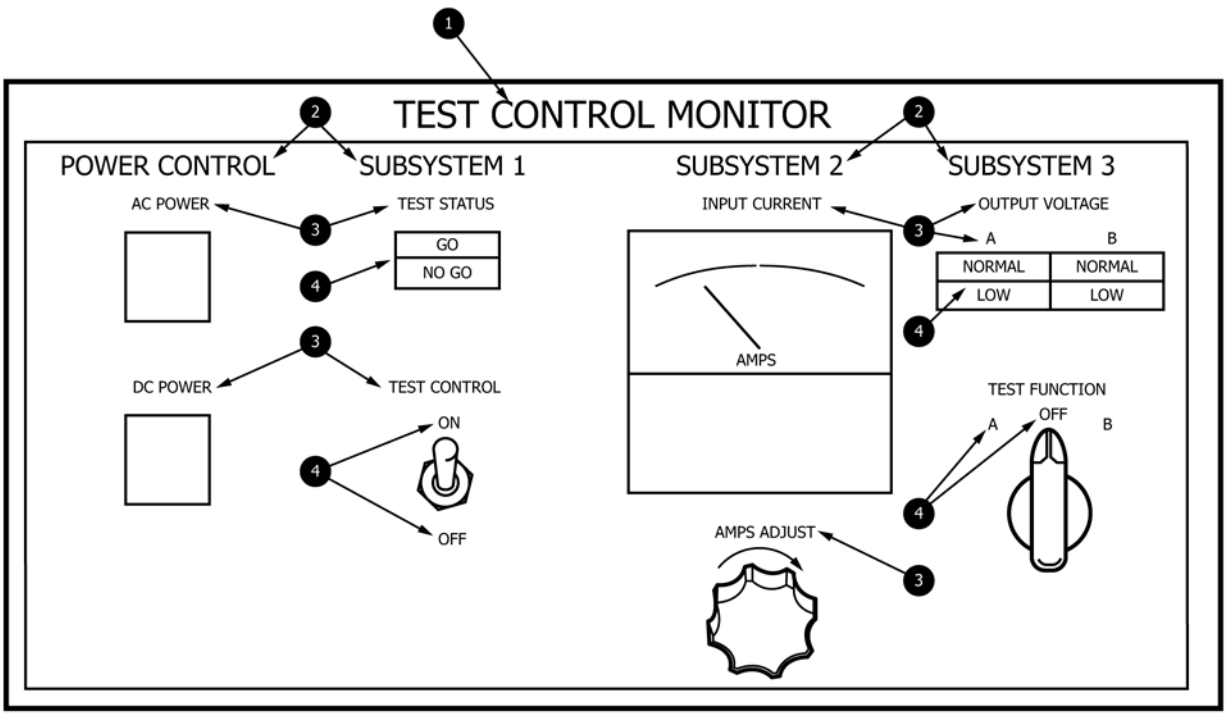
(2) POWER ADJUST rather than POWER ADJUSTER SWITCH.

15.4.2.2 *Describe Control Movement*—Control labels shall indicate the result of a control movement by either words or appropriate symbols (for example, RAISE, START, +, ↑, →).

15.4.2.3 *Include Units of Measure*—These units (for example, psig, volts, kPa, mm) shall appear on the face of displays, not on the labels.

15.4.2.4 *Label Components Consistently*—Label terminology shall be consistent for the same controls and displays on different equipment or systems.

15.4.3 *Relationship of Control and Control-Setting Labels*—Control function and control setting descriptions should appear on separate labels. Alternatively, they may be placed on a single label provided there is no confusion between the control label and the control setting label. See Fig. 150.



ITEM	LABEL DESIGNATION	CHARACTER SIZE mm/INCHES/POINT	LOCATION
1	PANEL TITLE	12/0.50/36	CENTERED; 6 mm (1/4 INCH) FROM TOP EDGE OF PANEL
2	PANEL SUBSECTION	10/0.37/26	CENTERED AT TOP OF SUBSECTION
3	SUBTITLE/SINGLE COMPONENT IDENTIFICATION	5/0.20/14	6 mm (1/4 INCH) ABOVE COMPONENTS OR 12 mm (1/2 INCH) ABOVE LABELS OF INDIVIDUAL COMPONENTS
4	SWITCH POSITION/ DISPLAY LABEL	3/0.125/9	6 mm (1/4 INCH) ABOVE AND/OR BELOW SWITCH

FIG. 149 Guidelines for Labels on Consoles and Panels

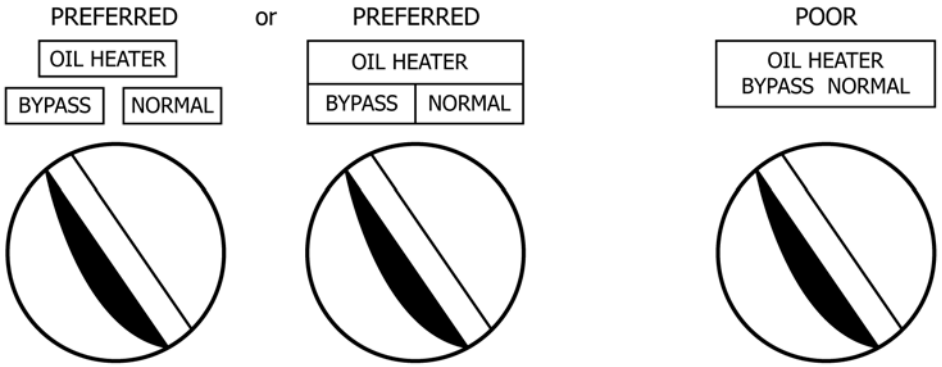


FIG. 150 Control and Control-Setting Labels

15.4.4 *Group Labels*—When controls and displays are grouped together, appropriate labels or panel demarcation lines (or both) shall be used to indicate their relationship (for example, functional, sequential, similar equipment) as shown in Fig. 151. The label shall be located above the group it identifies. When a line is used to demarcate a group and define its boundaries, the label shall be centered at the top of the group. The label shall be placed either in a break in the demarcation line or just below the demarcation line.

15.4.5 *Control-Setting Labels for Multiple Controls*—When multiple controls perform the same function for different equipment, and they are grouped together, the settings for each control shall be labeled as shown in Fig. 152.

15.5 *Equipment Identification Labels:*

15.5.1 *General*—Identification labels shall be placed on all equipment (for example, valves, gauges, sensor transmitters, filters, pumps, pressure vessels, electrical and communication equipment) requiring interface from operations or maintenance personnel in accordance with the requirements of 3.1.60 and 15.1.5. The label should contain a specific functional description of the equipment and a unique identifying number, provided in that order. (See Table 41.)

15.5.2 *Format*—The number and size of characters and the number of lines per label for different sized labels are shown in Fig. 153.

15.5.3 *Mounting Location:*

15.5.3.1 For permanently installed equipment, identification labels should be mounted directly on the piece of equipment. Alternatively, they may be mounted immediately adjacent to the equipment provided that it is immediately obvious which label and piece of equipment are related. Labels shall not be mounted on surfaces or equipment that may be replaced due to maintenance or repair.

15.5.3.2 Labels shall be placed on flat surfaces. If a flat surface is not available another mode of labeling (for example, attached tags) shall be used.

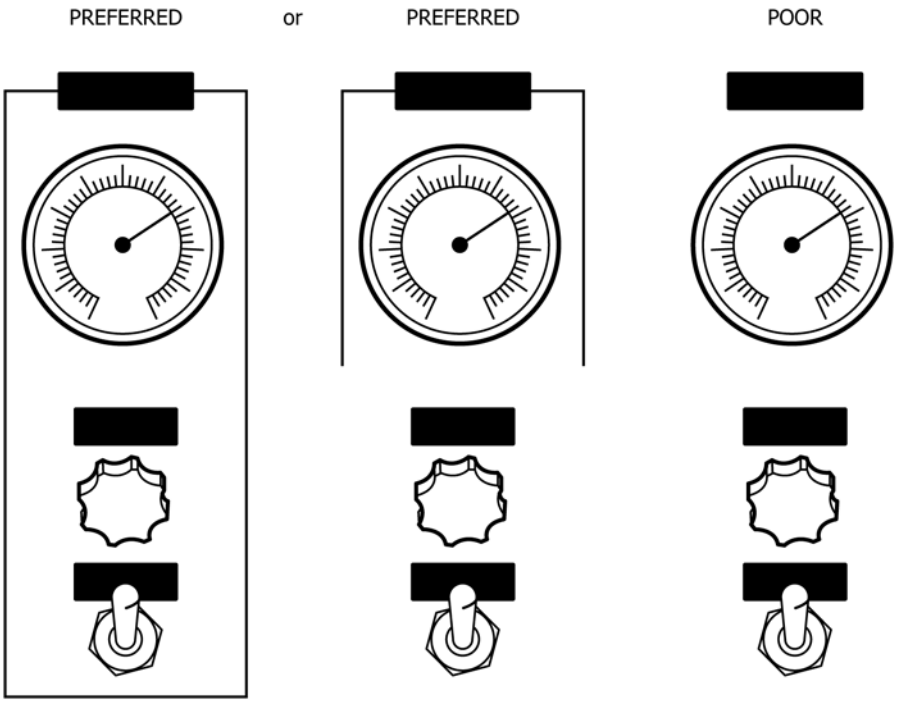


FIG. 151 Control and Display Group Labels

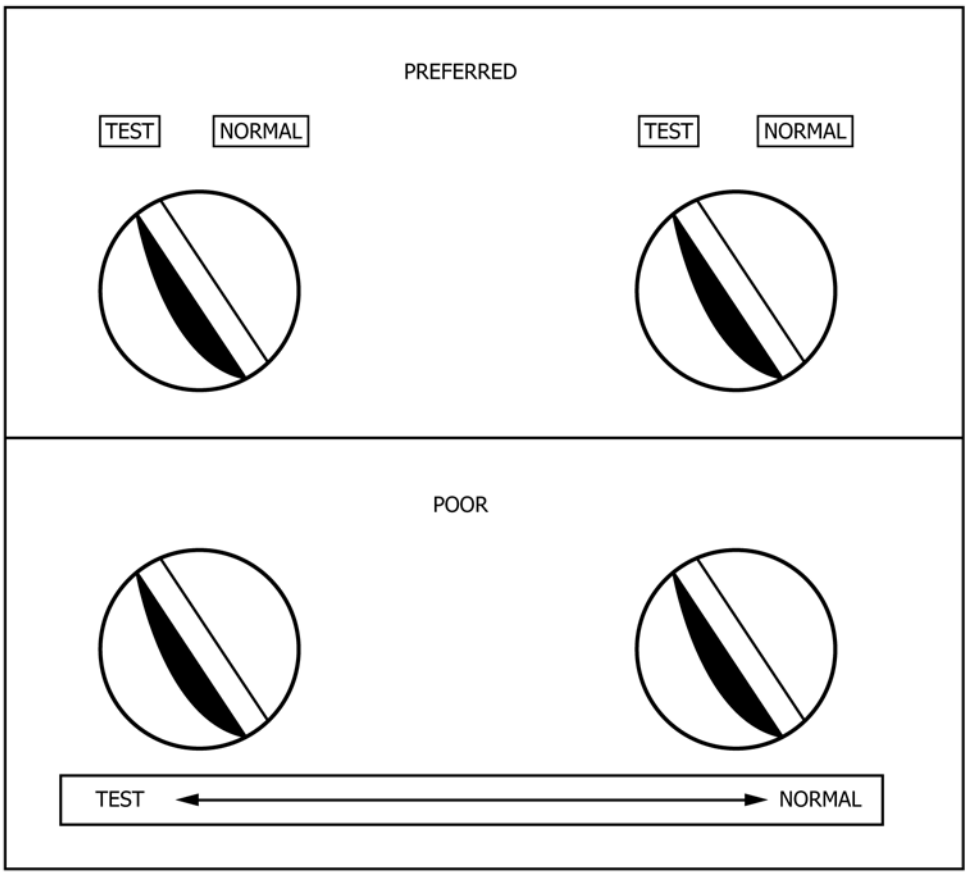


FIG. 152 Control-Setting Labels for Multiple Controls

TABLE 41 Examples of Equipment Labels

Item	Label
Lube Oil Pump For Generator Engine No. 1	LUBE OIL PUMP GENERATOR No. 1 PEP-100
Lighting Junction Box	LIGHTING JUNCTION BOX LJB-313X
Discharge Pressure Gauge on Cargo Pump No. 3	CARGO PUMP No. 3 DISCHARGE PRESSURE PI-211
Diesel Day Tank For Generator No. 4	DIESEL DAY TANK GENERATOR No. 4 CAPACITY 445 GAL DDT-4
Port Ballast Pump	PORT BALLAST PUMP PBE-1000
Flanged Ball Isolation Valve (Numbered N350-05) on the Steam Line Leading from a Steam Separator (NBD-350) to the Glycol Reboiler (HBG-640)	STEAM ISOLATION TO GLYCOL REBOILER HGB-640 N350-05
Low Output Pressure Sensor on a Ballast Pump	BALLAST PUMP PRESSURE SAFETY LOW PSL-2001

15.5.3.3 Ease of control operation shall be given priority over visibility of control position labels.

15.5.4 *Tank Labels*—Tanks shall be labeled with their content and capacity in barrels, weight gallons or metric units. The labels shall be black characters on a white background. The content identification shall be provided above the capacity numbers. Tank labels shall be in all capital letters. The height of the label shall be determined by tank height as shown below:

15.5.4.1 Greater than 10 m (33 ft), label height shall be 991 mm (39 in.).

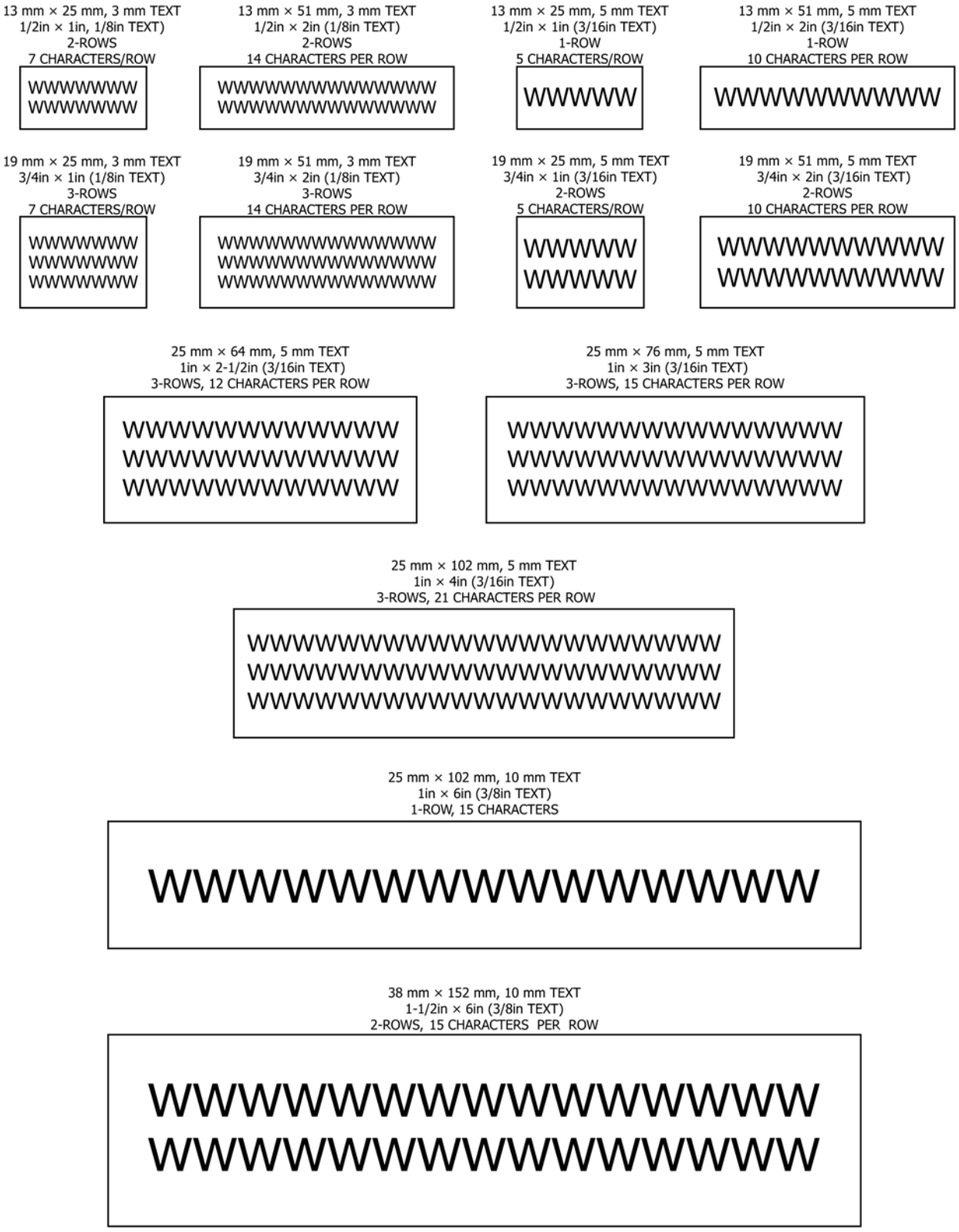


FIG. 153 Equipment Label Format

15.5.4.2 Between 5 m (16.5 ft) and 10 m (33 ft), label height shall be 610 mm (24 in.).

15.5.4.3 Less than 5 m (16.5 ft), label height shall be 305 mm (12 in.).

15.6 *Electrical System Labels:*

15.6.1 *General System Labels*—Each electrical cable should be labeled with a unique identifying code. The label should be located at the exit from the main switchboard, the distribution panel at the connection to the load and at the entrance and exit of intermediate panel boards, junction boxes, and controllers. Circuit breakers should be provided with identification labels, as described in 15.1.5, and 15.5, including both the written name of the circuit and the circuit code identified on the cable label.

15.6.2 *Sensor Labels*—When identifying sensors, [for example, pressure safety high (PSH), temperature safety low (TSL), flow safety high (FSH)], the label shall identify the unit of equipment to which the sensor is attached. It shall also include the sensor's identification number. The information shall be presented according to the following rules. An example is provide in Fig. 154.

15.6.2.1 *Line 1*—Equipment to which the sensor is attached.

15.6.2.2 *Line 2*—Function of sensor.

15.6.2.3 *Line 3*—Sensor identifier.

15.7 *Room, Deck Space, and Void Identification Labels:*

15.7.1 *General*—Identification labels for rooms, deck spaces, and voids shall be mounted on or directly above the door, manway, archway or other opening leading to the area. The style of the labeling, its character size and format shall follow Fig. 153, "Equipment Label Format," and the characters shall be in all capital black letters on a white background (see 3.1.60 and 15.1.5).

15.8 *Pipe Marker Labels:*

15.8.1 *General*—Pipe marker labels shall contain text to identify pipe contents and use arrows to indicate flow direction.

15.8.2 *Format:*

15.8.2.1 Pipe marker labels shall either use different colored backgrounds or bands of color on a solid neutral colored background to represent various pipe contents by means of a color-coding scheme.

15.8.2.2 Text and flow arrows shall be placed on the labels to identify pipe contents and its flow direction. Text labels shall appear in the center of the pipe marker label or immediately adjacent to the color band that identifies pipe contents.

15.8.2.3 Text labels shall be in all capital letters.

15.8.2.4 Flow arrows shall be positioned at one or both ends of the band. The colors for the text labeling and flow arrows shall be of a color that contrasts with the background color.

FIG. 154 Sensor Label

15.8.2.5 Preferred pipe marker label width, length, and associated text character height for various sizes of pipes are shown in Table 42. Fig. 155 provides examples of pipe marker labels.

15.8.3 *Selection of Colors:*

15.8.3.1 The colors used for the bands or text should be selected to be seen under all levels of lighting likely to be encountered on the vessel or offshore installation. The colors shall be compatible with other color codes and the scheme used for pipe marker labels should be the same throughout the vessel or offshore installation.

15.8.3.2 The colors chosen should be related to the contents carried by the pipe (for example, fire water pipes are red, potable water pipes are light blue, drilling mud pipes are brown, sea water pipes are green). An example of a color coding scheme is shown in Table 43. For consistency of color, the chromaticity coordinates of the suggested colors are provided in Table 44.

15.8.4 *Use of Two Colors or Two Bands of Color*—Additional colors or secondary color bands may be used to distinguish between several different types of the same contents, such as various grades of fuel or different types of waste. For example, one color would be chosen to represent "waste," however, the various types of waste could be differentiated using a second color presented as a band or stripe of color or two bands/stripes of color. When used, color bands should be 25 mm (1 in.) to 50 mm (2 in.) in width and of a color that contrasts with the primary color band (light band with a dark primary color band and dark with light color (see Fig. 156).

15.8.5 *Mounting Location:*

15.8.5.1 Pipe marker labels should be placed at or near the inlet or outlet connection to equipment (for example, pumps, pressure vessels, filters), at the termination of a pipe run (for example, loading station, hose reels, at bulkhead penetration), and approximately every 5 m (16.5 ft) on straight runs of pipe.

15.8.5.2 On vertical pipes, pipe marker labels should be placed approximately 1830 mm (72 in.) above the standing surface. They should be placed on both sides of a bulkhead, deck, or deckhead penetration, unless the label is visible from both sides of the penetration.

15.8.5.3 Where pipe marker labels are used on two or more pipes in a group of pipes located side by side, such as in a pipe rack, all of the pipe marker labels shall be installed side by side so they can be scanned at one time.

15.8.6 *Material:*

15.8.6.1 Pipe marker labels may be self-adhesive or the label can be painted directly on the pipe. Self-adhesive pipe marker labels shall be made from an abrasion- and chemical-resistant vinyl or polyester-type material. Where the pipe marker label may be exposed to sunlight, the material shall be resistant to ultra-violet (UV) damage. The material shall be durable enough to resist fading, chipping, or cracking. Self-adhesive labels shall adhere to themselves when wrapped around a pipe rather than adhere to the piping. Self-adhesive labels are not recommended in environments where corrosion may go undetected beneath the label.

TABLE 42 Pipe Label Format

Marker Type	Pipe Nominal Size	Length Along Pipe	Width Around Pipe	Character Height
Wrap around	10–15 mm (0.375–0.50 in.)	125 mm (5.0 in.)	N/A	N/A
Wrap around	20–65 mm (0.75–2.50 in.)	205 mm (8.0 in.)	N/A	20 mm (0.75 in.)
Wrap around	50–200 mm (2–8 in.)	305 mm (12.0 in.)	N/A	30 mm (1.25 in.)
Nonwrap around	More than 200 mm (More than 8 in.)	610 mm (24.0 in.)	100 mm (4.0 in.)	90 mm (3.50 in.)

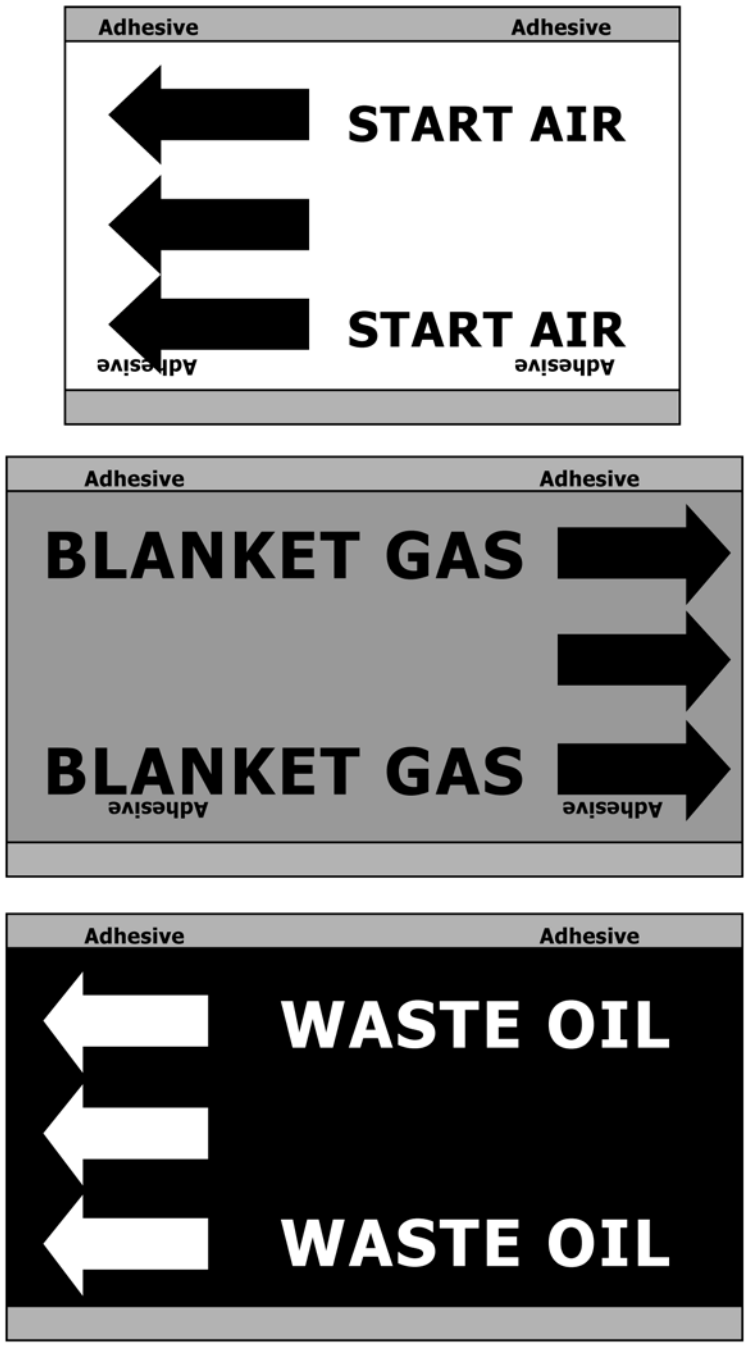


FIG. 155 Pipe Marker Labels

15.8.6.2 For fiberglass, copper-nickel materials, or other pipes for which self-adhesive pipe marker labels are not satisfactory, the text labels and flow arrows may be painted directly onto the pipe without the use of a color band. For

TABLE 43 Example Color-Coding Scheme for Vessel/Structure Piping

NOTE 1—Colors adopted from ISO 14726-1.

Main Colors	Medium
Black	Waste media (for example, wastewater, black water, gray water waste oil, exhaust gas)
Blue	Fresh water
Brown	Fuel
Green	Sea water[A]
Gray	Nonflammable gases
Maroon	Masses/bulk materials (dry and wet)[B]
Orange	Oils other than fuels
Silver	Steam
Red	Firefighting and fire protection
Violet	Acids, alkalis
White	Air in ventilation system
Yellow-ochre	Flammable gases

[A] For vessels with mixed navigation (sea-river vessels) all outside waters.
[B] Excluding fire-extinguishing materials.

copper-nickel pipe material, the color yellow or white is preferred for the text labels and flow arrows. For black, green, or red unpainted fiberglass pipe material, the color white is preferred.

15.9 *Safe Working Load Identification Labels:*

15.9.1 *General*—Safe working load identification labels shall specify the maximum safe load for each lifting device and shall include the appropriate units (for example, kilos, pounds, tons).

15.9.2 *Color and Wording*—The labels shall have black lettering on a yellow background.

15.9.3 *Character*—Lettering and numbers on the labels shall be large enough to be read from the standing surface on which personnel will be operating the lifting mechanism or reading the load limit label or both. In no case shall the lettering or numbering be smaller than 25 mm (1 in.) in height. Lettering shall be in all capital letters.

15.9.4 *Material*—Safe working load limit labels should be of a flexible vinyl, adhesive-backed, stick-on material. If the lifting mechanism is used outdoors, it shall be resistant to UV damage. Label material and adhesive should be guaranteed for a minimum of seven years.

15.9.5 *Mounting Locations*—Safe working load limits shall be mounted immediately adjacent to padeyes or other fixed lifting points, on the web of monorails, traveling cranes, jib booms, or other such structures supporting a moving load. The label shall be placed so that it is directly visible and oriented for horizontal reading by personnel when viewed from the standing surface from which the load will be lifted.

15.10 *Load Weight Identification Labels:*

15.10.1 *General:*

15.10.1.1 Caution placards for weight and center of gravity shall be placed on any unit of equipment to be moved whose weight exceeds 45.5 kg (100 lb). If the equipment is to be lifted or carried by more than one person, the label shall include the number of people recommended to lift or carry it.

15.10.1.2 The label shall be placed in a location on the item where personnel can see the label from the normal working/lifting position. The labels shall have black characters on a white background and shall be a minimum of 13 mm (0.5 in.) in height. Any text shall be all capital letters.

15.11 *Hazard Identification Signs:*

15.11.1 *General*—A hazard identification sign shall be used to identify and provide information about conditions that may pose hazards to personnel, equipment, or the environment.

15.11.2 *Signs with Text and Symbols:*

15.11.2.1 Hazard signs shall be prepared for the personnel expected to use the information. Hazard identification signs shall use simple language and understandable icons.

15.11.2.2 The following requirements apply to design of hazard identification signs:

(1) Formats and styles shall be consistent throughout the ship or maritime structure, including organization of information, use of font styles and sizes, and use of colors.

(2) Technical wording and symbols shall be consistent with other instances of written information. For example, if a specific hazard symbol is used on an alarm, or in a written procedure, hazard signs should use the same symbols and meanings.

(3) The language and wording of hazard identification signs shall be compatible with the expected population of readers and written in their native language.

(4) Where there is a mix of people of different spoken languages on a vessel or structure, text-only signs should be avoided.

15.11.3 *Text Only Signs*—The requirements that follow apply to text-only signs and the text portion of signs that also use warning symbols. For information concerning the design of symbols for hazard identification signs, see 15.3.

15.11.4 *Text Content*—Hazard labels shall contain the following in the order shown:

15.11.4.1 The signal word (DANGER, or CAUTION) at the top of the label.

15.11.4.2 A brief statement of the hazard, in as specific detail as possible (for example, 600 VAC, not HIGH VOLTAGE).

15.11.4.3 A brief statement on how to avoid the hazard, in detail if possible. If more than one step is involved, the hazard avoidance procedure should be provided in a step-by-step sequence.

15.11.4.4 A brief statement of the possible consequences if the avoidance instructions are not followed (for example, serious injury could occur, fire or explosion could occur, death could result).

15.11.5 *Hazard Signal Levels*—Two signal levels shall be used in identifying a safety hazard. These are defined below.

15.11.5.1 DANGER: indicates an imminently hazardous situation that, if not avoided, will result in death or serious injury, serious damage to equipment, serious degradation of the vessel or structure's mission capability, or serious damage to the environment. This signal word is to be limited to the most extreme situations.

15.11.5.2 CAUTION: indicates a potentially hazardous situation which, if not avoided, may result in minor or major injury, minor damage to equipment, minor damage to the environment. A "Caution" signal word may be used on a sign

TABLE 44 Chromaticity Coordinates for Color-Coding Vessel/Structure Piping[A]

NOTE 1—Colors and chromaticity coordinates adopted from ISO 14726-1.

NOTE 2—Markers are to be placed to allow easy replacement in the event of routine wear to the bands, or modification, maintenance, or repainting of the piping system or nearby structure.

Name of Color	Letter Code[A]	Chromaticity Coordinates of Corner Points Determining the Permitted Tighter Color Area as Given in CIE-Publication 15.2							
		1		2		3		4	
		X	Y	X	Y	X	Y	X	Y
Black	(BK)	0.385	0.355	0.300	0.260 0	0.260	0.310	0.345	0.395
Blue	(BU)	0.078	0.171	0.196	0.250	0.225	0.184	0.137	0.038
Brown	(BN)	0.510	0.370	0.427	0.353	0.407	0.373	0.475	0.405
Green	(GN)	0.313	0.682	0.313	0.453	0.209	0.383	0.013	0.486
Gray	(GY)	0.350	0.30	0.300	0.310	0.290	0.320	0.340	0.370
Maroon	(MN)	0.302	0.064	0.307	0.3	0.374	0.247	0.457	0.136
Orange	(OG)	0.610	0.390	0.535	0.375	0.506	0.404	0.570	0.429
Silver	(SR)	CIE chromaticity luminance factor β: $\beta > 0.50$							
Red	(RD)	0.690	0.310	0.595	0.315	0.569	0.341	0.655	0.345
Violet	(VT)	CIE chromaticity x and y, luminance factor β: $y < 0.17x + 0.233$; $y < 2.6x - 0.49$; $y > 0.559 - 0.394x$ $y > 7x - 1.845$ $0.36 < \beta < 0.50$							
White	(VH)	0.350	0.30	0.300	0.310	0.290	0.320	0.340	0.370
Yellow-ochre	(YEO)	0.522	0.477	0.470	0.440	0.427	0.483	0.465	0.534

[A] As given in IEC 60757.

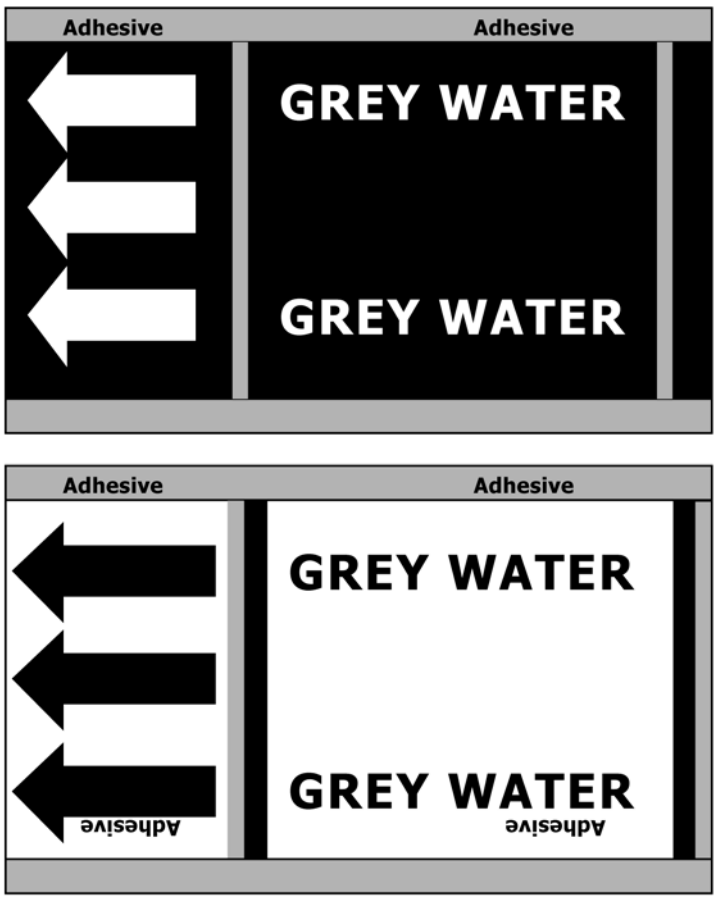


FIG. 156 Pipe Marker Labels with Two Colors

without symbols to signify situations where property damage or a minor pollution problem is possible.

15.11.6 *Header Color and Format*—Hazard label signal words shall be as shown in Fig. 157, "Hazard Signal Word Headers." Signal words shall appear at the top of the sign and shall be written in upper case letters and be preceded by an "Attention" symbol located within a triangle. A simple sans-serif character font, like Arial or SmartSigns Clearview should

FIG. 157 Hazard Signal Word Headers

be used. Colors associated with the various signal words and symbols are as follows:

15.11.6.1 The signal word "DANGER" shall be white letters on a red background. The attention symbol exclamation point shall be red. The equilateral triangle surrounding the exclamation point shall be white.

15.11.6.2 The signal word "CAUTION" shall be black characters on a yellow background. The attention symbol exclamation point shall be yellow. The equilateral triangle surrounding the exclamation point shall be black.

15.11.7 *Message Text Format*—The message text on a hazard identification sign shall use upper and lower case letters. Black characters on a white background are preferred. The character font should be a simple sans-serif character font, like Arial or SmartSigns Clearview. Fig. 158, "Examples of Text and Symbols on Signs" provides sample signs including text. Other rules and standards, such as the Globally Harmonized System of Classification and Labeling of Chemicals (GHS), may apply and have specific criteria for label elements which are different than those shown below. The user should consult the appropriate rule or standard when selecting signage and labels.

15.11.8 *Message Text:*

15.11.8.1 The message content shall consist of three parts: *(1)* description of the hazard, *(2)* description on what to do to avoid the hazard, and *(3)* description of the consequence if warning ignored.

15.11.8.2 The message content for all three parts shall be as specific as possible, but short (no more than two lines for each part). Message text shall be simple, that is, technical terms, trade jargon, or scientific terms should not be used.

15.11.8.3 The character height of the message text should be based on the label size as shown in Table 45, "Message Text Character Heights." The character height of the signal word should be at least 50 % higher than that of the message text. There should be at least two line widths separating the signal word and the first line of the hazard description and one line width separating each of the other two statements.

15.11.9 *Mounting Location*—Hazard labels shall be mounted at or immediately adjacent to the source of the hazard. The signs shall be readable before the personnel reach the hazard source. No more than three hazard labels should be mounted adjacent to each other.

15.12 *Information Signs:*

15.12.1 *General Signs or Placards*—Information labels shall be used to present non-procedural information of a general nature and shall only be used to provide information that will significantly contribute to the safety or efficiency or both of personnel. Information may be presented in step-by-step format or paragraph form. Where there are several items to be presented, they should be presented in list form. Subheadings within the list shall be used as appropriate to organize and identify related information.

15.12.2 *Character Height*—The height of the message text shall be the same as defined in 15.1.9. The signal word "NOTICE" shall be incorporated in the placard and shall be at least 50 % higher than the height of the subheadings (if any are

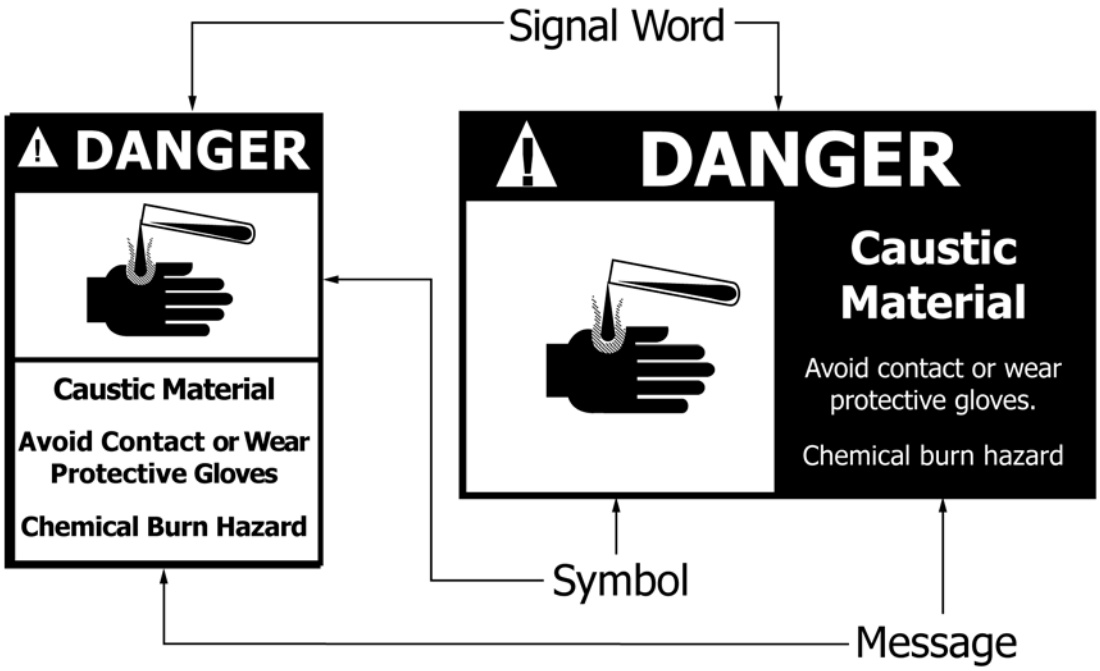


FIG. 158 Examples of Text and Symbol on Signs

TABLE 45 Message Text Character Heights

Label Size	Character Height
90 by 130 mm (3.5 by 5.0 in.)	3.2 mm (0.125 in.)
130 by 180 mm (5.0 by 7.0 in.)	3.2 mm (0.125 in.)
180 by 250 mm (7.0 by 10.0 in.)	8.0 mm (0.312 in.)
250 by 360 mm (10.0 by 14.0 in.)	14.0 mm (0.56 in.)

used), which in turn should be 25 % higher than the height of the text. If no subheadings are used, then the signal word shall be 50 % higher than the message text.

15.12.3 *Character Color*—The signal word "NOTICE" shall be in white italicized characters on a blue background as shown in Fig. 159, "Example of Information Sign" which provides a sample sign including text. Message text shall be black characters on white background. Message text should be all capitals (as shown below) for short messages less than two lines Uppercase and lowercase should be used for longer messages.

15.13 *Instruction Labels:*

15.13.1 *General*—All instruction labels shall be titled at the top of the label to identify the instructions as operating or maintenance, or both, and shall identify the equipment or system for which the instructions have been prepared.

15.13.2 *Format*—The instruction labels shall be prepared as follows:

15.13.2.1 Instructions shall be provided in a numbered step-by-step format with each step stated as briefly as possible. For instructions written in English, a command form should be used where the subject "you" is understood and not written in the instruction.

15.13.2.2 The instruction shall avoid the use of specific equipment model names or numbers, or other aspects of the equipment that may change at some future date and thus mandate the preparation of new instructions. Note that assigned equipment names and numbers that are specific to a vessel or structure shall be included in the instructions to aid the personnel in matching the instructions to the labels on equipment. Further, equipment names, numbers and symbols that appear in the instructions shall be identical to those that appear on the equipment, consoles, and panels and in all operating and maintenance manuals.

15.13.2.3 Hazard and safety information that pertains to a specific step in the instructions shall be provided immediately preceding the step in the instruction and shall be headed by the appropriate signal word, (that is, DANGER or CAUTION). Hazard and safety information that pertains to the procedure in general should appear at the beginning of the instruction.

15.13.2.4 Instructions shall be provided on a separate label from diagrams, schematics, charts, or other types of graphic labels that may be referenced in the instructions. However, the referenced labels shall be immediately adjacent to the instruction label to provide easy transfer between the two by personnel.

15.13.2.5 If both operating and maintenance instructions are provided, they shall be provided on separate postings or signs. They shall be clearly separate from one another and labeled with the appropriate headings.

15.13.2.6 Where instructions related to emergencies are provided, the following additional criteria shall be applied:

(1) Provide a title at the top to identify the instructions as emergency instructions and identify the type of emergency for which the instructions have been prepared.

(2) Instructions shall be concise, precise, specific, and explicit and shall not require interpretations or assumptions.

(3) Symbols should be used as appropriate to enhance universal comprehension.

15.13.3 *Text Requirements:*

15.13.3.1 Text on instruction labels shall be orientated normally for the language used (for example, for English, text would be oriented horizontally). The instructions, including any text and associated graphics or schematics, shall be visible and legible under all expected lighting conditions including bright sunlight and artificial lighting. Emergency instruction labels shall also be visible and legible under reduced emergency lighting conditions.

15.13.3.2 Text shall be a mix of uppercase and lowercase letters.

FIG. 159 Example of Information Sign

15.13.4 *Character Size*—The height of label text shall be sized as required for the reading distance, (see 15.1.9) but in no case shall it be less than 3.2 mm (0.125 in.). The label title shall be at least 50 % higher than the height of the subheadings (if any are used), and the subheadings shall be 25 % higher than the height of the smallest text.

15.13.5 *Mounting Location*—Instruction labels, including emergency instruction labels, shall be located so that they are fully visible at all times and free from obstructions including doors or covers, that in their open positions, could cover the labels. Instruction labels that contain graphics, photos, line drawings, or other real world depictions shall be located so that the instruction and the real world objects depicted in the instructions are spatially related as both the instruction and real world are viewed by the person reading the instruction.

15.13.6 *Material*—Instruction labels may be made of any of the following materials:

15.13.6.1 Reverse Screened Lexan.

15.13.6.2 Vinyl Cut Letters on a Plastic or Metal Backing Plate.

15.13.6.3 Silk Screened Vinyl with Laminate Overlay.

15.13.6.4 Engraved Plastic.

15.13.6.5 Ultraviolet-Resistant Vinyl Mounted on a Stainless Steel Backing.

15.13.6.6 Fiberglass.

15.14 *Graphical Schematics or Diagrams:*

15.14.1 *General*—Graphics or schematics shall be used to present information through line schematics, diagrams, or charts, tables, or pictures. All graphics should be titled at the top to identify the equipment, system, or information being presented. If more than one schematic, diagram, or chart is being presented on a single label, each should be labeled with a heading.

15.14.2 *Graphics or Diagrams*—All graphic symbols and special nomenclature used on a graphic label shall be defined in a legend box. Descriptive text shall be brief and not obscure the diagram or schematic. Information shall be provided on the label that indicates location or orientation, or both, of the equipment or system.

15.14.3 *Charts*—All charts of the same type or function, such as lubrication charts, shall be formatted with the same headings, units of measurement, organization, and presentation details.

15.14.4 *Character Size:*

15.14.4.1 The height of label text shall be sized as required for the reading distance, (see 15.1.9) but in no case should it be less than 3.2 mm (0.125 in.). The label title should be at least 50 % higher than the height of the subheadings (if any are used), and the subheadings should be 25 % higher than the height of the smallest text.

15.14.4.2 Text shall be a mix of uppercase and lowercase characters.

15.14.5 *Line Size*—Line widths on schematics and diagrams shall be a minimum of 1.5 mm (0.06 in.).

15.14.6 *Mounting Location*—Graphics shall be mounted as close as possible to the equipment, system, or component they represent. Graphics which show piping schematics or equipment arrangements shall be located so the spatial layout of the label directly matches the arrangement of the actual piping and equipment when both are viewed by the operator or maintainer facing the label.

15.15 *Orientation Plans:*

15.15.1 *General Requirements*—Orientation plans shall be prepared to:

15.15.1.1 Be titled at the top to identify the specific area and location where the plan or sign is located.

15.15.1.2 Provide a realistic pictorial/graphical presentation of the vessel or structure installation layout.

15.15.1.3 Be positioned so that they are spatially-orientated in terms of the vessel or structure from the perspective of personnel viewing the plan.

15.15.1.4 Orient personnel using the plan by marking where the person is located when viewing a particular sign (that is, You are here).

15.15.2 *Mounting Location*—Orientation plans shall be located in strategic areas around the vessel or structure (for example, at muster areas, main stair landings, close to fire-fighting areas, and at emergency exits/entrances, as applicable). They shall be clearly visible and legible, under all expected lighting conditions, including bright sunlight, artificial lighting, and reduced emergency lighting conditions.

15.16 *Emergency Instructions:*

15.16.1 *General*—Emergency instructions shall be prepared to:

15.16.1.1 Provide instructions in a step-by-step format with each step on a separate line.

15.16.1.2 Be concise but specific and explicit, with no interpretation or assumptions required.

15.16.1.3 Use imperatives for instructions.

15.16.1.4 Use short words and sentences.

15.16.1.5 Orient labels horizontally.

15.16.1.6 Ensure that text and diagrams are visible under all potential levels of ambient illumination.

15.16.1.7 Ensure that labels shall be visible at all times even when the doors are open.

15.16.1.8 Provide special cautionary words such as “urgent,” “hazard,” or “danger” for use by the reader to eliminate judgement by readers.

15.16.1.9 Ensure that pictures, drawing, and sketches are oriented spatially to the reader as he or she looks at the instruction.

16. Material Handling

16.1 *Design to Support Manual Material Lifting and Carrying:*

16.1.1 *General Design Requirements*—Design of maritime vessels and structures shall provide for safe and efficient lifting and moving of cargo, stores, equipment, spare parts, and other items requiring manual lifting and carrying. Specific requirements to be provided include:

16.1.1.1 Provision of illumination levels tied to the level of task detail involved in the preparation and conduct of manual material lifting and carrying.

16.1.1.2 Control of ambient noise in areas that require interpersonal communication during manual lifting and carrying.

16.1.1.3 Provision of laydown areas where materials can be transferred from one mode of transport to another (for example, from a dolly to a crane for movement on or off the vessel or structure).

16.1.1.4 Provision of visual monitoring of materials being moved.

16.1.1.5 Elimination of blind lifts by cranes.

16.1.1.6 Minimizing the number of transfers from one lifting/carrying mode to another during the movement of items.

16.1.1.7 Design of material movement routes to reduce the number of turns required through the full transfer movement.

16.1.1.8 Integration of both personnel and material traffic flow.

16.1.1.9 Design system for appropriate combination of stairs, ladders, passageways and mechanical assists.

16.1.1.10 Provision of deck surfaces that will allow easy movement of soft and hard-tired carts, dollies, mobile A-frame cranes and other lifting/carrying equipment.

16.1.2 *Rests and Stands:*

16.1.2.1 When required to support operations or maintenance functions, rests, or equipment stands on which units can be placed, including space for test equipment, tools, technical orders, and manuals, shall be provided. Such rests or stands should be part of the basic unit, rack, or console chassis.

16.1.2.2 Space around the rests or stands shall be provided to both support the equipment or item and allow for the number of personnel required to lift or work on the item.

16.1.3 *Extensions Connected to Equipment*—Accessories, utilities, cables, wave guides, hoses, or any other protuberance extending from the equipment or item to be lifted or carried shall be designed for easy removal or disconnection from the equipment or item before handling.

16.2 *Weight Lifting:*

16.2.1 *General Requirements:*

16.2.1.1 The weight limits in Table 46, "Design Weight Limits for Lifting," Conditions A and B, show the maximum weight of items that can be lifted by one person lifting with two hands.

16.2.1.2 Doubling the weight limits in Table 46 shall be used as the maximum weight of items requiring two-person lifting, provided the load is uniformly distributed between the two lifters. If the weight of the load is not uniformly distributed, the weight limit applies to the heavier lift point.

16.2.1.3 Where three or four persons are lifting simultaneously, not more than 75 % of the one-person value may be added for each additional lifter. A maximum of four persons should be used for any manual lifting task and only then if the object lifted is large enough and shaped so that the lifters do not interfere with one another and can distribute the load evenly while lifting.

16.2.1.4 Where it is not possible to define the height to which an object will be lifted in operational use, the weight limit for lifting to shoulder height shall be used. The values in Table 46 are applicable to objects with or without handles.

16.2.2 *Lifting Limits*—The values shown in Table 46 cover the 5th % female to the 95th % male and shall apply to any object to be lifted manually.

16.2.3 *Repetitive Lifting Weight Limits*—The equipment weight limits in Table 46 are not for repetitive lifting as found for example, in loading or unloading ship stores. If the frequency of lift exceeds 1 lift in 5 min or 20 lifts per 8 h, the permissible weight limits shall be reduced by (8.33 × LF) %, where LF is the lift frequency in lifts per minute. For example, if the lift frequency is six lifts per minute, then the maximum permissible weight is reduced by 50 % (8.33 × 6 = 50).

16.2.4 *Load Size Limits:*

16.2.4.1 The maximum permissible weight lift limits in Table 46 are applicable to an object with uniform mass distribution and a compact size not exceeding 457 mm (18 in.) high, 457 mm (18 in.) wide, and 305 mm (12 in.) deep (away from the lifter). If the depth of the object exceeds 610 mm (24 in.), the permissible weight shall be reduced by 33 %. If the depth of the object exceeds 914 mm (36 in.), the permissible weight shall be reduced by 50 %. If the depth of the object exceeds 1219 mm (48 in.), the permissible weight shall be reduced by 66 %.

16.2.4.2 These dimensions are appropriate for maritime populations from such regions as North America, Europe, and Australia but should be reduced by 15 % for individuals from such areas as Southeast Asia, South China, India, Japan, and Africa.

16.2.5 *Obstacles to Reach Over*—The values in Table 46 assume that there are no obstacles to reach over between the person lifting and the shelf, table, bench, or other surface on which the object is to be placed. Where there is a lower protruding shelf or other obstacle limiting the lifter's approach to the desired surface, the weight limit of the object shall be reduced by 33 % from that shown in Table 46 for an obstacle exceeding 305 mm (12 in.) in depth, 50 % for an obstacle exceeding 457 mm (18 in.), and 66 % for an obstacle of 610 mm (24 in.). No lift shall be performed at a reach distance greater than 610 mm (24 in.).

16.2.6 *Multiple Lifting Restrictions*—If the allowable weight must be reduced by the repetitive lifting limits (16.2.3), oversize load considerations (16.2.4) or the obstacle interference considerations (16.2.5), only the most restrictive single value shall apply, that is, two reductions shall not be applied.

16.2.7 *Twisting Postures*—Lifting tasks shall minimize or eliminate twisting of the body during the lifting task. If twisting motion is required, it should be limited to a maximum of 30° left or right of body centerline.

16.3 *Weight Carrying:*

16.3.1 *General Requirements:*

TABLE 46 Design Weight Limits for Lifting

NOTE 1—Dimensions for Condition A shall be reduced to 1194 mm (47 in.) and Condition B to 889 mm (35 in.) for personnel from such regions as China, Southeast Asia, South India, Japan, and West Africa.

Lifting Function	Male and Female Population	
	Kg	(lb)
A. Lift an object from the floor and place it on a surface not greater than 1.525 m (5 ft) above the floor.	16.8	(37)
B. Lift an object from the floor and place it on a surface not greater than 915 mm (36 in.) above the floor.	20.0	(44)

16.3.1.1 The weight limit in Table 47, "Design Weight Limits for Carrying," Condition A, shall be used as the maximum value in determining the design weight of items requiring one person carrying objects a distance of up to 10 m (33 ft). Condition B of Table 47 shall be used as the maximum value in determining the design weight limit when objects are required to be carried more than 10 m (33 ft). The maximum permissible carrying weight also applies to an object with a handle on top and carried with one hand (for example, tool box, test equipment).

16.3.1.2 Doubling this weight carrying limit shall be used as the maximum design weight of items requiring two-person carrying, provided the load is uniformly distributed between the two carriers. No more than two persons should be allowed to carry a load. Any load in excess of the two-person carrying limit should be transported with assisted lifting/carrying equipment. In all cases involving carrying, it is assumed that the object is first lifted from the floor, carried the required distance and placed on the floor or on another surface not higher than that described in Condition B of Table 46, "Design Weight Limits for Lifting." If the final lift is a higher height, the lift limit defined in Condition A of Table 46 applies as the more limiting carrying weight.

16.3.2 *Carrying Limits*—The values shown in Table 47 cover the 5th % female to the 95th % male and shall apply to any object to be carried manually.

16.3.3 *Repetitive Carrying Weight Limits*—The reduction formula expressed in 16.2.3 for repetitive lifting shall be applied in the same manner to repetitive carrying.

16.3.4 *Other Limiting Factors*—Other factors that will reduce the load lifting/carrying limits shown in Tables 46 and 47 are shown below in Table 48, "Limiting Factors" along with the percentage of reduction from the values shown in Tables 46 and 47 that must be applied if the factor is present.

16.3.5 *Labeling of Carried Weights*—Items exceeding the lifting and carrying weight and frequency limits of Tables 46 and 47 for a one-person lift by a male or female person shall be labeled with the weight of the object. Where assisted lifting devices are required, hoist and lift points shall be provided and clearly labeled. Labeling shall comply with Section 15.

16.3.6 *Obtain Assistance*—Establishment of lifting and carrying limits is dependent on many factors and is a complex task. If manual lifting and carrying is a frequent or significant task, assistance in establishing lifting and carrying limits for those tasks should be obtained from a specialists trained in human biomechanics.

TABLE 47 Design Weight Limits for Carrying

NOTE 1—The weights shown are for maritime personnel from North America. Reduce these values by 20 % for personnel from regions such as China, Southeast Asia, South India, Japan, and West Africa.

Carrying Function	Male and Female Population	
	Kg	(lb)
A. Carry an object 10 m (33 ft) or less.	19.0	(42)
B. Carry an object more than 10 m (33 ft):		
Package carried at side with one hand (tool chest, container with handles, and so forth).	13.6	(30)
Package with irregular sides (electronic equipment chassis, and so forth).	11.4	(25)
Box or other item with two hands.	14.0	(35)

TABLE 48 Limiting Factors

Limiting Factor	% Reduction from Tables 46 and 47
For personnel over 50 years of age	20 %
Absence of handles or poor handholds	10 %
Limited headroom (person works bent over)	35 %
Temperature exceeds 32°C (90° F)	12 %

16.4 *Design:*

16.4.1 *General Requirements*—All removable or carried units designed to be removed and replaced shall be provided with handles or other suitable means for grasping, handling, and carrying by bare hands or by gloved or mittened hands. Items requiring handling should be provided with a minimum of two handles or one handle and one grasp area. Items weighing less than 4.5 kg (10 lb) shall be exempt from this requirement unless specifically directed by the procuring activity.

16.4.2 *Location of Handles or Grasp Areas*—Handles or grasp areas shall be located relative to the center of gravity of the unit to preclude swinging or tilting when lifted. They shall be located to provide at least 76 mm (3 in.) of clearance from obstructions during handling.

16.4.3 *Non-Fixed Handles*—Non-fixed handles (for example, hinged or foldout) shall have a stop position for holding the handle perpendicular to the surface on which it is mounted and shall be capable of being placed into the carrying position with one hand with either the bare or covered (that is, gloved or mittened) hand.

16.4.4 *Grasping Surface*—Where an item's installation requires that its bottom surface be used as a handhold during removal or installation, a nonslip grasp surface (for example, grooved or frictional) shall be provided.

16.4.5 *Handle Dimensions*—Handles that are to be used with mittened, gloved, or ungloved hands shall be equal to the dimensions shown in Fig. 160.

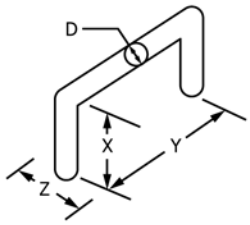
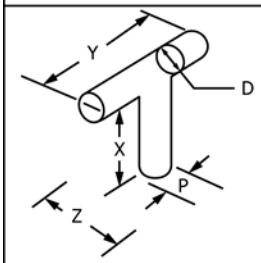
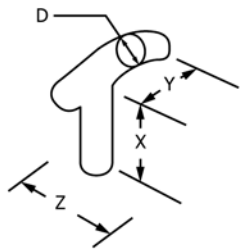
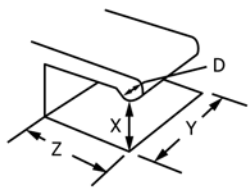
16.4.6 *Handle Materials*—Handles or grasp areas used with bare hands shall have surfaces that are not thermally or electrically conductive. The surface shall be sufficiently hard to prevent imbedding of grit and grime during normal use.

16.4.7 *Handle Shape*—Use hand-shape handles (for example, one-hand bar or T-bar) when items must be carried frequently or for long periods.

16.4.8 *Hoist Lugs*—Lifting eyes shall be provided on all equipment weighing more than 68 kg (150 lb) with a minimum of 102 mm (4 in.) of clear space around the eye.

16.5 *Design of Auxiliary Hoisting and Carrying Devices:*

16.5.1 *General Requirements*—Permanent or portable assisted lifting devices shall be provided to aid in the lifting or moving of loads or both that exceed the allowable manual lifting and carrying limits shown in Tables 46 and 47 and 16.2.2 and 16.3.2. When such devices are provided, space for the devices, personnel who use them, and area for device maneuvering shall be provided for all operational scenarios.

ILLUSTRATION	TYPE OF HANDLE	DIMENSIONS IN mm (inches)								
		(Bare Hand)			(Gloved Hand)			(Mittened Hand)		
		X	Y	Z	X	Y	Z	X	Y	Z
	Two-finger bar	32 (1 1/4)	65 (2 1/2)	75 (3)	38 (1 1/2)	75 (3)	75 (3)	Not applicable		
	One-hand bar	48 (1 7/8)	111 (4 3/8)	75 (3)	50 (2)	125 (5)	100 (4)	75 (3)	135 (5 1/4)	150 (6)
	Two-hand bar	48 (1 7/8)	215 (8 1/2)	75 (3)	50 (2)	270 (10 1/2)	100 (4)	75 (3)	280 (11)	150 (6)
	T-bar	38 (1 1/2)	100 (4)	75 (3)	50 (2)	115 (4 1/2)	100 (4)	Not applicable		
	J-bar	50 (2)	100 (4)	75 (3)	50 (2)	115 (4 1/2)	100 (4)	75 (3)	125 (5)	150 (6)
	Two-finger recess	32 (1 1/4)	65 (2 1/2)	50 (2)	38 (1 1/3)	75 (3)	50 (2)	Not applicable		
	One-hand recess	50 (2)	110 (4 1/4)	90 (3 1/2)	90 (3 1/2)	135 (5 1/4)	100 (4)	90 (3 1/2)	135 (5 1/4)	125 (5)

Curvature of Handle or Edge

(DOES NOT PRECLUDE USE OF OVAL HANDLES)

Weight of item
Up to 15 lbs (6.8 kg)
15 to 20 lbs (6.8 to 9.0 kg)
20 to 40 lbs (9.0 to 18 kg)
Over 40 lbs (over 18 kg)
T-bar Post

Minimum Diameter
D = 6 mm (1/4 in.)
D = 13 mm (1/2 in.)
D = 19 mm (3/4 in.)
D = 25 mm (1 in.)
T = 13 mm (1/2 in.)

Gripping efficiency is best if finger can curl around handle or edge to any angle of 2/3 π rad 120°) or more.

FIG. 160 Handle Dimensions

16.5.2 *Assisted Device Placement*—Assisted lifting devices provided to assist in lifting or moving equipment or both should be located directly over the item to be lifted so the lift is vertical to prevent swinging loads when the items are raised or lowered.

16.5.3 *Clearance Around Hoisting Device*—Permanent hoisting devices should be free of obstacles such as wireways, HVAC ducting, structural components, piping, and other equipment within a radius of at least 305 mm (12 in.) at the point of hookup to the device.

16.5.4 *Portable Hoisting Devices*—Portable hoisting devices such as moveable A-frame or other type of cranes, chain falls, or other devices that are attached to permanent hoisting points shall be self-contained and capable of being moved and erected at the work site without the aid of other lifting devices while meeting manual lifting and carrying limits contained in this chapter.

16.5.5 *Safe Working*—The safe working load shall be clearly marked on all auxiliary hoisting and carrying devices in accordance with the labeling requirement shown in Section 15.

16.5.6 *Hoisting Between Levels*—Locations in which materials will commonly be moved between levels, such as stairs and ladders, shall be provided with lifting points to allow for the use of lifting devices. These lifting points should be accessible for connecting lifting devices without use of ladders or other mobile platforms.

16.6 *Hand Trucks and Wheeled Dollies:*

16.6.1 *General Requirements*—In areas in which two-wheeled hand trucks and four-wheeled dollies will be used to move loads, deck surfaces shall be smooth enough to allow travel of the devices. Design and use of hand trucks or dollies shall be accomplished within the manual lifting and carrying limits contained within this chapter and shall not be used to move loads up or down stairs or ramps in excess of 7° maximum (4° preferred) angle of inclination. Where decking is expanded metal or not solid, or heavier loads are anticipated, larger diameter casters shall be used.

16.6.2 *Deck Access Requirement:*

16.6.2.1 Clear deck space shall be provided to move the hand trucks or dollies within the vessel or structure. Turning radius for hand trucks shall be a minimum of 1219 mm (48 in.) as shown in Fig. 161.

16.6.2.2 Turning radius for dollies will depend on their size and whether there are two or four casters, but the radius should allow for a minimum of 152-mm (6-in.) clearance between the edge of the dolly and any adjacent structure or obstruction (see Fig. 162, "Use of Dollies"). Dollies shall be constructed with the swivel casters located on the handle end.

16.7 *Crane Design:*

16.7.1 *General Design Requirements*—Individual crane controls and displays shall comply with the design requirements contained in Sections 5 and 6. Alarms, such as for excessive boom angle, overload, or anti-two block, shall comply with the requirements of Section 7. Integration of the controls, displays, and alarms shall comply with Section 8. Crane cab layout and arrangement shall comply with the requirements of Section 10. Communications to and from or within the crane shall comply with the requirements of Section 19. Should the crane cab contain any computer-generated or displayed information, or both, it shall comply the requirements of Section 13. Labeling of all components, controls and displays or posting of hazard warnings or informational signs in or on the crane shall comply with the requirements contained in Section 15. Internal or external access in or on the crane shall comply with the requirements of Section 11. The crane shall be designed to maximize ease and safety of maintenance in accordance with the requirements of Sections 17 and 18. Environmental criteria within the crane cab or inside the machinery compartment shall comply with the requirements of Section 14 and 16.7.6.

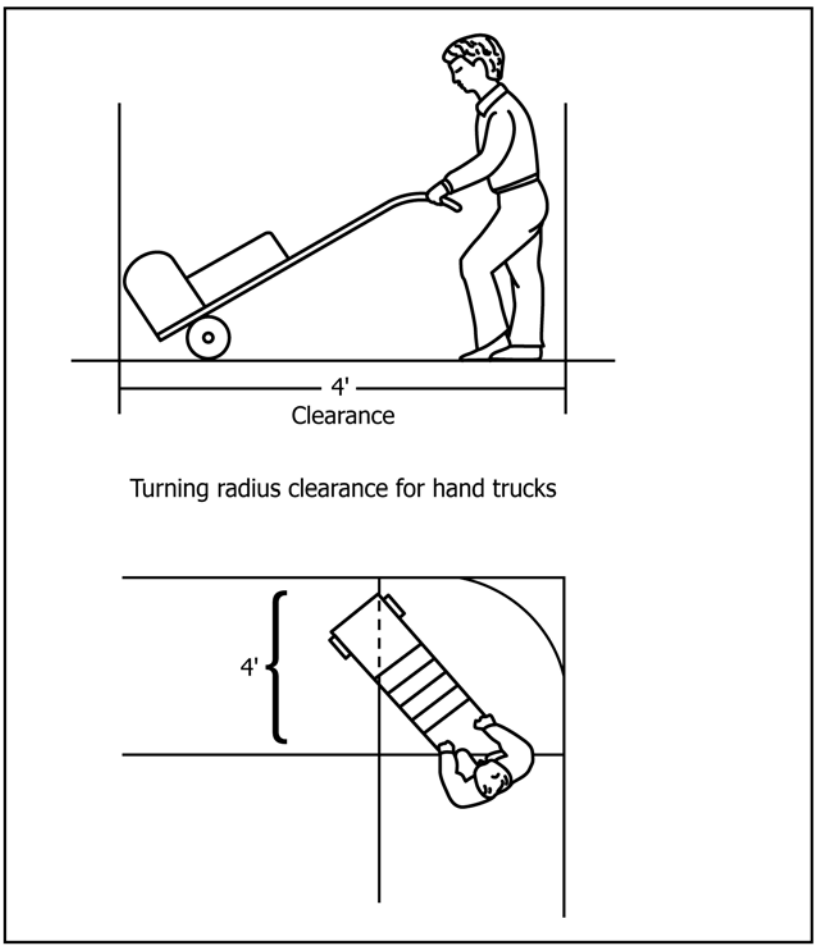


FIG. 161 Use of Hand Trucks

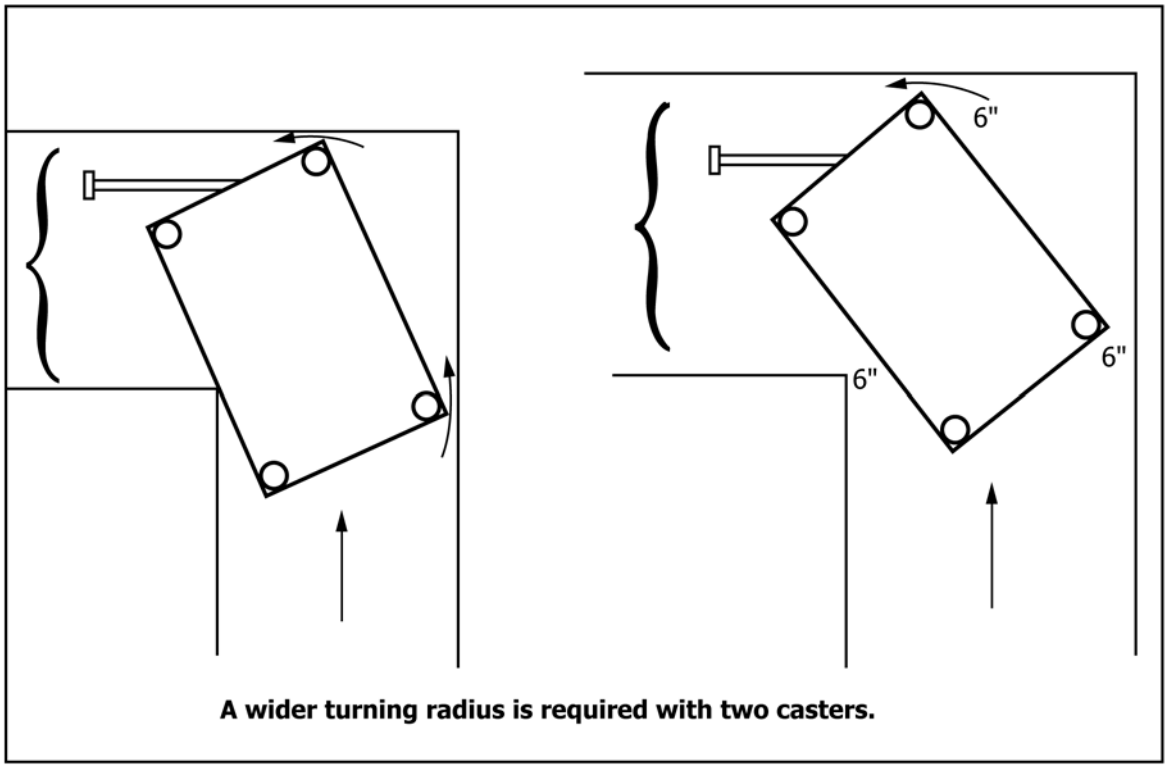


FIG. 162 Use of Dollies

16.7.2 *Boom Load Indicator and Alarm*—The actual and maximum allowed boom load capacity shall be indicated on the crane console and a visual and audible warning device shall be provided to indicate that the allowable boom load has been exceeded.

16.7.3 *Operator Visibility*—An unobstructed view of the crane working area, including the boom tip sheaves down to within a 3-m (10-ft) radius from the crane pedestal, should be visible to the crane operator ranging in size from the 5th % female to the 95th % male as defined in Section 9, "Anthropometry." Downward visibility from the operator's seated position shall not be restricted by the cab window frame structure or any other obstacle.

16.7.4 *Self-contained Maintenance Capability*—Cranes should be in close enough proximity to allow another crane to lift heavy objects such as motors or slew drives for maintenance or overhaul purposes, or each crane should contain jib cranes or other self-contained lifting devices to perform these tasks.

16.7.5 *Boom Tip Access*—An access walkway at least 305 mm (12 in.) wide shall be provided along the boom to provide access to the boom tip for maintenance of the boom tip sheaves. In addition, a permanent standing surface should be provided at the tip from which the tip maintenance tasks can be completed.

16.7.6 *Cab Habitability*—The crane cab shall meet the following habitability requirements:

16.7.6.1 Noise levels shall not exceed 75 dB(A).

16.7.6.2 The temperature in the cab shall be between 18°C (65°F) and 27°C (80°F).

16.7.6.3 Storage space for food, drink, manuals, flashlight, and other items shall be provided in the cab.

16.7.6.4 All platform alarms shall be presented in the cab.

16.7.6.5 Humidity shall not exceed 50 %.

16.7.6.6 Lighting shall be provided in the cab and machinery room at 325 lux (30ft-c) minimum, 540 lux (50 ft-c) preferred, and on and along the boom at a level sufficient to permit safe access along the boom and to light the work area below the boom.

17. Design for Maintenance

17.1 *General Design Requirements:*

17.1.1 *Modular Replacement*—Equipment design shall emphasize the breaking up of a unit of equipment into modules that are independent, interchangeable, and easily replaced. Other important design goals shall be ease of access to test and service points, ease of access to internal parts and components, and built-in testing, diagnostic, and fault localization capability.

17.1.2 *Non-Interruption of Service*—If any part of the system must operate continuously, it shall be capable of undergoing maintenance without interrupting the operation.

17.1.3 *Redundancy to Prevent Interruption*—If continuous operation is required, and required maintenance on a unit of equipment would interrupt the operation, redundant equipment shall be provided.

17.1.4 *Automation of Fault Detection and Isolation*—If required by regulation or classification society rules, equipment shall have automatic fault detection and isolation capability.

17.1.5 *Independent Design*—Units of equipment shall be independently designed (functionally, mechanically, electrically, and electronically).

17.1.6 *Design Requirements*—Designs shall incorporate the following features for maximum maintainability:

17.1.6.1 Simplification of operator and maintenance functions.

17.1.6.2 Use of modular or unit packaging or throwaway components designed for rapid and easy removal and replacement by one person with the weight limitations contained in Section 16.

17.1.6.3 Use of self-lubricating principles.

17.1.6.4 Use of sealed and lubricated components and assemblies.

17.1.6.5 Use of built-in testing and calibration features for major components.

17.1.6.6 Use of self-adjusting mechanisms.

17.1.6.7 Use of gear-driven accessories to eliminate belts and pulleys.

17.1.6.8 Minimum number and complexity of maintenance tasks.

17.1.6.9 Design to minimize skills and training requirements of maintenance personnel.

17.1.6.10 Design for accessibility to all systems, equipment, and components requiring maintenance, inspection, removal, and replacement.

17.1.6.11 Design to incorporate standard parts.

17.1.6.12 Design to facilitate manual handling required during maintenance and comply with established manual force criteria provided in Section 16.

17.1.6.13 Design in order for inputs to and outputs from each unit shall be kept to a minimum by grouping functions to minimize crisscrossing of signals.

17.1.6.14 Provide for displays that give the status of equipment indicating when maintenance must be performed (for example, differential pressure meter on strainer) and locate them so it is obvious which equipment they are associated with.

17.1.6.15 Design so it shall be possible to check and adjust each item, or function of an item, individually.

17.1.6.16 Design so equipment is capable of being removed, replaced, and repaired by personnel wearing personal and special purpose clothing and equipment appropriate to the maintenance concept, including NBC protective clothing for use on military vessels and structures.

17.1.6.17 Provide physical measures to preclude interchange of items of a same or similar form that are not in fact functionally interchangeable.

17.1.6.18 Provide physical measures to preclude improper mounting of units or components.

17.1.6.19 Design to make identification and interchange of interchangeable items more obvious.

17.1.6.20 Provide devices (for example, alignment pins) to make proper mounting of items easier.

17.1.6.21 Design to ensure that identification, orientation, and alignment provisions include cables and connectors.

17.1.6.22 When using maintenance manuals from vendors or other sources to design equipment or systems, the manuals must be used as a part of the design requirements to ensure maintainability of the finished system or equipment.

17.1.7 *Stacking Avoidance*—Parts shall be mounted in an orderly array on a "two-dimensional" surface, rather than stacked on one another (that is, a lower layer shall not support an upper layer), so subassemblies do not have to be removed to access other subassemblies within the equipment.

17.1.8 *Similar Items*—Similar items shall use a common mounting design and orientation within the unit. This mounting design shall preclude interchange of items that are not functionally interchangeable. Similar items that are not functionally interchangeable shall be made distinguishable by labeling, color coding, marking, or other means, to prevent inadvertent substitution.

17.1.9 *Delicate Items*—Components susceptible to maintenance-induced damage through rough handling, static electricity, abrasion, lack of cleanliness, or other such factors shall be clearly identified and guarded from abuse both physically and by procedural requirements.

17.1.10 *Labeling*—Equipment shall be labeled with a specific functional description of the equipment and a unique identifying number. In addition, signs and graphics, such as schematics, should be placed to provide hazard information and maintenance instructions. Guidance for these is provided in Section 15, "Labeling."

17.1.11 *Equipment Removal*—During the design process, consideration shall be given to how equipment is to be lifted or moved (for example, by personnel alone or using mechanical lifting aids) for maintenance purposes. Guidance on equipment handling is provided in Section 16, "Material Handling." Special consideration for equipment removal and replacement shall be provided for equipment which is essential for normal operations or emergency situations.

17.1.12 *Structural Members*—Structural members of units or chassis shall not prevent access to, or removal of items. Replaceable items shall not be mounted in a manner that will make them difficult to remove. Where accessibility depends upon removal of panel's cases and covers, measures shall be taken to ensure that such items are not blocked by structural members or other items.

17.1.13 *Large Items*—Large items that are difficult to remove shall be mounted so that they will not prevent convenient access to other items. Smaller or more fragile items shall be located so as not to be easily damaged during removal of the large items. Large items mounted on skids, (for example, pumps, motors, compressors, turbines), or items requiring frequent inspection or maintenance, should be placed at the periphery of the skid or located next to a walkway or open deck area for ease of access for maintenance purposes and direct access to transport routes if equipment must be removed.

17.1.14 *Rear Access*—Sliding, rotating, or hinged equipment to which rear access is required shall be free to open or rotate their full distance and remain in the open position without being supported by hand. Rear access shall also be provided to plug connectors for test points, soldering, and pin removal where connectors require such operations.

17.1.15 *Relative Accessibility*—Items most critical to system operation and which require rapid maintenance shall be

most accessible. When relative criticality is not a factor, items requiring most frequent access shall be most accessible.

17.1.16 *High-Failure Rate Items Accessibility*—High-failure rate items shall be accessible for replacement without moving non-failed items. Mechanical replacement items shall be removable with common hand tools and simple handling equipment.

17.1.17 *Moving Parts*—Maintenance tasks shall not be required on items for which the human must lean over or work directly around moving parts (for example, belts, elevator cables, rotating shafts, cutting blades), especially if it is necessary to have the moving parts active as a part of the maintenance procedure. Mechanical hazards associated with maintenance tasks shall be provided with guards in accordance with Section 18.

17.1.18 *Equipment Adjustment Controls*—Equipment adjustment controls shall be designed according to the following criteria:

17.1.18.1 Knobs rather than screwdriver controls shall be used when adjustments occur more than once per month. Knobs shall maintain their setting following adjustment.

17.1.18.2 Controls required for maintenance purposes shall comply with basic control design requirements in Section 5, "Controls" and labeling requirements in Section 15, "Labeling."

17.1.18.3 Screwdriver adjustments made without visual access are permissible only if mechanical guides are provided to align the screwdriver. Screw travel shall be limited to prevent the screw from falling out of its intended position.

17.1.18.4 A reference scale or other appropriate feedback shall be provided for all adjustment controls. The reference scale shall be visible to the person making the adjustment.

17.1.18.5 Mirrors or flashlights should not be required for adjustment.

17.1.18.6 Calibration or adjustment controls that are intended to have a limited degree of motion shall have mechanical stops with strength to prevent damage by a force or torque 100 times greater than the resistance to movement within the range of adjustment.

17.1.18.7 Critical and sensitive adjustment controls shall incorporate features to prevent inadvertent or accidental actuation. If a locking device is to be used to prevent inadvertent or accidental actuation, operation of the locking device shall not change the adjustment setting.

17.1.18.8 Where the operator or maintainer is subjected to disturbing vibrations or acceleration during the adjustment operation, suitable hand or arm support shall be provided near the control location to facilitate making adjustments.

17.1.18.9 Adjustment controls shall not be located close to [that is, within 254 mm (12 in.)] dangerous voltages, moving machinery, or any other hazards.

17.2 *Maintenance Accessibility:*

17.2.1 *Ladders, Stairs, Walkways, Platforms, and Ramps*—Ladders, stairs, walkways, platforms, and ramps provided to perform maintenance tasks shall comply with the design standards contained in Section 11.

17.2.2 *Work from Ladders*—Items to be maintained from a ladder shall require only one hand and shall be located no more than 965 mm (38 in.) from the ladder centerline. Maintenance tasks performed at this maximum distance shall involve only adjustments or other similar tasks that can be performed with the bare hand or light tools. Ladders should be located so the maintenance task is performed with the right hand.

17.2.3 *Maintenance of Masts*—Maintenance on masts or antenna, lights, or other equipment mounted on the mast, or other elevated structures, shall not require the person to be suspended from a safety harness, but rather shall be performed from a permanent or temporary work platform, vertical ladder with climber safety rail, work basket supported by a crane, or other similar stable standing surface. Vertical access must be provided with adequate clearance as stated in Section 11, "Access Aids." If this is not achievable, masts should be hinged and able to be lowered for maintenance; otherwise a rotating base shall be provided.

17.2.4 *Rechargeable Containers:*

17.2.4.1 Compressed gas bottles for inert gases (for example, nitrogen flasks in oil and water test labs, fire-extinguishing materials, start air flasks), shall be located in a space or compartment in a manner that allows their easy and quick removal by hand cart or other assisted lifting/transport device.

17.2.4.2 The gas bottles shall also be located and mounted in a manner so as not to require the removal of bottles from their storage racks in order to test for content level (for example, weighing, ultra sound, direct readout).

17.2.5 *Removal of Functioning Component or Part*—It should not be necessary to remove a part or component that is functioning to remove, repair, or maintain a part or component that is not functioning or one that requires regular service or maintenance.

17.2.6 *Tools*—Equipment shall be designed to minimize the numbers, types, and complexity of tools and test equipment required for maintenance and shall be provided to use effectively tools through their full range of motion. Special tools shall be used only when common hand tools cannot be used or when they provide significant advantages over common hand tools. Special tools required for operational adjustment maintenance shall be securely mounted within the equipment in an accessible location.

17.2.7 *Physical Access*—Physical access shall be provided to complete all maintenance tasks as described below.

17.2.7.1 Physical space shall be designed into and within the equipment and systems so that sufficient accessibility for all maintenance activities required is provided for the full range of personnel specified by the procuring activity, or if not specified by the procuring activity, with applicable body dimensions for the 5th % female to the 95th % male for the user population as defined in Section 9, "Anthropometry" wearing the appropriate clothing and carrying (or using) all equipment.

17.2.7.2 Where maintenance tasks require the assumption of various body postures the physical space requirements for these body postures shall be provided in accordance with Section 10.

17.2.7.3 Equipment design should permit maintenance from above and outside, rather than from underneath or inside components.

17.2.7.4 Adequate space, that is, 0.4 m^2 (4 ft^2), per person minimum should be provided for personnel, their clothing, including required personal protective equipment, tools, and equipment, as well as free space for the movements and activities required to perform maintenance task(s).

17.2.7.5 When maintenance requires the removal of large internal parts (for example, tube bundles from a heat exchanger) the working space provided must accommodate the person(s) performing the task, the physical size of the removed component, and any laydown area needed for the component, parts, tools, or equipment.

17.2.7.6 When maintenance tasks require the maintainer to work through a provided access opening while assuming a particular body posture (for example, squat, sit down, kneel, rest on one knee, lie down, or stand sideways), each access opening design shall accommodate these postures. Table 49, "Seated, Forward Reach (Both Arms)," Table 50, "Cross-Legged Seated, Forward Reach (Both Arms)," Table 51, "Standing, Forward Reach (Both Arms)," Table 52, "Standing Forward Reach (Preferred Arm)" and Table 53, "Standing, Lateral Reach (Preferred Arm)" provide guidance on maintainer reach capabilities in a variety of postures for five specific percentile sizes of the human body. The dimensions shown should be increased by 50 mm (2 in.) for one hand, 102 mm (4 in.) for two hands when the person is wearing winter gloves or mittens.

17.2.7.7 It is important to note that the dimensions shown in the following tables are for North American males. Use the anthropometric dimensions for other maritime world populations contained in Section 9, "Anthropometry," to estimate the changes in opening sizes and locations required to fit other populations.

17.2.8 *Access Openings*—Access openings shall be provided, as required, to all equipment or items that require testing, servicing, calibrating, adjusting, removing, replacing, or repairing. Access openings shall be large enough to accommodate hands, arms, and tools and also provide full visual access to the task area.

17.2.9 *Dimensions For Arm and Hand Access Openings:*

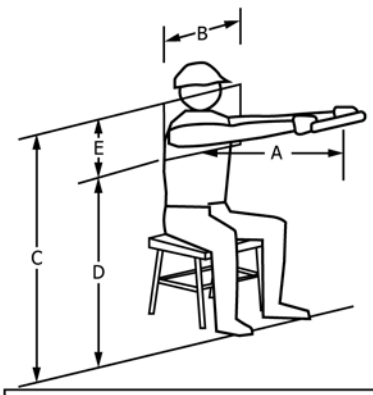
17.2.9.1 The dimensions of access openings for arms and hands shall be no less than those shown in Table 54, "Opening Dimensions for Single Hand Access with Tools," Table 55, "Opening Dimensions for Single Hand Access without Tools," Table 56, "Opening Dimensions for Arm Access without Tools," and Table 57, "Opening Dimensions for Two Hands Access." Allowances shall be made for the clearance of the maintainer's gloved or mittened hand or personal protective equipment, as appropriate.

17.2.9.2 The shape of an access opening shall allow easy passage of equipment, body appendage, or tools. The access opening shape shall permit passage of all equipment that must be replaced through the opening allowing for protrusions, attachments, and handles on the equipment.

17.2.9.3 Access openings shall be large enough to provide full visual access to the task area. Where this is not achievable, an auxiliary viewing port should be provided. Through the use of viewing ports or quick release access, frequent visual inspections shall be able to be done:

TABLE 49 Seated, Forward Reach (Both Arms)

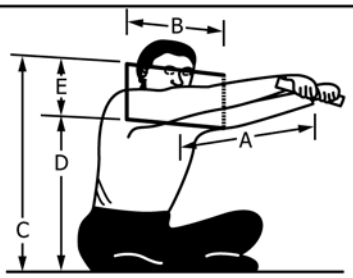
NOTE 1—Dimensions are based on North American males.



	Dimensions mm (in)				
	5th %	25th %	50th %	75th %	95th %
A. Depth of reach	350 **(15.0)**	420 **(16.5)**	450 **(17.8)**	500 **(19.5)**	565 **(22.3)**
B. Breadth of aperture	350 **(13.8)**	390 **(15.3)**	410 **(16.0)**	430 **(17.0)**	465 **(18.3)**
C. Floor to top of aperture	1016 **(40)**	1060 **(41.8)**	1090 **(43.0)**	1125 **(44.3)**	1180 **(46.5)**
D. Floor to bottom of aperture	870 **(34.3)**	900 **(35.5)**	930 **(36.5)**	950 **(37.5)**	100 **(39.0)**
E. Vertical dimension of aperture	310 **(12.3)**	310 **(12.3)**	310 **(12.3)**	310 **(12.3)**	310 **(12.3)**

TABLE 50 Cross-Legged Seated, Forward Reach (Both Arms)

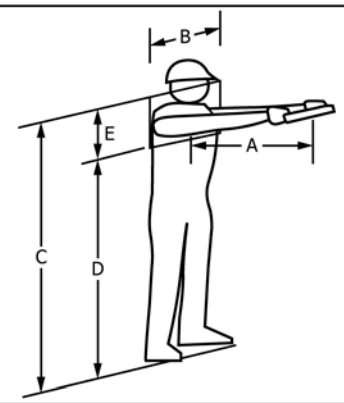
NOTE 1—Dimensions are based on North American males.



	Dimensions mm (in)				
	5th %	25th %	50th %	75th %	95th %
A. Depth of reach	350 (13.8)	400 (15.8)	425 (16.8)	460 (18.3)	510 (20.0)
B. Breadth of aperture	350 (13.8)	370 (14.8)	410 (16.0)	425 (16.8)	450 (17.8)
C. Floor to top of aperture	580 (22.8)	620 (24.3)	640 (25.3)	670 (26.3)	710 (28.0)
D. Floor to bottom of aperture	430 (17.0)	470 (18.5)	490 (19.3)	510 (20.0)	540 (21.3)
E. Vertical dimension of aperture	280 (11.0)	280 (11.0)	280 (11.0)	280 (11.0)	280 (11.0)

TABLE 51 Standing, Forward Reach (Both Arms)

NOTE 1—Dimensions are based on North American males.



	Dimensions mm (in)				
	5th %	25th %	50th %	75th %	95th %
A. Depth of reach	490 (19.25)	535 (21.0)	565 (22.25)	580 (22.75)	620 (24.50)
B. Breadth of aperture	395 (15.50)	430 (17.0)	450 (17.75)	470 (18.50)	495 (19.50)
C. Floor to top of aperture	1550 (61.0)	1610 (63.50)	1660 (65.25)	1690 (66.50)	1750 (69.0)
D. Floor to bottom of aperture	1380 (52.25)	1390 (54.75)	1420 (56.0)	1455 (57.25)	1500 (59.0)
E. Vertical dimension of aperture	425 (16.75)	425 (16.75)	425 (16.75)	425 (16.75)	425 (16.75)

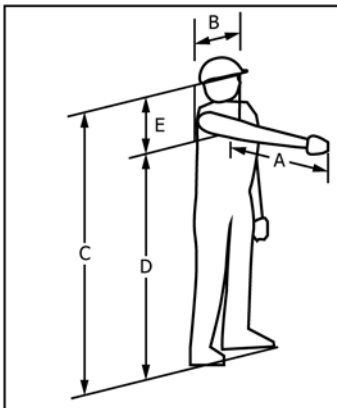
(1) From a normal position without required use of ladders, platforms, or other temporary standing surfaces,

(2) In neutral postures,

(3) With low forces, and

TABLE 52 Standing, Forward Reach (Preferred Arm)

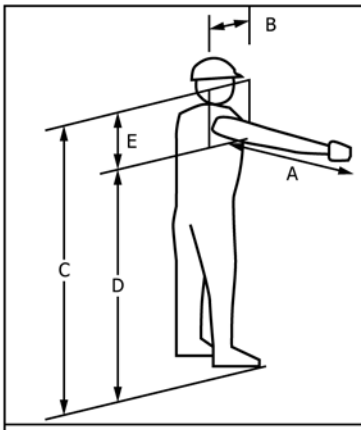
NOTE 1—Dimensions are based on North American males.



	Dimensions mm (in)				
	5th %	25th %	50th %	75th %	95th %
A. Depth of reach	515 (20.3)	565 (22.3)	605 (23.8)	635 (25.0)	680 (26.8)
B. Breadth of aperture	305 (12.0)	305 (12.0)	305 (12.0)	305 (12.0)	305 (12.0)
C. Floor to top of aperture	1550 (61.0)	1605 (63.3)	1650 (65.0)	1680 (66.3)	1750 (69.0)
D. Floor to bottom of aperture	1330 (52.3)	1390 (54.8)	1420 (56.0)	1455 (57.3)	1500 (59.0)
E. Vertical dimension of aperture	425 (16.8)	425 (16.8)	425 (16.8)	425 (16.8)	425 (16.8)

TABLE 53 Standing, Lateral Reach (Preferred Arm)

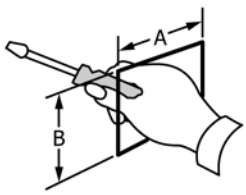
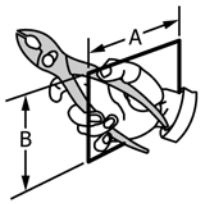
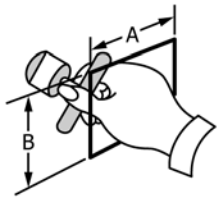
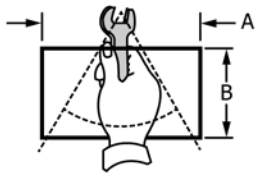
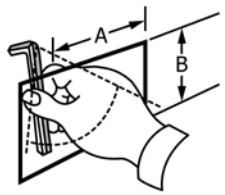
NOTE 1—Dimensions are based on North American males.



	Dimensions mm (in)				
	5th %	25th %	50th %	75th %	95th %
A. Depth of reach	560 (22.0)	597 (23.5)	630 (24.8)	655 (25.8)	680 (26.8)
B. Breadth of aperture	255 (10.0)	255 (10.0)	255 (10.0)	255 (10.0)	255 (10.0)
C. Floor to top of aperture	1545 (60.8)	1605 (63.3)	1630 (64.3)	1675 (66.0)	1745 (68.8)
D. Floor to bottom of aperture	1325 (52.3)	1390 (54.8)	1425 (56.0)	1455 (57.3)	1500 (59.0)
E. Vertical dimension of aperture	420 (16.5)	420 (16.5)	420 (16.5)	420 (16.5)	420 (16.5)

TABLE 54 Opening Dimensions for Single-Hand Access with Tools

NOTE 1—Dimensions are based on North American males. However, they are appropriate for all maritime populations worldwide with the possible exception for Northern Europeans where 25 mm (1 in.) should be added to both the horizontal and vertical dimensions.

Description of Opening		Minimum Dimensions mm (in)		Task Description
		A	B	
	Bare Hand	108 **(4.3)**	120 **(4.8)**	Using common screwdriver, test probe etc., with freedom to turn hand through 180°
	Gloved	165 **(6.5)**	178 **(7.0)**	
	Arctic Mitt	197 **(7.8)**	205 **(8.0)**	
	Bare Hand	127 **(5.0)**	115 **(4.5)**	Using pliers and similar tools
	Gloved	185 **(7.3)**	197 **(7.8)**	
	Arctic Mitt	216 **(8.5)**	171 **(6.8)**	
	Bare Hand	133 **(5.3)**	152 **(6.0)**	Using "T" handle wrench, with freedom to turn hand through 180°
	Gloved	191 **(7.5)**	210 **(8.3)**	
	Arctic Mitt	222 **(8.3)**	235 **(9.3)**	
	Bare Hand	267 **(10.5)**	205 **(8.0)**	Using open-end wrench, with freedom to turn wrench through 60°
	Gloved	318 **(12.5)**	260 **(10.3)**	
	Arctic Mitt	349 **(13.8)**	286 **(11.3)**	
	Bare Hand	121 **(4.8)**	152 **(6.0)**	Using Allen-type wrench, with freedom to turn wrench through 60°
	Gloved	178 **(7.0)**	197 **(7.8)**	
	Arctic Mitt	210 **(8.3)**	229 **(9.0)**	

(4) With minimum use of tools.

17.3 *Maintenance Environments:*

17.3.1 *Heat Limits*—When monitoring, servicing, repair, or other similar maintenance tasks to be performed in areas in which the temperature will exceed 29.5°C (85°F), air conditioning shall be provided.

17.3.2 *Cold Limits:*

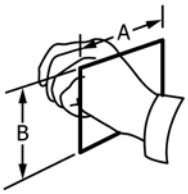
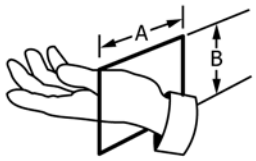
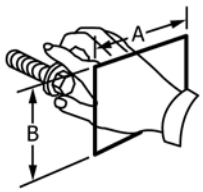
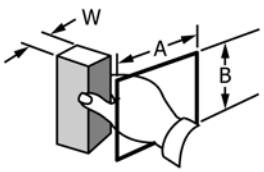
17.3.2.1 When monitoring, servicing, repair, or other similar maintenance tasks to be performed in areas in which the temperature will drop below 18°C (65°F), air heating shall be provided if the maintenance tasks are conducted in a shirt-sleeve environment.

17.3.2.2 If maintenance tasks are conducted in an outdoor or refrigerated environment, personal discomfort increases rapidly as the temperature drops below –12°C (10°F). When workers are properly dressed, they can perform between 0 and –18°C (32 and 0°F) for 30 min without interference from cold itself. Below –18°C (0°F), the decrement in human performance rapidly increases.

17.3.3 *Design for Cold Weather*—The following features shall be included in equipment design when the equipment can be expected to require maintenance in temperatures below 0°C (32°F):

TABLE 55 Opening Dimensions for Single-Hand Access Without Tools

NOTE 1—Dimensions are based on North American males but are appropriate for all maritime populations worldwide except possibly for the Northern Europeans where 25 mm (1 in.) should be added to both the horizontal (A) and vertical (B) dimensions.

Description of Opening		Minimum Dimensions mm (in)		Task Description
		A	B	
	Bare Hand	127 **(5.0)**	95 **(3.75)**	Empty hand Clinched fist extended to wrist
	Gloved	152 **(6.0)**	115 **(4.5)**	
	Arctic Mitts	215 **(8.5)**	178 **(7.0)**	
	Bare Hand	102 **(4.0)**	57 **(2.25)**	Empty hand Hand flat extended to wrist
	Gloved	152 **(6.0)**	102 **(4.0)**	
	Arctic Mitts	165 **(6.5)**	127 **(5.0)**	
	Bare Hand	114 **(4.5)**	121 **(4.8)**	Grasping small objects (up to 50 mm (2 in) or more wide) with one hand
	Gloved	171 **(6.8)**	178 **(7.0)**	
	Arctic Mitts	205 **(8.0)**	210 **(8.3)**	
	Bare Hand	W+45 **(W+1.8)**	127 **(5.0**)**	Grasping large objects, 50 mm (2 in) or more wide with one hand
	Gloved	W+102 **(W+4.0)**	178 **(7.0**)**	
	Arctic Mitts	W+159 **(W+6.3)**	222 **(8.8**)**	

** Or sufficient to clear part if part is larger than 127 mm (5 in).

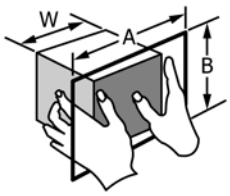
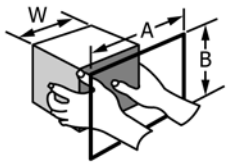
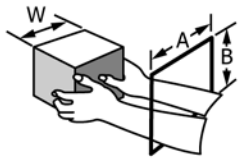
TABLE 56 Opening Dimensions for Arm Access Without Tools

NOTE 1—Dimensions are based on North American males but these are appropriate for maritime populations worldwide except for possibly the Northern Europeans where 50 mm (2 in.) should be added to the above dimensions.

Description of Clothing Type		Minimum Dimensions mm (in)	Dimension Description
	Light Clothing	102 mm (4.0 in) x 114 mm (4.5 in) or 114 mm (4.5 in) diameter	Arm to Elbow
	Arctic Clothing	178 mm (7.0 in) square or diameter	
	Light Clothing	152 mm (6.0 in) square or diameter	Arm to Shoulder
	Arctic Clothing	216 mm (8.5 in) square or diameter	

TABLE 57 Opening Dimensions for Two-Hand Access

NOTE 1—Dimensions are based on North American males but are appropriate for maritime populations worldwide except that 25 mm (1 in.) should be added to the horizontal width (A) for Northern European populations.

Description of Opening		Minimum Dimensions mm (in)		Task Description
		A	B	
	Bare Hand	W+76 **(W+3.0)**	127 **(5.0**)**	Grasping large objects with two Hands, with Hand extended through openings up to fingers
	Gloved	W+133 **(W+5.3)**	178 **(7.0**)**	
	Arctic Mitt	W+191 **(W+7.5)**	222 **(8.8**)**	
	Bare Hand	W+152 **(W+6.0)**	127 **(5.0**)**	Grasping large objects with two Hands, with arms extended through openings up to wrists
	Gloved	W+279 **(W+11.0)**	178 **(7.0**)**	
	Arctic Mitt	W+356 **(W+14.0)**	222 **(8.8**)**	
	Bare Hand	W+152 **(W+6.0)**	127 **(5.0**)**	Grasping large objects with two Hands, with arms extended through openings up to elbows
	Gloved	W+279 **(W+11.0)**	178 **(7.0**)**	
	Arctic Mitt	W+356 **(W+14.0)**	222 **(8.8**)**	

** Or sufficient to clear part if part is larger than 125 mm (5 in).

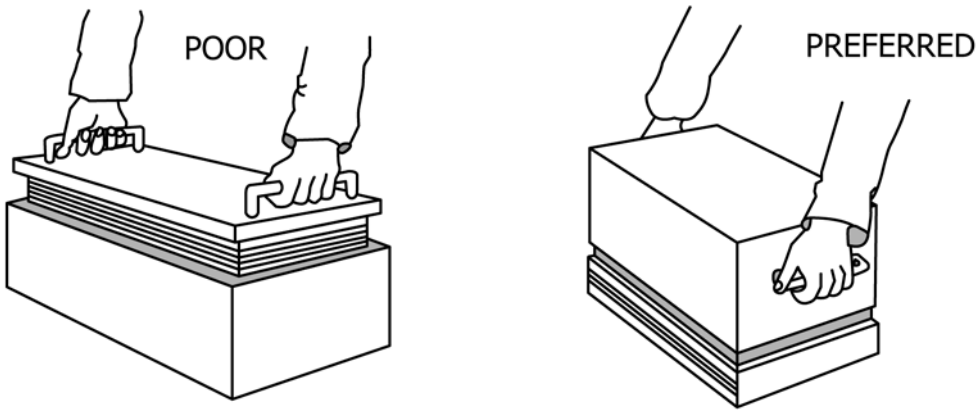


FIG. 163 Case Orientation

17.3.3.1 Provide for drying of equipment which is to be returned to out-of-door cold weather after shop maintenance has been performed.

17.3.3.2 Winterization equipment, such as pre-heaters, shall be positioned where they do not interfere with maintainer accessibility to perform maintenance tasks.

17.3.3.3 Locate access doors and panels so the effects of rain, snow, and formation of ice do not limit use of the doors and panels.

17.3.3.4 Provide work space access openings to accommodate personnel wearing cold weather clothing.

17.3.3.5 Provide drains that can be accessed and operated by personnel wearing cold weather clothing to drain liquids as required.

17.4 *Lubrication:*

17.4.1 *General*—Configuration of equipment containing mechanical items requiring lubrication shall permit both lubrication and checking of lubricant levels without disassembly. Extending fittings that are not directly accessible (for example, around steering gear stocks and around inside vertical package conveyor trunks) by means of tubing to a location where they

are directly accessible should not be used. Permanently lubricated items for which lubricant lasts for the life of the items are excluded from requiring access for lubrication.

17.4.2 *Lubricant Chart*—Where equipment has more than one type of fitting and uses more than one type of lubricant, the types of lubricants to be used and the frequency of lubrication shall be identified by means of a lubrication chart. The chart shall be of a permanent construction and mounted at or near the lube port or at the operator station of the equipment. The chart shall be prepared in accordance with the requirements of Section 15.

17.4.3 *Labeling:*

17.4.3.1 All lubrication storage or service tanks shall be labeled in accordance with the requirements of Section 15, "Labeling." Each label shall identify the type of lubricant and the capacity of the tank and shall be seen from the filling position.

17.4.3.2 If a lubrication chart is prepared, each fitting shall be labeled to match the chart identification name or number and the label placed immediately adjacent to the fitting.

17.4.4 *Prevention of Incorrectly Filling Lube Tank*—Where incorrect filling of a lubrication tank is possible (for example, a lube oil tank could mistakenly be filled with fuel oil), the tanks shall be designed in such a manner as to make it physically impossible for a person to put the wrong material in the wrong tank.

17.4.5 *Oil Drains*—Oil drains, when not permanently piped, shall be provided with a temporary hose attachment for gravity draining into small containers.

17.4.6 *Oil Sumps*—Oil sumps with a volume greater than 19 L (5 gal) should be equipped with either a facility for vacuum removal of the oil or a fixed pump out system with an auxiliary oil pump and pipelines to a storage/disposal tank.

17.5 *Cases:*

17.5.1 *General:*

17.5.1.1 Equipment shall be protected from damage when cases are removed or replaced. Cases shall not require manual support to remain in the open position during maintenance.

17.5.1.2 All portions of the equipment that are related to the maintenance task shall be accessible with the case open or removed. The open case shall not obscure or interfere with any controls, displays, test points, service points, or connections needed for the maintenance task. If the case is heavy or difficult to open, remove, or replace, then appropriate handles, grasping areas, lifting pad-eyes, or other lifting aids shall be provided. Handles mounted on cases either for lifting cases or transporting shall be designed in accordance with criteria in Section 16.

17.5.2 *Orientation*—Cases shall be designed to be lifted from items rather than items lifted from cases as shown in Fig. 163, "Case Orientation" so that they can be opened, removed, and replaced easily and without dismantling the equipment. The proper orientation of an item within its case shall be obvious, either through design of the case or by means of appropriate labels.

17.5.3 *Size*—Cases shall be sufficiently larger than the items they cover to minimize the possibility of damaging wires or other parts when the cases are put on or taken off.

17.5.4 *Guides*—Guides, tracks, and stops shall be provided as necessary to help align the case to prevent damage to equipment or injury to personnel.

17.5.5 *Transport*—Cases shall be removable and transportable by one hand, by one person, or by two persons, in that order of preference, in accordance with lifting and carrying limits defined in Section 16, "Material Handling." Handles, in accordance with Section 16, "Material Handling," shall be provided if the case is heavy, difficult to open, or difficult to handle.

17.6 *Covers:*

17.6.1 *General:*

17.6.1.1 An opening with no cover is preferred. If lack of a cover is likely to result in degraded system performance, safety concern, contamination, or insertion of foreign materials into equipment, a cover should be provided.

17.6.1.2 Covers shall be designed so it is clear how they open based on physical aspects or by providing instructions on or near the cover. Covers and their fasteners shall be designed and mounted so it is obvious whether or not they are fastened when they are in place. If the cover is removable, the cover shall be designed to prevent reattachment in any orientation except the correct one. When maintenance is required, the cover in the open position shall not obstruct or interfere with any part of the maintenance task. Fig. 164, "Access Opening Covers," provides examples of covers in order of design preference.

17.6.1.3 Bulkheads, brackets, and other equipment shall not obstruct visual or physical access for removal or opening of covers on equipment within which work must be performed in the installed condition. Covers, doors, or panels that must be opened to perform on-site maintenance shall be visually and physically accessible to the maintainers.

17.6.2 *Opening Instructions*—If the method of opening a cover is not obvious from the construction of the cover itself, instructions shall be permanently displayed on the outside of the cover. Instructions shall consist of simple symbols such as arrows or simple words such as "push" or "push and turn."

17.6.3 *Labeling*—Each access cover shall be labeled with nomenclature for items visible or accessible through it, nomenclature for auxiliary equipment to be used with it, and recommended procedures for accomplishing operations. Accesses shall be labeled with hazard signs advising of any hazards existing beyond the access. If instructions applying to a covered item are lettered on a hinged door, the lettering shall be properly oriented to be read when the door is open. Hazard notices shall be prepared in accordance with Section 15.

17.6.4 *Access Cover Attachments*—Covers shall be attached with the fewest number of simplest-to-operate fasteners. Fasteners shall be operable by hand or by common hand tools in that order of preference.

17.6.5 *Operational Design Requirements:*

17.6.5.1 Access covers shall be equipped with grasp areas or other means for opening them. Where operations will require opening and closing the covers while wearing gloves or special clothing, opening provision shall accommodate the gloves or special clothing.

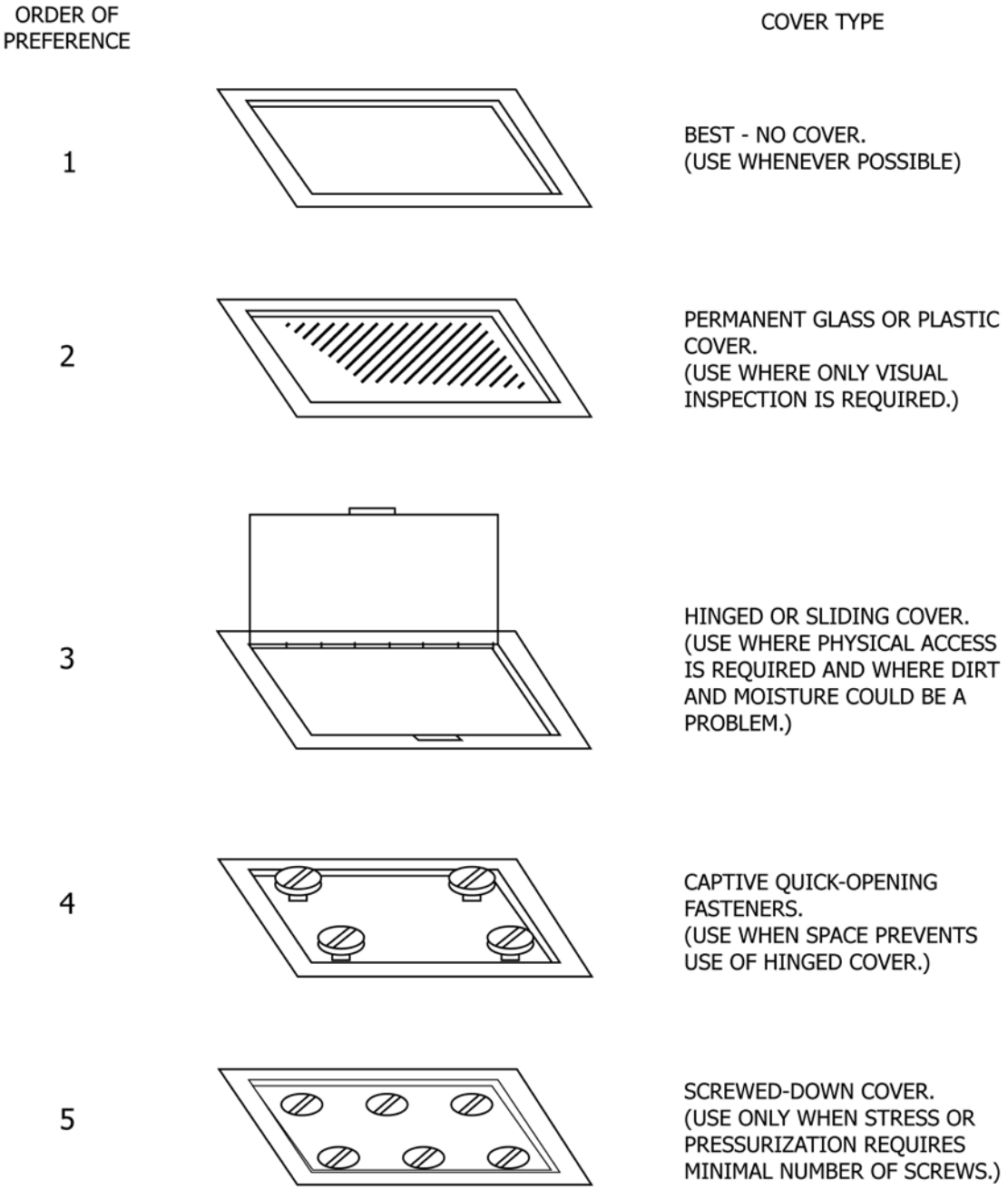


FIG. 164 Access Opening Covers

17.6.5.2 If a hazardous condition exists behind the access, for example, exposed conductors energized with dangerous voltages, the physical barrier over the access shall be equipped with an interlock that will de-energize the hazardous equipment when the barrier is opened or removed. Additional design criteria include:

(1) When hinged covers are adjacent, they shall open in the opposite directions.

(2) Use stops or retainers to keep covers from swinging into adjacent controls or fragile components, and so they will not spring their hinges.

(3) Design hinged caps over service or test points so they will not interfere with inserting or attaching service or test equipment.

17.7 *Fasteners:*

17.7.1 *General*—The number and diversity of fasteners used shall be minimized. Finger or hand-operated fasteners shall be used, except where screws with heads flush with the case or fastening surface are required for NBC survivability. Fasteners requiring nonstandard tools shall not be used. Fasteners used on items requiring use by NBC-suited personnel shall be quick acting, with no sharp edges or protrusions that could puncture or tear the NBC suit.

17.7.2 *Captive Fasteners*—Captive fasteners shall be used where dropping or loss of such items could cause damage to equipment or create a difficult or hazardous removal problem. Captive fasteners shall also be provided for access covers requiring frequent removal.

17.7.3 *Fastener Head Type*—Following are three types of fasteners:

17.7.3.1 *High-Torque Fasteners*—External hex or external double-hex wrenching elements shall be provided on all machine screws, bolts, or other fasteners requiring more than 14 N·m (10 ft·lb) of torque. When external wrenching fasteners cannot meet the mechanical function or personnel safety requirements, or in limited access situations, and where use is protected from accumulation of foreign material, internal wrenching fasteners may be used.

17.7.3.2 *Low-Torque Fasteners*—Hex-type internal grip head, hex-type external grip head, or combination head (hex or straight-slot internal grip and hex-type external-grip head), or torque-set fasteners shall be provided where less than 14 N·m (10 ft·lb) torque is required; however, internal-grip head fasteners shall be provided only where a straight or convex smooth surface is required for mechanical function or for personnel safety and where use is protected from accumulation of foreign material (such as ice or snow).

17.7.3.3 *Straight-slot or Phillips-type*—Internal grip fasteners of the straight – slot or Phillips type shall not be provided except as wood fasteners or where these type fasteners are provided on standard commercial items.

17.7.4 *Common Fasteners*—Identical screw and bolt heads shall be provided to allow various panels and components to be removed with one type of tool. Combination bolt heads such as the slotted hex head shall be selected whenever feasible.

17.7.5 *Number of Turns*—Fasteners for mounting assemblies and subassemblies shall require only one complete turn, provided that stress, alignment, positioning, and load considerations are not compromised.

17.7.6 *Type of Fasteners*—The type of fasteners (in order of preference) that shall be used are:

17.7.6.1 *Quick Connect-Disconnect Devices*—These devices are fast and easy to use, do not require tools, may be operated with one hand, and are very good for securing plug-in components, small components, and covers. These shall be used when components must be dismantled or removed frequently, they must fasten and release easily, without requiring tools, they shall fasten or unfasten with a single motion of the hand, and it shall be obvious when they are not correctly engaged.

17.7.6.2 *Latches and Catches*—These items are very fast and easy to use, do not require tools, and have good holding power; especially good for large units, panels, covers, and cases. Use long-latch catches to minimize inadvertent releasing of the latch, and spring-load catches so they lock on contact, rather than requiring positive locking. If the latch has a handle, locate the latch release on or near the handle so it can be operated with one hand.

17.7.6.3 *Captive Fasteners*—Captive fasteners are slower and more difficult to use, depending upon type, and usually require using common hand tools; but they stay in place. Use captive fasteners when lost screws, bolts, or nuts might cause a malfunction or excessive maintenance time. Use captive fasteners that can be operated by hand or with a common hand tool and that can be replaced easily if they are damaged.

17.7.6.4 *Regular Screws*—Square-head screws are preferable to round or flat ones. Slotted screw heads shall have deep slots that will resist damage. Use screws only when personnel can use screwdrivers in a straight-in fashion; do not require personnel to use offset screwdrivers.

17.7.6.5 *Bolts and Nuts*—Keep bolts as short as possible, use coarse threads instead of fine threads, avoid left-hand threads unless system requirements demand them, and use wing nuts (preferably) or knurled nuts for low-torque applications.

17.8 *Hatches, Manways, and Lightening Holes for Maintenance Access:*

17.8.1 *Size and Shape*—Round, square, rectangular, or oval hatches, manways, and lightening holes used for access into fuel, oil or water ballast tanks, voids, cofferdams, HVAC ducting, air plenums, sea chest compartments, interbottom spaces, or other enclosed spaces for the purpose of construction, maintenance, cleaning, inspection, or repair shall be sized as shown in 11.14.

17.9 *Diagnostics and Troubleshooting:*

17.9.1 *Equipment Design*—All equipment and systems shall be designed to facilitate diagnostics and troubleshooting through inclusion of the following in the design:

17.9.1.1 Rapid and positive fault detection and isolation of defective items shall be provided to permit their prompt removal and replacement.

17.9.1.2 Equipment shall have automatic fault detection and isolation capability.

17.9.1.3 Components performing similar functions shall be physically close to one another.

17.9.1.4 Components shall provide easily identifiable physical evidence of their status (for example, a blown fuse).

17.9.1.5 Replacement parts should be tested prior to installation.

17.9.1.6 Self-test fault and error messages shall be provided to:

(1) Standardize error messages.

(2) Provide accurate, up-to-date, reliable, and understandable error messages.

(3) Scale fault messages to meet the range of experience and skill levels of troubleshooters.

(4) Failure messages should identify the origin of the failure.

17.10 *Equipment Modularization:*

17.10.1 *Equipment Design*—Equipment and components should be designed into specifically defined units to aid in troubleshooting and replacement. Equipment should be replaceable as modular packages and should be configured for removal and replacement by one person, within structural, functional, and weight limitations provided in Section 16.

17.11 *Equipment Mounting and Installation:*

17.11.1 *General*—Equipment shall be designed so that it is physically impossible to insert a wrong item or so it cannot be mounted or installed improperly. Coding by such means as color, labels, or keys shall identify the correct item and its proper orientation for mounting or installation.

17.11.2 *Tools*—Field-removable items shall be replaceable by use of nothing more than common hand tools.

17.11.3 *Roll Out Racks, Slides or Hinges*—Items that are frequently pulled out of their installed positions for checking shall be mounted on roll out racks, slides or hinges. Roll out racks shall not shift the center of gravity to the extent that the entire rack or console falls. If this possibility exists, the console or rack shall be safely secured. The rollout racks shall operate with a force less than 17.8 N (4 lb).

17.11.4 *Limit Stops*—Limit stops shall be provided on racks and drawers which are required to be pulled out of their installed positions for checking or maintenance. The limit stop design shall permit convenient overriding of stops for unit removal.

17.11.5 *Interlocks*—Interlocks shall be provided to ensure disconnection of equipment that would otherwise be damaged by withdrawal of racks or drawers.

17.11.6 *Hinged Items Support*—Hinged items shall be provided with a brace or other means of support to hold equipment in the "out" position for checking, testing, maintenance, repair and replacement.

17.11.7 *Rear Access*—Sliding, rotating, or hinged equipment to which rear access is required shall be free to open or rotate their full distance and remain in the open position without being supported by hand. If access panels are provided do not require opening more than one to remove any single unit and keep all panel removals to a minimum.

17.11.8 *Layout*—Units shall be laid out so that a minimum of place-to-place movements will be required during checkout. Keep removable components under 13.6 kg (30 lb), preferred, 20.5 kg (45 lb) maximum. Position the heavier components so they are the easiest to reach and place the heavier units so they can be slid out rather than lifted out. Difficult to reach items shall weigh less than 11.3 kg (25 lb), and the items over 20.5-kg (45-lb) items shall be placed for two-person handling.

17.11.9 *Alignment Pins*—Alignment pins shall be used to facilitate proper mounting of items (see Fig. 165, "Example of Alignment Pins"). Pins shall be placed in such an arrangement that the two parts can be mated in only one way.

17.12 *Standardization:*

17.12.1 *Design*—Equipment shall be designed to use interchangeable components (for example, using identical valves throughout a piping system), measures (for example, all metric), and processes (for example, standard operating procedures). The following requirements shall be met to provide equipment standardization:

17.12.1.1 If existing design for equipment, modules, components, or parts meets the relevant requirements and the applicable ergonomics criteria in this Practice, the existing design shall be used.

17.12.1.2 Units of equipment should be designed to facilitate the interchangeability of modules, components, and parts.

17.12.1.3 Units of equipment or modules that are similar in size and shape to other items but different from them in functional purpose shall be identifiable and distinguishable. In addition, they shall not be physically interchangeable (for example, different connector types for breathing air versus nitrogen).

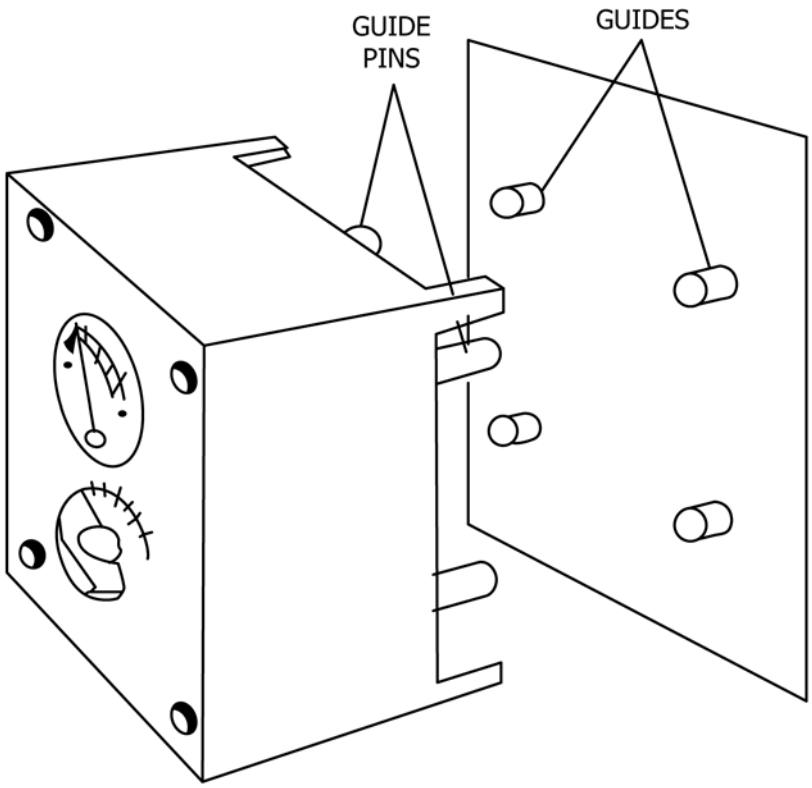


FIG. 165 Example of Alignment Pins

17.12.1.4 Equipment shall be designed to minimize the numbers and types of auxiliary equipment and tools required to accomplish maintenance tasks.

17.12.1.5 Uncommon or specially designed tools shall be used only when common hand tools do not satisfy the requirements or when the special tools provide a significant advantage over common hand tools.

17.13 *Electrical Wires and Cables:*

17.13.1 *Routing*—Cables should be routed over, rather than under pipes or fluid containers. Route cables so that they are not pinched by doors, lids, and slides; are not walked on or used for handholds; are accessible to the technician; are not under deck grating or behind panels or components that are difficult to remove, or routed through congested areas; and need not be bent or unbent sharply when connected or disconnected (see Fig. 166).

17.13.2 *Labeling*—Each cable or wire shall be labeled or coded throughout its entire length. Labels installed at a bench preparatory site shall be placed so they will be visible and in the proper orientation to the reader, once the wire or cable is installed. Cables shall be labeled with the name of the equipment to which they belong and the connectors to which they mate. Number codes shall be repeated over the entire length of the cable.

17.13.3 *Leads*—Enough slack shall be provided so terminal fittings can be replaced at least twice and preferably three times.

17.13.4 *Junction Box Arrangement*—Cables shall fan out in junction boxes for easy checking, (see Fig. 167, "Suggested Cable Arrangement in a Junction Box"). Each terminal in the junction box shall be clearly labeled and easy to reach with test probes.

17.13.5 *Junction Box Location:*

17.13.5.1 Junction boxes that contain many wires (for example, IC junction boxes) which will require continued access after installation should not be located under false decks or below deck grating, or in a location higher than the maximum height allowed for controls of standing operators as defined in Section 5.

17.13.5.2 Junction Boxes shall be located such that they do not obstruct access to items of equipment or machinery parts. Nor shall they be obstructed by items of equipment or machinery parts.

17.13.6 *Preformed Cables*—Preformed cables shall be used when possible.

17.13.7 *Location of Test Points:*

17.13.7.1 *Adjustment*—Test points used in adjusting a unit shall be located close to the controls and displays for that unit.

17.13.7.2 *Troubleshooting*—Sufficient test points shall be provided so that it will not be necessary to remove subassemblies from assemblies to accomplish troubleshooting.

17.13.7.3 *Location*—Test points and their associated labels and controls shall be located so they face the user in their test position.

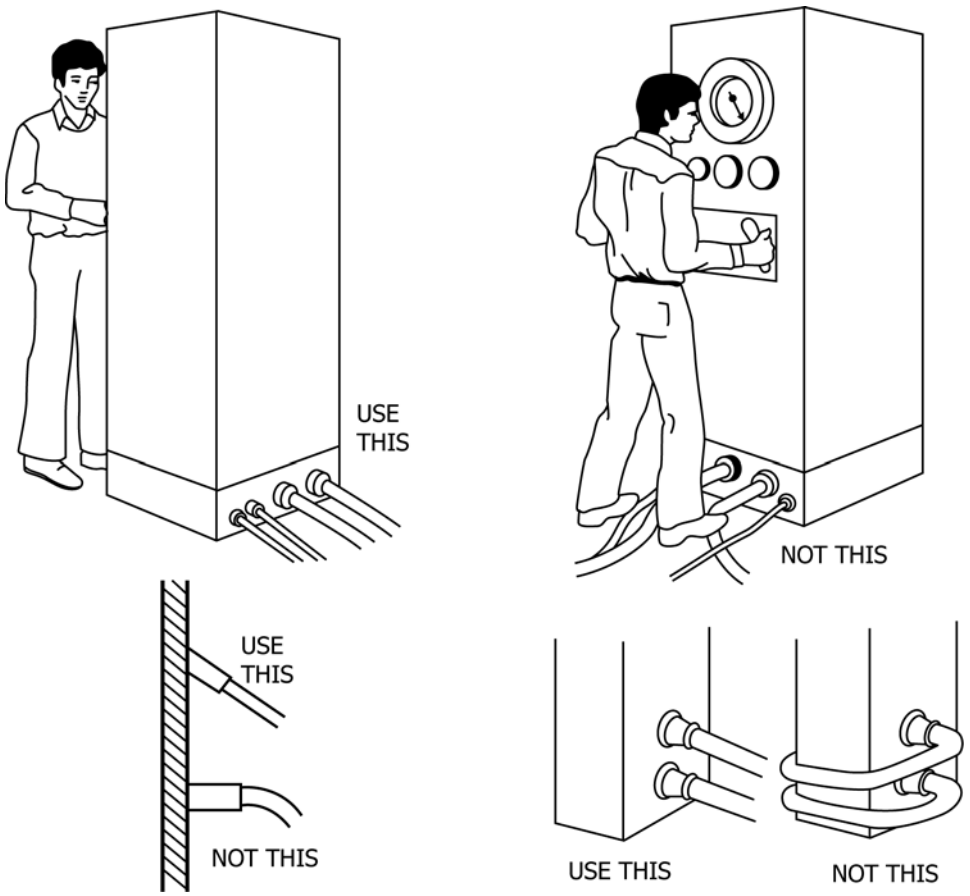


FIG. 166 Cable Arrangements

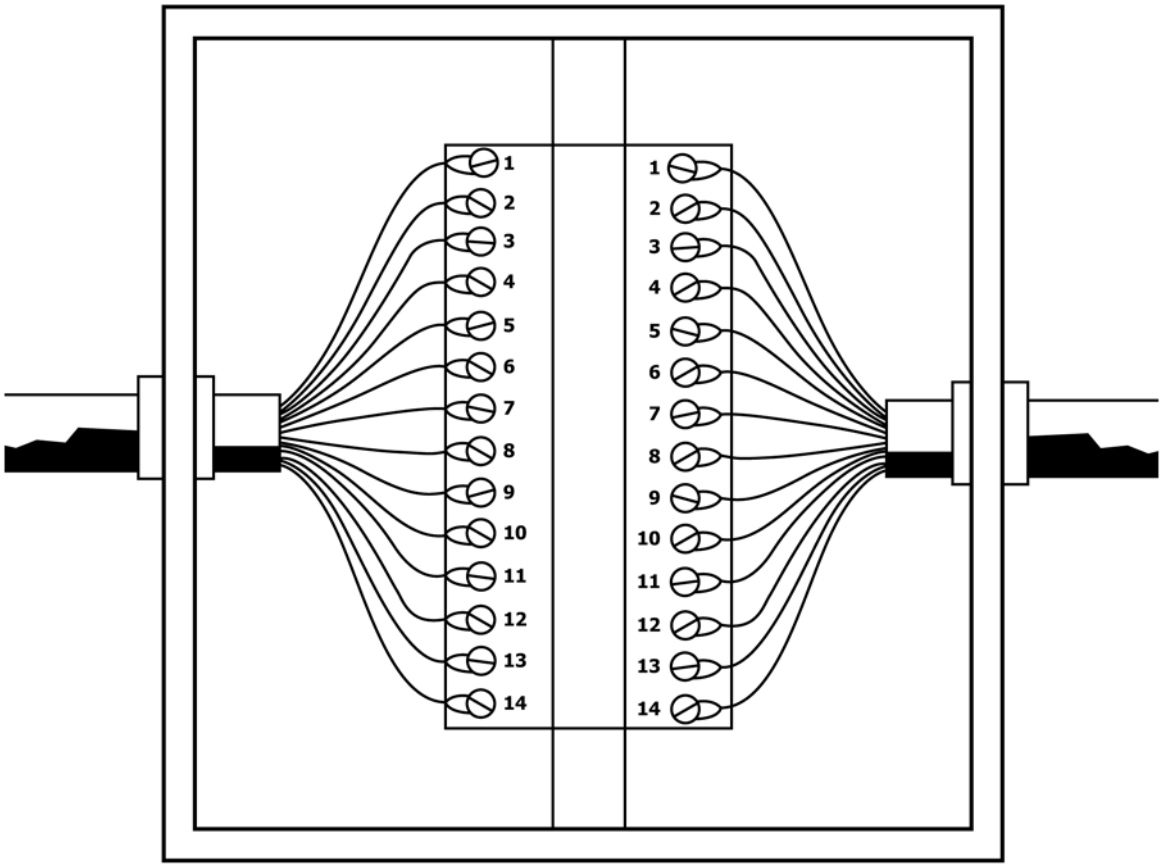


FIG. 167 Suggested Cable Arrangement in a Junction Box

17.13.8 *Design of Test Points*—Test points shall be designed as follows:

17.13.8.1 So that there will be a minimum of disassembly or removal of other equipment or items.

17.13.8.2 On surfaces on or behind accesses that may be easily reached or operated when the equipment is fully assembled and installed.

17.13.8.3 So that adequate clearance is provided between connectors, probes, and controls for easy grasping and manipulation. The following minimum design dimensions shall be provided:

(1) When only finger control is required, 19 mm (0.75 in.).

(2) When the gloved hand must be used, 76 mm (3 in.).

17.13.8.4 The following minimum design requirements shall be provided:

(1) Guards and shields to protect personnel and test or service equipment, particularly if the equipment must be serviced while operating.

(2) Avoid locating a single test or service point in an isolated position which would make it more likely to be overlooked or neglected.

(3) Windows to internal items requiring frequent visual inspections, such as gauges and indicators.

(4) Tool guides and other design features to facilitate operation of test or service points that require blind operation.

(5) Place test points within arm's reach or seeing distance to their related or corresponding controls, displays, fittings, and switches.

(6) Place test points away from dangerous electrical, mechanical, or other hazards. A hand's-width separation of 114 mm (4.5 in.) shall be provided from the nearest hazard, along with guards and shields, to prevent injury.

(7) Where adjustment controls are associated with test and service points, they shall be designed and positioned so that:

(a) They are capable of being quickly returned to the original settings.

(b) Adjustments are independent of each other.

(c) Those that require sequential adjustment are located in the proper sequence and marked to designate the order of adjustment.

(d) Knobs are used in preference to screwdriver adjustments except where inadvertent or unauthorized adjustments want to be avoided. In those cases, a screwdriver adjustment is preferred.

17.14 *Conductors:*

17.14.1 *Coding*—Cables containing individually insulated conductors with a common sheath shall be coded.

17.14.2 *Length*—Cables shall be long enough so that each functional unit can be checked in a convenient place. Extension cables shall be provided where this is not feasible.

17.14.3 *Cable Routing*—Cable routing shall not obstruct visual or physical access to equipment for operation or maintenance.

17.14.4 *Location*—The test cables shall terminate on control and display panels and the test receptacles shall be so located that the test cables will not interfere with controls and displays.

17.14.5 *Access*—Cables shall be routed so as to be directly accessible for inspection and repair.

17.14.6 *Susceptibility to Damage*—Cables shall be routed or protected in such a way that they may not be pinched by doors, lids, being walked on, used for handholds, or bent or twisted sharply or repeatedly during construction or maintenance, repair, or replacement.

17.14.7 *Identification*—Cables shall be labeled to indicate the equipment to which they belong and the connectors with which they mate. All replaceable wires and cables shall be uniquely identified with distinct color or number codes. Color-coded wires shall be color coded over their entire length. Number codes shall be repeated every 508 mm (20 in.) over the wire's entire length.

17.14.8 *Cable Protection*—If it is necessary to route cables and wires through holes in metal partitions, the conductors shall be protected from mechanical damage or wear by grommets or equivalent means. Where required for NBC survivability, cables shall be wrapped and sealed.

17.14.9 *Aligning Pins*—Aligning pins shall extend beyond the plug's electrical pins to ensure that alignment is obtained before the electrical pins engage. All aligning pins for a given plug or series of plugs shall be oriented in the same direction, unless this conflicts with precautions against mismatching.

17.15 *Connectors:*

17.15.1 *Quick-Disconnect Plugs*—Plugs requiring no more than one turn, or other quick-disconnect plugs, shall be provided.

17.15.2 *Keying*—Plugs shall be designed so that it will be impossible to insert a wrong plug in a receptacle or to insert a plug into the correct receptacle the wrong way.

17.15.3 *Identification*—Electrical plugs and receptacles shall be identified by color, shape, labels, or equivalent means. If labels are used, they shall be placed on the connector and receptacle, on plates attached to the connector and receptacle, or on tabs or tapes attached to the connector (in that order of preference).

17.15.4 *Orientation*—Plugs and receptacles shall be arranged so that the aligning pins or equivalent devices are oriented in the same relative position.

17.15.5 *Coding*—Plugs and receptacles shall have durable strips, arrows, or other indications to show the positions of aligning pins or equivalent devices for proper insertion.

17.15.6 *Spacing*—Connectors shall be spaced far enough apart so that they can be grasped firmly for connecting and disconnecting. Space between adjacent connectors, or between a connector and any adjacent obstructions, shall be compatible with the size and shape of the plugs, and the type of clothing worn by the maintainer (for example, cold weather hand-wear, NBC gloves), but shall be not less than 25 mm (1 in.), except where connectors are to be sequentially removed and replaced and 25-mm (1-in.) clearance is provided in a swept area of at least 4.71 rad (270°) around each connector at the start of its removal/replacement sequence. Where high torque is required to tighten or loosen the connector, space shall be provided for use of a connector wrench.

17.15.7 *Testing and Servicing*—The rear of plug connectors shall be accessible for testing and servicing, except where precluded by potting, sealing, or other requirements.

17.15.8 *Drawer Modules*—Drawer modules designed for remove-and-replace maintenance shall be provided with connectors mounted on the back of the drawer and mated with connectors in the cabinet to accomplish electrical interconnection between the drawer, other equipment in the rack, and external connectors. Guide pins or equivalent devices shall be provided to aid in alignment.

17.15.9 *Electronic Modules*—Replacement electronic items (for example, modules and high failure-rate components) should be provided with simple plug-in, rack-and-panel type connectors.

17.15.10 *Disassembly and Adapters*—Disassembly of connectors for reasons of changing pin connections shall be easily performed without special tools. When adapters are required, they shall be capable of being hand-tightened.

17.15.11 *Dust Covers*—If dust covers are required, captive types shall be used.

17.16 *Test Equipment:*

17.16.1 *Storage*—Storage space shall be provided within portable test equipment, its handling case, or lid to contain leads, probes, spares, manuals, and special tools required for operation.

17.16.2 *Operating Instructions*—Operating instructions for portable test equipment shall be provided on the face of the test equipment, in a lid, or in a special compartment. If the equipment requires calibration before each use, the instructions shall contain a reminder of this requirement. Instructions shall be written in a language used by the person that will be performing the tests, and printed large enough to be seen in the lowest light level likely to be encountered while performing the equipment test(s).

17.16.3 *Portable Test Equipment*—Portable test equipment should be designed as follows:

17.16.3.1 Rectangular or square shapes with dimensions to fit standard electrical racks.

17.16.3.2 Stands or casters shall be provided for devices weighing more than 13.6 kg (30 lb).

17.16.3.3 Wheels, casters, or hoist-lifting shall be provided for devices weighing more than 40.8 kg (90 lb).

17.16.3.4 Portable test equipment shall have rounded corners and edges.

17.16.3.5 Hinged, permanently attached covers.

17.16.3.6 The weight and dimensions of portable test equipment shall not exceed those for manual lifting and carrying as defined in Section 16.

17.17 *Fuses and Circuit Breakers:*

17.17.1 *General*—A positive indication should be provided to reveal that a fuse or circuit breaker has opened a circuit.

17.17.2 *Replacement and Resetting*—Fuses shall be accessible for removal and replacement. No other components shall require removal to gain access to fuses. No special tools shall be required for fuse replacement unless required by safety considerations. When resetting of circuit breakers is permissible, and is required for system operation during a mission, the breakers shall be located within reach of crew members in their normal operating posture.

17.17.3 *Markings*—The area of equipment served by the fuse or circuit breaker shall be identified. The current rating of fuses shall be permanently marked adjacent to the fuse holder. In addition, SPARE shall be marked adjacent to each spare fuse holder. Fuse ratings shall be indicated either in whole numbers, common fractions (such as ¼), or whole number and common fractions (such as 2-¼). Labeling of fuses and circuit breakers shall be legible in the anticipated ambient illumination range of the operator's location.

17.17.4 *Circuit Breaker Control*—Toggle bat and legend switch-actuated circuit breakers may be used to control electrical power. Push-pull-type breakers shall not be used as power switches.

17.17.5 *Printed Circuit Boards*—Printed circuit boards shall be designed and mounted for ease of removal and replacement, considering such factors as finger access, gripping aids, and resistance created by the mounting device. Feedback shall be provided to insure that the technician knows when the board is securely connected. Printed circuit boards shall be identified in accordance with MIL-STD-130 and reference designations for parts mounted on the printed circuit board shall be provided in accordance with MIL-HDBK-454. These standards are applicable only to military vessels.

17.17.6 *Circuit Breaker Dimensions and Separation*—Dimensions and separation for toggle bat and legend switch-actuated circuit breakers shall comply with the design criteria shown in Section 5.

17.17.7 *Other Design Considerations*—Fuses, or circuit breakers, shall be provided so that each unit of a system is separately fused and adequately protected from harmful power line variations or transient voltages.

17.17.7.1 Fuses shall be located on the front or side panel of the unit where they can be seen and replaced without removing other parts. Fuses shall not be located inside the equipment.

17.17.7.2 Fuses shall be grouped in a minimum number of central, accessible locations and shall be replaceable by the equipment operator whenever possible, without the use of tools.

17.17.7.3 Cups or caps shall be the quick-disconnect, rather than the screw-in type and they shall be knurled and large enough to be removed easily by hand.

17.17.7.4 Fuse installations shall be designed so that only the cold terminal of the fuse can be touched by personnel.

17.17.7.5 Printed circuit boards shall be designed and mounted for ease of removal and replacement, considering such factors as finger access, gripping aids, and resistance created by the mounting device. Appropriate feedback shall be provided to ensure that the technician knows when the board is securely connected.

17.18 *Hydraulic Systems:*

17.18.1 *Standardize*—Connectors in hydraulic systems shall be of standard design and handled with standard tools. In addition, standardization shall be applied to the greatest degree possible to the following:

17.18.1.1 Valves, cylinders, hose assemblies, couplings, fittings, and filters.

17.18.1.2 Hardware for mounting hydraulic components.

17.18.1.3 Connectors by the content of lines, and that the number of different sizes is held to a minimum. If there is a danger of mismating connectors for adjacent lines carrying different fluids, physically incompatible connectors for the two lines shall be used.

17.18.2 *Identification:*

17.18.2.1 Use color coding for hydraulic lines, valves, and filters at each end of the line. Also provide permanent identification and instruction markings and indicate periodic inspection and drain schedules on them.

17.18.2.2 Inlets, outlets, and connecting lines in hydraulic systems shall be identified at least every 457 mm (18 in.) and at both ends.

17.18.3 *Drain Cocks*—All drain cocks shall be closed when the handle is in the down position. Those with high rate drainage shall be fitted to all air receivers and oil reservoirs.

17.18.4 *Seals:*

17.18.4.1 Seals that are visible externally after they are installed should be used although O-ring seals are permitted. Seals shall not protrude or extrude beyond the coupling. For low-temperature operation, use special low-temperature materials.

17.18.4.2 Couplings that use permanent seals rather than those that must be removed and replaced should be used.

17.18.5 *Pressure Relief/Fluid Capture*—Hydraulic systems shall be designed to provide for safe release of pressurized lines and reservoirs, capture of released (as well as escaped or leaking) fluids and ease of blanking off or safe isolation, or both, of non-pressurized from pressurized systems.

17.18.6 *Other Design Requirements*—Other hydraulic system design requirements shall include the following: (see Fig. 168).

17.18.6.1 Provide mechanical stops for valve handles to prevent the valves from opening because of vibrations.

17.18.6.2 Self-sealing couplings shall be provided on complex hydraulic and pneumatic systems.

17.18.6.3 Consider the use of armor-covered flexible hose for hydraulic lines to facilitate replacement in the field form bulk stock.

17.18.6.4 Design for automatic bleeding of hydraulic systems whenever possible.

17.18.6.5 Incorporate quick-disconnect connectors whenever possible where maintenance needs dictate frequent removal or replacement.

17.19 *Stored Energy Devices:*

17.19.1 *Design Requirements*—Devices that operate under stored energy (for example, springs under compression, shock absorbers operated by pneumatic pressure, pressurized bottles) shall be designed so the energy can be safely released or constrained before any maintenance tasks are performed. The means of release or constraint shall be immediately apparent to

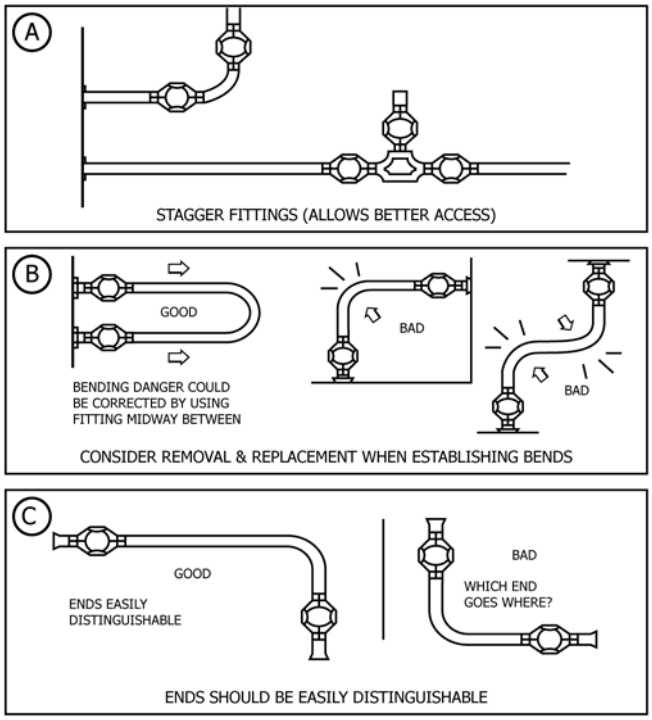


FIG. 168 Fluid Line Connection Recommendations

the maintainer and shall be designed so that the means cannot be inadvertently activated once it has been deactivated.

17.19.2 *Labeling*—All stored energy devices shall be labeled as such and shall have a DANGER hazard warning sign attached to the device. Procedures for releasing or constraining the energy shall be displayed on the unit and provided in accordance with the requirements contained in Section 15.

17.20 *Pipe Flanges, Spools, and Blinds:*

17.20.1 *Location:*

17.20.1.1 Pipe flanges that require frequent disconnection and connection (for example, breakdown joints) should be installed in vertical piping as a first choice at a height ranging between 610 mm (24 in.) and 1372 mm (54 in.).

17.20.1.2 Pneumatic tubing (for example, control air or instrument air) that is secured to the pipe with the breakdown joint shall also have its disconnect at the level of the breakdown flange.

17.20.1.3 Where breakdown joint flanges must be installed in horizontal piping, especially piping located in the overhead, all work should be done from the deck level or an elevated work platform (permanent or temporary).

17.20.2 *Access Around Flanges*—Clearance around pipe flanges shall correspond to those shown in Section 10.

17.20.3 *Spools:*

17.20.3.1 All spools exceeding the manual weight lifting/carrying limits contained in Section 16, "Material Handling" shall be designed and located to be supported or carried, or both, by assisted lifting/carrying devices.

17.20.3.2 Spools shall be designed to allow for complete drainage by gravity and be sectioned in length to allow for removal without interference with other piping, machinery, equipment, structures or wiring.

17.20.4 *Blinds/Spacers*—When manual handling of blinds and spacers will be required, they should be installed in a horizontal orientation, provided that they can be changed by rotation on one of the bolts.

17.21 *Test and Sample Points:*

17.21.1 *Access:*

17.21.1.1 Test and sample points that require regular access (twice a month or more) should be located so as to be accessible from deck level, or have a permanent access by stair. Vertical ladders shall not be used.

17.21.1.2 Test and sample points shall be located so the operator does not have to stand on pipes, cable trays, handrails, other equipment, or any object not meant specifically to be used as a standing surface.

17.21.1.3 If a sample point is located behind a cover, the cover shall be labeled and shall be capable of being opened without requiring any tools or the removal of any securing fasteners or other devices.

17.21.2 *Flexible Hoses*—Use of flexible hoses for retrieval of liquid samples should not be permitted without written approval of the procuring authority.

17.21.3 *Labeling*—All test and sample points shall be identified in accordance with the labeling requirements contained in Section 15, "Labeling." Hazard warning signs shall be posted immediately adjacent to the sample point if the liquid is above 45°C, (110°F), toxic, caustic, or in any manner hazardous to the operator's safety. Locate labels for test and sample points so they face the user in their testing or sampling posture.

17.21.4 *Spillage Containment*—Provisions for containment of spillage shall be provided at each sample point where spillage is possible.

17.21.5 *Lighting*—Lighting levels of at least 215 lux (20 ft-c) should be provided at each test and sample point.

17.21.6 *Separation from Hazards*—All test and sample points shall be at least 305 mm (12 in.) away from dangerous electrical, mechanical or other hazards. If it is impossible to maintain this minimum separation, then all hazards shall be guarded to prevent inadvertent contact by the crewmember.

17.21.7 *Grouping of Test/Sample Points*—Test and sample points shall be grouped in a line or matrix that reflects their sequence of use or their spatial relationship, or both, to the actual locations of the items being tested. Avoid locating a single test or sample point in an isolated position.

17.21.8 *Location*—Test and sample points used for adjusting a unit shall be located adjacent to the related controls and displays.

17.21.9 *Test/Sample Point Inside Enclosure*—If test or sample points are located inside an enclosure, provide a window so the points can be seen from outside the enclosure, or provide a access door and label to identify which points are behind the door.

18. Hazards and Safety

18.1 *Hierarchy of Controls:*

18.1.1 Follow the Hierarchy of Controls to identify hazards and eliminate them where possible. When a hazard cannot be eliminated, the associated risk should be reduced to the lowest

acceptable level by applying the system safety design order of precedence as shown below.

18.1.1.1 Eliminate hazards through design selection.

18.1.1.2 Reduce risk through design alteration.

18.1.1.3 Incorporate engineered features or devices such as guards, barriers or interlocks.

18.1.1.4 Provide warning devices.

18.1.1.5 Incorporate signage, procedures, training, and PPE.

18.1.2 This precedence flows from measures that are most effective to least effective.

18.1.2.1 *Risk Avoidance*—Prevent entry of hazards into a workplace by selecting and incorporating appropriate technology and work methods criteria during the design processes.

18.1.2.2 *Eliminate*—Eliminate workplace and work methods risks that have been discovered.

18.1.2.3 *Engineering Controls*—Incorporate engineering controls/safety devices.

18.1.2.4 *Warning*—Provide warning systems.

18.1.2.5 *Administrative Controls*—Apply administrative controls (the organization of work, training, scheduling, supervision, etc.).

18.1.2.6 *Personal Protective Equipment*—Provide Personal Protective Equipment (PPE).

18.2 *Safety Labels, Signs, and Excluded Area Markings:*

18.2.1 *Hazard Label Design Criteria*—All safety labels and signs shall comply with the requirements contained in Section 15, "Labeling." Every hazard identification label or sign should be written and mounted appropriately to address a specific hazard.

18.2.2 *Center-of-Gravity Marking*—The center of gravity of skids or pieces of equipment, uniquely shaped boxes or packages, or loads in excess 45.5 kg (100 lb) should be distinctly marked and visible to a person responsible for moving the load.

18.2.3 *Weight Lifting/Supporting Capacity*—The weight lifting or supporting capacity of stands, hoists, cranes, jacks, padeyes, rigging, and any other item used to lift, transport or support, equipment during operation or maintenance shall be marked in accordance with the criteria contained in Sections 15 and 16.

18.2.4 *Identification of Protective Areas*—Areas of operation or maintenance where special safety concerns exist such as no smoking during fueling operations, crew working aloft, radioactive chemical material in use for testing purposes, or where special personnel protective equipment (PPE) must be worn shall be specifically identified with the hazard and what one must do to prevent exposure to the hazard. Exclusionary areas where personnel should not enter should be marked on the deck or with barriers preventing personnel from entering the excluded area. Further, the area must be isolated so no unauthorized personnel can enter.

18.2.5 *NO-STEP Marking*—NO-STEP markings shall be placed at locations where personnel would likely step but in so doing could damage equipment or injure themselves. These markings shall be in all capital letters with black characters on a yellow background.

18.2.6 *Electrical Labels*—Electrical receptacles should be marked with their voltage, phase, and frequency characteristics, especially where portable hand tools are used.

18.2.7 *Hand Grasp Areas*—Areas of items capable of being used as a hand grasp by a person during completion of operation or maintenance tasks, or both (for example, piece of pipe, cable tray, or structure), shall be conspicuously and unambiguously marked.

18.2.8 *Pipe, Hose, and Tube Line Identification*—Pipe, hose, and tube lines for gas, steam, liquids, and high-pressure air shall be clearly and unambiguously labeled and or coded as to contents, pressure, heat, cold, or other specific hazards.

18.3 *General Workplace Hazards:*

18.3.1 *Overhead:*

18.3.1.1 Pipe hangers, or any other item mounted in the overhead of passageways, walkways or other dedicated walking areas, shall not protrude below a level, preferably 2134 mm (84 in.) and absolutely 2032 mm (80 in.), above the walking surface.

18.3.1.2 In addition, items (for example, pipe hangers) mounted to bulkheads to support pipe, or wireways, shall be placed only in the areas shown in Fig. 169.

18.3.2 *Storage Racks*—Storage racks located in passageways and secured to bulkheads for gas bottles, casualty cables, firefighting equipment, or other items, shall not impede traffic flow and shall not have securing studs or other sharp objects (for example, corners) protruding into the passageway.

18.3.3 *Cabinet Door Swings*—Hinges for doors on lockers, electrical cabinets, storage bins, equipment lockers, or other spaces shall be located so that a partial or fully opened door will not interfere with personnel or equipment flow or cause injury to personnel moving past these spaces.

18.3.4 *Thermal Temperature*—Equipment which, in normal operations, exposes personnel to surface temperatures greater or less than those shown in Table 58, "Thermal Limits Temperature Limits," shall be guarded to prevent personnel contact with the surfaces. Surface temperatures induced by climatic environment are exempt from this requirement. Cryogenic systems shall also be guarded.

18.4 *General Equipment-Related Hazards:*

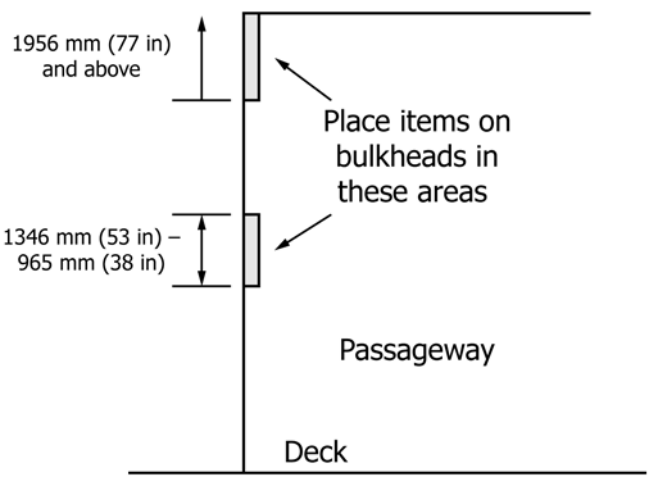


FIG. 169 Areas to Place Items on a Bulkhead

TABLE 58 Thermal Temperature Limits[A]

Exposure Type	Metal °C (°F)		Glass °C (°F)		Plastic or Wood °C (°F)	
	Lower Limit	Upper Limit	Lower Limit	Upper Limit	Lower Limit	Upper Limit
Momentary Contact	0° (32°) and below	60° (140°)[B] or above	0° (32°) and lower	68° (154°) and above	0° (32°) and below	85° (185°) and above
Prolonged Contact or Handling	0° (32°) and below	49° (120°) and above	0° (32°) and below	59° (138°) and above	0° (32°) and below	69° (156°) and above

[A] Hot or cold surfaces in machinery rooms or other locations where a person could fall into or lean on is considered a prolonged contact condition.
[B] Contact with metal surfaces at this temperature can cause severe pain and tissue damage.

18.4.1 *Interlocks and Alarms*—The operation of switches or controls that initiate potentially hazardous operations that could impact personnel in the immediate area of the operation, (for example, initiate movement of an overhead crane carrying a load near deck or floor level that could strike a person not aware of the crane movement) shall activate a visual and auditory alarm in the affected work area.

18.4.2 *Safe Access into Units:*

18.4.2.1 Units shall be so located and mounted that access to, or within them, can be achieved without danger to personnel from electrical charge, heat, moving parts, chemical contamination, radiation, or other hazards.

18.4.2.2 Where access must be achieved into units where the above listed hazards exist, interlocks that deactivate energy sources or moving parts shall be engaged when access door or ports are opened. The access door or cover shall be designed to actuate an internal light when opened, and a visible hazard warning label shall be provided on the outside of the door or cover.

18.4.3 *Edge Rounding*—All exposed edges and corners shall be rounded to a minimum of 0.76 mm (0.03 in.). Sharp edges and corners that present a personnel hazard or potential damage to equipment during usage shall be protected or rounded to a minimum radius of 13 mm (0.5 in.).

18.4.4 *Stored Energy*—Devices that possess stored energy (for example, compressed or expanded springs, air bottles, hydraulic and pneumatic equipment under compression and electrical capacitors and batteries) shall be designed and labeled in accordance with the requirements contained in Section 17, "Maintenance," for safety in operation and maintenance. The design shall incorporate provisions for the controlled, safe release of potentially hazardous energy prior to service or maintenance activities in accordance with the requirements contained in 17.19 "Stored Energy Devices." Furthermore, energy isolating devices for such equipment shall be designed to accept a lockout device.

18.5 *Electrical Hazards:*

18.5.1 *Electrical Shock:*

18.5.1.1 All electrical potentials of 30-V RMS or more are potential shock hazards and shall be protected from inadvertent contact by a person. Shock current intensities and their probable consequences are shown below in Table 59, "Shock Current Intensities and Their Probable Consequences." No inadvertent contact with electrical currents above that shown for "Surprise" effect shall be allowed.

18.5.1.2 One or more of the following shall be used to prevent inadvertent contact with live electrical wires, potentials, exposed contacts, or other sources of electrical current:

TABLE 59 Shock Current Intensities and their Probable Consequences

Current, Milliamperes (60 Hz)		Effects
AC	DC	
0–1	0–4	Perception
1–4	4–15	Surprise
4–21	15–80	Reflex Action
21–40	80–160	Muscular Inhibition
40–100	160–300	Respiratory Block
Over 100	Over 300	Usually Fatal

(1) Equipment shall be designed so that all external parts, with the exception of antenna and transmission line terminals, shall be grounded.

(2) Every door or access port that provides access to high-voltage potentials shall have an interlock.

(3) Capacitor discharge devices shall discharge the capacitor in 1 min or less.

(4) Tools and test leads to be used near high voltages shall be insulated.

(5) Plugs and receptacles shall be designed so that a plug of one voltage rating cannot be inserted into a receptacle of another rating.

(6) Equipment shall be designed so that all hot contacts will be socket contacts.

18.5.2 *Guards*—All exposed electrical contact that could shock or burn a person who came in contact with the exposed terminals, wires, or any other hot electrical lead should be covered with a guard, designed in compliance with the requirements covered in 18.6.1.

18.5.3 *Electrically Operated Hand Power Tools*—Electrically operated hand-held power tools shall be designed with three-wire power cords with one wire at ground potential and shall have exposed surfaces that are either nonconducting or are electrically connected to the ground wire. Exposed surfaces include cases, grips, handles, switches, triggers, chucks, and other surfaces that are capable of being contacted during operation. Where ground fault protection cannot be incorporated into system wiring, portable ground fault interrupters shall be provided for use with portable electric hand tools, pumps and other equipment.

18.5.4 *Dead Man Switch*—Hand tools with the potential for injury to personnel (for example, deck sanders, and large drills) shall be equipped with a dead man switch.

18.5.5 *Main Power Switch*—Every item of equipment shall have a clearly labeled main power switch that turns off all power to the item.

18.5.6 *Battery Storage or Charging Room:*

18.5.6.1 All rooms designed for battery storage or charging, or both, shall be provided with an eyewash fountain and

shower. Fountains and showers may be placed outside the room provided they are placed immediately adjacent to the entrance and are in compliance with the requirements of Section 10, "Workplace Arrangement."

18.5.6.2 Entrances into the room shall permit the use of hand trucks or dollies to move batteries into and out of the space.

18.5.6.3 Battery storage racks shall be designed and sized to permit the smallest user (for example, 5th % female) to install or remove the largest batteries to be stored or charged.

18.5.6.4 All batteries with a rating greater than 25 amp hours shall have terminal guards to prevent inadvertent short-circuiting of the battery under any circumstance during storage or charging or both.

18.6 *Mechanical Hazards:*

18.6.1 *Guards*—A guard shall be provided on all moving or rotating parts of machinery including pulleys, belts, gears, shafts, blades, or any other component in which a person could become entangled or struck by and cause injury or death. Guards shall conform to the following:

18.6.1.1 Guards shall be installed so as to require a special tool to be removed. Quick acting fasteners or any hand operated guard fasteners shall not be used.

18.6.1.2 Except for equipment identified as critical to abate a greater safety hazard (for example, propulsion and steering gear), all moving and rotating equipment will be disabled and unable to function as long as the guard is not permanently installed. Appropriate lock-out tag-out procedures or administrative controls shall be used whenever the guard is not in place.

18.6.1.3 If expanded metal is used as the guard material, the holes shall be no more than 13 mm (0.50 in.) in diameter or square.

18.6.1.4 Guards which require frequent visual inspection should be designed and installed to facilitate those inspections while maintaining the integrity of the guard.

18.7 *Fluid Hazards:*

18.7.1 *Connectors*—Each connector utilized in the handling or control of hazardous fluids, including propellants, solvents, hypergolics, and chemicals shall be incompatible with any other connectors within the access area of the connector.

18.7.2 *Fluid and Fuel Servicing Equipment*—Automatic shutoff devices shall be provided on fluid and fuel service equipment to prevent overflow and spillage.

18.7.3 *Flammable Liquid Lockers*—Flammable liquid lockers shall not be installed closer than 1.8 m (5 ft) to a door or exit if it is the only means of egress from the space or compartment, to an open control station, or from a door or exit leading to a control station used for emergency operations.

18.8 *Safety Barriers:*

18.8.1 *Safety Barriers*—Safety barriers should be used to protect a person from contacting a hazard (for example, rotating machinery, electrical contact, or hot pipe) as shown in Fig. 170.

18.9 *Fall Protection:*

18.9.1 *Fall Protection:*

18.9.1.1 Where feasible, designs shall minimize the requirement for work to be performed in elevated locations. Permanent barriers such as handrails shall be provided to protect routinely-used work stations and maintenance platforms. Handrails and related barriers will withstand a minimum of 200 lb of lateral force.

18.9.1.2 In addition to the fall protection provided by handrails required for stairs, ladders, walkways, and platforms as described in Section 11, "Access Aids," fall protection tie-off points where crew members can attach a safety harness shall be provided. Tie-off points shall be located anywhere in the ship or maritime structure where a person could be working in an elevated location in excess of 1524 mm (60 in.) above the deck.

18.9.1.3 Anchorage points will be reachable by hand without need for an extension device or unprotected access (without initial fall protection). Where this is infeasible, only the "first man up" shall be exposed to unprotected work and provisions shall be made to minimize the time and locations spent without positive fall protection. Anchorage points will be designed to withstand a minimum of 3600 lb of force. In areas where anchorage points for fall protection or for lifting or hoisting are required, two sets of anchorage points will be provided, one for equipment and one for personnel. Both will be designed to withstand the test force required by the more stringent criteria of the two (that required for lifting of equipment or that required for fall protection).

18.9.2 *Safety Harness Stowage*—Storage for safety harnesses shall be provided adjacent to ladders equipped with climber safety rails or areas where elevated work (as defined in 18.9.1) will be carried out on a regular basis.

18.10 *Emergency Egress:*

18.10.1 *Emergency Doors*—Emergency doors and exits shall be designed so that they:

18.10.1.1 Are simple to operate,

18.10.1.2 Are directly accessible,

18.10.1.3 Are unobstructed,

18.10.1.4 Are simple to locate and operate in the dark,

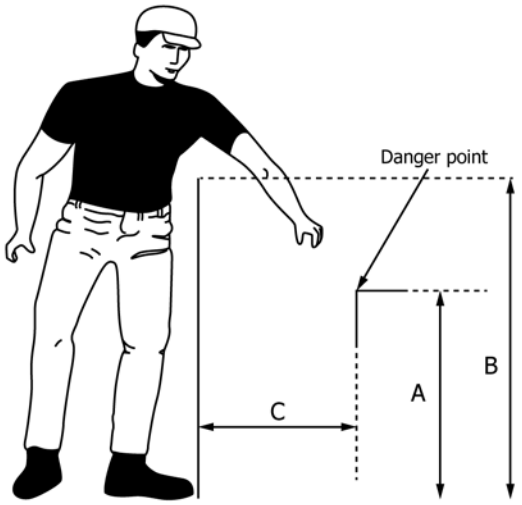
18.10.1.5 Are quick opening in 3 s or less, and

18.10.1.6 Require between 44 to 133 N (10 to 30 lb) of operating force to open.

18.10.2 *Escape from Flammable Compartments*—Two exits, doors, or kickout panels, shall be provided in any manned space where fuel, chemicals, or other flammable or toxic materials are used.

18.10.3 *Dual Escape Routes*—At least two separate escape routes shall be provided from any space in which ten or more persons occupy at any one time. The routes should be located in opposite corners and sides of the space. Stairs should be used for escape routes but one of the escape routes may be by means of a vertical ladder in any one space if all stair emergency escape routes are not feasible.

18.10.4 *Escape Route Signs*—Signs showing the direction to an escape route (for example, escape trunks in a machinery room, open route on a deck) shall be located throughout the ship or maritime structure so that at least one sign is visible to a person moving no more than 3 m (10 ft) from a position anywhere on the ship or structure. Exit signs shall be located



There should be no interpolation of the values in the table, see the following examples:

Example 1

The height of the danger point, "A", is 1500 mm (59.1 in) and its horizontal distance. "C", from the proposed barrier is 700 mm (27.6 in). Using the table, the height of the barrier, "B", should be 1800 mm (71.1 in).

Example 2

The height of the barrier, "B" is 1300 mm (51.3 in) and the height of the danger point, "A", is 2300 mm (90.6 in). Using the table, the barrier should be postitioned 600 mm (23.7 in) from the danger point.

Example 3

The height of the barrier, "B", is 1700 mm (66.9 in) and the horizontal distance, "C", from the danger point is 550 mm (21.7 in). Using the table, the danger point should not be between 1200 and 2200 mm (47.4 and 88.8 in)

Distance of danger point from floor "A" mm (in)	Height of edge of barrier "B" mm (in)							
	2400 (94.7)	2200 (86.8)	2000 (78.9)	1800 (71.1)	1600 (63.2)	1400 (55.3)	1200 (47.4)	1000 (39.5)
	Horizontal distance "C" from danger point mm (in)							
2400 (94.7)	–	100 (3.9)	100 (3.9)	100 (3.9)	100 (3.9)	100 (3.9)	100 (3.9)	100 (3.9)
2200 (86.8)	–	250 (9.9)	350 (13.8)	400 (15.8)	500 (19.7)	500 (19.7)	600 (23.7)	600 (23.7)
2000 (78.9)	–	–	350 (13.8)	500 (19.7)	600 (23.7)	700 (27.6)	900 (35.5)	1100 (43.4)
1800 (71.1)	–	–	–	600 (23.7)	900 (35.5)	900 (35.5)	1000 (39.5)	1100 (43.4)
1600 (63.2)	–	–	–	300 (19.7)	900 (35.5)	900 (35.5)	1000 (39.5)	1300 (51.3)
1400 (55.3)	–	–	–	100 (3.9)	800 (31.6)	900 (35.5)	1000 (39.5)	1300 (51.3)
1200 (47.4)	–	–	–	–	500 (19.7)	900 (35.5)	1000 (39.5)	1400 (55.3)
1000 (39.5)	–	–	–	–	300 (11.8)	900 (35.5)	1000 (39.5)	1400 (55.3)
800 (31.6)	–	–	–	–	–	600 (23.7)	900 (35.5)	1300 (51.3)
600 (23.7)	–	–	–	–	–	–	500 (19.7)	1200 (47.4)
400 (15.8)	–	–	–	–	–	–	300 (11.8)	1200 (47.4)
200 (7.9)	–	–	–	–	–	–	200 (7.9)	1100 (43.4)

FIG. 170 Safety Barriers

above doors as well as at deck level at every escape route opening. Emergency escape signs will be illuminated by emergency power in case of loss of normal power. Emergency escape signs shall be located so as to be visible under conditions of reduced illumination, such as loss of ship lighting or smoke or both. Self-illuminated arrows showing the direction of emergency egress routes shall be provided along the deck level.

18.10.5 *Escape Route Dimensions*—Walkways, passageways, doors, ramps, and stairs that constitute all or part of an emergency escape route shall be dimensioned as shown in Section 11, "Access Aids." Ramps shall have a maximum angle of inclination of 8°.

18.10.6 *Access to Vertical and Overhead Escape Hatches*—Access to hatches mounted in vertical walls or overheads for emergency escape purposes shall be sized and located as shown in Figs. 117 and 118.

19. Communications

19.1 *Communication System Requirements:*

19.1.1 *General Requirements*—The communication system shall be designed to:

19.1.1.1 Provide a sufficient number of communication channels to avoid excessive waiting for a free channel.

19.1.1.2 Provide dedicated channels for emergency communications or for communications that can be expected to be lengthy or very frequent.

19.1.1.3 Provide hands-free communications where required.

19.1.1.4 Provide headphones and telephone headsets for maximum operator comfort/performance.

19.1.1.5 Ensure that personnel wearing personnel protective equipment or heavy clothing can still use the communication system.

19.1.1.6 Locate telephones and emergency communication equipment in areas where most appropriate based on frequency of use and access in emergency conditions.

19.1.2 *Operating Range*—Microphones, headphones, loudspeakers, and associated equipment shall be designed to operate optimally in the range of 200 to 6100 Hz. Where system constraints necessitate narrower bandwidths, the minimum acceptable range shall be 250 to 4000 Hz.

19.1.3 *Speech Intelligibility*—When it is necessary to determine the speech intelligibility of a communication system, either or both of the modified rhyme test (MRT) or articulation index (AI) techniques may be used. The minimum performance score for both techniques is shown below in Table 60.

19.2 *Microphones:*

19.2.1 *Dynamic Range*—The dynamic range of a microphone used with a selected amplifier shall be great enough to allow variations in signal input of at least 50 dB(A).

19.2.2 *Noise-Canceling Microphones*—In noise environments in excess of 100 dB(A), noise-canceling microphones shall be provided and used. These shall be capable of effecting an improvement of not less than 10 dB(A) peak-speech to root-mean-square-noise ratio as compared with non-noise-canceling microphones.

19.2.3 *Microphone Noise Shields*—In intense noise fields (for example, in excess of 100 dB(A)), noise shields should be provided designed to meet the following requirements:

19.2.3.1 A volume of at least 250 cm^3 (15.25 $in.^3$) to permit a gradient microphone to function properly.

19.2.3.2 A good seal against the face.

19.2.3.3 A hole, or combination of holes, covering a total area of 65 mm^2 (0.1 $in.^2$) in the shield to prevent pressure buildup.

19.2.3.4 Prevention of a standing wave pattern by shape or by the use of sound-absorbing material.

TABLE 60 Minimum Speech Intelligibility Scores

Communication Requirement	MRT Score	AI Score
Exceptionally high intelligibility; separate syllables must be understood; 100 % intelligibility for all spoken words.	97 %	0.7
Normally understood intelligibility; about 98 % of sentences correctly heard and understood; single digits understood.	91 %	0.5
Minimally acceptable intelligibility; about 90 % of sentences understood; not acceptable for operating equipment or transmitting orders or commands.	75 %	0.3

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

19.2.4 *Directional Microphones*—Microphones with directional characteristics (rather than omni-directional pickup) may be used to overcome partially background noise when used by a single individual.

19.3 *Headsets:*

19.3.1 *Binaural Headsets*—In ambient noise environments in excess of 85 dB(A), binaural rather than monaural headsets shall be used. The binaural headsets should be wired so that the sound reaches the two ears in opposing phases. Attenuation qualities of the headsets should be capable of reducing the ambient noise level to less than 85 dB(A).

19.3.2 *When Not to Use Headsets*—Binaural headsets shall not be used in any operational environment with ambient noise levels below 85 dB(A) if that environment contains sounds that provide the user with useful information and that information cannot be directed to the user's headsets (for example, voices, machinery noise that could indicate wear, local alarms).

19.3.3 *Multiple Channel Feeds to Headphones*—Where multiple channels feed into headphones, the system shall be designed to respond uniformly over the frequency range of 100 to 4800 Hz.

19.3.4 *Volume/Gain Controls*—Volume and gain controls shall be provided and be accessible for each receiving communication channel.

19.3.5 *Squelch Control*—Where communication channels are to be continuously monitored, each channel shall be provided with signal-activated switching device (that is, squelch control) to suppress channel noise during no-signal periods. A manually operated ON-OFF switch shall be provided to deactivate squelching during the reception of weak signals.

19.3.6 *Dichotic Presentation*—When earphones will be worn in an operational environment, a dichotic presentation should be used with the signal alternating from one ear to the other by means of a dual-channel headset.

19.3.7 *Separate Channels*—An alarm signal delivered to a headset that might mask another essential audio signal should be delivered to one ear and the other signal to the other ear.

19.4 *Loudspeakers:*

19.4.1 *General Requirements*—Loudspeaker design criteria shall be as follows:

19.4.1.1 The number, placement, and amplitudes of the public address (PA) system loudspeakers shall be sufficient to ensure the intelligibility of announcements throughout the ship or maritime structure under all ambient noise conditions. The resulting articulation index should be 0.7 or greater.

19.4.1.2 In noisy areas where the intelligibility of speech is below an articulation index of 0.7, provide peak clipping for PA loudspeakers.

19.4.1.3 In large open areas, avoid excessive echoing by providing sufficient loudspeakers that keeps speaker separation at a maximum of 15.2 m (50 ft).

19.4.1.4 Where a single person uses a loudspeaker, it should be placed directly in front of the user and be equipped with a volume control and a jack box for use with a headphone.

19.4.1.5 Where the ambient noise level varies by 20 dB(A) or more, provision should be made for variable loudspeaker amplitude control that allows the volume setting to be monitored.

19.4.1.6 Loudspeakers located in offices, conference rooms, control rooms, medical spaces, or on the bridge shall be equipped with speaker volume controls that are accessible to regulate the loudness of the loudspeaker without climbing on chairs, tables, or any other item not specifically built to provide a standing surface. The controls shall be capable of lowering the speaker volume to a value of 10 dBA above ambient noise levels or to a level that will provide an AI of 0.5, whichever is lower.

19.4.1.7 If several channels are to be monitored simultaneously by means of loudspeakers, the speakers shall be mounted at least 10° apart in the horizontal plane frontal quadrant, from 45° left to 45° right of the user's normal forward-facing position.

19.5 *Telephone Systems:*

19.5.1 *Band Pass*—The standard telephone band pass of 200 to 3300 Hz should be used.

19.5.2 *Cords:*

19.5.2.1 Cords shall be non-kinking or self-retracting and of sufficient length to permit user mobility to all use points required from each phone.

19.5.2.2 Cords shall be positioned to avoid entangling controls or becoming entangled with passing people or objects.

19.5.3 *Handset Cradles*—Handset cradles mounted vertically shall be designed and located to prevent the handset from being knocked from the cradle by passing people or objects.

19.5.4 *Multiple Telephone Handsets*—If two or more telephones are located close to each other, they shall be coded to indicate circuit or function. The telephone handsets' accessibility shall be determined by their operational priority, that is, the most frequently used or most urgently needed handset shall be the most accessible.

19.5.5 *Press-to-Talk*—If a press-to-talk button is used, the button shall be convenient to both left- and right-handed people.

19.5.6 *Noisy Environments*—In noisy environments, volume controls on telephones should be provided for loudness of ringing and speaker output.

19.5.7 *Phone Booth*—Locate and orient telephone booths in high-noise areas so the booth opening is facing away from the high-noise sources.

20. Keywords

20.1 anthropometrics; ergonomics; human engineering (HE); human factors engineering (HFE)human systems integration (HSI)

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APPENDIXES

(Nonmandatory Information)

X1. SMALL BOAT AND HIGH SPEED CRAFT (HSC) APPENDIX

X1.1 Overview and Applicability

X1.1.1 *Overview*—The following Appendix X1, "Small Boat and High Speed Craft Appendix," provides additional requirements and guidance exclusively for application to small boats and HSC in addition to the requirements captured in ASTM Practice F1166. Due to differences in size and operational application, many specific design requirements for larger vessels either do not apply, or differ from those intended for small boats and HSC. The following appendix provides a de-confliction and consolidation of requirements contained in ASTM Practice F1166, and introduces specific small boat and HSC requirements through an incorporation of supplemental HSC-specific design standards and guidance. Items and design aspects not addressed in this Appendix X1, "Small Boat and High Speed Craft Appendix," shall conform to requirements in the present document, ASTM Practice F1166.

X1.1.1.1 *Applicability*—For purposes of the ASTM Practice F1166, Appendix X1, "Small Boat and High Speed Craft Appendix," the term HSC denotes a vessel with specific characteristics outlined in the International Maritime Organization (IMO) MSC.97(73): 2000 HSC Code (2000):

"1.4.30 'High-speed craft' is a craft capable of maximum speed, in metres per second (m/s), equal to or exceeding: (3.7) ($\nabla^{0.1667}$), where ∇ = volume of displacement corresponding to the design waterline (m^3) excluding craft the hull of which is supported completely clear above the water surface in non-displacement mode by aerodynamic forces generated by ground effect."

Other crafts and small boats not meeting the criteria in the definition above, should view these requirements as best practices and supplemental design guidance – especially for those vessels capable of exceeding 30 knots (U.S. Coast Guard Navigation and Vessel Inspection Circular 5, 2001 (NVIC 5-01)).

The design requirements noted in the ASTM Practice F1166, Appendix X1, "Small Boat and High Speed Craft Appendix" do not supersede IMO definitions or requirements for the design or operation of HSC, or other vessels.

X1.2 General Design Requirements

X1.2.1 *Forward Visibility, Horizontal Visibility, and Line of Sight*—Visibility from the operating position is generally captured by defining the maximum acceptable blind spot (measured in craft lengths) off of the bow during various modes of operation such as displacement and planning modes. Unless otherwise directed, blind spots shall be assessed using eye height reference points representative of the expected user population. HSC visibility also considers blind spots in the horizontal field of view caused by boat structure and other equipment. Appropriate understanding of the HSC operational application and the HSC structural characteristics shall be considered when assessing and applying visibility standards.

X1.2.1.1 Several standards exist to define the maximum acceptable blind spot off of the bow during various stages of craft acceleration (displacement, transition, planing). A summary list of these standards is shown below in Table X1.1. Before applying any of the visibility standards below, craft designers shall consider the craft characteristics and operational profile in order to determine correct and appropriate application. Each standard contains specific requirements for application including the craft's structural and performance characteristics. It is important to note that two of the standards shown below do not apply to HSC.

X1.2.2 *Seating*—Operator and crew seating shall mitigate operational environment whole-body shock and vibration in accordance with 14.4. Seating shall accommodate the anthropometric range (Section 9) of the expected user population and any added bulk or weight, or both, added by personal protective equipment (PPE). After seat adjustment the expected user population shall maintain a minimum leg, knee, and thigh clearance of 7 in. in front of and above the leg, knee, and thigh for the full range of seat travel.

X1.2.2.1 Operator seat location and adjustment capabilities shall be considered when assessing operator forward visibility requirements previously described. Seating shall be installed or adjustable, or both, to ensure that all operators, while properly seated and restrained, have feet supported such that the operator is flat-footed. Adjustable foot supports, if present, shall travel with the seat during shock-induced movement and shall be foldable/stowable when not in use.

X1.2.3 *Rounded Edges / Corners*—To prevent crew and passenger injury during HSC operations and craft movement, all exposed corners and edges shall be rounded or guarded in accordance with 18.3.3.

X1.2.4 *Tripping Hazards, Snag Hazards, and Non-skid Requirements*—Working deck space and transit areas shall be clear of tripping and snag hazards. Specific attention shall be placed on areas immediately around ingress and egress points including passageways inside and outside of the cabin (if present), walkways around the outside of the HSC to/from the bow/stern, hatches, ladders, and stairs. All walking and working surfaces shall be coated with non-skid material in accordance with 11.12.1.2.

TABLE X1.1 Visibility Standards for HSC and Small Boat Application

Standard	Applicability
IMO Resolution MSC.97(73), "Adoption of the International Code of Safety for HSC (2000 HSC Code)," Section 15.3, "Field of vision from the operating compartment"	HSC
ISO 8468:2007, "Annex A: Bridge layout for high speed craft"	HSC
ISO 11591:2019, "Small craft – Field of vision from the steering position"	Small craft up to 24 m length of hull (LH) in accordance with ISO 8666.
ABYC H-1, "Field of Vision from the Helm Position" (2019)	"…all boats powered by machinery…Exception: Sailboats"

X1.3 Requirements for Enclosed Cabins and Spaces

X1.3.1 *Impacts to Visibility*—Enclosed cabins or overhead structure above the operating position shall be considered when assessing forward visibility. Enclosed cabins and overhead structure can cause blind spots and affect the achievement of required visibility standards, especially for 95th percentile male operators.

X1.3.2 *Overhead Height*—Enclosed cabin overhead height shall be no less than 78 in. to accommodate a 95th percentile male user in boots and PPE. However, to account for differing shock and vibration environments experienced by HSCs (defined in 14.4), the IMO Maritime Safety Committee Circular 982 (2000) suggests a minimum clear height of 2.1 m (82.67 in.) between the deck surface covering and the lower edge of any overhead mounted equipment in open areas, passageways and at standing workstations.

X1.3.3 *Lighting*—Lighting level requirements are defined in Table 38. Lighting provided in enclosed HSC spaces shall be continuously dimmable from zero to 100 % and shall provide red lighting for nighttime operations. Overhead lighting shall be arranged or guarded, or both, to prevent glare on cabin windows in accordance with 14.3.

X1.4 Console Design and Control Layout

X1.4.1 *Console Size and Characteristics*—Console height and shape shall allow for maximum visibility from the operating position and limit blind spots in the horizontal and vertical field of view for the intended user population in accordance with applicable visibility standards.

X1.4.2 *Windshields and Windscreens*—Provided windshields and windscreens shall protect operators from relative wind and sea spray. If provided, windshields or windscreens shall not inhibit visibility in the operator's horizontal or

vertical field of view and shall account for glare, sea spray, and salt accumulation. To mitigate challenges to visibility caused by environmental factors, mechanical means (windshield wipers, washers) or physical considerations of windshield or windscreen size and placement shall be incorporated into the design.

X1.4.3 *Controls, Displays, and Console Layout*—The layout of displays and controls at the operating console shall be an iterative design process informed by the operational needs, expected tasks, and user information requirements. Throughout the iterative design process, the console layout shall be further refined through the use of mockups and design prototypes, evaluated by representative users and informed by human engineering requirements, until an acceptable final design is reached.

X1.4.3.1 Controls and displays shall be placed in accordance with operator information needs and expected tasks with priority given to controls deemed critical or high priority. In expected operating environments characterized by high shock and vibration (14.4), the placement of controls and displays shall be such that it preserves and maintains a positive operator posture and spinal alignment for the intended user anthropometric range (that is, 5th percentile female to 95th percentile male). Placement of controls within anthropometric limitations shall prevent the need for excessive postural bending and twisting while interacting with boat systems and controls. If present, seat adjustment capability shall be used to accommodate reach and field of view accommodations for expected user population. A stable and positive posture significantly lessens the effects of short and long term health, fatigue, and performance impacts caused by HSC shock and vibration (Dobbins, T., et al, 2008).

X1.4.4 *Functional Reach*—Forward functional reach measurements (Section 9, Table 15) combined with field of view (Fig. 21) measurements shall be used to control operator posture by defining the most efficient location of controls and displays for the expected user population. Measurements shall originate from reference points for properly seated and restrained users representing the user population. PPE impacts to reach and field of view measurements shall also be considered as bulky PPE can limit or further restrain operators, limiting reach capabilities. Additional size accommodations for PPE are accounted for as "cold weather" measurements in Section 9.

X1.4.4.1 Controls, interfaces, and peripherals shall be within the forward functional reach measurements for the user population. The functional reach measurements for the 5th percentile female and 95th percentile male populations for various countries and regions around the world are shown in Section 9, Table 15. The forward functional reach measurements for 5th and 95th percentile North American males and females are shown in Table X1.2.

X1.4.5 *Field of View*—The placement of controls and displays shall be prioritized using the "immediately readable" and "easily readable" measurements in Fig. 21. Categorization of display and controls as "immediately readable" or "easily readable," or both, shall be in accordance with specific operational information needs and requirements as defined by operational tasks. Immediately readable shall be defined as 35 degrees left and right (70 degree total arc) and 25 degrees up and 35 degrees down (60 degree total arc) from horizontal line of sight. This area shall be reserved for high priority displays and controls.

TABLE X1.2 Forward Functional Reach Measurements for North American Population (Reference: ASTM Practice F1166, Table 15)

	Forward Functional Reach[A]	
	5th Percentile	95th Percentile
Female	746 mm (29.4 in.)	876 mm (34.5 in.)
Male	842 mm (33.1 in.)	975 mm (38.4 in.)

[A] Measured from the back of shoulder to fingertips.

X1.4.5.1 Easily readable shall be defined as 60 degrees left and right (120 degree total arc) and 50 degrees up and 50 degrees down (100 degree total arc) from horizontal line of sight. This area shall be reserved for secondary displays and controls not deemed critical, however still required for operation.

X1.4.6 *Use and Function*—The use of controls and displays in the HSC environment presents unique perceptual challenges that shall be considered in equipment design and selection. In many cases oversized displays and increased button/knob/dial/switch size and spacing are required for use under the shock and vibration characteristics of HSC as well as to accommodate use with PPE. In addition to control requirements in Section 5, the spacing of individual buttons, knobs, dials, switches, and other input devices shall be designed in accordance with Table 3. Additionally, Table 11 shall be used to define increases in control spacing required for use with PPE (gloves, cold weather gear).

X1.4.6.1 Controls shall be located so that simultaneous operation of two controls will not necessitate a crossing or interchange of hands. Controls that are operated in association with specific displays shall be positioned to ensure easy operation as a combined activity (Dobbins, T., et al, 2008). All controls shall be arranged to prevent inadvertent activation. Controls that, if inadvertently activated would result in a potentially unsafe outcome (that is, emergency engine shutoff), shall be guarded.

X1.4.7 *Finger Rails*—Structural, console, or equipment-mounted support in the form of finger rails, hand/palm rests, or grasp areas shall be used to reduce shock and vibration effects by steadying the operator's hand during interaction with manual input devices and touchscreens. Finger rails or similar features shall be placed directly adjacent to the manual interaction point on the equipment (dial, touchscreen, control panel, etc.). Finger rail access and placement near controls shall accommodate used with gloved or mittened hand/fingers (Fig. 160).

X1.4.8 *Touch Screens*—Touch screen input shall not be the sole means of input for any display or control. Touchscreen devices shall have a secondary, non-touchscreen operated input device(s) capable of making all adjustments and inputs. Placement and characteristics of touchscreen displays shall be in accordance with Section 13.27.5.

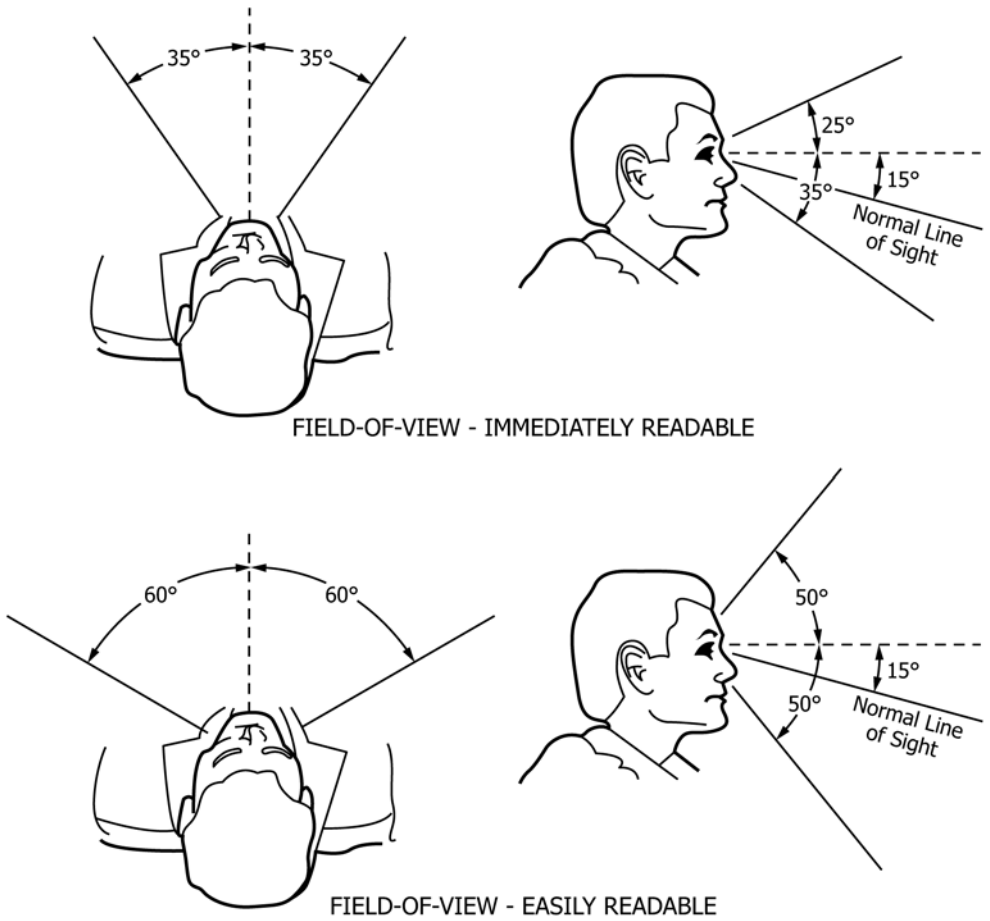

FIG. X1.1 Primary and Secondary Fields of View (Reference: ASTM 1166, Fig. 21)

X1.4.9 *Night Vision Capability*—All illuminated or backlit controls, indicators, and displays shall be continuously dimmable from 0 to 100 % to preserve operator night vision. The placement and characteristics of backlit displays and indicator lights shall be considered as to not become a distraction or negatively impact operator night vision. Displays and controls operating in a normal status shall not blink or flash. Flashing or blinking indicators shall be limited to active alarm statuses and to notify operators of transitioning or abnormal conditions. When the use of night vision devices (NVD) or night vision goggles (NVG) are required, lighting characteristics shall conform to Section 14.3.4.2.

X1.4.10 *Handholds*—Handholds shall be located throughout the HSC to facilitate operator stability while transiting around the craft by means of companionways, ladders, and stairways (ABYC, 2014). Handholds shall also serve to preserve operator posture and provide stability during operations and shall be provided at other seating locations intended to be occupied while the vessel is underway (ABYC, 2014). Handholds shall be placed at all operator consoles immediately forward of each operator, within reach of other passenger locations, within reach at standing passenger locations, and along transit routes around the HSC (that is, transiting to/from the bow/stern, or in/out of HSC cabins and spaces). Handholds shall be securely fastened and shall withstand a load of 400 lbs, in any direction, at any point, along their length without failure such that they no longer perform their intended purpose (ABYC, 2014).

X1.4.10.1 Overhead handholds shall be avoided to reduce the occurrence of shoulder injuries caused by shock and wave impact by the HSC. Handholds shall be placed as close as possible the central grasp area for expected user population, and shall be no greater than 48.3 in. from the standing surface (Fig. 50; 5th percentile female shoulder height). Handholds shall be located and sized to provide no less than a 3 in. clearance above or below the typical grasp area to accommodate access with a gloved or mittened hand in accordance with Fig. 160.

X1.4.11 *Alarms*—The following requirements shall be used in addition to the general requirements for alarms in Section 7:

X1.4.11.1 HSC alarms shall be grouped together on a single panel on the operator console, available to the operator(s) to view at a glance. Audible and visual indications shall be used simultaneously to gain operator attention to a specific alarm. Indicator lights shall be positioned and be clearly labeled as to the specific system actively alarmed. Audible alarms shall have the capability to be silenced while the issue is investigated. The visual indication shall remain active until the issue has been resolved or returned to normal levels. Alarm panels in different

operating spaces shall maintain consistent ordering and naming of alarms while using consistent alerting characteristics.

X2. HUMAN FACTORS ENGINEERING (HFE) CHECKLIST FOR DESIGNERS OF SHIPS AND MARITIME STRUCTURES

X2.1 Foreword

X2.1.1 This human factors engineering (HFE) checklist is intended to provide a quick reference to the principal HFE requirements that are contained within this practice. It is to be used by engineers and designers to check their proposed or completed designs quickly to ensure that they comply with the design requirements included throughout this practice. Obviously, no checklist can cover all of the HFE requirements contained in the ASTM HFE design standards, so it is incumbent upon the designer who uses this checklist to become intimately familiar with, and use, this practice, as well as use this checklist.

X2.1.2 For each checklist item, the section or paragraph within this practice that supports that item's inclusion is provided.

X2.1.3 The checklist is organized to match the organization of this practice to make it easier to use.

X2.1.4 If there is any question or doubt about the interpretation of any requirement in the checklist or this practice or any HFE issue associated with any part of the design effort, a HFE professional with an academic degree in HFE and experience in the design of ships and other maritime facilities should be consulted.

TABLE X2.1 Human Factors Checklist for Design

	Yes	No	NA
SECTION 5 CONTROLS			
GENERAL DESIGN PRINCIPLES			
1. Are all controls labeled in accordance with the requirements of Section 15? Section 5, paragraph 5.1.1	_____	_____	_____
2. Have the controls been selected to be compatible with the 5th to 95th percentile body dimensions of the full range of user population (male and female) expected on this ship? Section 5, paragraph 5.1.3	_____	_____	_____
3. Are all controls located and sized to be compatible with the clothing or personal protective equipment that could be worn by an operator (for example, arctic mittens, fire turnout coats, NBC protective suits)? Section 5, paragraphs 5.1.3 and 5.1.10	_____	_____	_____
4. Are the most important or frequently used controls located in the most favorable position with respect to the operator's ease of reach and grasping? Section 5, paragraph 5.2.1 (xii)	_____	_____	_____
5. Does the direction of movement of the controls comply with the control movement stereotypes shown in Section 5, paragraph 5.3.1 (Table 1 and Fig. 1)	_____	_____	_____
TYPE OF CONTROLS			
6. Are multi-rotational controls used when precision setting is required in accordance with Section 5, paragraph 5.1.5?	_____	_____	_____
7. Are detent controls used whenever the manual control requires discrete steps? Section 5, paragraph 5.1.6	_____	_____	_____
8. If controls are used solely for maintenance, are they covered during normal operations but directly accessible and visible to the maintenance technician when required? Section 5, paragraph 5.1.8	_____	_____	_____
LOCATION			
9. Are controls that require the finest degree of setting accuracy, or the most force to operate, assigned to the operator's right hand? Section 5, paragraph 5.1.4	_____	_____	_____
10. Are controls located principally for right handed use? Section 5, paragraph 5.1.4	_____	_____	_____
11. Are controls located to minimize their susceptibility to accidental activation? Section 5, paragraph 5.1.9	_____	_____	_____
12. Where controls are mounted inside equipment or enclosures, are they located so that the operator cannot come in contact with electrical contacts, hot pipes, or other hazardous objects? Section 5, paragraph 5.1.9.1	_____	_____	_____
13. Have the hand-operated controls been arranged and located to distribute the workload between the operator's two hands? Section 5, paragraph 5.2.1 (iii)	_____	_____	_____
14. Are all controls associated with ship motion located so movement of the control corresponds to the direction of the desired movement of the ship? Section 5, paragraph 5.2.1 (iv)	_____	_____	_____
ARRANGEMENT			
15. Is the arrangement of functionally similar or identical controls consistent from one panel, console, or workplace to another throughout the individual equipment, systems, or the total ship? Section 5, paragraph 5.1.11	_____	_____	_____
16. If controls are used in a fixed sequence, are they grouped together and are they arranged in the sequence of use (for example, a pattern running from left-to-right or top-to-bottom)? Section 5, paragraph 5.2.1 (xiii)	_____	_____	_____

TABLE X2.1 *Continued*

	Yes	No	NA
17. Does the minimum spacing between controls comply with the requirements of Section 5, paragraph 5.4.1 (Table 3)	_____	_____	_____
CONTROL DESIGN			
18. Were the guidelines provided in Section 5, paragraph 5.2 (Table 1) used in selecting, designing and arranging the controls?	_____	_____	_____
19. Are all "blind" controls (that is, controls which are operated by feel only) eliminated from the design? If not do "blind" controls comply with Section 5, paragraph 5.4.2?	_____	_____	_____
20. If controls are color coded are they in compliance with Section 5, paragraphs 5.5.2 through 5.5.2.3?	_____	_____	_____
21. Are controls that were shaped coded in compliance with Section 5, paragraph 5.5.3?	_____	_____	_____
22. Are controls that are size coded in compliance with the Section 5, paragraph 5.5.4?	_____	_____	_____
23. Are controls that are texture coded in compliance with the requirements in Section 5, paragraph 5.5.5?	_____	_____	_____
24. Are controls that are located coded in compliance with Section 5, paragraph 5.5.6?	_____	_____	_____
25. Are foot operated controls used only for conditions identified in Section 5, paragraphs 5.6.1.1, 5.6.2.1, or 5.6.3.1?	_____	_____	_____
26. Are foot-operated controls designed in compliance with Section 5, paragraphs 5.6.1 through 5.6.3 (Figs. 1-4)?	_____	_____	_____
27. Do discrete step rotary controls comply with the design requirements shown in Section 5, paragraph 5.6.4 (Figs. 5 and 6)?	_____	_____	_____
28. Are continuous adjustment rotary controls designed in compliance with Section 5, paragraph 5.6.5 (Fig. 7)?	_____	_____	_____
29. Do hand cranks comply with the design requirements shown in Section 5, paragraph 5.6.6 (Figs. 8 and 9)?	_____	_____	_____
30. Are pushbuttons designed in accordance with the requirements of Section 5, paragraph 5.6.7 (Fig. 10)?	_____	_____	_____
31. Do legend switches (that is, lighted pushbuttons) comply with the design requirements shown in Section 5, paragraph 5.6.8 (Figs. 11 and 12)?	_____	_____	_____
32. Do toggle switch controls comply with Section 5, paragraph 5.6.9 (Fig. 13)?	_____	_____	_____
33. Do rocker switches comply with the design requirements shown in Section 5, paragraph 5.6.10 (Fig. 14)?	_____	_____	_____
34. Are discrete slide switch controls in compliance with Section 5, paragraph 5.6.11 (Fig. 15)?	_____	_____	_____
35. Do continuous slide controls comply with the design requirements shown in Section 5, paragraph 5.6.12 (Fig. 16)?	_____	_____	_____
36. Do levers comply with the design requirements shown in Section 5, paragraph 5.6.13 (Figs. 17 and 18)?	_____	_____	_____
37 Do hand-operated displacement joy-stick controls comply with Section 5, paragraph 5.6.14 (Table 4)?	_____	_____	_____
38. Do hand-operated isometric joy-sticks comply with the design requirements in Section 5, paragraph 5.6.15 (Table 4)?	_____	_____	_____
39. Do push-pull controls comply with the design requirements in Section 5, paragraph 5.6.16 (Fig. 19)?	_____	_____	_____
SECTION 6 DISPLAYS			
GENERAL			
1. Does the presence or absence of a visual display comply with the requirements of Section 6, paragraph 6.1.1?	_____	_____	_____
LOCATION			
2. Are two displays (for example, annunciators) used to show when a piece of equipment or system is ON and OFF instead of using one light to show when it is ON (that is, when the light is lit) and the same light to show when the equipment is OFF by extinguishing the light? Section 6, paragraph 6.1.1	_____	_____	_____
3. Are all displays located and arranged so that the operator can read them from his/her normal working position without having to assume an awkward or uncomfortable position? Section 6, paragraph 6.2.1	_____	_____	_____
4. Are displays which provide an "in" and "out" reading (for example, suction and discharge, voltage in and out) arranged so the "in" reading is on the left (preferred) or top, and the "out" reading is on the right (preferred) or bottom? Section 6, paragraph 6.2.2	_____	_____	_____
5. Are the displays located so the operator does not have to stand on wireways, pipes, handrails, or equipment components to read them? Section 6, paragraph 6.2.3	_____	_____	_____
6. Are armored sight glass liquid level indicators or other displays which are visible only from a specific position properly located for operator use from the normal work position? Section 6, paragraph 6.2.4	_____	_____	_____
7. Are displays located adjacent to a walkway mounted at least 460 mm (18 in.) above the walking surface so they will not be kicked and broken? Section 6, paragraph 6.2.4	_____	_____	_____

TABLE X2.1 *Continued*

	Yes	No	NA
8. Is the location of functionally identical or similar displays consistent throughout the ship? Section 6, paragraph 6.2.5	_____	_____	_____
9. Is the distance between displays and the operator's eyes greater than the minimum of 330 mm (13 in.), at the preferred 510 mm (20 in.), or at most less than the maximum of 711 mm (28 in.)? Section 6, paragraph 6.2.14	_____	_____	_____
10. Are displays that are used most frequently grouped together and placed in the operator's primary visual field of view? Section 6, paragraphs 6.2.7 and 6.2.17 (Fig. 21)	_____	_____	_____
11. Are all critical displays placed within the operator's primary field-of-view? Section 6, paragraph 6.2.17 (Fig. 21)	_____	_____	_____
ARRANGEMENT			
12. Are similar or identical displays that appear in more than one location in the ship arranged in the same manner and orientation in each location (that is, is there consistency in how displays are presented to the operator from one location to another)? Section 6, paragraph 6.2.5	_____	_____	_____
13. Are displays arranged in relation to one another according to their:	_____	_____	_____
13.1 Sequence of use? Section 6, paragraph 6.2.9	_____	_____	_____
13.2 Functional Relationship? Section 6, paragraph 6.2.9	_____	_____	_____
VISIBILITY			
14. If displays are mounted directly on a pipe or equipment (for example, thermometers, pressure gauges), are they oriented so they are read upright or turned no more than 90° from the vertical position? Section 6, paragraph 6.2.4	_____	_____	_____
15. Are displays visible to personnel wearing Personnel Protective Equipment (PPE) that covers the head? Section 6, paragraph 6.1.10	_____	_____	_____
16. Are all displays readable with the existing ambient lighting (that is, the operator does not have to use a flashlight to read the displays)? Section 6, paragraph 6.2.10	_____	_____	_____
17. Are displays that are used during normal operation directly visible without having to remove a cover? Section 6, paragraph 6.2.3	_____	_____	_____
18. Are sight gauges containing clear liquid provided with a colored float or other means to make the liquid level indicator visible? Section 6, paragraph 6.2.12	_____	_____	_____
19. Have means been taken to reduce effects of vibration on operator visibility of displays? Section 6, paragraph 6.2.13	_____	_____	_____
20. Are displays that are used solely for maintenance covered or non-visible to the operator during normal operations? Section 6, paragraph 6.2.15	_____	_____	_____
21. Are displays to be viewed through night vision devices illuminated with the proper colored lighting? Section 6, paragraph 6.3.2	_____	_____	_____
INFORMATION CONTENT			
22. Do the displays provide information so the operator does not have to transpose, compute, interpolate, or mentally calculate the information presented before it can be used? Section 6, paragraph 6.1.3	_____	_____	_____
23. Is operator and maintained information displayed on separate displays? Section 6, paragraph 6.1.5	_____	_____	_____
24. Is it visually obvious to the operator that a display has failed? Section 6, paragraph 6.1.6	_____	_____	_____
25. Are trademarks, company names, model, or purchasing contract numbers or any other similar markings not related to reading the display information removed from the display face or panel or console front so as not to be visible by the operator? Section 6, paragraph 6.1.8	_____	_____	_____
26. Is information presented in either analog or digital form? Section 6, paragraph 6.1.14	_____	_____	_____
TRANSILLUMINATED DISPLAYS			
27. Are trans-illuminated displays designed in compliance with Section 6, Section 6.4.1 and Table 5?	_____	_____	_____
28. Are the transilluminated displays one of the two types described in Section 6, paragraph 6.4.1.2?	_____	_____	_____
29 Are transilluminated displays made in accordance with one of the two label/background contrasts defined in Section 6, paragraph 6.4.1.3?	_____	_____	_____
30. Are transilluminated displays coded in accordance with Section 6, paragraph 6.4.1.5*(1)* through 6.4.1.5*(6)*?	_____	_____	_____
31. Do lighted annunciators comply with the following color codes? Section 6, paragraph 6.4.1.5*(7)* (Table 5)	_____	_____	_____
31.1 Flashing red for emergency conditions requiring immediate operator response?	_____	_____	_____

TABLE X2.1 *Continued*

	Yes	No	NA
31.2 Steady red for emergency conditions which have been acknowledged by the operator? For electrical equipment red indicates that a motor is running or that a breaker is closed (that is, that the system or equipment is "hot").	_____	_____	_____
31.3 Amber or yellow for identifying an out-of-tolerance condition which the operator must attend to but which is not an emergency?	_____	_____	_____
31.4 Green for indicating that systems are operating normally? For electrical equipment green also means that a motor is off, a breaker is open, etc. (that is, that the equipment or system is not energized).	_____	_____	_____
31.5 White for identifying equipment or system conditions that have no right or wrong (for example, showing which of two pumps has been selected for operation)?	_____	_____	_____
31.6 Blue may be used for advisory lights but blue should be avoided whenever possible?	_____	_____	_____
32. Are transilluminated displays with flash coding designed in accordance with the requirements of Section 6, paragraph 6.4.1.8?	_____	_____	_____
33. Does changes in display status provide feedback as defined in Section 6, paragraph 6.4.1.8?	_____	_____	_____
CIRCULAR AND LINE GAUGES/DISPLAYS			
34. Are circular and line analog displays used in accordance with the requirements of Section 6, paragraph 6.4.2.1?	_____	_____	_____
35. Are circular and line gauges designed in accordance with the requirements of Section 6, Section 6.4.2 (Figs. 22-27)?	_____	_____	_____
36. Are displays shaped and oriented so they correspond with the direction of what they are representing (for example, vertical gauges for showing quantities that go up and down, such as the liquid level or pressure in a vessel)? Section 6, paragraph 6.4.2.4	_____	_____	_____
37. If gauges and other displays show readings that maintain a consistent operating range, are they marked (for example, color coded, shape coded, etc.) to show the acceptable and unacceptable operating ranges? Section 6, paragraph 6.4.2.17 (Fig. 25)	_____	_____	_____
DIGITAL DISPLAYS			
38. Are digital displays used only when exact values are required and not when rate of change information is required? Section 6, paragraph 6.1.14	_____	_____	_____
39. Are digital displays designed in compliance with Section 6, paragraph 6.4.3 (Table 6) (Fig. 28)?	_____	_____	_____
OTHER DISPLAY TYPES			
40. Are Cathode Ray Tube (CRT) displays designed in accordance with Section 6, paragraph 6.4.4?	_____	_____	_____
41. Are large screen displays designed in compliance with Section 6, paragraph 6.4.5?	_____	_____	_____
42. Are light emitting diode displays designed in agreement with Section 6, paragraph 6.4.6?	_____	_____	_____
43. Are dot matrix/segmented displays designed in accordance with the requirements of Section 6, paragraph 6.4.7?	_____	_____	_____
44. Are electroluminescent displays designed in compliance with Section 6, paragraph 6.4.8?	_____	_____	_____
45. Are liquid crystal displays designed in compliance with Section 6, paragraph 6.49?	_____	_____	_____
46. Are mimic displays designed in accordance with the requirements of Section 6, paragraph 6.4.11 and Section 8, paragraph 8.8 (Figs. 48 and 49)?	_____	_____	_____
47. Are audible displays designed in accordance with the requirements in Section 6, paragraph 6.5 (Table 7)?	_____	_____	_____
SECTION 7 ALARMS			
GENERAL REQUIREMENTS			
1. Was an overall alarm strategy prepared before any alarm design was initiated in accordance with the requirements of Section 7, paragraph 7.1.2?	_____	_____	_____
2. Are alarms either visual displays, flashing lights, or audible sounds and voice messaging, or a combination of two or more of these? Section 7, paragraph 7.1.3	_____	_____	_____
3. Are alarms acknowledged either through a dedicated alarm acknowledge control or integrated into each alarm display? Section 7, paragraph 7.1.5	_____	_____	_____
4. Is the alarm system designed to comply with the rate of alarms presented over a fixed period of time as defined in Section 7, paragraph 7.1.6?	_____	_____	_____
5. Has an effort been made to reduce false alarms in accordance with the requirements of Section 7, paragraphs 7.1.7 and 7.1.8?	_____	_____	_____
6. Is the alarm system designed to handle simultaneous alarms in accordance with Section 7, paragraph 7.19?	_____	_____	_____

TABLE X2.1 *Continued*

	Yes	No	NA
7. Have alarm been prioritized as required in Section 7, paragraph 7.1.10?	_____	_____	_____
8. If a master alarm silence control is provided does it silence only active audible signals in accordance with the requirements of Section 7, paragraph 7.1.12?	_____	_____	_____
9. Do repetitively appearing alarm groups have the same arrangement and relative location on all the different consoles or panels? Section 7, paragraph 7.1.14	_____	_____	_____
10. Is there a way of testing visual and audible alarms without disrupting the alarm system operation? Section 7, paragraph 7.1.15	_____	_____	_____
11. Is there a way to temporarily disable, or leave ON, alarms for maintenance purposes, and is this condition clearly displayed at all operator stations? Section 7, paragraph 7.1.16	_____	_____	_____
12. Are alarms located on the bridge in compliance with the requirements of Section 7, paragraph 7.1.17?	_____	_____	_____
13. Is a loss of a redundant system or piece of equipment alarmed even though the system or equipment is still functioning normally? Section 7, paragraph 7.1.18	_____	_____	_____
14. Is alarm filtering used, and if so, is it used only for alarms that have no current operational significance? Section 7, paragraph 7.1.20	_____	_____	_____
15. Is alarm suppression used, and if so, is it used in compliance with the requirements of Section 7, paragraph 7.1.21?	_____	_____	_____
VISUAL ALARMS			
16. Are visual alarms in compliance with the requirements of Section 7, paragraph 7.2.1 as for types of visual alarms allowed?	_____	_____	_____
17. Are the flash rates of flashing alarm lights between 3 and 5 Hz? Section 7, paragraph 7.2.2	_____	_____	_____
18. Under normal operating conditions are no visual alarms illuminated? Section 7, paragraph 7.2.3	_____	_____	_____
19. Are visual alarms coded (preferably by color)? Section 7, paragraphs 7.2.4 and 7.2.9 (Table 8)	_____	_____	_____
20. If a flashing alarm fails is it immediately identified? Section 7, paragraph 7.2.5	_____	_____	_____
21. Is the text that is placed on the face of a visual alarm annunciator readable whether or not the alarm is lit? Section 7, paragraph 7.2.7	_____	_____	_____
22. Is the text presented on visual alarms in compliance with the labeling requirements in Section 15? Section 7, paragraph 7.2.8	_____	_____	_____
23. Are visual alarms color coded in accordance with Section 7, paragraph 7.2.9 and Table 8?	_____	_____	_____
24. Are visual alarms always provided in conjunction with audible alarms in all spaces that exceed the noise limit of 85 dBA? Section 7, paragraph 7.2.10	_____	_____	_____
25. Are visual alarm panels designed as required in Section 7, paragraph 7.2.11?	_____	_____	_____
AUDIBLE ALARMS			
26. Are audible alarms the primary mode of alerting personnel to major general emergencies? Section 7, paragraph 7.3.1	_____	_____	_____
27. Was the selection of loudness, frequency, and use of wave form in compliance with the requirements of Section 7, paragraph 7.3.3 (Table 9)?	_____	_____	_____
28. Is the number of distinct tones used for ship or structure-wide alarms set at a maximum of 7, but 4 preferred? Section 7, paragraph 7.3.4	_____	_____	_____
29. Is the number of audio signals used for relative identification limited to 12? Section 7, paragraph 7.3.5	_____	_____	_____
30. Are audible signals used as alarms clearly and distinctly different than any other tone heard by the crew? Section 7, paragraph 7.3.7	_____	_____	_____
31. Was the selection of sounds used for alarms based on Section 7, paragraph 7.3.8 (Table 10)?	_____	_____	_____
32. Do the alarms used at local control panels or consoles to alert the operator that an equipment or system is out-of-tolerance consist of a siren (for dangerous situations) or a horn (for caution level hazards)? Section 7, paragraph 7.3.9	_____	_____	_____
33. Do persons who normally wear headsets covering both ears receive the audible alarms in their headsets? Section 7, paragraph 7.3.10	_____	_____	_____
34. Are the sound loudness levels for alarms in compliance with the requirements contained in Section 7, paragraph 7.3.11?	_____	_____	_____

TABLE X2.1 *Continued*

	Yes	No	NA
35. Is the loudness of audible tone alarms adjustable and is the method of adjustment restricted and administratively controlled? Section 7, paragraph 7.3.12	_____	_____	_____
36. Is there a provision to reset alarms, either automatically or manually in accordance with Section 7, paragraph 7.3.14?	_____	_____	_____
37. Are audible alarms coded to distinguish between alarm categories, types, or severity? Section 7, paragraph 7.3.17	_____	_____	_____
38. If audible alarms are coded does the number of different codes comply with the requirements of Section 7, paragraph 7.3.17?	_____	_____	_____
39. Is a Public Address (PA) system used with the alarm system and if so does it meet the design requirements defined in Section 7, paragraph 7.3.20?	_____	_____	_____
VOICE MESSAGES			
40. Are voice messages incorporated into all ship and structure-wide alarms in compliance with Section 7, paragraph 7.4.1?	_____	_____	_____
41. Is the voice alarm intensity in accordance with the requirements described in Section 7, paragraph 7.4.3	_____	_____	_____
42. Is the voice alarm message structure in compliance with the requirements of Section 7, paragraph 7.4.4?	_____	_____	_____
43. Are certain words avoided in verbal alarm messages in accordance with the requirements of Section 7, paragraph 7.4.5?	_____	_____	_____
ALARM INITIATION STATIONS			
44. Are the alarm initiation stations located throughout the ship or structure in compliance with Section 7, paragraph 7.5.1?	_____	_____	_____
45 Are alarm initiation stations designed in accordance with the requirements of Section 7, paragraph 7.5.2?	_____	_____	_____
IMO REQUIREMENTS			
46. Are audible alarm requirements instituted by IMO included in the alarm system design? Section 7, paragraph 7.6.1	_____	_____	_____
SECTION 8 CONTROL-DISPLAY-ALARM INTEGRATION			
1. Are controls located under, or to the right of, their associated displays and positioned so that neither the control nor the operator's hand obscures the display? Section 8, paragraph 8.1.1	_____	_____	_____
2. Are local control/displays (such as a motor controller or gauge board, or both) associated with a specific piece of equipment (for example, pump, filter, heater, etc.) located above or immediately adjacent to the equipment so it is visually obvious that the equipment, control and display are all functionally related? Section 8, paragraphs 8.1.2, 8.7.1 (Fig. 44), and 8.7.2 (Fig. 45)	_____	_____	_____
3. Where a control, display, and alarm are provided for a particular piece of equipment or system are the three arranged as defined in Section 8, paragraphs 8.1.3, 8.5.1 (Fig. 38), and 8.5.4 (Fig. 41)?	_____	_____	_____
4. Is the relationship between a display and its associated alarm indicator as described in Section 8, paragraph 8.1.4?	_____	_____	_____
5. Is the direction of a control movement consistent with the movement of its associated display, equipment, or vessel (for example, does a CW turn of a rotary knob cause a CW movement of the dial on a gauge associated with the rotary control)? Section 8, paragraphs 8.1.5 and 8.6 (Fig. 43)	_____	_____	_____
6. Are groupings of controls, displays, alarms visually separated? Section 8, paragraphs 8.1.6 and 8.3 (Figs. 34-37)	_____	_____	_____
7. Are controls, displays and alarms labeled in accordance with Section 15? Section 8, paragraph 8.1.7	_____	_____	_____
8. Are controls, displays, and alarms color coded? Section 8, paragraph 8.1.8	_____	_____	_____
9. Where a large number of controls and displays exist does their location and arrangement identify which control is associated with which display? Section 6, paragraph 6.1.10	_____	_____	_____
10. If a horizontal row of displays must be associated with a vertical row of controls, are they related in accordance with the requirements of Section 8, paragraph 8.1.11?	_____	_____	_____
11. If controls or displays are used by more than one person at a time are they arranged and placed for that purpose? Section 8, paragraph 8.1.12	_____	_____	_____
12. Where controls and displays are used on similar identical systems located in different locations in the same compartment, or in different compartments, are the controls and displays arranged in the same spatial relationship at each installation? Section 8, paragraphs 8.1.13, and 8.7.3 (Fig. 46)	_____	_____	_____
13. When both lighted annunciators and pushbuttons are used together is one of them coded (for example, shape, color, size) so it is visually obvious to the operator that one can be pushed (that is, pushbutton) and one cannot (that is, annunciator)? Section 8, paragraph 8.1.14	_____	_____	_____

TABLE X2.1 *Continued*

	Yes	No	NA
14. Are controls, displays, and alarms arranged in a group as defined in Section 8, paragraph 8.2 (Fig. 29, Fig. 30, Fig. 32, and Fig. 33)?	_____	_____	_____
15. Are mirror image arrangements of controls and displays eliminated? Section 8, paragraph 8.2.4 (Fig. 31)	_____	_____	_____
16. Are displays that show IN and OUT values arranged with the IN display on the left or top (preferred)? Section 8, paragraph 8.4.1	_____	_____	_____
17. Are controls or displays for ON and OFF, STOP and START, OPEN and CLOSE arranged as shown in Section 8, paragraph 8.4.1?	_____	_____	_____
18. If alarm lights are provided to show a high and low condition is the high alarm light located above, or to the right of, the low alarm light? Section 8, paragraph 8.4.1	_____	_____	_____
19. If an alarm matrix is used does it comply with the requirements of Section 8, paragraph 8.5.2?	_____	_____	_____
20. Are multiple controls and displays grouped in the same row arrangements? Section 8, paragraph 8.5.3 (Figs. 39 and 40)	_____	_____	_____
21. Does the positional relationship between controls and their related displays and alarms comply with the requirements shown in Section 8, paragraph 8.5 (Figs. 38-42)?	_____	_____	_____
22. Does the location and arrangement of controls and displays match the actual location and arrangement of the equipment (that is, is there a spatial relationship between the controls and displays and the actual equipment)? Section 8, paragraph 8.7.4 (Fig. 47)	_____	_____	_____
23. Are mimic displays designed and arranged in accordance with the requirements of Section 8, paragraph 8.8.1 (Figs. 48 and 49)?	_____	_____	_____
24. Are the controls and displays on the bridge integrated in accordance with the requirements contained in Section 8, paragraph 8.9.1?	_____	_____	_____
SECTION 9 ANTHROPOMETRY			
1. Are all designs involving human postures, or that have operators or maintainers working in environments requiring protective clothing or equipment, completed in accordance with Section 9, paragraph 9.1.1 (Table 11)?	_____	_____	_____
2. Do all designs provide for operation and maintenance by the 5th % female to the 95th % male of whatever user population is expected to crew the ship or maritime structure? Section 9, paragraph 9.1.2	_____	_____	_____
3. Were the designs altered to fit a special user population? Section 9, paragraph 9.1.3	_____	_____	_____
4. Were just the anthropometric data that set the design limits used in the design process? Section 9, paragraph 9.1.4	_____	_____	_____
5. Were the data used from Section 9, paragraph 9.2.1 (Figs. 50-54) for user populations from North America, UK, and Central Europe?	_____	_____	_____
6. Were the appropriate data used from Section 9, paragraphs 9.2.4 through 9.2.8, (Tables 13-17) when the user population was known to come from a geographical region other than those listed in #5 above?	_____	_____	_____
7. When data was taken from the figures and tables was it applied like the example given in Section 9, paragraph 9.2.2?	_____	_____	_____
SECTION 10 WORKPLACE ARRANGEMENTS			
GENERAL REQUIREMENTS			
1. Is the workplace designed to fit the full range of potential workers who may occupy the area (that is, 5th % to 95th % persons)? Section 10, paragraph 10.1.1	_____	_____	_____
2. If women are expected to be in the crew, is the workplace designed to fit the 5th % female? Section 10, paragraph 10.1.1	_____	_____	_____
3. Does the workplace provide for the operator/maintainer wearing special clothing (for example, winter coats) or special equipment (for example, air breathing bottles)? Section 10, paragraph 10.1.1	_____	_____	_____
4. Are guards provided around all safety hazards (for example, rotating equipment, hot or cold surfaces, electric contacts)? Section 10, paragraph 10.1.3	_____	_____	_____
5. Are all flushing, draining, and venting discharges located so as not to be a safety hazard to personnel or equipment? Section 10, paragraph 10.1.4	_____	_____	_____
6. Are large pieces of equipment that are mounted on skid packages located at the edge of the skids for ease of access for maintenance? Section 10, paragraph 10.1.5	_____	_____	_____
7. Are changes in walking surface elevations held to the absolute minimum, and all changes that are made in excess of 10 mm (⅜ in.) clearly marked? Section 10, paragraph 10.1.6	_____	_____	_____
8. Are walking surfaces slip resistant? Section 10, paragraph 10.1.7	_____	_____	_____

TABLE X2.1 *Continued*

	Yes	No	NA
9. Can all controls be reached, and displays read, from the operator's normal work position(s) without the operator having to assume awkward, uncomfortable, or unsafe body positions? Section 10, paragraph 10.1.8	_____	_____	_____
10. Are workplaces designed to prevent or curtail interferences among personnel during operations and maintenance? Section 10, paragraph 10.1.9	_____	_____	_____
11. Are pull spaces provided for equipment removal sized to provide room for the equipment, personnel, tools, lifting equipment, and laydown area? Section 10, paragraph 10.1.10	_____	_____	_____
SEATED WORK POSITIONS			
12. Are seated desk-type work stations designed in accordance with the requirements defined in Section 10, paragraph 10.2.2 (Fig. 57, Table 19)?	_____	_____	_____
13. Are seated computer workstations designed in compliance with the requirements of Section 10, paragraph 10.2.4 (Fig. 58, Table 20)?	_____	_____	_____
14. Are single and multiple person seated table-type workstations designed in accordance with the requirements of Section 10, paragraph 10.2.5 (Fig. 59)?	_____	_____	_____
15. Are seated CRT workstations designed in compliance with Section 10, paragraph 10.2.7 (Fig. 60)?	_____	_____	_____
16. Are items to be reached overhead from a seated position within the limits shown in Section 10, paragraph 10.2.8?	_____	_____	_____
17. Are clearances provided behind seated workstations in compliance with the requirements shown in Section 10, paragraph 10.2.9 (Fig. 61)?	_____	_____	_____
18. Do the mounting heights for controls and displays mounted on bulkheads, walls, or other vertical surfaces for a seated operator comply with the requirements as shown below:	_____	_____	_____
18.1 Controls: Section 10, paragraph 10.2.10 (Fig. 62)?	_____	_____	_____
18.2 Displays: Section 10, paragraph 10.2.11 (Fig. 63)?	_____	_____	_____
STANDING WORK POSITIONS			
19. Are windows used for viewing by standing operators in compliance with the requirements of Section 10, paragraph 10.3.1?	_____	_____	_____
20. Do the mounting heights for controls and displays, and overhead reach, for a standing operator comply with the requirements shown below:	_____	_____	_____
20.1 Controls: Section 10, paragraph 10.3.3 (Fig. 64)?	_____	_____	_____
20.2 Displays: Section 10, paragraph 10.3.4 (Fig. 65)?	_____	_____	_____
20.3 Overhead reach: Section 10, paragraph 10.3.2 (Table 21)?	_____	_____	_____
KNEELING WORK POSITIONS			
21. Are the mounting heights for controls and displays mounted on bulkheads, walls, or other vertical surfaces for a kneeling operator in compliance with:	_____	_____	_____
21.1 Controls: Section 10, paragraph 10.4.1 (Fig. 66)?	_____	_____	_____
21.2 Displays: Section 10, paragraph 10.4.2 (Fig. 67)?	_____	_____	_____
22. Is the clear area provided for a kneeling worker in compliance with Section 10, paragraph 10.4.3 (Fig. 68)?	_____	_____	_____
SQUATTING WORK POSITIONS			
23. Are the mounting heights for controls and displays mounted on bulkheads, walls, or other vertical surfaces for a squatting operator in compliance with:	_____	_____	_____
23.1 Controls: Section 10, paragraph 10.5.1 (Fig. 69)	_____	_____	_____
23.2 Displays: Section 10, paragraph 10.5.2 (Fig. 70)	_____	_____	_____
24. Is the clear area for a squatting worker in accordance with Section 10, paragraph 10.5.3 (Fig. 71)?	_____	_____	_____
SHELVING			
25. Are shelves installed in offices, warehouses, storage rooms, accommodations, and all other spaces in compliance with the requirements shown in Section 10, paragraph 10.6 (Figs. 72-75)?	_____	_____	_____
STATUS BOARDS AND FILING CABINETS			
26. Are status boards mounted as required in Section 10, paragraph 10.7.1 (Fig. 76)?	_____	_____	_____
27. Is the clearance in front of filing cabinets in compliance with Section 10, paragraph 10.7.2 (Fig. 77)?	_____	_____	_____

TABLE X2.1 *Continued*

	Yes	No	NA
28. Are filing cabinets located so the drawers open either fore or aft? Section 10, paragraph 10.7.2 (Fig. 77)	_____	_____	_____
WORK BENCHES			
29. Are work benches designed in accordance with the requirements contained in the following paragraphs for:	_____	_____	_____
29.1 Seated work bench dimensions: Section 10, paragraph 10.8.1?	_____	_____	_____
29.2 Standing work bench dimensions: Section 10, paragraph 10.8.2 (Fig. 78)	_____	_____	_____
29.3 Orientation of benches: Section 10, paragraph 10.8.3	_____	_____	_____
29.4 Location of benches: Section 10, paragraph 10.8.4	_____	_____	_____
STRAINERS & FILTERS			
30. Are vertical strainers and filters designed in accordance with the requirements contained in Section 10, paragraphs 10.9.1 through 10.9.4?	_____	_____	_____
REACH LIMITS AT WORKSTATIONS			
31. Are safe reach limits over obstacles at all workstations kept within the dimensions shown in Section 10, paragraph 10.10 (Fig. 79)?	_____	_____	_____
MISCELLANEOUS EQUIPMENT			
32. Are eyewash stations and fountains located and designed in accordance with the requirements shown in Section 10, paragraphs 10.11.1 through 10.11.3?	_____	_____	_____
33. Are pedestal mounted controls and displays designed in accordance with Section 10, paragraphs 10.12.1 through 10.12.3?	_____	_____	_____
34. Are hand cranks and pumps designed and mounted in compliance with the requirements defined in Section 10, paragraphs 10.13.1 through 10.13.3?	_____	_____	_____
35. Are bulkhead mounted equipment located in passageways kept clear of the areas shown in Section 10, paragraph 10.14.1 (Fig. 80)?	_____	_____	_____
36. Are bulkhead mounted electrical equipment placed at the right heights as shown in Section 10, paragraph 10.14.2 (Fig. 81)?	_____	_____	_____
37. Are equipment racks and cabinets located in accordance with the requirements of Section 10, paragraphs 10.15.1 through 10.15.3?	_____	_____	_____
CONSOLES AND PANELS			
38. Are all consoles and control panels in compliance with Section 10, Section 10.16 (Figs. 82-90)?	_____	_____	_____
39. Are control panels or consoles located, oriented, and laid out so the controls and displays seen by the operator as he or she faces the panel or console bear a direct relationship to the location of the actual equipment on the platform or in the plant (that is, are controls and displays on the left side of the panel or console related to the actual equipment which is to the left side of the operator as he or she faces the panel or console)? Section 10, paragraph 10.16.1 (Fig. 82)	_____	_____	_____
40. Are local control panels or consoles for multiple copies of the same type of equipment (for example, three sewage treatment pumps each mounted on its own skid or two diesel generators each housed in a separate enclosure) positioned in the same location and mounted in the same orientation at each piece of equipment? Section 10, paragraph 10.16.2	_____	_____	_____
41. If a console is oriented athwartship to monitor or control equipment or systems that run fore and aft, are the controls and displays and alarms designed and arranged in accordance with the requirements shown in Section 10, paragraph 10.16.3 (Fig. 83)?	_____	_____	_____
42. Are consoles or control panels provided as a part of a package (for example, from a vender furnished skid) located so the controls and displays on the console or panel are spatially-related when viewed by the operator? Section 10, paragraph 10.16.4?	_____	_____	_____
43. Is the viewing distance from the operator's eyes to the console or panel face in compliance with the requirements of Section 10, paragraph 10.16.6?	_____	_____	_____
44. Are vertical panels or consoles provided for seated operators designed and arranged in accordance with the requirements in Section 10, paragraph 10.16.5 (Fig. 84), paragraph 10.16.7 (Figs. 85 and 86), and paragraph 10.16.8 (Fig. 88)?	_____	_____	_____
45. Are vertical panels or consoles provided for standing operators designed and arranged in accordance with the requirements shown in Section 10, paragraph 10.16.8 (Fig. 87), paragraph 10.16.9 (Fig. 89), and paragraph 10.16.10 (Fig. 90)?	_____	_____	_____
46. Are console or control panels associated with control or monitoring of propulsion equipment, navigation (including chart tables), and steering (on the bridge and aft steering stations) shall be designed and installed so the operator faces forward? Section 10, paragraph 10.16.11	_____	_____	_____

TABLE X2.1 *Continued*

	Yes	No	NA
47. Are consoles or control panels associated with auxiliary machinery such as service generators, pumps, mooring winches, and thrusters that could appear in multiple spaces or rooms, located, arranged, and oriented in relation to their equipment(s) in the same manner in each space where they appear? Section 10, paragraph 10.16.12	_____	_____	_____
48. Has design requirements specific to a bridge contained in the ABS "Guidance Notes on Ergonomic Design of Navigation Bridges" been incorporated into the ship or maritime structure design? Section 10, paragraph 10.17.1	_____	_____	_____
SECTION 11 ACCESS AIDS (STAIRS, LADDERS, WALKWAYS, RAMPS, HANDRAILS, PLATFORMS, OPENINGS)			
GENERAL REQUIREMENTS			
1. Are stairs, ladders, or ramps provided for any change in walking surface elevation in excess of 305 mm (12 in.)? Section 11, paragraph 11.1.1	_____	_____	_____
2. Are stairs provided in compliance with the requirements shown in Section 11, paragraph 11.1.2 (i)?	_____	_____	_____
3. Are ramps provided in compliance with the requirements shown in Section 11, paragraph 11.1.2 (ii)?	_____	_____	_____
4. Has the final selection of vertical access devices provided been in compliance with requirements of Section 11, paragraph 11.1.3 (Table 22)?	_____	_____	_____
5. Do emergency escape devices comply with the requirements shown in Section 11, paragraph 11.1.4?	_____	_____	_____
STAIRS			
6. Does the angle of inclination of each stair fall between 30 and 50° with 38° preferred? Section 11, paragraph 11.2.1	_____	_____	_____
7. Do stair dimensions agree with Section 11, paragraph 11.2.3 (Fig. 91) (Table 23)?	_____	_____	_____
8. For each run of stairs are the riser heights and tread depths dimensions consistent? Section 11, paragraph 11.2.3.1	_____	_____	_____
9. Are leading edges of each stair tread colored in compliance with the requirements of Section 11, paragraph 11.2.3.2?	_____	_____	_____
10. Do stair treads have a coefficient of friction (COF) of 0.6 or greater measured when wet? Section 11, paragraph 11.2.4	_____	_____	_____
11. Is the top tread of the stair flush with the walking surface at the top? Section 11, paragraph 11.2.5	_____	_____	_____
12. Do stairs run fore and aft where possible? Section 11, paragraph 11.2.7	_____	_____	_____
13. Do stair widths comply with the requirements shown in Section 11, paragraph 11.2.8 (Table 24)?	_____	_____	_____
14. Are overhead clearances above stairs at least 2032 mm (80 in.) and 2134 mm (84 in.) preferred? Section 11, paragraph 11.2.9 (Fig. 91)	_____	_____	_____
15. Do stair landings comply with the requirements shown in Section 11, paragraph 11.2.10?	_____	_____	_____
16. Are stair railings and handrails provided as required in Section 11, paragraphs 11.2.11 through 11.2.11.2 (Table 25)?	_____	_____	_____
17. Are retractable rigid handrails provided for stairs that end at an upper deck where the stair opening can be blocked under certain battle conditions by a closed hatch? Section 11, paragraph 11.2.11.3	_____	_____	_____
19. Do individual steps comply with the design requirements shown in Section 11, paragraph 11.2.12?	_____	_____	_____
20. Are spiral stairs used only on tanks or other round structures whose diameter is 2.44 m (8 ft) or greater? Section 11, paragraph 11.2.13	_____	_____	_____
21. Are removable stairs provided where open stairwells are required for equipment removal except for stairs that are required for means of egress in an emergency? Section 11, paragraph 11.2.14	_____	_____	_____
RAMPS			
22. Do ramps comply with the design requirements shown in Section 11, paragraph 11.3.1 (Table 26)	_____	_____	_____
23. Are ramps used for personnel movement 914 mm (36 in.) wide minimum, 1219 mm (48 in.) preferred? Section 11, paragraph 11.3.2	_____	_____	_____
24. Are ramp railings and handrails in compliance with the requirements shown in Section 11, paragraph 11.3.3?	_____	_____	_____
25. Do ramps that have landings comply with the requirements of Section 11, paragraph 11.3.4 (Figs. 92-94)?	_____	_____	_____
26. Are ramps in excess of 5° angle of inclination provided with non-skid surfaces, and ramps in excess of 10° provided with cleats in accordance with Section 11, paragraph 11.3.5?	_____	_____	_____
27. Do ramp walking surfaces have a coefficient of friction (COF) of 0.6 or greater measured when wet? Section 11, paragraph 11.3.5	_____	_____	_____
VERTICAL LADDERS			

TABLE X2.1 *Continued*

	Yes	No	NA
28. Are all vertical ladders built in compliance with the general design requirements shown in Section 11, paragraph 11.4.1 (Fig. 95)?	_____	_____	_____
29. Are all ladder rungs in compliance with the requirements contained in Section 11, paragraphs 11.4.2 and 11.4.3 (Fig. 95)?	_____	_____	_____
30. Do ladder stringers comply with the requirements shown in Section 11, paragraph 11.4.4 (Fig. 95)?	_____	_____	_____
31. Is the maximum height of each ladder run less than 9.14 m (30 ft)? Section 11, paragraph 11.4.5	_____	_____	_____
32. Are all vertical ladders that require a step-through entrance/exit on or off the ladder at the top equipped with a self-closing gate? Section 11, paragraph 11.4.6	_____	_____	_____
INTERMEDIATE PLATFORMS			
33. Are intermediate platforms provided for use with vertical ladders designed in compliance with Section 11, paragraphs 11.4.7 through 11.4.7.4 (Figs. 96 and 97)	_____	_____	_____
VERTICAL LADDER–SAFETY CAGES			
34. Are vertical ladders in excess of 4.57 m (15 ft) in height equipped with safety cages? Section 11, paragraph 11.5.1	_____	_____	_____
35. Are safety cages designed in accordance with the requirements shown in Section 11, paragraphs 11.5.1 and 11.5.2 (Figs. 98 and 99)?	_____	_____	_____
VERTICAL LADDERS–POSITIVE FALL PROTECTION DEVICES			
36. Are vertical ladders in excess of 6.1 m (20 ft) in height equipped with positive fall protection devices? Section 11, paragraph 11.6.1	_____	_____	_____
37. Are vertical ladders equipped with positive fall protection devices designed in compliance with the dimensions shown in Section 11, paragraph 11.6.2 (Fig. 100)?	_____	_____	_____
38. Are the positive fall protection devices in compliance with one of the three types described in Section 11, paragraph 11.6.3?	_____	_____	_____
SPECIAL LADDER REQUIREMENTS			
39. Are vertical ladders located within 1829 mm (72 in.) from the edge of a deck that is higher than 610 mm (24 in.) above an adjacent surface equipped with special handrail fall protection as described in Section 11, paragraph 11.7.1 (Figs. 101-104)?	_____	_____	_____
HANDLES/HANDGRABS			
40. Are handles and hand grabs designed and installed in compliance with the requirements contained in Section 11, paragraph 11.8.1 (Figs. 105 and 106)?	_____	_____	_____
INDIVIDUAL LADDER RUNGS			
41. Do individual ladder rungs attached to bulkheads or other vertical surfaces comply with size and spacing requirements shown in Section 11, paragraph 11.9.1 (Fig. 107)?	_____	_____	_____
D-RING LADDERS			
42. Do D-Ring ladders comply with the size and spacing requirements shown in Section 11, paragraph 11.10.1 (Fig. 108)?	_____	_____	_____
43. Are D-Ring ladders used only when no other means of change in vertical elevation is possible? Section 11, paragraph 11.10.1	_____	_____	_____
HANDRAILS			
44. Are handrails provided at open sides of standing or walking surfaces designed in compliance with the requirements shown in Section 11, paragraph 11.11 (Figs. 109-112)?	_____	_____	_____
WALKWAYS, PASSAGEWAYS, OTHER MEANS OF PERSONNEL MOVEMENT			
45. Are all walkway widths in compliance with Section 11, paragraph 11.12.1 (Table 27)?	_____	_____	_____
46. Do all walkways, passageways, and all other walking surfaces have a coefficient of friction (COF) of 0.6 or greater measured when wet? Section 11, paragraph 11.12.1	_____	_____	_____
47. Are personnel movement features (for example, passageway clearances with doors open) and alternate means of personnel movement (crawling, sliding) sized in accordance with the requirements of Section 11, paragraph 11.12.2 (Fig. 113, Table 28)?	_____	_____	_____
48. Are T-bitts or other equipment with raised foundations recessed into the deck or protected in some manner from being a tripping hazard? Section 11, paragraph 11.12.4	_____	_____	_____
49. Are access walkways to tanker bows designed in compliance with Section 11, paragraph 11.12.5?	_____	_____	_____
ELEVATED WORK PLATFORMS			
50. Do elevated work platforms conform to the width and depth requirements shown in Section 11, paragraph 11.13.2?	_____	_____	_____

TABLE X2.1 *Continued*

	Yes	No	NA
51. Are handrails provided on all exposed sides of elevated work platforms as required by Section 11, paragraph 11.13.3?	_____	_____	_____
52. Are elevated work platforms located so the work task is at a height above the standing surface as defined in Section 11, paragraph 11.13.4?	_____	_____	_____
ACCESS OPENINGS–HATCHES, LIGHTENING HOLES, MANWAYS, KICK-OUT PANELS, INSPECTION PORTS			
53. Are openings provided for manual access throughout the ship or maritime structure designed, located, and oriented in accordance with the requirements of Section 11, paragraph 11.14 (Figs. 114-116)?	_____	_____	_____
54. Are accesses to bulkhead and overhead escape hatches in compliance with the requirements contained in Section 11, paragraphs 11.14.2 and 11.14.3 (Figs. 117 and 118)?	_____	_____	_____
55. Are raised cargo hold hatches designed for access in accordance with the requirements of Section 11, paragraph 11.14.4 (Fig. 119)?	_____	_____	_____
56. Are emergency kick-out escape panels clearly marked and sized to be at least 737 mm (29 in.) wide and 1016 mm (40 in.) high? Section 11, paragraph 11.14.5	_____	_____	_____
57. Are the design requirements for hatches shown in Section 11, paragraphs 11.14.6 through 11.14.13 met in all hatches?	_____	_____	_____
DOORS AND ARCHES			
58. Do large external doors used for movement of vehicles, helicopters, equipment, cargo contain separate personnel doors? Section 11, paragraph 11.15.1	_____	_____	_____
59. Are door locations near corners placed as shown in Section 11, paragraph 11.15.2 (Fig. 120)?	_____	_____	_____
60. Are doors (non-accommodation type) designed in compliance with the requirements shown in Section 11, paragraphs 11.15.3 through 11.15.9?	_____	_____	_____
PERMANENT MEANS OF ACCESS (PMA)			
61. Are stairs, ladders, walkways, ramps, and other structures provided exclusively for inspection access into cargo holds and tanks of oil tankers and bulk cargo carriers under SOLAS REG II-1/3-6 in compliance with the requirements identified in Section 11, paragraph 11.16.1?	_____	_____	_____
SECTION 12 VALVE PLACEMENT, ORIENTATION, AND DESIGN			
REACH AND ACCESS			
1. Was a valve criticality study completed? Section 12, paragraph 12.2	_____	_____	_____
2. Were the valves placed on the basis of the valve criticality study? Section 12, paragraph 12.2	_____	_____	_____
3. Are all valves located so the operator does not have to stand on adjacent pipes, cabletrays, handrails, equipment, or any surface not meant to specifically be a standing surface to operate, repair, maintain, or replace the valve? Section 12, paragraph 12.1.1	_____	_____	_____
4. Are valves used for emergency operations located so they are not behind a cover or below deck grating? Section 12, paragraph 12.1.3	_____	_____	_____
5. Are valves that weigh more than the manual lifting limits shown in Section 16 located for ease of lifting with lifting aids? Section 12, paragraph 12.1.8	_____	_____	_____
6. If valve handwheels are greater than 150 mm (6 in.) in diameter, are they located so they can be operated with two hands? Section 12, paragraph 12.3.1	_____	_____	_____
7. Are valve handwheel sizes in compliance with the requirements shown in Section 12, paragraph 12.3.3?	_____	_____	_____
8. Are mounting heights for handwheel-operated valves in compliance with the requirements shown in Section 12, Section 12.3.2 for:	_____	_____	_____
8.1 Vertical Stems (Fig. 122)?	_____	_____	_____
8.2 Horizontal Stems (Fig. 123)?	_____	_____	_____
8.3 Angled Stems (Fig. 124)?	_____	_____	_____
9. Are mounting heights for lever-operated valves in compliance with the requirements shown in Section 12, paragraph 12.4 for:	_____	_____	_____
9.1 Vertical Stems, paragraph 12.4.1 (Fig. 125)	_____	_____	_____
9.2 Horizontal Stems, paragraph 12.4.2 (Fig. 126)	_____	_____	_____
10. Are valves that are mounted above the operator's head and oriented parallel to the operator's standing surface: Section 12, paragraph 12.5.1	_____	_____	_____

TABLE X2.1 *Continued*

	Yes	No	NA
10.1 Located at 1955 mm (77 in.) above the walking or standing surface.	_____	_____	_____
10.2 Have handwheels less than 510 mm (20 in.) in diameter?	_____	_____	_____
10.3 Have an operating force of less than 15 N.m. (20 ft-lb)?	_____	_____	_____
11. Are valves that are accessible only from one side mounted so the handles operate as shown in Section 12, paragraph 12.5.3 (Fig. 127)?	_____	_____	_____
12. Are valves near deck level that require operation from a stooped or squatting position in compliance with the requirements shown in Section 12, paragraph 12.5.4 (Fig. 128)?	_____	_____	_____
13. Are valves that are located below the operator's standing surface in compliance with the requirements shown in Section 12, paragraph 12.5.5 (Fig. 129)?	_____	_____	_____
14. Are deck openings provided for operation of below deck valves in compliance with the requirements shown in Section 12, paragraph 12.5.6 (Table 29)?	_____	_____	_____
15. Are valves which must be operated off ladders located and oriented in accordance with the requirements shown in Section 12, paragraph 12.5.7 (Figs. 130-132)	_____	_____	_____
16. Are valve manifolds located and arranged so the valves, as faced by the operator, are spatially related to the valves in the ship or maritime structure? Section 12, paragraph 12.6 (Figs. 133-135)	_____	_____	_____
CLEARANCE			
17. Is there a minimum of 75 mm (3 in.) clearance between the outside rim of a valve handwheel or the end of a valve handle and any obstacle located within the field of travel of the handle or handwheel? Section 12, paragraph 12.1.2	_____	_____	_____
18. Is there sufficient clearance above each valve to pull the operating mechanism or complete all valve maintenance tasks? Section 12, paragraph 12.1.8	_____	_____	_____
19. Are valves set so that the handwheel or handle never protrudes into a walking area during its full length of travel? Section 12, paragraph 12.5.2	_____	_____	_____
ORIENTATION			
20. Do all valve handwheels and levers turn counterclockwise to open the valve and clockwise to close the valve? Section 12, paragraph 12.1.4	_____	_____	_____
21. Are valves that are equipped with valve position indicators installed so the indicator is facing the operator when he or she is operating the valve? Section 12, paragraph 12.1.4	_____	_____	_____
22. Are motorized valves with adjustable pots mounted so the door to the internal compartment opens toward the operator/maintainer? Section 12, paragraph 12.1.6	_____	_____	_____
SECTION 13 HUMAN COMPUTER INTERFACE (HCI)			
1. Does the design of the HCI comply with the general requirements of Section 13, paragraph 13.1?	_____	_____	_____
2. Are the system operations in compliance with Section 13, paragraph 13.2?	_____	_____	_____
3. Are the computer displays designed in accordance with Section 13, paragraph 13.3?	_____	_____	_____
4. Is the display content provided in accordance with the requirements of Section 13, paragraph 13.4?	_____	_____	_____
5. Is coding used to differentiate between items of information in accordance with the requirements of Section 13, paragraph 13.5?	_____	_____	_____
6. Are dynamic displays designed in accordance with Section 13, paragraph 13.6?	_____	_____	_____
7. Are display formats in agreement with the requirements of Section 13, paragraph 13.7?	_____	_____	_____
8. Is tabular data presented in accordance with the requirements of Section 13, paragraphs 13.7.13 through 13.7.13.4?	_____	_____	_____
9. Are textural data displays designed in accordance with Section 13, paragraph 13.8?	_____	_____	_____
10. Are graphic displays provided in compliance with Section 13, paragraph 13.9?	_____	_____	_____
11. If audio displays are provided, do they comply with the requirements of Section 13, paragraph 13.10?	_____	_____	_____
12. Are the data entry functions in compliance with Section 13, paragraph 13.11?	_____	_____	_____
13. Are system response times in compliance with Section 13, paragraphs 13.12.1 through 13.12.1.2 (Fig. 136)?	_____	_____	_____
14. Are interactive control functions provided in accordance with the requirements of Section 13, paragraph 13.12?	_____	_____	_____

TABLE X2.1 *Continued*

	Yes	No	NA
15. Are graphic control functions provided in accordance with Section 13, paragraph 13.13?	_____	_____	_____
16. Are the windows provided in agreement with Section 13, paragraph 13.14 (Fig. 141)?	_____	_____	_____
17. Are menus provided in accordance with Section 13, paragraph 13.15?	_____	_____	_____
18. Are prepared interactive form-filling operations provided in accordance with the requirements of Section 13, paragraph 13.16?	_____	_____	_____
19. Are alarms designed in accordance with the requirements of Section 13, paragraph 13.17?	_____	_____	_____
20. Does the command language for interactive controls comply with the requirements of Section 13, paragraph 13.18?	_____	_____	_____
21. Is feedback information that presents status data, confirmation or verification of actions taken comply with the requirements of Section 13, paragraph 13.19?	_____	_____	_____
22. Do provided prompts conform to Section 13, paragraph 13.20?	_____	_____	_____
23. Are default values provided in accordance with Section 13, paragraph 13.21?	_____	_____	_____
24. Is error management/data protection designed into the system in accordance with the requirements of Section 13, paragraph 13.22?	_____	_____	_____
25. Are data protected from unauthorized use in accordance with the requirements of Section 13, paragraph 13.23?	_____	_____	_____
26. Is on-line assistance provided in accordance with Section 13, paragraph 13.24?	_____	_____	_____
27. Does the software design comply with Section 13, paragraph 13.25?	_____	_____	_____
28. Are data transmission functions integrated with other information-handling functions in accordance with Section 13, paragraph 13.26?	_____	_____	_____
29. Was the selection of an input device done in compliance with Section 13, paragraph 13.27 (Tables 31-35) (Figs. 142 and 143)?	_____	_____	_____
30. Are cursors designed in accordance with Section 13, paragraph 13.28?	_____	_____	_____
31. Are printing operations provided in accordance with the requirements of Section 13, paragraph 13.29?	_____	_____	_____
SECTION 14 HABITABILITY			
1. Are the maximum noise levels in specific spaces in compliance with the requirements of Section 14, paragraph 14.1.1 (Table 36)?	_____	_____	_____
2. Are the maximum permissible daily noise exposure limits in accordance with the requirements of Section 14, paragraph 14.1.2 (Fig. 144)?	_____	_____	_____
3 Do hearing protectors provide noise attenuation levels equal to or greater than those identified in Section 14, paragraph 14.1.3?	_____	_____	_____
4. Are all areas where the noise level exceeds 85 dB(A) treated as “High Noise Areas” in accordance with Section 14, paragraph 14.1.4?	_____	_____	_____
5. Is the hearing protection defined in Section 14, paragraph 14.1.3 (Table 37) provided for all personnel?	_____	_____	_____
6. Is a DANGER hazard warning sign posted at every entrance leading into a “High Noise Area” in accordance with Section 14, paragraph 14.1.5?	_____	_____	_____
7. Are DANGER hazard warning signs posted at all sites where hand tool noise levels exceed 85 dB(A) in accordance with Section 14, paragraph 14.1.6?	_____	_____	_____
8. Are indoor climates in all manned spaces provided in compliance with Section 14, paragraph 14.2 (Fig. 145)?	_____	_____	_____
9. Is lighting provided throughout in accordance with the requirements shown in Section 14, paragraph 14.3 (Tables 38 and 39, and Fig. 146)?	_____	_____	_____
10. Is emergency lighting provided in accordance with Section 14, paragraph 14.3.9?	_____	_____	_____
11. Does whole body vibration remain below 0.4 m/s^2 in the frequency range of 0.5 to 80 Hz in accordance with Section 14, paragraph 14.4.1?	_____	_____	_____
SECTION 15 LABELING			
1. Are labels written for normal operation in the language and orientation of the proposed user population (for example, oriented horizontal and read left-to-right for North American and European seaman)? Section 15, paragraph 15.1.3	_____	_____	_____

TABLE X2.1 *Continued*

	Yes	No	NA
2. Are labels located above, or to the right of, displays or controls, or are they placed so that the operator's hand will not cover the label during operation of the control? Section 15, paragraph 15.1.4	_____	_____	_____
3. Are labels written in capital letters or upper and lower case letters in accordance with Section 15, paragraph 15.1.5?	_____	_____	_____
4. Are curved labels being avoided, especially for equipment labels? Section 15, paragraph 15.1.7	_____	_____	_____
5. Are labels made of black characters on a white background, except for when low ambient light levels and dark adaptation is required? Section 15, paragraph 15.1.8	_____	_____	_____
6. Are label characters and numerals design criteria used in accordance with Section 15, paragraph 15.1.10?	_____	_____	_____
7. Are pre-installed labels in the proper orientation after being placed in the finished construction? Section 15, paragraph 15.1.12	_____	_____	_____
8. Is irrelevant information being kept off the display faces? Section 15, paragraph 15.1.13	_____	_____	_____
9. Are label groups held to less than three in any one grouping? Section 15, paragraph 15.1.14	_____	_____	_____
10. Are abbreviations selected, created, and used in accordance with the requirements contained in Section 15, paragraph 15.2?	_____	_____	_____
11. Are all symbols used in labels in compliance with the requirements of Section 15, paragraph 15.3 (Fig. 148)?	_____	_____	_____
12. Do component identification labels comply with Section 15, paragraph 15.4 (Fig. 149)?	_____	_____	_____
13. Is the relationship between controls and control labels in compliance with the requirements of Section 15, paragraph 15.4.3 (Fig. 150)?	_____	_____	_____
14. Are control setting labels for multiple controls in accordance with Section 15, paragraph 15.4.5 (Fig. 152)?	_____	_____	_____
15. Are equipment identification labels placed on all equipment used by crew members and are they in compliance with the requirements of Section 15, paragraph 15.5.1 (Table 41)?	_____	_____	_____
16. Are labels in compliance with the design requirements for the number and size of characters for different sized labels as shown in Section 10, paragraph 15.5.2 (Fig. 153)	_____	_____	_____
17. Are mounting locations for identification labels as defined in Section 15, paragraph 15.5.3?	_____	_____	_____
18. Do all identification labels for tanks include the tank volume and contents? Section 15, paragraph 15.5.4	_____	_____	_____
19. Are labels for electrical systems in compliance with Section 15, paragraph 15.6 (Fig. 154)?	_____	_____	_____
20. Are room, compartment, deck space, passageway, void space, and other areas labeled in accordance with Section 15, paragraph 15.7.1?	_____	_____	_____
21. Are pipes marked in accordance with the requirements contained in Section 15, paragraph 15.8 (Figs. 155 and 156; Tables 42-44)?	_____	_____	_____
22. Are safe working load limit labels designed and installed in accordance with the requirements of Section 15, paragraph 15.9?	_____	_____	_____
23. Are weight and center-of-gravity labels placed on items that are heavy and have to be carried or lifted? Section 15, paragraph 15.10	_____	_____	_____
24. Are hazard identification labels prepared and used in compliance with the requirements of Section 15, paragraph 15.11?	_____	_____	_____
25. Are there only two levels of hazards, that is, DANGER and CAUTION? Section 15, paragraphs 15.11.5 and 15.11.6 (Fig. 157)	_____	_____	_____
26. Is the message text on hazard signs in compliance with Section 15, paragraphs 15.11.7 (Fig. 158) and 15.11.8 (Table 45)?	_____	_____	_____
27. Are information signs in compliance with Section 15, paragraph 15.12 (Fig. 159)?	_____	_____	_____
28. Are instruction labels prepared in compliance with the requirements of Section 15, paragraph 15.13?	_____	_____	_____
29. Are graphical schematics or diagrams prepared in compliance with Section 15, paragraph 15.14?	_____	_____	_____
30. Are orientation plans (that is, Safety Plans) prepared in compliance with Section 15, paragraph 15.15?	_____	_____	_____
31. Are emergency instructions in compliance with Section 15, paragraph 15.16.1?	_____	_____	_____

SECTION 16 MATERIAL HANDLING

TABLE X2.1 *Continued*

	Yes	No	NA
1. Has the ship or maritime structure been designed in accordance with the requirements of Section 16, paragraph 16.1.1 to make them suitable for safe and efficient movement of items requiring manual lifting and moving?	_____	_____	_____
2. Has space been provided for rests and stands for equipment storage during operation or maintenance? Section 16, paragraph 16.1.2	_____	_____	_____
3 Do all items that will be manually lifted comply with the weight and size requirements defined in Section 16, paragraph 16.2 (Table 46)?	_____	_____	_____
4. Do all items that must be manually carried comply with the requirements shown in Section 16, paragraph 16.3 (Tables 47 and 48)?	_____	_____	_____
5. Are all handles and grasp points used to lift or carry, or both, items in compliance with the requirements contained in Section 16, paragraph 16.5 (Fig. 160)?	_____	_____	_____
6. Are auxiliary hoisting and carrying devices designed in compliance with Section 16, paragraph 16.6?	_____	_____	_____
7. Is the ship or maritime structure designed and constructed in accordance with the requirements of Section 16, paragraph 16.7 (Figs. 160 and 161) so two-wheeled handcarts and four-wheeled dollies can be used to move loads exceeding the manual lifting and carrying limits?	_____	_____	_____
8. Are cranes that are provided for assisting lifting and moving loads designed and located in accordance with the requirements of Section 16, paragraph 16.8?	_____	_____	_____
SECTION 17 MAINTENANCE			
1. Does the equipment include the appropriate general design requirements defined in Section 17, paragraph 17.1?	_____	_____	_____
2. Does the design emphasize separation of equipment into modules that are independent, interchangeable, and easily replaced? Section 17, paragraph 17.1.1	_____	_____	_____
3. Are parts of the system that must operate continuously capable of undergoing maintenance while operating? Section 17, paragraph 17.1.2	_____	_____	_____
4. Are units that can have partial failures able to operate in a degraded mode while awaiting maintenance? Section 17, paragraph 17.1.4	_____	_____	_____
5. Are large items located so as to limit the damage to smaller components if the large part has to be removed? Section 17, paragraph 17.1.14	_____	_____	_____
6. Are large items of equipment that are skid mounted located near the edge of the skid for easier access and removal? Section 17, paragraph 17.1.14	_____	_____	_____
7. Are items that require rear access provided that access in accordance with the requirements of Section 17, paragraph 17.1.15?	_____	_____	_____
8. Does the design prohibit performance around moving parts as defined in Section 17, paragraph 17.1.18?	_____	_____	_____
9. Are adjustment controls provided for items that are adjusted in accordance with Section 17, paragraph 17.1.19?	_____	_____	_____
10. Are ladders placed so that maintenance tasks are performed by the right hand in accordance with the requirements of Section 17, paragraph 17.2.2?	_____	_____	_____
11. Are masts, and all equipment mounted on them, designed to be maintained from stable platforms instead of a person hanging in a chair? Section 17, paragraph 17.2.3	_____	_____	_____
12. Are rechargeable bottles located and mounted for easy removal in accordance with Section 17, paragraph 17.2.4?	_____	_____	_____
13. Is equipment designed so a working component does not have to be removed to repair or replace a non-working component? Section 17, paragraph 17.2.5	_____	_____	_____
14. Are the physical access requirements defined in Section 17, paragraph 17.2.7 (Tables 49-53) provided at each maintenance task site?	_____	_____	_____
15. Are arm and hand access openings provided for completing maintenance tasks in compliance with Section 17, paragraph 17.2.9 (Tables 54-57)?	_____	_____	_____
16. Are environments provided where maintenance tasks are performed in compliance with the requirements of Section 17, paragraph 17.3?	_____	_____	_____
17. Are the requirements of Section 17, paragraph 17.4 met in terms of lubricating the equipment?	_____	_____	_____
18. Are all cases provided for equipment designed in accordance with Section 17, paragraph 17.6 (Fig. 163)?	_____	_____	_____
19. Do all covers provided over maintenance access openings comply with the requirements of Section 17, paragraph 17.6 (Fig. 164)?	_____	_____	_____

TABLE X2.1 *Continued*

	Yes	No	NA
20. Where fasteners are provided to secure maintenance access covers, do they comply with the requirements of Section 17, paragraph 17.7?	_____	_____	_____
21. Do hatches, manways, lightening holes, or other openings referenced in paragraph 17.6 provide for full-body access to maintenance sites in accordance with the requirements of Section 15, paragraph 15.13?	_____	_____	_____
22. Are equipment designed to facilitate diagnostics and troubleshooting in accordance with the requirements of Section 17, paragraph 17.9?	_____	_____	_____
23. Is the equipment designed to comply with the mounting and installation requirements of Section 17, paragraph 17.11 (Fig. 165)?	_____	_____	_____
24. Are equipment components designed to be interchangeable in compliance with the requirements contained in Section 17, paragraph 17.12?	_____	_____	_____
25. Are electrical wires and cables routed as described in Section 17, paragraph 17.13 (Figs. 166 and 167)?	_____	_____	_____
26. Are the conductors selected and installed in compliance with Section 17, paragraph 17.14?	_____	_____	_____
27. Are connectors selected and installed in compliance with Section 17, paragraph 17.15?	_____	_____	_____
28. Is test equipment selected and used in compliance with Section 17, paragraph 17.16?	_____	_____	_____
29. Are fuses and circuit breakers designed in accordance with the requirements of Section 17, paragraph 17.17?	_____	_____	_____
30. Are hydraulic systems and components designed in compliance with Section 17, paragraph 17.18?	_____	_____	_____
31. Are stored energy devices (for example, springs under tensions or compression, pressurized bottles) designed, labeled, and installed in accordance with the requirements of Section 17, paragraph 17.19?	_____	_____	_____
32. Are pipe flanges, spools, and blinds installed in accordance with the requirements of Section 17, paragraph 17.20?	_____	_____	_____
33. Are test and sample points located for ease of access in accordance with the requirements of Section 17, paragraph 17.21?	_____	_____	_____
SECTION 18 HAZARDS AND SAFETY			
SAFETY SIGNAGE			
1. Are safety signs and markings in compliance with the requirements of Section 18, paragraph 18.1?	_____	_____	_____
2. Has each hazard warning sign been prepared specifically to the particular hazard? Section 18, paragraph 18.1.1	_____	_____	_____
GENERAL WORKPLACE			
3. Are objects not allowed to protrude into overhead clearances above walkways and passageways below 2032 mm (80 in.) minimum, 2134 mm (84 in.) preferred above the walking surface? Section 18, paragraph 18.2.1	_____	_____	_____
4. Are items mounted to the bulkhead (for example, pipe hangers, wireways) not allowed to be located in the areas shown in Section 18, paragraph 18.2.1 (Fig. 169)	_____	_____	_____
5. Are storages racks attached to bulkheads mounted in passageways or walkways located out of the way and without sharp corners or structures protruding into the walking area? Section 18, paragraph 18.2.2	_____	_____	_____
6. Are all hot or cold surfaces that could cause pain or injury when touched by a crewmember insulated or guarded from contact in accordance with the requirements of Section 18, paragraph 18.2.4 (Table 58)?	_____	_____	_____
EQUIPMENT HAZARDS			
7. Do all equipment comply with general safety design requirements shown in Section 18, paragraphs 18.3.1 through 18.3.4?	_____	_____	_____
ELECTRICAL			
8. Are electrical potentials listed in Section 18, paragraph 18.4.1 (Table 59) protected from inadvertent contact by a crewmember?	_____	_____	_____
9. Are electrically associated hazards protected in accordance with the requirements in Section 18, paragraphs 18.4.2 through 18.4.5?	_____	_____	_____
10. Are battery charging or stowage rooms, or both, designed in accordance with the requirements of Section 18, paragraph 18.4.6?	_____	_____	_____
MECHANICAL HAZARDS			
11. Are mechanical safety hazard points (for example, rotating machinery, gears, shafts, blades, or any other hazard points) protected by means of guards designed in accordance with Section 18, paragraph 18.5.1?	_____	_____	_____
FLUID HAZARDS			

TABLE X2.1 *Continued*

	Yes	No	NA
12. Are connectors used in the handling or control of hazardous fluids incompatible with any other connector within the access area of the connector? Section 18, paragraph 18.6.1	_____	_____	_____
13. Are automatic shut-off devices installed on all fluid and fuel service equipment in accordance with the requirements of Section 18, paragraph 18.6.2?	_____	_____	_____
14. Are flammable liquid lockers installed away from egress doors or emergency control stations at least 1524 mm (60 in.)? Section 18, paragraph 18.6.3	_____	_____	_____
SAFETY BARRIERS			
15. Are safety barriers designed and installed in accordance with the requirements of Section 18, paragraph 18.7.1 (Fig. 170)?	_____	_____	_____
FALL PROTECTION			
16. Is fall protection provided from any work area which is in excess of 1524 mm (60 in.) above the deck in accordance with the requirements of Section 18, paragraph 18.8.1?	_____	_____	_____
17. Have provisions been made for the stowage of fall protection harnesses in close proximity to where they will be used [for example, near vertical ladders in excess of 6.1 m (20 ft) in height] in compliance with Section 18, paragraph 18.8.2?	_____	_____	_____
EMERGENCY EGRESS			
18. Are emergency doors and exits designed in accordance with the requirements of Section 18, paragraph 18.9?	_____	_____	_____
SECTION 19 COMMUNICATIONS			
1. Have all of the system requirements in accordance with Section 19, paragraph 19.1.1 been provided?	_____	_____	_____
2. Does the communication equipment operate:	_____	_____	_____
2.1 Optimally in the range of 200 Hz to 6100 Hz? Section 19, paragraph 19.1.2	_____	_____	_____
2.2 Minimally in the range of 250 Hz to 4000 Hz? Section 19, paragraph 19.1.2	_____	_____	_____
3. Do communication systems meet speech intelligibility requirements of Section 19, paragraph 19.1.3 (Table 60)	_____	_____	_____
MICROPHONES			
4. Does the dynamic range of microphones allow variations in signal output of at least 50 dB(A)? Section 19, paragraph 19.2.1	_____	_____	_____
5. Are noise canceling microphones provided in noise environments in excess of 100 dB(A)? Section 19, paragraph 19.2.2	_____	_____	_____
6. Are noise shields provided for microphones in noise areas in excess of 100 dB(A) and do they comply with the requirements defined in Section 19, paragraph 19.2.3?	_____	_____	_____
HEADSETS			
7. Are binaural instead of monaural headsets used in noise environments in excess of 85 dB(A)? Section 19, paragraph 19.3.1	_____	_____	_____
8. Are binaural headsets not used in noise environments less than 85 dB(A) if environmental sounds useful to the operator must be heard? Section 19, paragraph 19.3.2	_____	_____	_____
9. When multiple channels feed into headphones is the system designed to respond uniformly over the frequency range of 100 Hz to 4800 Hz? Section 19, paragraph 19.3.3	_____	_____	_____
10. Are volume and gain controls provided and accessible for each receiving communicating channel? Section 19, paragraph 19.3.4	_____	_____	_____
11. Is a manual ON-OFF switch provided to deactivate squelching during reception of weak signals? Section 19, paragraph 19.3.5	_____	_____	_____
12. When an alarm signal is delivered to a headset that might mask another audio signal is the alarm signal delivered to one ear and the other signal to the other ear? Section 19, paragraph 19.3.7	_____	_____	_____
LOUDSPEAKERS			
13. Are all loudspeakers designed in accordance with the requirements shown in Section 19, paragraph 19.4.1?	_____	_____	_____
TELEPHONE SYSTEMS			
14. Are telephone systems designed in accordance with the requirements of Section 19, paragraph 19.5 that are not otherwise listed in this checklist?	_____	_____	_____
15. Are phone cords positioned to avoid entangling controls or becoming entangled with passing people? Section 19, paragraph 19.5.2	_____	_____	_____
16. If two or more telephones are located close together are they: Section 19, paragraph 19.5.4	_____	_____	_____

TABLE X2.1 *Continued*

	Yes	No	NA
16.1 Color coded by circuit or function?	_____	_____	_____
16.2 Accessible by their priority, frequency of use, or importance?	_____	_____	_____
17. Are volume controls provided for loudness of ring and speaker output on telephones in noise areas in excess of 65 dB(A)? Section 19, paragraph 19.5.6	_____	_____	_____
18. Are telephone booths provided in noise environments in excess of 75 dB(A) located and oriented so the booth opening is facing away from the high noise sources? Section 19, paragraph 19.5.7	_____	_____	_____