GUIDANCE NOTES ON

THE APPLICATION OF ERGONOMICS TO MARINE SYSTEMS

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Foreword

The maritime industry is increasingly responsive to the important influence the human element has on effective safety standards and practices. With increased attention to human element concerns being paid by organizations such as the United States Coast Guard (USCG), the United Kingdom's Health and Safety Executive (HSE), and the International Maritime Organization (IMO), among others, it is expected that the application of ergonomic data and principles to maritime systems will expand rapidly. This is entirely appropriate since many studies and authorities cite human error as the principal component for a majority of maritime accidents, yet the amount of ergonomic design guidance available to marine architects, designers, and engineers remains sparse. To meet this need, in 1998 ABS initially published its *Guidance Notes on the Application of Ergonomics to Marine Systems*, which underwent revision in 2003. The document has enjoyed an enthusiastic reception by the maritime industry, and many organizations have adopted the Guidance Notes as a design reference. That success is due to the provision of industry-specific, internationally applicable ergonomic principles and criteria.

Since its initial publication, and revision, on-going use and review of the document has led to industry feedback motivating ABS to again revise and update these Guidance Notes. This edition updates the previous Guidance Notes through the inclusion of more recent data and includes new, industry-requested guidance with respect to applications not included in the predecessor Guidance Notes.

This revision to the ABS *Guidance Notes on the Application of Ergonomics to Marine Systems* will continue the promotion, application, and understanding of ergonomic data and principles to vessel and offshore installation design. It is hoped that as these Guidance Notes are used, in concert with human-system interface design processes, they will provide a wide range of information and data needed to integrate humans and systems, and thereby improve personnel performance and safety, and reduce human error.

The ergonomic data and principles contained are provided as guidance. Compliance is not required, although ABS advises designers, owners, and operators to consider adopting this guidance where feasible.

These Guidance Notes become effective on the first day of the month of publication.

Users are advised to check periodically on the ABS website www.eagle.org to verify that this version of these Guidance Notes is the most current.

We welcome your feedback. Comments or suggestions can be sent electronically by email to rsd@eagle.org.

Terms of Use

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THE APPLICATION OF ERGONOMICS TO MARINE SYSTEMS

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SECTION 1 Introduction *(1 August 2013)*

1 General

The importance of the human element in maritime safety is increasingly being recognized by the shipping and offshore communities and is receiving increased levels of attention due to the efforts of organizations such as the United States Coast Guard (USCG), the United Kingdom's Health and Safety Executive (HSE), and the International Maritime Organization (IMO). IMO's primary efforts have concentrated on human element issues relating to management, training, and personnel, as reflected by the *International Management Code for the Safe Operation of Ships and for Pollution Prevention* (the ISM Code) in 1993 and the update of the *International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers* (STCW) in 2012. While organizations like IMO have issued other documents, circulars, and guidelines related to aspects of ergonomics, systematic application of ergonomics in the maritime industry remains limited. This lack of systematic application occurs even though ergonomics has been recognized to be central to improving safety and productivity. These Guidance Notes are intended to promote the application and understanding of ergonomic knowledge to maritime and offshore systems.

Ergonomics (also called human factors engineering) can be defined as follows:

> *Ergonomics is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theoretical principles, data, and methods to design in order to optimize human well-being and overall system performance (International Ergonomics Association, 2012).*

The focus of ergonomics is the design of the human-system interface. This includes interfaces between personnel and the hardware, software, and physical environments associated with systems. It also involves the interfaces between personnel, individual tasks, and the overall work system (e.g., its structure, management, policies, and procedures).

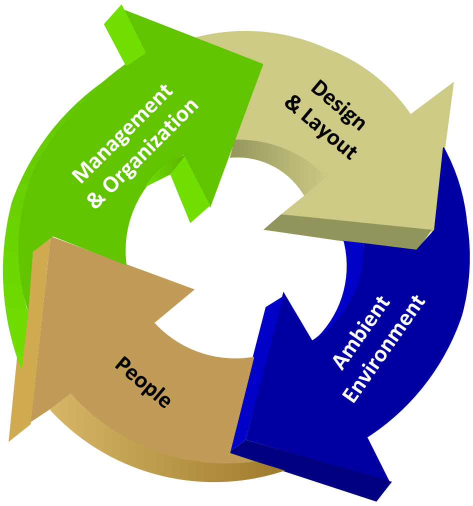
These Guidance Notes introduce important ergonomic principles and criteria that need to be considered during the design of a vessel or offshore installation. A development effort without ergonomic considerations is likely to result in designs that encourage human error. Applying the ergonomic principles and criteria contained in this document within the context of engineering design processes allows for improved safety, productivity, and efficiency. For guidance for vessels or structures operating in cold environments, please see the ABS *Guide for Vessels Operating in Low Temperature Environments.*

Adherence to the ergonomic guidance in this document is recommended, but compliance is not mandatory.

2 The ABS Ergonomics Model: Elements that Enhance Safety

The ABS Ergonomics Model (See Section 1, Figure 1, "ABS Ergonomics Model") encapsulates important elements that affect safety and efficiency in job performance: vessel or offshore installation design and layout considerations, workplace ambient environmental elements, management and organizational issues related to operations, and the personnel who operate the vessel or offshore installation. Insufficient attention to any of these elements may adversely affect safety, productivity, and efficiency. These Guidance Notes primarily address ergonomic design and layout concerns, and to a lesser extent the ambient environment.

FIGURE 1
ABS Ergonomics Model



2.1 Design and Layout Considerations

It is the design and layout aspect of the ABS Ergonomics Model that forms the basis for these Guidance Notes. Design and layout considers the integration of personnel with equipment, systems, and interfaces. Examples of interfaces include: controls, displays, alarms, video-display units, computer workstations, labels, ladders, stairs, and overall workspace arrangement.

2.2 Ambient Environmental Considerations

The ambient environmental aspect of the ABS Ergonomics Model addresses the habitability and occupational health characteristics related to human whole-body vibration, noise, indoor climate, and lighting.

2.3 Considerations Related to People

Personnel readiness and fitness-for-duty are essential for vessel or offshore installation safety. This is particularly so as tasks and equipment increase in complexity, requiring ever greater vigilance, skills, and experience. The following factors should be considered when selecting personnel for a task:

i) Knowledge, skills, and abilities that stem from an individual's basic knowledge, general training, and experience

ii) Maritime-specific or craft-specific training and abilities (certifications and licenses), and vessel or offshore installation-specific skills and abilities

iii) Bodily dimensions and characteristics of personnel such as stature, shoulder breadth, eye height, functional reach, overhead reach, weight, and strength

iv) Physical stamina; capabilities, and limitations, such as resistance to and freedom from fatigue; visual acuity; physical fitness and endurance; acute or chronic illness; and substance dependency

v) Psychological characteristics, such as individual tendencies for risk taking, risk tolerance, and resistance to psychological stress

2.4 Management and Organizational Considerations

This aspect of the ABS Ergonomics Model considers management and organizational considerations that impact safety throughout a system lifecycle. The effective implementation of a well-designed safety policy that includes ergonomics creates an environment that minimizes risks and reflects a good corporate safety culture. Commitment of top management is essential if a safety policy is to succeed.

3 Terminology

Access Aid: A device that makes operation of, or access to, operating or maintenance components possible, or more immediate. For example, a reach rod that extends access to a valve actuator below a deck grating, or a ladder of an access platform.

Accessibility: The ability for personnel to access equipment that requires maintenance, inspection, removal, or replacement while wearing the appropriate clothing, including personal protective equipment, and the ability to use all necessary tools and test equipment.

Accessible Valves: Readily or Immediately Accessible Valves are:

- Located in a space entered without requiring tools or keys
- Clear of obstructions, moving equipment and hot surfaces
- Within operator's reach without requiring use of extenders, ladders, or other access aids

Accommodations: Areas where the primary purpose is to rest or recreate. Accommodations spaces include cabins and staterooms, medical facilities, offices, and public and recreational rooms. Accommodations also include service spaces, such as mess rooms, laundry, storerooms, and workshops.

Active Protection: A safety design or device that actively (or directly) requires a person to take specific actions before a potential loss, for example, donning a fall arrestor fitted to both the ladder and the climber.

Alarm Priority: A predicted assessment of the potential consequence of a condition or situation and the resulting urgency of mitigating responses required of personnel. Generally, the more severe the potential consequence, the higher the alarm priority.

Alarm: A visual and/or audible signal of a condition, or a predetermined out-of-tolerance condition, for machinery, equipment, components, or systems that require attention.

Ambient Environment: Ambient environmental conditions that personnel are exposed to during periods of work, leisure, or rest. Ambient environmental conditions include human whole-body vibration, noise, indoor climate, and lighting.

Anthropometrics: The measurement of human variability of body dimensions and strength as a function of gender, race and regional origin.

Assisted Lifting: The use of devices such as cranes, hoists, counter-balancing mechanisms, trolleys, monorails, come-alongs, padeyes, or A-frames by personnel to perform materials handling tasks.

Audible Alarm: An alarm comprised of tones, verbal messages, or verbal messages preceded by tones. Not all audible alarms are associated with visual alarms.

Auditory Display: A device that provides readings, status or condition of machinery, equipment, or systems operating parameters through the use of sound signals or spoken messages.

Case: The part of equipment that encloses and protects the equipment from its surroundings and protects the surroundings–including personnel–from the equipment.

Cognition: The mental process of knowing, including aspects such as awareness, perception, reasoning, and judgment.

Communications: Human voice communication for a vessel or offshore installation, whether internal or external.

Console: A 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 those individual equipment of systems. Consoles may be freestanding units, and include angled and vertical surfaces.

Continuous Control: A continuous control is an actuator that operates at any point or value along a continuous scale (e.g., engine throttle).

Control: A device an operator or maintainer uses to input a signal or uses to change the operating status of equipment or systems. Examples include switches, knobs, cranks, thumbwheels, levers, keyboards, and foot pedals.

Crew Habitability: The acceptability of vessel or offshore installation conditions in terms of vibration, noise, indoor climate, and lighting as well as physical and spatial characteristics, according to prevailing research and standards for human efficiency and comfort.

Crew Member: Any person on board a vessel, including the Master, who is not a passenger. This term is used interchangeably throughout this document with "seafarer".

Cross-Coupling: The movement of the follower (e.g., cursor or tracking symbol) in the orthogonal direction.

Design Load: The maximum intended load, being the total of all loads including the weight of the personnel, materials, and equipment, including the means of access structure.

Detent Controls: A 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. These types of controls are preferable for machinery equipment or system operation requiring control in discrete steps or different modes.

Discrete Control: A discrete control is an actuator that allows for the selection between two or more mutually exclusive operating functions or points along a scale (e.g., switching a machine ON or OFF, or selecting one of three pumps to run).

Display: Means by which a device presents information to an operator or maintainer, including conventional instrumentation.

Enclosed Space: The interior portions of a vessel where people work and live.

Equipment and Room/Space Identification Label: A type of label used to identify individual equipment, (e.g., valves, gauges, junction boxes, filters, pumps, transmitters, controls, pressure vessels), or spaces (e.g., rooms, buildings, etc.).

Error Control: Exercising control over the probability, frequency, criticality, and recoverability from human error.

Function: The appropriate action of any special components or parts of a system to meet some defined purpose or objective; specific occupation or role, or an assigned duty or activity.

General Emergency Alarms: An alarm given in the case of an emergency to all persons on a vessel or offshore installation. Often, its purpose is to summon personnel to muster stations. These alarms typically sound throughout a vessel or offshore installation and are intended to be heard by all personnel. 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 offshore installation.

Glare: The luminance, or amount of light per unit area emitted or reflected from a surface, within a specific area of the operator's or maintainer's field of view, which is greater than the luminance to which the eye is adjusted compared to the remainder of the field of view.

Graphic Label: A type of label used to present information through line schematics, diagrams, charts, tables, pictures, etc.

Guardrail (or safety rail): Device for protection against accidental fall or accidental access to a hazardous area, with which stairs, step ladders or landings, platforms and walkways, or deck edges and other fall points, may be equipped.

Handle or Handgrab: Bent round bar of various sizes for use above access openings, on miscellaneous access opening covers or on hatch covers.

Handrail: Top element designed to be grasped by the hand for body support which can be used individually or as the upper part of a rail.

Hazard Identification Sign: A type of sign used to identify and provide information about situations that may be hazardous to personnel, equipment, or the environment. There are three types of hazards, "DANGER", "WARNING", and "CAUTION".

Heuristic: A speculative formula or conceptual model that serves as a guide in the investigation or solution of a problem; a "rule of thumb".

Human Task: A piece of work performed; a function performed; an objective.

Human Whole-Body Vibration: Mechanical vibration (or shock) transmitted to the human body as a whole. Human whole-body vibration is often due to the vibration of a surface supporting the body.

Information Label or Placard: A type of label or placard used to present non-procedural information of a general nature.

Instruction Label: A type of label used to present instructions for accomplishing a specific task or tasks, along with any hazard or safety information related to performing the task(s).

Layout: Physical arrangement of the parts and components that make up a module or a unit of equipment.

Maintainability: The ability to carry out maintenance tasks, such as testing, servicing, calibrating, adjusting, removing, replacing or repairing rapidly and effectively in order to allow equipment and systems to achieve a specified level of performance.

Maintenance Item, Critical: Includes those maintenance actions which are system and safety critical, meaning a system critical to the safe operation of the vessel cannot function without that aspect being functional, and moderate to frequent maintenance actions are required. These are referred to as Category 1 maintenance items for maintenance access criticality categorization purposes.

Maintenance Item, Non-Critical: Includes those maintenance actions which are not system critical as defined above but are maintenance actions that are required frequently for the proper operation of the vessel. These are referred to as Category 2 maintenance items for maintenance access criticality categorization purposes.

Maintenance Item, Infrequently Used Non-Critical: Includes those maintenance actions which are considered to be non-critical to system status and safety, and that do not require frequent access. These are referred to as Category 3 maintenance items for maintenance access criticality categorization purposes.

Maintenance: All activities necessary to keep equipment in, or restore it to, a specified level of performance.

Manual Materials Handling: Actions taken by personnel to physically (manually) lift, lower, push, pull, hold, or carry loads.

Manual Valve: A valve that is manually opened by a human operator using a handwheel, lever, chain, extender, or other hand-operated device.

Monitoring: To keep track of systematically with a view to collecting information in order to detect any changes.

Motor Task: Human motion in moving, posturing, and manipulating equipment.

Newton: SI unit of force. One Newton is equal to the amount of net force required to accelerate a mass of one kilogram at a rate of one meter per second squared.

Newton-meters (N-m): SI unit of torque. One Newton-meter is equal to the torque resulting from a force of one Newton applied perpendicularly to a moment arm which is one meter long.

Operating Alarms: Alarms presented within specific operating spaces that are intended to prompt a response by personnel in those spaces.

Operating Torque: The force an operator or maintainer exerts by pushing or pulling on a lever or turning a handwheel.

Panel: Any surface where controls, displays, and/or alarms relating to equipment or system conditions are placed. Panels typically are flat vertical surfaces. Panels are sometimes referred to as control boards.

Passive Protection: A safety design or device that requires a person to take no specific action prior to a potential loss, for example, a safety cage permanently fitted to a ladder. See also "Active protection" above.

Percentile: Given the range of variability of [human] bodily dimensions, anthropometric data are typically expressed as percentile statistics, such as 5th or 95th percentile. A percentile statistic defines the anthropometric point at which a percentage of a population falls above or below that value. 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 that this figure, and 95% will have a lesser seated eye height.

Perception: The acquisition and processing of physical energy and matter to see, hear, taste, smell or feel the environment.

Pipe Marker Labels: Labels with colored markings (e.g., bands of color), text, and flow arrows. These are placed on pipes to identify pipe contents and flow direction.

Pound Force: One pound force is equal to the gravitational force exerted on a mass of one pound on the surface of the Earth.

Reach Rod: A rod for operating a remote valve that would otherwise not be accessible (for example, to operate a valve below a deck grating).

Saturation: The extent to which a chromatic color differs from a gray of the same brightness. It is a measure on an arbitrary scale from 0 percent (gray) to 100 percent.

Seafarer: Any person onboard a vessel, including the Master, who is not a passenger. This term is used interchangeably throughout this document with "crew member".

Shall: Expresses a provision that is mandatory.

Should: Expresses a provision that is recommended or preferred practice.

Situation Awareness: The degree of accuracy by which a person's perception of the current environment reflects reality.

Staffing Levels: The number of personnel who will staff systems during operations. This addresses workload, both immediate (number of tasks that must be performed in a short period of time) and ongoing (work done over the course of a voyage).

Stair: One of a flight or series of steps for going from one level to another, as opposed to a ladder offering two vertical or nearly vertical risers between which rungs forming a means of climbing up or down.

Static Lift: The physical act of a person lifting a load using muscle contraction but no motion. A static lift is also known as an isometric lift.

Task-Based Design: Design of interfaces based on the complexity, sequence, importance and error tolerance of tasks performed at a workstation.

Toeboard: A barrier placed along the edge of a walking surface to prevent personnel from placing their foot over the edge of an elevated walking surface. It should also prevent objects from sliding or rolling over the edge onto personnel below.

Valve, Critical: Valves that require rapid and/or frequent access during normal operations or emergency conditions. These are referred to as Category 1 Valves for valve criticality categorization purposes.

Valve, Infrequently Used Non-Critical: Valves that are not critical for operations or routine maintenance and that are infrequently used for particular tasks like commissioning, start-up, shutdown, or rarely performed maintenance tasks. These are referred to as Category 3 Valves for valve criticality categorization purposes.

Valve, Non-Critical: Valves that are not critical for operations but that are required for routine maintenance. These are referred to as Category 2 Valves for valve criticality categorization purposes.

Visual Alarms: Alarms presented visually, and carry visually loaded information, such as coding priority by color, or the presenting of text information.

Visual Display: A device that provides readings, status, or condition of machinery, equipment, or systems operating parameters. Examples of visual displays include: indicators, annunciators, sight glasses, gauges, digital counters, computer monitors, or video display units.

Work Schedules: The number of continuous hours and the work shift patterns performed by personnel.

Workspaces: Areas allocated for work. Categories of workspaces include: navigation spaces, service spaces (galley, laundry) and machinery spaces.

Workstation: Position at which one or several tasks constituting a particular activity are carried out. This position includes a combination of all job-related items, such as the console with all devices, equipment, and furniture, to perform certain tasks.

4 Scope of the Guidance Notes

These Guidance Notes provide the design and layout guidance related to ergonomics at sea, including the design of human-system interfaces at the individual task and workstation levels. Physical and perceptual issues for the design of the personnel interface with controls, displays, alarms, video-display units, labeling, workspace access, and workspace arrangement are discussed in the document.

These Guidance Notes can be used in designing human-system interfaces that are required to be "easily accessible", "readily operable", designed based on "sound ergonomic principles", and similar terms used extensively in ABS documents. Ergonomic guidance is derived from empirical data, operator and maintainer expectations, models of human behavior, reasoned from known facts and research, and user and expert opinion.

The benefit of addressing human element concerns is noted in numerous international, flag Administration, national, and industry documents. These include International Maritime Organization (IMO), International Labor Organization (ILO), United Kingdom Health Safety Executive (UK HSE), United States Code of Federal Regulations (US CFR), etc. Most of the principles and criteria providing ergonomic guidance are found in industry standards and ergonomic design references. Examples include American Society for Testing and Materials (ASTM), International Organization for Standardization (ISO), and British Standards (BS). The source of all guidelines, standards, and recommendations stated in these Guidance Notes are referenced in Appendix 3, "References/Bibliography" of this document.

5 Contents of the Guidance Notes

These Guidance Notes address numerous aspects of ergonomics. The early Sections cover human-system interface issues that can directly affect equipment and system performance. The following Sections discuss ergonomic aspects that have traditionally been associated with occupational health and safety concerns. Appendix 1, "Anthropometric Design Principles and Dimensions" is provided to allow designers and engineers to modify criteria as needed to match the needs of various groups of people throughout the world. Appendix 2, "Application of Ergonomics to Design" presents a simplified explanation of a human-system interface design process and two application examples.

SECTION 2 Controls *(1 August 2013)*

1 General *(1 August 2013)*

1.1 Application

The principles and guidelines of this Section generally apply to devices used for control, on equipment, consoles and panels.

2 Principles

2.1 Labeling

Controls should be labeled to convey the information needed for proper identification and utilization of the control. Principles of control labeling are described in Section 8, “Labeling, Signs, Graphics, and Symbols”.

2.2 Feedback

Personnel should be provided with a positive indication of control activation. This can be provided via feel (e.g., snap action), an audible clicking noise, or a display.

2.3 Integration with Displays and Alarms

Displays and alarms can be used to provide feedback of control action. For principles and criteria covering the integration of controls with their associated displays and alarms, see Section 5, “Integration of Controls, Displays, and Alarms”.

2.4 Coding

Any coding used to enhance the transfer of information to personnel should be consistent and meaningful. The coding system should also be appropriate for the industry, organization, and culture of the personnel aboard the vessel or offshore installation.

2.5 Simultaneous Operation of Controls

Controls should 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 should be duplicated, where practical, 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 should be provided.

2.6 Controls for Maintenance

Controls used solely for maintenance or adjustment should be covered or otherwise protected during normal operations, but within arm’s reach and visible when needed for maintenance.

2.7 Prevention of Accidental Activation

Controls should be designed and located so they are not susceptible to accidental activation. Methods to reduce the likelihood of accidental activation include:

i) Locating and orienting the control so that bumping is unlikely to cause an activation

ii) Providing sufficient control resistance to prevent unintentional movements

iii) Requiring complex motions for control activation, such as an interlock or rotary motion

iv) Restricting access to controls by isolating them or by providing a cover guard or physical barrier

2.8 Compatibility with Clothing

It should be possible to operate controls wearing both normal clothing and personnel protective equipment (e.g., gloves, boots).

3 General Guidelines

3.1 Control Selection

The following guidelines should be used in selecting controls:

i) Controls requiring rapid or precise setting should be assigned to the hands.

ii) Controls requiring large or continuous forward applications of force generally should be assigned 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.

iii) Controls should be distributed so that no one limb is overburdened.

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

v) Select multi-rotation controls (e.g., cranks) when precise settings are required over a wide range of adjustments. Because the range of movement of a linear control is limited, it does not permit high precision over a wide range of adjustment. With this type of control, desired precision can be obtained by appropriate gearing, although consideration will need to be given to its effect on operating time.

vi) Select discrete-adjustment (detent) controls or pushbutton 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.

vii) Discrete-adjustment controls (i.e., controls that snap into place) can be positioned with one movement. Continuous adjustment controls require a slowing movement and a fine adjustment movement and thus more time and attention.

viii) Continuous-adjustment controls should be selected when precise adjustment along a continuum is needed.

ix) Select controls that can be easily identified. All controls should be made identifiable, in part by standardizing their locations. All critical and emergency controls should be identifiable both visually and by touch (e.g., shape coding). Identification information should not hinder the manipulation of the control nor increase the likelihood of accidental activation.

x) Combine functionally related controls to reduce reaching movements, to aid in sequential or simultaneous operations, or to economize panel space.

xi) Multi-axis continuous controllers (e.g., joysticks, track balls) should be used to provide continuous control within a two-dimensional space (e.g., positioning a pointer on a computer screen) or a three-dimensional space (e.g., operating a crane).

3.2 Control Movement

Direction of control movement should be consistent among the same function and application and should operate according to the cultural expectations of the intended operators. Widely accepted movement expectations are indicated in Section 2, Figure 1, “Control Movement Expectations” and Section 2, Table 1, “Control Movement Expectations”. 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. Note that a toggle switch located above and behind the head operates in a different orientation to a toggle switch located directly in front of the body. For this reason, this figure should be closely examined when assigning control settings.

3.3 Control Spacing

Adequate spacing should be provided between controls and controls and obstructions so that manipulation of one will not inadvertently affect the others. Minimum spacing between controls is shown in Section 2, Table 2, "Minimum Spacing Between Two Controls". Spacing between a control and an obstruction or two different types of controls should be at least the comparable distance in Section 2, Table 2. Unless otherwise specified, dimensions for hand-operated controls assume bare-handed operation, and should be increased as necessary if the personnel may be wearing gloves.

FIGURE 1
Control Movement Expectations

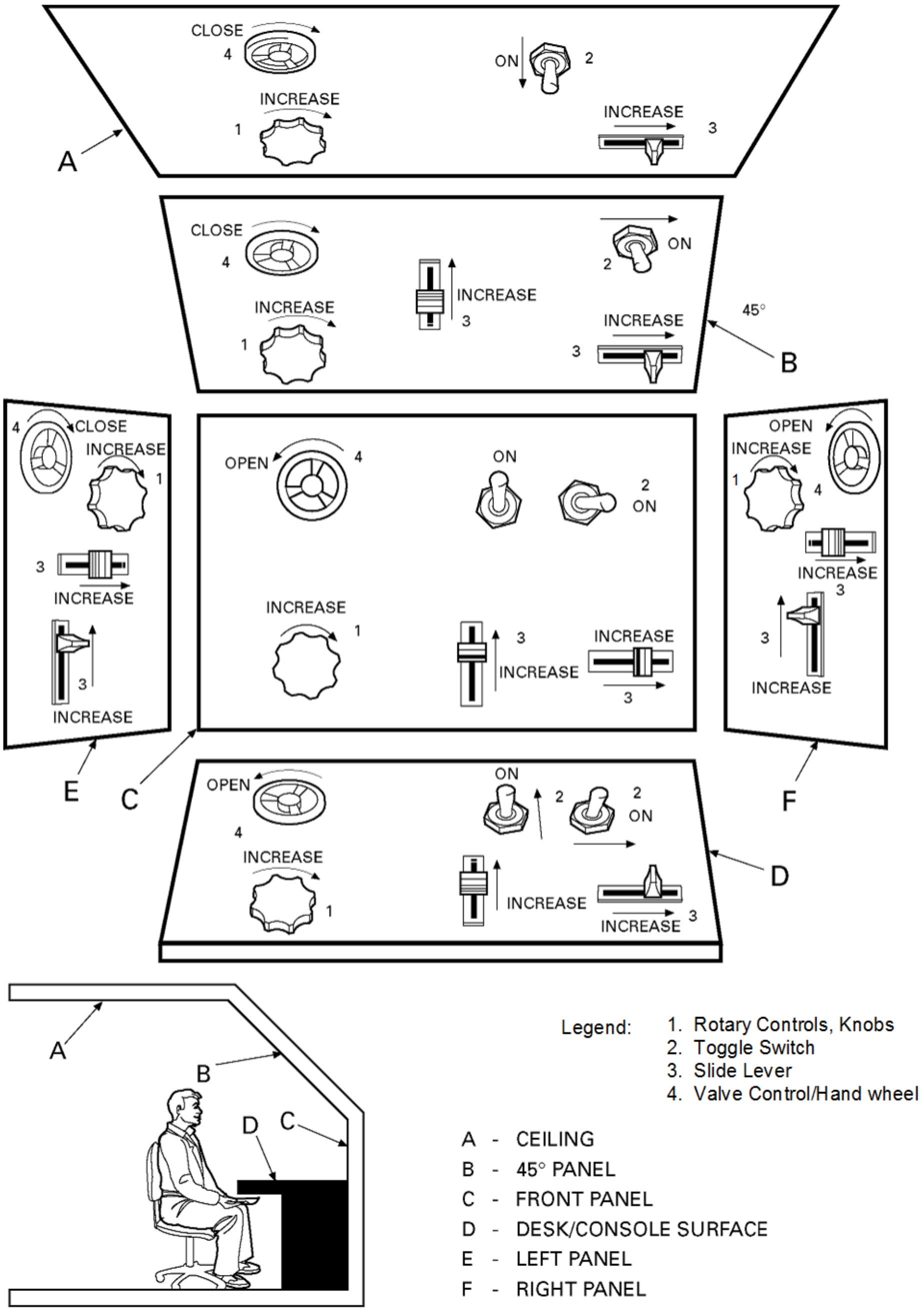


TABLE 1
Control Movement Expectations*

Direction of Movement	*Function*
Up, right, forward, clockwise, pull (push-pull type switch)	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

* Reprinted with permission from the Annual Book of ASTM Standards, copyright American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

TABLE 2
Minimum Spacing Between Two Controls

	Toggle Switches	*Pushbuttons**	*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.)

* For pushbuttons not separated by barriers.

Notes:

1 All values are for one hand operation.

2 Distances are measured from the edge of each control.

3.4 Mounting

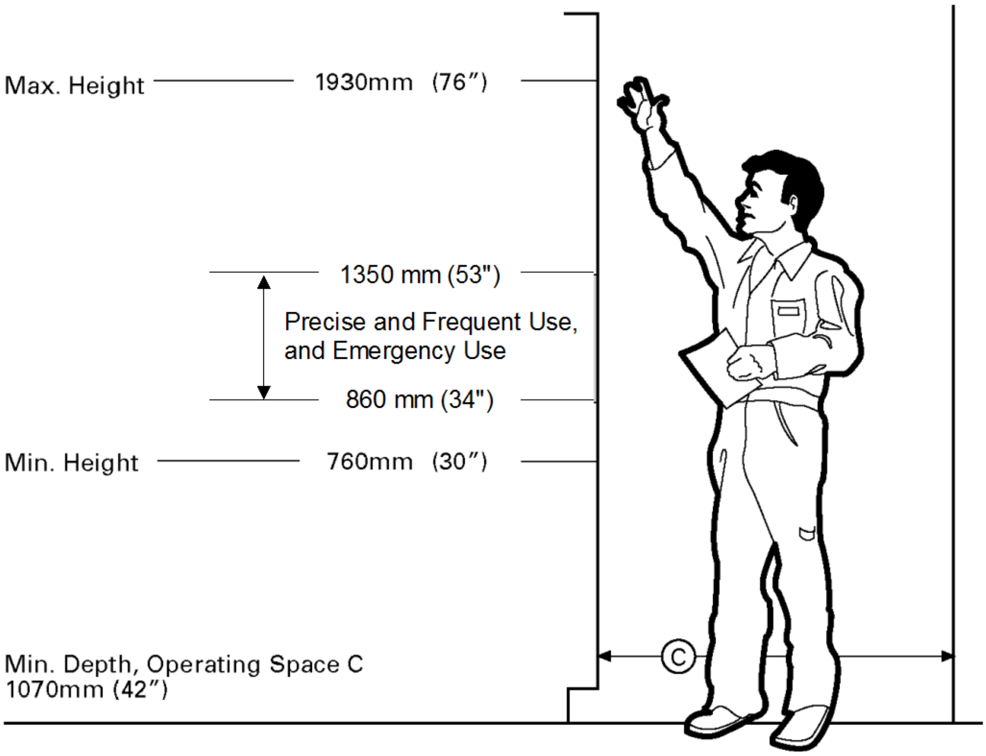
3.4.1 Mounting Heights on Panels

Preferred mounting heights for controls are indicated in Section 2, Figure 2, “Control Mounting Height for Standing Personnel” and Section 2, Figure 3, “Control Mounting Height for Seated Personnel”. Frequently used controls should be located within a radius of 460 mm (18 in.) from the operator’s centerline while less frequently used controls should be located within a radius of 800 mm (31.5 in.) from the operator’s centerline.

3.4.2 Mounting Heights for Kneeling and Squatting

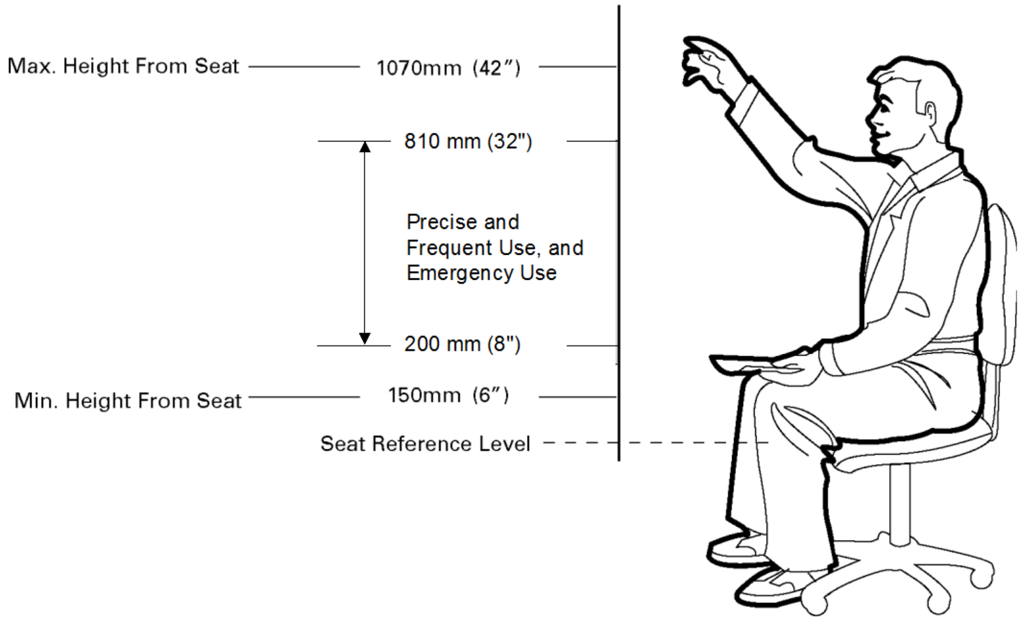
While not preferred for normal operations or maintenance, if necessary, kneeling or squatting positions may be adopted by personnel. For kneeling, see Section 2, Table 3, “Controls and Kneeling Dimensions”, and for squatting, see Section 2, Table 4, “Controls and Squatting Dimensions”.

FIGURE 2
Control Mounting Height for Standing Personnel*



* Dimensions are based on North American males.

FIGURE 3
Control Mounting Height for Seated Personnel*



* Dimensions are based on North American males.

TABLE 3
Controls and Kneeling Dimensions*

Dimension	*Size*
Maximum Height	1450 mm (57 in.)
Preferred Maximum Height	1080 mm (42.5 in.)
Preferred Minimum Height	540 mm (21 in.)
Minimum Height	460 mm (18 in.)
Minimum Depth for Kneeling	1070 mm (42 in.)

* Dimensions are based on North American males.

TABLE 4
Controls and Squatting Dimensions*

Dimension	*Size*
Maximum Height	1250 mm (49 in.)
Preferred Maximum Height	800 mm (32 in.)
Preferred Minimum Height	400 mm (16 in.)
Minimum Height	360 mm (14 in.)
Minimum Depth for Squatting	915 mm (36 in.)

* Dimensions are based on North American males.

3.5 Coding

Coding refers to the use of size, shape, color, texture, location, labeling, or other scheme to assist with the identification of states and control functions. Several coding methods may be combined to achieve maximum identification and differentiation.

3.5.1 Color

Color coding should 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. Cultural expectations[1] should be considered when color coding. 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 (e.g., night time on the navigation 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.

For additional information concerning factors to be considered when determining color codes, see 3/3.5, "Color Coding".

3.5.2 Shape

Coding by shape is useful when controls should be identified without the use of vision. Using different shapes provides for tactile identification of controls and aids in visual identification. Where feasible, shapes that suggest the purpose of the control should be used.

3.5.3 Size

Coding by size is useful when controls are to be identified without the use of vision. Controls can be coded by size, but if personnel are to rely on touch alone, at most three sizes of controls should be used. Size coding, as with other coding methods, should be used consistently. In general, knobs should differ by at least 13 mm (0.5 in.) in diameter or by 10 mm (0.4 in.) in thickness to be identified accurately by touch.

3.5.4 Precautions with Shape and Size Coding

The shape or size coding should not interfere with operation of the control and should be identifiable by feel regardless of the position or orientation of the control. Knobs and handles, which are shape or size coded, should be attached to their shafts so as to preclude removal and incorrect replacement. If individuals wearing gloves will use the control, the shape or size should be identifiable by feel through the gloves.

3.5.5 Texture

Use of texture differences can provide effective coding when knobs are to be identified by feel. Three surface characteristics can be used together to provide reasonably accurate discrimination: smooth, fluted, and knurled. Different degrees of fluting or knurling should not be used together to provide discrimination.

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[1] A study of differences in color perception between populations of the US and China revealed that of the 784 Chinese participants, comprising both sexes from various occupational groups, less than 50% associated the color red with stop and green with go. The ratio for their American counterparts was almost 100% (Courtney, 1986).

SECTION 3 Displays *(1 August 2013)*

1 General *(1 August 2013)*

1.1 Application

The principles and guidelines in this Section apply to instruments or devices that present visual or audible information.

2 Principles

2.1 Labeling

Visual displays should be labeled to convey the basic information needed to identify and interpret displayed information. Principles of display labeling are described in Section 8, "Labeling, Signs, Graphics, and Symbols".

2.2 Content

Displays are intended to convey information to operators or maintainers. Displayed information should be clear, concise, consistent, and follow appropriate standards and conventions. For principles covering the integration of displays with their associated alarms and controls, see Section 5, "Integration of Controls, Displays, and Alarms".

2.3 Coding

Any coding used to enhance the transfer of information to personnel should be consistent and meaningful. The coding system should be also be appropriate for the industry, organization, and culture of the personnel aboard the vessel or offshore installation.

2.4 Status Information

Visual displays should provide a positive indication of the state of the equipment such as: ready, running, not running, or "out-of-tolerance". The absence, or non-activated state, of a visual display should not be relied upon to convey status information. Where equipment status must always be available (e.g., stop/start, on/off, etc.), it is appropriate to provide status indication of each state.

2.5 Operations versus Maintenance

Separate and distinct information required for operations and maintenance should not be combined in a single display. Displays used solely for maintenance should be covered or non-visible during normal operations, but should be immediately available to the maintainer when required for use.

2.6 Avoid Clutter

Markings (e.g., trademarks, company names, or other similar markings) should not interfere with the reading of the visual display.

2.7 Detectability of Audible Displays

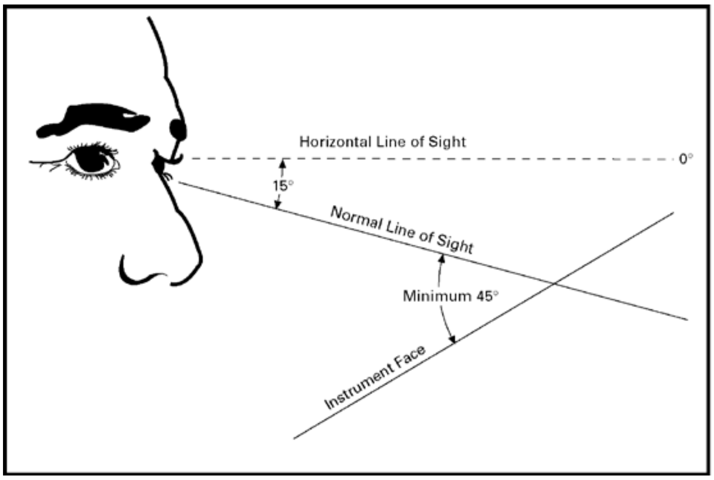
When information is conveyed to personnel through sound signals, the signals should be distinct and detectable under all expected conditions.

3 General Visual Display Guidelines

3.1 Line-of-Sight and Orientation

A display should be perpendicular to the normal line-of-sight but not less than 45 degrees, as indicated in Section 3, Figure 1, "Line-of-Sight". The normal line-of-sight is typically 15 degrees below the horizontal line-of-sight.

FIGURE 1
Line-of-Sight



3.2 Readability

3.2.1 Accuracy

Visual displays should be located to allow reading to the required degree of accuracy from the normal operating position. The normal reading distance for displays is 330 mm (13 in.) to 710 mm (28 in.).

3.2.2 Local Displays

Individual local displays, such as sight gauges on tanks and thermometers or pressure gauges attached to pipes, should be mounted so they are read upright without requiring personnel to assume awkward, uncomfortable, or unsafe postures. In addition, personnel should not have to use or stand on structures not meant to be walking or standing surfaces in order to view displays.

3.2.3 Lighting Levels

Lighting levels should 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 the various ABS *Guides for Crew Habitability* (for ships, workboats, offshore installations, or MODUs).

3.2.4 Location for Operations

In general, visual displays used for operations should be readily visible at all times. Display locations which require the removal of a cover or deck plate should only be used for non-critical operations and infrequently used displays. These locations should be provided with a clearly marked quick-opening access door requiring no tools to open or close it.

3.3 Mounting

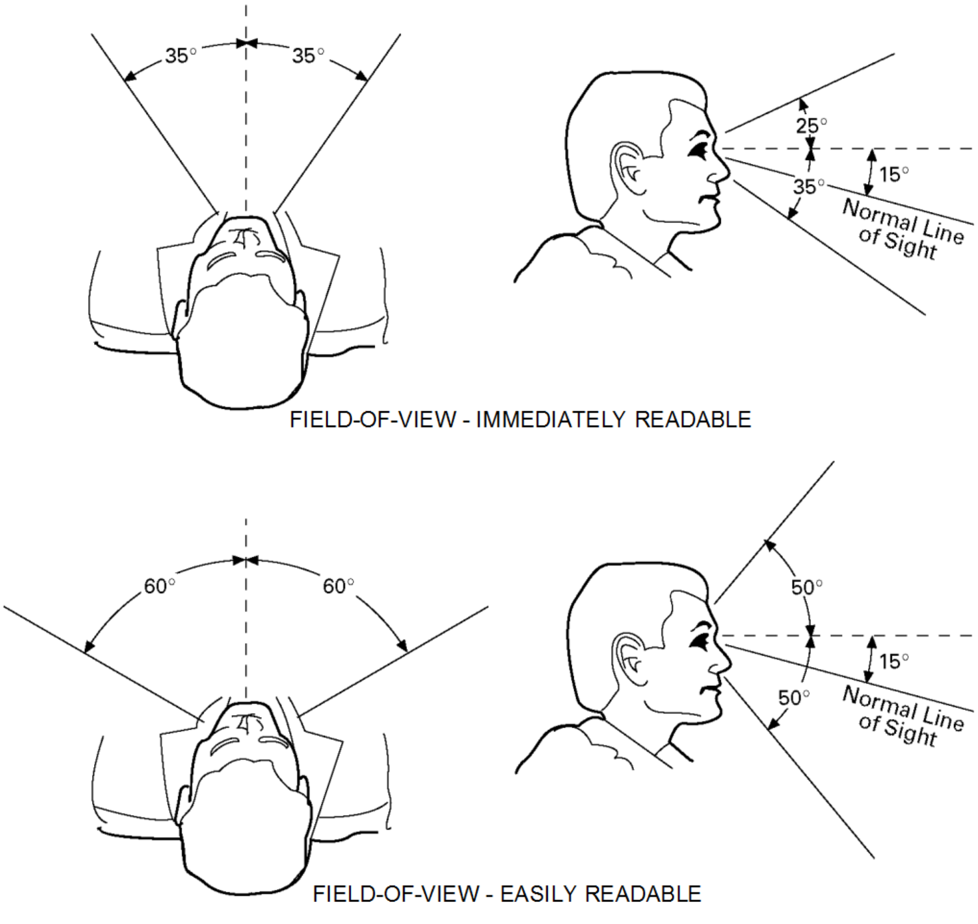
3.3.1 Field-of-View – Primary Displays

Primary displays include those used frequently, those used for obtaining precise readings or those used in emergencies. These should be located within personnel's immediately readable field-of-view as indicated in Section 3, Figure 2, "Field-of-View".

3.3.2 Field-of-View – Secondary Displays

Secondary displays include those used for normal operations and those not requiring accurate readings. These should be located within personnel's easily readable field-of-view as indicated in Section 3, Figure 2, "Field-of-View". Reference displays that are used infrequently may be located in an area outside personnel's easily readable field-of-view.

FIGURE 2
Field-of-View*

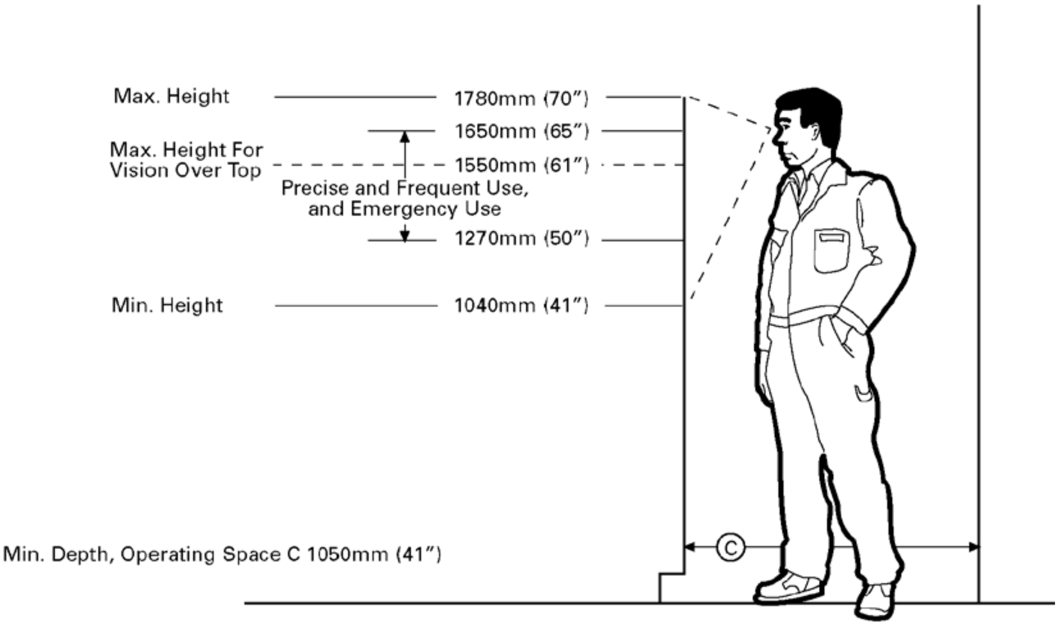


* Dimensions are based on North American males.

3.3.3 Height on Panels

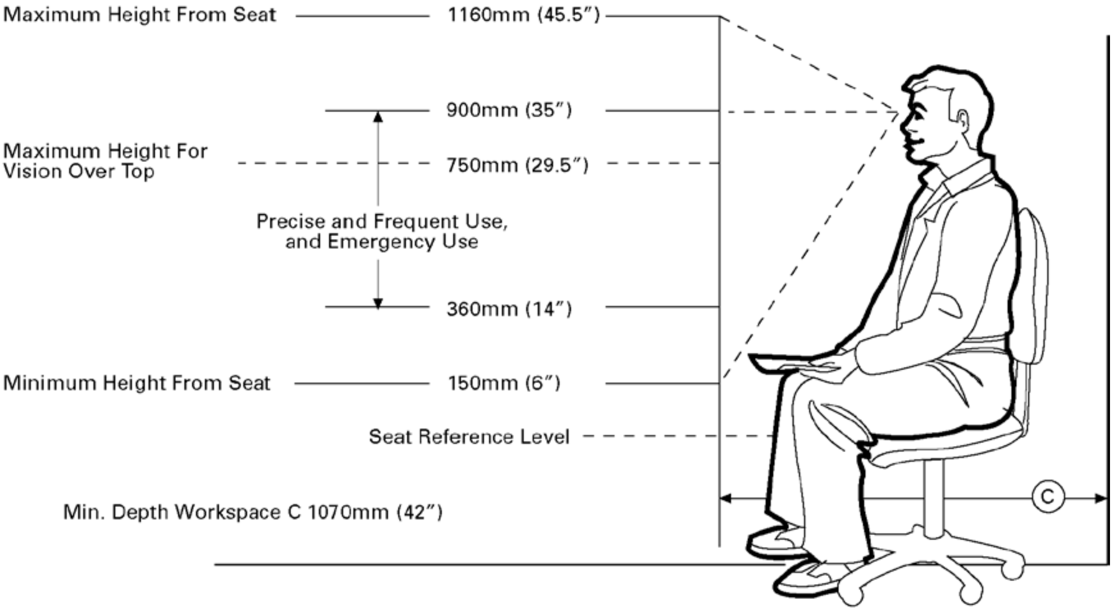
Preferred mounting heights for vertical displays on a flat surface such as a panel or bulkhead are shown in Section 3, Figure 3, "Display Mounting Height for Standing Personnel" and Section 3, Figure 4, "Display Mounting Height for Seated Personnel". Displays located immediately adjacent to a walkway should not be located within 460 mm (18 in.) of the standing surface (e.g., deck) in order to prevent them from being easily damaged.

FIGURE 3
Display Mounting Height for Standing Personnel*



* Dimensions are based on North American males.

FIGURE 4
Display Mounting Height for Seated Personnel*



* Dimensions are based on North American males.

3.3.4 Heights for Kneeling and Squatting

While not preferred for normal operations or maintenance, if necessary, kneeling or squatting positions may be adopted by personnel. For kneeling, see Section 3, Table 1, "Displays and Kneeling Dimensions", and for squatting, see Section 3, Table 2, "Displays and Squatting Dimensions".

TABLE 1
Displays and Kneeling Dimensions

Dimension	*Size*
Maximum Height	1450 mm (57 in.)
Preferred Maximum Height	1320 mm (52 in.)
Preferred Minimum Height	950 mm (37 in.)
Minimum Height	700 mm (28 in.)
Minimum Depth for Kneeling	1150 mm (45 in.)

TABLE 2
Displays and Squatting Dimensions

Dimension	*Size*
Maximum Height	1250 mm (49 in.)
Preferred Maximum Height	1020 mm (40 in.)
Preferred Minimum Height	750 mm (30 in.)
Minimum Height	520 mm (20 in.)
Minimum Depth for Squatting	1050 mm (41 in.)

3.4 Size Coding *(1 August 2013)*

When size coding is used with displays such as simple indicator lights, no more than three distinct sizes should 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.

Most displays are designed for a viewing distance of up to 710 mm (28 in.). Where the viewing distance (*y*) is greater, the size (*x*) of the display markings and numbers must be increased, using the following formula:

Dimension at y (mm) = [dimension at 710 mm] × [y mm]/710; or

Dimension at y (in.) = [dimension at 28 in.] × [y in.]/28

3.5 Color Coding

The interpretation of color codes by personnel is contingent on a number of factors, including:

3.5.1 Culture

Where color meanings may be particular to a geographic area. For example, in parts of Europe, the colors white-on-green are used on emergency exit signs, while in North America, the colors white and red are used for emergency exit signs.

Another example of the effect of culture on color meanings is demonstrated in a study between populations of the United States and China. The results revealed that of the 784 Chinese participants, comprising both sexes from various occupational groups, less than 50% associated the color red with stop and green with go. The ratio for their American counterparts was almost 100% (Courtney, 1986).

3.5.2 Personnel History and Expectations

Personnel's history and expectations influence the learned associations of color meanings, and it is based on an individual's experience in operating equipment that employs specific color coding. Different personnel may have different expectations. For example, some personnel with commercial electrical-power generation experience associate an open/flowing state with red and a closed/stop state with green, while some United States Navy personnel have the reverse associations (EPRI NP-3659). In other instances, an individual may have been exposed to many different, often conflicting color codes.

3.5.3 Context *(1 August 2013)*

The context of color-coded information varies according to the context of presentation, and personnel quickly learn to associate coded meanings within those contexts. For example, a yellow-orange alarm may convey an out-of-tolerance condition, while yellow-orange on a pipe marker label may indicate the pipe contains gas.

In most industrial contexts, there are many more demands to code information than can be provided using eleven or so different colors. For example, in North American culture, red may be used to denote: danger, immediate operator attention is required, a pump is running, a valve is open, a circuit breaker is closed or a pipe is conveying fire fighting media, among others. It is context that allows personnel to quickly and reliably identify a color's meaning.

For displays, two basic contexts exist: display of equipment status and display of alarm/annunciation conditions. When an operator is overlooking a sea of red and green indicator lights associated with, for example, a ballast control panel, there is no immediate call for operator action as long as the sea of lights presents the normal status of valves, pumps, and so on. When that same operator notes red indicators within a panel dedicated to alarms (an entirely different context), red immediately assumes an entirely different meaning, and a different operator response.

Given this, there are several general principles associated with the use of color coding:

- Devise and use color codes that are consistent with the expectations of the majority of personnel, whether derived from native culture or operating experience.
- Employ those color codes consistency throughout a vessel, fleet, offshore installation, or a company.
- Use color coding consistently and strictly within each context. For example, when designing a control station or computer program to align and control ballasting systems, avoid physically locating an alarm such that it could be hidden amongst the alignment indicator status lights. It is better to dedicate specific alarm panels that allow quick scanning and that resolve all contextual ambiguity where color coding of alarms is concerned.

Section 3, Table 3, "Typical Display and Alarm Color Codes for North American Industry", presents commonly used color-coding schemes in North America. This Table does not provide specific recommendations for color coding of displays and alarms for all applications or geographical regions, as there can be variance across industries and cultures. Designers should identify regional and industry color meaning expectations, as well as any statutory requirements, when defining color-coding requirements.

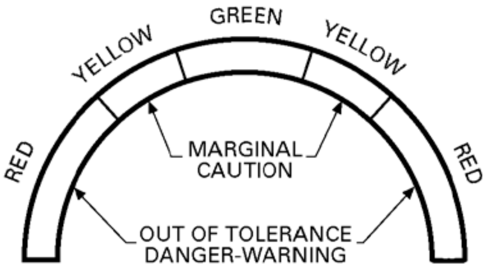
3.6 Scale Coding *(1 August 2013)*

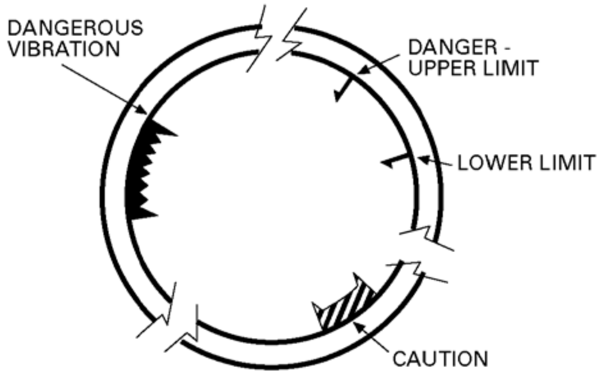
Where operating values fall within a range, the ranges may be identified by a color or shape coding applied to or adjacent to the face of the display as indicated in Section 3, Figure 5, "Color and Shape Coding of Ranges on an Analog Display".

TABLE 3
Typical Display and Alarm Color Codes for North American Industry

Color	*Typical Display/Alarm Color Meanings*
Red	Danger, hot, unsafe condition, critical parameter value is out-of-tolerance Immediate operator action is required
Amber	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 (e.g., 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 (e.g., Pump No. 1 selected), or transitory conditions (e.g., 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.

FIGURE 5
Color and Shape Coding of Ranges on an Analog Display *(1 August 2013)*





4 Auditory Displays

There are three basic forms of information displays using sound:

i) Voice communications (aided and unaided)

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

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

Guidance for the design of the audible portion of alarm systems is presented in Section 4, “Alarms”. Guidelines for design of general auditory displays are presented below.

4.1 Use of Auditory Signals

Auditory signals can be used:

i) Where messages or information are simple and short (e.g., on/off, cycle complete, watertight doors closed)

ii) When information will not need to be referred to at a later time

iii) To orient an operator to a location (e.g., to direct visual attention to a radar display)

iv) When an immediate action is required (e.g., alarms and warnings)

v) When vision is poor (e.g., smoke filled spaces, in holds and tanks)

vi) To present information independent of visual orientation

4.2 Design Characteristics of Auditory Display

Design characteristics of auditory displays should be consistent with the following:

i) Each signal has a single specific meaning or required operator action.

ii) Signals are clearly distinct from each other.

iii) The number of coded signals should be limited to five. Where more than five coded signals are needed, use a two-phase signal.

iv) When using a two-phase signal, use the same signal characteristics for the alerting portion of the signal. For the second phase, use intelligible spoken messages to indicate the condition that initiated the alarm and/or any actions to be taken.

v) Each signal should have sufficient attention-demanding properties (see Section 4, Table 2, "General Recommendations for Sound Loudness and Frequency" and Section 4, Table 3, "Guidelines for Selecting Audible Signal Devices").

vi) Signals are clearly audible in the expected normal or worst case ambient noise environment.

vii) Signal sound source should propagate from the immediate vicinity of where operator or maintainer action (e.g., examine a display or operate a control) is performed.

viii) Signals are of fixed duration and termination is automatic (e.g., operator or maintainers do not have to acknowledge or manually silence an audible signal, except under alarm conditions).

ix) Audible signals should be clearly detectable, but should not be so loud as to invoke a startle response.

SECTION 4 Alarms

1 General *(1 August 2013)*

IMO Resolution A.1021(26), *Code on Alerts and Indicators*, presents "general design guidance to promote uniformity of type, location, and priority…" for alerts and indicators. Where applicable, that IMO resolution should be used for determining design and implementation of alarms, alerts, and associated indicators. The document also presents tables of required alarms and indicators for spaces of different functionality, machinery, and ship or structure type.

1.1 Application

The principles and guidelines of this Section apply to visual and auditory alarms/alerts and associated controls, local and remote, which require the attention of personnel. Alarms can generally be categorized as follows:

i) Visual alarms

ii) Visual alarms accompanied by audible tones

iii) Audible alarms

2 Principles

These principles apply to visual and audible alarms located on local panels or central control area panels or consoles (e.g., control rooms, navigation bridges). These principles do not necessarily apply to general emergency alarms.

2.1 Types of Alarms

Alarms are used to indicate an out-of-tolerance condition to personnel. Visual alarms can be coded for priority as system conditions escalate or change. Visual alarms may be used in high noise areas to attract attention and inform personnel of out-of-tolerance conditions (e.g., a hydrogen-sulfide beacon).

Audible alarms can also be used to indicate an out-of-tolerance condition to personnel. These alarms are generally used in conjunction with visual alarms to call attention to or emphasize the information.

Audible alarms with verbal messages may include the general emergency alarm, abandonment alarm, and those alarms demanding immediate personnel response to attend to conditions such as a fire, collision, or flooding. These allow specific instructions to be conveyed to personnel.

2.2 Alarm Set Points

The limits or set points for initiating the alarm signals should:

i) Not occur so frequently as to be considered a nuisance by personnel

ii) Provide personnel adequate time to respond to the condition

2.3 False Alarms

A means should 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.

2.4 Alarm Priorities

When simultaneous alarms are active, the alarms should be prioritized so that personnel can first respond to those conditions that are more urgent. Prioritization should be accomplished using two to four levels. Priority can be conveyed with either visual or auditory coding methods. Prioritization should be based on a combination of:

i) Relative severity of the consequences of not responding to the condition or situation

ii) Time constraints imposed on personnel to respond

If alarms are presented on a dedicated printer, those of higher priority should be presented first, and the others presented in descending order of priority. If alarms are presented on a video display, active alarms should be viewable as sorted by priority, onset sequence or by system function.

2.5 Alarm Integration

In the event of a complete system failure, a single summary alarm (e.g., “Diesel Generator Set B Failure”) should indicate the failure rather than requiring personnel to integrate the information presented by numerous component level alarms (e.g., “Low Bus Voltage”, “Stator Trouble”, or “Lube Oil Pressure Low”).

2.6 Alarm Response

Each alarm should prompt personnel action. Where multiple alarm conditions prompt the same action, there should only be one alarm. If there is no action required, then that function should not be conveyed via an alarm, but through a status indication.

2.7 Alarm Acknowledgement

Alarms should require personnel acknowledgment after alarm onset. An acknowledge control should be provided. The control should terminate the flashing of a visual alarm and allow the alarm to remain illuminated until the alarm condition is cleared. The control can also mute the audible signal or a separate silence control can be provided. An acknowledge control should be provided near the controls and displays associated with the alarm.

2.8 Master Silence Control

The master silence control should only silence active audible signals. It should not block audible signals at the onset of subsequent alarms. The master silence control should not affect the visual portion of the alarm.

2.9 Subsequent Alarms

Each alarm onset should activate visual and audible signals such as a flashing visual indicator and audible alerting signal. This should occur regardless of the condition of any other active alarms (e.g., acknowledged, not acknowledged, cleared, uncleared, or reset). If a single alarm has multiple inputs, any new alarm condition should reactivate that alarm.

2.10 Repetitive Alarms/Controls

Repetitive groups of alarms should have the same arrangement and relative location on different panels and consoles. Any alarm controls (e.g., silence, acknowledge, reset, clear) should be consistent between panels and consoles.

2.11 Test Function

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

2.12 Temporary Disconnection of Alarms

Alarm circuits may be temporarily disabled (e.g., for maintenance) if such action is coordinated with appropriate personnel (e.g., 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. Permanent alarms (e.g., fixed lights or tiles, as opposed to computer driven displays) should be provided with a means to indicate their status (e.g., by tag out or sticker indicating that the alarm is disabled).

3 Visual Alarms

3.1 General Guidance

Additional general guidance applicable to alarms can be found in Section 3, "Displays".

3.2 Alarm Onset

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

3.3 Alarms and Normal Operations

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

3.4 Priority Coding

A method for coding the visual alarms for the various priority levels should be employed. Acceptable methods for priority coding include color, position, shape, size, flash rate, or symbols.

3.5 Color Coding

Where applicable, visual alarms should be color coded in conformance with the IMO Assembly Resolution A.830(19), "*Code on Alarms and Indicators*". In other cases, Section 4, Table 1, "Guidelines for Color Coding" should be followed. This color-coding scheme should be used throughout the vessel or offshore installation.

TABLE 1
Guidelines for Color Coding

Color	*Meaning*	*Explanation*	*Typical applications*
Red	Danger or alarm	Warning of danger or a situation that requires immediate action.	Stop of essential machinery, (e.g., lubricating oil pump for the propulsion engine or motor, failure of pressure in the lubricating system for the propulsion machine, etc.) Temperature and pressure values (water, oil, etc.) at critical levels Activation of a safety system
Yellow	Caution	Change or impending change of conditions.	Temperature and pressure values which differ from the normal levels, but not critical
Blue	Instruction/Information (specific meaning assigned according to the case considered)	Blue may be given specific meaning that is not covered by the colors: red, yellow, and green.	Motor ready to start No-load generator ready to be connected Electrical heating circuit for idle electrical machines
White	No specific meaning assigned (neutral)	Any meaning; may be used whenever doubt exists about the application of the colors red, yellow, and green, often used for confirmation.	Earth insulation indicators Synchronizing lamps Telephone calls Appliances automatically controlled

3.6 Flasher Failure

If a panel or console alarm flasher fails, then at the onset of an alarm condition the alarm light should illuminate and burn steadily, rather than not illuminate.

3.7 Contrast Detection

There should be sufficient contrast between flashing and fully illuminated alarms, and between illuminated and non-illuminated alarms, so that personnel can reliably discriminate each state.

3.8 Text Visibility and Legibility

The text on visual alarms should be easily readable whether or not the alarm is illuminated.

3.9 Wording Criteria

If text is used for alarms, wording should be in accordance with the following criteria:

i) Wording should be concise, specific, and unambiguous.

ii) Wording should address a specific condition (e.g., do not use one alarm for HIGH-LOW, TEMPERATURE-PRESSURE).

iii) Abbreviations and acronyms should have consistent usage throughout the vessel or offshore installation.

iv) Words should be legible in worst-case conditions.

v) Personnel should 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.

4 Audible Alarms

4.1 General

Significant benefits of audible alarms, or of an audible component of a visual alarm, include:

i) Providing indication to personnel about conditions without requiring constant monitoring of visual displays

ii) A general reduction in personnel workload associated with equipment and safety monitoring

iii) A general increase in the reliability of equipment and status monitoring, enhancing safety, production, and efficiency

iv) The ability to announce the status and conditions of equipment to a wide operating area, immediately alerting those conditions to a potentially wide audience

v) The ability to immediately compel personnel to attend to off-normal or emergency conditions

vi) The ability to quickly and effectively influence safety behavior in the form of general emergency alarms

4.2 Content

Audible alarms may be tones or tones used with verbal messages. Audible alarms with verbal messages should consist of an initial alerting (non-speech) signal to attract attention and a brief, standardized verbal message to identify the specific condition and/or suggest an appropriate action.

4.3 Sound Characteristics

The selection of loudness, frequency, and use of sound waveforms should be in accordance with the guidelines given in Section 4, Table 2, “General Recommendations for Sound Loudness and Frequency”.

TABLE 2
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 in the same space.

4.4 Number of Distinct Audible Alarms

The number of distinct audible alarms (in terms of the auditory characteristics of each) should not exceed seven (7), and it is recommended that the number not exceed four (4) in order to prevent confusion as to the meaning of different alarms.

4.5 Selection of Audible Signal Devices

Devices such as a whistle, siren, bell, klaxon, or horn can be used to provide audible signals. General guidance for the selection of devices is given in Section 4, Table 3, "Guidelines for Selecting Audible Signal Devices". For specific vessel or offshore installation applications, the IMO documents referenced in Subsection 4/7, "Alarm Required Requirements by IMO" should be used.

TABLE 3
Guidelines for Selecting Audible Signal Devices *(1 August 2013)*

Device	*Loudness*	*Frequency*	*Attention Demanding*	*Noise-Penetration Ability*
Foghorn	Very high	Very low	Good	Poor with low frequency background noise. Good with high frequency background 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 with frequent pitch rising and falling	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

4.6 Sound Loudness

Recommended sound loudness qualities are as follows:

i) Audible signals should be at least 10 dB(A), preferably, 20 dB(A), above ambient noise levels during normal operations.

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

iii) A signal-to-noise ratio of at least 20 dB(A) should be provided in at least one octave band between 200 and 5000 Hertz at the operating position of the intended receiver.

iv) Audible signal sound levels in a space should not exceed 120 dB(A).

v) For large spaces, more than one audible alarm may be required for the sound level to be heard throughout the space.

vi) 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 should supplement the audible signal. Red light beacons should only be used for fire alarms, unless this conflicts with appropriate statutory, regulatory, or class requirements.

4.7 Sound Frequency

With the exception of bells, audible signals should have a signal frequency between 200 and 2500 Hertz, with the preferable range between 500 and 1500 Hertz.

4.8 Control of Loudness

The loudness of an audible signal should be designed to be adjustable. The control mechanism should be restricted and administratively controlled to prevent reducing the volume to an inaudible level or increasing it to an unacceptably high level.

4.9 Detection Level

Each audible signal should 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 should be readily detectable anywhere in the control room. General emergency alarms (e.g., emergency or evacuation) should be readily detectable throughout the vessel or offshore installation (e.g., in hull, topsides, accommodations, etc.).

4.10 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 (e.g., 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.

4.11 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.

4.12 Cleared Alarms

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

4.13 Audible Coding of Priority Levels

Coding methods for audible 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 (3). If duration is used, the number of levels should not exceed three (3). If frequency coding is used, the number of levels should not exceed five (5).

4.14 Caution Signal Controls

Audible caution signals should be provided with manual reset and volume controls.

4.15 Location of Equipment Generating Audible Signals

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 so 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.

4.16 Verbal Messages

4.16.1 Content

Verbal messages should indicate the required response from personnel on the vessel or offshore installation (e.g., abandon ship or offshore installation, or report to emergency stations) rather than simply the nature of the emergency.

In selecting words to be used in verbal messages, priority should be given to intelligibility, appropriateness, and conciseness, in that order.

4.16.2 Type of Voice and Delivery Style

The voice used in recording verbal messages should be distinctive and mature. Verbal messages should be presented in a formal, impersonal manner.

4.16.3 Speech Processing

Verbal messages should be electronically processed only if necessary to increase or preserve intelligibility (e.g., by increasing the strength of consonant sounds relative to vowel strength).

4.16.4 Verbal Message Intensity

Guidance for verbal message intensity is as follows:

i) Verbal message intensity for critical functions should be at least 20 dB(A) above ambient noise levels at the typical operating positions of the intended receivers, but should not exceed 85 dB(A).

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

iii) Verbal message intensity, if adjustable, should be controlled by administrative procedures.

iv) Changes in the intensity of verbal message broadcasts should be followed by tests and verification of speech intelligibility.

5 General Emergency Alarms

General emergency alarms intended to alert a general audience (e.g., all personnel on a vessel or offshore installation) should be indicated primarily by audible alarms, including a unique tone and preferably a verbal message. These include the general emergency alarm, abandonment alarm, and those alarms warning of immediate personnel hazards such as the release of certain fire extinguishing media.

5.1 Guidance by Exception

This Subsection modifies some of the alarm guidance provided above to address specific issues related to the design of general emergency alarms.

5.2 Acknowledgement of Alarms

General emergency alarms should not be acknowledged but cleared when the condition that has triggered the alarm has been resolved or a general alarm of greater priority is engaged.

5.3 Master Silence Control

A master silence control associated with any system or equipment alarms should not silence any general emergency alarm. A separate control should be provided for general emergency alarms.

5.4 Alarm Integration

General emergency alarms should not be integrated with other alarms or alerting devices (e.g., equipment or system alarms).

5.5 Temporary Disconnection of Alarms

General emergency alarm circuits are of such importance to safety that they should not be disabled without the provision of another system for alarm notification.

5.6 Repetitive Controls

Controls that activate the general emergency alarm system should be the same in appearance and operation at each location at which they exist throughout the vessel or offshore installation.

5.7 Alarm Content

General emergency alarms may be distinct tones or tones with a verbal message added at regular intervals.

5.8 Caution Signal Controls

General emergency alarms should not be used as caution signals.

5.9 Duration of Alarm Flashing

Visual alarms associated with general emergencies should flash until the emergency is cleared.

5.10 Color and Priority Coding

Guidance for priority coding of general emergency alarms is as follows:

i) General emergency alarms should use a coding scheme that indicates their high level of priority for the audible portion of the signal.

ii) Any visual signal should make use of the appropriate color code by referring to appropriate statutory, regulatory, or class requirements. The use of a prominent position for alarm indication should be considered as well as the use of flashing mechanisms for demanding attention.

iii) The general emergency color-coding scheme should be adhered to throughout the vessel or offshore installation.

6 Navigation Bridge Alarms

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

7 Alarm Requirements by IMO *(1 August 2013)*

Alarm requirements imposed by IMO should follow the guidelines contained in IMO Assembly Resolution A.1021(26), *Code on Alerts and Indicators (2009)*, and further the IMO resolution MSC.128(75) requiring a Bridge Navigational Watch Alarm System.

8 Alarm Requirements Imposed by Other Regulatory Bodies

Where requirements for alarms specified by other regulatory bodies (e.g., Flag State Administrations and Port State authorities) are inconsistent with the guidance contained herein, those requirements take precedence over these Guidance Notes.

SECTION 5 Integration of Controls, Displays, and Alarms *(1 August 2013)*

1 General *(1 August 2013)*

1.1 Application

The principles and guidelines in this Section apply to the design, layout, and placement of individual controls, displays, and alarms within the context of operations and maintenance activities performed in association with consoles and panels. The figures in this Section are provided as examples to demonstrate control, display, and alarm integration concepts. These figures are not intended to serve as functional models or designs for any system or equipment. Actual designs must adhere to appropriate Statutory, Class, or other applicable requirements from regulatory bodies.

2 Principles

2.1 Control/Display Relationship

The relationship of a control with its associated display should be immediately apparent and unambiguous to personnel. Controls should be located adjacent to (e.g., normally under or to the right of) their associated displays and positioned so that neither the control nor the hand normally used for operating the control will obscure the display.

2.2 Control/Display/Equipment Relationship

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

Where other design considerations dictate, or where a deliberate choice is made to place the controls and displays remote from the equipment, the controls and displays should be mounted in such a manner that the relationship of the location of the controls and displays matches the arrangement of the associated equipment.

2.3 Control/Display/Alarm Relationship

On consoles or panels, controls associated with displays or alarms should be located below or to the right of the display or alarm.

2.4 Display/Alarm Relationship

The relationship between a display and the associated alarm indication should be immediately apparent and unambiguous to personnel. Displays and alarms should be located at the top of a console or panel, with the associated controls below or to the right. Alarms should be located adjacent to (e.g., normally above or to the left of) associated displays and controls. Alarms should be positioned so that neither the control nor the hand normally used for operating the control will obscure the display or alarm.

2.5 Control and Display Movement Ratio

The response of a display to a control movement should be consistent, predictable, and based on personnel's movement expectations. For principles of control movement expectations, refer to Subsection 5/6, "Control and Display Movement Relationships".

2.6 Grouping Relationships

There are two general types of ergonomic principles for arranging controls and displays on a console or panel. The first set of principles applies to determining the general location of the controls or displays and the second set of principles is for their specific arrangement within a given panel area.

2.6.1 General Location

The more important or frequently used controls and displays should be located in the center of a console or panel.

2.6.2 Control and Display Arrangement and Grouping

Controls and displays should be arranged according to task requirements (e.g., by sequence of use, precision, frequency of use) and by common function (e.g., locating two sets of auxiliary power generator unit controls and displays in two adjacent areas on a panel or console).

2.7 Segregation of Groups of Controls and Displays

Groups of controls and displays should be physically and visually segregated (e.g., a group of controls and displays associated with Generator Set A are adjacent to, but physically and visibly separated from, Generator Set B).

2.8 Labeling of Controls, Displays, and Alarms

Console and panel labels should be used to identify individual or groups of controls, displays, or alarms. Each control, display, and alarm should be labeled as described in Section 8, “Labeling, Signs, Graphics, and Symbols”.

2.9 Color Coding

Color used as a coding technique should be consistent with that of displays and should follow the guidance in 3/3.5, “Color Coding”.

2.10 Feedback

Feedback on equipment/system response to a control action should be provided as rapidly as possible. Feedback can be provided through direct visual observation of equipment or by an associated display.

3 Position Relationship of Displays and Alarms

Display arrangement, whenever possible, should provide viewing from left-to-right or top-to-bottom. This arrangement should take into consideration the cultural expectations of the intended operators and maintainers.

Displays that are functionally or otherwise related to each other should be positioned in a consistent manner to each other. As an example, dual displays providing IN and OUT type information (e.g., suction and discharge pressure), should 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

Lighted annunciators used as alarms to identify two critical positions of a measured parameter (e.g., high and low temperature, high and low pressure, high and low flow rate), should be located so that the high alarm annunciator is directly above or to the right of the low alarm annunciator.

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 right or top

OFF: On the left or bottom

START: On the right or top

STOP:	On the left or bottom
OPEN:	On the right or top
CLOSE:	On the left or bottom

4 Position Relationship of Controls to Associated Displays and Alarms

4.1 General *(1 August 2013)*

The positioning of controls to displays and visual alarms should be such 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 Section 5, Figure 1, "Position of Individual Controls and Associated Displays". 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 should be placed as shown in Section 5, Figure 2, "Row Arrangement of Multiple Controls and Displays".

4.2 Design

Control/display relationships should be apparent through proximity, similarity of groupings, coding, boundary lines, borders, labeling, or similar techniques.

4.3 Multiple Controls, Displays, and Alarms *(1 August 2013)*

For controls that cannot be located beneath or to the right of their respective displays or visual alarms, the controls should be grouped in the same row arrangement as are the displays, as shown in Section 5, Figure 2, "Row Arrangement of Multiple Controls and Displays".

FIGURE 1
Position of Individual Controls and Associated Displays

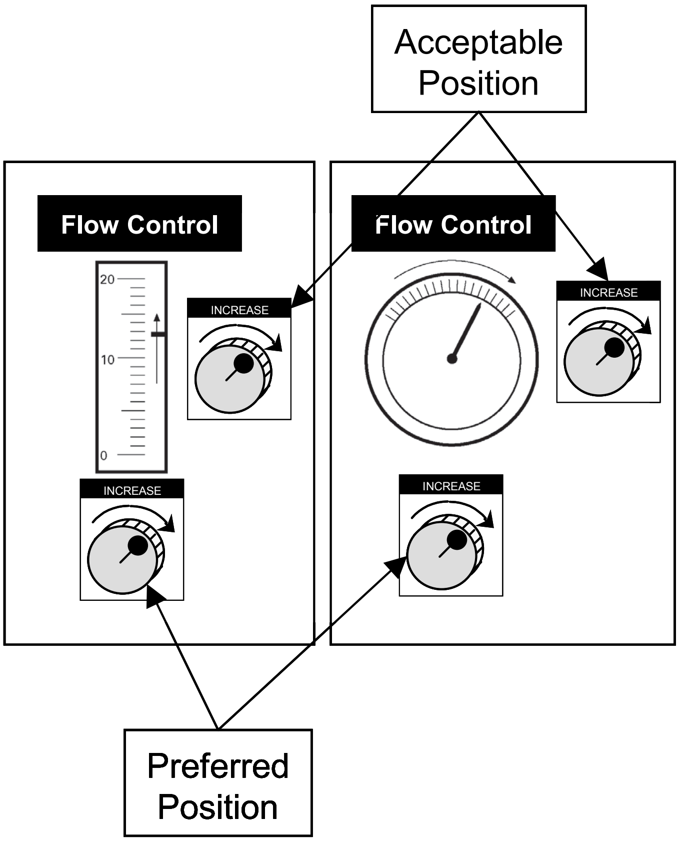
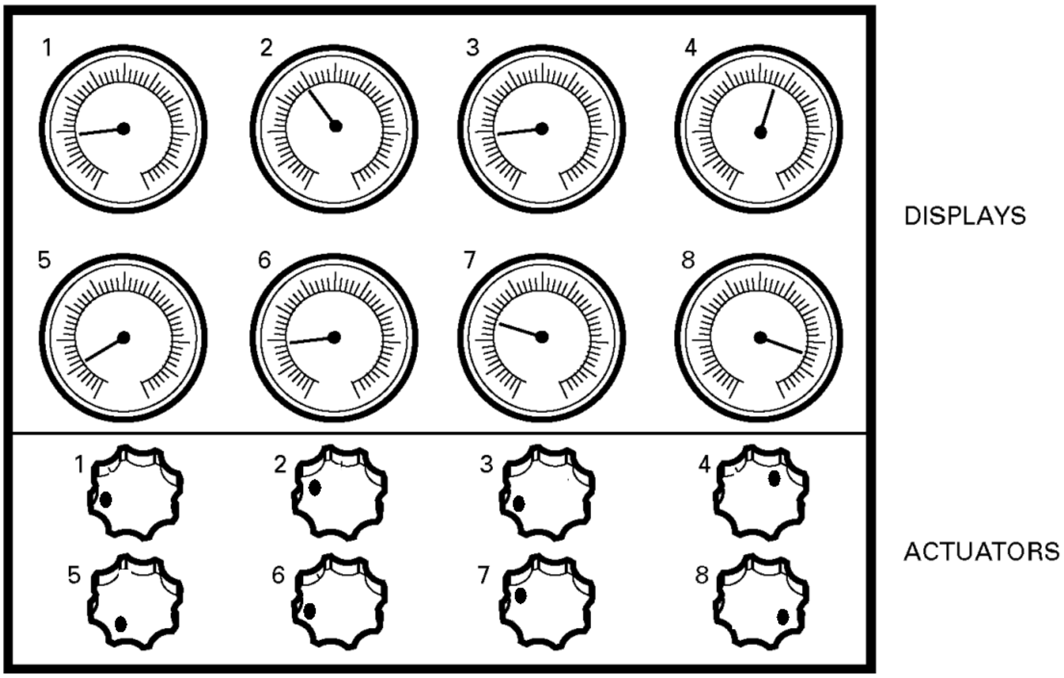


FIGURE 2
Row Arrangements of Multiple Controls and Displays



5 Location of Alarms and Alarm Response Controls

5.1 Alarm Panel Location

Matrices of visual alarms should be located on local or control room panels, above the related controls and displays which are required for corrective or diagnostic action in response to the alarm. Alarms that refer personnel to another, or to a more detailed annunciator panel outside the primary operating area, should be minimized.

5.2 Positioning of Alarms and Alarm Response Controls

Repetitive groups of alarms should have the same arrangement and relative location at different workstations. Any alarm response controls (e.g., silence, acknowledge, reset, clear) should be consistent from control panel to control panel.

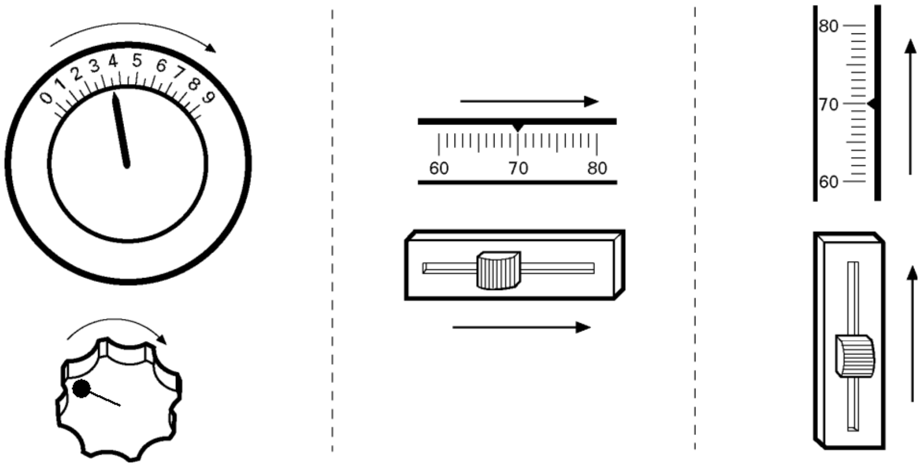
6 Control and Display Movement Relationships

The response of a display to a control movement should be consistent, predictable and based on the expectations of personnel who will use the equipment. For principles of control movement expectations, see 2/3.2, "Control Movement".

6.1 Control/Display Movement Consistency

Display indicators should clearly and unambiguously direct and guide the appropriate control response. The direction of movement of a display should be the same as the direction of movement of the control, as shown in Section 5, Figure 3, "Control and Display Movement Relationship". Clockwise movement of a rotary control or movement of a linear control forward, up, or to the right should produce a clockwise movement of the pointer in a circular display or a movement up or to the right for horizontal and vertical displays causing an increase in the magnitude of the display reading.

FIGURE 3
Control and Display Movement Relationship



6.2 Control/Display Response Characteristics

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 that speed, a high control/display ratio (low gain) is preferred. If both speed and accuracy are important, the ratio may be optimized for the specific task.

7 Grouping Relationships – Principles of Arrangement *(1 August 2013)*

Functionally related controls and displays should be located close to one another. An example is provided in Section 5, Figure 4, "Grouping by Common Function or System". Specific principles for locating components are presented below.

7.1 Determining the General Location

A combination of the following principles should be used to determine the item's location:

i) *Importance.* More important or critical controls or displays should be centrally located on a console or panel.

ii) *Frequency of Use.* More frequently used items should be centrally located.

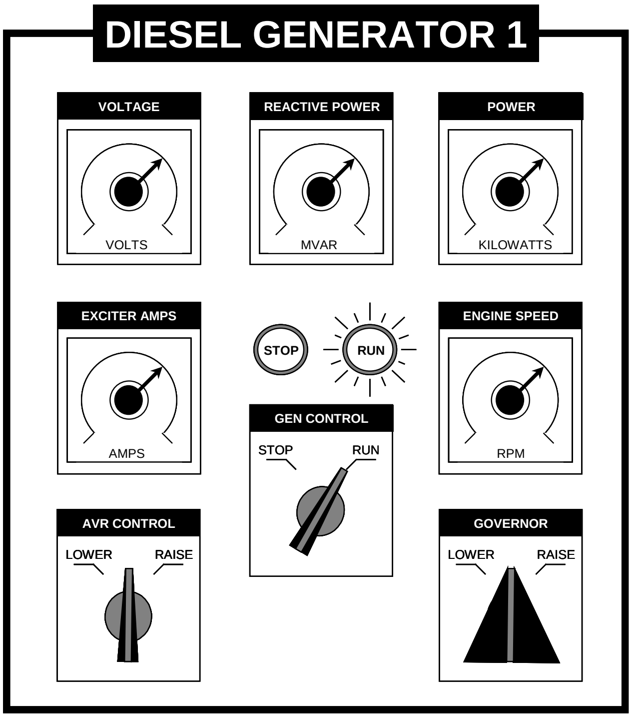
iii) *Function.* Functionally related controls and displays should be located together.

7.2 Determining the Specific Arrangement within a General Location

Items should be arranged within a given panel area using the most appropriate of the following:

i) *Common Function.* Group items having the same or similar function together, such as similar generator displays as shown in Section 5, Figure 4, "Grouping by Common Function or System".

FIGURE 4
Grouping by Common Function or System



ii) *Common Equipment.* Group common equipment, such as all controls, displays, and/or visual alarms associated with a specific piece of equipment.

iii) *Common Systems.* Group all controls, displays, and/or visual alarms associated with a complete system. An example is provided in Section 5, Figure 5, “Grouping by Common Equipment”.

iv) *Sequence of Use.* Group items in accordance with the sequence in which they are used. For example, controls, displays, and/or visual alarms used in a specific sequence, such as start-up or shutdown of equipment or a system. An example is provided in Section 5, Figure 6, “Grouping by Sequence of Use”.

FIGURE 5
Grouping by Common Equipment

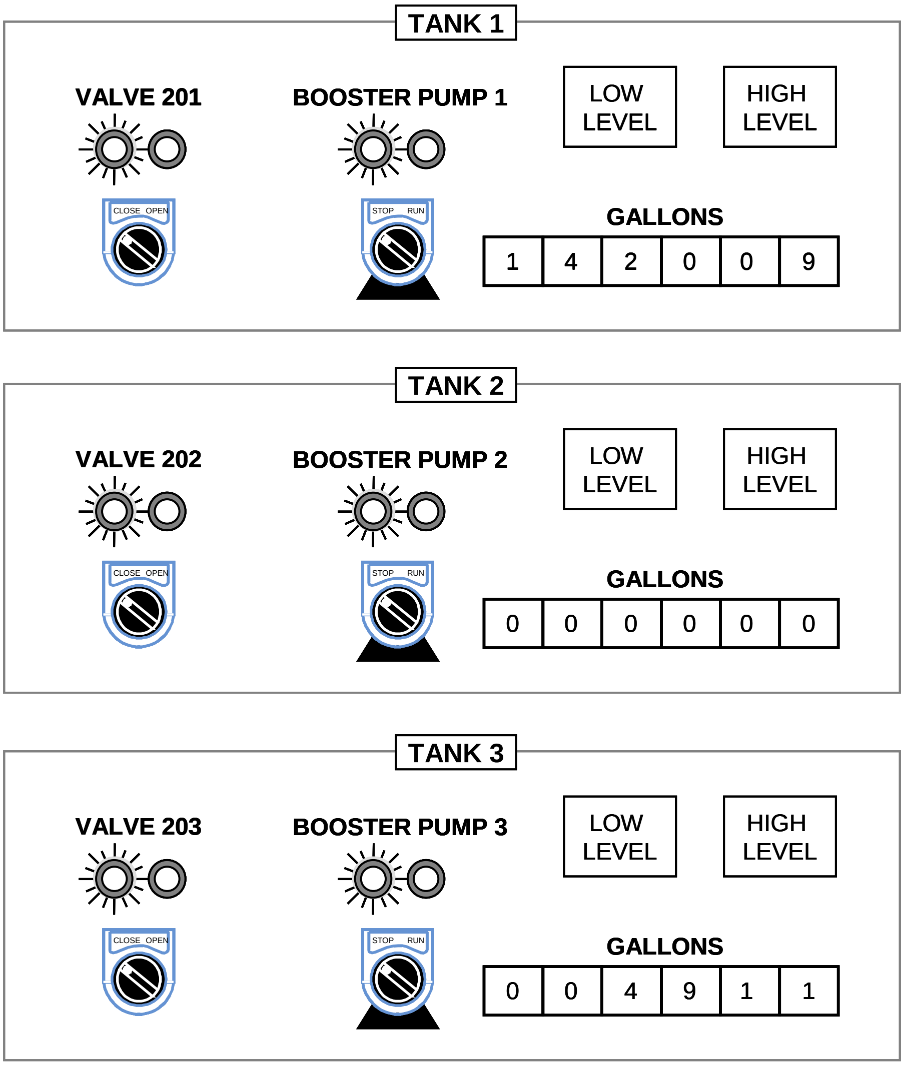
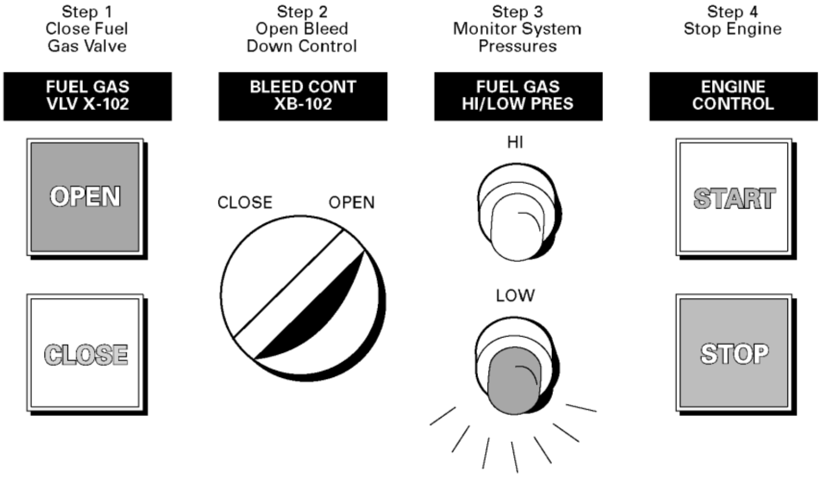


FIGURE 6
Grouping by Sequence of Use



7.3 Consistency

Controls and displays used for similar equipment or systems should be oriented the same way on different panels or consoles. An exception to this guidance would be situations where the spatial relationships of sets of equipment or subsystems differ from location-to-location and where the personnel are performing operations within sight of the equipment or subsystems. For additional guidance, see Subsection 5/9, "Spatial Relationship of Controls and Displays to Equipment".

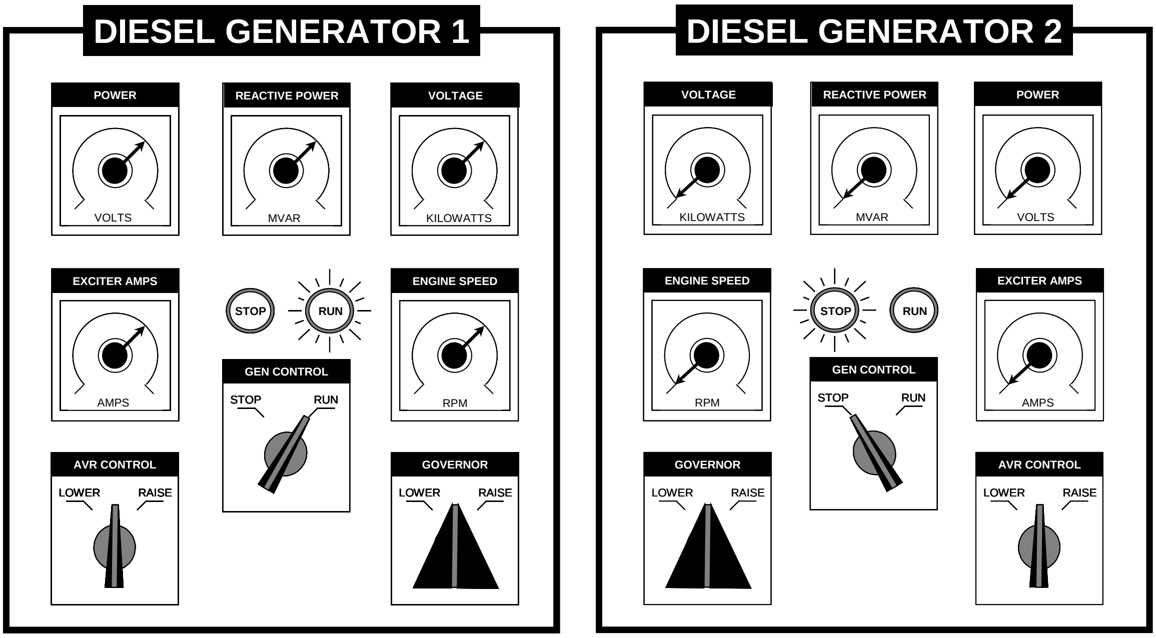
7.4 Design

Control/display relationships should be apparent through proximity, coding, the use of boundary lines and borders, labeling, or other similar techniques.

7.5 Functional Group Consistency

Location of recurring functional groups and individual items should be similar from panel to panel. Generally, *mirror-imaged arrangements should be avoided*. An example is presented in Section 5, Figure 7, "Mirror-Image Arrangement to be Avoided" where the two groups of equipment have the same function and where spatial orientation is not important to the use of the equipment, thus the mirror-imaged arrangement is likely to confuse personnel and result in human errors. Mirror-imaged arrangements are acceptable when the corresponding arrangement of the equipment or systems is also mirror-imaged and where personnel are mindful of their location at a console or panel in reference to the layout of the equipment or system itself.

FIGURE 7
Mirror-Image Arrangement to be Avoided



7.6 Feedback

Feedback on control response (displays or equipment) should be located close to its control.

7.7 Emergency Use

Emergency controls and displays that require immediate action to prevent injury to personnel or damage to the equipment or the environment should be located where they can be seen and reached with minimum delay.

8 Grouping Segregation

The general principle of grouping segregation is to provide a natural relationship among controls, displays, and equipment. Once a grouping is established based on a chosen relationship, this grouping should be segregated from other groupings. See Subsection 5/7, "Grouping Relationships – Principles of Arrangement", for guidance about how to establish groupings.

One or more of the following methods can be used to accomplish segregation of groups:

i) Physically separate the groups as shown in Section 5, Figure 8, "Grouping with Physical Separation". Horizontal separations are preferred over vertical separations.

ii) Use of boundary lines and borders around particular groups as shown in Section 5, Figure 9, "Grouping with Boundary Lines and Borders".

iii) Use of colored or shaded areas around a particular group to create a different background color from the rest of the panel or console as shown in Section 5, Figure 10, "Grouping with Colored or Shaded Areas".

iv) Use of separate subpanels mounted to a background plate as shown in Section 5, Figure 11, "Grouping with Subpanels".

FIGURE 8
Grouping with Physical Separation

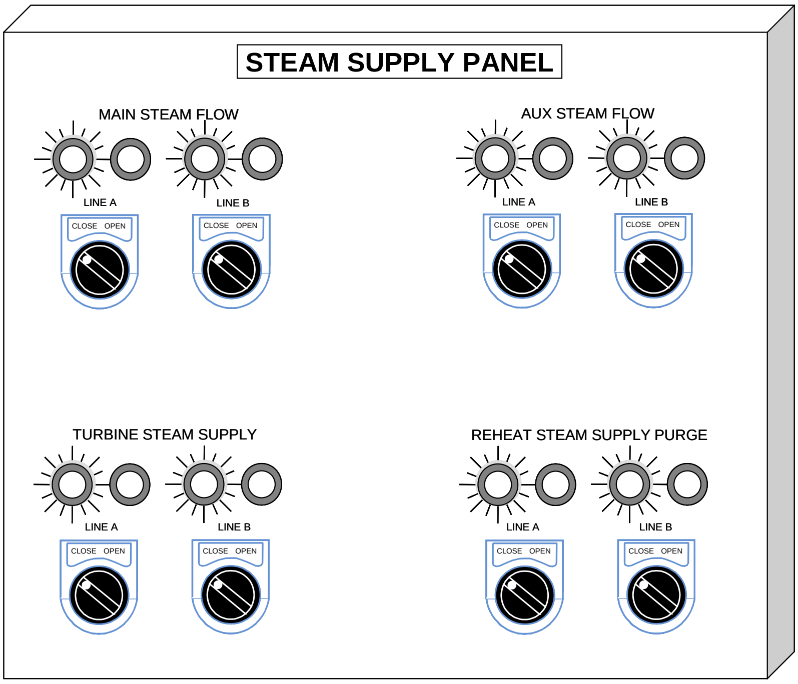


FIGURE 9
Grouping with Boundary Lines and Borders

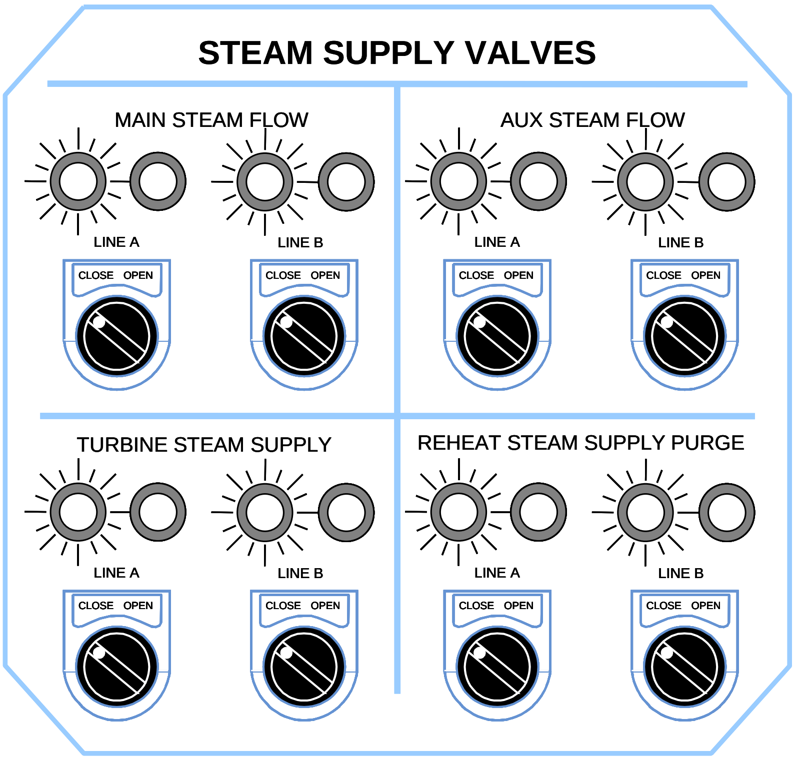


FIGURE 10
Grouping with Colored or Shaded Areas

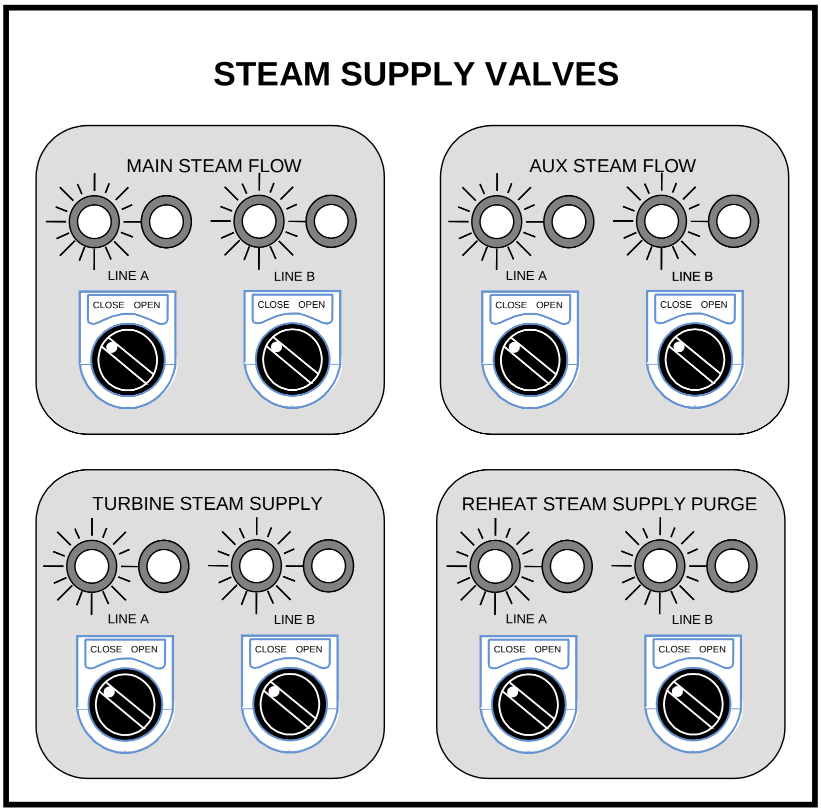
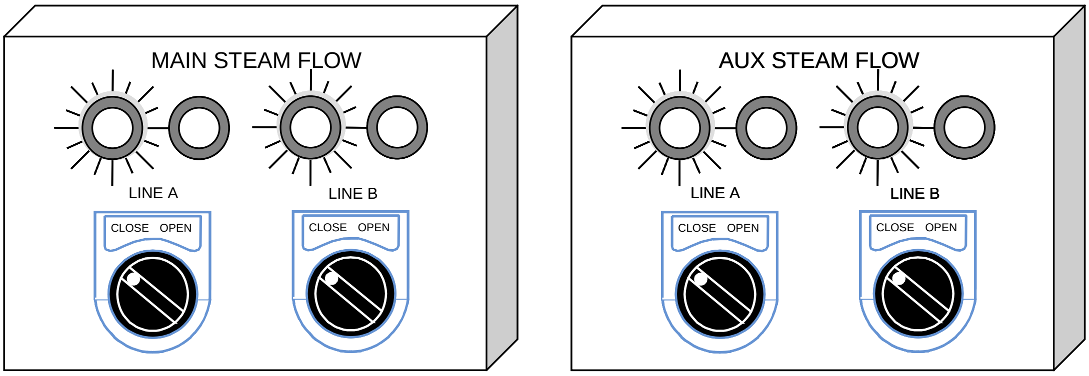


FIGURE 11
Grouping with Subpanels

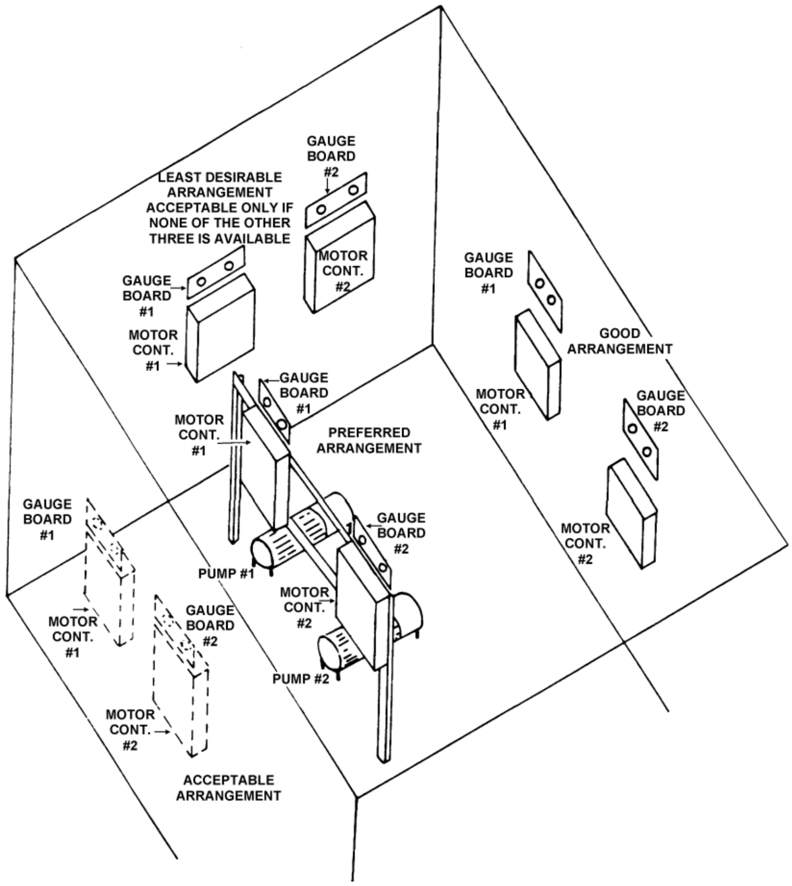


9 Spatial Relationship of Controls and Displays to Equipment

9.1 Local Position

Where local control of equipment is provided, controls or displays associated with a specific piece of equipment (e.g., 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 as shown in Section 5, Figure 12, "Relationships Between Control and Display Position and Equipment".

FIGURE 12
Relationships Between Control and Display Position and Equipment



Controls and displays for redundant or identical systems, separated within a space, or in different spaces, should be positioned with the same spatial relationship to the equipment at each location, as shown in Section 5, Figure 13, "Relationship of Local Panel with Redundant Equipment" and Section 5, Figure 14, "Relationship of Redundant Layouts in Separate Locations".

Where other design considerations dictate, or where a deliberate choice is made to place the controls and displays remote from the equipment, then the controls and displays should be mounted in such a manner that the relationship of the location of the controls and display matches the arrangement of the equipment to which they belong. Examples are provided in Section 5, Figure 15, "Example of Mounting Controls so that the Relationship Between Controls and Equipment is Visually Obvious" and Section 5, Figure 16, "Panel Layout Consistent with Equipment Arrangement and Orientation".

Where the relationship of controls, displays, and equipment is according to a process (for example, a flow arrangement of pumps, tanks, and valves), then consider use of mimic lines and demarcation to make the relationships apparent. An example of this is presented as Section 5, Figure 17, "Alternate Approaches to Panel Design: Use of Mimic Lines versus Functional Grouping with Demarcation".

FIGURE 13
Relationship of Local Panel with Redundant Equipment

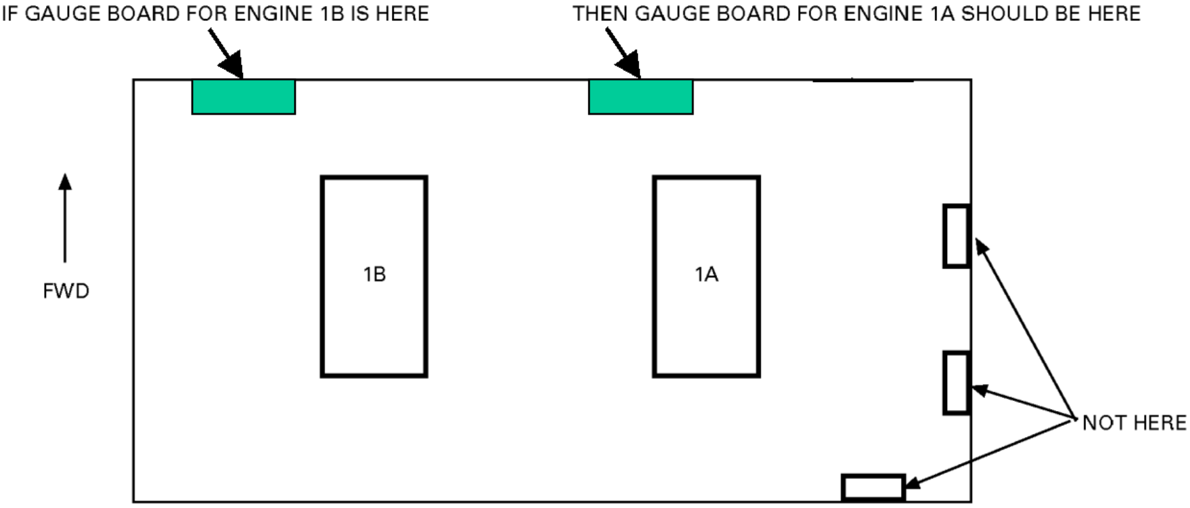


FIGURE 14
Relationship of Redundant Layouts in Separate Locations

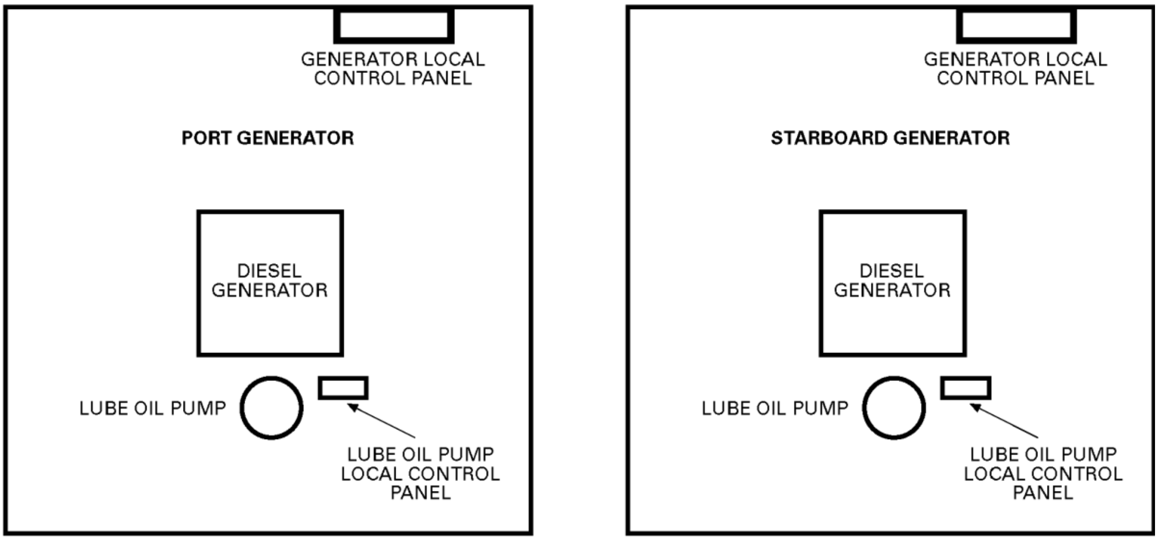


FIGURE 15
Example of Mounting Controls so that the Relationship Between Controls and Equipment is Visually Obvious

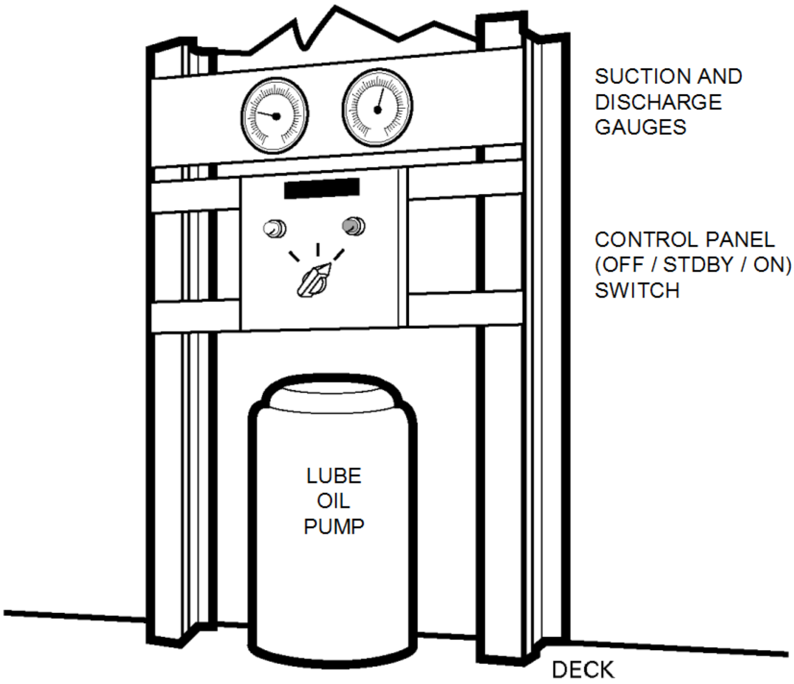


FIGURE 16
Panel Layout Consistent with Equipment Arrangement and Orientation

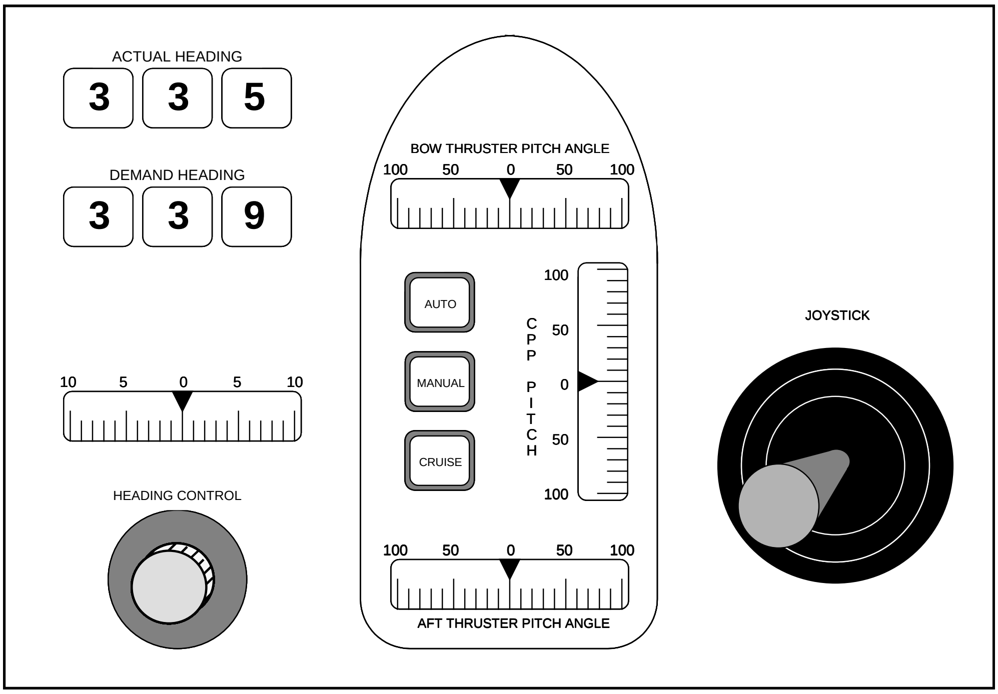
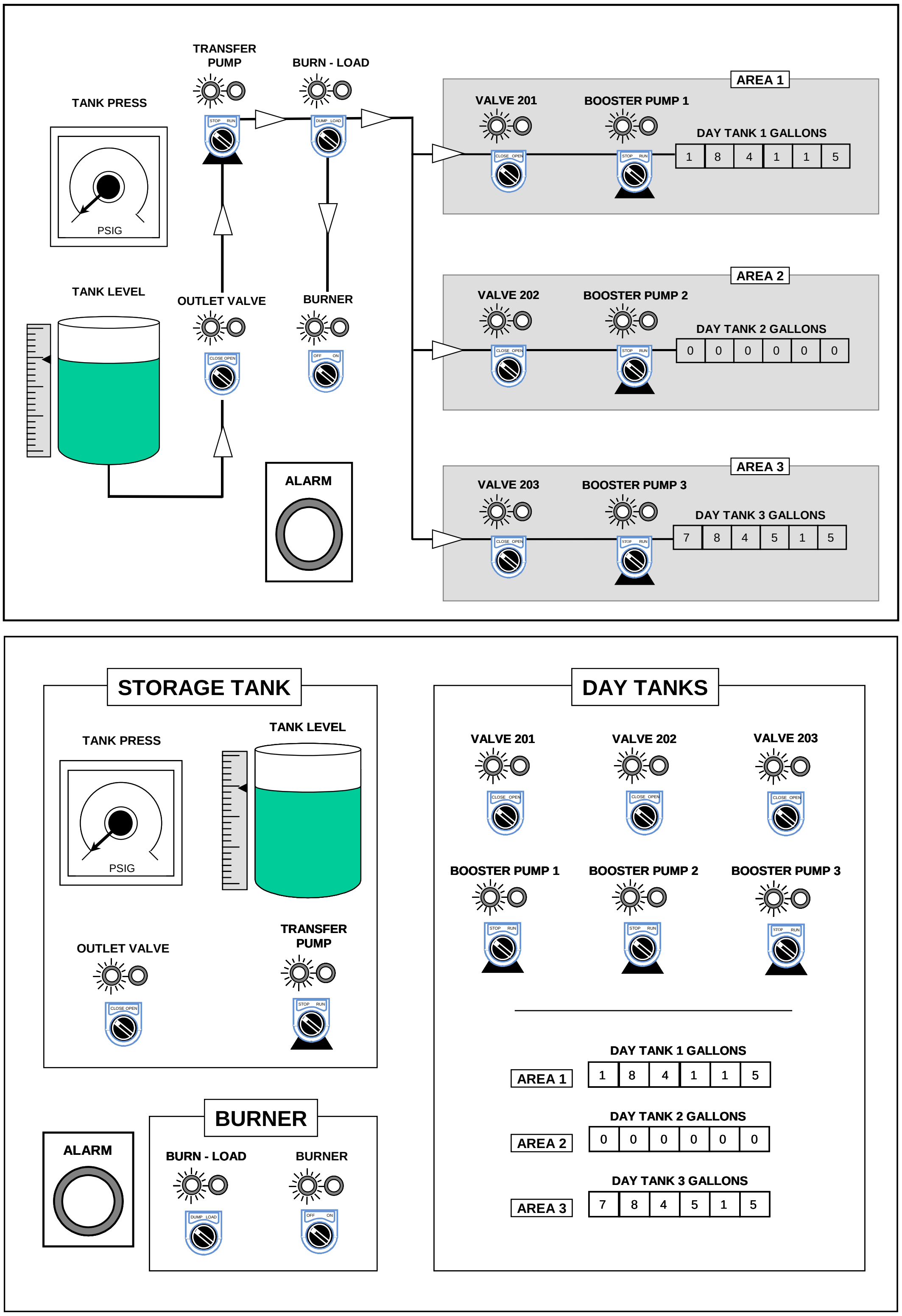


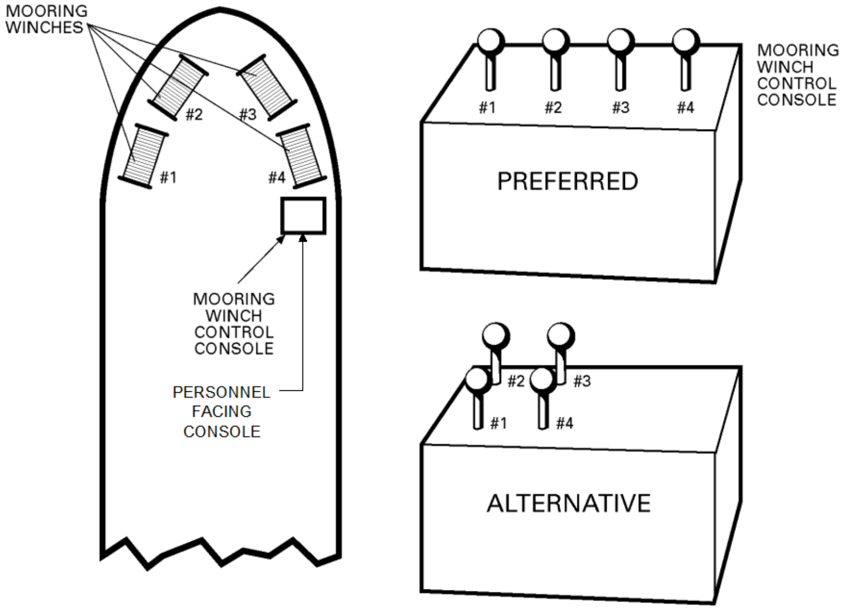
FIGURE 17
Alternate Approaches to Panel Design: Use of Mimic Lines versus Functional Grouping with Demarcation



9.2 Position on Local Console

Controls and displays on a local console (or panel) should be arranged such that their physical location on the console has a direct relationship, called *spatial relationship*, with the physical location of the associated equipment. This is particularly important where personnel working at the console are able to view the equipment from the console location. As an example, controls and displays on the left side of the console should be associated with equipment physically located to the left side of personnel, and controls and displays on the right side of the console should be associated with equipment physically located to personnel's right while facing the console. See Section 5, Figure 18, "Direct Spatial Relationships Between Controls and Equipment".

FIGURE 18
Direct Spatial Relationships Between Controls and Equipment



When a console is arranged athwartships on a vessel to control or monitor equipment or systems which are physically arranged fore and aft on the vessel (e.g., piping and pumps on a tanker), the preferred control and display arrangement on the console is shown in Section 5, Figure 19, "Spatial Relationship of Fore and Aft Equipment to Controls and Displays on a Console Located Athwartships".

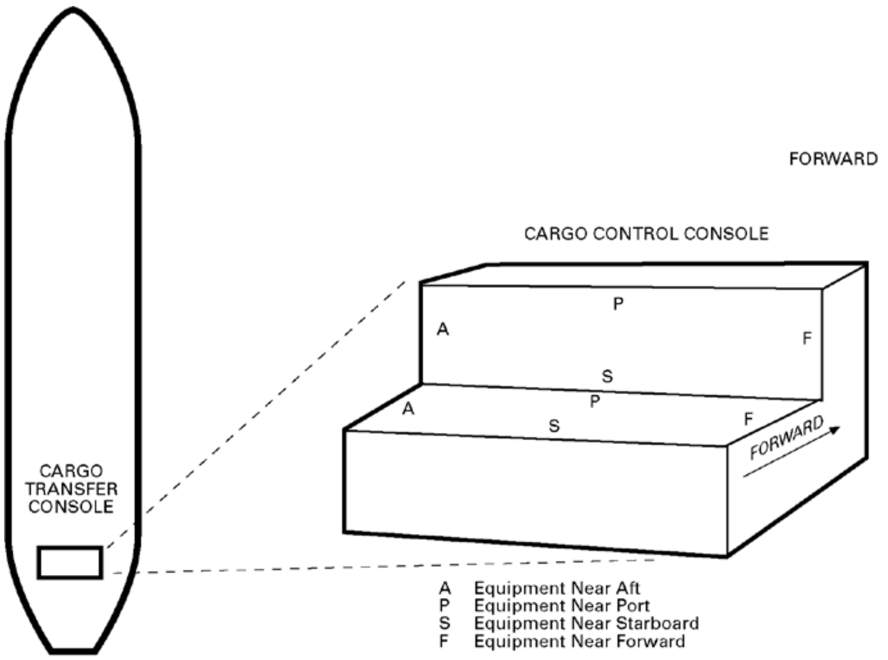
i) Controls and displays positioned on the right side of the console should be for equipment located forward. Correspondingly, those on the left side of the console are for equipment located aft.

ii) 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.

iii) This arrangement may also be used for panels and consoles oriented where personnel face port.

iv) The same rules apply to vertical control panels.

FIGURE 19
Spatial Relationship of Fore and Aft Equipment to Controls and Displays on a Console Located Athwartships



9.3 Panel Orientation for Equipment Packages

For equipment packages, including skid mounted equipment, control panels should be located and oriented so personnel can directly view the equipment being controlled and/or monitored. The panel(s) should be oriented so personnel face the equipment and panel.

9.4 Panel Layout and Spatial Relationships

Where a panel is arranged so that the control and display arrangement correlates directly to equipment, the controls and displays closest to the right side of the panel should control or monitor the equipment closest on the right. The controls and displays on the left side of the panel should be related to equipment on the left.

10 General Console Arrangements

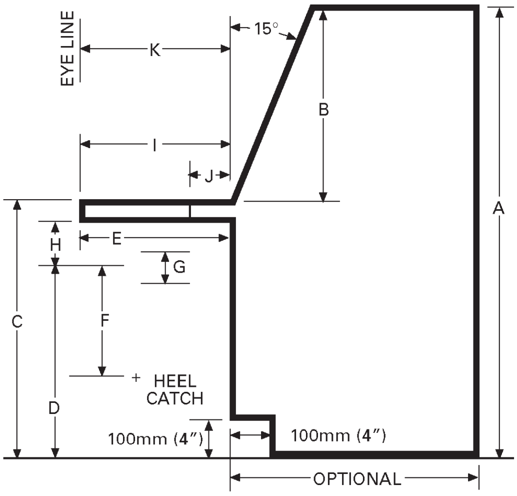
10.1 Console Dimensions

Console types include those designed for standing operations, seated operations, or for a combination of standing and seated operations. Console dimensions for these variations with and without vision over the top of the console are shown on Section 5, Figure 20, "Console Dimensions". Dimensions for consoles with video-display units are shown in Section 5, Figure 21, "Seated Video-Display-Unit Console" and Section 5, Figure 22, "Sit/Stand Video-Display-Unit Console".

Controls and displays should be grouped by importance and frequency of use. Frequently used controls and displays and those requiring precise reading or settings should be centered in the primary view and reach area. Controls and displays that are used less frequently should be located nearer to the extreme ends of the console.

Additional information regarding video-display units which are not embedded into consoles is contained in Section 6, "Computer Workstation Design".

FIGURE 20
Console Dimensions*



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	460mm	(18")
F[2,3]	Foot support to sitting surface	460mm	(18")
G[2]	Seat adjustability	150mm	(6")
H[2]	Minimum thigh clearance at midpoint of "G"	190mm	(7.5")
I	Writing surface depth including shelf	400mm	(16")
J	Minimum shelf depth	100mm	(4")
K	Eye line-to-console front distance	400mm	(16")

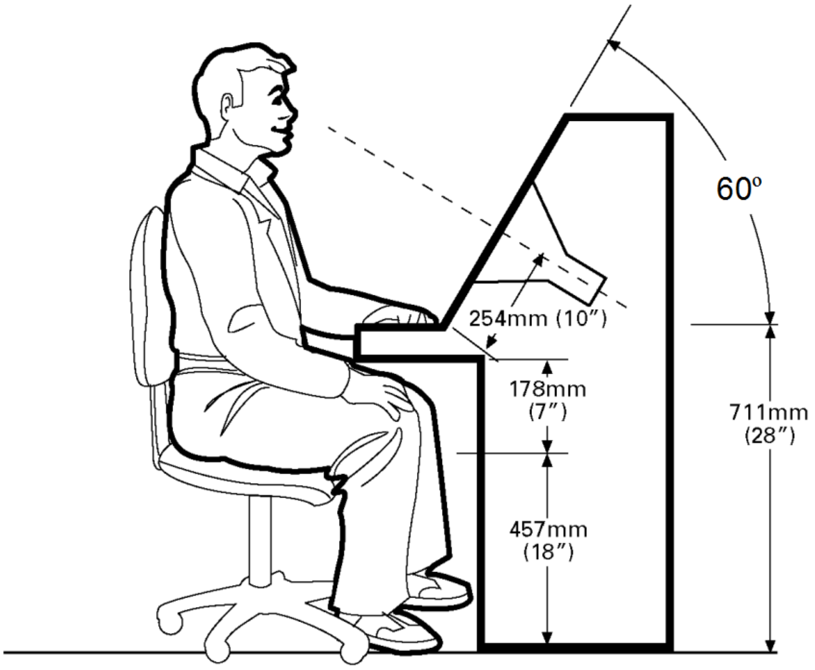
1 For A through D, see below.
2 Not applicable to console Types 4 and 5 of table below.
3 Since this dimension must not be exceeded, a heel catch must be added to the chair if "D" exceeds 400mm (18").
NOTE: A shelf thickness of 25mm (1") is assumed. For other shelf thicknesses, suitable adjustments should be made.

Type of Console	Maximum Total Console Height from Standing Surface		Suggested Vertical Dimension of Panel (Including Sills)		Writing Surface: Shelf Height from Standing Surface		Seat Height from Standing Surface at Midpoint of G		Maximum Console Width (not shown)	
	A		B		C		D			
	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."

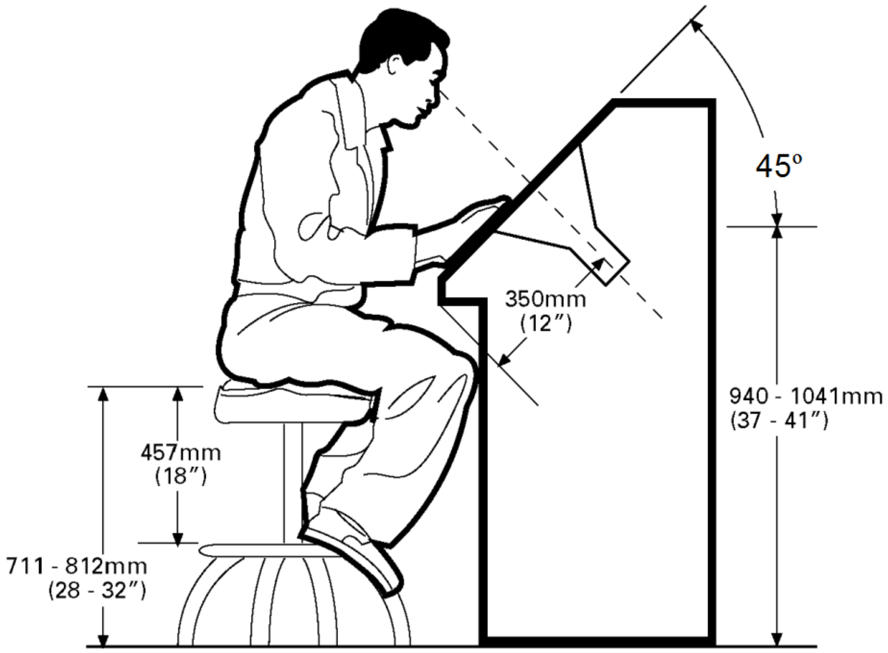
* Dimensions are based on North American males.

FIGURE 21
Seated Video-Display-Unit Console*



* Dimensions are based on North American males.

FIGURE 22
Sit/Stand Video-Display-Unit Console*



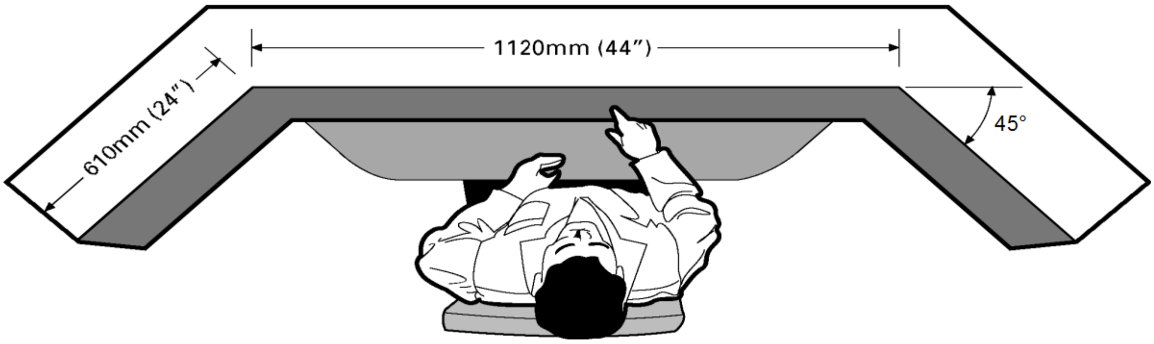
* Dimensions are based on North American males.

10.2 Extra-Width Consoles

Seated consoles should be 1120 mm (44 in.) or less in width, and standing consoles should be 1525 mm (60 in.) or less in width. There may, however, be conditions where it is preferred to have wider consoles. Acceptable alternatives include:

i) *Wrap-Around.* A console may be configured as a wrap-around console. A seated console is shown in Section 5, Figure 23, "Wrap-Around Seated Console" with an 1120 mm (44 in.) center span and 610 mm (24 in.) wings. A standing console would be similar but with a 1525 mm (60 in.) center span and 915 mm (36 in.) wings. Additional dimensions should be as shown in Section 5, Figure 20, "Console Dimensions".

FIGURE 23
Wrap-Around Seated Console



ii) *Special-Width.* A console may be configured as an extra-width seated console, as shown in Section 5, Figure 24, "Special-Width Console". Frequently used controls should be within a distance of 460 mm (18 in.) from the console's centerline and the less frequently used controls may be located within a distance of 800 mm (31.5 in.) from the console's centerline. These dimensions are based on the assumption of a single-person workstation. All other dimensions should be as shown in Section 5, Figure 20, "Console Dimensions".

iii) Additional information regarding video displays which are not embedded into consoles is contained in Section 6, "Computer Workstation Design".

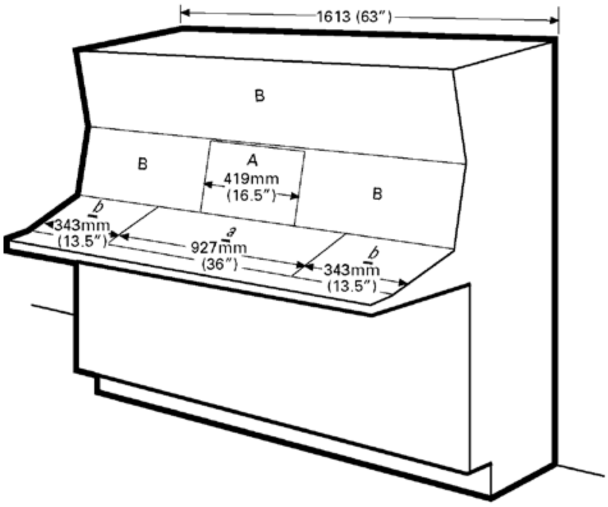
10.3 Extra-Height, Multi-Tiered Console

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 Section 5, Figure 25, "Multi-Tiered Standing Console" and Section 5, Figure 26, "Multi-Tiered Seated Console".

10.4 Desktop Consoles for Standing Personnel

Dimensions for desktop consoles for standing personnel are shown in Section 5, Figure 27, "Dimensions for Desktop Standing Console". Although it is preferred that desktop standing consoles be 1220 mm (48 in.) or less in width, consoles of greater width may be allowed for specific applications, such as a navigation bridge or propulsion control consoles. In those instances, the console layouts should separate control and display groups into segments no greater than 1220 mm (48 in.) in width on the console face. Additional information regarding video displays which are not embedded into consoles is contained in Section 6, "Computer Workstation Design".

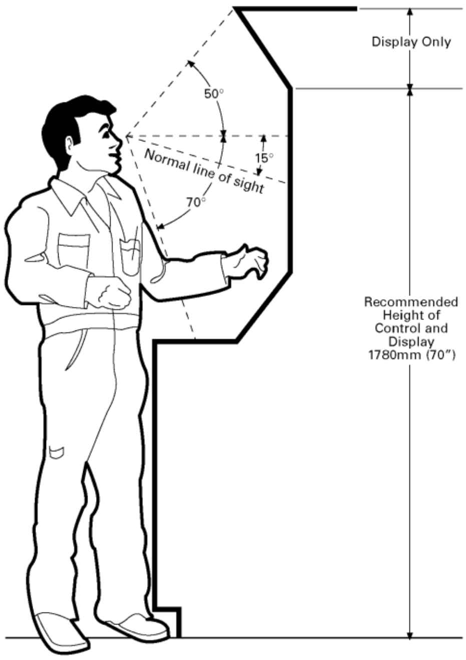
FIGURE 24
Special-Width Console*



A / a	**PRIMARY** Displays Controls	Precise and frequent use and emergency use.
B / b	**SECONDARY** Displays Controls	Normal and infrequent use.

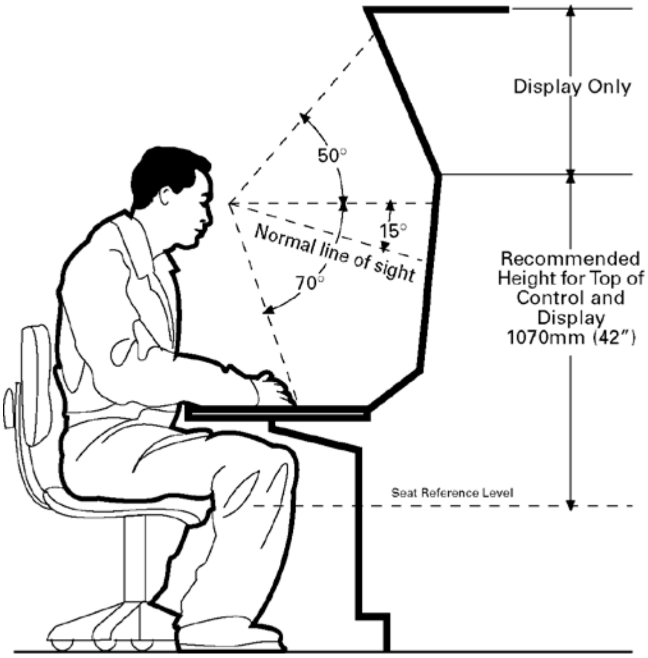
* Dimensions are based on North American males.

FIGURE 25
Multi-Tiered Standing Console*



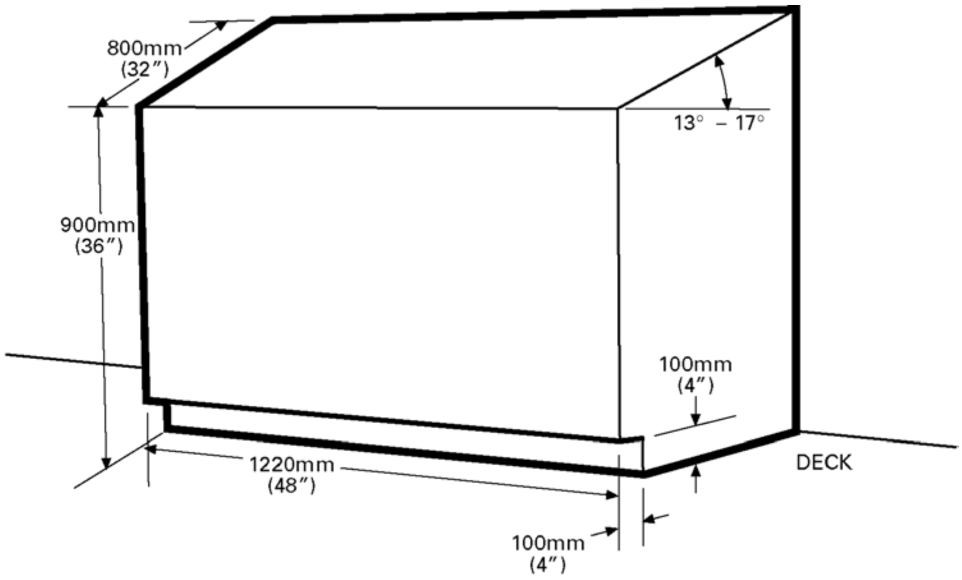
* Dimensions are based on North American males.

FIGURE 26
Multi-Tiered Seated Console*



* Dimensions are based on North American males.

FIGURE 27
Dimensions for Desktop Standing Console*



* Dimensions are based on North American males.

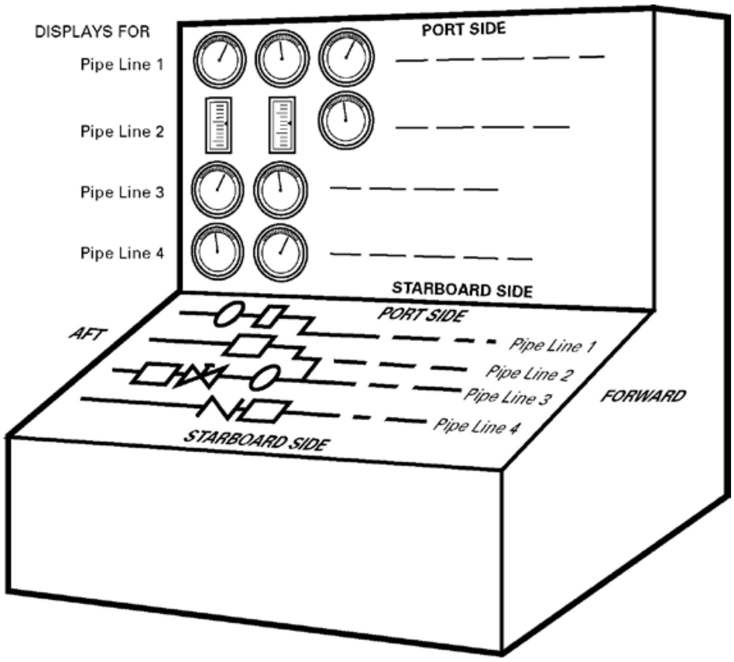
11 Specific Console Applications

11.1 Cargo and Ballast Transfer Consoles

Cargo and ballast transfer controls and displays on the console should be arranged so their orientation is spatially related to the actual tanks, valves, pumps, etc., located on the vessel or offshore installation. In the case of vessels, control panels and consoles should be installed so that personnel face forward or port.

On multi-tier consoles which use a combination of mimics, controls, and their associated displays and/or visual alarms (e.g., cargo transfer console on tankers), the layout of the bottom portion of the console and the upper tier should maintain the same relationship as shown in Section 5, Figure 28, "Cargo and Ballast Transfer Console". The top or upper area of the console face should 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.

FIGURE 28
Cargo and Ballast Transfer Console



11.2 Propulsion, Navigation, and Steering Consoles

Consoles associated with the control of propulsion engines; navigation, including chart tables, radar, electronic chart displays, and steering should be installed so that personnel face forward in the direction in which the vessel travels. This should be done whether or not personnel have visual contact with the outside of the vessel.

11.3 Auxiliary Machinery Consoles

Consoles associated with auxiliary machinery, such as vessel service generators, pumps, mooring winches, or thrusters, should 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 or aft thruster room, the console for each piece of equipment should be located and oriented the same in each space.

SECTION 6 Computer Workstation Design *(1 August 2013)*

1 General

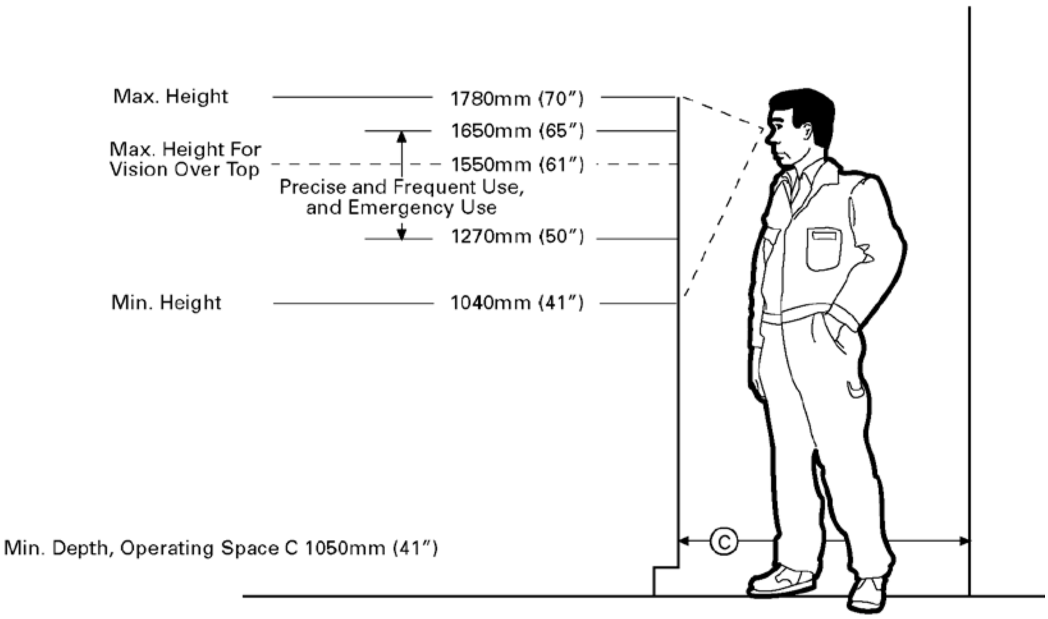
Computer workstations should comply with the following design recommendations to facilitate task performance and minimize fatigue in personnel.

2 Anthropometrics

Computer workstations should be designed to accommodate the expected range of personnel. Section 6, Figure 1, "Display Heights for Standing Personnel" and Section 6, Figure 2, "Seated Workstation Illustration", present general computer workstation arrangements. These figures' dimensions are based on North American males.

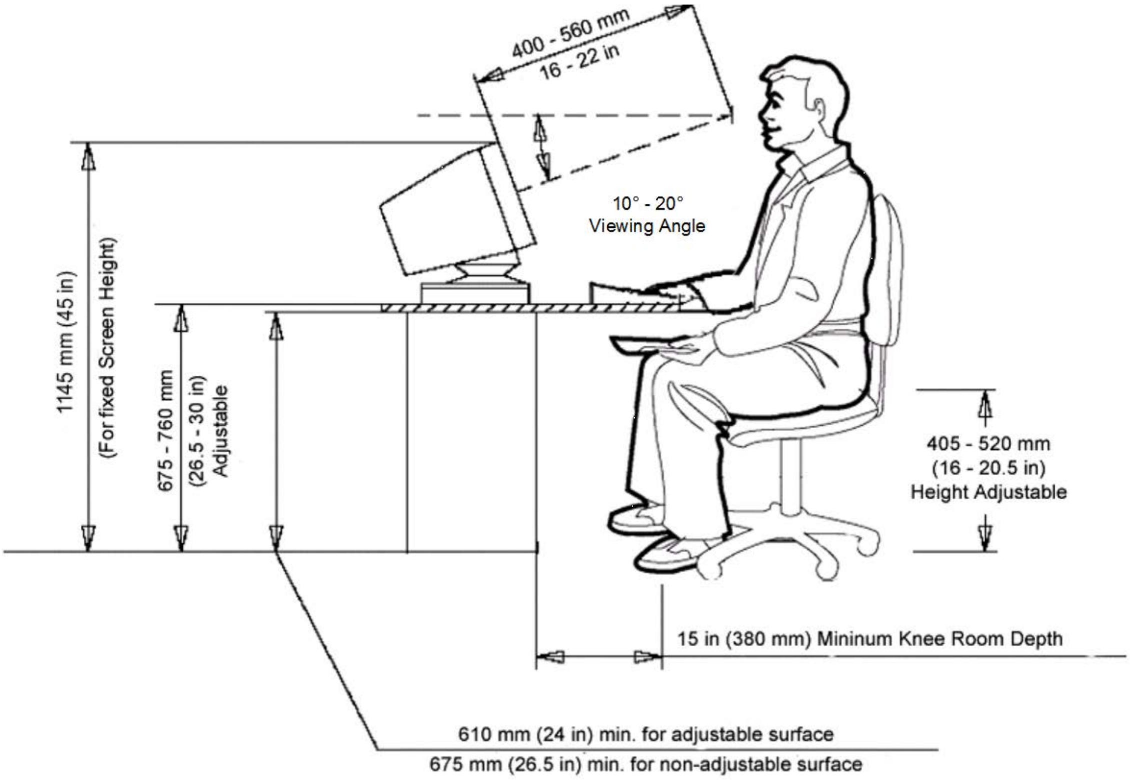
All designs based on anthropometric data should consider differences in size and stature of personnel from different ethnic and geographic groups. Given the international nature of the marine and offshore industries, consideration should be made for the widest range of possible personnel populations. Appendix 1, "Anthropometric Design Principles and Dimensions" contains detailed anthropometric data for many international populations.

FIGURE 1
Display Heights for Standing Personnel*



* Dimensions are based on North American males.

FIGURE 2
Seated Workstation Illustration*



* Dimensions are based on North American males.

3 Usability and Workstation Adjustability

In order for a workstation to be useable, it may be necessary for an operator or maintainer to configure that workstation to meet individual requirements. In particular, seated workstations should be provided with adjustable seating, sufficient arm support and workspace for the intended task.

4 Maintainability

Workstations should be designed to provide access to necessary hardware and equipment for maintenance purposes.

5 Workstation Ambient Environment

Whole-body vibration, noise, indoor climate, and lighting characteristics of computer workstation areas should follow the guidance presented in Section 12, "Crew Habitability".

6 Consoles and Desks

A console is a single piece of furniture that accommodates the video display and associated hardware. Desks are more general purpose workspaces and typically do not provide storage for computers or video displays. The console or desk supplied should provide a suitable work surface height, working area, and knee room. See Section 6, Figure 2, "Seated Workstation Illustration", for design recommendations. All workstation designs based on anthropometric data should consider differences in size and stature of persons from different ethnic and geographic groups. Appendix 1, "Anthropometric Design Principles and Dimensions", contains detailed anthropometric data for many international populations. Also see Subsection 5/10, "General Console Arrangements" for examples of video-display units embedded in consoles.

7 Writing Surfaces

A writing surface should be at least 400 mm (16 in.) deep and 610 mm (24 in.) wide. For surfaces where a keyboard and mouse may be used, the width should be at least 760 mm (30 in.).

It is suggested that writing and working surface heights be adjustable in order to prevent overexertion or strain of the back or appendages.

8 Working Surface Height

The working surface should be between 710 mm (28 in.) and 760 mm (30 in.) above the floor surface on which the chair sits. Where practical, writing and working surface heights should be adjustable.

9 Seating

For most tasks, office chair seating is acceptable. The height of the seat pan should be adjustable in order to accommodate a variety of personnel. This height should be adjustable from 380 mm (15 in.) to 520 mm (20.5 in.) when measured from the surface on which the chair sits to the top of the seat pan. Seating should also have adjustable seat pan angle, seat back height, and seat back angle.

10 Keyboard Height

Keyboard support surfaces should be adjustable between 585 mm (23 in.) and 710 mm (28 in.) above the floor surface on which the chair sits.

11 Viewing Distance

Viewing distance from the operator or maintainer's eye to the video display should be between 400 mm (16 in.) and 560 mm (22 in.). A viewing distance of between 460 mm (18 in.) and 510 mm (20 in.) is recommended. The top height of the video display should be 1145 mm (45 in.), creating a viewing angle of 10 degrees to 20 degrees. See Section 6, Figure 2, "Seated Workstation Illustration".

12 Video Display Height

Video display height should be adjustable so that the topmost line of display on the screen should not be higher than the operator or maintainer's eyes. If a fixed height is mandated by hardware constraints the top of the screen should be 1145 mm (45 in.) above the surface on which the chair sits.

13 Knee Space

Knee space under the keyboard support surface should be a minimum of 610 mm (24 in.) for an adjustable surface or 675 mm (26.5 in.) for a non-adjustable support surface. The width of this space should be a minimum of 510 mm (20 in.), and the depth should be a minimum of 380 mm (15 in.). See Section 6, Figure 2, "Seated Workstation Illustration".

SECTION 7 Manual Valve Operation, Access, Location, and Orientation *(1 August 2013)*

1 General *(1 August 2013)*

1.1 Application

The principles and guidelines of this Section apply to the manual operation of valves, including those operated by handwheels or levers.

2 Principles

2.1 General Access

For valves required by function or design to be readily accessible, the valve or its control should be:

i) Located in a space normally entered without using tools

ii) Clear of and protected from obstructions, moving equipment, and hot surfaces that may prevent or delay operation or maintenance

iii) Within arm's reach. See Section 7, Figure 1, "Mounting Heights for Handwheel Valves With Vertical Stems" and Section 7, Figure 2, "Mounting Heights for Handwheel Valves with Horizontal Stems"

Valves should be located so that 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 standing surface for the operation, maintenance, repair, or replacement of any valve. A minimum of 75 mm (3 in.) clearance should 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. Valves should not be mounted in positions where stems on handwheels or levers will extend into normal walking areas.

2.2 Emergency Access

Valves used for emergency operations should not be located below deck gratings or behind covers. If it is absolutely necessary to locate valves behind covers, (e.g., to meet a regulatory requirement) the cover should be capable of being opened without requiring any tools or the removal of any securing fasteners. The cover should be clearly labeled to identify the valve.

2.3 Valve Operators and Indicators

Valves should close with a right hand (clockwise) motion of the handwheel or lever when facing the end of the stem. Valves should be provided with a means to determine 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.

For valves that cannot be operated 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 should be provided with the control.

2.4 Labeling

Labels should be used to identify manual valves. Subsection 8/4, "Equipment Identification Labels" provides guidance on valve labeling.

2.5 Maximum Force

The maximum force to initially crack open a manual valve should not exceed 450 N (100 lb).

3 Categorization of Valves for Selection of Location *(1 August 2013)*

3.1 Applicability

Valve location, accessibility, orientation and ease of use should be determined on the basis of a Valve Criticality Analysis or other analytic means to determine valve location and access based on criticality and method and frequency of use. Identification of individual valve criticality can be of joint participation among vessel designers, operators, and owners. The following three categories define valve criticality.

3.2 Category 1 Valves

Category 1 valves include those essential to normal or emergency operations where rapid and unencumbered access and operation or maintenance is essential; thus, permanent access should be provided at a deck level or via a permanent standing surface. If such access is not practical, access by stair or ladder is acceptable. Valves meeting any of the following will be qualified as Category 1 valves:

i) Valves that are essential for operations

ii) Overboard valves

iii) Equipment isolation valves

iv) Valves that are essential for personnel or process safety, cargo protection, and pollution prevention

v) Valves where there is a high likelihood of failure

vi) Valves where the consequence of failure or lack of quick access would result in damage to personnel or property, loss of productivity, or damage to equipment or the environment)

vii) Valves where an expected operational and/or maintenance frequency is greater than once in a six-month period

Examples of valves typically included in Category 1 are:

i) Control valves, their bypasses and isolation valves

ii) Relief valves and depressuring valves

iii) Trip and anti-surge control valves

iv) Ballast water discharge valves

3.3 Category 2 Valves

Category 2 valves are those that are not critical for normal or emergency operation or maintenance but are used during routine maintenance activities.

These should be located with permanent access at deck level, access via stair or other access aid with a purpose-built standing surface/landing.

Examples of valves typically in Category 2 are:

i) Sewage treatment valves

ii) Drain valves

iii) Service oil valves

iv) Battery limit valves

v) Gas freeing connections

vi) Manual valves with an expected operating and/or maintenance frequency of less than once per six months

vii) Valves where quick action is not required

3.4 Category 3 Valves

Category 3 valves are those used in particular circumstances on an infrequent or rare basis. While no specific location guidelines are imposed for Category 3 valves, several guidelines exist related to safety of Category 3 valve use and operation.

Examples of valves typically included in Category 3 are:

i) Valves used in drydock only

ii) Valves used in initial commissioning

iii) Valves used for decommissioning

iv) Valves used to isolate pressure vessels, tanks, etc., for inspections

v) Valves for pressure test

3.5 Assignment of Guidance by Valve Category

For Category 1 valves, unless otherwise indicated, all the guidelines stated in this Section apply to Category 1 valves.

Category 2 valve guidelines are indicated in the guidelines statements. Any guideline that applies to Category 2 valves also applies to Category 1 valves.

Category 3 valves have no specific access, positioning or orientation guidelines; however, safety of use and operation guidelines are imposed on Category 3 valves.

3.6 Valve Operators and Indicators

Valves should close with a right-hand (clockwise) motion of the handwheel or lever when facing the end of the stem, or where left-handed valves are provided, direction or turn to close the valve should be indicated on the valve, its label or on the handwheel itself. (Category 1 and 2)

Valve position indicators should be installed on each valve. (Valves where the position of the stem (i.e., rising stem valves) or the position of the handle (i.e., ball valve) provides a direct indicator of the valve position do not require and additional "valve position indicator"). (Category 1 and 2)

Valve position indicators should be directly visible to the operator or maintainer from the normal body position required to open or close the valve. (Category 1 and 2)

Valves should capable of being operated without mechanical extenders such as a reach rod or chain operators. (Category 1)

For valves fitted for remote control:

i) An independent indicator showing the position of the valve (open, closed or midway) should be provided at the control. (Category 1 and 2)

ii) An independent indicator showing the position of the valve (open, closed or midway) should be provided at the physical location of the valve. (Category 1 and 2)

iii) Category 1 valves should be provided with redundant controls located near or on the valve body itself (for the cases where remote means of operation is not working).

3.7 Labeling, Marking and Coding

i) Labels should be provided to identify manual valves. (Category 1 and 2)

ii) Labels, markings and coding should be visible to the operator from the normal body position required to open or close the valve. (Category 1 and 2)

3.8 Clearances

i) Clearance of at least 300 mm (12 in.) for wrenches should be provided adjacent to flanged connections for valves and equipment where bolts can be accessed from one side only. (Category 1 and 2)

ii) Clearance of at least 760 mm (30 in.) should be maintained on both sides of pipe where access for work or maintenance is required. Where simply accessing bolts from both sides of the pipe, greater than 300 mm (12 in.) clearance should be provided. (Category 1 and 2)

iii) A 75 mm (3 in.) clearance should be maintained all around valve handwheels, except that 40 mm (1.5 in.) and smaller valves where operation is by hand or wrist motion may have less clearance, minimum 40 mm (1.5 in.) finger clearance. (Category 1 and 2)

3.9 Maximum Force

The maximum force to initially crack open a manual valve should not exceed 450 N (100 pound force). (Category 1 and 2)

3.10 Turning Aids

Knurling, indentation, high-friction covering or a combination of these should be built into handwheels to facilitate the operator's grasp for applying maximum force. (Category 1 and 2)

3.11 Handwheel Rim Dimension

i) The handwheel rim for handwheels with diameters larger than 150 mm (6 in.) should be cylindrical to facilitate grasping and applying maximum force. (Category 1 and 2)

ii) The rim diameter should be 20 to 40 mm (0.75 to 1.5 in.). (Category 1 and 2)

3.12 Human Endurance

i) The human endurance limit applied should be 100 turns maximum to open or close a valve at a rate between 15 and 60 revolutions per minute. (Category 1 and 2)

ii) Where the above guideline (item *i)*) is not met, a hand-held power (pneumatic, hydraulic, or electric) valve-turning machine should be provided. (Category 1 and 2)

iii) The weight of such a hand-held valve-turning machine should not be in excess of 20 kg (44 lbs). (Category 1 and 2)

4 Preferred Valve Mounting Heights and Orientations *(1 August 2013)*

4.1 Handwheel-Operated Valves

Handwheels of less than 100 mm (4 in.) in diameter should be provided when intended for one-hand operation. Handwheels of greater than 150 mm (6 in.) diameter should be provided when intended for two-hand operation. (Category 1 and 2)

Handwheels with diameters between 100 mm (4 in.) and 150 mm (6 in.) should be avoided (since they are too large for one-hand operation and too small for two-hand operation). (Category 1 and 2)

Valve handwheels should be located as shown in the following figures for orientation of valve stem in the vertical, horizontal or angled position.

- Figure 1, "Mounting Heights for Handwheel Valves with Vertical Stems"
- Figure 2, "Mounting Heights for Handwheel Valves with Horizontal Stems"
- Figure 3, "Mounting Heights for Handwheel Valves with Angled Stems"

Per Section 7, Figures 29, 30, and 31, Category 1 valves can be located in either Category 1 or 2 valve locations when:

i) Handwheels are in excess of 600 mm (24 in.) diameter, or

ii) Valves are used for emergency responses, (for example, fire fighting or deballasting), or

iii) Stem freeze-up is possible, or

iv) Handwheel operating torque is in excess of 54 N-m (40 ft-lbs), or

v) The valve may be expected to be operated by a short male or female.

Per the figures, Category 2 valve locations are reserved for Category 2 valves, and Category 1 valves should not be fitted in those locations.

Category 1 or Category 2 valves should not be fitted outside the indicated locations.

FIGURE 1
Mounting Heights for Handwheel Valves with Vertical Stems *(1 August 2013)*

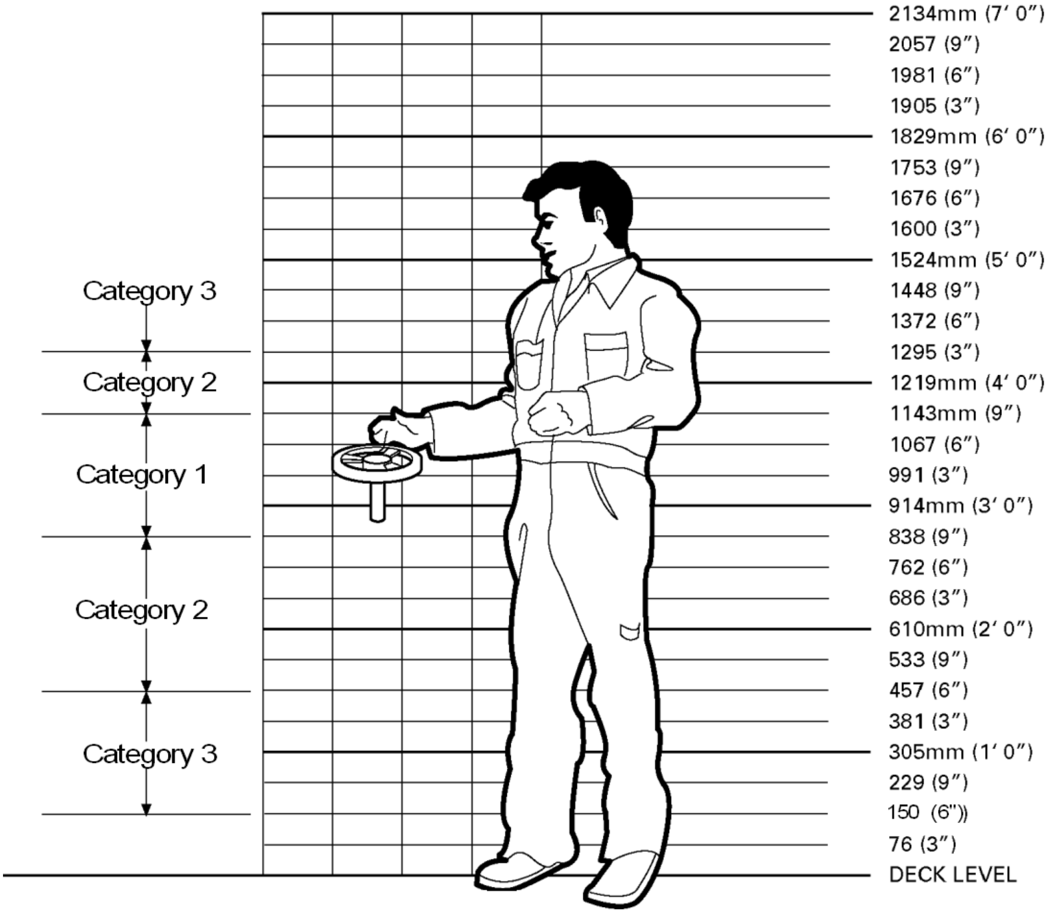


FIGURE 2
Mounting Heights for Handwheel Valves with Horizontal Stems *(1 August 2013)*

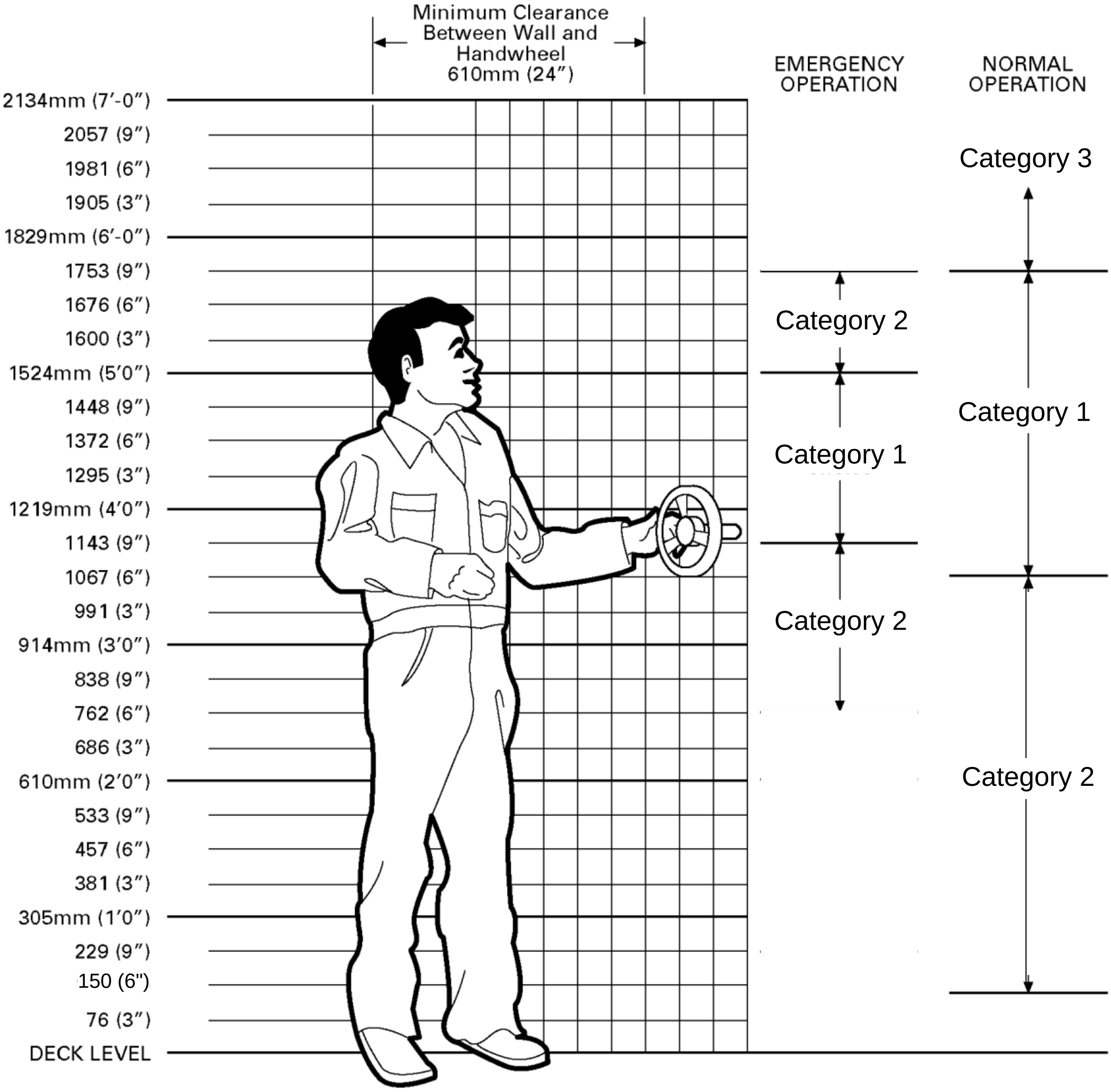
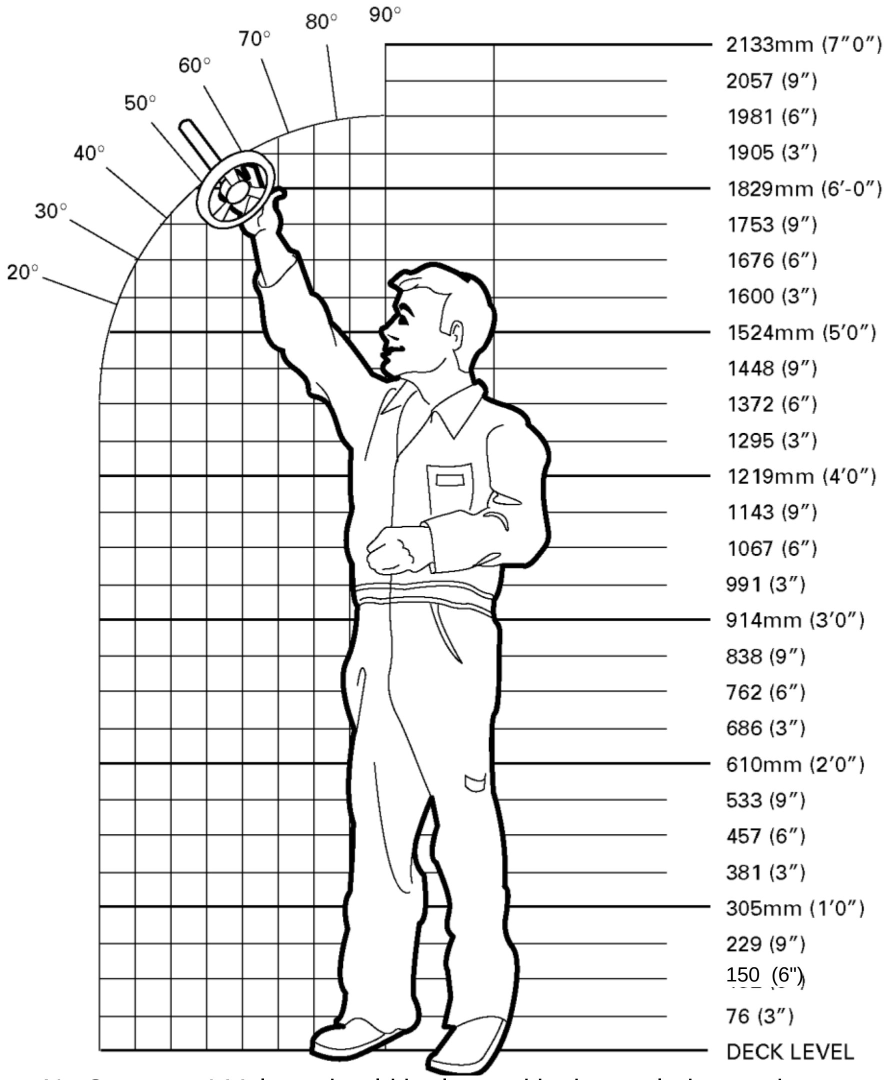


FIGURE 3
Mounting Heights for Handwheel Valves with Angled Stems *(1 August 2013)*



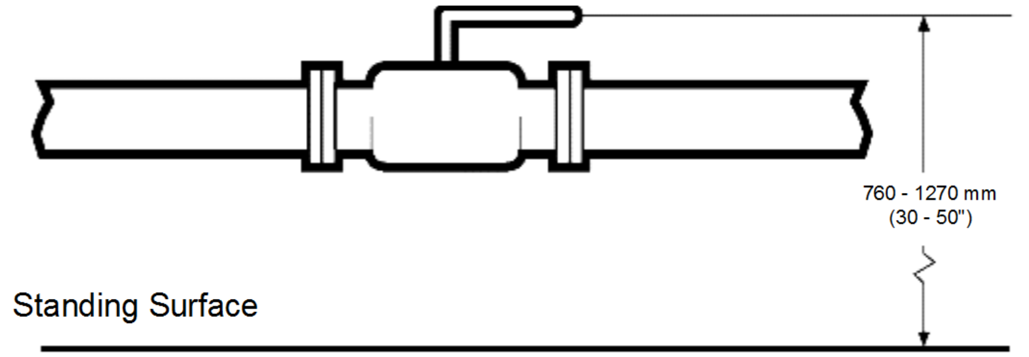
No Category 1 Valves should be located in the angled area shown (20° to 90°)".

No Category 2 valves can be positioned above 40 degrees.

4.2 Lever-Operated Valves

Lever-operated valves oriented with the stem in a vertical position should be provided when the valve lever can be located between 760 mm (30 in.) and 1270 mm (50 in.) above the standing surface, as shown in Section 7, Figure 4, "Mounting Heights for Lever-Operated Valves with Vertical Stems". (Category 1 and 2)

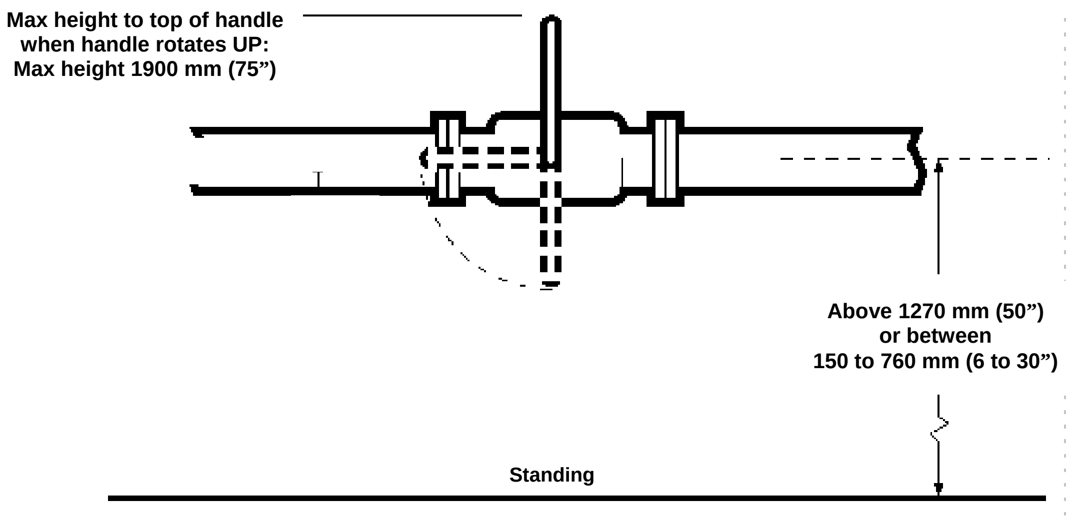
FIGURE 4
Mounting Heights for Lever-Operated Valves with Vertical Stems *(1 August 2013)*



Lever-operated valves oriented with the stem in a horizontal position should be provided when the lever is located between 150 mm (6 in.) and 760 mm (30 in.), or more than 1270 mm (50 in.) above the standing surface, as shown in Section 7, Figure 5, "Mounting Heights for Lever-Operated Valves with Horizontal Stems". The maximum height above the standing surface to the lever tip should not exceed 1900 mm (75 in.). (Category 1 and 2)

Horizontal stem valves should not be located overhead in working areas. (Category 1 and 2)

FIGURE 5
Mounting Heights for Lever-Operated Valves with Horizontal Stems *(1 August 2013)*



5 Alternative Valve Orientations

5.1 Valves in Overhead Position *(1 August 2013)*

When it is necessary to locate a manual valve's actuator above a user's head, the operating torque should be no more than 27 N-m (20 ft-lbs). (Category 1 and 2)

Valve handwheels should not be larger than 510 mm (20 in.) in diameter. (Category 1 and 2)

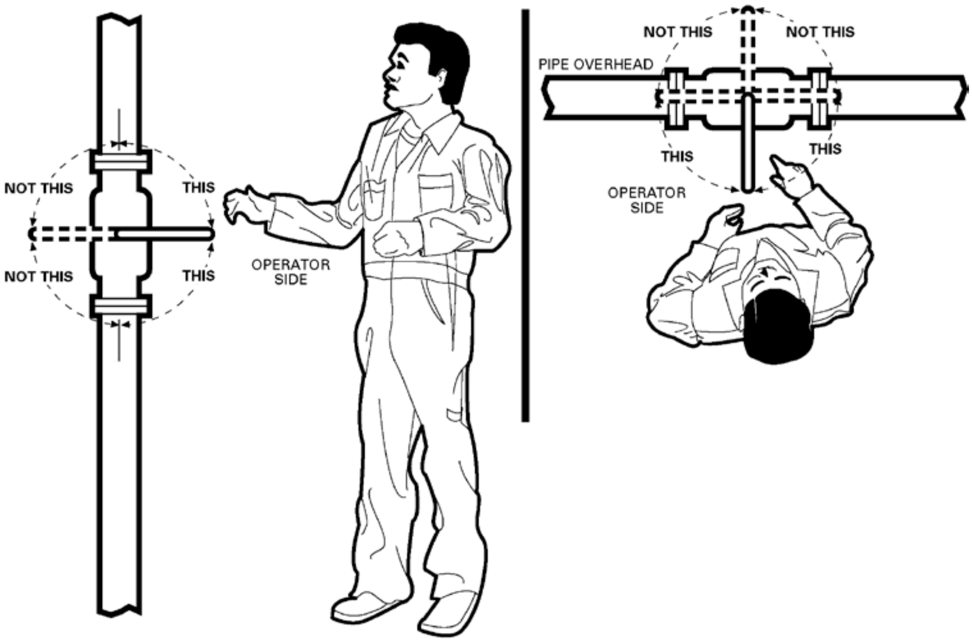
5.2 Valves in Walkways *(1 August 2013)*

Valve orientation should not place the valve lever into a passageway. (Category 1, 2 and 3)

5.3 Valves Accessible from One Side Only

When access to a lever-operated valve is available from one side only, the valve should be mounted such that the lever moves to and from the accessible side where the operator or maintainer will be positioned, as shown in Section 7, Figure 6, "Direction of Travel for Valve Levers Accessible from One Side Only". (Category 1 and 2)

FIGURE 6
Direction of Travel for Valve Levers Accessible from One Side Only



5.4 Valves at or Below Standing Surface *(1 August 2013)*

If a valve is located at or below the standing surface, requiring stooping or squatting to operate the valve, the valve position in relation to an operator's or maintainer's body position should be as shown in Section 7, Figure 7, "Physical Reach from a Stooping or Squatting Position". (Category 3 only)

When it is necessary to locate handwheel or lever valves below the operator's or maintainer's standing surface, horizontally- or vertically-oriented valves should be installed as shown in Section 7, Figure 8, "Mounting Position For Valve Levers and Handwheels Below Standing Surface". (Category 3 only)

Deck opening sizes to reach and operate levers or handwheels located below the standing surface and oriented parallel to the standing surface should be as shown in Section 7, Table 1, "Access Opening and Mounting Depth Dimensions for Levers and Handwheels Oriented Parallel to the Standing Surface". This table also includes guidance on mounting depths for valves. (Category 3 only)

FIGURE 7
Physical Reach from a Stooping or Squatting Position

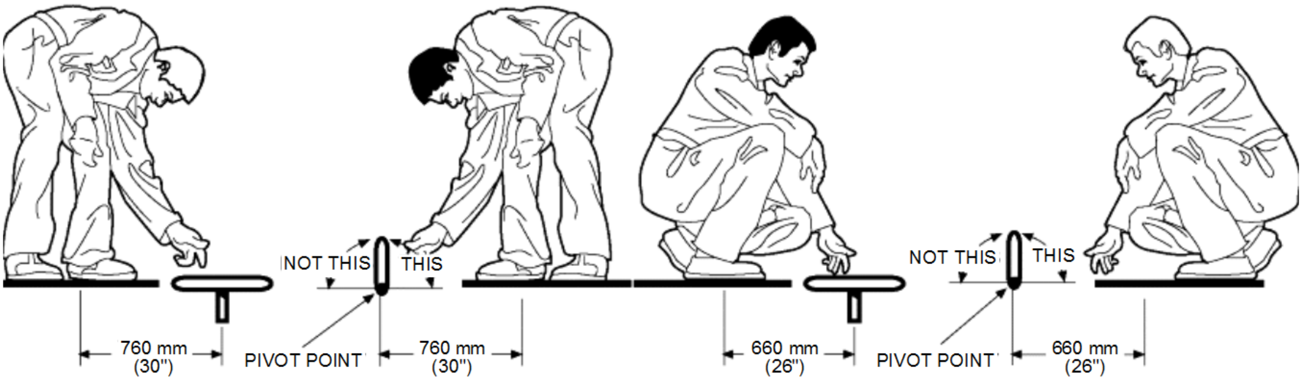


FIGURE 8
Mounting Position for Valve Levers and Handwheels Below Standing Surface *(1 August 2013)*

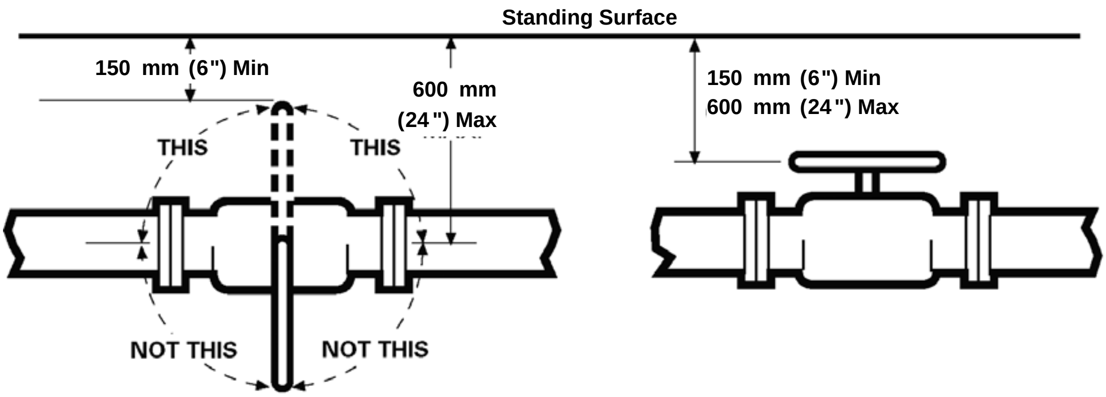


TABLE 1
Access Opening and Mounting Depth Dimensions for Levers and Handwheels Oriented Parallel to the Standing Surface

Valve Handle (Diameter or Length)	*Depth Below Deck*	*Deck Opening Size (square or diameter)*
Handwheel		
130 mm (5 in.) or less	150 - 255 mm (6 - 10 in.)	180 mm (7 in.)
	Greater than 255 mm (10 in.)	215 mm (8.5 in.)
130 mm (5 in.) or more	150 mm (6 in.) to 510 mm (20 in.)	The diameter of the handwheel plus 150 mm (6 in.) with a minimum of 360 mm (14 in.)
Lever		
Any Lever Length	Any Depth	Lever Length greater than 50 mm (2 in.)

5.5 Valves Operated from a Ladder *(1 August 2013)*

Where valves must be operated from a permanent ladder, they should be limited to those that can be operated with one hand (valves with handwheels less than 155 mm (6 in.) in diameter and lever valves) (Category 1 and 2)

Valve levers should not intrude into the ladder climbing place. (Category 1, 2 and 3)

The ladder should be positioned to allow operation of a valve within a 610 mm (24 in.) distance forward of the ladder or 1220 mm (48 in.) distance from the side of the ladder, as shown in Section 7, Figure 9, "Orientation and Reach for Ladder Parallel to Valve Levers" and Section 7, Figure 10, "Orientation and Reach for Ladder Perpendicular to Valves". (Category 1 and 2)

These figures show the required ladder orientation in relation to valves. The valve orientation, direction of valve operation, and distances shown are applicable to both lever and handwheel-operated valves. Section 7, Figure 11, "Operating Lever Valves from a Ladder" gives additional guidance for placement of valves in relation to ladders. (Category 1 and 2)

FIGURE 9
Orientation and Reach for Ladder Parallel to Valves *(1 August 2013)*

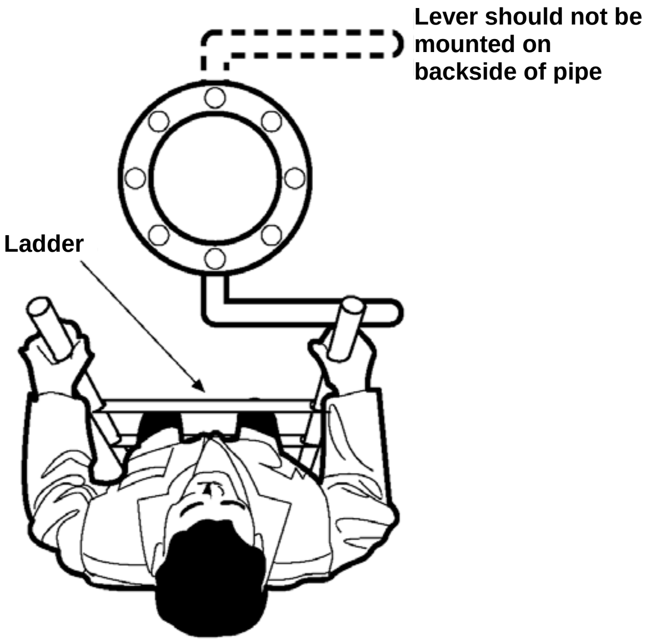


FIGURE 10
Orientation and Reach for Ladder Perpendicular to Valves *(1 August 2013)*

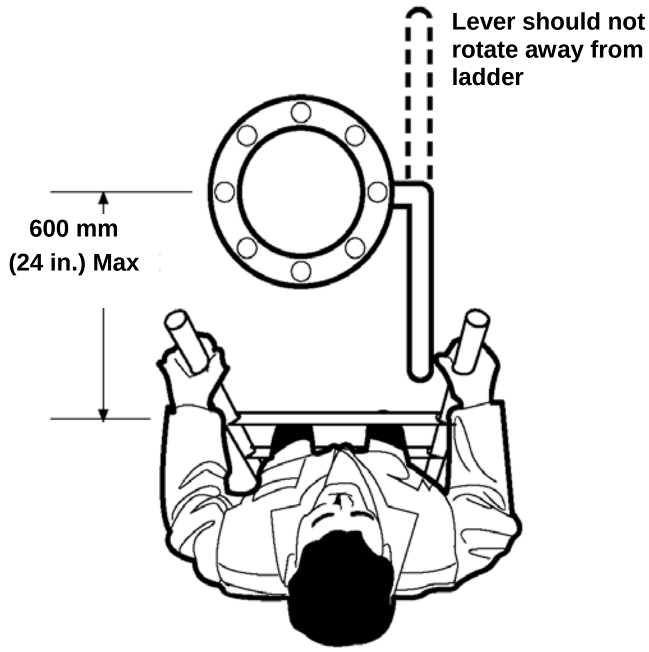
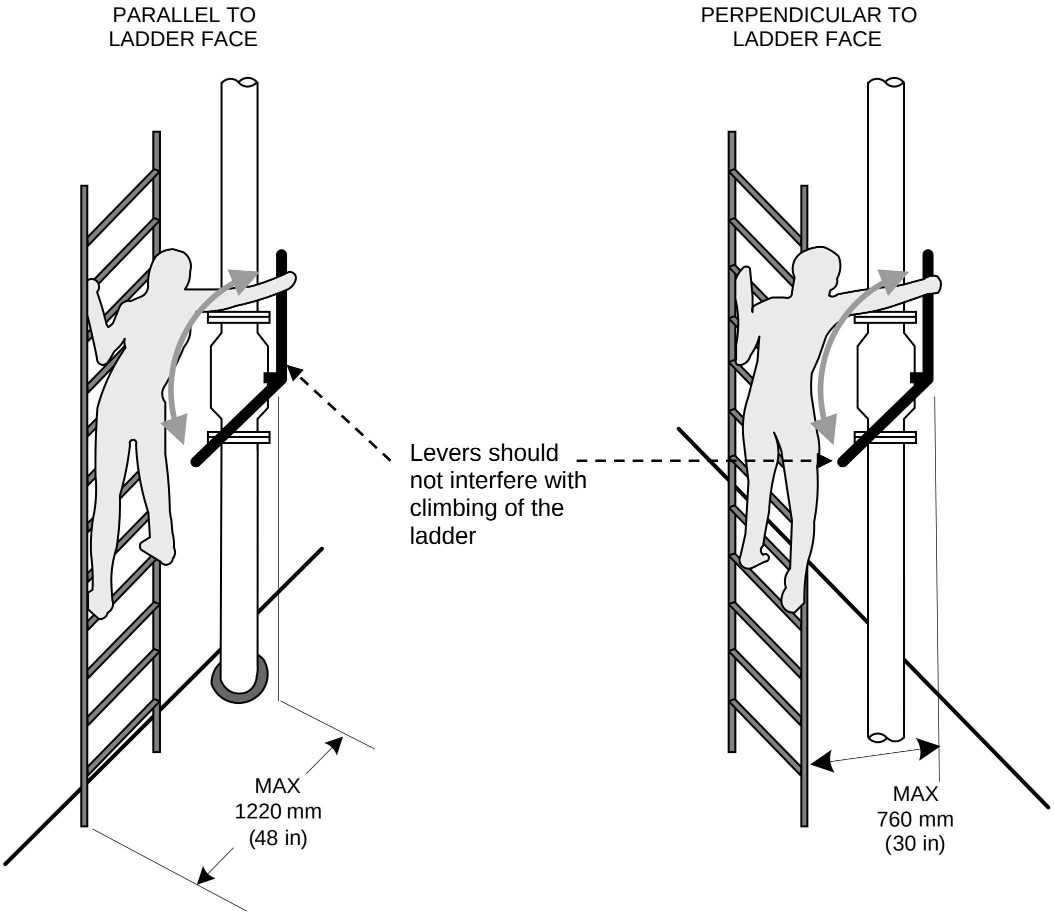


FIGURE 11
Operating Lever Valves from a Ladder *(1 August 2013)*



5.6 Valve Handwheel Accessibility from Elevated Platforms *(1 August 2013)*

Valve handwheels operated from elevated platforms 1830 mm (72 in.) or more above grade should be located within the confines of the platform railing. (Category 1 and 2)

6 Valve Manifolds

Where valves are mounted together to create a valve manifold (e.g., fuel oil transfer or cargo oil transfer), the valves handles should be arranged such that:

i) 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 Section 7, Figure 12, "Valve Manifold for Tanks Located Athwartship" and Section 7, Figure 13, "Valve Manifold for Tanks Located Fore and Aft".

FIGURE 12
Valve Manifold for Tanks Located Athwartship

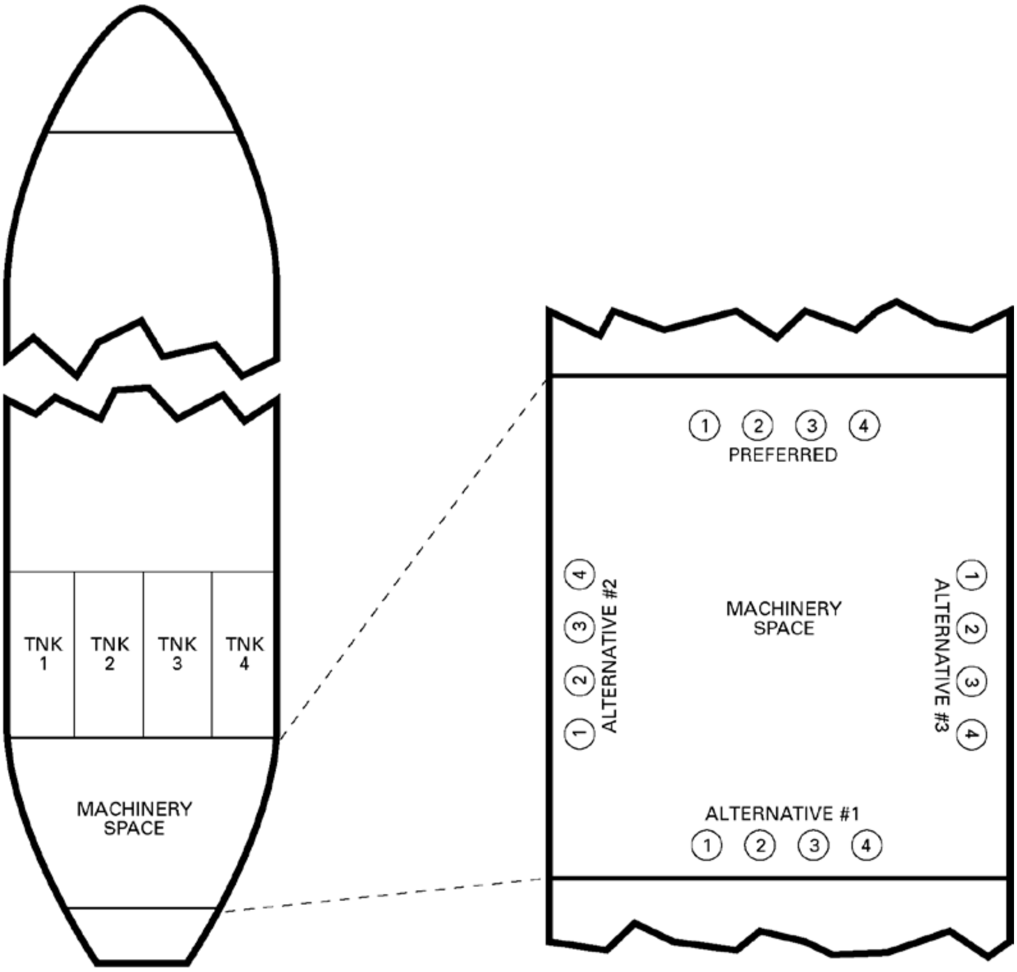
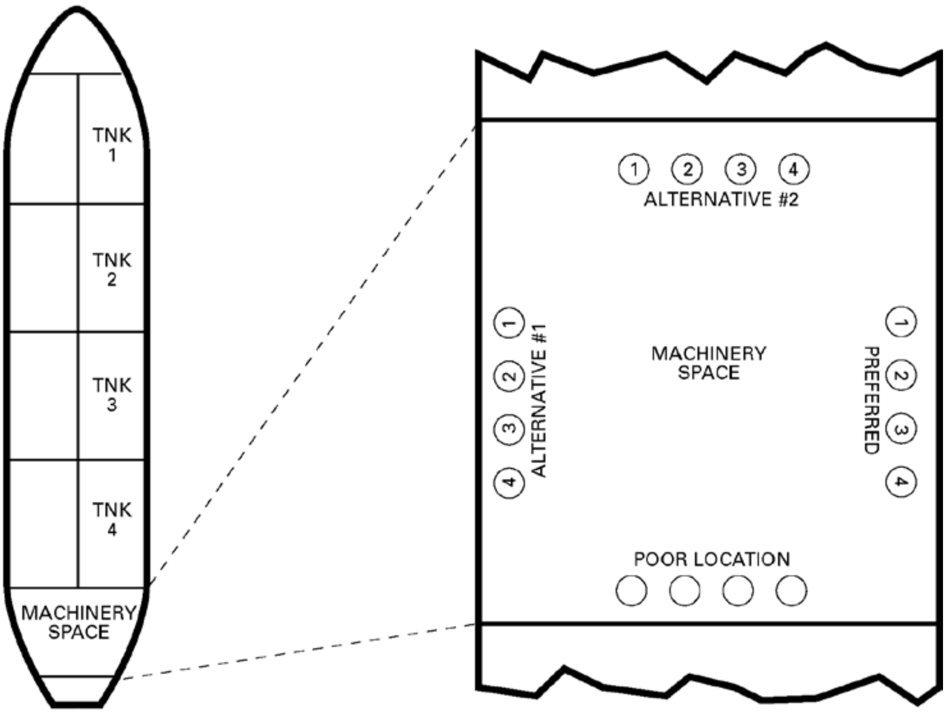


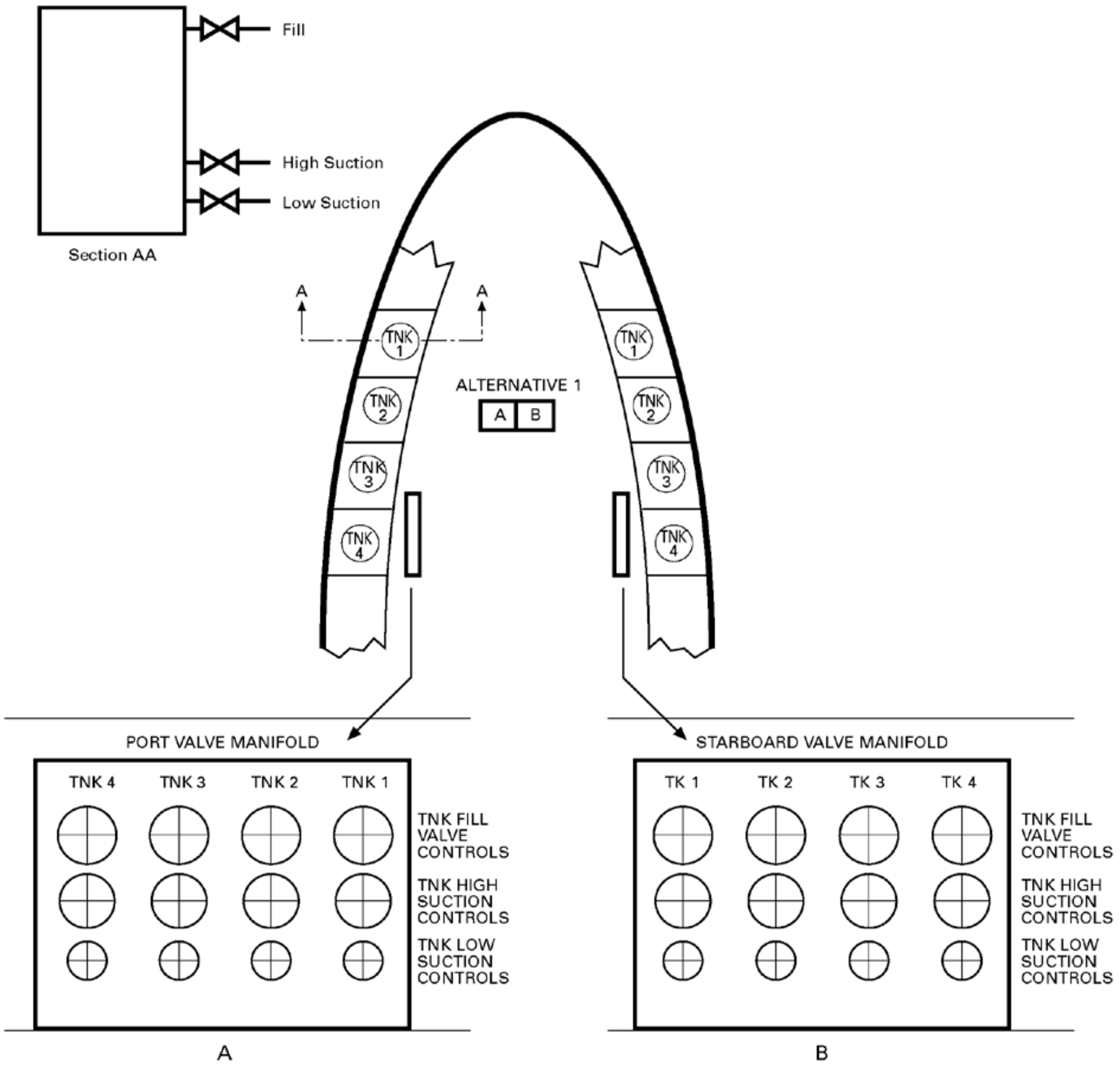
FIGURE 13
Valve Manifold for Tanks Located Fore and Aft*



* In Section 7, Figure 13, "Valve Manifold for Tanks Located Fore and Aft", 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 preferred console orientation is facing forward or to port with the forwardmost items located on the right hand side of the console.

ii) 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 (e.g., tank, pump, exchanger, etc.) asscociated with the valves. See Section 7, Figure 14, "Valve Manifold for Fill, High Suction, and Low Suction".

FIGURE 14
Valve Manifold for Fill, High Suction, and Low Suction



SECTION 8 Labeling, Signs, Graphics, and Symbols

1 General *(1 August 2013)*

1.1 Application

The principles and guidelines of this Section apply to any plate, sign, placard, inscription, legend, marking, or combination of these that gives information, warning, or instructions via text, graphics, or symbols.

It should be noted that when labels, signs, graphics, or symbols are addressed in regulations from the International Maritime Organization (IMO), flag Administrations, Class Societies, or other applicable regulatory bodies, those requirements take precedence.

2 Principles

The following principles apply to the design and placement of labels.

2.1 Content

Labels and signs should use words and abbreviations familiar to personnel. Full words should be used wherever possible. Abbreviations should rarely be used and only if there is insufficient space for the words or if the abbreviation is more commonly known and understood than the actual word (e.g., AFFF rather than Aqueous Film Forming Foam).

Trade names, company logos, model numbers, or other information not directly required for operation should be avoided on the face of a display, control, or labels corresponding to these components. No more than three hazard, information, instruction, or graphic labels should be grouped in a row or placed close together.

Within the text of a label, references to other documents or sources of information should not be made if the referenced material is required to complete a task, avoid a hazardous situation or understand the purpose of the label.

2.2 Background Color and Characters

In general, characters should be black on a white background. Letters on labels should be of a simple block-type format using all upper case letters. Upper and lower case letters should be used for extended sentence messages. 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.

2.3 Orientation and Placement

Text should be written in the normal orientation for the language used. For example, labels written in Indo-European languages would be horizontal and read from left-to-right.

Labels, graphical schematics, or diagrams should be positioned to be read from the normal operating or working position. Labels, signs, and other posted information should be placed in locations that will not be covered by movable items such as doors, racks, access openings, or equipment. Care should be taken so that these are not placed in locations where equipment or other items are likely to be temporarily stored.

Labels, signs, and other posted information should be mounted on, or immediately adjacent to, the location where the information is used. Labels should not be placed on components that turn where the label could be placed in an unreadable position. Labels, signs, and other posted information should be fully visible to personnel and preferably on flat surfaces. Attached tags should be used, where adequate surfaces are not available for mounting labels.

2.4 Multiple Labels, Signs, Graphics, or Symbols

The grouping of more than three hazard, information, instruction, or graphic labels in a row, or close together, should be avoided.

2.5 Material

Labels, signs, or graphics should be made from materials, and manufactured by a process, which will be suitable for all expected conditions in the operating environment. The material should also be compatible with the surface on which it is attached and be resistent to ultra-violet (UV) damage, if exposed to sunlight.

3 Component Labels on Consoles and Panels

Labels should be used to identify individual controls, displays, or groups of controls and displays on consoles and panels. Each display and control, including their setting positions, should be labeled in accordance with the following guidelines.

3.1 Label All Controls and Displays

Each control, control setting, and display on every console or panel should be labeled. Also any individual control or display mounted on a pole, desk, or other structure should be labeled.

3.2 Character Size

The character size of labels should follow the guidelines shown in Section 8, Figure 1, "Guidelines for Labels on Consoles and Panels". Character sizes greater than the minimum are acceptable, if applied consistently to all levels of labeling.

3.3 Mounting Location

As shown in Section 8, Figure 1, "Guidelines for Labels on Consoles and Panels", the preferable location of labels is above the controls and displays they identify. This facilitates natural eye movement during reading. In addition, placing labels above controls will prevent a person's hand from obscuring the label when using the control. The relative placement of labels to their respective controls and displays should be consistent. In limited circumstances, when placement above a control or display may result in an unreadable height, the label may be placed below the control or display, provided any confusion with other components or labels is minimized.

3.4 Content

The content of labels can be determined by using the following guidelines:

i) *Describe Function*. Control and display labels should indicate the function of the device rather than the technical name for the device. For example:

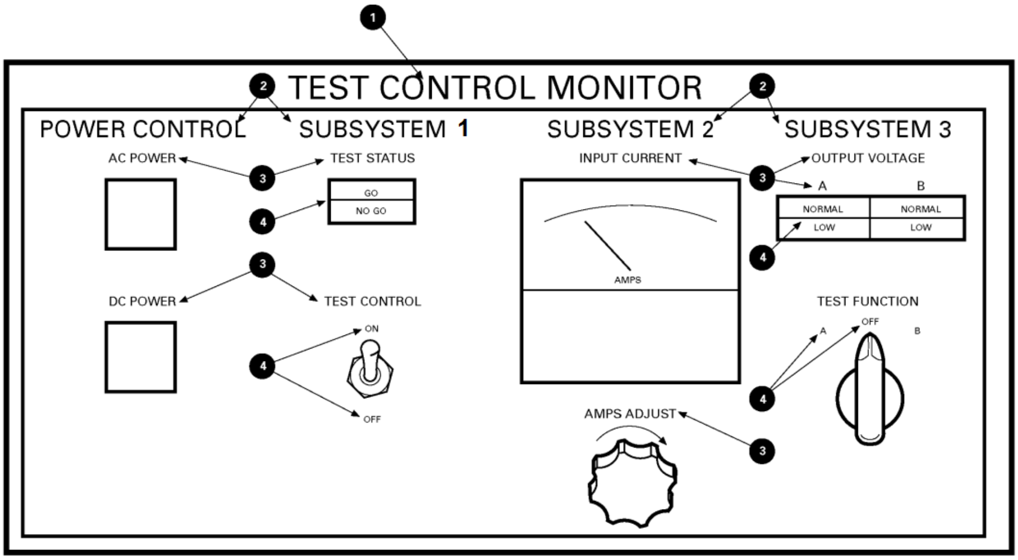
- VOLTAGE rather than VOLTMETER
- POWER ADJUST rather than POWER ADJUSTER SWITCH

ii) *Describe Control Movement*. Control labels should indicate the result of a control movement by either words or appropriate symbols (e.g., RAISE, START, +, ↑, →).

iii) *Include Units of Measure.* These (e.g., psig, volts, kPa, mm) should appear on the face of displays, not on the labels.

iv) *Label Components Consistently*. Label terminology should be consistent for the same controls and displays on different equipment or systems.

FIGURE 1
Guidelines for Labels on Consoles and Panels

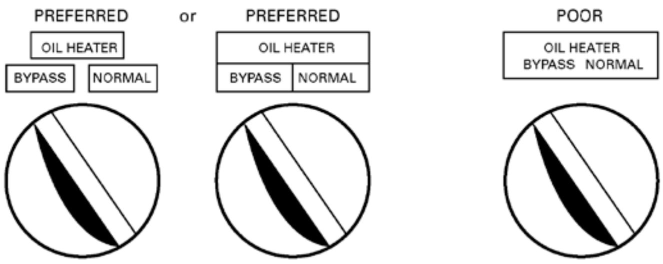


ITEM	LABEL DESIGNATION	CHARACTER SIZE mm/INCHES/POINT	LOCATION
1	PANEL TITLE	12/0.50/36	CENTERED; 6mm (1/4 INCH) FROM TOP EDGE OF PANEL
2	PANEL SUBSECTION	10/0.37/26	CENTERED AT TOP OF SUBSECTION
3	SUBTITLE/SINGLE COMPONENT IDENTIFICATION	5/0.20/14	6mm (1/4 INCH) ABOVE COMPONENTS OR 12MM (1/2 INCH) ABOVE LABELS OF INDIVIDUAL COMPONENTS
4	SWITCH POSITION/ DISPLAY LABEL	3/0.125/9	6mm (1/4 INCH) ABOVE AND/OR BELOW SWITCH

3.5 Relationship of Control and Control Setting Labels

It is preferred to place control functional and control setting descriptions 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 labels. See Section 8, Figure 2, "Control and Control Setting Labels".

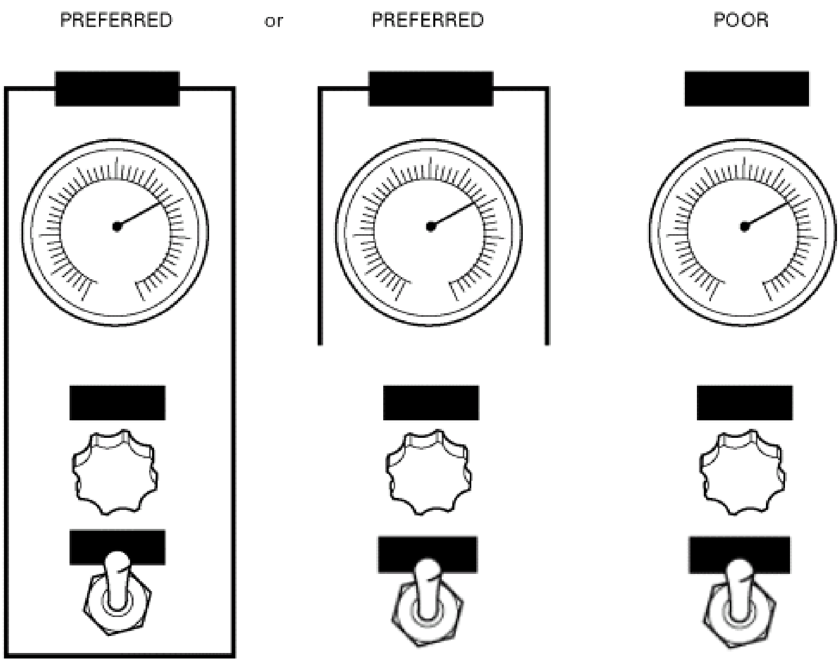
FIGURE 2
Control and Control Setting Labels



3.6 Group Labels

When controls and displays are grouped together, appropriate labels or panel demarcation lines (or both) should be used to indicate their relationship (e.g., functional, sequential, similar equipment) as shown in Section 8, Figure 3, "Control and Display Group Labels". The label should be located above the group it identifies. When a line is used to demarcate a group and define its boundaries, the label should be centered at the top of the group. The label should be placed either in a break in the demarcation line or just below the demarcation line.

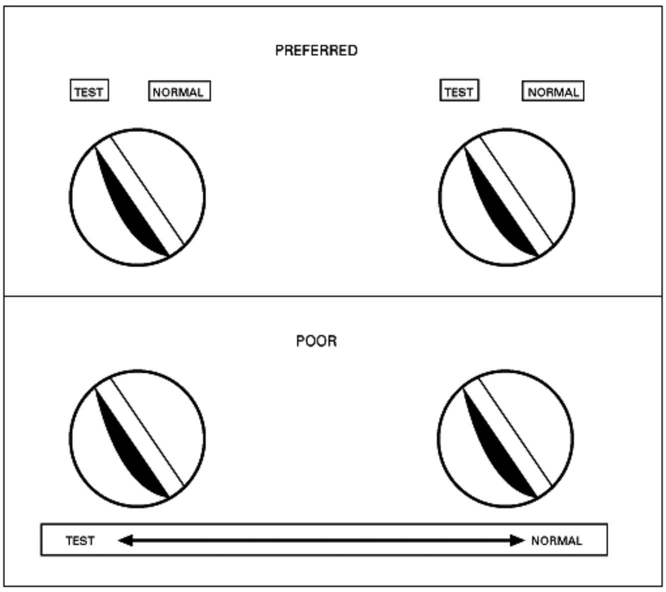
FIGURE 3
Control and Display Group Labels



3.7 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 should be labeled as shown in Section 8, Figure 4, "Control Setting Labels for Multiple Controls".

FIGURE 4
Control Setting Labels for Multiple Controls



3.8 Material

Control and display labels should be made of durable materials such as engraved plastic, reverse lexan, or flexible vinyl. Where labels may be exposed to sunlight, the label material should be resistent to ultra-violet (UV) damage.

4 Equipment Identification Labels

4.1 Description and Equipment Number

Identification labels should be placed on all equipment (e.g., valves, gauges, controls, filters, pumps, pressure vessels, electrical and communication equipment) requiring interface from operations or maintenance personnel. The label should contain a specific functional description of the equipment and a unique identifying number for it. See Section 8, Table 1, "Examples of Equipment Labels".

TABLE 1
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 Gage 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

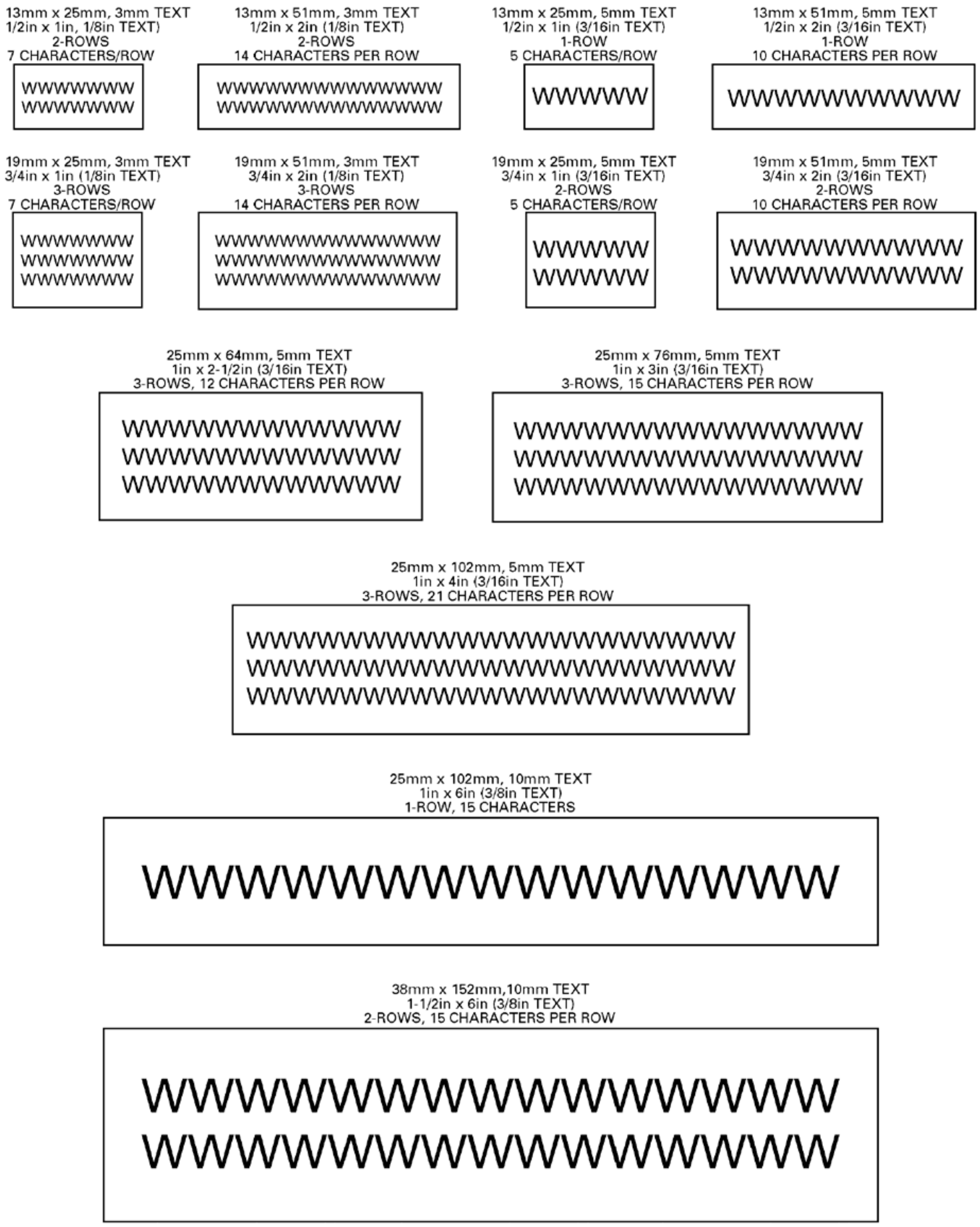
4.2 Format

The number and size of characters and the number of lines per label for different sized labels are shown in Section 8, Figure 5, "Equipment Label Format".

4.3 Mounting Location

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 it is immediately obvious which label and piece of equipment are related. Labels should not be mounted on surfaces or equipment that may be replaced due to maintenance or repair.

FIGURE 5
Equipment Label Format



5 Electrical System Labels

Each electrical cable should be labeled with a unique identifying code as described in Subsection 8/3, "Component Labels on Consoles and Panels". 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 Subsection 8/4, "Equipment Identification Labels", including both the written name of the circuit and the circuit code identified on the cable label.

6 Sensor Labels

When identifying sensors, [e.g., pressure safety high (PSH), temperature safety low (TSL), flow safety high (FSH)], the label should identify the unit of equipment to which the sensor is attached. It should also include the sensor's identification number. The information should be presented according to the following rules. An example is provide in Section 8, Figure 6, "Sensor Label".

i) Line 1: Equipment to which the sensor is attached

ii) Line 2: Function of sensor

iii) Line 3: Sensor identifier

FIGURE 6
Sensor Label

PORT BALLAST PUMP PRESSURE SAFETY LOW PSL-2001

7 Room or Space Identification Labels

Identification labels should be mounted on the door leading into a room or space. The style of the labeling, its character size and format should follow Section 8, Figure 5, "Equipment Label Format". Labels should be placed at or slightly below personnel's standing eye height. For 50th percentile North American personnel, the label would be located approximately 1650 mm (65 in.) above the standing surface.

8 Pipe Marker Labels

8.1 Usage

Pipe marker labels should contain text to identify pipe contents and use arrows to indicate flow direction. This is recommended in order to accomplish the following:

i) Identify those pipes carrying fire fighting mediums (e.g., water, foam) to aid personnel in damage control or other emergency situations.

ii) Identify those pipes which contain flammable liquids.

iii) Reduce the chance of injury during maintenance from cutting into a pipe carrying dangerous contents, such as high-pressure gases or corrosive liquids.

iv) Assist personnel in becoming familiar with the piping system.

8.2 Format

Pipe marker labels should either use different colored backgrounds or bands of color on a solid neutral colored background to represent various pipe contents via a color-coding scheme. Text and flow arrows are placed on the labels to identify pipe contents and its flow direction.

Text labels should appear in the center of the pipe marker label or immediately adjacent the color band that identifies pipe contents. Flow arrows should be positioned at one, or both, ends of the band. The colors for the text labeling and flow arrows should be of a color that contrasts with the background color. Section 8, Figure 7, "Pipe Marker Labels", provides examples of a pipe marker label. Pipe marker label preferred width, length, and associated text character height for various sizes of pipes are shown in Section 8, Table 2, "Pipe Label Format".

FIGURE 7
Pipe Marker Labels

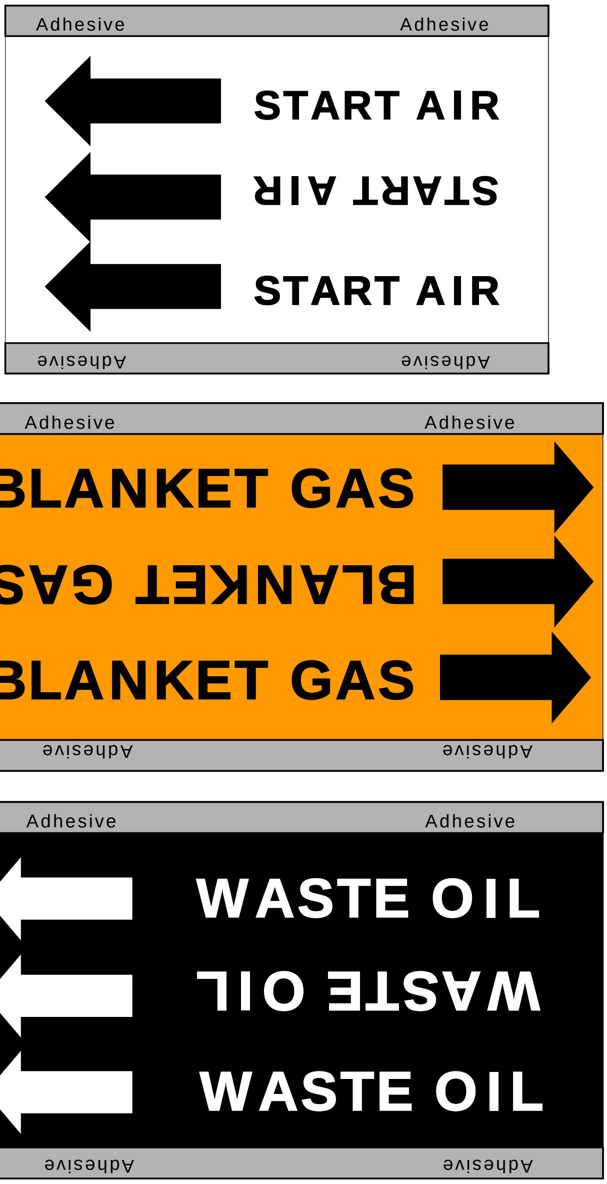


TABLE 2
Pipe Label Format

Marker Type	*Pipe Nominal Size*	*Length Along Pipe*	*Width Around Pipe*	*Character Height*
Wrap around	10 mm – 15 mm (0.375 in – 0.50 in.)	125 mm (5.0 in.)	N/A	N/A
Wrap around	20 mm – 65 mm (0.75 in – 2.50 in.)	205 mm (8.0 in.)	N/A	20 mm (0.75 in.)
Wrap around	50 mm – 200 mm (2 in – 8 in.)	305 mm (12.0 in.)	N/A	30 mm (1.25 in.)
Non-wrap around	More than 200 mm (More than 8 in.)	610 mm (24.0 in.)	100 mm (4.0 in.)	90 mm (3.50 in.)

8.3 Selection of Colors

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 should be compatible with other color codes and the scheme used for pipe marker labels should be the same thoroughout the vessel or offshore installation.

Where possible, the colors chosen should be related to the contents carried by the pipe (e.g., fire water pipes are red, drilling mud pipes are brown, sea water pipes are green). An example of a color coding scheme is shown in Section 8, Table 3, “Example Color-Coding Scheme for Vessel Piping”. For consistency of color, the chromaticity coordinates of the suggested colors are provided in Section 8, Table 4, “Chromaticity Coordinates for Color Coding of Vessel/Offshore Installation Piping”.

TABLE 3
Example Color-Coding Scheme for Vessel Piping*

Main Colors	*Medium*
Black	Waste media (e.g., waste water, black water, gray water waste oil, exhaust gas)
Blue	Fresh water
Brown	Fuel
Green	Sea water (1)
Gray	Non-flammable gases
Maroon	Masses/bulk materials (dry and wet) (2)
Orange	Oils other than fuels
Silver	Steam
Red	Fire fighting and fire protection
Violet	Acids, alkalis
White	Air in ventilation system
Yellow-ochre	Flammable gases

* Colors adopted from ISO 14726-1.

Notes:

1 For vessels with mixed navigation (sea-river vessels) all outside waters.

2 Excluding fire-extinguishing materials.

TABLE 4
Chromaticity Coordinates for Color Coding Vessel/Offshore Installation Piping*

Name of Color	*Letter Code**	*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	0.270	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	0.360	0.300	0.310	0.290	0.320	0.340	0.370
Maroon	(MN)	0.302	0.064	0.307	0.203	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	0.360	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

* As given in IEC 60 757.

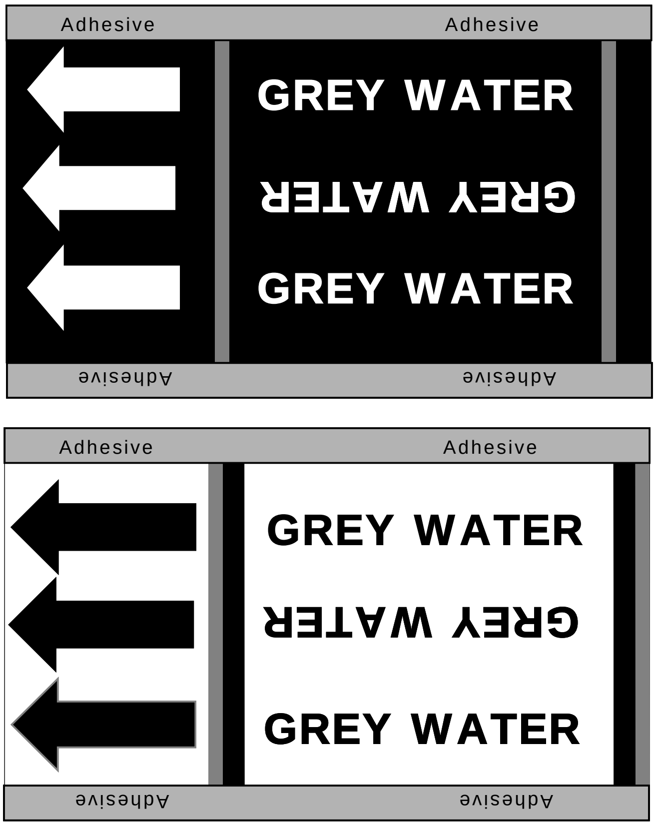
Notes:

1. Colors and chromaticity coordinates adopted from ISO 14726-1.
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.

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 bands). Color bands should be placed at each end of label text. See Section 8, Figure 8, “Pipe Marker Labels with Two Colors” for examples.

FIGURE 8
Pipe Marker Labels with Two Colors



8.5 Mounting Location

Pipe marker labels should be placed at or near the inlet or outlet connection to equipment (e.g., pumps, pressure vessels, filters), at the termination of a pipe run (e.g., loading station, hose reels), and approximately every 5 m (16.5 ft) on straight runs of pipe.

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 readily visible from both sides of the penetration.

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 should be installed side-by-side so they can be easily scanned at one time.

8.6 Material

Pipe marker labels may be self-adhesive or the label can be painted directly on the pipe. Self-adhesive pipe marker labels should 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 should be resistent to ultra-violet (UV) damage. The material should be durable enough to resist fading, chipping, or cracking. (Note: Most self-adhesive labels are manufactured such that the label can adhere to itself when it is wrapped around a pipe rather than to adhere to piping. This allows the marker to be easily removed without affecting the pipe, its surface, or its insulation).

For fiberglass, copper-nickel materials, or other pipes for which self-adhesive pipe marker labels are not satifactory, the text labels and flow arrows may be painted directly onto the pipe without the use of a color band. For 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.

9 Safe Working Load Identification Labels

9.1 Applicability

Safe working load identification labels should specify the maximum safe load for a lifting device. They should include the appropriate units (e.g., kilos, pounds, tons, tonnes)

9.2 Color and Wording

The labels should have black letters on a yellow background. An example of the text on a safe working load indentification label could be "CAPACITY 20 TONNES".

9.3 Character Size

Lettering and numbers on the labels should be large enough to be read from the standing surface on which personnel will be operating the lifting mechanism and/or reading the load limit label. In no case should the lettering or numbering be smaller than 25 mm (1 in.) in height.

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 should be resistant to ultra-violet (UV) damage. Label material and adhesive should be guaranteed for a minimum of seven (7) years.

9.5 Mounting Locations

Safe working load limit labels should be mounted immediately adjacent to padeyes or other fixed lifting points, or on the web of monorails, traveling cranes, jib booms, or other such structures supporting a moving load. The label should 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.

10 Load Weight Identification Labels

The actual weight of items weighing in excess of 20 kg (45 lbs) should be marked on the item. The weight label should be placed in a location on the item where personnel can see the label from the normal working/lifting position. The labels should have black characters on a white background. Numbers should be a minimum of 13 mm (0.5 in.) in height.

11 Hazard Identification Signs

11.1 Regulatory Requirements

A hazard identification sign should be used to identify and provide information about conditions that may pose hazards to personnel, equipment, or the environment. Often, flag Adminstrations or other regulatory bodies may specify when such signs are requried and the format and content of signs. Where this is true, those regulatory requirements take precedence over any guidance presented in this Subsection.

11.2 Signs with Text and Symbols

To be effective, hazard identification signs should be appropriate for the personnel expected to use the information. It should be remembered that personnel who live and work on vessels or offshore installations are often from different cultures, may speak different language and represent a wide range of educational backgrounds. To accommodate these factors, hazard identification signs should use simple and understandable safety symbols accompanied with explanatory text. The more traditional "word only" signs remain effective for homogenous and literate crews, when those signs are worded in the crew's native language. Regardless of the approach taken, the following guidance applies to design of hazard identification signs.

i) Formats and styles should be consistent, including organization of information, use of font styles and sizes, and use of colors.

ii) Technical wording and symbols should 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.

iii) The language and wording of hazard identification signs should be compatible with the expected population of readers and written in their native language.

iv) Where there is a mix of people of different spoken languages on a vessel or offshore installation, text-only signs should be avoided.

The guidance that follows, presents design information for text-only signs and for the text portion of signs that also use warning symbols. For information concerning the design of symbols for hazard identification signs, see Subsection 8/16, "Symbols".

11.3 Text Content

Hazard labels should contain the following:

i) The signal word (DANGER, WARNING, or CAUTION) at the top of the label.

ii) A brief statement of the hazard, in as specific detail as possible (e.g., 600 VAC, not HIGH VOLTAGE).

iii) 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 step-by-step sequence.

iv) A brief statement of the possible consequences if the avoidance instructions are not followed (e.g., serious injury could occur, fire or explosion could occur, death could result).

11.4 Text Signal Levels

Three signal levels are recommended by ANSI Z535.2, *Environmental and Facility Safety Signs*, for use with hazard identification labels. This standard specifies signal levels based on the potential effect of hazards to personnel. Additional guidance has been provided in the following signal level descriptors to include potential effects to property or the environment.

i) **Danger:** indicates an imminently hazardous situation that, if not avoided, will result in death or serious injury. This signal word is to be limited to the most extreme situations.

ii) **Warning:** indicates a potentially hazardous situation, which, if not avoided, could result in death or serious injury. A "Warning" signal word may be used on a sign to signify situations that could result in serious damage to vital equipment, or a major pollution problem

iii) **Caution:** indicates a potentially hazardous situation which, if not avoided, may result in minor or major injury. A "Caution" signal word may be used on a sign without symbols to signify situations where property damage or a minor pollution problem is possible.

11.5 Header Color and Format

Hazard label headers, including signal words, are shown in Section 8, Figure 9, "Hazard Signal Word Headers". Signal words should appear at the top of the sign in a header. The signal word should be written in upper case letters and be preceeded by an "attention" symbol located within a triangle. A simple sans-serif character font, like Arial or SmartSigns Clearview® should be used. Colors associated with the various signal words and symbols are as follows:

i) The signal word "DANGER" should be white letters on a red background. The attention symbol exclamation point should be red. The equilateral triangle surrounding the exclamation point should be white.

ii) The signal word "WARNING" should be black characters on an orange background. The attention symbol exclamation point should be orange. The equilateral triangle surrounding the exclamation point should be black.

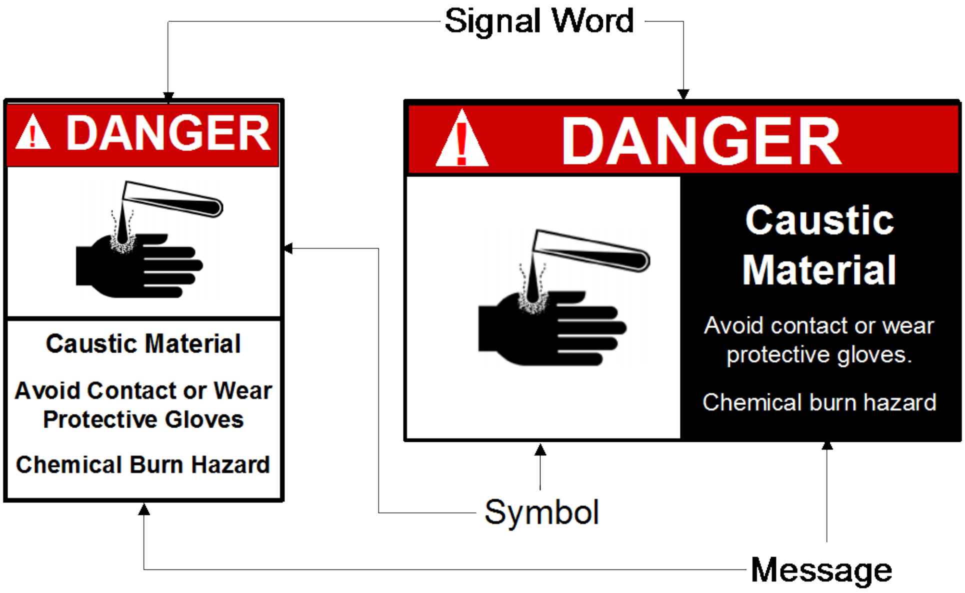
iii) The signal word "CAUTION" should be black characters on a yellow background. The attention symbol exclamation point should be yellow. The equilateral triangle surrounding the exclamation point should be black.

FIGURE 9
Hazard Signal Word Headers

11.6 Message Text Format

Message text, other than the signal word header, on a hazard identification sign should use upper and lower case letters. Either black characters on a white background or white characters on a black background should be used. The character font should be a simple sans-serif character font, like Arial or SmartSigns Clearview®. Section 8, Figure 10, "Examples of Text and Symbols on Signs" provides sample signs including text.

FIGURE 10
Examples of Text and Symbol on Signs



11.7 Message Text

The character height of the message text should be based on the label size as shown in Section 8, Table 5, "Message Text Character Heights". The character height of the signal word should be at least 50 percent higher that 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.

TABLE 5
Message Text Character Heights

Label Size	*Character Height*
90 mm × 130 mm (3.5 in × 5.0 in.)	3.2 mm (0.125 in.)
130 mm × 180 mm (5.0 in × 7.0 in.)	3.2 mm (0.125 in.)
180 mm × 250 mm (7.0 in × 10.0 in.)	8.0 mm (0.312 in.)
250 mm × 360 mm (10.0 in × 14.0 in.)	14.0 mm (0.56 in.)

11.8 Mounting Location

Hazard labels should be mounted at or immediately adjacent to the source of the hazard. The labels should be readable before personnel reach the point of the hazard source. Preferably, no more than three hazard labels should be mounted adjacent to each other.

12 Information Signs or Placards

Information labels should be used to present non-procedural information of a general nature and should only be used to provide information that will significantly contribute to the safety and/or efficiency of personnel. Information may be presented in step-by-step format. Where there are several items to be presented, they should be presented in list form. Sub-headings within the list should be used as appropriate to organize and identify related information.

12.1 Character Height and Line Spacing

The height of the message text should be the same as defined in Subsection 8/11, "Hazard Identification Signs". The signal word "NOTICE" should be incorporated in the placard and should be at least 50 percent higher than the height of the sub-headings (if any are used), which in turn should be 25 percent higher than the height of the text. If no sub-headings are used, then the signal word should be 50 percent higher than the message text.

12.2 Character Color

The signal word "NOTICE" should be in white italiczed characters on a blue rectangular background. Message text should be black characters on a white background. Section 8, Figure 11, "Example of Information Sign" provides a sample sign including text.

FIGURE 11
Example of Information Sign

13 Instruction Labels

13.1 General

All instruction labels should be titled at the top of the label to identify the instructions as operating or maintenance, or both, and should identify the equipment or system for which the instructions have been prepared.

13.2 Format

The instruction labels should be prepared as follows:

i) Instructions should 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.

ii) The instruction should 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 an offshore installation should be included to aid the personnel in matching the instructions to the labels on equipment.

iii) Hazard and safety information that pertains to a specific step in the instructions should be provided immediately preceding the step in the instruction and should be headed by the appropriate signal word, (i.e., DANGER, WARNING, or CAUTION). Hazard and safety information that pertains to the procedure in general should appear at the beginning of the instruction.

iv) Instructions should 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 should be immediately adjacent to the instruction label to provide easy transfer between the two by personnel.

v) If both operating and maintenance instructions are provided, they should be provided on separate postings or signs. They should be clearly separate from one another and labeled with the appropriate headings.

vi) Where instructions related to emergencies are provided, the following additional criteria should be applied:

- 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.
- Instructions should be concise, precise, specific, and explicit and should not require interpretations or assumptions
- Symbols should be used as appropriate to enhance universal comprehension.

13.3 Text

Text on instruction labels should be orientated normally for the language used (e.g., for English, text would be oriented horizontally). The instructions, including any text and associated graphics or schematics, should be visible and legible under all expected lighting conditions including bright sunlight and artificial lighting. Emergency instruction labels should also be visible and legible under reduced emergency lighting conditions.

13.4 Character Size

The height of label text should be sized as required for the reading distance, but in no case should it be less than 3.2 mm (0.125 in.). The label title should be at least 50 percent higher than the height of the sub-headings (if any are used), and the sub-headings should be 25 percent higher than the height of the smallest text.

13.5 Mounting Location

Instruction labels, including emergency instruction labels, should be located so that they are fully visible at all times and free from obstructions including doors or covers in open positions.

13.6 Material

Instruction labels may be made of any of the following materials:

- Reverse Screened Lexan
- Vinyl Cut Letters on a Plastic or Metal Backing Plate
- Silk Screened Vinyl with Laminate Overlay
- Engraved Plastic
- Ultra-Violet Resistant Vinyl Mounted on a Stainless Steel Backing
- Fiberglass

14 Graphical Schematics or Diagrams

Graphics are used to present information through line schematics, diagrams, 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. The following guidelines apply to graphics.

14.1 Schematics and Diagrams

All graphic symbols and special nomenclature used on a graphic label should be defined in a legend box. Descriptive text should be brief as possible and not obscure the diagram or schematic. Information should be provided on the label that indicates location and/or orientation of the equipment or system.

14.2 Charts

All charts of the same type or function, such as lubrication charts, should be formatted with the same headings, units of measurement, organization, and presentation details.

14.3 Character Size

The height of label text should be sized as required for the reading distance, but in no case should it be less than 3.2 mm (0.125 in.). The label title should be at least 50 percent higher than the height of the sub-headings (if any are used), and the sub-headings should be 25 percent higher than the height of the smallest text.

14.4 Line Size

Line widths on schematics and diagrams should be a minimum of 1.5 mm (0.06 in.).

14.5 Mounting Location

Graphics should be mounted as close as possible to the equipment, system, or component they represent.

Graphics which show piping schematics or equipment arrangements should 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 Orientation Plans

15.1 Format

The orientation plan labels should be prepared as follows:

- All orientation plans should be titled at the top to identify the specific area and location where the plan or sign is located.
- All orientation plans should provide a realistic pictorial/graphical presentation of the vessel or installation layout.
- Orientation plans should be positioned so that they are spatially orientated in terms of the vessel or offshore installation from the perspective of personnel viewing the plan.
- Orientation plans should orient personnel using the plan by marking where the person is located when viewing a particular sign (i.e., You are here).

15.2 Mounting Location

Orientation plans should be located in strategic areas around the vessel or installation (e.g., at muster areas, main stair landings, close to fire fighting areas, and at emergency exits/entrances, as applicable). They should be clearly visible and legible, under all expected lighting conditions, including bright sunlight, artificial lighting, and reduced emergency lighting conditions.

16 Symbols *(1 August 2013)*

Independent symbols and internationally recognized symbols, such as those of the International Maritime Organization (IMO), should be used. Flag Administrations or regulatory bodies may also require the use of particualar symbols to convey information. Sources of internationally accepted graphic symbols for hazard identification signs and placards include:

i) IMO Resolution A.1021(26) – *Code on Alerts and Indicators*

ii) British Standard 5499 – Graphical symbols and signs

iii) IMO Resolution A.760 (18) – Symbols related to life-saving appliances and arrangements

iv) IMO Resolution A.654 (16) – Graphical symbols for fire control plans

v) International Maritime Dangerous Goods Code (IMDG Code)

vi) American National Standards Institute Z535.3, *Criteria for Safety Symbols*

vii) Marine Safety Committee Circular 451 (MSC/Circ.451) – Guidance concerning the location of fire control plans for the assistance of shoreside fire-fighting personnel

viii) International Labor Organization – Accident prevention aboard ship at sea and in port

SECTION 9 Stairs, Ladders, Ramps, Walkways, Platforms, and Hatches

1 General *(1 August 2013)*

1.1 Application

The principles and guidelines of this Section apply to the design of stairs, vertical ladders, ramps, walkways, work platforms, and hatches. Criteria are also provided for handles.

2 Principles

2.1 Use

Stairs, vertical ladders, and ramps should be provided whenever operators or maintainers must change elevation abruptly by more than 300 mm (12 in.). These structures should be used, when appropriate, for passage over low objects (e.g., pipes, lines, ridges).

2.2 Selection

The selection of stairs, vertical ladders or ramps should be based on the purpose, frequency of use, and angle of ascent. See Section 9, Table 1, "Selection of Access Type" for related guidance on angle of inclination.

TABLE 1
Selection of Access Type

Type	*Angle of Inclination (in Degrees)*	*Preferred Angles of Inclination (in Degrees)*
Stairs	30 – 50°	38°
Inclined Ladders	50 – 60°	Not Used
Vertical Ladders	75 – 90°	75 – 85°
Ramps for Personnel	7 – 15°	7 – 15°
Ramps for Materials Handling	4 – 7°	4°

2.3 Operations Requirements

Requirements for operations access should be determined as follows:

i) Stairs are the most appropriate means for changing from one walking or work surface to another when space is available. Examples of where stair access is recommended include:

- When operations activities require regular travel between levels or decks by personnel
- When access is required to elevated work platforms (e.g., mezzanines) daily, or at least once a shift
- When quick escape may be needed from elevated work areas or platforms where personnel could be exposed to caustics, chemicals, gases, or other toxic materials
- When employees could be hand-carrying heavy or bulky tools and/or equipment

ii) Ramps may be preferred in the following situations when the change in vertical elevation exceeds 610 mm (24 in.) in height:

- To move people, vehicles, or materials. In these circumstances, the angle of inclination should be 15 degrees or less for foot traffic and 7 degrees or less for vehicles and materials.
- When a ramp would allow more efficient egress along an emergency access/egress route, as long as the angle of inclination is 15 degrees or less.

iii) When space is unavailable for stairs or a ramp, access may be provided using separate steps or a vertical ladder.

2.4 Maintenance Requirements

Maintenance access requirements should be determined as follows:

i) Stairs are recommended when access is required to elevated work platforms (e.g., mezzanines) one or more times per day.

ii) Where the maintainer must carry bulky loads or loads in excess of 13 kg (29 lbs), a ramp or elevator should be provided. Alternatively, access may be provided for personnel via stairs, steps, or ladders, as long an adequate lifting mechanism is provided for the load.

iii) Ramps, elevators, or equivalent means should be provided when maintainers must transport heavy or bulky equipment.

iv) Ladders should not be used when maintainers carry equipment because both hands should be free to grasp and climb ladders.

2.5 Emergency Access

Stairs should be the primary mean of egress from spaces. However in areas where two means of egress (e.g., mezzanine deck) are provided, a vertical ladder can be used as the secondary egress means.

i) *Restrictions.* A ladder leading to a deck scuttle is not used as a means of escape except on vessels less than 19.8 m (65 ft) in length, or as not more than one of the means of escape from any crew accommodations space or work space.

ii) *Dimensions.* Each ladder used as a means of escape should have the following design features:

- The ladder is mounted at least 205 mm (8 in.) from the nearest permanent object in the back of the ladder.
- Rungs are at least 410 mm (16 in.) in width.
- Rungs are between 275 mm (11 in.) and 300 mm (12 in.) apart.
- Rungs are uniformly spaced for the length of the ladder.

3 Stairs

3.1 General *(1 August 2013)*

The following are general requirements for stairs:

i) Stairs are appropriate means for changing from one walking surface to another when the change in vertical elevation is greater than 600 mm (23.5 in.).

ii) Stairs should be provided in lieu of ladders or ramps in accommodations spaces, office spaces or to the navigational bridge.

iii) The angle of inclination should be sufficient to provide the riser height and tread depth that follows, with a minimum angle of 38 degrees and maximum angle of 45.

iv) Stairs exposed to the elements should have additional slip resistance due to potential exposure to water and ice.

v) Stairs should be used in living quarters instead of inclined ladders.

vi) No impediments or tripping hazards should intrude into the climbing spaces of stairs (for example, electrical boxes, valves, actuators or piping).

vii) No impediments or tripping hazards should impede access to stair landings (for example, piping runs over the landing or combings/retention barriers).

3.2 Stair Risers and Treads *(1 August 2013)*

Stair risers and treads should have the following design:

i) A riser height should be no more than 230 mm (9 in.) and a tread depth of 280 mm (11 in.), including a 25 mm (1 in.) tread nosing (step overhang).

ii) For stairs, the depth of the tread and the height of riser should be consistent.

iii) Minimum tread width on one-way (where there is expected to be only one person transiting, ascending *or* descending stairway) stairs shall be at least 700 mm (27.5 in.)

iv) Minimum tread width on two-way (where there may be two persons, ascending *and* descending, or passing in opposite directions) stairs shall be at least 900 mm (35.5 in.)

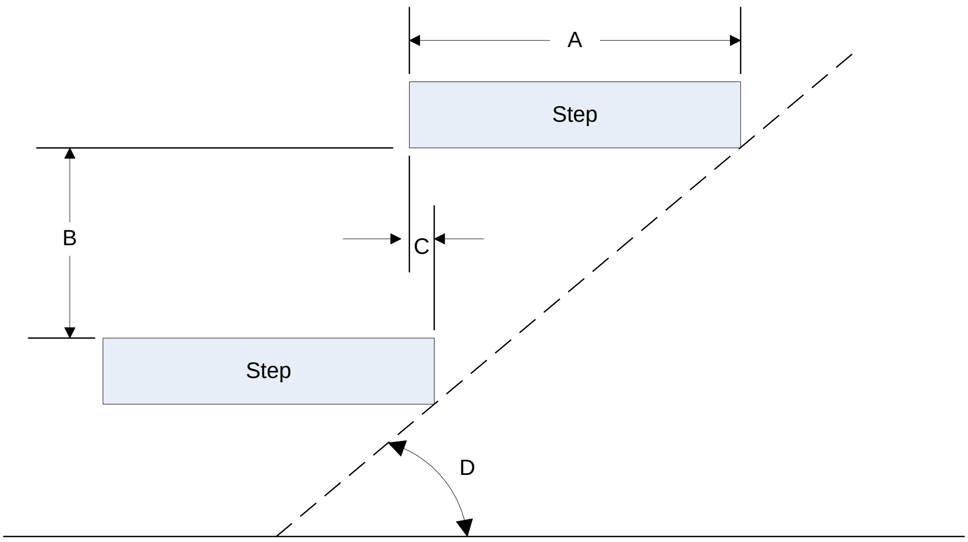
v) Once a minimum tread width has been established at any deck in that stair run, it should not decrease in the direction of egress.

vi) Nosings should have a non-slip/skid surface that should have a coefficient of friction (COF) of 0.6 or greater measured when wet.

Stairs serving accommodations and those in the escape route should be a minimum of 1120 mm (44 in.) in width. Other stairs should be a minimum of 915 mm (36 in.). However, infrequently used stairs may be 710 mm (28 in) in width.

FIGURE 1
Stair Step Riser and Tread Design *(1 August 2013)*

Dimension		*Requirements*
A	Tread Depth	280 mm (11.0 in.)
B	Vertical distance between steps	≤ 230 mm (9.0 in.)
C	Step overhang distance	25 mm (1.0 in.)
D	Steps angle of inclination	38 to 45 degrees



3.3 Stair Landings *(1 August 2013)*

3.3.1 Clear Landing

A clear landing at least as wide as the tread width and a minimum of 915 mm (36 in.) long should be provided at the top and bottom of each stairway.

3.3.2 Intermediate Landing

An intermediate landing should be provided at each deck level serviced by a stair, or a maximum of every 3500 mm (140 in.) of vertical travel for stairs with a vertical rise of 6100 mm (240 in.).

3.3.3 Change in Climb Direction

Any change of direction in a stairway should be accomplished by means of an intermediate landing at least as wide as the tread width and a minimum of 915 mm (36 in.) long.

3.3.4 Maximum Angle of Inclination

Stairways should have a maximum angle of inclination from the horizontal of 45 degrees.

3.3.5 Accommodating Stretchers

Where stairs change directions, intermediate landings along paths for evacuating personnel on stretchers should be 1525 mm (60 in.) or greater in length to accommodate rotating the stretcher.

3.4 Stair Handrails *(1 August 2013)*

Stair handrails should be fitted as follows:

i) Stairs with three or more steps should be provided with handrails, as detailed in Section 9, Table 2, “Stair Handrail Arrangements”.

ii) A single-tier handrail to maintain balance while going up or down the stairs should be installed on the bulkhead side(s) of stairs.

iii) A two-tier handrail to maintain balance and prevent falls from stairs should be installed on non-enclosed sides of stairs.

TABLE 2
Stair Handrail Arrangements *(1 August 2013)*

Arrangement	*Handrail Requirement*
1120 mm (44 in.) or wider stair width with bulkhead on both sides	Single tier handrail on both sides
Less than 1120 mm (44 in.) stair width with bulkhead on both sides	Single tier handrail on one side, preferably on the right side descending.
1120 mm (44 in.) or wider stair width, one side exposed, one with bulkhead	Two tier handrail on exposed side, single tier on bulkhead side
Less than 1120 mm (44 in.) stair width, one side exposed, one with bulkhead	Two tier handrail on exposed side
All widths, both sides of stairs exposed	Two tier handrail on both sides

3.5 Dimensions *(1 August 2013)*

i) Handrails should be constructed with a circular cross section with a diameter of 40 mm (1.5 in.) to 50 mm (2.0 in.).

ii) Square or rectangular handrails should not be fitted to stairs.

iii) The height of single tier handrails should be 915 mm (36 in.) to 1000 mm (39 in.) from the top of the top rail to the surface of the tread.

iv) Two-tier handrails should be two equally spaced courses of rail with the vertical height of the top of the top rail 915 mm (36 in.) to 1000 mm (39 in.) above the tread at its nosing.

v) A minimum clearance of 75 mm (3 in.) should be provided between the handrail and bulkhead or other obstruction.

3.6 Individual Steps

Individual steps comprised of tread surfaces attached directly to a structure may be used to change vertical elevations where a stair or vertical ladder is not practical. All dimensions for such steps should comply with the stair treads described in 9/3.2, "Risers and Treads". Handrails, as described in 9/3.4, "Stair Handrails", should be provided for stairs with three or more steps.

3.7 Spiral Stairs

Spiral stairs should not be permitted, except on tanks or other round structures whose diameter is greater than 2.4 m (8 ft), and where a normal stair design is inappropriate.

The stair should ascend in a clockwise direction to allow the stair rail to be on the right-hand side during descent.

3.8 Removable Stairs

Stairs may be pinned at the top and bottom for easy removal in locations where removable stairs would enhance ease of equipment removal for maintenance or replacement. However, stairs that serve as a required means of egress in emergencies should be permanently installed.

4 Vertical Ladders *(1 August 2013)*

This Subsection contains requirements related to the design of the different attributes of vertical ladders, inclined ladders and individual rung ladders. The requirements included in the figures and tables below provides the design and dimension requirements. Requirements related to topside stairs are provided in Subsection 9/3, "Stairs".

The considerations listed below apply to the design of vertical and inclined ladders and are not represented in the following figures.

Vertical ladders, inclined ladders or ramps should be provided whenever operators or maintainers must change elevation abruptly by more than 300 mm (12.0 in.). (Requirements relating to ramps are found in Subsection 9/11 "Ramps".) These structures, or a simple step, should also be used for passage over low objects (e.g., pipes, lines, ridges).

Vertical ladders and inclined ladders should be provided with skid/slip resistant on the rungs that shall have a coefficient of friction (COF) of 0.6 or greater measured when wet. See Section 9, Table 3, "Inclination of Ladders" for requirements on angle of inclination.

TABLE 3
Inclination of Ladders *(1 August 2013)*

Dimension	*Requirements*
Inclined Ladders	45 to 60 degrees
Vertical Ladders	80 to 90 degrees

4.1 General

General requirements for vertical ladders are:

i) Permanent vertical ladders should be attached to a permanent structure.

ii) Fitted with a maximum distance from the ladder's centerline to any object that must be reached by personnel from the ladder not exceeding 965 mm (38.0 in.).

iii) Should be provided with skid/slip resistant on the rungs that should have a coefficient of friction (COF) of 0.6 or greater measured when wet.

iv) Located so as not to interfere with the opening and closing of hatches, doors, gratings or other types of access.

v) No impediments should intrude into the climbing space (for example, electrical boxes, valves, actuators or piping).

4.2 Design Loads

The design loads listed in the following subparagraphs are design load requirements; however, if requirements for design loads specified by other regulatory bodies (e.g., flag Administrations and port State authorities) are more limiting, those requirements take precedence over these Guidance Notes.

These Guidance Notes define "design load" as the maximum intended load, being the total of all loads including the weight of the personnel, materials, equipment and means of access structure, and should be as follows:

i) Ladder handrails should withstand anticipated loads but not less than 90 kg (200 lbs) at any point and in any direction when applied to the top rail.

ii) For vertical ladders, the design load should be determined by the anticipated usage of the ladder, but should not be less than a single concentrated live load of 90 kg (200 lbs). The weight of the ladder and attached appurtenances together with the design load should be considered in the design of rails and fastenings.

iii) Inclined ladders should be designed and constructed to carry a load of at least three times the normal load anticipated.

Ladders exposed to the elements should have additional slip resistance due to potential exposure to water and ice.

4.3 Dimensions

4.3.1 Ladder Rungs

Rungs should be covered with a non-skid surface to prevent slipping. Where multiple runs of ladders are provided to cover the vertical distance, the same rung spacing should be used in each run. See Section 9, Figure 2, "Staggered Vertical Ladder".

4.3.2 Ladder Stringers

Ladder stringers should be provided on both sides of the ladder over the full length and should be constructed of pipes with preferable nominal diameter of 40 mm (1.5 in.). Flat bar should be avoided for stringers. For multiple runs of vertical ladders, the stringers should extend 1070 mm (42 in.) above landings or intermediate platforms. See Section 9, Figure 2, "Staggered Vertical Ladder".

4.3.3 Ladder Heights

Continuous ladders should not exceed 9.1 m (30 ft) in height. Where the vertical height exceeds 9.1 m (30 ft), intermediate landings and separate multiple ladder runs of equal length should be provided.

4.3.4 Clearances

A minimum of 760 mm (30 in.) horizontal clearance should be provided for the total width and length of the ladder on the climbing side as measured perpendicular to the ladder rungs. A minimum horizontal distance of 180 mm (7 in.) (205 mm (8 in.) is preferred) should be provided behind the rungs and 100 mm (4 in.) behind the stringer. A minimum overhead clearance of 2.1 m (7 ft) should be provided above the step-off rung and a horizontal distance of 380 mm (15 in.) between the ladder centerline and the nearest obstruction on either side.

4.3.5 Top Rungs on Step-Through Ladders

For vertical ladders that personnel use to access a deck, work platform, building roof, or top of a tank by stepping through the ladder to a walking or standing surface, the top (or step-off) rung should be flush with that surface. See Section 9, Figure 2, "Staggered Vertical Ladder".

4.3.6 Intermediate Platforms

Platforms used to access a vertical ladder should provide a minimum clear standing area of 760 mm (30 in.) in front of the ladder with at least 460 mm (18 in.) of width on each side of the ladder centerline. See Section 9, Figure 2, "Staggered Vertical Ladder".

4.3.7 Intermediate Platforms – Use of Handrails/Toeboards

Intermediate platforms should be provided with handrails and toeboards, as described in 9/12.3, "Handrails for Walkways and Work Platforms", and on all sides not used to access a vertical ladder, as shown in Section 9, Figure 2, "Staggered Vertical Ladder".

4.3.8 Horizontal Separation between Ladder and Platform

The distance from the edge of the ladder stringer to the side step platform being accessed should be no more than 300 mm (12 in.), with a preferred distance of 150 mm (6 in.). There should be a rung on the vertical ladder at the same height as the standing surface of the intermediate platform. See Section 9, Figure 2, "Staggered Vertical Ladder".

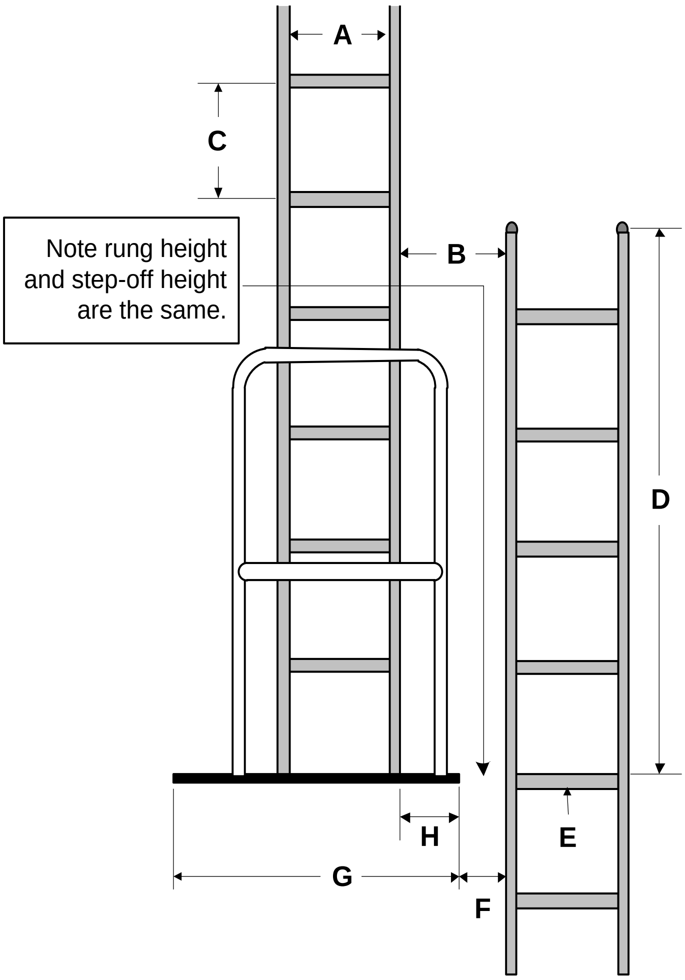
4.3.9 Horizontal Separation between Two Ladders

The horizontal separation between two vertical ladders, stringer to stringer, using an intermediate platform should not be greater than 460 mm (18 in.). See Section 9, Figure 2, "Staggered Vertical Ladder".

FIGURE 2
Staggered Vertical Ladder* *(1 August 2013)*

	Dimension	*Requirements*
A	Stringer separation	400 to 450 mm (16.0 to 18.0 in.)
B	Horizontal separation between two vertical ladders, stringer to stringer	≥ 225 mm (9 in.) ≤ 450 mm (18 in.)
C	Distance between ladder rungs (rungs evenly spaced throughout the full run of the ladder)	≥ 275 mm (11.0 in.) ≤ 300 mm (12.0 in.)
D	Stringer height above landing or intermediate platform	≥ 1350 mm (53.0 in.)
E	Rung Design – (Can be round or square bar; where square bar is fitted, orientation shall be edge up)	Square bar 25 mm (1.0 in.) × 25 mm (1.0 in.) Round bar 25 mm (1.0 in.) diameter
F	Horizontal separation between ladder and platform	≥ 150 mm (6.0 in.) ≤ 300 mm (12.0 in.)
G	Landing or intermediate platform width	≥ 925 mm (36.5 in.)
H	Platform ladder to Platform ledge	≥ 75 mm (3.0 in.) ≤ 150 mm (6.0 in.)

* *Note:* Left side guardrail of platform omitted for clarity.



4.4 Vertical Ladder Design and Dimensions

The following figures present requirements for vertical ladders design and dimensioning:

- Figure 2, "Staggered Vertical Ladder"
- Figure 3, "Vertical Ladders (General Criteria)"
- Figure 4, "Vertical Ladders to Landings (Side Mount)"
- Figure 5, "Vertical Ladders to Landings (Ladder through Platform)"

FIGURE 3
Vertical Ladders (General Criteria) *(1 August 2013)*

	Dimension	*Requirements*
A	Overhead Clearance	2130 mm (84.0 in.)
B	Ladder distance (gap accommodating toe space) from surface (at 90 degrees)	≥ 175 mm (7.0 in.) ≤ 200 mm (8.0 in.)
C	Horizontal Clearance (from ladder face and obstacles)	≥ 750 mm (29.5 in.) or ≥ 600 mm (23.5 in.) (in way of openings)
D	Distance between ladder attachments /securing devices	≤ 2.5 m (8.0 ft)
E	Ladder angle of inclination from the horizontal	80 to 90 degrees
F	Rung Design – (Can be round or square bar; where square bar is fitted, orientation should be edge up)	Square bar 22 mm (0.9 in.) × 22 mm (0.9 in.) Round bar 25 mm (1.0 in.) diameter
G	Distance between ladder rungs (rungs evenly spaced throughout the full run of the ladder)	≥ 275 mm (11.0 in.) ≤ 300 mm (12.0 in.)
H	Skew angle	≤ 2 degrees
I	Stringer separation	400 to 450 mm (16.0 to 18.0 in.)
J	Ladder height: Ladders over 6 m (19.7 ft) require intermediate/linking platforms)	≤ 6.0 m (19.5 ft)

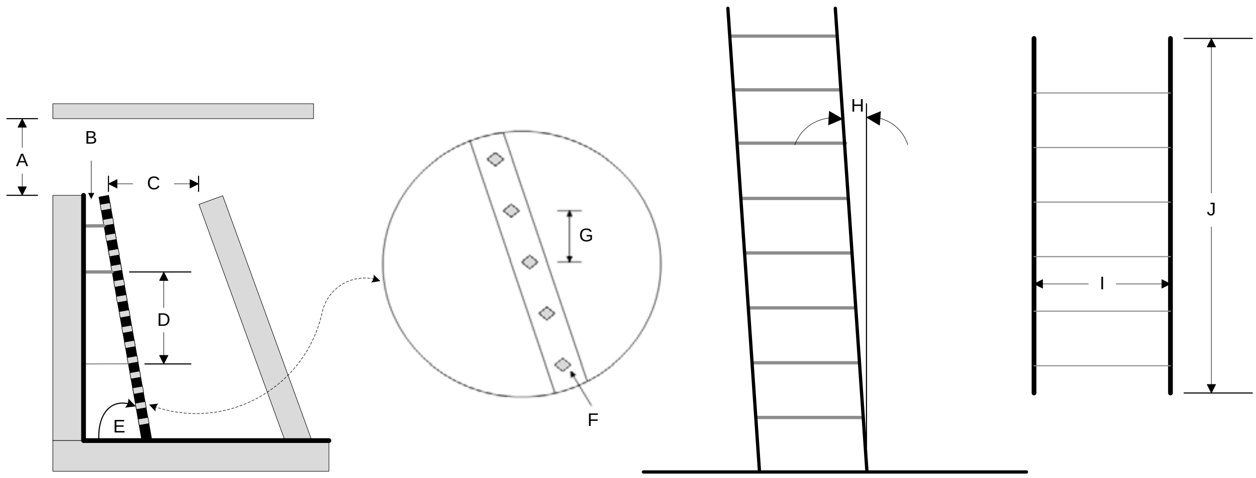


FIGURE 4
Vertical Ladders to Landings (Side Mount)* *(1 August 2013)*

Dimension		*Requirements*
A	Platform depth	≥ 750 mm (29.5 in.)
B	Platform width	≥ 925 mm (36.5 in.)
C	Ladder distance from surface	≥ 175 mm (7.0 in.)
D	Horizontal separation between ladder and platform	≥ 150 mm (6.0 in.) and ≤ 300 mm (12.0 in.)

* *Note:* Top view. Guardrails/Handrails not shown.

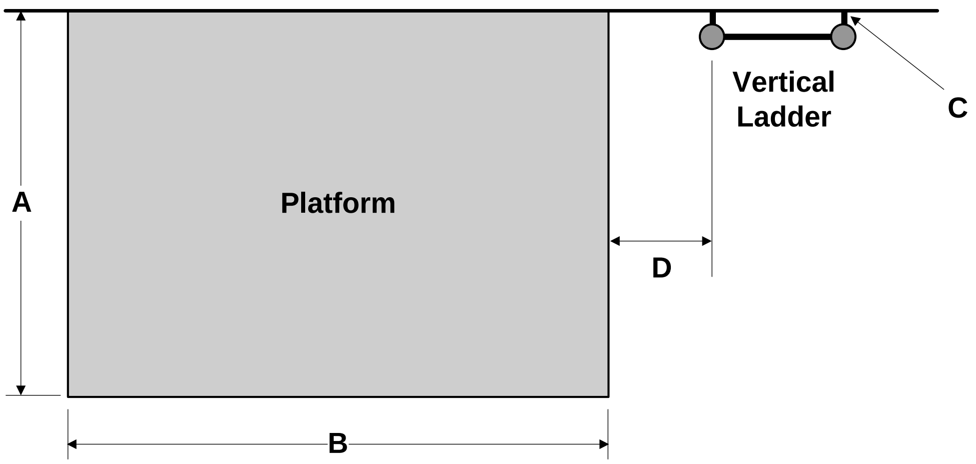
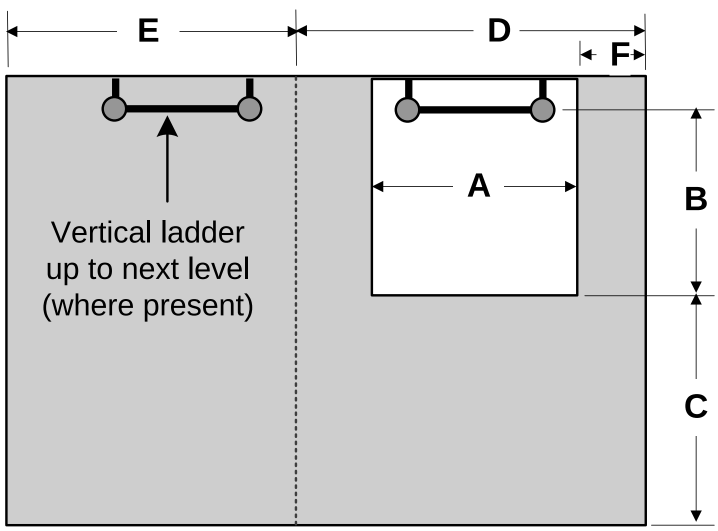


FIGURE 5
Vertical Ladders to Landings (Ladder through Platform)* *(1 August 2013)*

	Dimension	*Requirements*
A	Vertical ladder opening	≥ 750 mm (29.5 in.)
B	Distance from front of vertical ladder to back of platform opening	≥ 750 mm (29.5 in.)
C	Minimum clear standing area in front of ladder opening – Depth	≥ 750 mm (29.5 in.)
D	Minimum clear standing area in front of ladder opening – Width	≥ 925 mm (36.5 in.)
E	Additional platform width for intermediate landing (where present)	≥ 925 mm (36.5 in.)
F	Horizontal separation between ladder and platform	≥ 150 mm (6.0 in.) and ≤ 300 mm (12.0 in.)

* *Note:* Top view. Guardrails/Handrails not shown.



4.5 Individual Rung Ladders

The requirements listed below apply to individual rung ladders and are not represented in the following figure.

i) Individual rungs may be attached directly to a bulkhead, tank or steel structure and used as a vertical ladder, but should be limited to changes in vertical elevation of 3.6 m (12.0 ft) or less.

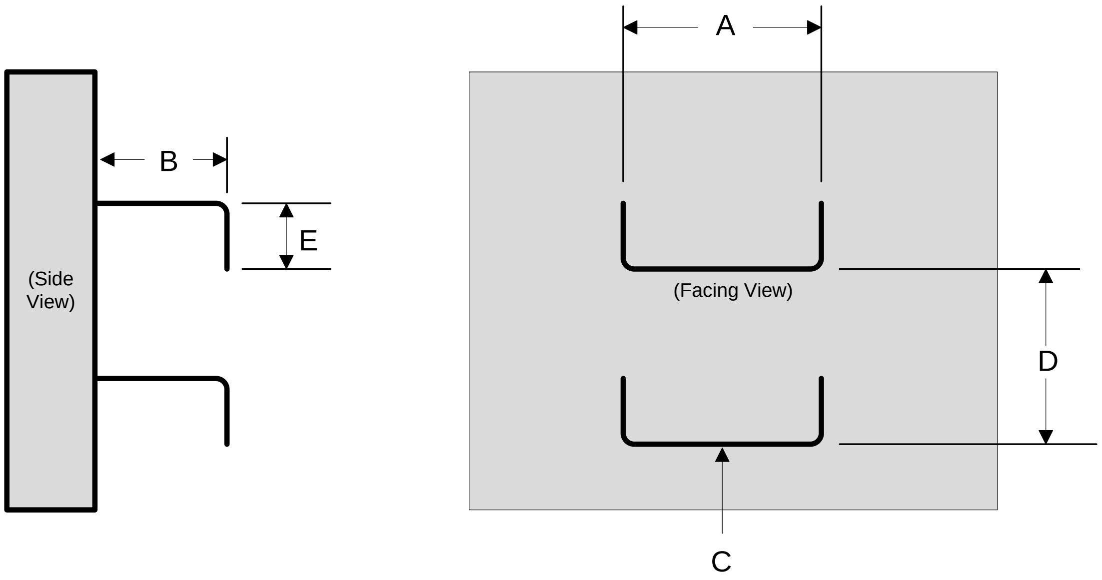
ii) Each rung should be attached to the structure to fully support a climber and any design loads.

iii) Rungs should be provided with lateral support for the foot.

Individual rung ladder design is presented in Section 9, Figure 6, “Individual Rung Ladder Design”.

FIGURE 6
Individual Rung Ladder Design *(1 August 2013)*

Dimension		*Requirements*
A	Rung width	≥ 400 mm (16.0 in.) ≤ 450 mm (18.0 in.)
B	Rung depth	≥ 175 mm (7.0 in.) ≤ 200 mm (8.0 in.)
C	Rung Design – (Can be round or square bar; where square bar is fitted, orientation shall be edge up)	Square bar 22 mm (0.9 in.) × 22 mm (0.9 in.) Round bar 25 mm (1.0 in.) diameter
D	Distance between ladder rungs (rungs evenly spaced throughout the full run of the ladder)	≥ 275 mm (11.0 in.) ≤ 300 mm (12.0 in.)
E	Height of foot slip protection	50 mm (2.0 in.)



5 Inclined Ladders *(1 August 2013)*

5.1 General

i) Inclined ladders should be attached to a permanent structure.

ii) Where inclined ladders change directions and are used to carry personnel on stretchers, intermediate landings along paths should be 1525 mm (60.0 in.) in length to accommodate rotating a stretcher.

iii) Inclined ladders and handrails should be located so as not to interfere with the opening and closing of hatches, doors, gratings or manholes.

iv) No impediments should intrude into the climbing space (for example, electrical boxes, valves, actuators or piping).

5.2 Tread/Step Design

i) Steps should be equally spaced along the entire flight of the inclined ladder.

ii) Square bar, round bar, or full steps can be used to form the step. Where square bar is used, treads/steps should be fitted with an edge pointing upward. Where full steps are use, the steps should be parallel to the deck surface.

iii) These steps should also be carried through the side stringers and attached by double continuous welding.

5.3 Handrail Design

Handrail design loads are presented in 9/4.2, "Design Loads".

i) Square handrails should not be used.

ii) A clearance of at least 75 mm (3.0 in.) should be provided between the handrail and bulkhead or other obstruction.

5.4 Inclined Ladder Design

The following figures present requirements for inclined ladder design and dimensioning:

- Figure 7, "Inclined Ladders"
- Figure 8, "Inclined Ladders with Landings"
- Figure 9, "Inclined Ladder Landing/Platform"

FIGURE 7
Inclined Ladders *(1 August 2013)*

Dimension		*Requirements*
A	Handrail diameter	≥ 40 mm (1.5 in.) to ≤ 50 mm (2.0 in.)
B	Handrail height (from leading edge of tread)	≥ 915 mm (36.0) and ≤ 1000 mm (39.0 in.)
C	Tread/step spacing – equally spaced along entire ladder	≥ 200 mm (8.0 in.) and ≤ 300 mm (12.0 in.)
D	Step depth Use of square bar is optional	≥ 100 mm (4.0 in.)
E	Handrail to handrail width	≥ 450 mm (18.0 in.) ≤ 560 mm (22.0 in.)
F	Angle of inclination	45 to 60 degrees

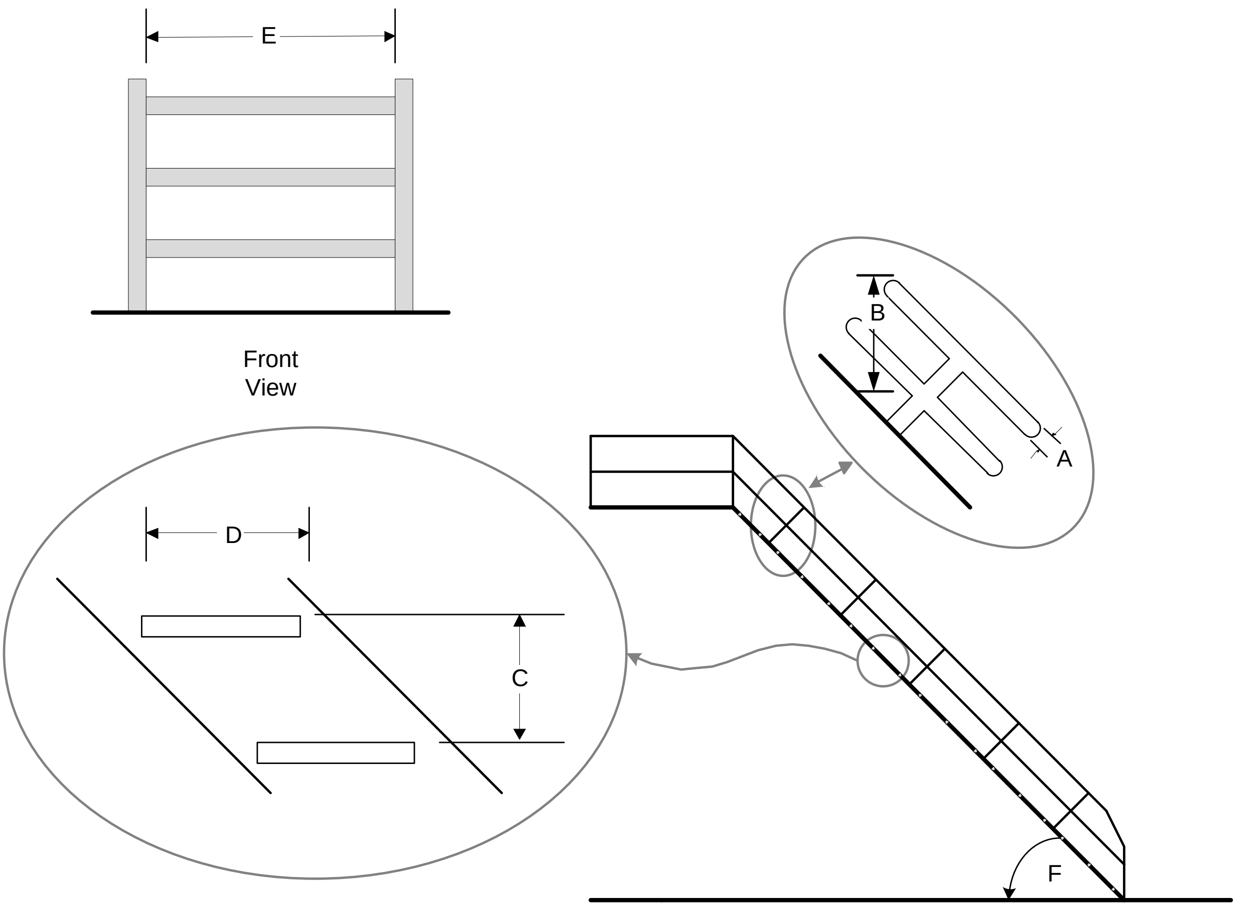


FIGURE 8
Inclined Ladders with Landings *(1 August 2013)*

Dimension		*Requirements*
A	Overhead Clearance	2130 mm (84.0 in.)
B & C	Maximum continuous height	≤ 6 m (19.7 ft)
D	Deck to lower landing level	≥ 2.5 m (8.2 ft)
E	Height of intermediate rail	535 mm (21.0 in.)
F	Height of top rail	535 mm (21.0 in.)
G	Landing/Platform dimensions	See Section 9, Figure 9, "Inclined Ladder Landing/Platform"
H	Vertical obstruction height above ladder	2030 mm (80 in.)
I	Height of rail around platform	1070 mm (42.0 in.)
J	Stringer height (ladder) above landing or intermediate platform	≥ 1350 mm (53.0 in.)
K	Angle of inclination	45 to 60 degrees

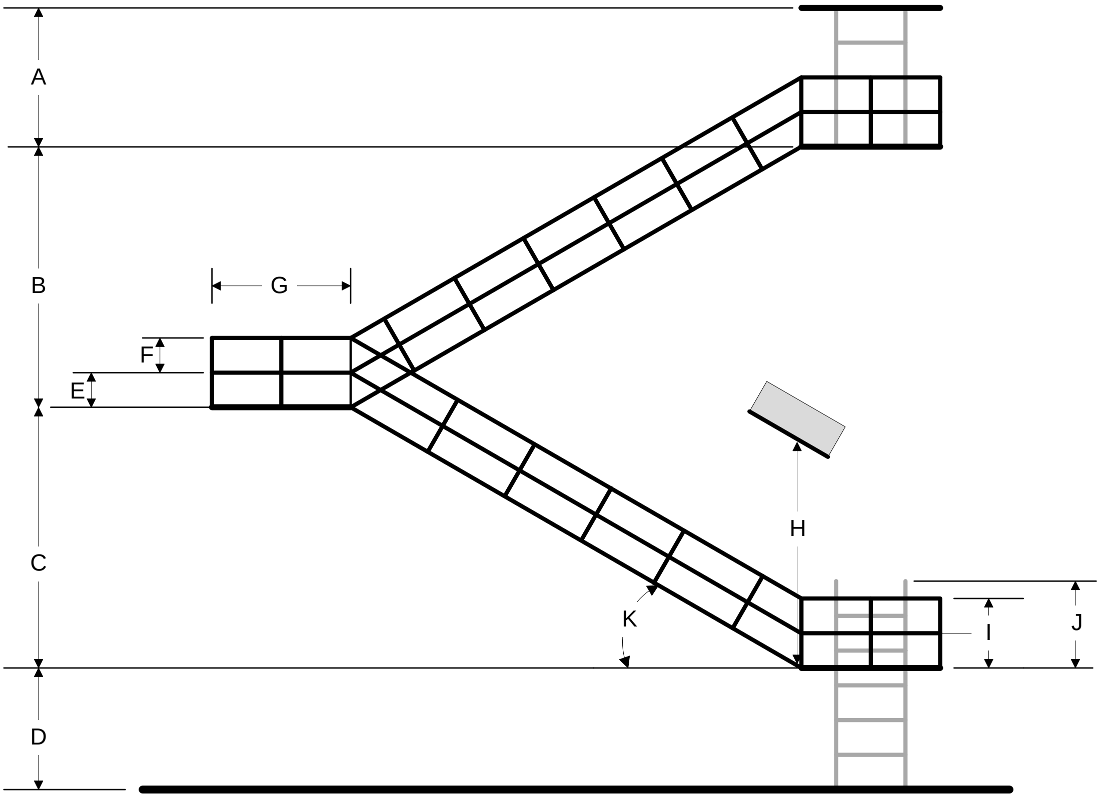
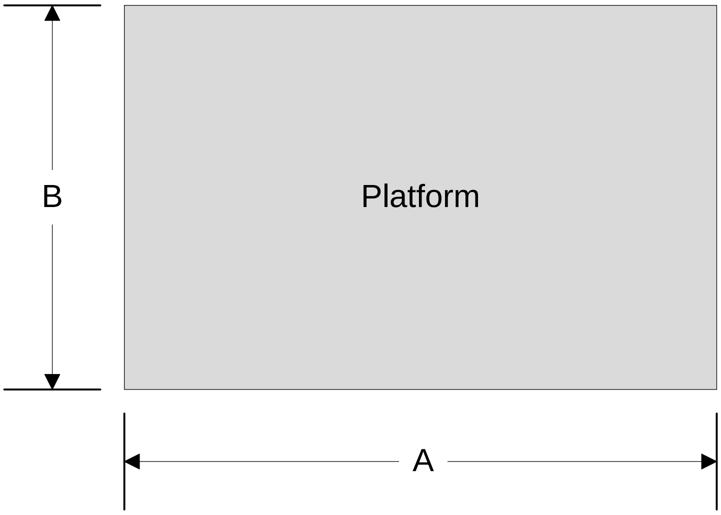


FIGURE 9
Inclined Ladder Landing/Platform* *(1 August 2013)*

Dimension		*Requirements*
A	Minimum landing length	≥ 975 mm (38.5 in.)
B	Minimum landing width/depth	600 mm (23.5 in.) for the last flight of inclined ladder. If landing is used to access another inclined ladder flight, then the landing width shall be at least twice the width of the inclined ladder.

* *Note:* Top view. Guardrails/Handrails not shown.



6 Cargo Hold Stairs and Ladders

6.1 General *(1 August 2013)*

As far as possible, stairs and ladders installed in cargo holds should minimize the likelihood of slips and falls. However, when approved by the appropriate authorities, such as flag Administrations, alternative designs can be used for cargo hold stairs and ladders.

6.2 Access

Access to cargo hold ladders should be through a trunkway. Access by climbing over the main deck cargo hatch coaming is not recommended.

Generally, for cargo vessels, vertical ladders may be fitted where the length of the ladder does not exceed 6.1m (20 ft). When the length exceeds 6.1 m (20 ft), stairways should be fitted in lieu of ladders.

For cargo vessels, a vertical entrance section of up to 2.5 m (8 ft) may be fitted with a vertical ladder, provided the remaining distance to the bottom is fitted with a stairway. As an alternative arrangement, a vertical ladder, with a maximum height of 6.1 m (20 ft), may be substituted at the lower end of the stairway closest to the tank bottom, provided the shortened length of the stairway is not less than 2 m (6.6 ft) vertically.

7 Guardrails and Climber Safety Devices *(1 August 2013)*

This Subsection includes general principles as well as the design requirements for the design and arrangement of handrails and climber safety devices for fall protection, whether by active protection (safety rails and harnesses) or passive protection (safety cages). These requirements include:

i) Height and diameter of handrails

ii) Span and gap between handrail stanchions

iii) Distance between handrail and any obstruction

iv) Intermediate rails

v) Climber safety equipment

7.1 General Principles

The principles listed below apply to the design of walkways and ramps and are not represented in the following figures or tables.

i) Guardrails should be provided at the exposed side of any walking or standing surface that is 600 mm (23.5 in.) or higher above the adjacent surface and where a person could fall from the upper to the lower surface.

ii) Where stays are provided for supporting stanchions, they should be fitted so as not to obstruct safe passage.

iii) Stanchion scantlings can be formed of flat or round bar.

iv) The top handrail should be round bar.

v) Brackets joining the guardrail stanchions to the means of access should be oriented in a way to avoid causing a trip hazard (e.g., parallel to direction of the walkway).

Means should be provided for deicing of guardrails and climber safety devices.

7.2 Handrail Dimensions with a Toeboard

Requirements for handrail dimensions and associated toeboard are presented in Section 9, Figure 10, "Handrail/Guardrail Dimensions with a Toeboard"

7.3 Provision of Safety Railings

7.3.1 Railings

Rails should be installed parallel to the deck along deck edges and walkways and around open hatches, elevators, working platforms and along other boundaries in the following areas:

i) Wherever there is danger of operators or maintainers falling to a lower level of ≥ 600 mm (23.5 in.)

ii) Wherever there is danger of operators or maintainers becoming enmeshed with operating machinery

iii) Around openings with a coaming height below 760 mm (30 in.)

Note: Temporary rails can be used around unprotected opening into which a person may slip, trip or fall.

7.3.2 Storm Rails

Suitable storm rails/handrails should be provided in all interior passageways where persons onboard might have normal access:

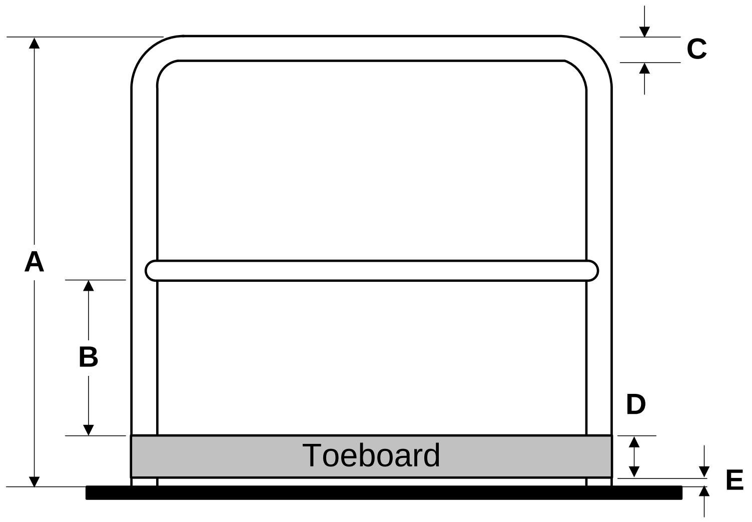
i) Storm rails/handrails should be installed on both sides of passageways that are 1830 mm (72 in.) or more in width.

ii) Storm rails/handrails should be 865 mm (34 in.) to 965 mm (38 in.) high.

iii) The distance between storm rails/handrails and any obstruction is 75 mm (3 in.) or greater.

FIGURE 10
Handrail/Guardrail Dimensions with a Toeboard *(1 August 2013)*

Dimension		*Requirements*
A	Height of handrail/guardrail	1070 mm (42.0 in.)
B	Height of intermediate rail above toeboard	425 mm (16.75 in.)
C	Outside diameter of handrail	40 mm (1.5 in.) to 50 mm (2.0 in.)
D	Height of toeboard	100 mm (4.0 in.)
E	Gap between toeboard and surface	6 mm (0.25 in.)



7.4 Deck Edge, Elevated Walkway Railing Design

Deck edge and elevated walkway railings should have the following design (see Section 9, Figure 11, "Deck Edge and Elevated Walkway Rail Dimensions"):

i) The heights of rails or bulwarks should be at least 1070 mm (42 in.) from the deck.

ii) Rail courses or equivalents should be installed between a top rail and the deck so that the opening below the lowest course does not exceed 230 mm (9 in.) and the distance between the remaining courses is not more than 380 mm (15 in.).

iii) Toeboards should be at least 100 mm (4.0 in.) in height and have no more than a 6 mm (0.25 in.) clearance between the bottom edge of the toeboard and the walking surface.

iv) Vertical stanchions for railings should be spaced no more than 1525 mm (60 in.) apart horizontally.

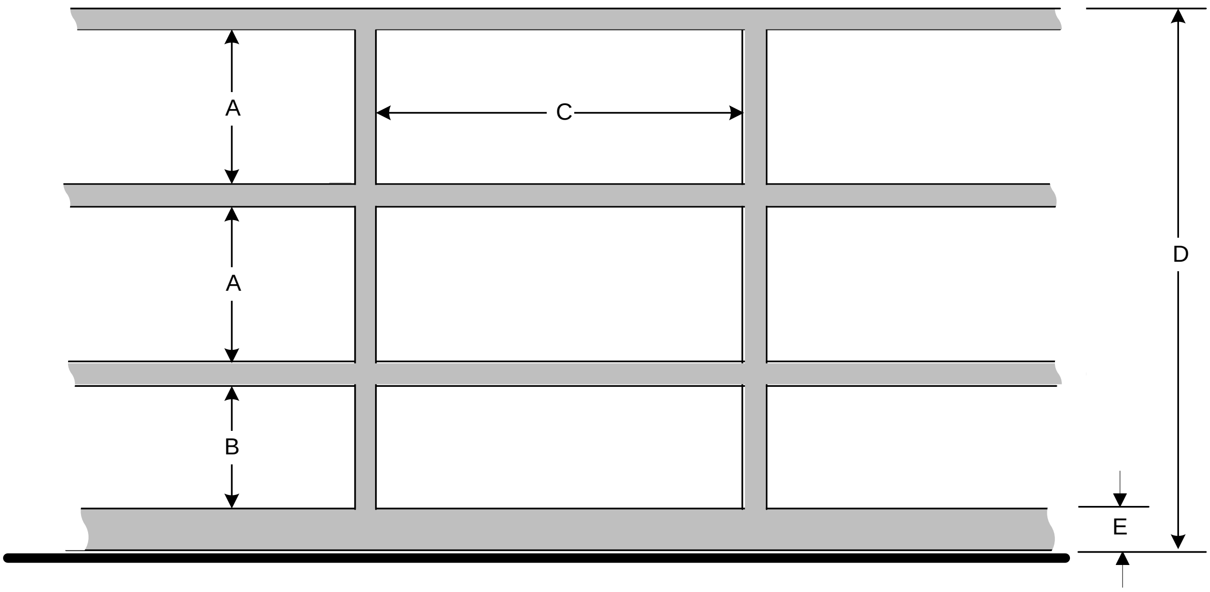
v) At least every third vertical stanchion should be supported by a bracket or stay.

vi) Chain or wire rope should not be used as a deck edge or elevated walkway rail.

FIGURE 11
Deck Edge and Elevated Walkway Rail Dimensions *(1 August 2013)*

Dimension		*Requirements*
A	Upper rail courses vertical separation	≤ 380 mm (15 in.)
B	Lower rail course vertical separation	≤ 230 mm (9 in.)
C	Vertical stanchion separation	≤ 1525 mm (60 in.)
D	Rail height from deck to top of rail*	≥ 1070 mm (42 in.)
E	Toeboard height	100 mm (4.0 in.)

* *Note:* Assumes Guardrail diameter of 50 mm (2 in.).



7.5 Safety Cages

Below are requirements related to climber safety cage design:

i) Cages should be used on vertical ladders over 4.5 m (15.0 ft) in height.

ii) Climber safety rails or cables should be used on vertical ladders in excess of 6.1 m (20.0 ft).

iii) Requirements for the construction of the safety cage are shown in Section 9, Figure 12, "Arrangement for Climber Safety Cage of Vertical Ladder" and Section 9, Figure 13. "Climber Safety Cage of Vertical Ladder – Side View".

iv) Cages should extend 1400 mm (54 in.) above the top-landing surface.

v) Cages equipped with intermediate landings should extend 1400 mm (54 in.) above the intermediate landing with the cage open on the side facing the landing.

vi) Safety cages should be provided for ladders ≤ 4.5 m (15.0 ft) in height where a fall to a level or deck below the ladder base is possible (e.g., within 1825 mm (72 in.) of the edge of a deck).

FIGURE 12
Arrangement for Climber Safety Cage of Vertical Ladder *(1 August 2013)*

Dimension		*Requirements**
A	Distance from centerline of ladder rung to point of radius of the safety cage horizontal guards	350 mm (14.0 in.)
B	Horizontal guard radius	Horizontal guard at bottom of cage – 425 mm (17.0 in.)
		All other horizontal guards – 350 mm (14.0 in.)
C	Vertical separation of horizontal guard placement	≤ 1200 mm (47.0 in.)

* *Note:* Or meet flag State standards.

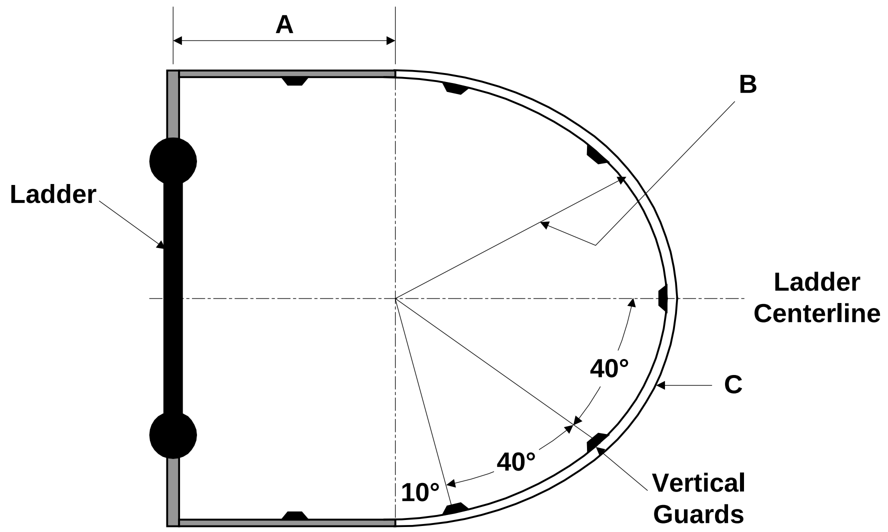
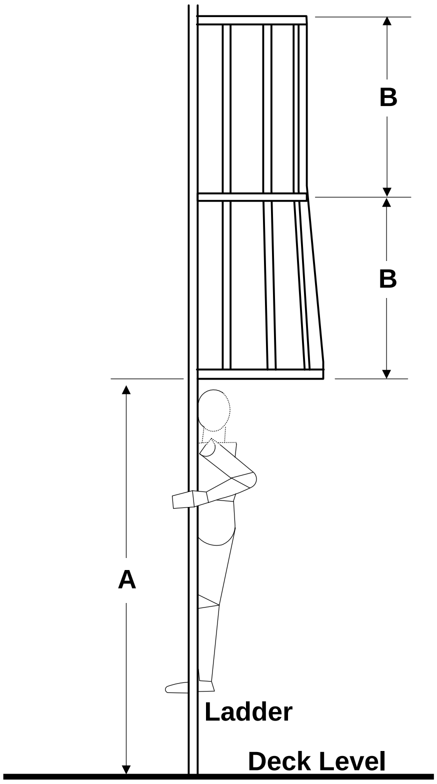


FIGURE 13
Climber Safety Cage of Vertical Ladder – Side View *(1 August 2013)*

Dimension		*Requirements*
A	Distance above standing surface	≥ 2200 mm (87.0 in.) ≤ 2500 mm (98.0 in.)
B	Vertical separation of horizontal guard placement	≥ 1140 mm (45.0 in.) ≤ 1220 mm (48.0 in.)



7.6 Climber Safety Rails or Cables

Listed below are requirements related to the use of climber safety rails or cables, where provided.

i) A climber safety rail or cable should be installed at each permanently installed topside ladder on masts, kingposts and other similar topside structures providing access to fall hazard locations.

ii) Climber safety rail should be stainless steel flat bar and equipped with two safety slides, which can be attached to the flat bar or cable.

iii) If climber safety devices are used, the ladder stringers at a top landing should be designed to allow personnel to access any associate landing without unfastening (See Section 9, Figure 14, "Ladders with Climber Safety Rails or Cables").

FIGURE 14
Ladders with Climber Safety Rails or Cables[1] *(1 August 2013)*

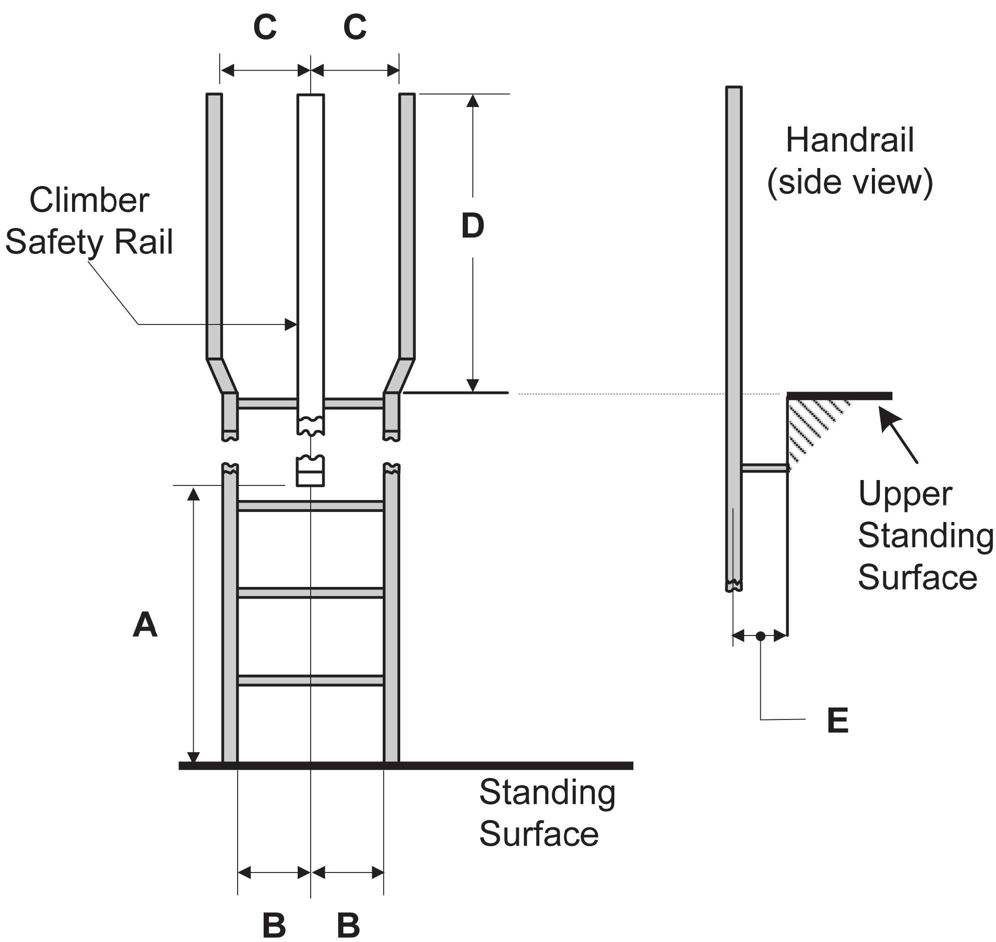
Dimension		*Requirements*[2]
A	Distance to bottom of climber safety rail	≥ 900 mm (35.5 in.) ≤ 950 mm (37.5 in.)
B	Inside clearance[3] (ladder rungs)	225 mm (9.0 in.) 250 mm (10.0 in.)
C	Inside clearance[3] (upper hand rails)	380 mm (15.0 in.)
D	Top of climber safety rail and handrail height above upper standing surface	≥ 1070 mm (42.0 in.)
E	Distance from opposing vertical surface	≥ 175 mm (7.0 in.) ≤ 200 mm (8.0 in.)

Notes:

1 No safety cage provided.

2 Dimensions differ from other ladder types as the presence of the safety rail and the wearing of climber harnesses changes the ergonomic requirements imposed on the design.

3 Stringer separation increased to accommodate width of climber safety device.



7.7 Safety Drop Bars

All fixed ladders serving elevations 760 mm (30 in.) or more above ground, platform or floor level should be equipped with drop bars or safety gates. Drop bars should be attached as follows:

i) Side access ladders should hinge at the ladder side.

ii) Front access ladders should hinge at the right when facing the ladder from the platform side.

iii) Drop bars should not be placed beyond the outer edge of the platform.

iv) Chains should not be used in lieu of a drop bar.

7.8 Safety Gates

Where a self-closing safety gate is provided, the following should apply:

i) The self-closing safety gate should be installed at the top of each ladder and should cover the full width of the opening between the ladder stringers.

ii) The gate should open away from the person climbing up the ladder.

iii) Safety gates should be sufficiently robust to resist the full weight of a 90 kg (200 lbs) person in both the vertical and horizontal direction.

iv) Chains should not be used in lieu of a safety gate.

8 Fall Protection from Secondary Fall Points *(1 August 2013)*

8.1 General

Vertical ladders should not be located within 1.83 m (6 ft) of other nearby potential fall points (including the deck edge, cargo holds and lower decks) without additional fall protection such as guardrails.

Additional fall protection should be provided for the ladder climber for the case:

i) If a vertical ladder (of any height) is located within 1.83 m (6 ft) of another and nearby potential (secondary) fall point (for example overboard or to a lower deck or landing),

and

ii) If the potential fall distance is greater than 4.600 m (15 ft). (The potential fall distance is the height of the ladder plus the height of the secondary fall),

and

iii) If no active fall protection is fitted to the ladder (a safety cage is not considered to provide active protection),

then

iv) Additional fall protection to the ladder climber shall be provided, regardless of whether a climber safety cage is fitted to the ladder, as described in 9/8.2.

Note: Passive Fall Protection is a safety design or device that requires a person to take no specific action prior to a potential loss, for example, a safety cage permanently fitted to a ladder.

Active Fall Protection is a safety design or device that actively (or directly) requires a person to take specific actions before a potential loss, for example, donning a fall arrestor fitted to both the ladder and the climber.

8.2 Protection for Vertical Ladders without Safety Cages or Climber Safety Rails/Cables

The following should apply to vertical ladders less than of 4.5 m (15.0 ft) that are not fitted with a safety cage or a safety rail.

Guardrail requirements are found in the following:

i) Section 9, Table 4, "Guardrail Requirements for Vertical Ladders without Safety Cages or Climber Safety Rails/Cables" provides the dimensions for requirements to guardrails near the base of the ladder.

ii) Section 9, Figure 15, "Front View of Guardrail Requirements for Vertical Ladders without Safety Cages or Climber Safety Rails/Cables" and Section 9, Figure 16, "Side View of Guardrail Requirements for Vertical Ladders with or without Safety Cages or Climber Safety Rails/Cables" provide dimensions and graphical representations.

Other designs and arrangements that serve to protect personnel from falls may also be deemed to be acceptable.

TABLE 4
Guardrail Requirements for Vertical Ladders without Safety Cages or Climber Safety Rails/Cables *(1 August 2013)*

Dimension	*Requirement**
Height of vertical guardrail	Height shall extend to within 760 mm (30 in.) of the top of the ladder.
Width of vertical guardrail	Protection shall be provided for a minimum of 1220 mm (48 in.) on each side of the centerline of the ladder, space permitting.
Distance between guardrail courses or tiers	A maximum of 460 mm (18 in.) shall be provided between guardrail courses or tiers of the guardrail extension. The measurement shall be taken from the course or tier's outside diameter to outside diameter as shown in Section 9, Figure 15.

** Note:* If the vertical ladder is movable (e.g., can rotate because it is mounted on the side of a crane cab), the height of the vertical guardrail shall continue horizontally to a distance of 600 mm (23.5 in.) from each side of the centerline of the movable object when it is at its travel limits.

FIGURE 15
Front View of Guardrail Requirements for Vertical Ladders without Safety Cages or Climber Safety Rails/Cables *(1 August 2013)*

	Dimension	*Requirements**
A	Horizontal spacing between ladder centerline and rail end	≥ 1220 mm (48.0 in.)
B	Vertical distance from top of ladder to top of rail	≤ 760 mm (30.0 in.)
C	Spacing between top rail and mid-rail	≤ 380 mm (15.0 in.)
D	Height of toeboard	100 mm (4.0 in.)

* *Note:* Vertical ladder requirements apply. (See Subsection 9/4, "Vertical Ladders")

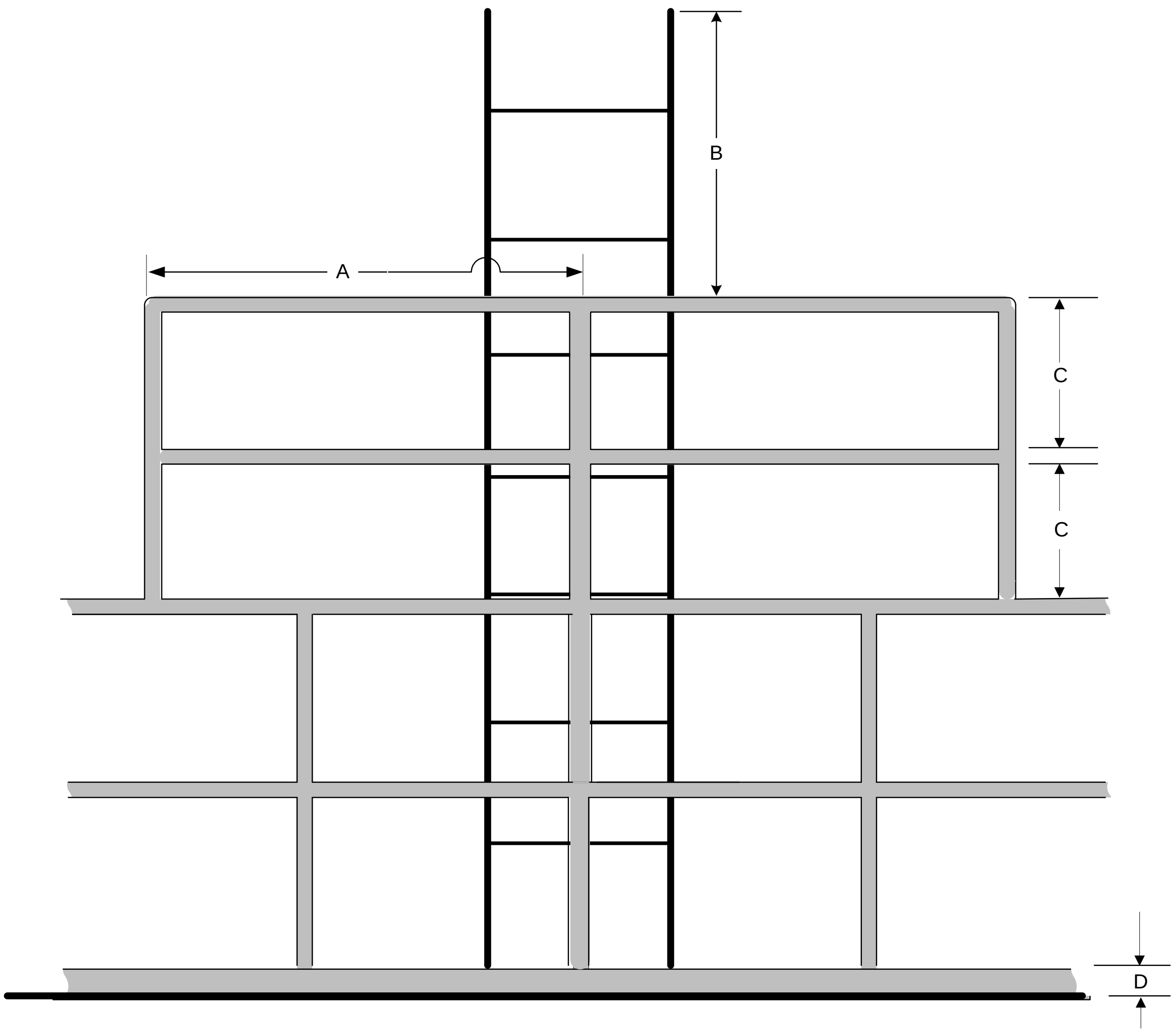
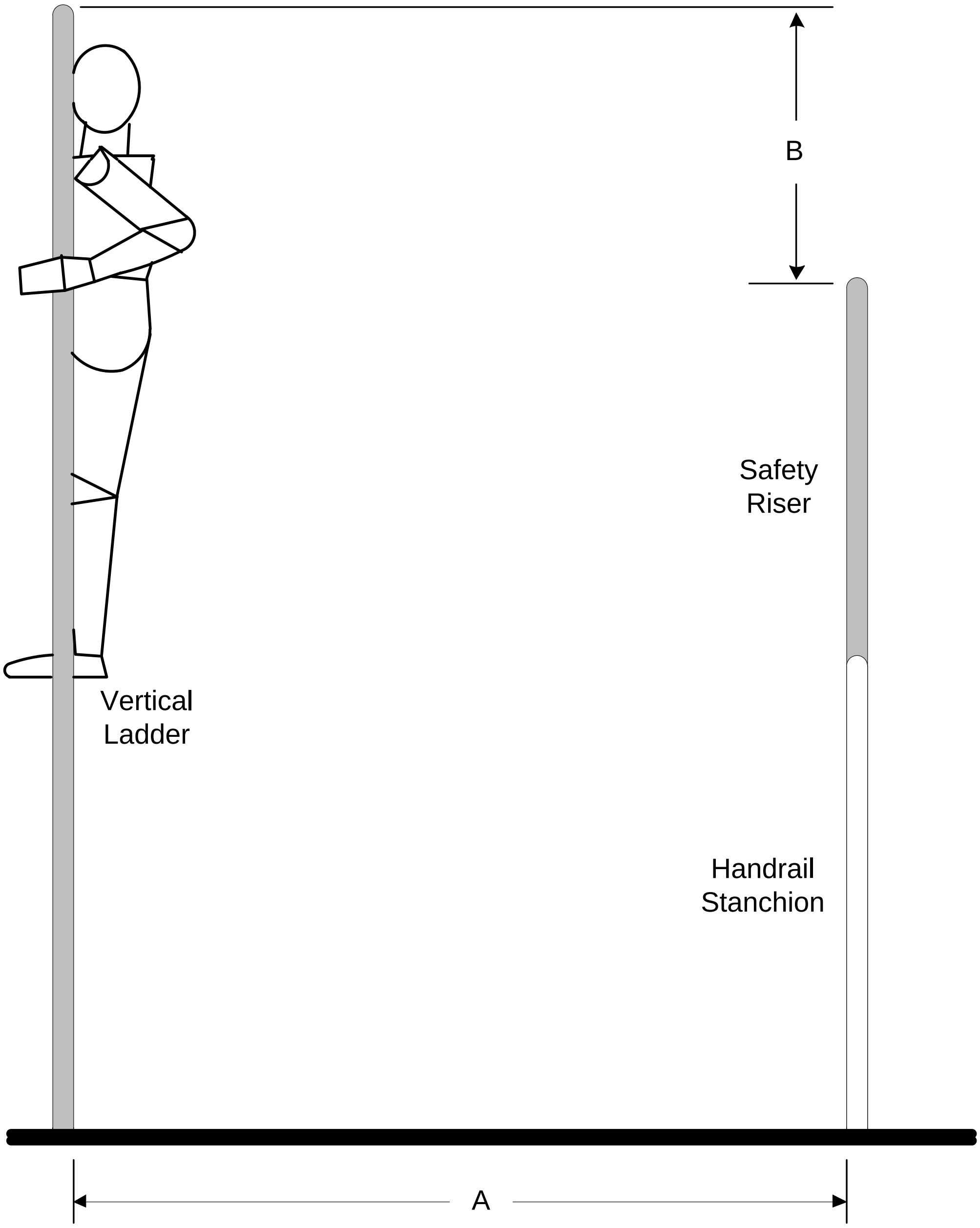


FIGURE 16
Side View of Guardrail Requirements for Vertical Ladders without Safety Cages or Climber Safety Rails/Cables *(1 August 2013)*

Dimension		*Requirements*
A	Horizontal distance between ladder and rails	≤ 1830 mm (72.0 in.)
B	Vertical distance from top of rail to top of ladder	≤ 760 mm (30 in.)



8.3 Protection for Vertical Ladders with Safety Cages and without Climber Safety Rails/Cables

Guardrail requirements are found in the following:

- Section 9, Table 5, "Guardrail Requirements for Vertical Ladders with Safety Cages and without Climber Safety Rails/Cables" provides requirements for guardrails near the base of the ladder.
- Section 9, Figure 17, "Front View of Guardrail Requirements for Vertical Ladders with Safety Cages and without Climber Safety Rails/Cables" provides dimensions and graphical representations. Note that Dimension A of Section 9, Figure 17 also applies to Guardrail Requirements for Vertical Ladders with Safety Cages and without Climber Safety Rails/Cables.

Other designs and arrangements that serve to protect personnel from falls may also be deemed to be acceptable.

TABLE 5
Guardrail Requirements for Vertical Ladders with Safety Cages and without Climber Safety Rails/Cables *(1 August 2013)*

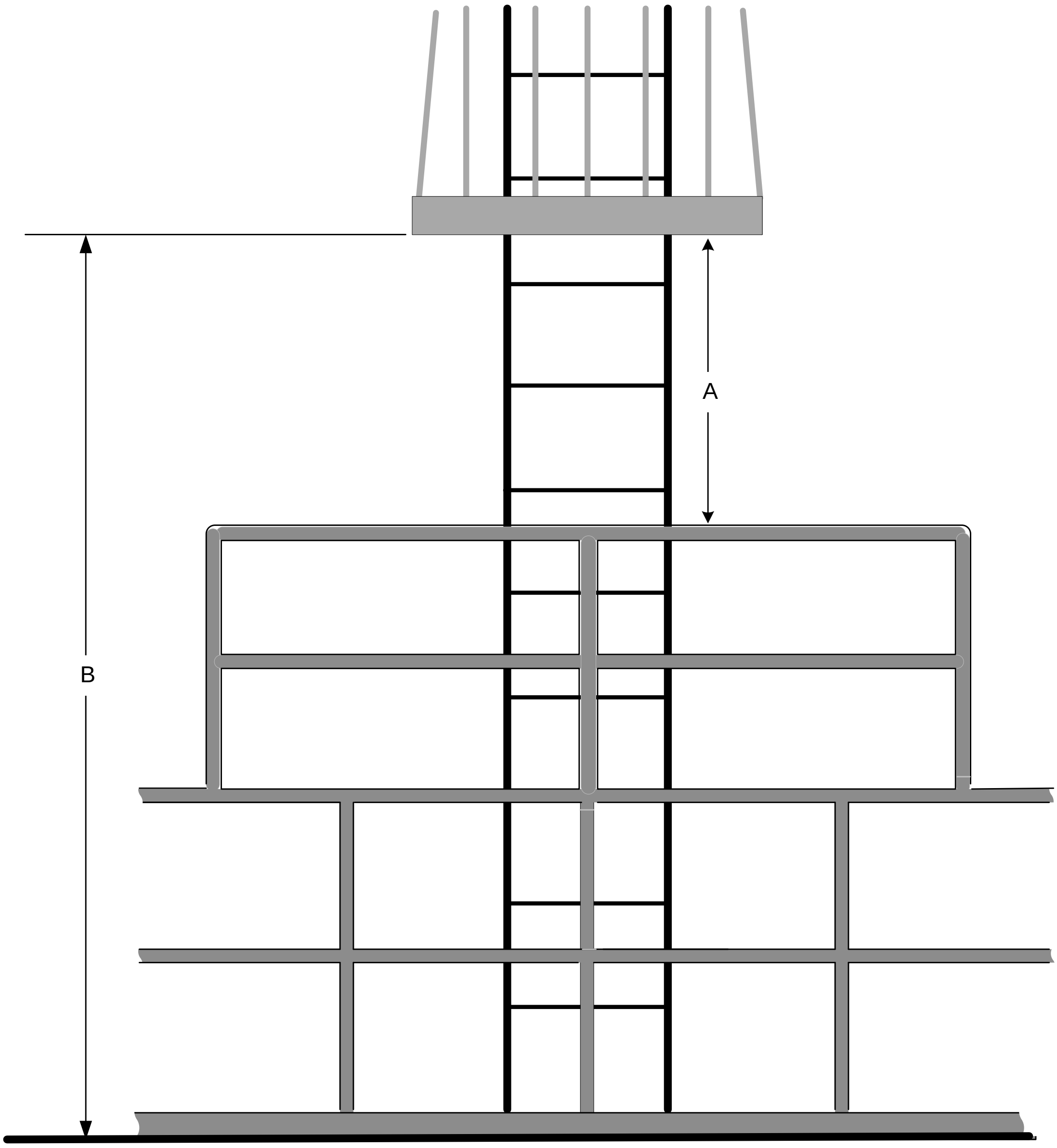
Dimension	*Requirement**
Height of vertical guardrail	The height shall extend to within 760 mm (30 in.) of the lower edge of the safety cage
Width of vertical guardrail	Protection shall be provided for a minimum of 1220 mm (48 in.) on each side of the centerline of the ladder, space permitting.
Distance between guardrail extension courses or tiers	A maximum of 460 mm (18 in.) shall be provided between guardrails courses or tiers of the guardrail extension. The measurement shall be taken from the course or tier outside diameter to outside diameter as shown in Section 9, Figure 16.
Horizontal distance between ladder and rails	1830 mm (72.0 in.) (Refer to Dimension A of Section 9, Figure 16, "Side View of Guardrail Requirements for Vertical Ladders without Safety Cages or Climber Safety Rails/Cables")

* *Note:* If the vertical ladder is movable (e.g., can rotate because it is mounted on the side of a crane cab), the height of the vertical guardrail shall continue horizontally to a distance of 600 mm (23.5 in.) from each side of the centerline of the movable object when it is at its travel limits.

FIGURE 17
Front View of Guardrail Requirements for Vertical Ladders with Safety Cages and without Climber Safety Rails/Cables* *(1 August 2013)*

	Dimension	*Requirements*
A	Vertical distance between safety cage and rail	≤ 760 mm (30.0 in.)
B	Vertical distance between the safety cage and platform	2130 mm (84.0 in.)

* *Note:* Assumes that the potential fall distance is greater than 4575 mm (15 ft) where a safety cage, but no climber safety rail or cable is present.



8.4 Guardrail Requirements for Movable Vertical Ladders

If the vertical ladder is movable (e.g., can rotate because it is mounted on the side of a crane cab), the elevated height of the vertical guardrail should continue horizontally to a distance of 600 mm (23.5 in.) from each side of the centerline of the movable object when it is at its travel limits.

8.5 Use of Vertical Ladder Safety Gates or Bars versus Safety Chains

Safety gates or bars, rather than safety chains, should be used to protect personnel near the opening at the top of a vertical ladder.

Safety gates should comply with the following:

i) A self-closing safety gate covering the full width of the opening between the ladder stringers should be installed at the top of each ladder to protect personnel from falling while near the top of a ladder.

ii) Where ladders provide access to small platforms and that do not provide sufficient space for the self-closing gate to swing horizontally, manually operated gates that open and close via a vertical swing should be installed.

iii) The gate should open away from the person climbing up the ladder.

9 Ladder and Access Handles *(1 August 2013)*

This Subsection contains requirements related to the design of handles. The considerations listed below apply to the design and placement of handles and are not represented in the following figures.

9.1 General

i) Handles should be designed to accommodate personnel wearing either lightweight and medium weight gloves or cold weather gloves and mittens. (See Section 9, Figure 18, “Handle Dimensions”).

ii) Handles should be constructed of round bar.

iii) Handles are particularly useful where a vertical ladder comes up to a manhole from the deck below where the ladder does not extend through the platform (see Section 9, Figure 19, “Handle Placement (Ladder not Extending Through Platform)” or while passing through access hatches (see Section 9, Figure 20, “Handle Placement (Stepping Through a Vertical Hatch)”).

iv) Handles should be accessible at all stages during climbing or traversing through access hatches (embarking and disembarking) and within reach of the shortest (e.g., 5th percentile female) user.

v) To provide for safe ascending and descending, while stepping onto or from ladders, individual ladder rungs or steps and through hatches or lightening holes, suitably located handles or handgrabs should be provided. See Section 9, Figure 21, “Handle Placement (Stepping to or from a Vertical Ladder)”.

Handles exposed to the elements should have additional slip resistance due to potential exposure to water and ice.

9.2 Handle Design/Placement

The following figures represent the different aspects of handle design, placement and dimensioning.

- Figure 18, “Handle Dimensions”
- Figure 19, “Handle Placement (Ladder not Extending Through Platform)”
- Figure 20, “Handle Placement (Stepping Through a Vertical Hatch)”
- Figure 21, “Handle Placement (Stepping to or from a Vertical Ladder)”

FIGURE 18
Handle Dimensions *(1 August 2013)*

Dimension		*Requirements*
A	Handle width	≥ 300 mm (12.0 in.) ≤ 350 mm (14.0 in.)
B	Handle height	100 mm (4.0 in.)
C	Radius (bend)	25 mm (1.0 in.)
D	Round bar diameter	25 mm (1.0 in.)

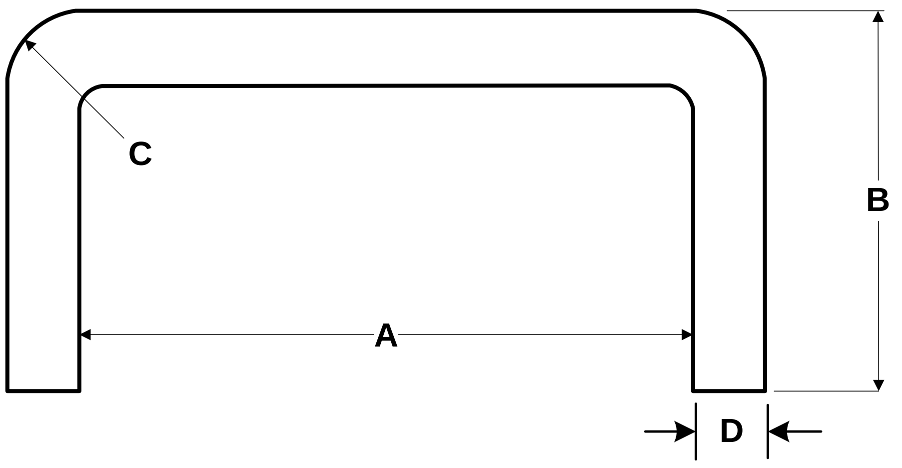


FIGURE 19
Handle Placement (Ladder not Extending through Platform) *(1 August 2013)*

	Dimension	*Requirements**
Four Horizontal Handles		
A	Handle height above top of ladder and between handles	≥ 275 mm (11.0 in.) ≤ 300 mm (12.0 in.)
E	Round Bar Diameter	25 mm (1.0 in.)
Two Vertical Handles		
B	Height from top deck to handle	200 mm (8.0 in.)
C	Clearance between handles	400 mm (16.0 in.)
D	Height of handles	1000 mm (39.5 in.)
E	Round Bar Diameter	25 mm (1.0 in.)

* *Note:* Vertical ladder requirements apply (See Subsection 9/4, "Vertical Ladders").

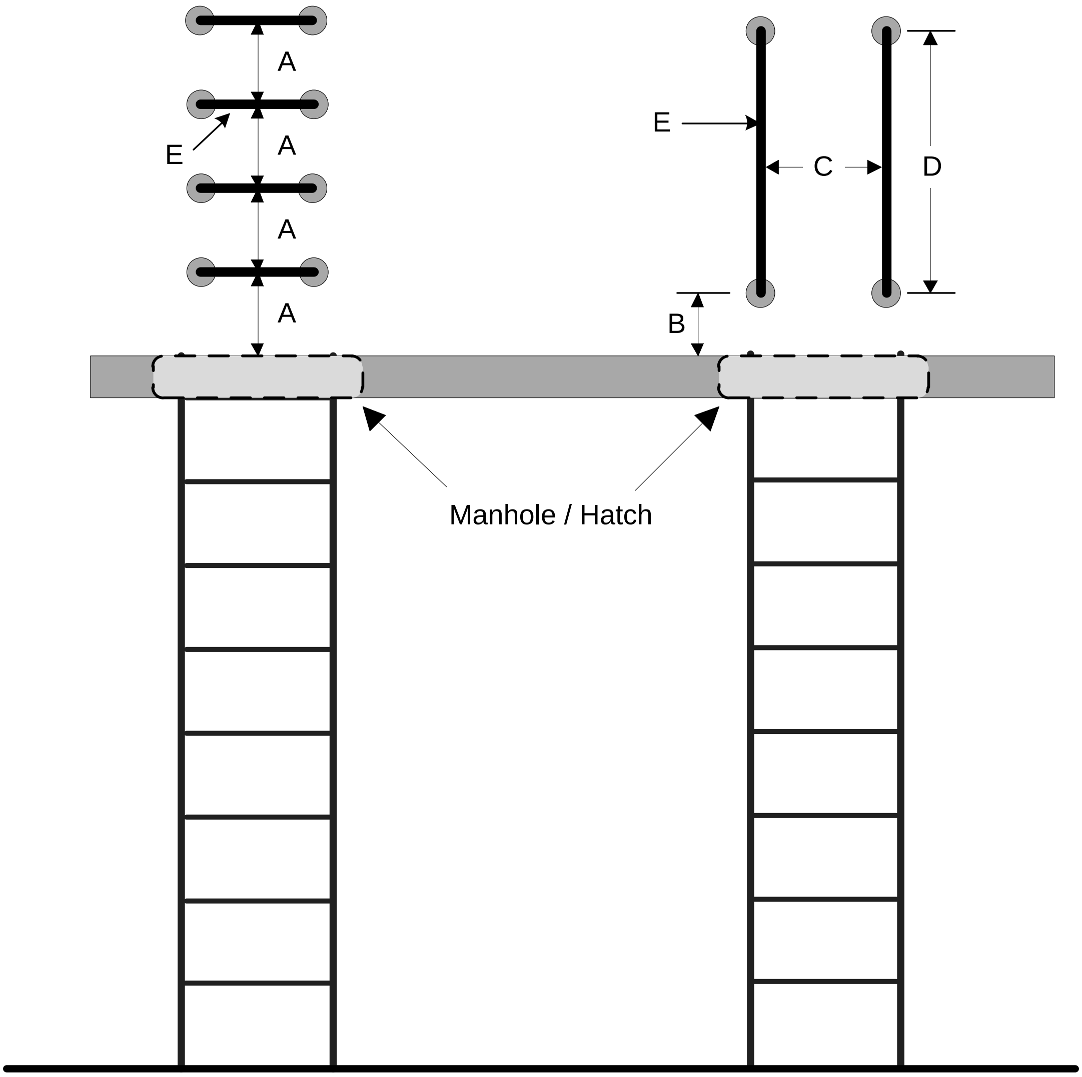


FIGURE 20
Handle Placement (Stepping Through a Vertical Hatch)* *(1 August 2013)*

Dimension		*Requirements*
A	Handle height (above top of opening)	100 mm (4.0 in.)
B	Distance between lower and upper edge of the hatch	≥ 1000 mm (39.5 in.)
C	Height required for a step	> 600 mm (23.5 in.)
D	Handle width (no upper limit in this case)	≥ 300 mm (12.0 in.)
E	Step height	One half of dimension C
F	Step width, hatch width	≥ 800 mm (31.5 in.) or ≥ Hatch width
G	Step depth (not shown in figure)	≥ 275 mm (11.0 in.) ≤ 300 mm (12.0 in.)

* *Note:* Handles and steps are provided on both sides of the hatch.

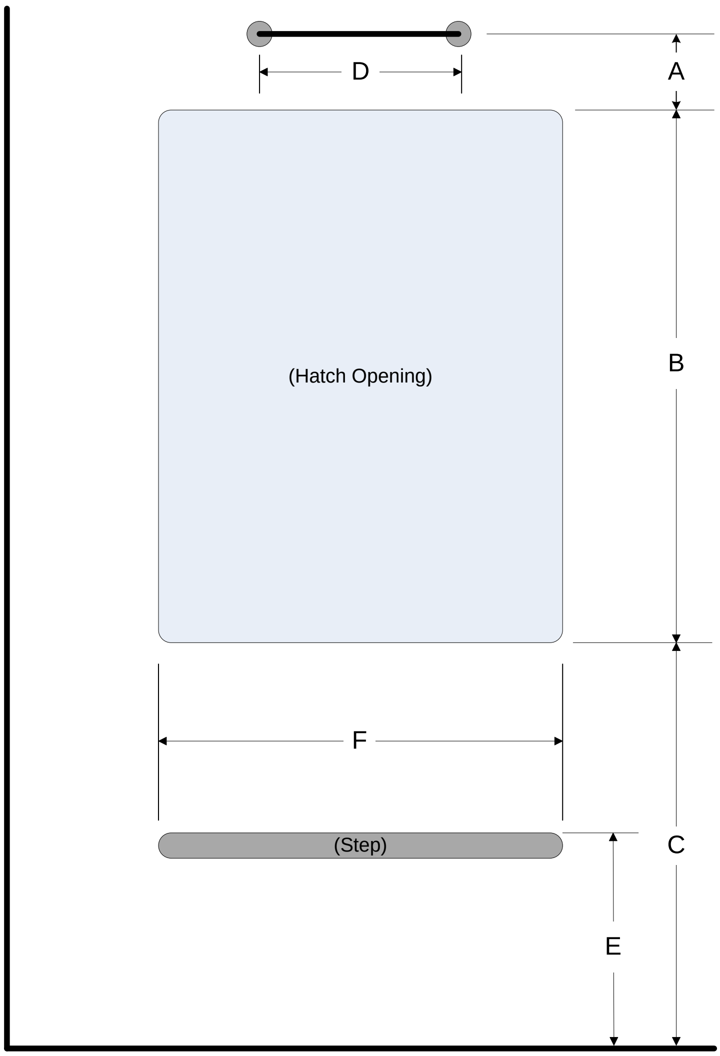


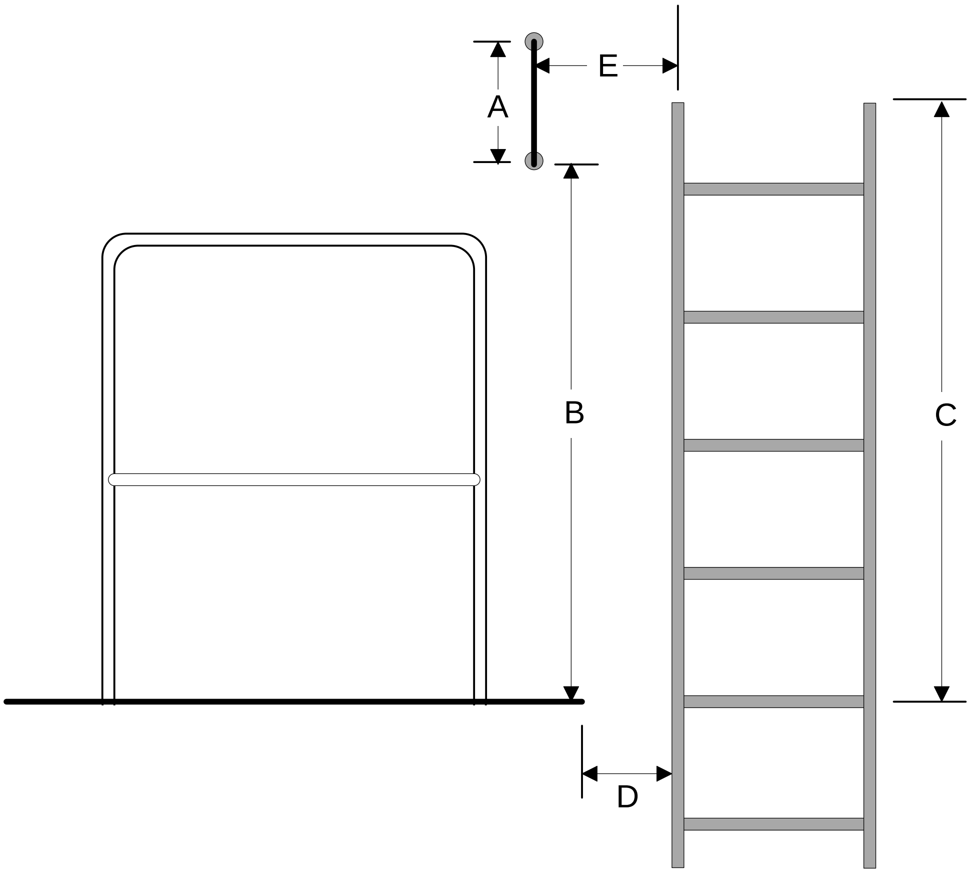
FIGURE 21
Handle Placement (Stepping to or from a Vertical Ladder)[1, 2] *(1 August 2013)*

Dimension		*Requirements*
A	Length of handle	≥ 300 mm (12.0 in.)
B	Handle starting height above landing or platform	≥ 1270 mm (50.0 in.)
C	Ladder stringer height above platform	≥ 1350 mm (53.25 in.)
D	Horizontal separation between vertical ladders and platform	≥ 150 mm (6.0 in.) ≤ 300 mm (12.0 in.)
E	Horizontal separation between vertical ladder and handle	≥ 225 mm (9.0 in.) ≤ 450 mm (18.0 in.)

Notes:

1 Vertical ladder requirements apply (See Subsection 9/4, "Vertical Ladders").

2 Toeboard not shown.



10 Walkways and Work Platforms *(1 August 2013)*

This Subsection includes general principles as well as the design requirements for the arrangement of walkways and ramps and the provision of guardrails.

10.1 General Principles

The principles listed below apply to the design of walkways and ramps and are not represented in the following figures or tables.

i) Handrails should be provided at the exposed side of any walking or standing surface that is 600 mm (23.5 in.) or higher above the adjacent surface and where a person could fall from the upper to the lower surface.

ii) Ramps are used with changes in vertical elevations of less than 600 mm (23.5 in.).

iii) Ramps are provided with a non-skid surface that should have a coefficient of friction (COF) of 0.6 or greater measured when wet.

iv) Headroom in all walkways should be ≥ 2130 mm (84 in.).

v) Toeboards should be provided on elevated walkways, platforms and ramps.

vi) Walkways and ramps exposed to the elements should have additional slip resistance due to potential exposure to water and ice.

vii) No impediments or tripping hazards should intrude into the transit space (for example, electrical boxes, valves, actuators or piping).

viii) No impediments or tripping hazards should impede access to a walkway or ramp (for example, piping runs, hatch covers, deck impediments (e.g., through bolts) or combings/retention barriers).

10.2 Design Loads

Where requirements for design loads specified by other regulatory bodies (e.g., flag Administrations and port State authorities) are greater, those requirements take precedence over these Guidance Notes.

These Guidance Notes define “design load” as the maximum intended load, being the total of all loads including the weight of the personnel, materials and equipment, including the means of access structure.

10.2.1 Guardrails

Guardrails should withstand anticipated loads but not less than 90 kg (200 lbs) at any point and in any direction when applied to the top rail.

10.2.2 Design Loads and Maximum Deflection

The minimum design loads for the walkways and ramps are:

i) 2.0 kN/m^2 (0.29 lbf/in^2) under uniform load for the structure, and

ii) 1.5 kN (337 lbf) concentrated load applied in the most unfavorable position over a concentrated load area of 200 mm × 200 mm (8 in. × 8 in.) for the flooring.

iii) When loaded with the design load, the deflection of the flooring should not exceed 1/200th of the span and the difference between the loaded and adjacent unloaded flooring should not exceed 4 mm in height.

10.3 Walkway Design

The dimensions relating to the design of walkways and ramps are presented in Section 9, Figure 22, "Walkway and Ramp Design".

10.3.1 Opening in Gratings

i) The maximum opening in a walkway grating under which the presence of persons is expected should be less than 22 mm (0.9 in.).

ii) The maximum opening in a walkway grating under which the presence of persons is not expected should be less than 35 mm (1.7 in.).

10.3.2 Toeboards

Toeboards should have a height of 100 mm (4.0 in.) and have no more than a 6 mm (0.25 in.) clearance between the bottom edge of the toeboard and the walking surface.

11 Ramps

11.1 General

Ramps are best used with changes in vertical elevations of less than 610 mm (24 in.), but may be used for any height provided that the angle of inclination to the horizontal complies with Section 9, Table 6, "Recommended Ramp Inclination". Ramps should be used where hand-carrying bulky loads or loads in excess of 13 kg (29 lbs) is required.

TABLE 6
Recommended Ramp Inclination

Ramp Use	*Recommended Incline in Degrees*
Pedestrian Traffic without Materials Handling	7° (recommended) - 15° (Maximum)
Materials Handling	4° (recommended) - 7° (Maximum)

11.2 Dimensions

The following dimensions are applicable to ramps for pedestrian traffic or materials handling.

i) Ramps should have level landings, at least as wide as the ramp with a minimum length of 1525 mm (60 in.), at the top and bottom of each ramp. To provide adequate space for people and equipment to turn where ramps change direction at landings, the minimum landing size should be 1525 mm by 1525 mm (60 in by 60 in.).

ii) Ramps should be at least 915 mm (36 in.) wide.

iii) Handrails, per the requirements of 9/12.3, "Handrails for Walkways and Work Platforms", should be provided on any open side of a ramp provided the vertical distance from the ramp to the nearest adjacent surface is 610 mm (24 in.) or greater.

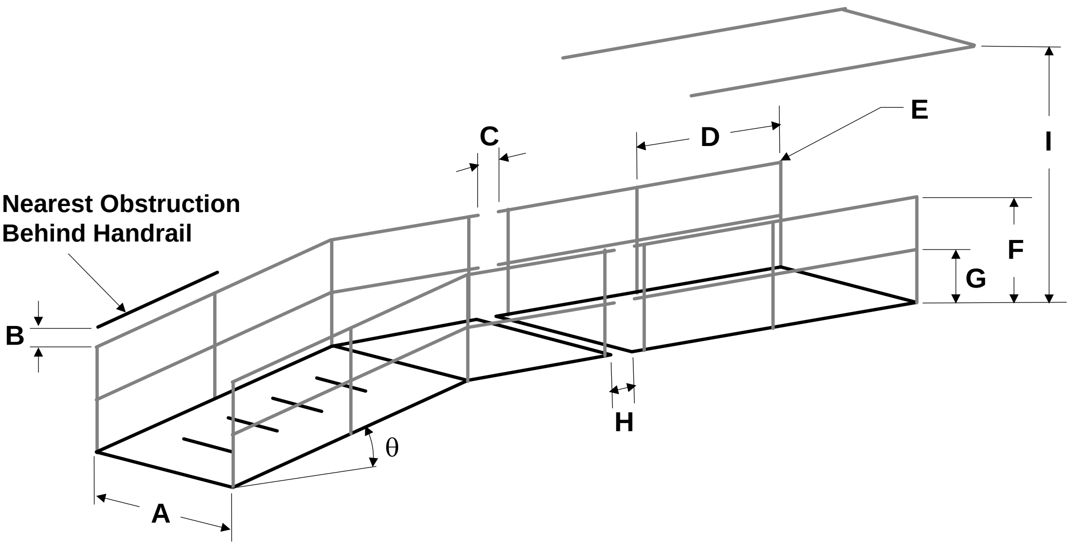
iv) Ramps, especially those with an angle of inclination greater than 8 degrees, should be provided with a non-skid surface.

FIGURE 22
Walkway and Ramp Design[1] *(1 August 2013)*

Dimension		*Requirements*
A	Walkway width – one person[2]	≥ 710 mm (28 in.)
	Walkway width – two-way passage, or means of access or egress to an entrance	≥ 915 mm (36 in.)
	Walkway width – emergency egress, unobstructed width	≥ 1120 mm (44 in.)
B	Distance behind handrail and any obstruction	≥ 75 mm (3.0 in.)
C	Gaps between two handrail sections or other structural members	≤ 50 mm (2.0 in.)
D	Span between two handrail stanchions	≤ 2.4 m (8 ft)
E	Outside diameter of handrail	≥ 40 mm (1.5 in.) ≤ 50 mm (2.0 in.)
F	Height of handrail	1070 mm (42.0 in.)
G	Height of intermediate rail	500 mm (19.5 in.)
H	Maximum distance between the adjacent stanchions across handrail gaps	≤ 350 mm (14.0 in.)
I	Distance below any covered overhead structure or obstruction	≥ 2130 mm (84 in.)
θ	Ramp angle of inclination – unaided materials handling	≤ 5 degrees
	Ramp angle of inclination – personnel walkway	≤ 15 degrees

Notes:

1. Toeboard omitted for clarity.
2. The walkway width may be diminished to ≥ 500 mm around a walkway structure web frames.



12 Work Platforms *(1 August 2013)*

Work platforms should be provided at locations where personnel must perform tasks that cannot be easily accomplished by reaching from an existing standing surface.

Work platforms exposed to the elements should have additional slip resistance due to potential exposure to water and ice.

12.1 General Principles

The principles listed below apply to the design of work platforms.

i) Platforms should be of sufficient size (see Section 9, Figure 23, "Work Platform Dimensions") to accommodate the task and allow for placement of any required tools, spare parts or equipment.

ii) Work platforms more than 600 mm (23.5 in.) above the surrounding surface should be provided with guardrails and handrails as described in Section 9, Figure 22 "Walkway and Ramp Design".

12.2 Design Loads

Where requirements for design loads specified by other regulatory bodies (e.g., flag Administrations and port State authorities) are greater than these design loads, those requirements take precedence over these Guidance Notes.

These Guidance Notes define "design load" as the maximum intended load, being the total of all loads including the weight of the personnel, materials and equipment, including the means of access structure.

12.2.1 Guardrails

Guardrails should withstand anticipated loads but not less than 90 kg (200 lbs) at any point and in any direction when applied to the top rail.

12.2.2 Design Loads and Maximum Deflection

The minimum design loads for the working platforms and landings are:

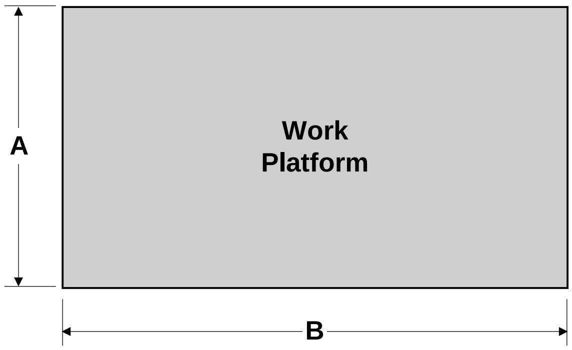
i) 2.0 kN/m^2 (0.29 lbf/in^2) under uniform load for the structure, and

ii) 1.5 kN (337 lbf) concentrated load applied in the most unfavorable position over a concentrated load area of 200 mm × 200 mm (8 in. × 8 in.) for the flooring.

iii) When loaded with the design load, the deflection of the flooring should not exceed $1/200^{th}$ of the span and the difference between the loaded and adjacent unloaded flooring should not exceed 4 mm in height.

FIGURE 23
Work Platform Dimensions *(1 August 2013)*

Dimension		*Requirements*
A	Work platform width	≥ 750 mm (30.0 in.)
	Work platform width (if used for standing only)	≥ 380 mm (15.0 in.)
B	Work platform length	≥ 925 mm (37.0 in.)
	Work platform length (if used for standing only)	≥ 450 mm (18.0 in.)



12.3 Handrails for Walkways, Ramps, and Work Platforms

12.3.1 General Guidelines

Platform handrails should be provided at the exposed side of any platform surface that is 610 mm (24 in.) or higher above the adjacent surface and where a person could fall from the upper to the lower surface. Handrails should be two-tiered and be provided with a toeboard. Height of the handrail should be 1070 mm (42 in.) from the top of the top rail to the walking surface, with the intermediate rail located 460 mm (18 in.) below the top rail. Vertical stanchions should be provided at a maximum spacing of 2.4 m (8 ft). The handrails should be constructed of 40 mm (1.5 in.) outside diameter pipe. The toeboard should be 100 mm (4 in.) in height and should have no more than 6 mm (0.25 in.) clearance between the bottom edge of the toeboard and the top of the walking surface.

12.3.2 International Convention on Loadlines

For locations requiring handrails or guardrails in accordance with the *International Convention on Loadlines*, the handrail or guardrail should be of three tiers. The height of the top tier should be at least 1000 mm (39.5 in.) from the deck, except where this height would interfere with the normal operation of the vessel; a lesser height may be considered. The opening below the lowest course of the guardrail should not exceed 230 mm (9 in.). The intermediate course should not be more than 380 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 Guidance Notes.

12.4 Access Walkway to Tanker Bows

Tankers, including oil tankers, chemical tankers and gas carriers, should 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:

i) The access should not be less than 1000 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.

ii) The access should be fitted at each side throughout its length with a toeboard and guardrails supported by stanchions. Such rails should consist of no less than 3 courses, the lowest being not more than 230 mm (9 in.) and the uppermost being at least 1000 mm (40 in.) above the gangway or walkway, and no intermediate opening more than 380 mm (15 in.) in height. Stanchions should be at intervals of not more than 1500 mm (60 in.).

iii) The access should be constructed of fire-resistant, non-slip material and have a level surface.

iv) The access should be provided with openings in the handrails and with ladders, where appropriate, to and from the deck. Openings should not be more than 40 m (131 ft) apart.

v) 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.

vi) If the access is obstructed by permanently installed pipes or other fittings, means for passage over such obstruction should be provided.

13 Hatches *(1 August 2013)*

13.1 General

This Subsection contains requirements related to the design of hatches.

13.2 General Principles

The principles listed below apply to the design of hatches and lightening holes and are not represented in the following figures or tables.

i) For access through horizontal hatches, the dimensions should be sufficient to allow a person wearing a self-contained air-breathing apparatus and protective equipment to ascend or descend any ladder without obstruction and also provide a clear opening to facilitate the movement of an injured person through the hatch.

Where hatch covers are heavy [e.g., above 11 kg (24.3 lbs)] or unwieldy, aids should be provided to assist in lifting or lowering the hatch cover.

13.3 Hatch Design

Section 9, Figure 24, "Hatch Design" and Section 9, Figure 25, "Hatch Design (Alternative Arrangement)" present guidelines related to shapes and dimensions of hatches. Section 9, Figure 25 illustrates an IACS-approved alternative design for access. This design is subject to the verification of easy evacuation of injured or stretcher-borne personnel.

FIGURE 24
Hatch Design *(1 August 2013)*

Dimension		*Requirements*
A	Access – vertical height	≥ 1000 mm (39.50 in.)
B	Access – horizontal width	≥ 800 mm (31.50 in.)
C*	Height above deck or stepping tread	≤ 600 mm (23.5 in.)

* *Note:* If a vertical opening is at a height of more than 600 mm, steps and handgrips shall be provided.

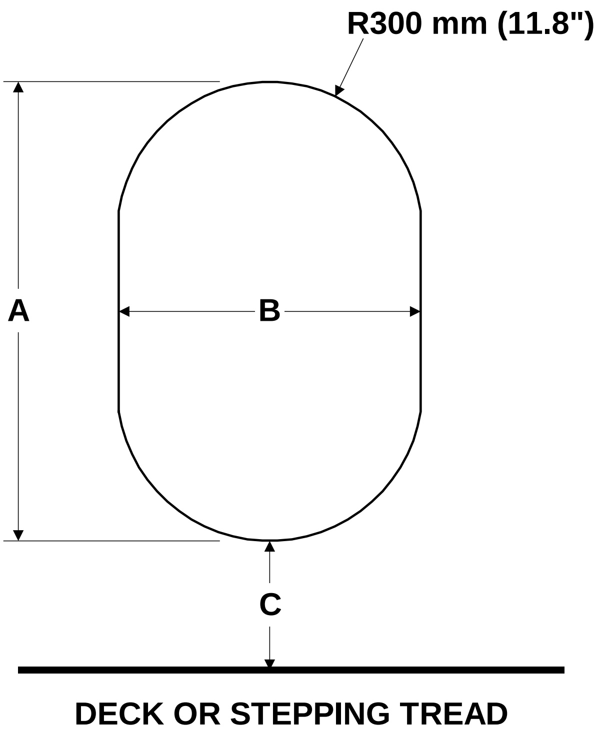
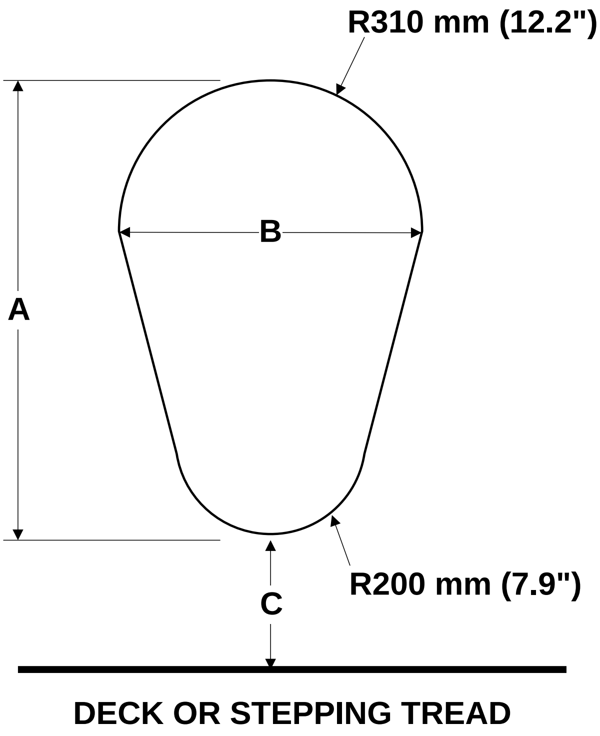


FIGURE 25
Hatch Design (Alternative Arrangement) *(1 August 2013)*

Dimension		*Requirements*
A	Access – vertical height	≥ 1000 mm (39.4 in.)
B	Access – horizontal width	≥ 800 mm (31.50 in.)
C*	Height above deck or stepping tread	≤ 600 mm (23.5 in.)

* *Note:* If a vertical opening is at a height of more than 600 mm, steps and handgrips shall be provided. For more guidance, see Section 9, Figure 20, "Handle Placement (Stepping Through a Vertical Hatch)".



13.4 Horizontal Hatch Access Near a Coaming

When access to a cargo hold is arranged through the cargo hatch, the top of the ladder should be placed as close as possible to the hatch coaming (see Section 9, Figure 26, "Ladder Distance from Hatch Coaming"). Access hatch coamings having a height greater than 900 mm (35.5 in.) should also have steps on the outside in conjunction with the ladder (see Section 9, Figure 27, "Access Hatch Heights of ≥ 900 mm (35.5 in.)").

FIGURE 26
Ladder Distance from Hatch Coaming *(1 August 2013)*

Dimension		*Requirements*
A	Distance from ladder to hatch coaming	≥ 175 mm (7.0 in.) and ≤ 200 mm (8.0 in.)

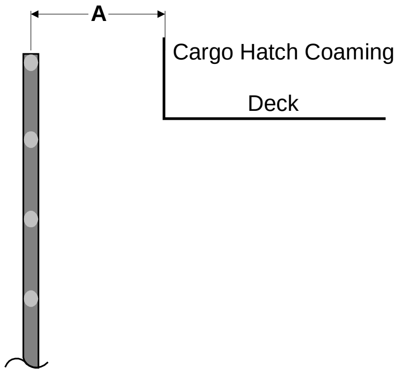
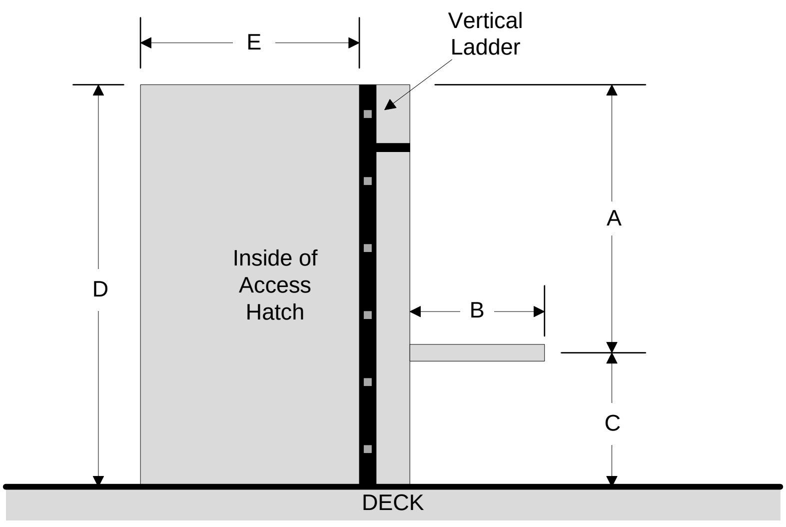


FIGURE 27
Access Hatch Heights of ≥ 900 mm (35.5 in.) *(1 August 2013)*

Dimension		*Requirements*
A	Distance from step to access hatch	600 mm (23.5 in.)
B	Step depth	≥ 275 mm (11.0 in.) ≤ 300 mm (12.0 in.)
C*	Step height	≤ 300 mm (12.0 in.)
D	Height to require steps along with the ladder	≥ 900 mm (35.5 in.)
E	Dimension inside of hatch without obstruction	≥ 750 mm (29.5 in.)

* *Note:* The limiting height is dimension 'A'. This height is set by the crotch height of the 5th percentile female. Once 'D' exceeds 900 mm (35.5 in.), a step is needed. Therefore, 'C' could be anything from 25 mm (1 in.) up to 300 mm (12 in.).

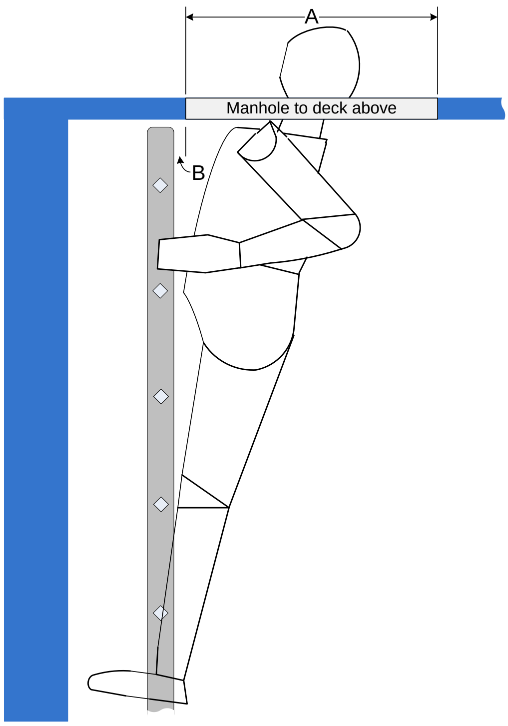


13.5 Horizontal Hatch Access through a Deck

For access to the deck from a ladder below, the top of the ladder should be placed within 50 mm (2 in.) of the leading edge of the hatch opening (see Section 9, Figure 28, "Horizontal Hatch Access through a Deck"). Minimum dimensions of the opening (round or square) are 810 mm (32 in.).

FIGURE 28
Horizontal Hatch Access through a Deck *(1 August 2013)*

Dimension		*Requirements*
A	Dimension of Opening (Circular or Rectangular)	≥ 810 mm (32 in.)
B	Ladder to edge of opening separation	≤ 50 mm (2 in.)



14 Doors and Scuttles *(1 August 2013)*

14.1 General

This Subsection contains guidelines related to the design of doors and scuttles.

14.2 Means of Escape or Egress

14.2.1 Door Operation

Doors, hatches, or scuttles used as a means of escape shall be capable of being operated by one person, from either side, in both light and dark conditions. Doors shall be designed to prevent opening and closing due to vessel motion and shall be operable with one hand.

14.2.2 Door Dimensions

Doors (other than emergency egress) used solely by crew members shall have a clear opening width of at least 710 mm (28 in.) The distance from the deck to the top of the door shall be at least 1980 mm (78 in.).

14.2.3 Clear Means of Escape

The method of opening a means of escape shall not require the use of keys or tools. Doors in accommodation spaces (with the exception of staterooms), stairways, stair towers, passageways, or control spaces, shall open in the direction of escape or egress.

14.2.4 Markings

The means of escape should be marked from both the inside and outside.

14.3 Deck Scuttles

Deck scuttles that serve as a means of escape should be fitted with a release mechanism that does not require use of a key or a tool, and should have a holdback device to hold the scuttle in an open position.

Deck scuttles that serve as a means of escape should have the following dimensions:

i) Round – 670 mm (26.5 in.) or greater in diameter

ii) Rectangular – 670 mm (26.5 in.) by 330 mm (13 in.) or greater

SECTION 10 Maintenance Considerations

1 General *(1 August 2013)*

1.1 Application

The principles and guidelines of this Section apply to maintenance, including equipment access and task requirements. Additional information is also available from the ABS *Rules for Building and Classing Steel Vessels*, see sections:

- 4-6-2/9.17 Accessibility of Valves
- 4-8-3/1.13 Accessibility
- 4-8-3/5.3.1 Enclosures and inspection
- 4-8-3/5.3.3(c) Withdrawable current breakers
- 4-8-3/7 Clear working space around switchboards, and
- 4-8-3/9.3 Switchboard disconnection arrangements for maintenance purposes
- 4-8-4/9.1 Clear working space around motor controllers

2 Principles *(1 August 2013)*

These maintainability and accessibility principles are directed toward the accomplishment of necessary maintenance tasks quickly, safely, accurately and effectively with minimum requirements for personnel, skills and special tools.

2.1 Maintenance or Operational Access Criticality Analysis

Equipment location and accessibility should be determined on the basis of a maintenance criticality analysis based on the criticality, frequency, and inherent safety of inspection, planned maintenance, or repair (see Appendix 2, Maintenance Task Access Analysis, for guidance). The assessments of safety or system criticality can be achieved by conduct of risk analyses, failure modes analyses, or other commonly accepted and applied techniques. Identification of criticality is used to determine the specific applicability of the requirements in this section to specific access locations. Identification of individual access criticality can be of joint participation among vessel designers, operators, and owners. The following three categories define maintenance criticality.

2.1.1 Category 1 Maintenance or Operational Access

Category 1 maintenance or operational criticality should include those maintenance actions that are system and safety critical, meaning a system necessary for the safe operation of the vessel cannot function without that aspect being functional. All of the requirements in this section apply to Category 1 maintenance items.

2.1.2 Category 2 Maintenance or Operational Access

Category 2 maintenance or operational criticality should include those maintenance actions which are important to maintain operations, or any maintenance actions that are performed frequently. The requirements in this section that apply to Category 2 maintenance or operational items are identified as part of each requirement statement.

2.1.3 Category 3 Maintenance or Operational Access

Category 3 maintenance or operational criticality include those maintenance actions which are considered to be non-critical to system status and safety, and that do not require frequent access.

2.2 Maintenance Task Access Analysis

2.2.1 Analysis

An analysis of maintenance tasks should be performed for the purpose of sizing and outfitting maintenance workspaces. The analysis addresses concerns such as: design of maintenance platforms; work surfaces; work envelopes; tools, spare parts and spent part stowage; and consumables storage at a maintenance site during planned or corrective maintenance.

The analysis is also intended to identify requirements for lifting and carrying devices for heavy or awkward loads; and to facilitate maintenance action work flow.

This analysis should be applied to all Category 1 and 2 maintenance actions.

2.2.2 Typical Analysis Steps

A maintenance area task and requirements analysis typically includes the following steps:

Step 1 List (1) general and frequent maintenance tasks (such as housekeeping and routine or and recurring maintenance), and (2) list major planned maintenance or corrective maintenance actions

- *i)* Number of participants/maintainers involved for each task
- *ii)* List of major equipment/components to be removed, and replaced, or repaired in place or nearby for each task

Step 2 For each maintenance task, identify and list the following items requiring space allocation:

- *i)* Consumables (lubricants, adhesives, connectors)
- *ii)* Test equipment, stowed in place and/or portable
- *iii)* Tools or special tools
- *iv)* Replacement parts
- *v)* Need for aided or unaided voice communications
- *vi)* Any required Personal Protective Equipment (PPE)
- *vii)* Lifting aids required
- *viii)* Number of people involved in the immediate maintenance area
- *ix)* Any required procedures, technical manuals, or checklists
- *x)* Whether the maintenance action occurs in a workshop, or directly on installed equipment

Step 3 For each maintenance task, estimate and then sum the space requirements. Allocate maintenance work area space based on the analysis, including (where possible) a space allocation margin of 30% or more.

Step 4 Identify and allocate or fit any requirements for storage surfaces for procedural materials, or ready access to consumables.

Step 5 Identify requirements for parts and materials carts (for deck level access to maintenance areas), or lifting supports (including overhead crane, chain falls, padeyes, I-beams, etc.) for very heavy components or when in the presence of ramps or stairs to gain maintenance access or transfer. This also requires lifting from one engine room/deck level to another. (For example, from the one engine room deck to another shop level above or below, or from an engine room deck lifting to a maintenance pedestal or platform.

Step 6 Special space accommodation should be made for access to, and use of, PPE.

Step 7 Identify locations of pre-positioned items (such as tools, special tools, consumables) that can be located with the equipment to be maintained.

Step 8 Develop maintenance area workspace concepts and drawings, considering the above sizing requirements and each maintenance actions activity sequence. This includes provision of suitable space in areas around a piece of equipment (e.g., behind the equipment near a bulkhead) that is needed to remove internal parts, motors, shafts, or attached equipment and the personnel/equipment required to accomplish these tasks.

Step 9 Refine the concepts and drawings and prepare them as part of build-to packages.

2.3 General Access

Structural components (e.g., stiffeners, stairs, pedestals, etc.) should not prevent access to, or removal of, maintained equipment. (Category 1 and 2)

Maintenance items that need to remain accessible should not be blocked by removal of panel cases and covers. (Category 1 and 2)

Maintenance items that are exposed to the external environment should be provided with means of deicing. (Category 1 and 2).

2.4 Equipment Design

Design should include identification (such as labels), orientation, and alignment of components and subassemblies (including cables and connectors). (Category 1 and 2)

Skids (generators, air compressors, etc.) should provide direct means of access to doors and removable panels to provide access to internal components for maintenance. (Category 1 and 2)

3 Access Design *(1 August 2013)*

3.1 General

i) Equipment should allow for access without the removal of other parts or components, and clearance shall be provided to effectively use tools through their full range of motion. (Category 1 and 2)

ii) Permanent access aids including ladders, stairs, platforms and ramps should be provided for all Category 1 and 2 maintenance items. (Category 1 and 2)

iii) Every ladder should have a padeye for chain fall attachment so repair parts and tools can be hauled up if the overhead crane is not available or is not accessible. (Category 1 and 2)

iv) Equipment design should permit maintenance from above, in front, from behind and outside with visibility, rather than from underneath or inside components or without complete visibility. (Category 1 and 2)

v) A minimum of 2.0 m^2 (18 ft^2) per person minimum should be provided for personnel, their clothing (including required PPE), tools and equipment as well as free space for the movements and activities required to perform maintenance tasks. (Category 1 and 2)

vi) When maintenance requires the removal of large internal or external parts (e.g., tube bundles from a heat exchanger, cylinder heads), a lay down area should be provided for the component, parts, tools and equipment. (Category 1 only)

vii) Lateral clearance for hand access between a bulkhead and nearby structures (for example, a skid) should not be less than 425 mm (17 in.). (Category 1 and 2)

3.2 Physical Access

When maintenance tasks require the maintainer to squat, kneel, sit down, or stand sideways, access design should accommodate these postures according to the following tables and associated figures (Category 1 and 2 applies to Section 10, Tables 1 through 6):

- Table 1, “Seated, Forward Reach – Both Arms”
- Table 2, “Cross-Legged Seated, Forward Reach – Both Arms”

- Table 3, "Standing, Forward Reach – Both Arms"
- Table 4, "Standing, Single Arm Forward Reach"
- Table 5, "Standing, Single Arm Lateral Reach"
- Table 6, "Squatting, Kneeling Space Dimensions"

The dimensions in these tables apply to vessel structure access and vendor-supplied equipment and systems (skids).

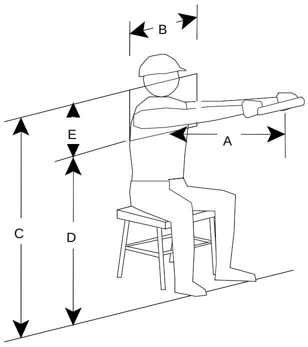


TABLE 1
Seated, Forward Reach – Both Arms *(1 August 2013)*

	Dimensions
A. Depth of reach	500 mm (19 in.) minimum
B. Breadth of aperture	425 mm (17 in.) minimum
C. Floor to top of aperture	1125 mm (44 in.) minimum
D. Floor to bottom of aperture	950 mm (37 in.) minimum
E. Vertical dimension of aperture	300 mm (12 in.) minimum

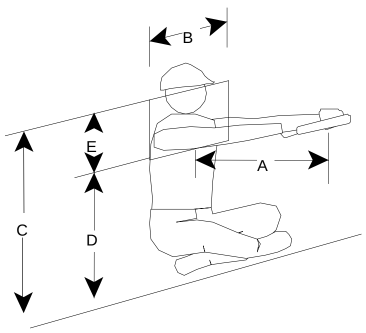


TABLE 2
Cross-Legged Seated, Forward Reach – Both Arms *(1 August 2013)*

	Dimensions
A. Depth of reach	450 mm (18 in.) minimum
B. Breadth of aperture	425 mm (17 in.) minimum
C. Floor to top of aperture	675 mm (26 in.) minimum
D. Floor to bottom of aperture	500 mm (20 in.) minimum
E. Vertical dimension of aperture	275 mm (11 in.) minimum

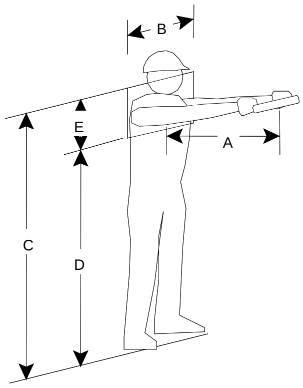


TABLE 3
Standing,
Forward Reach – Both Arms
(1 August 2013)

	Dimensions
A. Depth of reach	575 mm (23 in.) minimum
B. Breadth of aperture	475 mm (18 in.) minimum
C. Floor to top of aperture	1700 mm (66 in.) minimum
D. Floor to bottom of aperture	1450 mm (57 in.) minimum
E. Vertical dimension of aperture	425 mm (17 in.) minimum

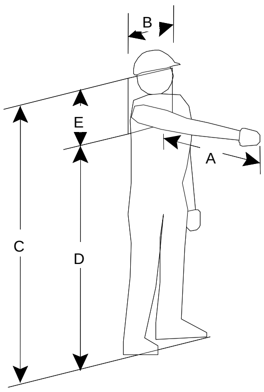


TABLE 4
Standing,
Single Arm Forward Reach
(1 August 2013)

	Dimensions
A. Depth of reach	650 mm (25 in.) minimum
B. Breadth of aperture	300 mm (12 in.) minimum
C. Floor to top of aperture	1675 mm (66 in.) minimum
D. Floor to bottom of aperture	150 mm (57 in.) minimum
E. Vertical dimension of aperture	425 mm (17 in.) minimum

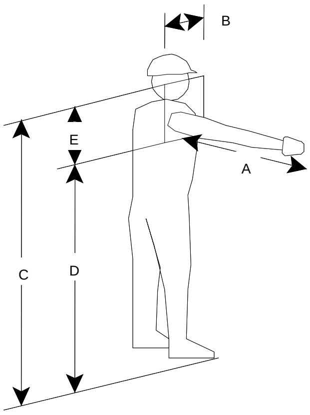
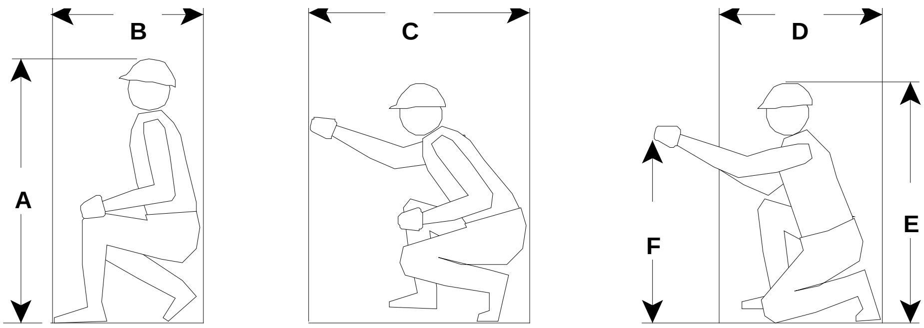


TABLE 5
Standing, Single Arm Lateral Reach *(1 August 2013)*

	Dimension
A. Depth of reach	650 mm (25 in.) minimum
B. Breadth of aperture	25 mm (10 in.) minimum
C. Floor to top of aperture	1675 mm (66 in.) minimum
D. Floor to bottom of aperture	1450 mm (57 in.) minimum
E. Vertical dimension of aperture	400 mm (16 in.) minimum

TABLE 6
Squatting, Kneeling Space Dimensions *(1 August 2013)*



Squatting Work Space:	*Minimum Dimensions*
A. Height	1300 mm (51 in.)
B. Depth	925 mm (6 in.)
C. Depth	1025 mm (40 in.)
Kneeling Work Space:	*Minimum Dimensions*
D. Depth	1225 mm (48 in.)
E. Height	1550 mm (60 in.)
F. Optimum work point	775 mm (27 in.)

3.3 Access Openings

3.3.1 General

Access openings should be provided, as required, to all equipment or items that require testing, servicing, calibrating, adjusting, removing, replacing or repairing during normal maintenance efforts. (Category 1 and 2)

Access openings should be large enough to accommodate hands, arms and tools and also provide full visual access to the task area. (Category 1 and 2)

3.3.2 Dimensions

The dimensions of access openings for arms and hands should be no less than those shown in (Category 1 and 2):

- Table 7, "Opening Dimensions for Single Hand Access with Tools"
- Table 8, "Opening Dimensions for Single Hand Access without Tools"
- Table 9, "Opening Dimensions for Arm Access without Tools"
- Table 10, "Opening Dimensions for Two Hands Access"
- Table 11, "Two Hand Access without Visual Access"

3.3.3 Visual Access

Access openings should provide full visual access to the task area or an auxiliary viewing port should be provided through the use of viewing ports or quick release access.

Visual inspections should be able to be done without use of special tools. (Category 1 and 2)

TABLE 7
Opening Dimensions for Single Hand Access with Tools *(1 August 2013)*

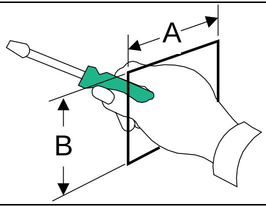
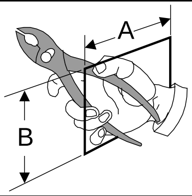
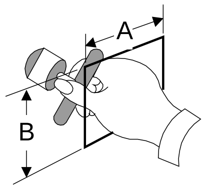
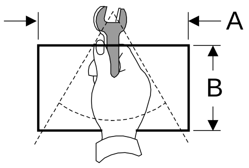
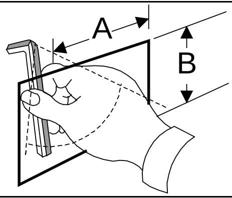
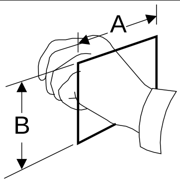
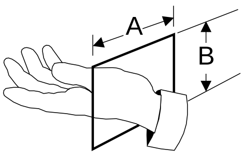
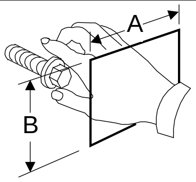
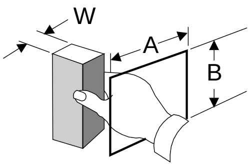
Description of Opening		*Minimum Dimensions mm (in.)* A	*Minimum Dimensions mm (in.)* B	*Task Description*
	Bare Hand	110 (4.25)	120 (4.75)	Using common screwdriver, test probe etc., with freedom to turn hand through 180°
	Gloved	165 (6.5)	180 (7.0)	
	Bare Hand	125 (5.0)	115 (4.5)	Using pliers and similar tools
	Gloved	175 (7.25)	200 (7.75)	
	Bare Hand	150 (6.0)	150 (6.0)	Using “T” handle wrench, with freedom to turn hand through 180°
	Gloved	190 (7.5)	210 (8.25)	
	Bare Hand	275 (11)	200 (8.0)	Using open-end wrench, with freedom to turn wrench through 60°
	Gloved	325 (12.75)	260 (10.25)	
	Bare Hand	120 (4.75)	150 (6.0)	Using Allen-type wrench, with freedom to turn wrench through 60°
	Gloved	175 (7.0)	200 (8.0)	

TABLE 8
Opening Dimensions for Single Hand Access without Tools (1 August 2013)

Description of Opening		*Minimum Dimensions mm (in.)* A	*Minimum Dimensions mm (in.)* B	*Task Description*
	Bare Hand	125 (5.0)	100 (3.75)	Empty hand Clenched fist extended to wrist
	Gloved	150 (6.0)	115 (4.5)	
	Bare Hand	100 (4.0)	60 (2.25)	Empty hand Hand flat extended to wrist
	Gloved	150 (6.0)	100 (4.0)	
	Bare Hand	115 (4.5)	120 (4.75)	Grasping small objects (up to 50 mm (2 in.) or more wide) with one hand
	Gloved	170 (6.75)	175 (7.0)	
	Bare Hand	W+45 (W+1.75)	125 (5.0*)	Grasping large objects, 50 mm (2 in.) or more wide with one hand
	Gloved	W+100 (W+4.0)	175 (7.0)	

* Or sufficient to clear part if part is larger than 125 mm (5.0 in.).

TABLE 9
Opening Dimensions for Arm Access without Tools (1 August 2013)

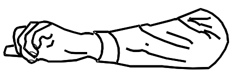
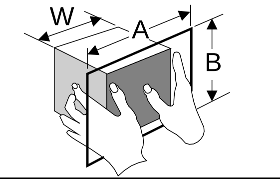
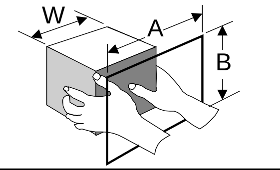
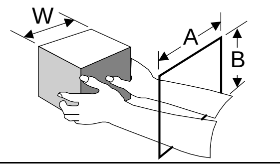
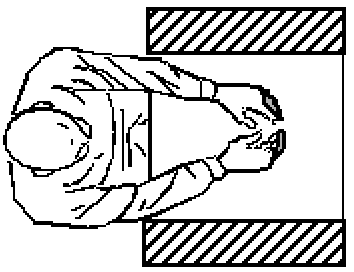
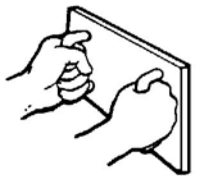
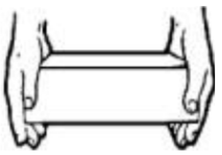
Description of Clothing Type		*Minimum Dimensions mm (in.)*	*Dimension Description*
	Light Clothing	100 mm (4.0 in.) × 115 mm (4.5 in.) or 115 mm (4.5 in.) diameter	Arm to Elbow
	Cold Weather Clothing	180 mm (7.0 in.) square or diameter	
	Light Clothing	125 mm (6.0 in.) square or diameter	Arm to Shoulder
	Cold Weather Clothing	215 mm (8.5 in.) square or diameter	

TABLE 10
Opening Dimensions for Two Hand Access *(1 August 2013)*

Description of Opening		*Minimum Dimensions mm (in.)* *A*	*B*	*Task Description*
	Bare Hand	W+75 (W+3.0)	125 (5.0*)	Grasping large objects with two hands, with hand extended through openings up to fingers
	Gloved	W+130 (W+5.25)	180 (7.0)	
	Bare Hand	W+150 (W+6.0)	125 (5.0*)	Grasping large objects with two hands, with arms extended through openings up to wrists
	Gloved	W+280 (W+11.0)	180 (7.0)	
	Bare Hand	W+150 (W+6.0)	125 (5.0*)	Grasping large objects with two hands, with arms extended through openings up to elbows
	Gloved	W+280 (W+11.0)	180 (7.0*)	

* Or sufficient to clear part if part is larger than 125 mm (5.0 in.).

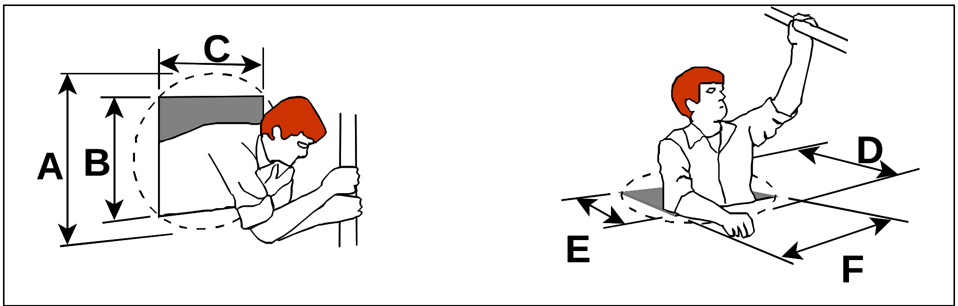
TABLE 11
Two Hand Access without Visual Access *(1 August 2013)*

Use Illustration	*Minimum Access Requirements*		
	Reaching with both hands to depth of 152 to 489 mm (6.0 to 19.25 in.):		
	Light Clothing	Width	200 mm (8 in.) or the depth of reach, whichever is larger
		Height	130 mm (5 in.)
	Cold Weather Clothing	Width	150 mm (6 in.) plus 3/4 depth of reach
		Height	180 mm (7 in.)
	Reaching full arm's length (to shoulders) with both arms		
	Width	500 mm (19.5 in.)	
	Height	130 mm (5 in.)	
	Inserting box grasped by handles on the front		
	13 mm (0.5 in.) clearance around box, assuming adequate clearance around handles		
	Inserting box with Hand on the sides		
	Light Clothing	Width	Box plus 115 mm (4.5 in.)
		Height	125 mm (5.0 in.) or 13 mm (0.5 in.) around box
	Cold Weather Clothing	Width	Box plus 180 mm (7 in.)

3.4 Hatches

Round, square, or rectangular hatches should be sized as shown in Section 10, Table 12, "Hatch Shapes and Dimensions". Depending on their shape and orientation (i.e., side, top or bottom entry), these dimensions may require adjustment if personnel are likely to be wearing bulky clothing or personnel protective equipment (e.g., breathing air canisters) when using a hatch for access to areas such as tanks, bilges, ship double bottoms areas or other confined spaces. Where hatch covers are heavy [e.g., above 11 kg (25 lbs)] or unwieldy, consideration should be given to providing aids for lifting or handling the hatch cover.

TABLE 12
Hatch Shapes and Dimensions *(1 August 2013)*



Access – Shape and Dimension	*Minimum*
Side Access	
Round – A	685 mm (27 in.)
Square	660 mm (26 in.)
Rectangle – B	660 mm (26 in.)
– C	760 mm (30 in.)
Top or Bottom Access	
Round – D	635 mm (25 in.)
Square	580 mm (23 in.)
Rectangle – E	330 mm (13 in.)
– F	610 mm (24 in.)

4 Labeling *(1 August 2013)*

Equipment should be labeled with an accurate description specific to the equipment, including an exclusive identifying number. In addition, signs and graphics, such as schematics, should be placed to provide hazard information and maintenance instructions.

Each cable or wire should be labeled or coded throughout its entire length. Labels installed at a bench preparatory site should be placed so they will be visible and in the proper orientation to the reader once the wire or cable is installed. Cables and wires should be labeled with the name of the equipment to which they belong and the connectors to which they mate.

Pipes should be color-coded for identification of content and direction of flow. The color-coding should also differentiate between grades of fuel.

All stored energy devices should be labeled as such and should have a "DANGER" hazard warning sign attached to the device. Procedures for releasing or constraining the energy should be displayed on the unit.

Each access cover should be labeled with terminology for items visible or accessible through it, terminology for auxiliary equipment to be used with it, and recommended procedures for accomplishing operations. Accesses should 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 should be properly oriented to be read when the door is open.

5 Equipment Design *(1 August 2013)*

5.1 Design

Systems should be designed to facilitate diagnostics and troubleshooting to minimize the amount of time spent locating a problem, thus expediting the repair process. Design guidance includes:

i) Equipment design should facilitate rapid and positive fault detection and isolation of defective items to permit their prompt removal and replacement.

ii) When warranted, equipment should have automatic fault detection and isolation capability.

iii) Components performing similar functions should be physically close to one another.

iv) Components should provide easily identifiable physical evidence of their status (e.g., a blown fuse).

v) Whenever possible test replacement parts prior to installation.

vi) Provide self-test fault and error messages:

- Standardize error messages
- Provide accurate, up-to-date, reliable, and understandable error messages
- Scale fault messages to meet the range of experience and skill levels of troubleshooters
- Failure messages should identify the origin of the failure.

5.2 Equipment Modularization

Designing equipment and components into specifically-defined units to aid in troubleshooting and replacement may also enhance the maintenance function. Design guidance includes:

i) Where possible, equipment should be replaceable as modular packages and should be configured for removal and replacement by one person, within structural, functional, and weight limitations.

ii) Heavy, large, or complex equipment should be divided into modules. Modularization of equipment can make it easier to:

- Locate and isolate malfunctions,
- Properly allocate maintenance functions and responsibilities,
- Reach, remove, and maintain components, and
- Handle the equipment for installation and repair.

5.3 Equipment Mounting and Installation

Equipment should be designed so that it cannot be mounted or installed improperly.

Methods to help prevent equipment from being improperly mounted or installed include:

i) Measures (e.g., coding) to facilitate identification and interchange of interchangeable items

ii) Measures (e.g., alignment pins) to facilitate proper mounting of items. See Section 10, Figure 1, "Example of Alignment Pins".

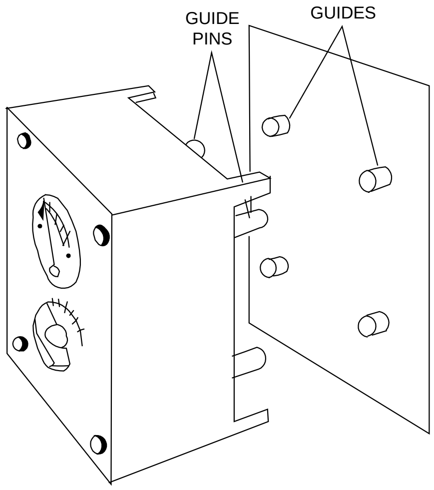
iii) Identification, orientation, and alignment provisions for cables and connectors

iv) Provision of adequate separation of components to ease access during installation and removal

v) Provision of supports and guides for the handling, aligning, and positioning of components:

- For loads up to 11 kg (25 lbs), provide bottom mounted alignment pins or side mounting brackets to allow for sliding rather than lifting
- For loads 11 kg (25 lbs) or greater, provide for two-person handling or provide a mechanical means to aid lifting.

FIGURE 1
Example of Alignment Pins



5.4 Fasteners and Connectors

Fasteners are available in a wide variety of types and sizes. However, the diversity of fasteners and connectors used in a specific design should be minimized. Fasteners or connectors requiring the use of special tools should not be used.

5.5 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 should be designed for easy removal or disconnection from the equipment or item before handling.

5.6 Requirements-Based Maintenance Design

Equipment that is part of a system that must operate continuously should be capable of undergoing maintenance without interrupting the operation of the overall system. If continuous operation is required and required maintenance on a unit of equipment would interrupt the operation, redundant equipment should be provided, with the following guidance in mind:

i) Equipment should be designed so that components that fail frequently (e.g., lamps and fuses) can be easily replaced.

ii) Degraded operation should not cause damage to other equipment or components, nor should it aggravate the original fault.

iii) When warranted by its importance in a system, a unit of equipment that has a partial failure should be designed to operate in a degraded mode while awaiting maintenance.

iv) Degraded operation and faults should be sensed and appropriate information identified, displayed, or transmitted to maintainers and, if appropriate, to operators.

5.7 Standardization

Equipment Standardization is the design of systems and equipment to use interchangeable components (e.g., using identical valves in a piping system), measures (e.g., all metric), and processes (e.g., standard operating procedures). The following guidance is provided regarding standardization:

i) Standard parts should be used whenever possible.

ii) If an existing design for equipment, modules, components, or parts meets the relevant requirements and the applicable ergonomics criteria in this document, designers should use that existing item rather than design a new one.

iii) Units of equipment should be designed to facilitate the interchangeability of modules, components, and parts.

iv) Units of equipment or modules that are similar in size and shape to other items but different from them in functional purpose should be easily identifiable and distinguishable. In addition, they should not be physically interchangeable (e.g., different connector types for breathing air versus nitrogen).

v) Equipment should be designed to minimize the numbers and types of auxiliary equipment and tools required to accomplish maintenance tasks.

6 Equipment Handling *(1 August 2013)*

6.1 Rests and Stands

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, should be provided. Such rests or stands should be part of the basic unit, rack or console chassis. Space around the rests or stands should be provided to both support the equipment or item and allow for the number of personnel required to lift or work on the item.

7 Tools *(1 August 2013)*

Uncommon or specially designed tools should be used only when common hand tools do not satisfy the guidelines or when the special tools provide a significant advantage over common hand tools.

8 Safety *(1 August 2013)*

8.1 Elevated Work Platforms and Handrails

The following apply to elevated work safety:

i) Work platforms should be provided at locations where personnel must perform tasks that cannot be easily accomplished by reaching from an existing standing surface.

ii) Platforms should be of sufficient size to accommodate the task and allow for placement of any required spare parts or equipment.

iii) Work platforms should be no less than 760 mm (30 in.) wide and 915 mm (36 in.) deep or larger to accommodate tools, equipment and additional maintenance personnel, except for platforms used exclusively for standing which may be no less than 380 mm (15 in.) wide and 460 mm (18 in.) in depth.

iv) Work platforms more than 610 mm (24 in.) above the surrounding surface should be provided with handrails and toeboards.

v) Work platform handrails should be provided at the exposed side of any platform surface that is 610 mm (24 in.) or higher above the adjacent surface and where a person could fall from the upper to the lower surface.

vi) Handrails should be two-tiered and be provided with a toeboard. Height of the handrail should be 1070 mm (42 in.) from the top of the top rail to the walking surface with the intermediate rail located 460 mm (18 in.) below the top rail.

vii) Vertical stanchions should be provided at a maximum spacing of 2.4 m (8 ft).

viii) The handrails should be constructed of 40 mm (1.5 in.) outside diameter pipe.

ix) The toeboard should be 100 mm (4 in.) in height and should have no more than 6 mm (0.25 in.) clearance between the bottom edge of the toeboard and the top of the walking surface.

8.2 Fall Protection

Where feasible, designs should minimize the requirement for work to be performed in elevated locations. Permanent barriers such as handrails should be provided to protect routinely-used work stations and maintenance platforms. Handrails and related barriers will withstand a minimum of 200 pounds of lateral force.

Where safety cages are installed:

i) Safety cages should be installed on vertical ladders where the vertical height exceeds 4.5 m (15 ft). Consideration should be given to providing safety cages for ladders less than 4.5 m (15 ft) in height as well where a fall to a level or deck below the ladder base is possible (e.g., within 1830 mm (72 in.) of the edge of a deck).

ii) Cages should start 2.1 m (7 ft) above the bottom-landing surface and should extend to 1400 mm (54 in.) above the top-landing surface.

iii) Cages used on vertical ladders equipped with intermediate landings should extend 1400 mm (54 in.) above the intermediate landing with the cage open on the side facing the landing.

For ladders over 6.1 m (20 ft), a climber safety rail or cable should be considered. Additional consideration should be given to adopting such devices based on the consequence of a fall (e.g., falls onto equipment, other decks, overboard).

Climber safety rails or cables should begin approximately 915 mm (36 in.) above the standing surface and extend to approximately 1070 mm (42 in.) above the standing surface of the upper landing.

A climber safety rail should be stainless steel flat bar and equipped with two safety slides, which can be attached to the rail or cable.

The ladder stringers at a top-landing where climber safety devices are used should be designed to allow personnel to access the landing without unfastening. From the centerline of the rail or cable to the inside of each ladder stringer should be a minimum distance of 380 mm (15 in.).

In addition to the fall protection provided by handrails required for stairs, ladders, walkways and platforms, fall protection tie-off points where maintenance personnel can attach a safety harness should be provided. Tie-off points should be located anywhere in the ship or maritime structure where personnel could be working in an elevated location in excess of 1524 mm (60 in.) above the deck.

Anchorage points should be reachable by hand without need for an extension device or unprotected access. Anchorage points should be designed to withstand a minimum of 3600 pounds of force. In areas where anchorage points for fall protection or for lifting or hoisting are required, two sets of anchorage points should 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). A sufficient number of anchorage points should be provided so personnel are always tied-off. Double lanyards should be used.

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 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, but then can be easily and quickly installed to provide a rigid and sturdy solid handrail.

Removable handrails should not be used unless there is an approved operational or maintenance need, but are not be used for ease of fabrication. Removable solid handrails may be used to facilitate the removal of equipment or material handling, provided the safety of personnel is not jeopardized. Bolted posts or sockets can be used for removable hand railing and should be stored in such a place as to be easily accessible when needed for hatch opening.

8.3 Tripping Hazards

Elevation changes in work areas or walkways should be avoided. Any elevation change in excess of 6 mm ($^1/_4$ in.) should be clearly visible or marked to alert personnel of a potential tripping hazard.

The handle on all vertical stem valves should not rotate into a walkways or working areas so as to become a tripping or knee knocker hazard.

Deck hatches provided in structures to access and transfer equipment should be flush with the adjacent floor or deck surface so as not to create a tripping hazard. Hatch lifting aids should not become a tripping or safety hazard.

8.4 Hot or Cold Surfaces

Hot surfaces having an external surface temperature sufficient to burn human tissue with momentary contact and located within 2134 mm (7 ft) vertically from walking or working surfaces or 381 mm (15 in.) horizontally from floor, working level, stairs, ramps or fixed ladders should be insulated or otherwise guarded against accidental contact. Generally, metal surfaces with a surface temperature of 60°C (140°F) or more should be insulated or guarded. Insulation is the preferred means of protection from hot surfaces, unless heat retention is undesirable and should be of sufficient thickness to reduce the surface temperature to a maximum of 60°C (140°F). Guarding can also be used to provide protection from hot surfaces.

Cold equipment should be evaluated to prevent “cold” burns.

8.5 Guarding

If a hazardous condition (such as exposed, high voltage conductors) exists behind the access, the physical barrier over the access should be equipped with an interlock that will de-energize the hazardous equipment when the barrier is open or removed. Both the presence of the hazard and the fact that an interlock exists should be noted on the equipment case or cover such that it remains visible when the access is open.

8.6 Hazard Signs

Hazard signs should be used to identify and provide information about conditions that may pose hazards to personnel, equipment or the environment. These hazards include, but are not limited to:

- High noise areas
- Fire/explosion hazards
- Steam (drains, etc.) hazards
- High temperature hazards
- Electrical hazards
- Mechanical hazards
- Confined space hazards
- Fall hazards
- Crane hazards
- Access hazards
- Toxic/caustic hazards
- Other maintenance hazards

Hazard identification signs should use simple language and understandable icons.

8.7 Access Aids

Maintenance access guidelines are as follows:

i) Permanent barriers such as handrails should be provided to protect routinely-used work stations and maintenance platforms. (Category 1 and 2)

ii) Stairs should be provided when access is required to elevated work platforms (e.g., mezzanines) one or more times per day. (Category 1 and 2)

iii) Ladders should not be used when maintainers carry equipment. In all cases, both hands should be free to grasp and climb ladders. (Category 1 and 2)

iv) Items to be maintained from a ladder should require only one hand and should not be located more than 965 mm (38 in.) from the ladder's centerline. (Category 1 and 2)

v) Maintenance on masts or antenna, lights or other equipment mounted on the mast, or other elevated structures, should not be performed while suspended by a safety harness, and permanent structural accesses (such as platforms) should be provided. (Category 1 and 2)

vi) Vertical access should be provided with adequate clearance. If this is not achievable, masts should be hinged and be able to be lowered for maintenance; otherwise, a rotating base should be provided. (Category 1 and 2)

vii) Portable ladders should not be used to access permanent work platforms to perform temporary, infrequent maintenance. (Category 1)

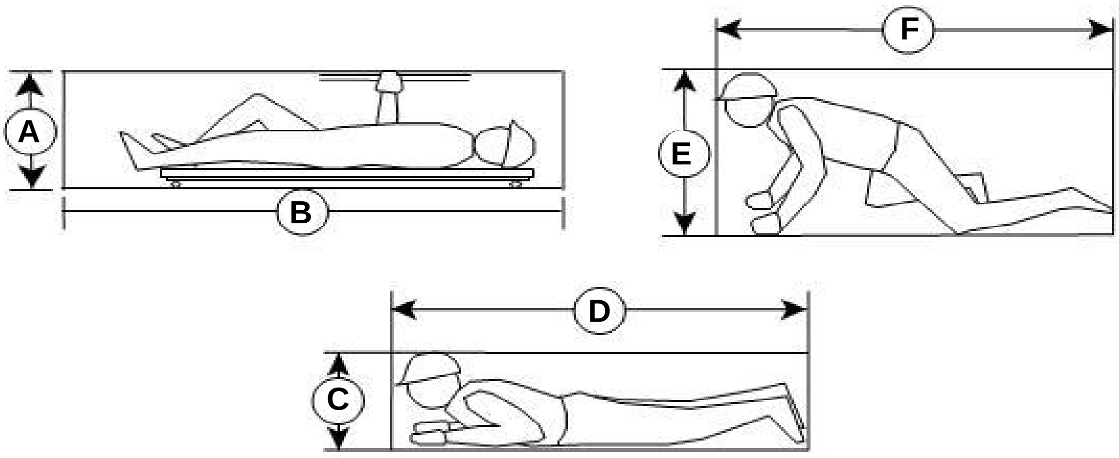
viii) Where the maintainer must carry bulky loads or loads in excess of 13 kg (29 lbs), a ramp or elevator should be provided. Alternatively, access may be provided for personnel via stairs, steps or ladders, as long an adequate lifting mechanism is provided and used.

ix) Ramps, elevators or equivalent means should be provided when maintainers must transport heavy or bulky equipment.

8.8 Crawlways

Crawl spaces should conform to the guidelines expressed in Section 10, Table 13, "Minimum Dimensions for Crawlways" below. (Category 1 and 2)

TABLE 13
Minimum Dimensions for Crawlways *(1 August 2013)*



Supine work space (Lying on Back):	
A. Height – Visual Inspection	350 mm (14 in.)
A. Height – Hand Arm Reach	550 mm (22 in.)
B. Length	1875 mm (74 in.)
Crawling space:	
C. Height	425 mm (17 in.)
D. Length	1525 mm (60 in.)
Prone work or crawl space:	
E. Height	775 mm (31 in.)
F. Length	2875 mm (113 in.)

SECTION 11 Materials Handling

1 General *(1 August 2013)*

1.1 Application

The principles and guidelines in this Section apply to materials handling. Both manual and assisted materials handling are addressed, though particular emphasis is placed upon aspects and factors affecting manual lifting and carrying capacities.

2 Principles

There are many factors that affect personnel's ability to safely and effectively perform materials handling tasks, including the design of the task, the form of the material handled, the design of the working area, the availability of assisted lifting devices, and the physical/physiological characteristics of the personnel themselves.

2.1 Keys to Acceptable Materials Handling and Lifting

A general approach to designing for materials handling and lifting tasks include the following:

i) Avoid manual materials handling altogether, whenever possible

ii) Redesign the load

iii) Redesign the lifting/carrying task

iv) Redesign the working environment

v) Introduce assisted lifting devices

2.2 One-versus Two-Person Lifting and Carrying

In general limits on lifting and carrying are as follows:

i) Items weighing up to 20 kg (45 lbs) or less may be lifted or carried by one person.

ii) Items weighing more than 20 kg (45 lbs) and less than 40 kg (90 lbs) should be lifted or carried by two persons, provided the lifting load is distributed equally between the two.

2.3 Assisted Lifting

Assisted lifting devices (e.g., padeyes, chain falls, come-alongs, rail cranes, mono-rails, etc.) should be provided for items or devices under the following conditions:

i) Load weight in excess of 11 kg (25 lbs), for loads which are lowered from or placed in locations greater than 1525 mm (60 in.) high

ii) Load weight in excess of 11 kg (25 lbs), which needs to be supported during removal, replacement, or installation

iii) Load weight in excess of 20 kg (45 lbs), where the load is not distributed evenly or is unwieldy

iv) Load weight in excess of 40 kg (90 lbs)

3 Materials Handling Factors

There are numerous factors that impact the safety and efficiency of materials handling tasks. For this reason, pre-planning of materials handling tasks should be undertaken before lifting, carrying, or moving any load. Key factors include the actual materials handling task, the size and weight of the load, how the load will be lifted (e.g., manually or with assisted lifting devices), how the load will be moved or transported, the working area, personnel capabilities, and safety considerations. Each factor, either alone, or in combination with other factors, can significantly impact materials handling tasks.

3.1 Task-Related Factors

Task-related factors for both manual materials handling and assisted lifting that should be considered as a part of pre-planning include:

i) Vessel and offshore installation layout in terms of porches, hatches, removable plates, crane placement, pathway size, and location for moving loads

ii) Vessel or installation motions or movement, as well as motions or movement associated with support or supply vessels

iii) The material's location with regard to access, pathways, hatches, doors, porches, and any obstructions (overhead or on the deck) in the path of movement

iv) Distance the load needs to be moved, from the origin of the lift to its final destination

v) Type of lifting method (e.g., manually or with assisted lifting devices)

Task-related factors related solely to manual materials handling that should also be considered during pre-planning include:

i) Need for support equipment (e.g., carts, trolleys, overhead rail or conveyor systems)

ii) How personnel will handle the load (e.g., lifting, lowering, carrying, pushing, pulling, and static lifting/loading)

iii) The duration and frequency of the handling task (e.g., how long and how often will personnel be performing the handling task?)

iv) The required body postures for lifting and placing (e.g., reaching, bending, and twisting of the torso and flexion of joints such as the wrist, elbow, neck, and knees)

v) The distance of the load from the torso of the worker

vi) Load height at lift origin and termination, as well as carry distance

vii) Effects of gloves and/or other personal protective equipment

viii) Rest/recovery time

3.2 Load-Related Factors

Load-related factors, for both manual materials handling and assisted lifting that should be considered as a part of pre-planning include:

i) Weight, size, and dimensions of the load

ii) "Unwieldiness" of the load and the potential difficulty in securing (e.g., strapping) or manually grasping the load

iii) Stability or instability of the load (e.g., likelihood of the load to shift, including within a container, during movement)

iv) Center of gravity of the load

3.3 Working-Area Related Factors

Working-area related factors for both manual materials handling and assisted lifting that should be considered as a part of pre-planning include:

i) Vessel and offshore installation layout in terms of space availability for the securing (e.g., strapping) or manually grasping the load

ii) The material's location with regard to access, pathways, hatches, doors, porches, and any obstructions (overhead or on the deck) in the path of movement

iii) The design of stairs, ladders, pathways, hatches, and doors

iv) Extremes of temperature, humidity, and/or air movement

v) Area lighting where the loads are secured, grasped, lifted, and placed

Working-area factors related solely to manual materials handling that should also be considered during pre-planning include:

i) Walking/working surfaces (e.g., slippery, unstable, moving, variable, inclined)

ii) Design and condition of handling aides (e.g., hand trucks, carts, etc.)

3.4 Personnel Capacity-Related Factors

The factors related to the personnel involved with or performing the manual or assisted materials handling tasks that should be considered in relationship to the task, the load, and the work area factors during pre-planning include:

i) Anthropometrics (e.g., international population differences)

ii) Strength

iii) Physical condition (e.g., cardiovascular and muscular endurance)

iv) Flexibility (range of motion)

v) Health habits (e.g., smoking, alcohol consumption)

vi) History of previous injury or predisposition for injury

vii) Manual and assisted materials handling knowledge, training, and experience

3.5 Safety Considerations

Safety should be considered for both manual and assisted materials handling. Safety concerns should be examined within the context of the task, load, working area, and the personnel involved with or performing the handling task. Safety considerations include:

i) Clearance for equipment through walkways, passages, doorways, etc., and any obstructions (overhead or on the deck) in the path of movement

ii) Availability of motorized/mechanized equipment to support inspection and handling

iii) Vehicles and equipment securing (e.g., brakes, chocks, etc.) while loading and unloading

iv) Surfaces likely to be effected by wind gusts (e.g., sheets of boarding)

v) Noise levels (e.g., ambient and impulse)

vi) Obstruction of vision (e.g., crane operator or other load handling personnel)

vii) Housekeeping requirements (e.g., is the work area provided with amenities for keeping the area free from clutter or obstructions)

viii) Load swinging

ix) Flammable, corrosive, or reactive substances

x) Surface characteristics for personnel or placement of temporary assisted lifting equipment (e.g., even surfaces, those that are likely to abrade, puncture, cut or burn) *xi)* Exposure to vibration and shock for personnel or the load

xii) Personnel slip, trip, and fall hazards

xiii) Consequences associated with dropping the load

4 Manual Materials Handling Planning Tools

There are many tools available for the evaluation and design or re-design of manual materials handling tasks. These tools can assist with planning activities by allowing manual materials handling tasks to be prioritized and by determining when assisted lifting may be required. The majority of these tools are based on a North American population, but some do exist for international populations. Section 11, Table 1, "Material Handling Planning and Analysis Tools", identifies several tools, their uses and their sources.

TABLE 1
Material Handling Planning and Analysis Tools

Analysis Tool	*Uses*	*Source*
NIOSH Lifting Equation	Analysis of lifting with several constraints on its application	Waters, T., Putz-Anderson, V., and Garg, A. (1994). *Applications Manual for the Revised NIOSH Lifting Equation.* US Department of Health and Human Services (NIOSH) Publication No. 94-110.
Psychophysical Tables	Analysis of lifting, lowering pushing, pulling, carrying	Snook, S. H. and Ciriello, V. M. (1991). *The design of manual handling tasks: Revised tables of maximum acceptable weights and forces. Ergonomics* 34:1197.
Psychophysical Lifting Capacity for Chinese Subjects	Lifting capacity of Chinese subjects, as well as anthropometric considerations	Wu, Swei-Pi. (1999). *Psychophysically determined infrequent lifting capacity of Chinese participants, Ergonomics* 42(7).
Job Stress Index	Analysis of lifting	Mital, A., Nicholson, A., and Ayoub, M. (1993). A Guide to Manual materials Handling, Taylor and Francis, Washington, DC.
Energy Expenditure Model	Analysis of lifting, lowering, and carrying	Garg, A., Chaffin, D., and Herrin, G.: *Prediction of Metabolic Rates for Manual Materials Handling Jobs,* American Industrial Hygiene Journal, 38, 661 – 674 (1978).

5 Manual Materials Handling Planning

The values in Section 11, Table 2, "Design Weight Limits for Lifting" and Section 11, Table 3, "Design Weight Limits for Carrying" provide maximum values based on the "ideal" lift or carry for manual material handling tasks. The "ideal" lift or carry includes ergonomic consideration of all the factors and considerations listed in Subsection 11/3, "Materials Handling Factors". The "ideal" lift is a lift of a box with a stable load and good handholds, with the center of the load placed 150 mm (6 in.) away from the lifter's body, at elbow height, carried to the final destination, less than 10 m (33 ft) away, over a dry deck, and placed on a surface at elbow height.

5.1 Personnel Lifting Limits

The weight limits in Section 11, Table 2, "Design Weight Limits for Lifting" should be used as maximum values in determining the design weight of items requiring one person lifting with two hands.

The weight limits can be doubled for two person lifts, provided the load is uniformly distributed between the lifters and both lifters have the same handles or handholds. If the weight of the load is not uniformly distributed, the weight limit applies to the heavier lift point.

5.2 Object Load Size

The weight limits in Section 11, Table 2, “Design Weight Limits for Lifting” apply to an object with uniform mass distribution and a compact size not exceeding 460 mm (18 in.) high, 460 mm (18 in.) wide, and 300 mm (12 in.) deep (see Section 11, Figure 1, “Ideal Object Size and Carrying Mode”). This places the center of the load at half the object’s depth, or 150 mm (6 in.) away from the body. If the depth of the object being lifted exceeds 300 mm (12 in.), see Section 11, Table 4, “Lifting and Carrying Multipliers” for weight limit adjustments.

5.3 Lifting in the Presence of Obstacles

The weight limits in Section 11, Table 2, “Design Weight Limits for Lifting” assume that there are no obstacles between the person lifting and the surface onto which the object is to be placed. If there is an obstacle, such as a lower shelf, see Section 11, Table 4, “Lifting and Carrying Multipliers” for weight limit adjustments.

5.4 Lifting Frequency

The weight limits in Section 11, Table 2, “Design Weight Limits for Lifting” are not for repetitive lifts as found in the loading or unloading of supply vessels. If the frequency of lifts exceeds one lift in 5 minutes or 20 lifts per 8 hours, see Section 11, Table 4, “Lifting and Carrying Multipliers” for weight limit adjustments.

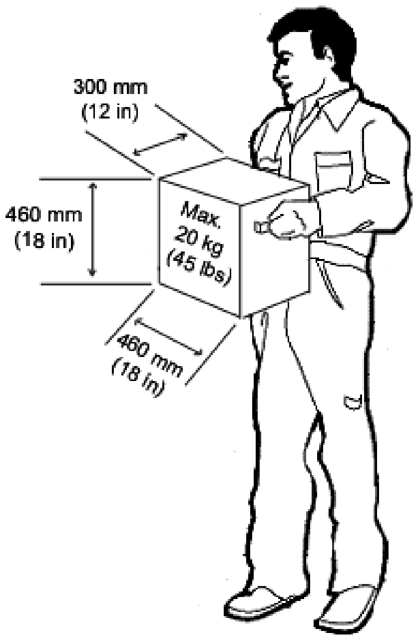
TABLE 2
Design Weight Limits for Lifting*

Handling Function	*Male and Female Handlers*	*All Male Handlers*
Lift an object from the floor and place it on a surface not greater than 1525 mm (60 in.) above the floor.	16.8 kg (37 lbs)	20.00 kg (45 lbs)
Lift an object from the floor and place it on a surface not greater than 915 mm (36 in.) above the floor.	20.0 kg (45 lbs)	20.0 kg (45 lbs)

* 1 See Section 11, Table 4, “Lifting and Carrying Multipliers” for weight limit adjustments.

2 Weight limits are based on a North American population.

FIGURE 1
Ideal Object Size and Carrying Mode



5.5 Personnel Carrying Limits

The weight limits in Section 11, Table 3, "Design Weight Limits for Carrying" should be used as the maximum value in determining the design weight of items requiring one person carrying of objects.

The weight limits can be doubled for two person carries, provided the load is uniformly distributed between the carriers. If the weight of the load is not uniformly distributed, the weight limit applies to the heavier lift point.

For carrying activities, it is assumed that the object is first lifted from the floor, carried, and placed on the floor or on another surface not higher than 915 mm (36 in.).

5.6 Carrying Frequency

The weight limits in Section 11, Table 3, "Design Weight Limits for Carrying" are not for repetitive carries. If the frequency of carry exceeds one carry in 5 minutes or 20 carries per 8 hours, see Section 11, Table 4, "Lifting and Carrying Multipliers" for weight limit adjustments.

5.7 Object Carry Size

The weight limits in Section 11, Table 3, "Design Weight Limits for Carrying" apply to an object with uniform mass distribution and a compact size not exceeding 460 mm (18 in.) high, 460 mm (18 in.) wide, and 300 mm (12 in.) deep (see Section 11, Figure 1, "Ideal Object Size and Carrying Mode"). This places the handholds at half the depth, or 150 mm (6 in.), away from the body. If the load size exceeds these dimensions, see Section 11, Table 4, "Lifting and Carrying Multipliers" for weight limit adjustments.

TABLE 3
Design Weight Limits for Carrying*

Handling Function	*Male and Female Handlers*	*All Male Handlers*
Carry an object 10 m (33 ft) or less	19.0 kg (42 lbs)	20.0 kg (45 lbs)
Carry an object more than 10 m (33 ft):		
Object carried at side with one hand (tool chest, container with handles, etc.)	9.5 kg (21 lbs)	10 kg (22.5 lbs)
Object with irregular sides (electronic equipment chassis, etc.)	11.4 kg (25 lbs)	14.0 kg (35 lbs)
Object or other item with two hands	14.0 kg (35 lbs)	20.0 kg (45 lbs)

* 1 See Section 11, Table 4, "Lifting and Carrying Multipliers" for weight limit adjustments.

2 Weight limits are based on North American populations.

TABLE 4
Lifting and Carrying Multipliers

Lifting or Carrying Situation	*Multiplier*
Age – For personnel over 50 years old	0.80
Asymmetrical lifting – When a worker must twist the torso 45° or more	0.70
Asian male	0.80
Asian female	0.85
Handholds – In the absence of handles or with poor handholds	0.90
Lifting or carrying frequency – If the frequency of lift or carry exceeds one in 5 minutes or 20 lifts or carries per 8 hours, the weight limits should be reduced by the factor (8.33 × *LF*)/100, where *LF* is the lift frequency in lifts per minute. For example, if the lift frequency is 6 lifts per minute, then the maximum permissible weight is reduced by (8.33 × 6)/100, which equates to .5	(8.33 × *LF*)/100
Lifting or carrying load size	
– If the depth of the object exceeds 61 cm (24 in.)	0.66
– If the depth of the object exceeds 91 cm (36 in.)	0.50
– If the depth of the object exceeds 122 cm (48 in.)	0.33
Limited Headroom – Where personnel must remain "bent" at the waist	0.65
Obstacles – If a lower protruding shelf or other obstacle limits the lifter's approach to the desired surface	0.66
Temperature – For temperatures greater than 32°C (90°F)	0.88

5.8 Reducing or Eliminating Manual Materials Handling

As mentioned in 11/2.1, "Keys to Acceptable Materials Handling and Lifting", where possible, manual materials handling tasks may be reduced or eliminated by applying any or all of the following strategies:

i) Avoid manual materials handling altogether, whenever possible

ii) Redesign the load

iii) Redesign the lifting/carrying task

iv) Redesign the working environment

v) Introduce assisted lifting devices

Assisted lifting aids include devices such as cranes, hoists, counter-balancing mechanisms, trolleys, mono-rails, come-alongs, padeyes, A-frames, etc. Regardless of the choice, in order to use assisted lifting devices, sufficient space is needed either to permanently install a new lifting device or to temporarily place removable equipment in addition to space needed for the load, its manipulation, and personnel assisting with the materials handling task.

6 Materials Handling Planning for Assisted Lifts

In cases where large (e.g., 40 kg (90 lbs) or greater) loads are anticipated, it is best if a materials handling study is undertaken during the design stage of a vessel or offshore installation in order to determine the following:

- Identify which equipment or items are likely to need removal or replacement
- The dimensions and weights associated with the equipment or items
- The location of the equipment or items within the vessel or installation
- The frequency of materials handling for these

- The assisted lifting methods and devices, including:
  - Single lift, multi-staged lift, lift to a vessel or dock, etc.
  - Whether devices will be permanently installed or moveable
  - The best locations for the permanently installed assisted lifting devices
  - The storage locations for moveable or erectable assisted lifting devices
  - The availability of assisted lifting devices that must be obtained from outside sources
- Transport method within the vessel or offshore installation
- Transport method off the vessel or offshore installation

Materials handling studies should determine all lifting, carrying, moving, and transporting activities related to operations or maintenance in all modes of operation from regular replenishment activities for food stores or supplies to emergency situations. Where such studies are not performed during the design stage, the same types of factors should be considered within the context of the existing vessel or offshore installation when planning an assisted materials handling task.

SECTION 12 Crew Habitability

1 General *(1 August 2013)*

1.1 Application

The principles and guidelines of this Section apply to the living and working conditions aboard vessels and offshore installations. Guidance in this document provides target minimum levels. These are consistent with overall values and goals of these Guidance Notes in providing specific assistance while improving human performance. The criteria should not be taken as minimum values for regulatory or classification purposes. Where conflicts exist between guidance in this Section and regulations or rules from the International Maritime Organization (IMO), flag Administrations, Class Societies, or other regulatory bodies, the regulations or rules take precedence.

Additional guidance is provided in the:

- ABS *Guide for Crew Habitability on Ships*
- ABS *Guide for Crew Habitability on Offshore Installations*
- ABS *Guide for Crew Habitability on Workboats*
- ABS *Guide for Crew Habitability on Mobile Offshore Drilling Units (MODUs)*

The above Guides also provide owners and operators with assessment methodologies related to requirements for obtaining an optional ABS Habitability class notation.

For cases of operation in cold environments, please refer to the ABS *Guide for Vessels Operating in Low Temperature Environments*.

2 Principles

Crew habitability typically comprises five aspects of vessel or offshore installation design and layout. These are the design and layout of accommodations spaces, as well as the ambient environmental characteristics of human whole-body vibration, noise, indoor climate, and lighting. Each of these aspects has the ability to affect performance and quality of life. To help maintain acceptable levels of performance, the following principles apply to the personnel who serve on vessels and offshore installations:

i) Maintenance of enhanced levels of mental and physical fitness is important to promote reliable human performance by reducing the potential for fatigue and human errors.

ii) Extreme levels of whole-body vibration, either low-frequency or high-frequency, can expose the human body to acceleration vectors of varying directions and magnitudes, which can consume energy and induce fatigue.

iii) High-noise levels from environmental or mechanical sources, can significantly affect voice communications, audibility of signals and alarms, and the ability to rest.

iv) Appropriate lighting levels are critical to personnel performance because vision is the dominant sensory channel for receiving information.

v) Indoor climate variables can influence performance when conditions either change or become extreme resulting in fatigue and reduced personnel performance.

3 Accommodations Spaces *(1 August 2013)*

One factor that influences personnel performance is facility design. The design of the accommodations (where personnel sleep, eat, and relax) influences job performance and quality of life. Quality of life is influenced by the location, arrangement, and outfitting of accommodations spaces.

Where an owner/operator wishes to gain access to accommodations design guidance or to have crew habitability assessed and/or obtain the Habitability class notation, reference should be made to any of the ABS Habitability Guides.

4 Human Whole-Body Vibration *(1 August 2013)*

Working and/or living aboard vessels or offshore installations impose a series of low- and high-frequency vibrations, as well as single-impulse shock loads, on personnel. Loads are transmitted through the feet of standing personnel, the buttocks, back, and feet of seated personnel, or the supporting area of recumbent personnel in the frequency range of 0.5 – 80 Hertz.

Low-frequency vibrations are created by various sea states, wind actions, vessel speed, maneuvering, etc. Low-frequency vibrations may result in motion sickness, motion-induced instabilities/ interruptions and/or motion-induced muscle fatigue. Higher-frequency vibrations (up to 80 Hz for those frequencies affecting humans) are generally associated with high-speed rotating machinery. High-frequency vibrations induce corresponding motions and forces within personnel, creating discomfort and resulting in a likely reduction of their performance and health. Other factors that affect the severity of this type of vibration include the size of the vessel or offshore installation, location of personnel, sea conditions, speed, direction of travel, personnel's body posture, duration of exposure and the availability of stabilizing, ballasting or vibration-dampening equipment.

Prolonged exposure to excessive levels of whole-body vibration can affect work quality, productivity, safety, health, comfort, and can induce motion sickness. Vibration can also modify an operator or maintainer's perception, influence control motions, cause motion-induced instabilities and interruptions, and impair speech. These factors are likely to result in increased reaction and response times, as well as an increase in the probability of human error.

Human whole-body vibration levels should be measured in weighted root-mean-square acceleration. For more information on maximum vibration levels and measurement procedures, refer to any of the ABS Habitability Guides.

5 Noise

5.1 General

Another factor that can significantly influence personnel performance is noise. Prolonged exposure to noise can interfere with speech, communications, impair concentration, and result in a sensation of annoyance. Owners and operators of vessels and offshore installations control noise levels to conserve their personnel's hearing. However, additional steps should be taken to further reduce noise levels to promote reliable personnel performance, communications, and reduce the potential for human errors.

5.2 Hearing Conservation *(1 August 2013)*

To prevent the occurrence of potentially hazardous noise levels, vessels and offshore installations should be designed to comply with appropriate maximum recommended exposure limits for noise, such as the IMO Assembly Resolution A.468(XII) - *Code on Noise Levels on Board Ships* (currently under revision).

The maximum recommended noise levels for specific spaces within a vessel or offshore installation should not exceed those indicated in Section 12, Table 1, "Maximum Recommended Noise Levels".

For those spaces where the maximum noise level is greater than 85 dB(A), personnel should wear hearing protection when in the space. Refer to 12/5.3, "Noise Exposure Limits" for guidance on noise exposure limits and hearing protection.

TABLE 1
Maximum Permissible Noise Levels*

Space	*Noise Limit dB(A)Maximum*
Work Spaces	
Machinery space (continuously manned)	90
Machinery space (not continuously manned)	110
Machinery control rooms	75
Workshops	85
Non-specified spaces	90
Navigation Spaces	
Navigation bridge and chartroom	65
Listening post, including bridge wings and windows	70
Radio rooms	60
Radar room/areas	65
Accommodation Spaces	
Cabins and hospitals	60
Mess rooms and Recreation rooms	65
Open recreation areas	75
Offices	65
Service Areas	
Galleys	75
Serveries and pantries	75
Normally unoccupied spaces	
Spaces not specified	90

* Table adapted from IMO Assembly Resolution A.468(XII).

Note: For measurement techniques, refer to IMO Assembly Resolution A.468(XII).

5.3 Noise Exposure Limits

Permissible daily and occasional noise exposure limits are shown in Section 12, Figure 1, "Permissible Noise Exposure Limits" and discussed below:

i) *Maximum exposure with protection, Zone A of Figure 1, "Permissible Noise Exposure Limits".* No personnel should be exposed to levels exceeding 120 dB(A) or to an L_{eq}(24) (24-hour equivalent continuous sound level) exceeding 105 dB(A) even while wearing hearing protectors.

ii) *Occasional exposure, Zone B of Figure 1, "Permissible Noise Exposure Limits".* Only occasional exposure should be allowed in Zone B and both ear muffs and ear plugs should be used unless the exposure duration is restricted to not more than 10 minutes when only ear muffs or plugs are required.

iii) *Occasional exposure, Zone C of Figure 1, "Permissible Noise Exposure Limits".* In Zone C, only occasional exposures should be allowed and ear muffs or plugs should be required.

iv) *Daily exposure, Zone D of Figure 1, "Permissible Noise Exposure Limits".* If personnel routinely work with daily exposure in spaces with noise levels within Zone D, hearing protectors should be worn.

v) *Maximum exposure without protection, Zone E of Figure 1, "Permissible Noise Exposure Limits".* For exposures of less than eight hours, personnel without hearing protection should not be exposed to noise levels exceeding 85 dB(A). When personnel remain for more than eight hours in spaces with a high noise level, an L_{eq}(24) of 80 dB(A) should not to be exceeded. Consequently, for at least a third of each 24 hours the personnel should be subject to an environment with a noise level not exceeding 75 dB(A).

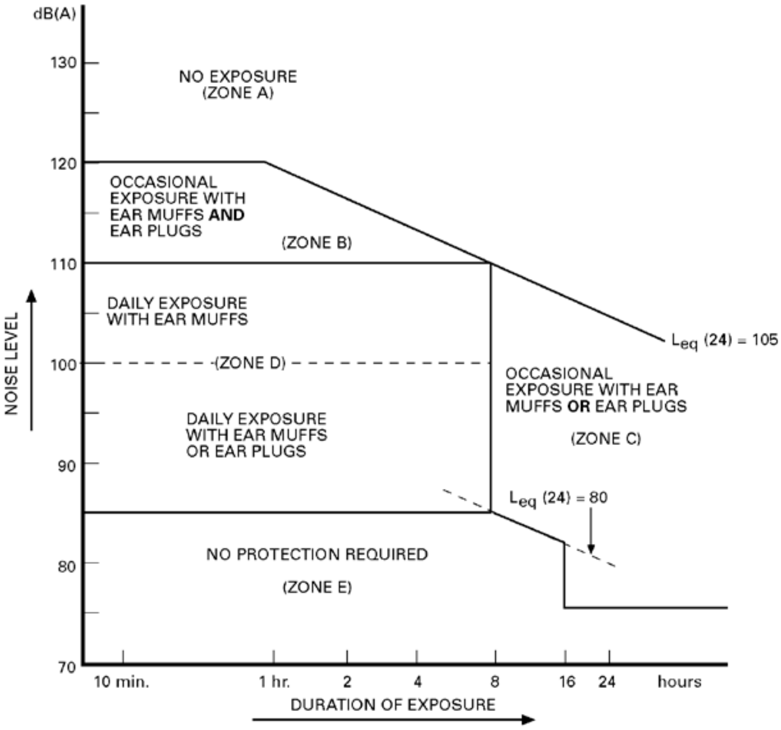
vi) *24-Hour equivalent continuous sound level, "Permissible Noise Exposure Limits"*. As an alternative to Figure 1, the personal exposure to a 24-hour equivalent continuous sound level should be no greater than 80 dB(A). Each individual's daily exposure duration in spaces requiring the use of hearing protectors should not to exceed four hours continuously or eight hours in total.

5.4 Task Performance and Comfort Noise Levels *(1 August 2013)*

In addition to conserving personnel's hearing, noise levels can be provided that promote task performance. This is accomplished by ensuring noise levels in a workspace allow it to be used for its intended purpose with minimal interference or annoyance from noise. Additionally, appropriate noise levels for living spaces can be provided that promote relaxation and rest. Task performance and comfort noise criteria for typical vessel and offshore installations spaces are given in any of the ABS Habitability Guides.

These criteria have been selected to improve personnel performance and to facilitate communication, rest and sleep in appropriate vessel or offshore installation spaces. The suggested noise criteria in the ABS Guides are given as equivalent continuous A-weighted sound pressure levels (L_{Aeq}) and are expressed in decibels [dB(A)]. These Guides also provide noise assessment methodologies.

FIGURE 1
Permissible Noise Exposure Limits*



* Figure and description adapted from IMO Assembly Resolution A.468 (XII).

5.5 Hearing Protection and Warning Information

Hearing protection should be used upon the entrance of all spaces with a noise level of 85 dB(A) and greater. The use of earplugs, earmuffs, or both is based on the noise level and length of exposure. Hearing protectors should provide at least the following noise attenuation at the ear:

- Ear plugs 20 dB(A)
- Ear muffs 30 dB(A)
- Ear plugs and ear muffs 35 dB(A)

When noise levels exceed 85 dB(A) in any space, a symbol and supplementary warning sign should be posted at each entrance. If hand tools or other portable equipment produce noise levels above 85 dB(A) under normal working conditions, a hazard identification sign should be posted at the work site to identify the hazard and require the use of hearing protection. Further guidance with respect to hazard identification signs is provided in Section 8, "Labeling, Signs, Graphics, and Symbols".

6 Indoor Climate

6.1 General *(1 August 2013)*

The effect of indoor climate is not perceived by personnel until conditions either change or become extreme. Thermal comfort is subjective, and thus it is difficult to specify an ambient indoor climate that will satisfy everyone. Thermal comfort is largely determined by the interaction of ambient environmental factors such as air temperature, mean radiant temperature, air velocity, humidity, and the personal factors of activity and clothing.

The Heating Ventilation and Air Conditioning (HVAC) system on a vessel or offshore installation should be designed to effectively control the indoor climatic variables to within limits. This should be accomplished within the range of external environmental conditions to which the vessel or offshore installation may be subjected. HVAC systems that are adjustable provide a further enhancement for comfort by allowing for a range of personal preferences to be met. Indoor climate criteria and assessment methodologies are included in the ABS Habitability Guides.

6.2 Air Temperature, Humidity, Thermal Gradients and Air Velocity Criteria *(1 August 2013)*

Guidance for desired levels of air temperature, humidity, thermal gradient and air velocity are given in the ABS Habitability Guides. This is provided for personnel wearing typical indoor clothing occupied in light, primarily sedentary activities and resulting in a thermal environment acceptable to at least 80 percent of the occupants.

6.3 Ventilation

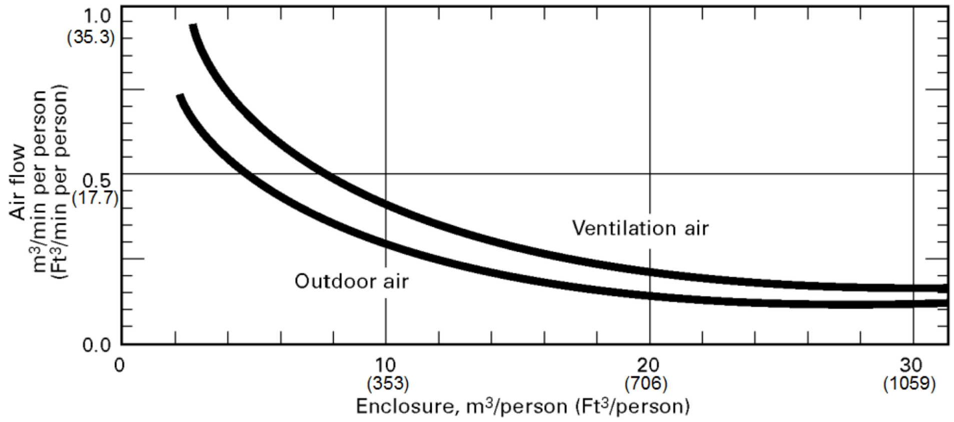
Adequate ventilation should be assured by introducing fresh air into all normally manned spaces. For small spaces (e.g., enclosed volume of 4.25 cubic meters (150 cubic ft) or less per person), a minimum of 0.85 cubic meters (30 cubic ft) of ventilation air-per-minute-per-person should be provided with 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 Section 12, Figure 2, "Large Enclosure Ventilation Requirements". The rate of air change 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 or sources of odor.

Ventilation should not produce air velocities exceeding 30 m/minute (100 ft/minute), measured on average. 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/minute (200 ft/minute). In areas where manuals or other loose papers are used, the air velocity preferably should be 20 m/minute (65 ft/minute) but no more than 30 m/minute (100 ft/minute).

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.*

To reduce potential health hazards caused by exposure to oil and inhalation of oil mist, consideration is to be given to the installation, location, and ventilation of equipment, which may produce oil vapor and mist. Intakes for ventilation systems should be located to minimize the introduction of contaminated air from sources such as exhaust pipes and incinerators.

FIGURE 2
Large Enclosure Ventilation Requirements*



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7 Lighting

7.1 General *(1 August 2013)*

Sufficient lighting is required for effective and efficient personnel performance. For most tasks, vision is the main sense for receiving information and lighting is therefore a critical element in design. The lighting of work and accommodations spaces should facilitate visual task performance and the movement of people in the space, and enhance the visual environment. Lighting design integrates adequate lighting for safe working, well-being of personnel and for the tasks encountered on the vessel or offshore installation. Visual discomfort can impair visual performance.

Visual tasks encountered on vessels and offshore installations vary widely. In addition to the lighting level, other factors such as contrast with the background, reflectance, object size, brightness and the time available for viewing or recognition help to determine the visibility of an object within the visual field. Consideration should also be given to task duration, visual fatigue, task criticality, glare, reflections, shadows and the age and visual acuity of the likely observer. Aesthetics, color and the psychological effects of lighting should also be considered. These factors are all interrelated, so no single aspect of lighting should be considered in isolation.

7.2 Lighting Design

Lighting should 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 should not exceed 5:1. To reduce glare, non-reflective or matte finished surfaces should be provided on consoles, panels, and other work surfaces. Placement of smooth, highly polished surfaces within 60 degrees of a person's normal visual field should be avoided.

When night vision is required for extended periods of time, low-level white lighting is preferred to low-level red lighting. Red lighting should not be used in areas where color recognition is required.

7.3 Brightness

The brightness ratio between the lightest and darkest areas or between a task area (e.g., computer screen) and its surroundings (e.g., bulkhead behind the screen) should be no greater than specified in Section 12, Table 2, "Maximum Brightness Ratios".

TABLE 2
Maximum Brightness Ratios*

	Environmental classification		
Comparison	*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	b
Between tasks and more remote lighter surfaces	1 to 10	1 to 20	b
Between luminaries and adjacent surfaces	20 to 1	b	b
Between the immediate work area and the rest of the environment	40 to 1	b	b

* Adopted from DOT/FAA/CT-96/1—*Human Factors Design Guide*.

Notes:

A Interior areas where reflectances of entire space can be controlled for optimum visual conditions.

B Areas where reflectances of nearby work can be controlled, but there is only limited control over remote surroundings.

C Areas (indoor and outdoor) where it is completely impractical to control reflectances and difficult to alter environmental conditions.

b Brightness ratio control is not practical.

7.4 Reflectance

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. Preferred surface reflectance values for spaces such as offices, control rooms, and maintenance areas are shown in Section 12, Figure 3, “Surface Reflectance Values”.

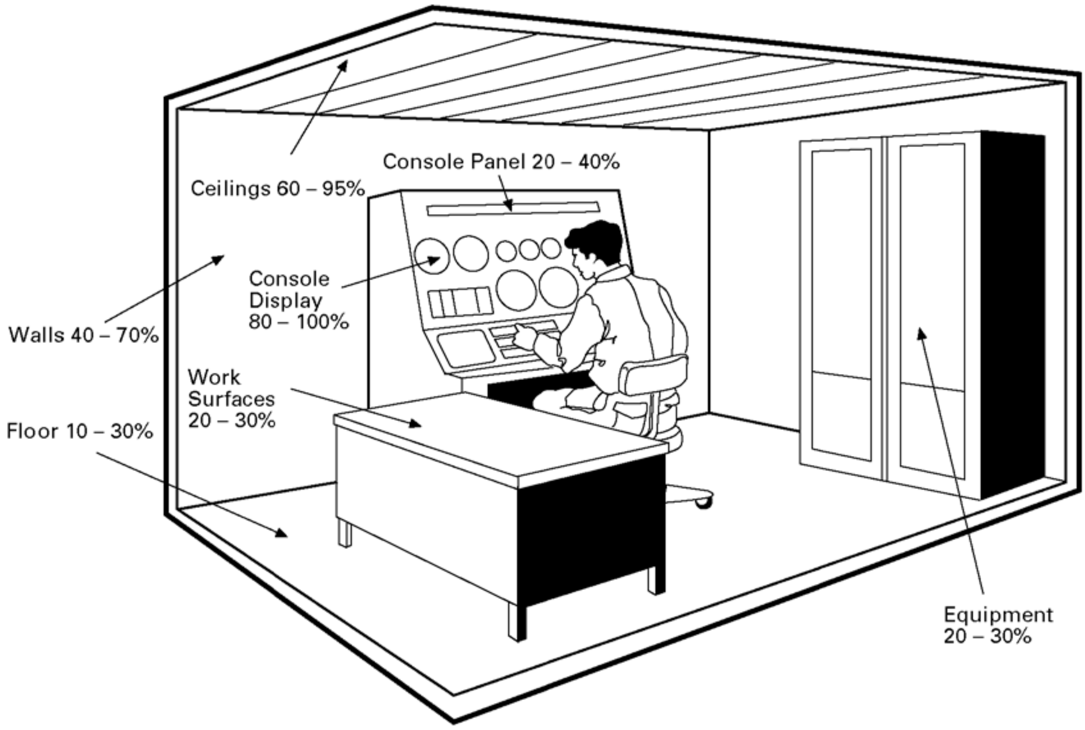
7.5 Lighting Criteria *(1 August 2013)*

For further criteria on lighting, refer to any of the ABS Habitability Guides.

7.6 Emergency Lighting Criteria *(1 August 2013)*

Emergency lighting requirements exist in Statutory, Class and other regulatory documents including the ABS *Rules for Building and Classing Steel Vessels* (SVR 4-8-2/5.5), the ABS *Rules for Building and Classing Mobile Offshore Drilling Units,* the IMO *Convention for the Safety of Life at Sea* (SOLAS), and the *Mobile Offshore Drilling Unit* (MODU) *Code.* As a result, these Guidance Notes do not provide criteria related to emergency lighting.

FIGURE 3
Surface Reflectance Values*



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APPENDIX 1 Anthropometric Design Principles and Dimensions

1 General *(1 August 2013)*

1.1 Application

The principles and data in this Appendix apply to the sizing of equipment, accesses, and clearances to provide physical compatibility of the human body (in terms of physical dimensions) and design of interfaces such as: hardware, chairs, hatches, doorways, consoles, panels, and clothing. Sizing of these interfaces is usually done within the context of performing general tasks, such as reaching a control, viewing over a console, sitting in a chair, or exiting through a hatch. Throughout the main body of these Guidance Notes extensive guidance is presented that relates to anthropometric dimensions. Specifically, see the following:

i) Section 5, "Integration of Controls, Displays, and Alarms"

ii) Section 6, "Computer Workstation Design"

iii) Section 7, "Manual Valve Operation, Access, Location, and Orientation"

iv) Section 9, "Stairs, Ladders, Ramps, Walkways, Platforms and Hatches"

v) Section 10, "Maintenance Considerations"

Much of the anthropometric guidance presented in main body of these Guidance Notes is applicable to the size and strength characteristics of North American males. Since these Guidance Notes are intended to have international appeal, this Appendix is provided so that the main body anthropometric guidance can be modified for use in designs to be operated and maintained by peoples of other regions with different body dimensions.

1.2 Background

The science of anthropometry focuses on the measurement of human variability of body dimensions and strength as a function of gender, race, and regional origin. The application of anthropometry to design establishes limits (or boundary conditions) for sizing equipment for human use. In essence, it defines size limits in design based on the dimensions of the anticipated population of operating and maintenance personnel. By imposing size limits in design (e.g., designing so the shortest expected operator or maintainer can reach all controls), it follows that personnel who are less demanding in their requirements will also be accommodated (e.g., have greater reach than the limiting personnel).

For any body dimension, the 5th percentile value indicates that 5% of the population will be equal to or smaller than that value, and 95% will be larger. On the other hand, the 95th percentile value indicates that 95% of the population will be equal to or smaller than that value, and 5% will be larger. Therefore, use of a design range from the 5th to the 95th percentile (for *either* male or female populations, but not both) values will theoretically provide coverage for 90% of that (male or female) population using those limiting dimensions, and only those smaller than the 5%, and larger than the 95% will be excluded by design.

Using limiting dimensions for males *and* females (5th percentile female and 95th percentile male) will accommodate approximately 94% of the entire design population (since over 99% of males are larger than the 5th percentile female, and over 99% of females are smaller than the 95th percentile male, so few small males, or large females, are excluded).

Note that the notion of the "average person" is misleading in that an individual will vary among different anthropometric dimensions. For example, individuals who are of average (50%) stature, can be comparatively smaller or larger on other dimensions, such as arm length.

2 Principles

In general, there are four principles of applied anthropometrics in design:

2.1 Design for the Smallest

This principle applies primarily to application of physical force and vertical and lateral reach distances. For example, the forces required to pull, push, or turn a handle. Usually, the maximum force that can be readily applied by the 5th percentile person for that movement is used as the criterion. Similarly, the reach of the 5th percentile person is often used as the criterion.

2.2 Design for the Largest

This principle applies primarily to clearances, such as escape hatches, maintenance accesses, lifeboats, walkways, and overhead clearances. Clearances generally are such that at least 95% of the expected population is accommodated. In some cases, persons whose body size exceeds the designed clearances are precluded from selection for the system.

2.3 Design for the Average

This principle applies to workstations that are not adjustable (e.g., fixed height tables, desks, or other work surfaces). In these situations, designing for the average person better accommodates the entire population.

2.4 Design for the Range

This principle is applied to determining the amount of *adjustability* that should be built into such things as variable height work surfaces and workstation seating (e.g., horizontal and vertical adjustability). In general, the dimension criteria used for designing adjustability readily accommodates the middle 90% of the population.

3 Anthropometric Data

The guidance and data provided herein can be used in designing human-system interfaces which are required to be "easily accessible", "readily operable", "based on sound ergonomic principles", and similar phrases used extensively in ABS documentation.

The following summarizes the figures and tables containing anthropometric data:

- Figure 1, "Differences in 50th Percentile Male Stature for 12 Regions, in Millimeters and Inches, from the Average Stature of 1717 mm (67.6 inches)"
- Figure 2, "Differences in 50th Percentile Female Stature for 11 Regions, in Millimeters and Inches, from the Average Stature of 1593 mm (62.7 inches)"
- Table 1, "Essential International Anthropometric Data for Males"
- Table 2, "Essential International Anthropometric Data for Females"

The remaining tables present three critical anthropometric dimensions for each of these twenty regions. Also note that Appendix 1, Figure 3, "Anthropometric Illustrations" provides a graphical representation of the various measurement points associated with the anthropometric dimensions provided in the following tables:

- Table 3, "Anthropometric Geographical Regions" defines twenty (20) geographic regions.
- Table 4, "Standing Height Dimensions"
- Table 5, "Sitting Eye Height Dimensions"
- Table 6, "Forward Functional Reach"

4 Clothing and Postural Effects

The effect of clothing, special equipment, and personal protective equipment (PPE) should be accounted for in the design for the operation and maintenance of a vessel or offshore installation. Most anthropometric data has been gathered from minimally clothed or nude subjects. Clothing, special equipment, and PPE can affect clearances, ranges of motion, reach envelopes, dexterity, mobility, strength, tactile sensitivity, and grasping capability. Given this, the effect of shoes, boots, hard hats, coats, gloves, other "standard" clothing, respirators, fire fighting equipment, and barrier suits, as applicable, should be accommodated by design.

Postural effects should also be accommodated by design, in particular postural slump. Non-specific clothing and posture slumping data is provided in Appendix 1, Table 7, "Clothing and Postural Effects". Modifications to clothing, special equipment, and PPE allowances may be needed depending on the particular design, and should be measured and accounted for before design.

5 Adapting Data for Various Populations

To illustrate how the data in this Appendix can be used, the following examples are provided.

5.1 Example 1 – Specifying Overhead Clearances in a Hardhat Area *(1 August 2013)*

Design of the decks on an offshore installation is underway and the walking overhead clearance needs to be specified. There will be overhead pipes, pipe hangers, cable trays, and ductwork in this particular area. The area will require the wearing of hardhats and steel-toed shoes. Personnel for this offshore installation are expected to predominantly be Northern European men.

9/10.1, "General Principles" of these Guidance Notes states that, "Headroom in all walkways should be ≥ 2130 mm (84 in.)".

To specify (or verify) a walking overhead clearance for 95th percentile Northern European men:

i) Identify a regional population of expected users. In this case it will be Northern Europeans.

ii) Select a percentage of the population to be accommodated, thereby establishing a preliminary limiting dimension. In this case, the 95th percentile male is chosen, since overhead clearance is a safety concern, and selecting this will protect 95% of be Northern European men, and virtually all females. This limiting dimension is 1910 mm (75.2 in.) according to Appendix 1, Table 4, "Standing Height Dimensions".

iii) Identify clothing allowances, in this case, steel-toed shoes and hardhat. For footwear, there is an allowance of 25 mm (1 in.), and for the hardhat, there is an allowance of an additional 75 mm (3.0 in.). These allowances are added to the limiting dimension, and thus stature becomes 2010 mm (79.2 in.).

iv) Allow for the dynamic characteristics of walking and starting and a clearance safety factor. Walking, starting, and some gaits are typically assumed to add a variability of approximately 50 mm (2 in.). Adding a safety clearance factor is a matter of assumption and judgment. In this case, a factor of 75 mm (3 in.) is reasonable. Adding these, the minimum overhead clearance should be approximately 2135 mm (84 in.), providing a dynamic walking clearance of approximately 75 mm (3 in.) for 95% Northern European males and over 99% of be Northern European females wearing steel-toed footwear and hard hat.

v) Specify a minimum overhead clearance of 2135 mm (84 in.) for all areas where personnel are expected to walk (without crouching or slumping). That minimum includes potential overhead hazards such as the bottom of a pipe, cable tray, or their hangers, lever-operated valves in any position, hanging wires, etc.

As a matter of interest, 2.1 m (7 ft) is a typical overhead clearance specified internationally. Some points to make in the above sample:

i) Many of the dimensions are easily specified based on the tables in this Appendix. However, it is important to select an appropriate group as even adjacent regions can offer very different anthropometric values. Looking at 95th percentile European males in Appendix 1, Table 1, "Essential International Anthropometric Data for Males", reveals a stature of 1847 mm (72.7 in.). Looking at 95th percentile Northern European males in Appendix 1, Table 4, "Standing Height Dimensions", reveals a stature of 1910 mm (75.2 in.): a difference of 63 mm (2.5 in.).

ii) Frequently, assumptions need to be made, as in the example above, for a clearance safety factor. Safety factors need to be identified and considered in light of safety risks. For example, risk associated with a taller person having to bend at the waist to access a control situated to accommodate shorter personnel pales to the risk of taller personnel moving rapidly in areas with marginal overhead clearances.

iii) Dynamic aspects of motion need to be taken into account. Anthropometric data are often based on static values, with measurements taken under strictly adhered to postures and procedures. Dynamic characteristics are much harder to quantify, and therefore assumptions need to be made.

5.2 Example 2 – Design a Door Label Mounting Height

There is a general need to identify spaces and equipment on vessels and offshore installations, to accommodate new personnel, visitors, technical representatives, contractors, and the like.

Subsection 8/7, "Room or Space Identification Labels", states: "Identification labels should be mounted on the door leading into a room or space. Labels should be placed at or slightly below personnel's standing eye height. For 50th percentile North American male personnel, the label would be located approximately 1650 mm (65 in.) above the standing surface".

To specify an effective compartment/space entrance labeling height suitable for a different population of personnel, the following provides an example of how to determine where to situate a door label:

i) Identify a regional population of expected users. In this case it will be Japanese, since the vessel under design is a Japanese fishing vessel.

ii) Select a percentage of the population to be accommodated, thereby establishing a preliminary labeling height above the deck. In this case, the 50th percentile male is chosen, since there are no safety concerns associated with extreme dimensions (5th or 95th percentiles) in this task, and choosing the 50th percentile will accommodate the greatest number of personnel, who are expected to be, for the most part, Japanese males.

iii) According to Appendix 1, Table 1, "Essential International Anthropometric Data for Males", the standing eye height of the target population is 1568 mm (61.7 in.).

iv) Identify clothing allowances, in this case, shoes: an allowance of 25 mm (1 in.).

v) There are no dynamic characteristics for which to account, and there are no safety margins that need to be considered, therefore, door label heights should be approximately 1593 mm (63 in.).

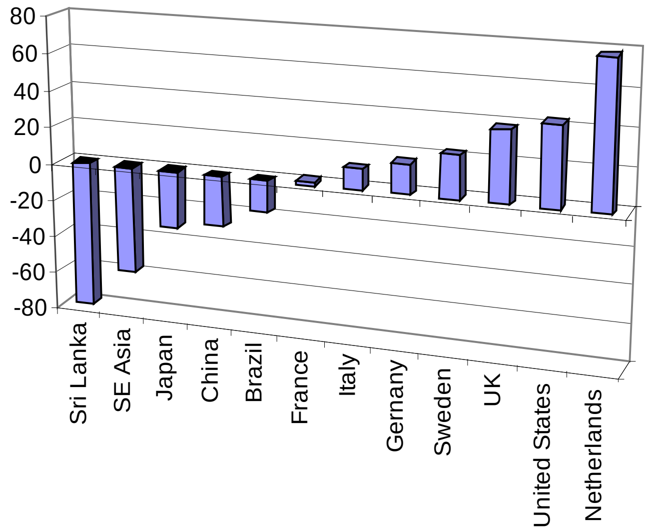
5.3 Example 3 – Reassessment of Water Survival Craft Seat Width

The *International Life-Saving Appliance Code* [IMO Resolution MSC.48(66)] specifies anthropometric requirements for seating on lifeboats. The objective of the IMO in generating these requirements was to optimize seating on lifeboats to anthropometrically accommodate as many passengers as possible, while maximizing the human payload capacity. The IMO Resolution specifies a seat accommodation of 215 mm (17 in.). This seat size coincides with the 95th percentile North American male hip width as reported by AdultData (1998) (presumably, the IMO figure is based on the 95th percentile hip width of an international population, and was not based on North American male dimensions).

According to *Safety Alert No. 192, Water Survival Craft* (January 2001) of the United States Minerals Management Service, it was later noted that in the Gulf of Mexico offshore workers were too large to fit in lifeboats. Field anthropometric measurements of Gulf of Mexico offshore workers revealed an appropriately clothed hip width of 533 mm (21 in.): 100 mm (4 in.) greater than the design specification. This deviation of specified seat width compared to the hip width of Gulf of Mexico offshore worker suggests that lifeboat manufacturers would overestimate maximum lifeboat occupancy in the Gulf of Mexico by about 20%. Similarly, the *International Life Saving Appliance Code* specifies an average weight of 75 kilograms (165 pounds) for sizing lifeboats. In the Gulf of Mexico, the observed average weight was 95 kilograms (210 pounds), a difference of 20 kilograms (44 pounds), potentially affecting buoyancy and stability.

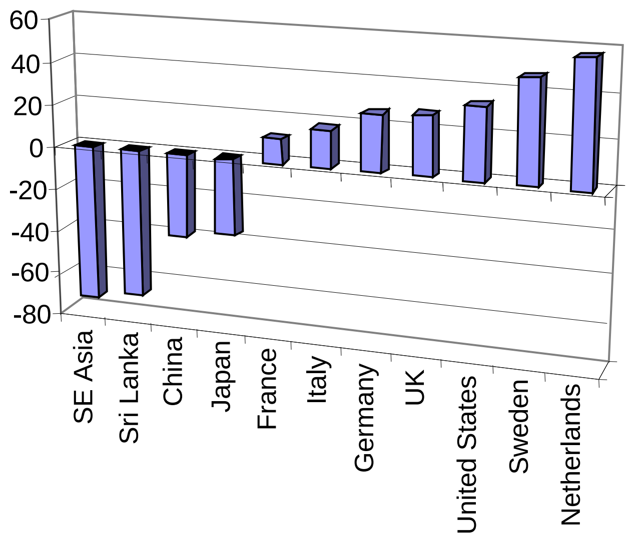
This example makes some strong points about the use of anthropometric data. First, subpopulations may vary dramatically from the parent population, as was the case for Gulf of Mexico offshore workers when compared to North American males. Second, these variations can present significant safety concerns, (as evidenced by the possible 20% overestimation of lifeboat occupancy in the Gulf of Mexico). Finally, where the application of anthropometric data to design can have serious safety implications, particularly in special or unique environments, data verification studies should be considered.

FIGURE 1
Differences in 50th Percentile Male Stature for 12 Regions, in Millimeters, from the Average Stature of 1717 mm (67.6 inches)



Males	mm	in
Sri Lanka	-78	-3.1
SE Asia	-57	-2.2
Japan	-30	-1.2
China	-27	-1.1
Brazil	-17	-0.7
France	2	0.1
Italy	11	0.4
Gernany	16	0.6
Sweden	23	0.9
UK	38	1.5
United States	43	1.7
Netherlands	78	3.1

FIGURE 2
Differences in 50th Percentile Female Stature for 11 Regions, in Millimeters, from the Average Stature of 1593 mm (62.7 inches)



Females	mm	in
SE Asia	-73	-2.9
Sri Lanka	-70	-2.7
China	-39	-1.5
Japan	-36	-1.4
France	11	0.4
Italy	17	0.7
Gernany	26	1.0
UK	27	1.1
United States	33	1.3
Sweden	47	1.9
Netherlands	57	2.3

TABLE 1
Essential International Anthropometric Data for Males

Males (mm and inches)	*North America (US)*			*Japan*			*Southeast Asia*†			*Europe**		
	5%	*50%*	*95%*	*5%*	*50%*	*95%*	*5%*	*50%*	*95%*	*5%*	*50%*	*95%*
Stature (floor to top of head)	1644	1760	1876	1593	1687	1781	1530	1630	1720	1604	1728	1847
	64.7	69.3	73.9	62.7	66.4	70.1	60.2	64.2	67.7	63.1	68.0	72.7
Seated Stature (buttocks to top of head)	862	923	984	855	913	970	790	840	900	836	894	959
	33.9	36.3	38.7	33.7	35.9	38.2	31.1	33.1	35.4	32.9	35.2	37.8
Shoulder Breadth (deltoid to deltoid)	449	509	569	413	448	484	380	410	430	420	456	496
	17.7	20.0	22.4	16.3	17.6	19.1	15.0	16.1	16.9	16.5	18.0	19.5
Standing Eye Height	1529	1643	1758	1474	1568	1661				1509•	1613•	1720•
	60.2	64.7	69.2	58.0	61.7	65.4				59.5•	63.4•	67.7•
Seated Eye Height (buttocks to eye)	733	793	853	726	775	832	680	730	780	740‡	796‡	851‡
	28.9	31.2	33.6	28.6	30.5	32.8	26.8	28.7	30.7	29.1‡	31.3‡	33.5‡
Back of Knee Height (approximate maximum seat height)	404	450	496	369	408	447	380	415	445	425	473	521
	15.9	17.7	19.5	14.5	16.1	17.6	15.0	16.3	17.5	16.7	18.6	20.5
Forward functional reach (back of shoulder to fingertips)	842	909	975	758	820	882	730	780	820	711‡	771‡	827‡
	33.1	35.8	38.4	29.8	32.3	34.7	28.7	30.7	32.3	28.0‡	30.4‡	32.6‡
Standing Overhead Reach (floor to tip of extended middle finger)	2067	2237	2407	1959	2121	2282						
	81.4	88.1	94.8	77.1	83.5	89.8						
Arm Length (fingertip to shoulder)	737	796	856	682	735	787				711	771	827
	29.0	31.3	33.7	26.9	28.9	31.0				28.0	30.4	32.6
Hip Breadth	312	372	432	299	328	357				310•	344•	368•
	12.3	14.6	17.0	11.8	12.9	14.1				12.2•	13.5•	14.5•

† Represented by Brunei, Indonesia, Laos, Malaysia, Philippines, Singapore, Thailand, and Viet Nam. Source: *International Data on Anthropometry*. International Labor Organization, 1990. The data in this source dates to the middle 1960's 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.

* 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.

‡ French population data. • German population data.

TABLE 2
Essential International Anthropometric Data for Females

Females (mm and inches)	*North America (US)*			*Japan*			*Southeast Asia†*			*Europe**		
	5%	*50%*	*95%*	*5%*	*50%*	*95%*	*5%*	*50%*	*95%*	*5%*	*50%*	*95%*
Stature (floor to top of head)	1512	1627	1742	1474	1558	1641	1440	1530	1620	1500	1610	1710
	59.5	64.1	68.6	58.0	61.3	64.6	56.7	60.2	63.8	59.1	63.4	67.3
Seated Stature (buttocks to top of head)	802	861	920	793	848	902	750	800	850	794	852	904
	31.6	33.9	36.2	31.2	33.4	35.5	29.5	31.5	33.5	31.3	33.5	35.6
Shoulder Breadth (deltoid to deltoid)	381	474	567	376	409	441	340	380	410	366	401	447
	15.0	18.7	22.3	14.8	16.1	17.4	13.4	15.0	16.1	14.4	15.8	17.6
Standing Eye Height	1406	1517	1628	1370	1448	1527				1402•	1502•	1596•
	55.4	59.7	64.1	53.9	57.0	60.1				55.1•	59.1•	62.8•
Seated Eye Height (buttocks to eye)	677	735	794	679	721	764	660	700	740	703‡	751‡	801‡
	26.7	28.9	31.3	26.7	28.4	30.1	26.0	27.6	29.1	27.7‡	29.6‡	31.5‡
Back of Knee Height (approximate maximum seat height)	354	400	446	331	362	393	365	385	405	380	431	481
	13.9	15.7	17.6	13.0	14.3	15.5	14.4	15.2	15.9	15.0	17.0	18.9
Forward functional reach (back of shoulder to fingertips)	746	811	876	696	753	810	690	730	780	652‡	704‡	761‡
	29.4	31.9	34.5	27.4	29.6	31.9	27.2	28.7	30.7	25.7‡	27.7‡	30.0‡
Standing Overhead Reach (floor to tip of extended middle finger)	1890	2057	2225	1796	1935	2075						
	74.4	81.0	87.6	70.7	76.2	81.7						
Arm Length (fingertip to shoulder)	649	718	788	613	660	706				652	704	761
	25.6	28.3	31.0	24.1	26.0	27.8				25.7	27.7	30.0
Hip Breadth	307	404	500	291	316	342				314•	358•	405•
	12.1	15.9	19.7	11.5	12.4	13.5				12.4•	14.1•	15.9•

† Represented by Brunei, Indonesia, Laos, Malaysia, Philippines, Singapore, Thailand, and Viet Nam. 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.

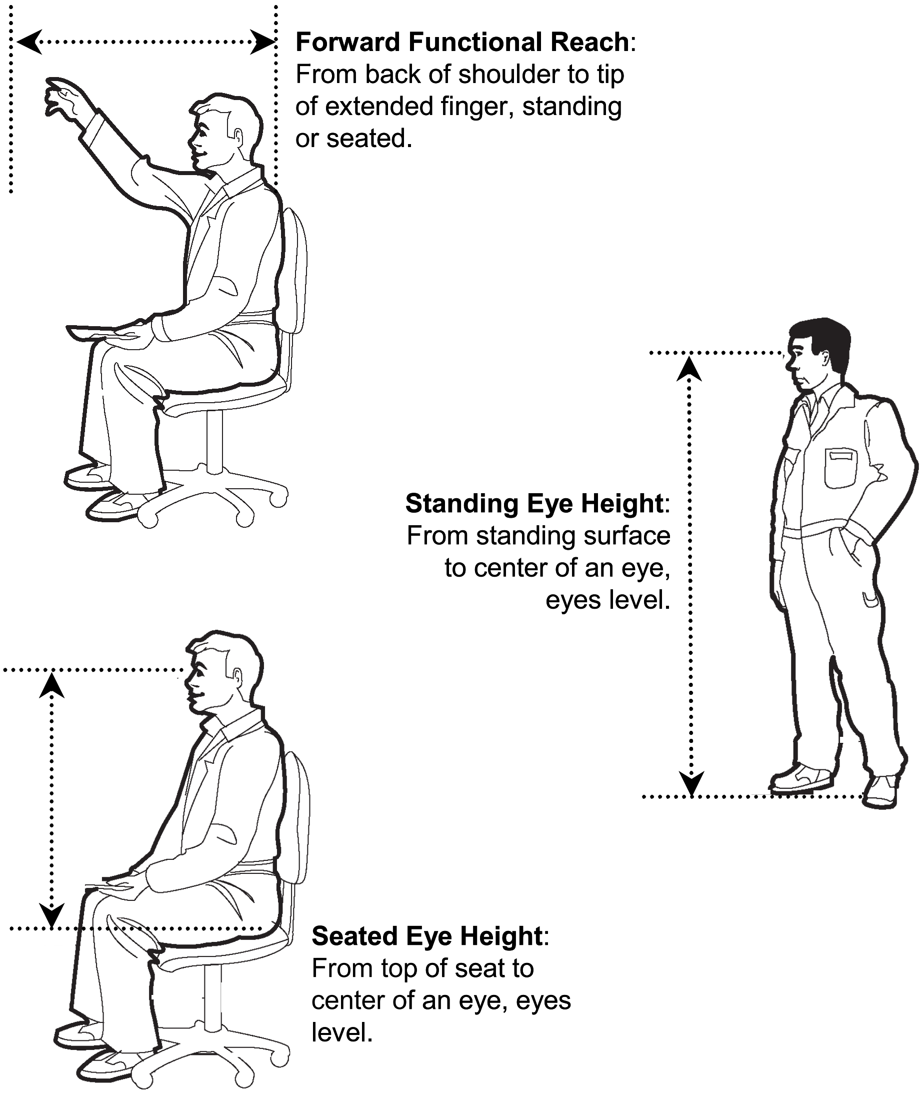
* Represented by data from Sweden, Germany, Italy, and France. Source: *ADULTDATA: The Handbook of Adult Anthropometric and Strength Measurements – Data for Design Safety*. Institute for Occupational Ergonomics, University of Nottingham, UK. 1998.

‡ French population data. • German population data.

TABLE 3
Anthropometric Geographical Regions *(1 August 2013)*

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, Slovenia, Croatia, Bosnia and Herzegovina, Serbia and Montenegro
Japan	North Korea, South Korea, Japan
North Asia	China (Northern), Mongolia, Russian Federation
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

FIGURE 3
Anthropometric Illustrations*



* Figure 3, "Anthropometric Illustrations", defines the anthropometric dimensions presented in Appendix 1, Tables 4 to 6.

TABLE 4
Standing Height Dimensions

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	1664 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.)

Sources:

International Data on Anthropometry. International Labor Organization, 1990.

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

TABLE 5
Sitting Eye Height Dimensions

Region	Male 5%	Male 95%	Female 5%	Female 95%	Min	Max
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.)
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.)

Sources:

International Data on Anthropometry. International Labor Organization, 1990.

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

TABLE 6
Forward Functional Reach

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.)

Sources:

International Data on Anthropometry. International Labor Organization, 1990.

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

TABLE 7
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.)

APPENDIX 2 Application of Ergonomics to Design *(1 August 2013)*

1 Introduction

The previous Sections of these Guidance Notes provide ergonomics principles, guidelines, and criteria for both vessels and offshore installations with the intention of assisting naval architects, designers, and engineers with integrating ergonomics in marine system design. To apply that information systematically, a human-system interface design process should be used.

This Appendix offers a practical way to implement such a process. It outlines a simplified and structured approach for addressing ergonomics within the context of engineering design through three sets of activities: Analysis, Design, and Verification and Validation.

2 Objective of Integrating Ergonomics in Engineering Design *(1 August 2013)*

Ergonomics focuses on and represents operator and maintainer needs and requirements throughout the life cycle of systems. The goal is to minimize human error, thereby maximizing human and total system safety and effectiveness. This can be accomplished through:

i) The application of ergonomic principles, guidelines and criteria

ii) Conduct of appropriate analyses and solicitation of operator or maintainer input to derive task requirements and needs

iii) Application of a logical, practical, human-system interface design process

This Section presents a basic human-interface design process that emphasizes the infusion of ergonomics principles and criteria into engineering design. This process can be performed during the design or modification of maritime systems. It starts with analysis, moves on to design activities and ends with verification and validation processes. The process described is written to acquaint those unfamiliar with human-interface design processes and is not meant to provide a detailed approach. Such details can be found in the following:

- ASTM F 1337, *Standard Practice for Human Engineering Program Requirements for Ships and Marine Systems, Equipment, and Facilities*.
- ISO 13407. *Human-Centered Design Processes for Interactive Systems*.
- Carey, M. *Proposed Framework for Addressing Human Factors in IEC 61508*. Sudbury, Suffolk, England: HSE Books, 2001.
- Hendrikse, E.J, et al, Effectively including Human Factors in the Design of New Facilities. *Proceedings of the 2nd International Workshop on Human Factors in Offshore Operations: Demystifying Human Factors – Practical Solutions to Reduce Incidents and Improve Safety, Quality and Reliability*. Houston, Texas: April 8-10, 2002.
- Thomas, J., et al, Application of Human Factors Engineering in Reducing Human Error in Existing Offshore Systems. *Proceedings of the 2nd International Workshop on Human Factors in Offshore Operations: Demystifying Human Factors – Practical Solutions to Reduce Incidents and Improve Safety, Quality and Reliability*. Houston, Texas: April 8-10, 2002.

3 Ergonomic Design Activities

The effective integration of ergonomic considerations into system development is structured, systematic, interdisciplinary, and requirements-driven. It is a top-down design approach that starts with high-level goals that are divided into the functions necessary to achieve those goals. Functions are allocated to human and system resources. Human functions are then divided into discrete human tasks. Tasks are grouped into meaningful jobs and the human-system interface is designed to support task requirements.

A basic human-interface design approach is comprised of three phases:

i) Analysis of ergonomic design requirements

ii) Development of interface designs

iii) Performance of design verification and validation

Each of these is discussed below. The design and evaluation process described is generic and highly simplified. These general activities are appropriate to any specific design project, be it large-scale (e.g., design of a new vessel, offshore installation, or navigation bridge) or small (e.g., the design of a single piece of equipment, such as an electronic chart display).

4 Analysis of Ergonomic Design Requirements

There are five related issues to consider in the analysis of human-interface design requirements, each of these is discussed below.

4.1 Analysis of Previous Designs

One of the first human-interface design activities to be performed in any system design is the analysis of previous designs. The objective of this activity is to identify the successes and failures of previous designs to provide a basis for improvements in the new design or modification. The scope of the analysis generally includes:

i) Experiences with ergonomics from similar previous designs

ii) Interviews with subject-matter experts, such as designers, engineers, operators, and maintainers

The basic result of this effort is a list of lessons learned, in terms of both positive aspects of previous designs (including such things as coding and established expectancies) that should be carried forth, and awkward or clumsy design aspects that should be changed or improved.

4.2 Analysis of Human Functions and Tasks

One of the earliest and most critical human-interface design activities is the analysis of human functions and tasks. Task analysis focuses on understanding the functions and tasks that personnel will perform with the system in terms of:

i) The inputs and outputs for those tasks with regard to required information and control actions

ii) Feedback provided to an operator after the manipulation of a control

iii) Dependencies between tasks

iv) Sequence of task performance

v) Time and frequency of performance

vi) Accuracy requirements

vii) Criticality or importance of the tasks

viii) Error tolerance

By performing a task analysis, the designer develops an understanding of the how a workstation or work area can be designed and arranged to support reliable task performance. Task analysis also focuses on understanding the flow and sequence of human activity as work is performed. It can be used to understand how personnel move between controls, displays, consoles, panels, workstations, equipment, and work areas in performing a series of tasks. This information is used to arrange consoles, panels, and workstations based on task sequences, frequencies, and criticality.

4.3 Characteristics of Personnel

Given that ergonomics concentrates its efforts on the human-system interface, it is necessary to identify the characteristics of the system users, namely, the operators and maintainers. This requires that personnel capabilities and limitations be identified, including:

i) Training, certifications, and licenses

ii) Experience levels

iii) Physical characteristics, such as eyesight, strength, and physical size

iv) Cultural characteristics related to behavioral expectancies

v) Management styles

The characteristics of personnel need to be identified, as these can influence design (e.g., determining color-coded meanings that can vary as a function of nationality) and influence training, certification, and licensing requirements.

4.4 Environmental Analysis

Since living and workplace environmental conditions influence human performance, the environmental conditions to which personnel will be exposed need to be identified. Environmental analyses are performed to characterize external and internal factors, such as expected platform motions and sea states, temperature extremes, exposure to high noise and vibration, and lighting. All of these factors have implications for design. The analyses are typically tabletop exercises where environmental conditions are identified for the expected operating areas and associated seasonal variations.

4.5 Identify Worst-Case Situations *(1 August 2013)*

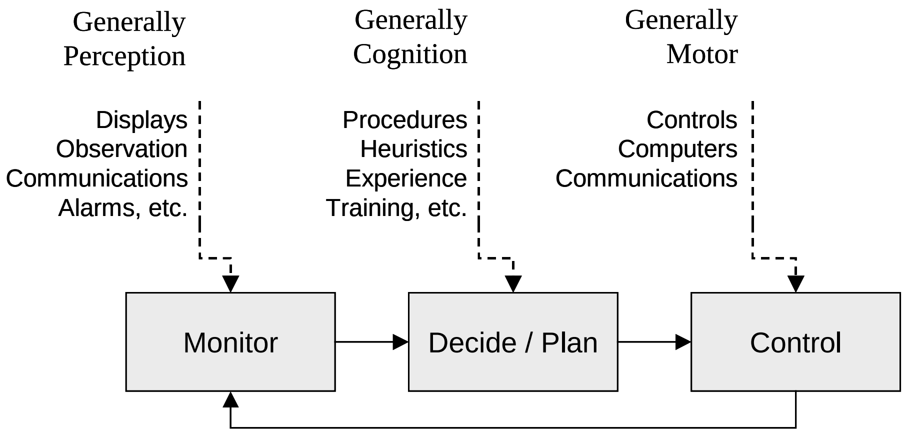
In most design efforts, it is important to predict what the likely worst-case operational and maintenance scenarios might be. For example, tasks may be required to be performed under extreme heat or cold conditions with poor lighting, or relief personnel may have lesser/inadequate training for task performance. In other situations, personnel may need to perform while stressed and under emergency conditions where some system functions are unavailable or severely degraded.

As a result, the design may be made as simple as possible, or instructions may be mounted with equipment. In other cases, functions may be automated or special tools or protective equipment provided to allow personnel to accomplish tasks under extreme conditions.

5 Develop Human System Interface Designs

The objective of design activities that integrate ergonomics principles, guidelines, and criteria is to provide human-system interfaces to support specific functions or tasks that will need to be performed by operators or maintainers. The ergonomics design activities are directed towards integrating function, task and staffing requirements identified with analysis into human-system interface designs consistent with the detailed ergonomic design guidance contained in standards, specifications, and guidelines, such as these Guidance Notes. Basically, design proceeds within the context of: human-system interface requirements identified during analysis, the guidance contained in documents like these Guidance Notes and a simple framework of human control, such as that presented in Appendix 2, Figure 1, “System Control Process”.

FIGURE 1
System Control Process



Depending on the function or to be performed, personnel will be involved in monitoring, deciding, planning, controlling activities, or some combination of these. Once this is known, determining the basic category of interface to provide becomes simpler. For example, where a person may be monitoring a system to verify that all essential parameters are within specified limits, the individual will be using their perceptual abilities. To support the monitoring task, displays and alarms can be provided according to the guidance in Section 3, "Displays" and Section 4, "Alarms" of these Guidance Notes. Furthermore, Section 5, "Integration of Controls, Displays, and Alarms", would serve to guide how the displays and alarms might be presented together to personnel.

Whether the design effort generally entails assembling "off-the-shelf" equipment (e.g., radar sets or diesel generator sets) or represents a completely new design (e.g., a new turret disconnect panel), the human-system interface should result from a process that considers the human-system interface requirements identified during analysis activities.

5.1 Perform Tradeoff Analyses

In the practice of applying ergonomic principles in design, an ongoing process of considering tradeoffs will occur within and among the elements of the ABS Ergonomic Model:

i) Design and layout (e.g., controls, displays, workspace arrangements)

ii) Ambient environment (e.g., noise, vibrations, temperature, humidity, design of accommodations)

iii) Personnel (e.g., training and certifications, health, anthropometry, susceptibility to fatigue)

iv) Management and organization (e.g., policies, written procedures, safety plans)

Tradeoffs allow designers to compensate across these domains to provide an appropriate level of human performance and safety. Ergonomic design of human-system interfaces will influence job complexity, which in turn affects personnel knowledge, skill requirements, training requirements, etc. There are of course, other significant factors contributing to the outcome of tradeoff decisions, including:

i) Cost (e.g., engineering, construction, commissioning, operating, decommissioning)

ii) Risk tolerance (e.g., business, human safety, environmental, technical, financial, societal reputation)

iii) Statutory (e.g., laws and agreements that govern functionality and design)

iv) Competitiveness

There are certainly others. However, the point here is that human element and ergonomic concerns should represent a significant component of the tradeoff and design process. In other words, human element and ergonomic concerns should have a competitive status with regard to other tradeoff elements.

Examples of tradeoffs within the context of the ABS Ergonomic Model are as follows:

i) *Personnel selection*. A way of matching personnel capabilities with the knowledge and skill demands of a given job is to select persons who already possess those knowledge and skills. Trade-offs between human-system interface design and personnel selection are performed to achieve an optimum person-job match. (Note that inadequate ergonomic design of human-system interfaces can induce human errors, and these likely cannot be compensated for by selection.)

ii) *Training*. Ergonomic design principles can be used to introduce consistent expectations in the design of the human-system interface. Where consistently applied, this reinforces the learning experience and reduces the duration and complexity of training. Note as above, training is ineffective in overcoming the error-inducing characteristics of inadequate ergonomic design.

iii) *Job aids*. Design and use of job aids can reduce workload and knowledge and skill demands. Job aids have also proven highly effective in reducing human error, enhancing task performances, reducing training and lowering minimum selection requirements.

5.2 Develop and Explore Human-System Interface Concepts

As in most situations, there are often multiple human-system interface alternatives that could be used to meet a particular need. For this reason, it is necessary to develop and explore various design concepts based on functions, requirements, human allocated tasks and selected equipment. The basic steps for concept development are illustrated in Appendix 2, Figure 2, “Concept Development and Exploration”, and are briefly described below.

5.2.1 Develop Concepts for Human-System Interface Designs

Concepts are typically developed among a group comprised of designers, engineers, ergonomists, and experienced operators and maintainers. Various approaches to human-system interface design will be developed based on the output from the analyses discussed above. In some cases, a “brain-storming” process can be employed where requirements are integrated, and design concepts are developed in the context of a tradeoff process. An aspect of the tradeoff process is that of selection of components (e.g., video displays, joysticks, radar sets, etc.) that will be arranged into a human-system interface on a console, panel, etc. Device selection generally occurs as a result of a review of human-system interface requirements, and comparison of those requirements (tradeoff criteria) to the availability of competing commercial devices (e.g., hardwired displays versus video displays from different manufacturers).

5.2.2 Develop Prototypes

Prototypes can be prepared for the various human-system interface design concepts. Initially these may consist of no more than drawings, and they can progress to more complex mockups using cardboard, plywood, or computer simulations. One advantage of a prototype is that designers, engineers, ergonomists, operators, and maintainers can look at the physical representation and perform evaluations based on the model. Another advantage is that the various personnel involved with developing design concepts can interface with the potential user (i.e., operators and maintainers) to consider alternatives to design aspects that can be improved. In addition, informal “tests” of design concepts can be conducted by simulating task performance based on representative scenarios.

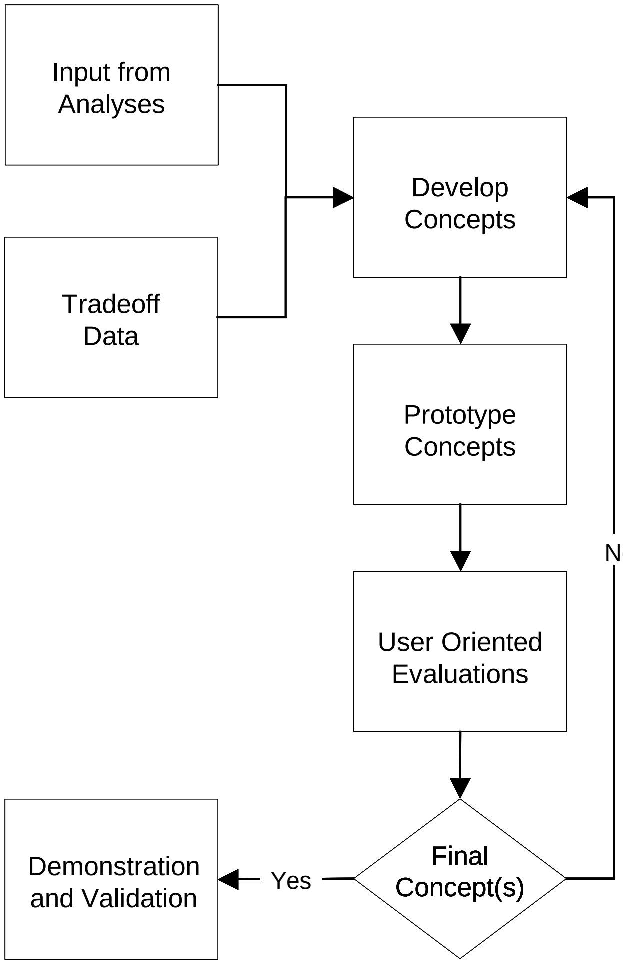
5.2.3 Evaluate the Concepts

Whether prototypes are developed or not, the various human-system interface concepts should be evaluated from an ergonomics perspective so that a satisfactory human-system interface is developed. Types of evaluations that can be conducted include:

- Subject-matter expert assessments
- Operator evaluations
- Walkthroughs and formal usability testing
- Applying checklists related to ergonomic design guidance

The results of these evaluations can be used to improve design concepts.

FIGURE 2
Concept Development and Exploration



5.3 Develop Maintainability Concepts

Design activities often focus on operations and operator needs. Maintenance issues are also critical to overall system safety and performance. To promote system reliability, availability, and safety, maintenance activities should also be analyzed and provisions made to incorporate ergonomics data and maintenance requirements into design for maintainability. Designing for maintainability should address any time constraints to repair/reinstate equipment. Repair times may need to be assumed and any assumptions should be explicitly expressed in design documents where maintainability concepts are discussed. In addition, the resources provided for maintenance, in terms of both staffing and equipment, should be sufficient to meet this goal. Throughout these Guidance Notes, maintainability design principles, guidance and criteria are provided. Before applying that information, the following should be identified and considered:

i) Maintenance concepts and goals

ii) Task-based maintenance interface design

iii) Location and design of maintenance accesses

iv) Provisions for maintenance safety

v) Tool requirements, including any special tools

vi) Provisions for logistics and spares

vii) Schedules for preventative maintenance *viii)* Testing and calibration requirements

ix) Training and certification of maintainers

x) Necessary materials handling devices and processes

6 Ergonomics Verification and Validation

The objective of ergonomics verification and validation (or test and evaluation) is to determine that human-system interface designs conform to human-interface design principles and whether the interface enables personnel to perform tasks while meeting safety and operational goals. Below are typical steps of an ergonomics verification and validation process:

i) *Task-Support Verification*. A check to confirm that the human interface addresses all identified personnel tasks.

ii) *Ergonomics Design Verification*. A check to determine whether the design of each individual interface reflects ergonomics principles, standards, and guidelines.

iii) *Integrated System Validation*. Performance-based evaluations of the integrated design to confirm that human interfaces support safe and efficient operation of the vessel or installation.

iv) *Final Design Verification*. The final product, as built, conforms to the verified and validated design that resulted from the ergonomics design process.

6.1 Subjective Evaluations

Designs can be evaluated subjectively by knowledgeable subject-matter experts (generally a team of engineers, operators, maintainers, and ergonomists). This can begin with drawings early in the design cycle and follow through to the construction phase of a project. As the design proceeds, mockups, functional prototypes, and simulations can be used to support these evaluations. The main objective of the subjective evaluation is to obtain operator and maintainer input while modifications to the design are possible.

6.2 Checklists

Drawings, mockups, and prototype equipment can be evaluated using checklists that contain ergonomics criteria, such as those in these Guidance Notes, or other ergonomics standards, specifications, or guidelines. Where design characteristics are found to deviate from criteria/guidance in a checklist, a review of the tasks and their importance to safe and efficient operations, can be performed to assess whether a design modification is needed.

6.3 Performance-Based Tests

Performance-based tests involve collecting data on human-system performance upon which to base objective evaluations of design concepts. For example, when considering which of two chart displays to acquire, having a sample of mariners try the two displays during simulated task performance can provide usability data for each device. This data on usability and performance (as well as subjective opinion) can be used to compare relative performance. The results of those comparisons can be used to select the better designs.

Documentation of the interface design includes:

i) The technical basis for human-system interface design requirements

ii) The detailed description of the human-system interface design, including its form, function, and performance characteristics

iii) The basis for the human-system interface design characteristics with respect to operating experience, tradeoff studies, engineering evaluations and experiments, and benchmark evaluations

7 Integrating Ergonomic Principles, Criteria, and Process

This Section provides guidance about a systematic and simplified human-systems interface design process. The process described earlier in this Section can be broken down at its most basic level to three sets of activities: Analysis, Design, and Verification and Validation. In this Subsection, a review of these is provided in the context of integrating the process with ergonomic principles and guidance contained in these Guidance Notes.

7.1 Analysis

For any human-system interface, three factors should be analyzed: the task to be undertaken, who will perform the task and where the task will be undertaken. These issues can be analyzed at a high level by addressing the questions presented in Appendix 2, Table 1, "Candidate Analysis Questions".

7.2 Human-System Interface Design

Once the various analyses have been completed to specify which functions and tasks will be performed by humans and under what conditions, work can begin to design the human-system interfaces using ergonomics principles and criteria. Early decisions concern the level of automation anticipated for the vessel or offshore installation. These decisions influence what functions and tasks will be conducted by personnel, and what will be assigned to equipment.

Based on automation decisions, design can proceed to determine the controls needed. These Guidance Notes can then be used to design control interfaces (see Section 2, "Controls"). Displays and alarms can be selected to provide feedback to personnel for control actions or system interventions (see Section 3, "Displays" and Section 4, "Alarms"). Selected devices can then be integrated using Section 5, "Integration of Controls, Displays, and Alarms" on or near actual equipment, on local panels or in centralized locations, such as navigation bridges or in control rooms. Where appropriate, control or feedback (displays and alarms) can be provided via video-display units placed on local panels or in centralized areas. Section 6. "Computer Workstation Design" will be helpful for these types of designs.

For equipment located in engineering spaces, on open decks, in the hull or topsides, different design considerations will be needed. Issues such as the placement of equipment, including manual valves, are also part of human-system interface design efforts. For such equipment, the physical location, identification, and access to the location are important. To assist with decision-making, designers and engineers may refer to the principles and guidance located in:

- Section 7, "Manual Valve Operation, Access, Location, and Orientation"
- Section 8, "Labeling, Signs, Graphics, and Symbols"
- Section 9, "Stairs, Ladders, Ramps, Walkways, Platforms and Hatches"

TABLE 1
Candidate Analysis Questions

Type of Analysis	*Candidate Question*
Task	What are the specific tasks required of personnel to operate and maintain the equipment or system? What are the worst-case conditions under which the task will be performed? • Under time pressure? • During an emergency? • Without vital systems? What is the likelihood of a human error while performing this task? Are errors easily reversible? What are the potential consequences associated with a human error while performing this task? • Personnel safety? • Environmental impacts? • Property damage? • Efficiency?
Personnel	Who will be operating or maintaining the equipment? What abilities will personnel need to apply to the task? • Perceptual skills for monitoring • Cognitive skills for making decisions or planning • Motor skills for controlling or maintaining What skills and knowledge, including special training, certifications, or licenses, will these personnel need? Who will these personnel be in terms of nationality, cultural background, behavioral tendencies, past work experience? Will personnel be company employees, contractors, or a combination?
Environment	What will the working environment be under which the tasks are performed? • On an open deck subject to various weather conditions? • On a vibrating surface? • In high noise conditions? • In hot or cold or humid conditions? • At night? • Inside a tank or void space?

Up to now, the text in this Subsection has focused on operability issues, but to promote system reliability and availability, human-system interfaces for maintenance should also be addressed. Many of the human-system interfaces design issues for maintenance are similar to those for operability. For example, controls will need to be provided for some maintenance tasks along with maintenance-related displays and alarms. To avoid confusion during normal operations, such interfaces are often covered or otherwise protected, but easily accessible to maintainers, as needed. Various sections of these Guidance Notes provide maintenance-specific guidance along with guidance directed at operations support. Two sections, however, focus on particular maintenance considerations. Section 10, "Maintenance Considerations" gives designers and engineers guidance related to maintenance access and task support, while Section 11, "Materials Handling" addresses manual and assisted lifting and materials handling concerns.

In addition to workplace concerns, designers and engineers of vessels and offshore installations are likely to be involved with designing accommodation spaces. Section 12, "Crew Habitability" has been provided to give basic information related to accommodation design and ambient environmental concerns. It also refers to sources of specific guidance that should prove useful for designing both living and working spaces.

7.3 Tradeoffs

Throughout the activities described in this Section, tradeoffs will need to be made. Designers, engineers, ergonomists, and even construction yard personnel will find themselves in the position of constantly trying to find a balance between the structural/equipment/system design requirements and the following human element concerns:

- Which personnel should be selected for tasks?
- How much training personnel can be assumed to have or to need?
- What jobs aids, in terms of procedures, labeling, signs, and instructions, will suffice?

Furthermore, these human element concerns will need to be weighed against other business considerations including capital and operating costs; risk tolerance; statutory, regulatory and company requirements, and competitiveness.

7.4 Verification and Validation

Once a design has been established, ergonomics criteria can be used during design reviews to check the suitability of the design for operability, maintainability, and compliance with ergonomics criteria. The criteria in these Guidance Notes can used as a part of verification and validation exercises. The criteria can be arranged into checklists in order to make assessments easier to conduct. Beyond the application of ergonomics criteria, design reviews should be completed by operators and maintainers. These reviews will help to determine where modifications are needed before the start of construction.

Final verification and validation activities can be completed in the construction yard. Here the constructed interfaces and physical layout can be checked for compliance with drawings and design intentions. Checklists can be used as well. While in the construction yard, all field-run equipment (e.g., cable trays, piping, ducting) would be checked to verify that equipment, access ways, aisleways, egress paths, overhead clearances, or assisted lifting devices are accessible and do not intrude into walkways or areas occupied by personnel.

7.5 Example 1 – Application to Equipment Design

This example involves the design and arrangement of a control station for three mooring winches located near the bow of a bulk carrier vessel. One winch is to the port side of centerline, the second is on the vessel centerline, and the third is to the starboard of centerline. All three winches may be used for mooring the vessel on either the port or starboard side.

7.5.1 Step #1 *(1 August 2013)*

Define the tasks that will be required of the operator or maintainer. In this instance the operator's tasks involve controlling the direction of winch rotation to pay out and take in the mooring lines while observing both the shore connection (e.g., T-Bitt) and the person-in-charge of the mooring operation on the deck of the vessel. The operator must monitor the hydraulic pressure at each winch to confirm that sufficient pressure is present to rotate the windlass drum. Also the operator must monitor the tension of the mooring wire to prevent over-tensioning that can cause the wire to break and possibly backlash across the vessel's deck.

In this case, the designer must recognize that the provided controls need to satisfy the operator's expectation between control movement and winch rotation. A movement of the control away from the operator's body should pay out the winch cable and a movement toward the operator's body should take in the cable. Further, this operational expectation supports the use of lever type controls for these winches.

A control station for all three winches should be provided on both the port and starboard sides of the vessel to satisfy the visual tasks of observing both the shore connection and the person-in-charge. Further, it is possible that an elevated platform may assist with the visual tasks on shore as well as on the vessel's deck.

7.5.2 Step #2

Identify the personnel who will perform the task, including nationality and regional origin.

7.5.3 Step #3

Identify the operating environments that the controls may be used in (e.g., hot and humid tropical climates to very cold winter conditions) or during day and night hours. This dictates whether or not the controls need to be designed for use by operators wearing personnel protective equipment (e.g., mittens or gloves) and if the controls and displays should be illuminated.

7.5.4 Step #4

Identify the potential "worst case" under which the system could be operated, such as a combination of extreme weather, (e.g., cold temperatures and high winds) and the vessel's condition (e.g., fully loaded).

With this background, the designer can now define the design requirements, which are:

i) Use of lever-type controls for each winch with control movement to match the operator's expectations

ii) Use of an analog gauge to display the hydraulic pressure at each winch

iii) Design of the controls for use by gloved hands

iv) Locate controls that provide the operator with visual contact with the shore connections and person-in-charge on deck

v) Mount the controls and displays at a height to be operated by personnel of various regional origins

vi) Illuminate the displays and control labeling to be read at night; and

vii) Provide an automatic torque limiting control on the winches to prevent over-stressing the mooring line.

With the design requirements defined, the designer can now go to these Guidance Notes, or other sources of ergonomic guidance, for specific principles to consider in the development of the design.

Section 2, "Controls" provides pertinent paragraphs on control actuators, control movement expectancy, and control actuator integration for control panels.

To establish the proper mounting height for the controls, Section 2, Figure 2, "Control Actuator Mounting Height for Standing Operator", indicates that the controls should be 860 mm (34 in.) to 1350 mm (53 in.) above the operator's standing surface. Control and display labeling requirements are provided in Section 8, "Labeling, Signs, Graphics, and Symbols". Following the above process will result in ergonomically designed control panels for the three mooring windlasses.

7.6 Example 2 – Application to ABS Machinery Rules

Section 4-6-4, "Piping Systems" of the ABS *Rules for Building and Classing Steel Vessels* provides requirements for gravity drain systems through shipside. Specifically, 4-6-4/3.3 requires that, "…the discharge pipe may have two non-return valves without positive means of closing, provided the inboard non-return valve is always accessible for examination under service conditions".

An accepted interpretation of this requirement is that the valve should be located above the deepest load waterline and that it should not be in a space that is inaccessible, such as a ballast tank.

7.6.1 Step #1

Define the tasks to meet the stated ABS Rule. In this instance, personnel must be able to make a visual inspection of the valve and its flanged connections. Sufficient lighting and placement of the valve must be provided to be capable of both visual inspection and physical contact for operation and maintenance.

However, if the valve is leaking, or if there is evidence that seawater is backing up the line, the valve may need to be repaired or replaced. This will require additional personnel tasks such as removing bolts at the flange, lifting the old valve out and replacing it with a functioning valve. These tasks require physical exertion. This implies that a suitable working surface should be provided, since both hands are necessary to do the job.

7.6.2 Step #2

Identify the personnel who will perform the task. If it is known who will be crewing the vessel (e.g., North Americans, Asians, Northern Europeans), the task of identifying the physical dimensions of personnel (i.e., the anthropometric dimensions) becomes easier. However, as this is unknown at this stage, and it is likely that different nationalities will be involved, it is preferable to design for an anthropometrically smaller population (e.g., South-East Asian).

7.6.3 Step #3

Identify the operating environment. In this example, the tasks are largely physical (as compared to mental) and of a short duration. Thus, the effect of the physical work environment might not be of critical importance (e.g., temperature, humidity, and noise). However, the one environmental issue that could be of importance is the lighting level of the work area.

7.6.4 Step #4 *(1 August 2013)*

Identify the potential "worst case" in which tasks may be performed. The worst case might be a combination of the following:

i) The crew member normally trained to complete a task is not available for whatever reason, and the task should be completed by someone with less training or experience

ii) That the task is required to be performed under stressful (i.e., emergency) conditions; or

iii) That it be completed under severe operating conditions (e.g., rough weather or extreme environmental limits).

These "worst case" conditions should be anticipated at the time of vessel design in order to reduce the chance of human error if these conditions exist. The following design objectives may then be established:

i) Adequate lighting levels at the valve

ii) Means to allow personnel to access the valve

iii) If desired, a work platform to allow valve repair operation

Lighting can be provided by standard engine room fixtures or dedicated lighting. In this particular case, lighting may also be provided by a portable lighting source (e.g., a flashlight). Section 6, Table 4, "Lighting Criteria for Operating and Maintenance Spaces", of the ABS *Guide for Crew Habitability on Ships*, states an illuminance level of at least 300 lux for machinery control rooms and 150 lux for other machinery spaces (e.g., generator rooms, fan rooms). Considering the relatively simple nature of the task to be completed (i.e., visual or physical inspection of the valve flanges), the lower lighting level should be adequate.

To enable personnel to see or reach the valve, the standing surface should be within the extended overhead arm reach of the 5th percentile South-East Asian male. Section 7, Figure 3, "Mounting Heights for Handwheel Valves with Angled Stems" shows that valves may be mounted overhead up to a height of 1980 mm (78 in.). This dimension is based on North American males and any adjustments to this height should be based on a review of the anthropometric data contained in Appendix 1, "Anthropometric Design Principles and Dimensions".

However, if that standing surface is also used to access the valve for repair or replacement, it should be closer to the valve, since applying torque to loosen bolts and/or lifting a valve above the head can be difficult and hazardous operations.

If the valve height above a permanent deck or other standing surface exceeds that discussed above, a ladder or other means should be provided to allow personnel to safely reach the valve. Suggested design criteria for ladders are contained in Section 9, "Stairs, Ladders, Ramps, Walkways, Platforms and Hatches". If vertical access were required just for valve examination, then a vertical ladder would probably be sufficient, since the task requires only one hand. If however, the vertical access was to be used for valve repair or replacement, some form of work platform would be needed below the valve, since this task would require the use of both hands. Suggested criteria are contained for both in Section 9, "Stairs, Ladders, Ramps, Walkways, Platforms and Hatches".

i) Standing platforms (i.e., valve inspection 380 mm (15 in.) wide × 460 mm (18 in.) in depth)

ii) Working platforms (i.e., valve repair or replacement 760 mm (30 in.) wide × 915 mm (36 in.) in depth)

Following the above process would provide a reasonable and safe working environment for the range of personnel populations likely to be employed on a vessel or offshore installation.

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APPENDIX 4 Acronyms and Abbreviations

°	Degree
°C	Degrees Celsius
°F	Degrees Fahrenheit
ABS	American Bureau of Shipping
ANSI	American National Standards Institute
ASTM	American Society of Testing and Materials
BS	British Standard
cd/m^2	Candela-per-square meter
CIE	Commission Internationale De L'eclairage
dB(A)	Decibels measured using the A-weighted scale
ft	Feet
ft/s	Feet-per-second
ft^2	Square feet
HAB	Habitability notation
HSE	Health and Safety Executive
HVAC	Heating, Ventilation, and Air Conditioning
Hz	Hertz
ILO	International Labor Organization
IMO	International Maritime Organization
in.	Inch
ISO	International Organization for Standardization
kPa	Kilopascals
L_{Aeq}	Equivalent continuous A weighted sound pressure level
m	Meter
m/s	Meters-per-second
m/s^2	Meter-per-square second
m^2	Square meter
mm	Millimeter
PPE	Personal Protective Equipment
psi	Pounds-per-square inch
UK	United Kingdom
USCG	United States Coast Guard
VDT's	Visual Display Terminals