Designation: F1166 – 23

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 *ASTM Standards:*[3]

F1646 Terminology Relating to Walkway Safety and Footwear

F2508 Practice for Validation, Calibration, and Certification of Walkway Tribometers Using Reference Surfaces

F2965 Guide for Selection of Walkway Surfaces and Treatments When Considering Aggressive Contaminant Conditions in Commercial and Industrial (Not Including Construction) Environments (Withdrawn 2022)[4]

F3132 Practice for Selection of Walkway Surfaces When Considering Pedestrian Safety

F3539 Practice for Creation of Walkway Tribometer Interlaboratory Study Reports and Test Procedures

2.2 *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

2.3 *Alarms:*

DOT/FAA/HF-STD-001B Ahlstrom, V. (2016). Human Factors Design Standard (HFDS) Atlantic City International

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[4] The last approved version of this historical standard is referenced on www.astm.org.

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.1021(26) Code on Alarms and Indicators

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

ABS Guidance Notes on Ergonomic Design of Navigation Bridges October 2003 (Updated August 2018) Guidance Notes on Ergonomic Design of Navigation Bridges

2.5 *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

2.6 *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

2.7 *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

2.8 *Habitability:*

ABS Guide for Crew Habitability on Ships, February 2016
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

2.9 *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

2.10 *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

2.11 *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

2.12 *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

2.13 *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

2.14 *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)

2.15 *Slip-resistant Walking Surfaces:*

ANSI A326.3 Test Method for Measuring Dynamic Coefficient of Friction of Hard Surface Materials
EN 16165 Determination of slip resistance of pedestrian surfaces – Methods of evaluation
Vessel Sanitation Program 2018 Construction Guidelines U.S. Department of Health and Human Services, U.S. Public Health Service, CDC
SA HB 198:2014 Handbook: Guide to the specification and testing of slip resistance of pedestrian surfaces, Standards Australia

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 *available friction, n*—an inherent characteristic of a walkway surface that would result in measurable friction upon the attempted or actual sliding of another object across that surface; can only be measured using a method, apparatus and contaminant (if any) that have their own inherent influences on the measurement value itself. **F3132**

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

3.1.18.1 *Discussion*—Commonly used in telephones.

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

3.1.20 *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.

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

3.1.22 *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.

3.1.23 *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.

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

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

3.1.26 *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.

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

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

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

3.1.29 *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.

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

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

3.1.31 *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.

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

3.1.33 *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.

3.1.34 *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.

3.1.34.1 *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 an 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.

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

3.1.36 *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.

3.1.37 *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.

3.1.38 *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).

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

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

3.1.40 *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.

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

3.1.42 *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.

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

3.1.44 *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).

3.1.45 *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/π candela per square foot, or 3.426 candela per square metre (the corresponding SI unit).

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

3.1.47 *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.

3.1.48 *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.

3.1.48.1 *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.

3.1.49 *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.

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

3.1.51 *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.

3.1.52 *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.

3.1.53 *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."

3.1.54 *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.

3.1.54.1 *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.

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

3.1.55 *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.

3.1.56 *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.

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

3.1.58 *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.

3.1.59 *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.

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

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

3.1.61 *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.

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

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

3.1.64 *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.

3.1.65 *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.

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

3.1.67 *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.

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

3.1.69 *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.

3.1.70 *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.

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

3.1.71 *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.

3.1.72 *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.

3.1.73 *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.

3.1.73.1 *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.

3.1.74 *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.

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

3.1.76 *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.

3.1.77 *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.

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

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

3.1.79 *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.

3.1.80 *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.

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

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

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

3.1.84 *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.

3.1.85 *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.

3.1.86 *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.

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

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

3.1.89 *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.

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

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

3.1.90.1 *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.

3.1.91 *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.

3.1.92 *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.

3.1.93 *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.

3.1.93.1 *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.

3.1.94 *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.

3.1.95 *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.

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

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

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

3.1.98 *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.

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

3.1.99 *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.

3.1.100 *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).

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

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

3.1.103 *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.

3.1.104 *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.

3.1.105 *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.

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

3.1.107 *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.

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

3.1.109 *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.

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

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

3.1.111 *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.

3.1.112 *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.

3.1.113 *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.

3.1.114 *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.

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

3.1.116 *slip resistance, n*—the relative force that resists the tendency of the shoe or foot to slide along the walkway surface. Slip resistance is related to a combination of factors including the walkway surface, the footwear bottom, and the presence of foreign materials between them. **F1646**

3.1.116.1 *Discussion*—Slip resistance is dependent upon many factors, such as material and condition of the walkway surface, material and condition of the shoe sole or heel material, the physical abilities of the user, the attempted or proposed activities of the user, the presence of any contaminants on any, or both, of the surfaces, and other factors.

3.1.117 *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. **F1646**

3.1.118 *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.

3.1.118.1 *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).

3.1.119 *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.

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

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

3.1.121 *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.

3.1.122 *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.

3.1.123 *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.

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

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

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

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

3.1.128 *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.

3.1.129 *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.

3.1.130 *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.

3.1.131 *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.

3.1.132 *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.

3.1.133 *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.

3.1.134 *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.

3.1.134.1 *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.

3.1.135 *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.

3.1.135.1 *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.

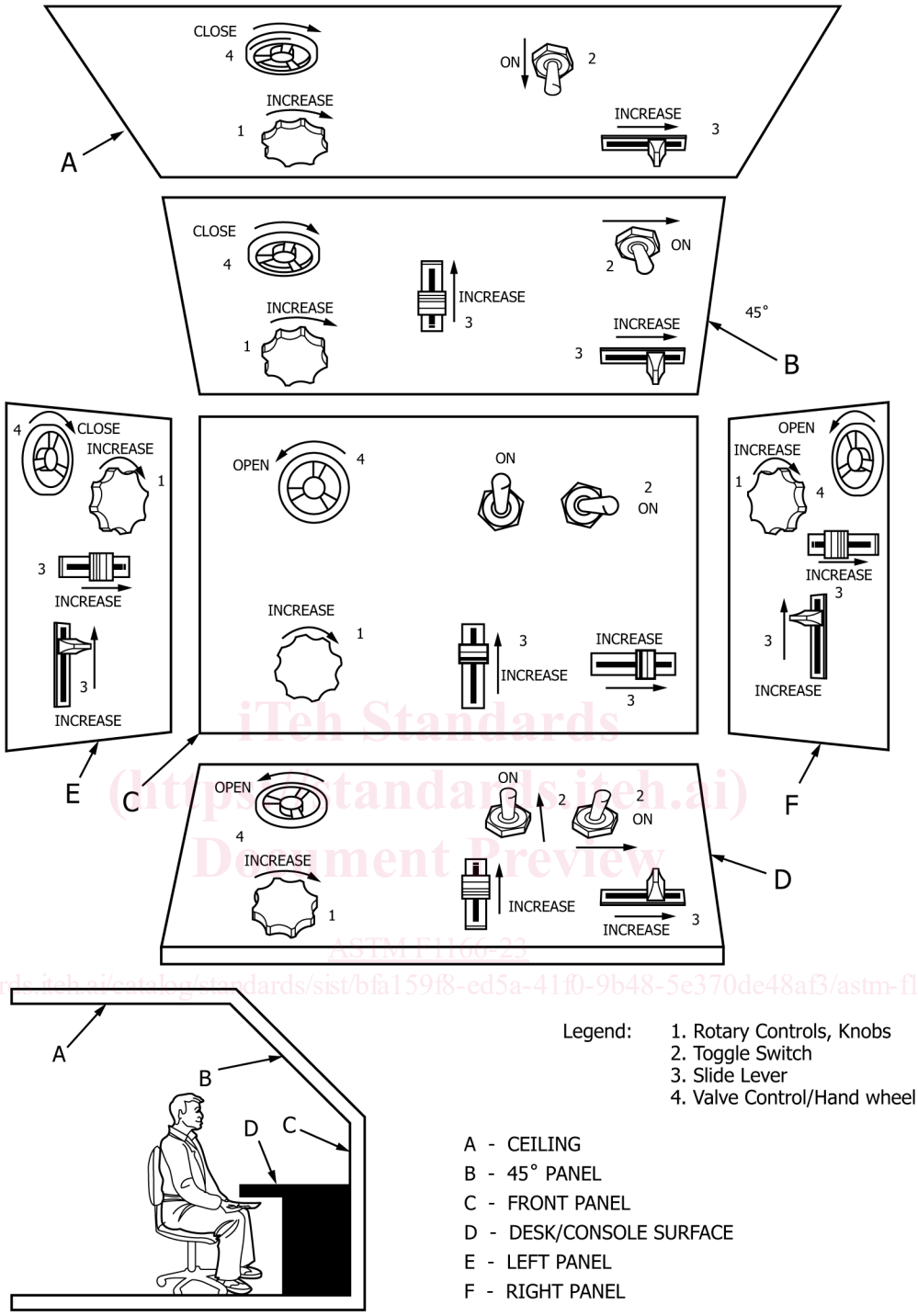


FIG. 1 Control Movement Expectations

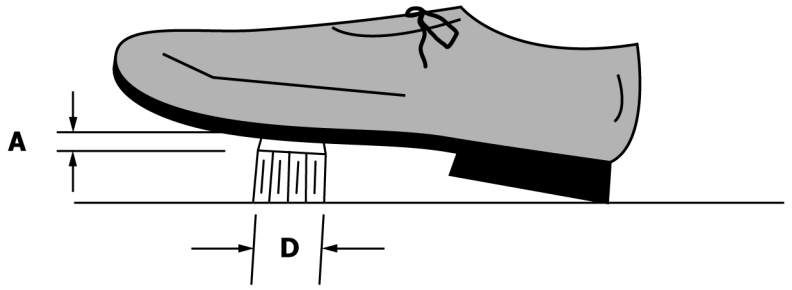
5.1.9.1 *Hidden or Internal Controls*—Hidden or internal controls shall be protected from inadvertent activation or unintentional movement. They shall also be located so the operator cannot come in contact with electrical contacts, hot pipes or other hazards.

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:



	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

5.2.1.1 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.

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.

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