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GUIDELINES ON ERGONOMIC CRITERIA FOR BRIDGE EQUIPMENT AND LAYOUT

1 The Maritime Safety Committee, at its seventy-third session (27 November to 6 December 2000), adopted the annexed Guidelines on Ergonomic Criteria for Bridge Equipment and Layout which have been developed to assist designers in realising a sufficient ergonomic design of the bridge, with the objective of improving the reliability and efficiency of navigation.

2 These Guidelines have been prepared to support provisions of the revised regulation V/15 of the SOLAS Convention – Principles relating to bridge design, design and arrangement of navigational systems and equipment and bridge procedures, which is expected to enter into force on 1 July 2002.

3 Member Governments are invited to bring these Guidelines to the attention of all parties concerned.

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ANNEX

GUIDELINES ON ERGONOMIC CRITERIA FOR BRIDGE EQUIPMENT AND LAYOUT

Contents

1 Scope

The Guidelines are developed to realize a successful ergonomic design of the bridge and the equipment on the bridge, which will improve the reliability and efficiency of navigation. These Guidelines therefore contain ergonomic requirements as well as a functionally oriented bridge layout to support watch-keeping personnel in their tasks by a user-centred design of the bridge equipment and layout.

2 Purpose

The purpose of these Guidelines is to provide ergonomic requirements for the bridge equipment and layout to render assistance to enable consistent, reliable and efficient bridge operation.

3 Application

These Guidelines are intended to apply to new ships.

4 Description of the Workstations on the Bridge

Workstation for navigating and manoeuvring:
Main workstation for ship's handling conceived for working in seated/standing position with optimum visibility and integrated presentation of information and operating equipment to control and consider ship's movement. It should be possible from this place to operate the ship safely, in particular when a fast sequence of actions is required.

Workstation for monitoring:
Workstation from which operating equipment and surrounding environment can be permanently observed in seated / standing position; when several crew members are working on the bridge it serves for relieving the navigator at the workstation for navigating and manoeuvring and/or for carrying out control and advisory functions by master and/or pilot.

Workstation for manual steering (Helmsman's workstation):
Workstation from which the ship can be steered by a helmsman as far as legally or otherwise required or deemed to be necessary, preferably conceived for working in seated position.

Workstation for docking (bridge wing):
The workstation for docking operations on the bridge wing should enable the navigator together with a pilot (when present) to observe all relevant external and internal information and control the manoeuvring of the ship.

Workstation for planning and documentation:
Workstation at which ship’s operations are planned (e.g. route planning, deck log). Fixing and documenting all facts of ship's operation.

Workstation for safety:
Workstation at which monitoring displays and operating elements or systems serving safety are co-located.

Workstation for communication:
Workstation for operation and control of equipment for distress and safety communications (GMDSS) and general communications.

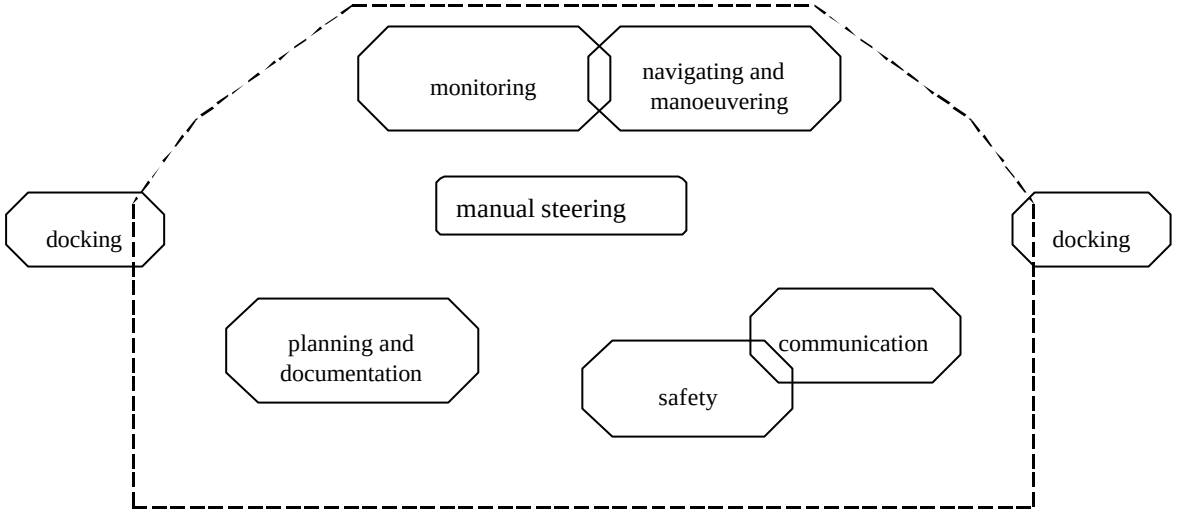


Fig. 1: Example of function areas – showing a possible location of workstations

In APPENDIX 2 the recommended equipment for the various workstations is listed.

Ergonomic Requirements

5.1 Bridge Layout

5.1.1 Sight

5.1.1.1 Field of Vision

5.1.1.1.1 Minimum Field of Vision

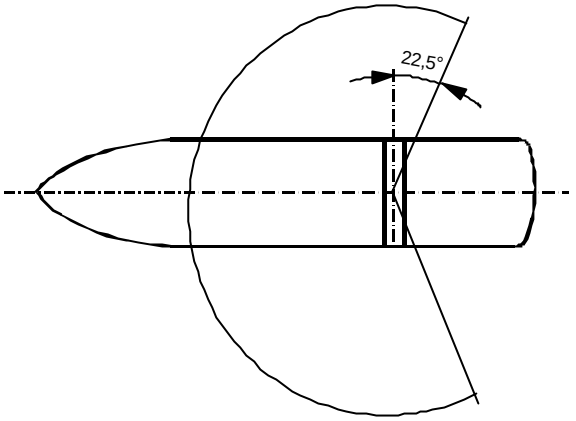
The view of the sea surface from the navigating and manoeuvring workstation should not be obscured by more than two ship lengths or 500 m, whichever is less, forward of the bow to 10° on either side under all conditions of draught, trim and deck cargo.

5.1.1.1.2 Field of Vision around the Ship

There should be a field of vision around the vessel of 360° obtained by an observer moving within the confines of the wheelhouse.

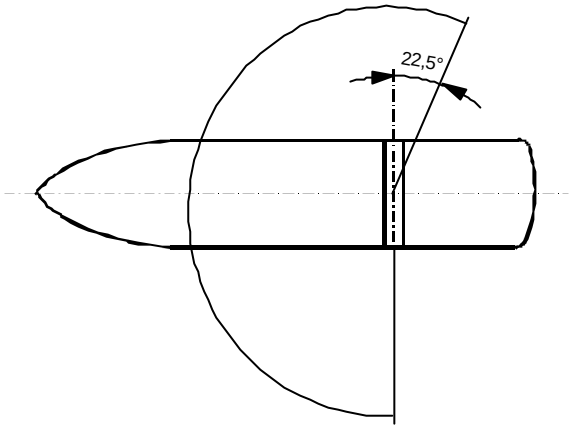
5.1.1.1.3 Navigating and Manoeuvring Workstation

The horizontal field of vision from the navigating and manoeuvring workstation should extend over an arc of not less than 225°, that is from right ahead to not less than 22.5°, abaft the beam on either side of the ship.



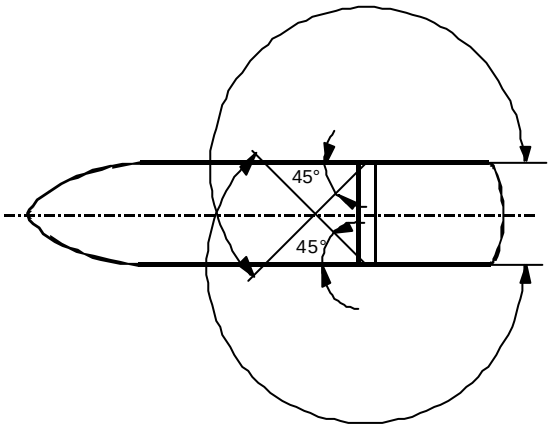
5.1.1.1.4 Monitoring Workstation

From the monitoring workstation, the field of vision should extend at least over an arc from 90° on the port bow, through forward, to 22.5° abaft the beam on starboard.



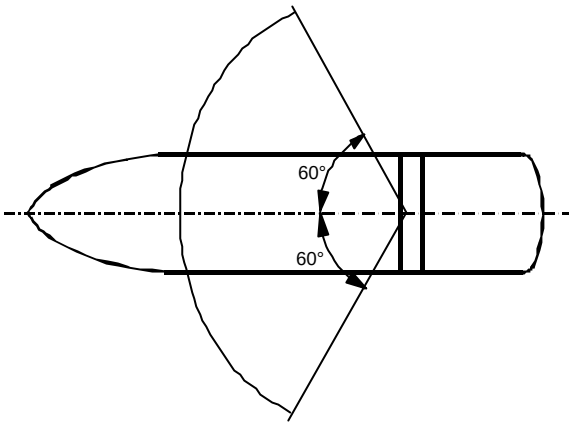
5.1.1.1.5 Bridge Wing

From each bridge wing the horizontal field of vision should extend over an arc at least 225°, that is at least 45° on the opposite bow through right ahead and then from right ahead to right astern through 180° on the same side of the ship.



5.1.1.1.6 Main Steering Position

From the main steering position (workstation for manual steering) the horizontal field of vision should extend over an arc from right ahead to at least 60° on each side of the ship.



5.1.1.1.7 Blind Sectors

The safe look-out from the navigating and manoeuvring workstation should not be influenced by blind sectors.

No blind sector caused by cargo, cargo gear or other obstructions outside of the wheelhouse forward of the beam which obstructs the view of the sea surface as seen from the navigating and manoeuvring workstation, should exceed 10°. The total arc of blind sectors should not exceed 20°. The clear sector between two blind sectors should be at least 5°. Over an arc from right ahead to at least 10° on each side, each individual blind sector should not exceed 5°.

5.1.1.1.8 View of the Ship's Side

The ship’s side should be visible from the bridge wing. Bridge wings should be provided out to the maximum beam of the ship. The view over the ship’s side should not be obstructed.

5.1.1.2 Windows

5.1.1.2.1 Lower Edge of the Front Window

The height of the lower edge of the front windows should allow a forward view over the bow for a person in a sitting position at the workstation for navigating and manoeuvring and the workstation for monitoring.

Within the required field of vision the height of the lower edge of the windows above the bridge deck should be kept as low as possible. In no case should the lower edge present an obstruction to the forward view as described in 5.1.1.1.

5.1.1.2.2 Upper Edge of the Front Window

The upper edge of the front windows should allow a forward view of the horizon for a person in a standing position with an eye height of 1.800 mm above the bridge deck at the navigating and manoeuvring workstation, when the ship is pitching in heavy seas. If 1.800 mm eye height is unreasonable and impractical, the eye height may be reduced, but not less than 1.600 mm.

5.1.1.2.3 Framing Between Windows

Framing between windows should be kept to a minimum and not be installed immediately forward of any workstation, or the centre-line. If stiffeners between windows are to be covered, this should not cause further obstructions of the field of view from any position inside the wheelhouse.

5.1.1.2.4 Front Window Inclination

To help avoid reflections, the bridge front windows should be inclined from the vertical plane top out, at an angle of not less than 10° and not more than 25°.

5.1.1.2.5 Rear and Side Window Inclination

To help avoid reflections, rear and side windows should be inclined from the vertical plane top out, at an angle of not less than 10° and not more than 25°. Exceptions can be made for windows in bridge wing doors.

5.1.1.2.6 Removable Sunscreens

To ensure a clear view and to avoid reflections in bright sunshine, sunscreens with minimum colour distortion should be provided at all windows. Such screens should be readily removable and not permanently installed.

5.1.1.2.7 Glass Characteristics

Polarized and tinted windows should not be fitted.

5.1.1.2.8 Clear View

A clear view through at least two of the bridge windows and, depending on the bridge configuration, an additional number of windows with a clear view should be provided at all times, regardless of the weather conditions.

5.1.2 Arrangement

5.1.2.1 Wheelhouse Dimensions

The clear ceiling height in the wheelhouse should be designed with regard to the installation of overhead panels and devices. The clear height between the bridge deck surface covering and the underside of the deck head beams should be at least 2.25 m. The lower edge of deckhead mounted equipment should be at least 2.1 m above the deck in open areas, passageways and at standing workstations.

5.1.2.2 View of the area in front of the bridge superstructure

It should be possible to watch the area in front of the bridge superstructure from the wheelhouse.

5.1.2.2.1 Position close to the Forward Centre Window

A position should be provided close to the forward centre window.

If the view in the centre-line is obstructed by large masts, cranes, etc., two additional positions giving a clear view ahead should be provided, one on the port side and one on the starboard side of the centre-line, no more than 5 m apart.

5.1.2.2.2 Access to Front Window

A second close approach access besides the position should be possible or the width of the position should be sufficient to accommodate two persons.

5.1.2.3 Position of the Workstation for Navigating and Manoeuvring

The workstation for navigating and manoeuvring should be laid out if practicable, at the starboard side close to the centre-line.

5.1.2.4 Position of the Workstation for Manual Steering

The workstation for manual steering should preferably be located on the ship's centre-line. If the view ahead is obstructed by large masts, cranes, etc., the steering station should be located a distance to starboard of the centre-line, sufficient to obtain a clear view ahead. If the workstation for manual steering is located off the centre-line, special steering references for use by day and night should be provided, e.g. sighting marks forward.

5.1.2.5 Position of the Workstation for Monitoring

The workstation for monitoring should be laid out if practicable, at the port side close to the centre-line.

5.1.2.6 Bridge Wing Communication

An internal communication system between the workstation for docking and the workstation for navigating and manoeuvring should be provided when the distance between the workstations is greater than 10 m. An internal communication system should always be provided between the workstation for navigating and manoeuvring and open bridge wings. Where workstations are widely spread, internal communication systems should be provided so that unhampered communications can be achieved under all operating conditions. It is important that all order/action communication systems be two-way.

5.1.2.7 Doors

All wheelhouse doors should be operable with one hand. Bridge wing doors should not be self-closing. Means should be provided to hold bridge wing doors open.

5.1.2.8 Portable Items

Portable items, such as safety equipment, tools, lights, pencils, should be stored at appropriate places, specially designed wherever necessary.

5.1.3 Accessibility and Movement

5.1.3.1 Clear Route

A clear route across the wheelhouse from bridge wing to bridge wing should be provided. The width of the passageway should be at least 1 200 mm.

5.1.3.2 Adjacent Workstation Distances

The distance between adjacent workstations should be sufficient to allow unobstructed passage to persons not working at the stations.

The free passage in passageways between different workstation areas should be at least 700 mm. The workstation operating area should be part of the workstation not of the passageway.

5.1.3.3 Passageway Dimensions

The distance from the bridge front bulkhead, or from any consoles or installations placed against the front bulkhead, to any consoles or installations placed away from the bridge front should be sufficient for two persons to pass each other. The distance of a passageway between the front bulkhead and any consoles should preferably be at least 1 000 mm, and not less than 800 mm.

5.2 Work Environment

5.2.1 Climate

5.2.1.1 Effective Temperature

The optimum range of effective temperature for accomplishing light work while dressed appropriately for the season or climate is 21 - 27 °C in a warm climate or during the summer, and 18 - 24 °C in a colder climate or during the winter.

5.2.1.2 Temperature Differences

Temperature difference between any two points within the workplace should be maintained below 5 °C, e.g. the temperature of the air at floor level and at head level.

5.2.1.3 Humidity

Humidity should be maintained between 20 % and 60% with 40 % to 45 % preferred. Approximately 45% relative humidity should be provided at 21°C. This value should decrease with rising temperatures, but should remain above 20 % to prevent irritation and drying of body tissues, eyes, skin, and respiratory tract.

5.2.2 Ventilation and Air-conditioning

5.2.2.1 Air-conditioning

The wheelhouse should be equipped with an adequate air-conditioning or mechanical ventilation system to regulate temperature and humidity. The temperature and the humidity should be adjustable within the limits of the foregoing requirements 5.2.1, by closed wheelhouse doors and windows.

5.2.2.2 Hot Air Discharge

Heating systems should be designed so that hot air discharge is not directed at personnel.

5.2.2.3 Cold Air Discharge

Air conditioning systems should be designed such that cold air discharge is not directed at personnel.

5.2.2.4 Air Velocities

Ventilating systems should not produce air velocities exceeding 0,5 m/s. If possible, the preferred air velocity of 0,3 m/s should be used to preclude manual pages from being turned or papers from being blown off work surfaces.

5.2.3 Noise and Acoustics

Workplace noise should be maintained at levels that do not: (1) interfere with necessary voice, telephone and radio communications, (2) cause fatigue or injury and (3) degrade overall system effectiveness.

5.2.4 Vibration

Uncomfortable levels of vibration should be avoided on the bridge. Vibrations on the bridge should be reduced to such extent that the bridge personnel are neither hindered in their functions nor put at a health risk.

5.2.5 Illumination and Lighting

A satisfactory level of lighting should be available to enable the bridge personnel to complete such tasks as maintenance, chart and office work satisfactorily, both at sea and in port, daytime and night time.

5.2.5.1 Dark Adaptation

Red or filtered white light should be used to maintain dark adaptation whenever possible in areas or on items of equipment requiring illumination in the operational mode. This should include devices in the bridge wings.

5.2.5.2 Luminance Contrast

High contrast in luminance between work area and surrounding should be avoided, i.e. luminance of the task area should not be greater than 3 times the average luminance of the surrounding area.

5.2.5.3 Flexible Lighting System

The lighting system should enable the bridge personnel to adjust the lighting in brightness and direction as required in different areas of the bridge and by the needs of individual devices. The following table lists the recommended general illumination:

Place	Colour/Illumination
Bridge, night	Red or filtered white, continuously variable from 0 to 20 lux
Adjacent corridors and rooms, day	White, continuously variable from 0 to at least 300 lux
Adjacent corridors and rooms, night	Red or filtered white, continuously variable from 0 to 20 lux
Obstacles, night	Red spotlights, continuously variable from 0 to 20 lux
Chart table, day	White floodlight, continuously variable from 0 to 1000 lux White spotlights, continuously variable from 0 to 100 lux
Chart table, night	Filtered white floodlight or spotlights, continuously variable from 0 to 20 lux

5.2.5.4 Light Dimming

A light dimming capability should be provided.

5.2.5.5 Glare Avoidance

Up most care should be taken to avoid glare and stray image reflections in the bridge environment.

5.2.5.6 Lighting Sources

Lighting sources should be designed and located to avoid creating glare from working and display surfaces.

5.2.5.7 Reflection in Windows

Reflection in windows of devices, instruments and consoles and other reflective enclosures should be avoided.

5.2.5.8 Glare and Reflection Avoidance

Devices should be designed and fitted to minimize glare or reflection or being obscured by strong light.

5.2.5.9 Flicker Avoidance

Light sources should not have a perceptible flicker.

5.2.5.10 Lighting Controls

Lighting controls should be provided at entrances and exits of enclosed workplace areas.

5.2.5.11 Lighting Control Illumination

Lighting controls should be illuminated.

5.2.5.12 Interior Colour Design

For the interior nonsaturated colours should be chosen which give a calm overall impression and minimize reflectance. Bright colors should not be used. Dark or mid-green colours are recommended, alternatively blue or brown may be used.

5.2.6 Occupational Safety

5.2.6.1 Non-slip Surfaces

Wheelhouse, bridge wings and upper bridge decks should have non-slip surfaces.

5.2.6.2 General Wheelhouse Safety

There should be no sharp edges or protuberances which could cause injury to personnel.

5.2.6.3 Hand and Grab Rails

Sufficient hand- or grab-rails should be fitted to enable personnel to move or stand safely in bad weather. Protection of stairway openings should be given special consideration.

5.2.6.4 Safety Equipment Marking

All safety equipment carried on the bridge should be clearly marked, be easily accessible and have its stowage position clearly indicated.

5.3 Workstation Layout

5.3.1 Consoles

5.3.1.1 Workstation Area

The workstations for navigating and manoeuvring, monitoring and for the bridge wings should be planned, designed and placed within an area spacious enough for not less than two operators, but close enough for the workstations to be operated by one person.

5.3.1.2 Single Operator Console Width for Seated Operations

The console should be dimensioned and configured so that all relevant controls can be reached from a sitting position.

5.3.1.3 Left-to-Right Viewing Angle

The console should be designed that from the normal working position the total required left-to-right viewing angle should not exceed 190°. This angle shall be reduced whenever possible through appropriate control-display layout.

5.3.1.4 Console Height

The top of the consoles should not exceed a height of 1200 mm.

5.3.1.5 Console Leg Room

The upper leg room of the console should have a minimum of 450 mm in depth and the lower leg room a minimum of 600 mm in depth.

5.3.1.6 Chart Table Dimensions

The chart table should be large enough to accommodate all chart sizes normally used internationally for navigation.

5.3.1.7 Chair Design

Chairs at workstations designed for a sitting position should be capable of rotating with the foot rest being arrested, adjustable in height, and capable of being arrested on the floor. Chairs should be movable out of the operating area.

5.3.2 Device, Control and Display Integration

5.3.2.1 Logical Arrangement

The devices, displays and controls should be fitted in a logical arrangement and combined into function groups.

5.3.2.2 Location Consistency

Location of recurring functional groups and individual items should be similar from console to console.

5.3.2.3 Visual Information for more than one User

Displays providing visual information to more than one person on duty should be located for easy viewing by all users concurrently, or if this is not possible, the displays should be duplicated.

5.3.2.4 Control and Display Location

Controls and their associated displays should be located that the information on the displays can be easily read, during the operation of the controls.

5.3.2.5 Simultaneous Use

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

5.3.2.6 Control/Indicator Discernability

Controls or combined controls/indicators should be visually and tactually distinguishable from elements which only indicate.

5.3.2.7 High Priority Displays

Where two operators must use the same display, and the displays have high priority duplicate sets should be provided whenever there is adequate space. Otherwise, displays should be centred between the operators, alternatively they can be placed that they can be easily monitored by both operators, e.g., above the front window.

5.3.2.8 Centring of Shared Displays

Where two operators must use the same display, and secondary displays must be shared, they should be centred between the operators if they are equally important to each operator. If the displays are more important to one operator than to the other, they should be placed nearest the operator having the principal requirements for using them, alternatively they can be placed that they can be easily monitored by both operators, e.g., above the front window.

5.3.3 Arrangement and Grouping of Controls

5.3.3.1 Control Placement

Controls requiring frequent or accurate settings should not be placed more than 675 mm from the front edge of the console.

5.3.3.2 Control Positioning for Simultaneous Operation

Controls should be located so that simultaneous operation of two controls will not necessitate a crossing or interchanging of hands.

5.3.3.3 Location of Primary and Frequently Used Controls

The most important and frequently used controls should have the most favourable position with respect to ease of reaching and grasping (particularly rotary controls and those requiring fine settings), e.g., keys for emergency functions should have a prominent position.

5.3.3.4 Consistent Arrangement

The arrangement of functionally similar or identical controls should be consistent from workstation to workstation, panel to panel throughout the bridge.

5.3.3.5 Spacing Between Controls

Appropriate spacing between the controls should be provided.

5.3.4 Display Arrangement

5.3.4.1 Immediate Field of View

The most important and/or frequently used displays should be located within the operator's immediate field of view (viewing area with eye rotation only) (Fig. 5.1).

5.3.4.2 Preferred Viewing Area

The preferred viewing area should be reserved exclusively for the most important and/or frequently used displays (Fig. 5.1).

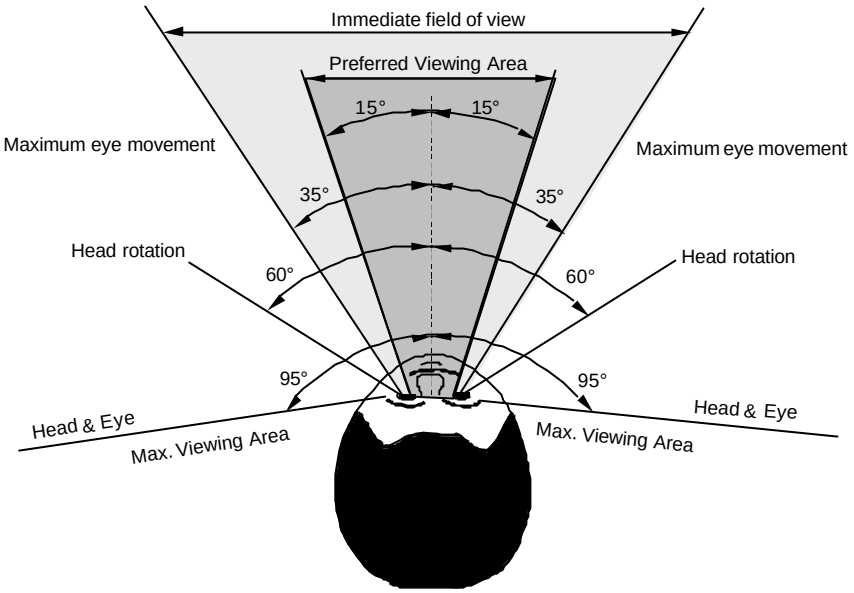


Fig. 5.1: Horizontal field of view

5.3.5 Labelling of Controls and Displays

5.3.5.1 Functional Labelling

Controls and displays should be labelled clearly and unequivocally according to their function, possibly by using standardized symbols.

5.3.5.2 Label Terminology

The selection and use of terminology for labels should be consistent between controls and displays.

5.3.6 Lighting of Devices

5.3.6.1 Adjustable Lighting

Adjustable lighting (dimming control) should be provided for controls and visual displays, including display, control, and panel labels and critical markings, that must be read at night or under darkened conditions. The range of the dimming control should permit the displays to be legible under all ambient illumination conditions.

5.3.6.2 Dimming Capabilities

The lighting of the devices should be continuously or multiple step adjustable down to zero, except the lighting of warning and alarm indicators and the control of the dimmers which should remain readable.

5.3.6.3 Individual Lighting Adjustment

Each device should be fitted with an individual lighting adjustment. In addition functional groups of devices, displays and controls should be equipped with common light adjustment.

5.4 Alarms

5.4.1 Alarm Management

5.4.1.1 Alarm Acknowledgement

A method of acknowledging all alarms (silence audible alarms and set visual alarms to steady state), including the indication of the source of the alarm, should be provided at the navigating and manoeuvring workstation, to avoid distraction by alarms which require attention but have no direct influence on the safe navigation of the ship and which do not require immediate action to restore or maintain the safe navigation of the ship.

5.4.1.2 Fire and Emergency Alarms

The alarm indicators and controls of the fire alarm and emergency alarm should be located at the safety workstation.

5.4.1.3 Failure or Reduction of Power Supply

Alarms should be provided to indicate failure or reduction in the power supply which would effect the safe operation of the equipment.

5.4.1.4 Sensor Input Failure or Absence

Alarms should be provided to indicate sensor input failure or absence.

5.4.1.5 Alarm Status

Alarm systems should clearly distinguish between alarm, acknowledged alarm, and no alarm (normal condition).

5.4.1.6 Acknowledgement of Alarms

Alarms should be maintained until they are acknowledged.

5.4.1.7 Cancellation of Alarms

Alarms and acknowledged alarm should only be capable of being cancelled if the alarm condition is rectified. This cancellation should only be possible at the individual equipment.

5.4.1.8 Alarm Minimization

The number of alarms should be minimized.

5.4.1.9 Alarm Testing

Provision should be made for functionally testing alarms.

5.4.1.10 Power supply

Required alarm systems should be continuously powered and should have an automatic change-over to a stand-by power supply in case of loss of normal power supply.

5.4.1.11 Indication of Alarms

Alarms should be indicated in order of sequence and provided with aids for decision-making. An explanation or justification of an alarm should be available (on request).

5.4.1.12 Presentation of Alarms

The presentation of alarms should be clear, distinctive, unambiguous, and consistent.

5.4.1.13 Modes of Alarms

All required alarms should be presented through both visual and auditory means.

5.4.2 Visual Alarms

5.4.2.1 Discrimination of Visual Alarms

Visual alarms should clearly differ from routine information on displays.

5.4.2.2 Presentation of Visual Alarms

Visual alarms should be flashing. The flashing display should change to steady display upon acknowledgement.

5.4.2.3 Presentation of Acknowledged Alarms

Acknowledged alarms should be presented by steady display.

5.4.2.4 Presentation of Normal Conditions (No Alarm)

Alarm indicators should be designed to show no light in normal conditions (no alarm) or should be non-existent on displays.

5.4.2.5 Flash Rate

Flashing visual alarms should be illuminated for at least 50 % of the cycle and have a pulse frequency in the range of 0.5 Hz to 1.5 Hz.

5.4.2.6 Night Vision

Visual alarms on the navigating bridge should not interfere with night vision.

5.4.3 Audible Alarms

5.4.3.1 Use of Audible Alarms

Audible alarms should be used simultaneously with visual alarms.

5.4.3.2 Audible Alarms

Audible alarms should go off upon acknowledgement.

5.4.3.3 Focusing on Audible Alarms

Audible alarms should be differentiated from routine signals, such as bells, buzzers, and normal operation noises.

5.4.3.4 Sound Characteristic

Under normal working conditions, the alarm signals should be heard properly inside the wheelhouse and outside on the bridge wings and their sound characteristics should not be inconvenient to the human ear.

5.4.3.4.1 Sound Pressure

Audible alarm sound pressure, one metre from the source should be at least 75 dB(A), and at least 10 dB(A), or preferable 20 dB(A), above ambient noise levels existing during normal operations. Audible alarm sound pressures in a space should not exceed 115 dB(A).

5.4.3.4.2 Sound Frequency

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

5.5 Input Devices

5.5.1 Movement of Controls

Movement of a control forward, clockwise to the right, or up, should:

- turn the equipment or component on, or
- cause the quantity to increase, or
- move the equipment or component forward, clockwise, to the right, or up.

5.5.2 Corresponding Movements

Controls should be selected so that the direction of movement of the control will be consistent with the related movement of an equipment component, or vessel. The direction of motion of operating elements for manoeuvring equipment should correspond with the direction of the effect on the ship caused by the installations controlled.

5.5.3 Return to Navigation Monitoring Mode

When a single device is used simultaneously for voyage planning and navigation monitoring it should be possible to revert to the monitoring mode with a single operator action.

5.5.4 Minimal User Actions

Control actions should be simple, particularly for real-time tasks requiring fast user response; control logic should permit completion of a transaction sequence with the minimum number of actions.

5.5.5 Consistency of Control Actions

The same functions should be activated on devices by the same control actions, as far as practicable.

5.5.6 Feedback

Visual, auditory or mechanical feedback should be provided to indicate that a controller input has been registered.

5.5.7 Operation of Controls

Controls should be easy to identify and operate.

5.5.8 Accessibility of Controls for Important Functions

The controls for the most important and/or frequently used functions should be easily visible and accessible to the user from the normal working position.

5.5.9 Operation of Controls for Important Functions

The controls for the most important and/or frequently used functions should require only a single actuation to accomplish their function.

5.5.10 Assignment of Controls of Important Functions

The controls for the most important and/or frequently used functions should be assigned to only one function.

5.5.11 Accidental Input or Actuation Prevention

The system should be designed to prevent the accidental manipulation of controls, e.g. physical protection, which could result in changes to the status of the system, the system functions, components, or data, e.g. loss of power.

5.6 Information Display

5.6.1 General Display Requirements

5.6.1.1 Lack of Ambiguity

Display indicators should clearly and unambiguously direct and guide the appropriate control response.

5.6.1.2 Use of Digital Displays

Digital displays should be used for the presentation of quantitative data when exact values are required and continuos trend or rate of change information is not required.

5.6.1.3 Digital Readout

A digital readout should not be used when the information changes with a frequency of more than 0,5 Hz; a higher frequency may be used when the information perception from other displays is not disturbed.

5.6.1.4 Update of Information

The displayed information should be continuously updated.

5.6.1.5 Information Duration

For signals or displays which frequently or consistently change their outputs, the information displayed should have duration's of sufficient length to be reliably detected under expected operator workload and operational environment.

5.6.1.6 Display Simplicity

Displays should present the simplest information consistent with their function; information irrelevant to the task should not be displayed, and extraneous text and graphics should not be present.

5.6.1.7 Only Necessary Data Displayed

Displayed data should be tailored to users needs, providing only necessary and immediately usable data for any transaction. Displays should not be overloaded with extraneous data.

5.6.1.8 Uncluttered Displays

Displays should be as uncluttered as possible.

5.6.1.9 Display of Important Information

Highly important and/or frequently used information should be permanently displayed.

5.6.1.10 Display Fields for the Display of Important Information

The display fields for the presentation of the most important and/or frequently used information should be assigned exclusively to them and should not be used to display any other information.

5.6.1.11 Graphic Display Enhancement With Numeric Values

When precise reading of a graphic display is required, the display should be annotated with actual data values to supplement their graphic representation.

5.6.1.12 Indication of Scale

The scale of maps and charts (data) shown on the display should always be indicated.

5.6.1.13 Aiding Distance Judgements

When a user must judge distances accurately on a map or other graphic display, computer aids should be provided for that judgement.

5.6.2 Arrangement of Visual Information

5.6.2.1 Screen Organization

A standard display screen organization should be evident for the location of various system functions (such as a data display zone, control zone, message zone) from one display to another.

5.6.2.2 Grouping of Information in a Display

Information on a display should be grouped according to obvious principles, e.g., by task, system, function, sequence, etc., based upon the user's requirements in performance of the ongoing task.

5.6.2.3 Demarcation of Groups

Information groups should be visually distinct, e.g., separated by blanks, lines, colour coding, or other means.

5.6.2.4 Consistent Presentation

The arrangement and presentation of identical visual information should be consistent from application to application.

5.6.3 Visual Display Units (VDU)

5.6.3.1 Night Display

All information should be presented emitting as little light as possible at night.

5.6.3.2 Day and Night Legibility

Displays should be capable of being read day and night.

5.6.3.3 Background Colour

A single neutral background colour should be used that has a hue which allows the information (foreground) to be easily visible and which does not distort or interfere with the coding aspects of the display.

5.6.3.4 VDU Resolution

The display should have adequate resolution; i.e., users can discriminate all display elements and codes from the maximum intended viewing distance.

5.6.3.5 VDU Contrast

The contrast ratio of the display should be greater than 3 : 1 and less than 15 : 1; a contrast ratio of 7: 1 is preferred.

5.6.3.6 Background Luminance

A background luminance level of 15 cd/m^2 to 20 cd/m^2 should be used at daylight.

5.6.3.7 Display Luminance

The display luminance should be between 80 cd/m^2 to 160 cd/m^2 at daylight.

5.6.3.8 Flicker

The display should be "flicker free"; the refresh rate should have a minimum of 65 Hz.

5.6.3.9 Image Continuity

The display should maintain the illusion of a continuous image, i.e., users should not be able to resolve scan lines or matrix spots.

5.6.3.10 CRT Image Linearity

The display should be free of geometric distortion.

5.6.4 Coding and Highlighting

5.6.4.1 Highlighting Selected Data

When a user is performing an operation on some selected display item, that item should be highlighted.

5.6.4.2 Flash Coding

Red flash coding should be reserved for Alarms.

5.6.4.3 Redundant Colour Coding

Colour coding should be redundant with some other display feature, i.e. add colour coding after displays have already been designed as effectively as possible in a monochrome format.

5.6.4.4 Easily Discriminable Colours

When selecting colours for coding discrete categories of data, those colours should be easily discriminable.

5.6.4.5 Minimum Colour Differences

When colour coding is used for discriminability or conspicuity of displayed information, all colours in the set should differ from one another by a minimum of 40 ΔE (CIE L*u*v*) distances.

5.6.4.6 Establishing Standards for Shape Coding

When shape coding is used, codes should be based on established standards or conventional meanings.

5.6.5 Display Elements

5.6.5.1 Font Style

A clearly legible font should be utilized. Fonts should have true ascenders and descenders, uniform stroke width, and uniform aspect ratio. .

5.6.5.2 Meaningful Abbreviations

When abbreviations or acronyms are used, they should be meaningful, in common usage and kept to a minimum.

5.6.5.3 Units of Measurement

The units of measurement (volts, psi, inches, etc.) should be labelled.

5.6.5.4 Appropriate Use of Icons

Icons should be designed to look like the objects, processes, or operations they represent, by use of literal, functional, or operational representations.

5.6.5.5 Representation and Discrimination

Each icon or symbol should represent only one object or function, and should be easily discriminable from all other icons and symbols.

5.6.5.6 Size

Icons and symbols should be large enough for the user to perceive the representation and discriminate it from other icons and symbols.

5.6.5.7 Highlighting

An icon or symbol that the user has selected should be highlighted.

5.6.5.8 Scaling in Standard Intervals

Scales should have tick marks at a standard interval of 1, 2, 5, or 10 (or multiples of 10) for labelled divisions; intervening tick marks to aid visual interpolation should be consistent with the labelled scale interval.

5.6.5.9 Expansion of Graphic Displays

When a graphic display has been expanded from its normal coverage, some scale indicator of the expansion factor should be provided.

5.6.5.10 Unobtrusive Grids

When grid lines are displayed, they should be unobtrusive and not obscure data elements (e.g., curves, plotted points).

5.7 Interactive Control

5.7.1 General User Input Guidelines

5.7.1.1 Consistent Procedures

Procedures for entering commands or information should be consistent in form.

5.7.1.2 Standard Procedures

Standard procedures should be used for updating and deleting information.

5.7.1.3 Consistent Wording of Commands

All terms employed in the user-system interface, and their abbreviations, should be consistent in meaning from one transaction to another, and from one task to another.

5.7.1.4 Unnecessary Entry of Information

A user should not be required to re-enter information already entered to the system.

5.7.1.5 Only Available Options Offered

Only control options that are actually available for the current transaction should be offered to users.

5.7.2 User Input Formats

5.7.2.1 Logical Ordering of Menu Options

Menu options should be ordered and grouped logically.

5.7.2.2 Consistent Design of Hierarchic Menus

The display format and selection logic of hierarchic menus should be consistent at every level.

5.7.2.3 Consistent Display of Menu Options

When menus are provided in different displays, they should be designed so that option lists are consistent in wording and ordering.

5.7.2.4 Minimal Steps in Sequential Menu Selection

When users must step through a sequence of menus to make a selection, the hierarchic menu structure should be designed to minimize the number of steps required.

5.7.2.5 Return to Higher-Level Menus

Users should have to take only one simple key action to return to the next higher level in hierarchic menus.

5.7.2.6 Return to General Menu

Users should have to take only one simple key action to return to the general menu at the top level in hierarchic menus.

5.7.2.7 Explanatory Title for Menu

An explanatory title should be provided for each menu that reflects the nature of the choice to be made, so that the function of the menu is evident to the user.

5.7.2.8 ON/OFF Menu Items

For menu items that can be in an "On" or "Off" state, the "On" state should be indicated by making the item perceptually distinct.

5.7.2.9 Form Filling for Command Entry

Form filling should be provided as an aid for composing complex command entries.

5.7.3 System Operational Information

5.7.3.1 Indicating System Status

The system status should be indicated to users at all times.

5.7.3.2 Operational Mode

The currently selected mode should clearly be indicated, when the results of user action are contingent upon different operational modes.

5.7.3.3 Status and Type of External Sensors

The type and status of external sensors should be permanently indicated.

5.7.3.4 Presentation of Planned and Actual Data

When a device is used for planning it must be clear to the user that this mode is selected so that there is no confusion between the presentation of planned and actual data.

5.7.3.5 Source of Position Information

The information of position should be displayed with an indication of its source.

5.7.3.6 Simulated Operations

Simulated operations should be clearly distinguished from real operations.

5.7.4 System Response

5.7.4.1 Standard Display Location

System messages should appear in standard locations.

5.7.4.2 Familiar Wording

System messages should use familiar terminology.

5.7.4.3 Periodic Feedback

When system functioning requires the user to stand-by, periodic feedback should be provided to indicate normal system operation.

5.7.4.4 Distinctive and Consistent Warnings

Warnings should be distinctive and consistent.

5.7.4.5 Informative Error Messages

When the information systems detects an error, an error message should be displayed stating the error and possible subsequent operations.

5.7.4.6 Task-Oriented Error Messages

Error messages should be appropriate to the task.

5.7.4.7 On-Line Guidance

Users should be able to request on-line guidance information regarding system capabilities, procedures, commands and abbreviations, etc..

5.7.5 Prevention/Detection/Correction of Errors

5.7.5.1 Protection from Data Loss by Interruption

When a proposed user action will interrupt a current transaction sequence, automatic means to prevent data loss should be provided.

5.7.5.2 Segregating Real from Simulated Data

When simulated data and system functions are displayed or provided, real data should be protected.

APPENDIX 1

DEFINITIONS

Alarm: An alarm announces by audible means, or audible and visual means, a condition of an abnormal situation requiring attention.

Alphanumerics: Characters presented on a visual display as letters, numbers, digits, and usually other characters, such as punctuation marks or combinations of them.

Ambient Light: Light originating from sources other than the operator's visual displays, i.e., the general level of illumination on the bridge due to sunlight or lights and lamps.

Ambient Noise: All of the background sounds in the work environment, e.g., the general level of background noise on the shipbridge.

Brightness: An attribute of visual sensation that is determined by the intensity of light radiation reaching the eye. Along with hue and saturation, a component of perceived colour.

Character: A letter, digit, or other symbol that is used as part of the organization, control, or representation of data. A character is often in the form of a spatial arrangement of adjacent or connected strokes.

Character Size: Measured by the height of a displayed character in terms of its visual angle.

Coding: Use of a system of symbols, shapes, colors, or other variable sensory stimuli to represent specific information.

Console: The structural framework for the integration of devices, equipment, and storage and which together compromise a workstation.

Contrast: The difference in luminance between foreground objects and their background or, generally, between any two areas of a display, measured with the contrast ratio (division of the luminance of the foreground by the luminance of the background).

Control: A mechanism used to regulate or guide the operation of a machine, equipment component, subsystem, or system.

Cursor: A highlighted, moveable indicator on the computer screen that shows the current location for data entry, editing, or selection of a displayed object.

Display (Visual): Means which presents visual information, including conventional instrumentation.

Display Field: An area of the display screen reserved for the display of information.

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

Ergonomics: The study and design of working environments (e.g., workstation, cockpit, ship bridges) and their components, work practices, and work procedures for the benefit of the worker's productivity, health, comfort, and safety. Application of the human factor in the analysis and design of equipment, work and working environment.

Field of Vision: Angular size of a scene that can be observed from a position on the ship's bridge.

Glare: Excessive demand for visual adaptation brought on by the retina's exposure to more light than it can tolerate. Produced when any luminance within the visual field is sufficiently greater than the luminance to which the eye is adjusted.

Highlighting: Emphasizing displayed data or format features, e.g., through the use of underlining, bolding, or inverse video, for calling the user's attention to some displayed area or information.

Hue: One component of the perception of colour (for example, red, green, yellow). Other components are saturation and brightness.

Icon: Pictorial or other nonverbal representation of objects or actions.

Illumination: The amount of light (luminance flux) falling on a surface, measured in lumen/m^2 = lux.

Input Device: A workstation component used for data entry and display control, e.g., keyboard, trackball, mouse.

Label: Alphanumeric information that identifies or describes an object or displayed data.

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

Line of Sight: An imaginary line extended from the plane of the viewer's eyes; the horizontal line of sight occupies the same horizontal plane as the centre of the pupils. The normal line of sight declines 15 degrees below the horizontal; maintaining a horizontal or higher line of sight takes effort and can be fatiguing over time.

Luminance: Luminance is the amount per unit area emitted or reflected from a surface and is measured in candela per square meters (cd/m^2).

Menu: A set of related options listed together for selection by the user, i.e. a type of dialogue in which a user selects one item out of a list of displayed alternatives.

Mode: An internally defined state or condition of computer operation, such as keyboard input mode, help mode, edit mode, save mode, planning mode or operational mode.

Reflection: A mirror image of the surrounding environment that is coincidentally superimposed on screen content.

Resolution: A characteristic of a visual display, expressed in pixels per square inch.

Symbol: A graphic or alphanumeric representation of something by reason of relationship, association, or convention.

Workstation: The combination of all job-related items, including the console with all devices, equipment and the furniture, to fulfil certain tasks.

APPENDIX 2

PROPOSED EQUIPMENT FOR WORKSTATIONS

Workstation for navigating and manoeuvring	
Equipment	Accessory
• radar / radar plotting • ECDIS • automatic visual position indicator • information of position fixing systems • information of Automatic Ship Identification System (AIS) • (adjustment) heading / track control system • controls for main engine(s) incl. crash manoeuvres, emergency stop • controls for main rudder (incl. override facility) • controls for thruster • indications for ∗ for propeller revolutions (actual and desired) ∗ main engine revolution in the case of reduction geared engine ∗ propeller pitch in the case of controllable pitch propeller ∗ torque ∗ starting air ∗ lateral thrust ∗ speed (possibly longitudinal and lateral) ∗ rudder angle ∗ rate-of-turn ∗ gyro compass heading ∗ magnetic compass heading ∗ heading reminder (pre-set heading) ∗ water depth incl. depth warning adjustment ∗ time ∗ wind direction and velocity ∗ air and water temperature + ∗ group alarms (with aids for decision-making) • signal transmitter for ∗ whistle ∗ automatic device for fog signals, ∗ general alarm ∗ morse signalling light • automatic device for emergency alarm • controls for console lighting • two-way VHF radiotelephone (walkie-talkie) with charging connection and/or paging system • internal communication equipment • public address system • VHF point with channel selector • remote control for search light • rudder pump selector switch • steering mode selector switch • steering position selector switch • controls for windscreen wiper, washer, heater • night vision equipment • sound reception system • acknowledgement of watch alarm	• sufficient shelves for binoculars, ashtray cup, etc. • writing space • adjustable chair

Workstation for monitoring	
Equipment	Accessory
• radar / radar plotting • signal transmitter for whistle • acknowledgement of watch alarm • indications for ∗ propeller revolutions ∗ pitch of controllable pitch propeller ∗ speed ∗ rudder angle ∗ gyro compass heading ∗ time ∗ rate-of-turn ∗ water depth ∗ alarms • internal communication equipment • VHF point with channel selector • Controls for windscreen wiper, washer, heater	• shelf for binoculars etc. • shelf for notes etc. • adjustable chair

Workstation for manual steering (helmsman's)	
Equipment	Accessory
• steering wheel / steering lever • rudder pump selector switch • indications for ∗ gyro compass heading ∗ magnetic compass heading ∗ pre-set heading ∗ rudder angle ∗ rate of turn • talkback to bridge wing workstation • controls for windscreen wiper, washer, heater	• adjustable chair

Workstation for docking (bridge wing)	
Equipment	Accessory
• controls for main engine(s) • controls for thruster • controls for rudder • controls for whistle • steering position selector switch • indications for ∗ gyro compass heading ∗ propeller revolutions ∗ main engine revolution in the case of reduction geared engine ∗ propeller pitch in the case of controllable pitch propeller ∗ lateral thrust ∗ rate-of-turn ∗ rudder angle ∗ longitudinal and lateral movement of ship ∗ wind direction and velocity • talkback system to the workstations navigating and manoeuvring, monitoring, manual steering, and to manoeuvring stations, except muster stations • system for external communication with tugs, pilot boat (VHF point) • controls for morse lamp and searchlight • acknowledgement of watch alarm	

Workstation for planning and documentation	
Equipment	Accessory
• ECDIS including navigation planning station • route planning devices • chart table • position fixing receiver • retaining device for drawing triangles, dividers, magnifying lens, pencils, etc. • weather chart plotter • main clock • chronometer with receiving facility for time signals • radio direction finder • log, incl. distance indicator, course plotter • echograph • barograph • indication for air and water temperature [+] • command printer • VHF point	• facility for storing charts • facility for storing nautical publications, manuals, etc.

Workstation for safety	
Equipment	Accessory
• fire alarm for areas machinery, superstructure/accommodations, cargo • remote control and monitoring of fire-extinguishing system • remote control and monitoring of watertight doors/fire doors (open/closed) • emergency stop for air condition, ventilation and refrigerating installations • controls for anti-rolling device • indicator for bilge monitor • indicator for strength load incl. alarm • indicator for further safety systems • clinometer • keys and control-elements for lights and signals (navigation lights, signal lamps, bridge lighting, deck lighting searchlights, as well as all fuses) • internal communication system, in particular to muster stations • adjustment of watch alarm system and acknowledgement button • status indication for bow-, rearflap • controls/indications for ballast water handling • tools for documentation • main station for two-way VHF radiotelephone (walkie-talkie) [++]	• writing space

Workstation for communications	
Equipment	Accessory
• GMDSS equipment as required for the applicable sea area: ∗ VHF-DSC, radiotelephone ∗ MF-DSC, radiotelephone ∗ MF/HF-DSC, NBDP, radiotelephone ∗ Inmarsat-SES ∗ NAVTEX/EGC/HF direct printing telegraph ∗ EPIRB trigger ∗ main station for two-way VHF radiotelephone (walkie-talkie) [++]	• writing space • chair

[+] Located at the workstation for navigating and manoeuvring or at the workstation for planning and documentation.

[++] Located at the safety or communication workstation.

APPENDIX 3

EXISTING INTERNATIONAL STANDARDS DEALING WITH ERGONOMIC CRITERIA FOR BRIDGE EQUIPMENT AND LAYOUT

		Relevant Requirements	**For additional Information**	
	Contents of the Guidelines	IMO Resolutions and Guidelines	IEC Standards	ISO Standards
Work Stations	4	MSC/Circ.603 Annex 2, 1993		ISO 8468 ISO 14612
Ergonomic requirements	5.1 Bridge Layout	SOLAS Chapter V, reg. 22		ISO 8468
	5.2 Work Environment			ISO 8468
	5.3 Work Station Layout	IMO A.694(17)	IEC 60945 rev.4	ISO 8468 ISO 14612
	5.4 Alarms	IMO A.839(19) MSC.64(67) IBS MSC.86(70) INS	IEC 60945 rev.4 IEC 61209 IEC 61924	ISO 8468
	5.5 Input Devices	IMO A.694(17)	IEC 60945 rev.4	
	5.6 Information Display	IMO A.694(17)	IEC 60945 rev.4 IEC 60936 IEC 60872 IEC 61174	
	5.7 Interactive Control	IMO A.694(17)	IEC 60945 rev.4	
Equipment at workstations	Appendix 2	MSC/Circ.603 Annex, 1993		ISO 14612

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