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Integrated Design of Bridge Deck Based on Ergonomics Rules towards One Man Control Bridge

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Bridge is the most neuralgic place on a ship. Currently a bridge control system of modern ship is designed for one-man-operation. Improper of bridge design and placement of equipment in bridge control console that is not based on ergonomics rules and physical condition of operators, will easily lead to human fatigue. This can trigger the occurrence of ship accident at sea because the increasing number of human errors. The ergonomic bridge design must consider in to human anthropometry for Matching work, between humans and work systems (man-machine system), so that the operator can work comfortably, efficiently and reduce workload.

Current problem that arises is the unavailability of specific regulations or rules to regulate the ergonomic design of bridge decks for ships in Indonesia, which according to anthropometry Indonesian people. Based of these problems, an attempt was made to develop an integrated bridge design program based on ergonomics rules and provide recommendations on equipment layout of bridge and Bridge console in accordance with the Indonesian anthropometry. This recommendation includes ergonomic requirements are centered on comfort and equipment layout in the bridge deck, which is functionally oriented to support the operator in the design of one-man-operated bridge in their duties. The recommendations was implemented by developing a computer-based program, and then used as a simulator bridge deck ergonomics analysis process in providing aid consistency, reliability and efficiency of ships operations. The developed program was able to provide improved ergonomics redesign the bridge deck, so the number of ships accidents can be reduced.

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1. INTRODUCTION

The current bridge in modern ship control system is designed for one-man operation. The bridge design can make decisions both single human mind by means of integrated automation systems between equipment in navigation console. Bridge design and placement equipment that is not based on principles of ergonomics and physical condition of the operator, will easily lead to fatigue of the body. This can trigger a number of ship accidents caused by human error [1]. Bridge design based on ergonomics rules should consider the human anthropometry in it, for the matching of work between humans and systems of work (man-machine system). Indonesia does not have specific regulations or standards governing design of ship's bridge decks based on ergonomic rules in accordance with Indonesian anthropometry. So it needs to create a bridge design based on ergonomics rules and provide a recommendation for equipment layout in bridge decks that suit Indonesian anthropometry.

In the present paper, aiming to achieve decision support system or to support designer for designing bridge deck based on ergonomics rules and provide a recommendation for equipment layout in bridge decks that suit Indonesian anthropometry. More than 70% of Indonesian ferry ships are second hand ships imported from other countries, where the bridge deck were not arranged according to anthropometry of Indoesian people. So many accidents happened in Indonesia caused by Human factor and one of the reason may be was caused of impoper of bridge design and placement of equipment in bridge control console.

This recommendation includes ergonomic requirements centered on convenience and layout of equipment on bridge deck, functionally oriented to support operator in the design of one-man-operated bridge in their duties. The recommendation will be implemented by developing a computer-based program, and then used as a simulator bridge deck ergonomics analysis process in providing aid consistency, reliability and efficiency of ship operations. The developed program can provide insight in improving the ergonomic design of bridge deck, so the number of ship accidents may be reduced [2-4].

2. STRUCTURE OF BRIDGE DECK

Ergonomics is often called as the Human Factor Engineering, a science that governs how people work. According to the American Bureau of Shipping (ABS) rules, ergonomics is a discipline that deals with an understanding of the interaction between man and elements in a system. The main concern in ergonomics design is efficiency is measured based on the speed and accuracy of human performance in the use of equipment. Safety and comfort factors of workers have been included in the definition of efficiency. The ABS Guide for Bridge Design and Navigational Equipment/Systems presents requirements that "are applicable to vessels possessing SOLAS certificates and having the bridge so designed and equipped as to enhance the safety and efficiency of navigation."[5-7].

The purpose of this study is to achieve the automated guidence and support designer to arrange bridge deck. This Guide also recommends that the design of bridges is to be based on sound ergonomic principles. Guidance in this document is consistent with the principal international statutory and discretionary guidance addressing the design of bridge systems (such as: IACS Standard for Bridge Design, Equipment and Arrangement; SOLAS V; and IMO Guidelines on Ergonomic Criteria for Bridge Equipment and Layout).

2.1 Overall Arrangement of Bridge Deck

The layout of the bridge, including location and layout of the individual workstations should ensure the required field of view for each function.

Fig. 1 shows an example of ergonomic design of the navigation bridge for route monitoring, maneuvering, traffic surveillance and monitoring. Equipment to be installed at the workstations for route monitoring, maneuvering, traffic surveillance and monitoring should be located for easy use from standing position, whereof means for traffic surveillance, heading and speed adjustments, internal and external communication should be located for easy use also from seated position. The workstation for navigating and maneuvering should be arranged to allow an assisting officer to carry out route monitoring, which may include manual plotting of the ship's position, and course adjustments when required, while the officer in charge concentrates

on traffic situations and adjustment of course and speed as required to follow the route and avoid danger of collision.

The relevant workstations are to be designed and positioned so that navigational and traffic surveillance/ maneuvering, docking and other tasks may be performed by the officer of the watch in cooperation with other persons manning individual workstations. Workstation is a workplace where one or several tasks will form certain activities that will be implemented, designed, and arranged to provide information, systems and equipment required for safety and efficient performance, as well as the specific tasks bridge team collaboration.

In general, workstations are to be divided into three parts:

a) Vertical Part: Instruments dealing with information/presentation of data are to be placed in the vertical part.
b) Horizontal Part: Controls of the relevant equipment are to be placed in the horizontal part.
c) Width: Based on sound ergonomic principles, the width of workstations designed for single person operation is not to exceed 1.6 m (5 ft. 3 in.).

2.2 Instruments and Equipments at Navigating and Maneuvering Workstation

In accordance with the International SOLAS regulations 1974 and Colreg (Collision regulation 1972) throughout the vessel must be equipped with navigation equipment. The instruments and equipment should be located to meet bridge personnel needs at each workstation.

a) Navigation Workstation consist of

- Navigation radar display
- Position-fixing systems
- Depth indicator
- Chart table with instruments.

b) Maneuvering Workstation consist of

- Radar display
- Automatic radar plotting aid (ARPA)
- Engine and thruster controls or telegraphs
- Rudder angle indicator
- Propeller revolution indicator(s)
- Pitch indicator
- Speed and distance indicator.

C) Manual Steering Workstation consist of

- Manual steering device
- Gyro repeater
- Rudder angle indicator
- Rate of turn indicator
- Magnetic compass display
- Course indicator
- Talkback to bridge wings

D) Bridge Wing Workstations consist of

- Engine control
- Thruster control
- Rudder control
- Rudder angle indicator
- Gyro repeater
- Rate of turn indicator
- Sea bottom tracking Speed indicator
- Whistle control
- Communication (external and internal)
- Morse light keys

E) Monitoring Workstation consist of

- VHF radiotelephone
- Intercommunication Systems
- Gyro repeater
- Speed and distance indicator
- Rudder angle indicator
- Propeller revolution indicator(s)
- Alarms
- Emergency stop controls
- Monitoring systems
- Rate of turn indicator

2.3 Man Machine Interface

Man Machine Interface is the means by which the operator receives information about the status of the machine or system and can send back commands and settings from the guard so easy in the control, the ship is laying example of indicators on the bridge deck such as engine RPM indicator, ballast indicator, bilge indicator until the emergency button to shut down the system in the engine room. Another example is the indicator driving wheel which can be viewed on the navigation deck how many degrees has been turned; it must be the same with its own steering movement in the water axis of the Steering shaft.

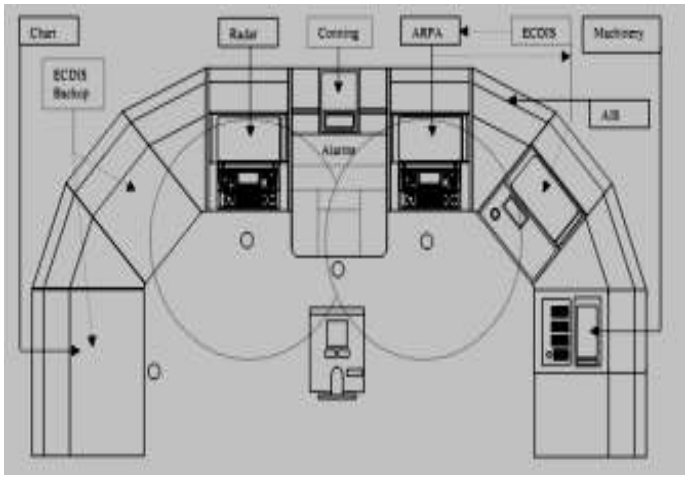


Fig. 1. Bridge arrangement and working environment

3. DEVELOPED PROGRAM

3.1 Architecture of the Developed System

During the system's design, the decision was made to divide the system into two parts. The first part implemented the common knowledge based, and the second part implemented the graphic user interface software modules. Fig. 2 describes the architecture of the developed system, which contains the following two main diagrams:

1) Common knowledge bases for carrying out the design support process.
2) Window display interface for communication between the operator or designer and developed system.

3.1.1 Common knowledge bases system

A Common knowledge based system is a computer program designed to represent organized knowledge for designing of bridge deck based on ergonomics rules and to simulate the performance of a designer in the field. The Common Knowledge Base contains all the information necessary to solve the design process of bridge deck.

In this study, a common knowledge base has been proposed. This knowledge base holds all the components and rules representing the knowledge about the arrangement of bridge deck. The knowledge about a structure of bridge deck usually does not change. The rules are made for common patterns and specific facts are not encoded. The specific data (facts) related with the component are provided during the session.

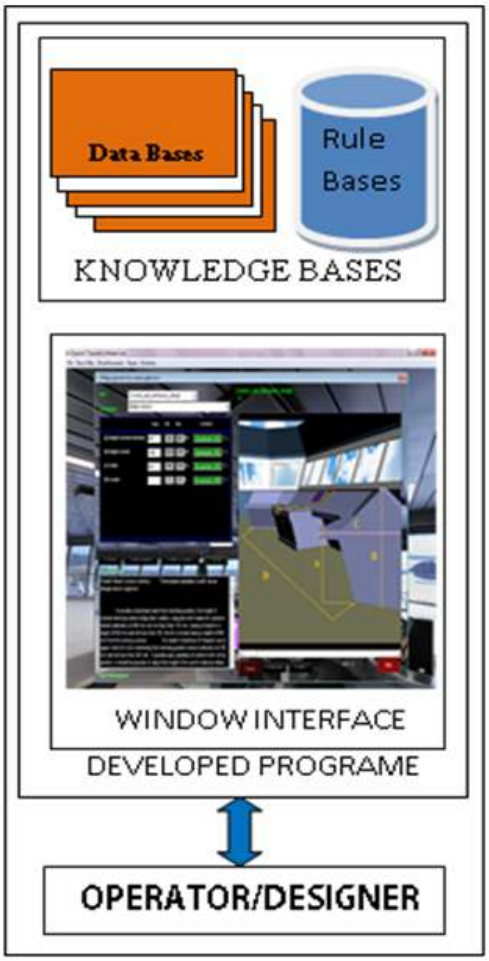


Fig. 2. Architecture of developed program

The Common Knowledge contains the following sets of rules:

- General rules about component and standard ergonomic bridge design;
- Rules for making standard framework and making the list brackdown as limitations of ergonomic design rules
- Rules for evaluation of the framework
- Rules for making recommendations in the context of ergonomic design of the bridge deck ship according anthropometry of Indonesia.

3.1.2 Data collection

The Data of the anthropometry of Indonesian people is needed for developing program of guide lines for designing bridge decks. These guidelines are used as a reference to determine whether the analyzed equipment already meets the ergonomic rules. Data are collected from the guidelines and recommendations, questionnaires, ships general arrangement and dimensions of the equipment and Bridge Arrangement. An example of data base is shown in Fig. 3.

3.1.3 Window display interface for communication between operator or designer and developed system

In this study, we have developed a graphics system that simulates the actual bridge deck in a ship. The interface represents the following information:

- Diagrams of Instruments and Equipments at Navigating and Maneuvering Workstation.
- System command windows, allowing to control the application (loading knowledge base, start simulations, terminating the program);
- Window for input data;
- Message window, allowing the user to be notified by the knowledge system about the recommendation made by the developed system.
- Full report window, this window is used to display all the recommendations, and this report can be saved as txt files.

4. EXAMPLE OF DEVELOPED SYSTEM OPERATION

For analyzing the arrangement of bridge deck using the developed program needs data for the ship. An example of data of a ship such as follow:

General specifications:

- Name of vessel : MT.AA
- Length [LOA] :170.00 meters
- Length [Lpp] :162.00 meters
- Breadth [B] : 27.40 meters
- Depth [D] : 13.00 meters
- Draft [Designed] : 7.50
- Draft [Scantling] : 8.50
- Dead weight [At design draft] : 20,000 M. T
- Dead weight [At scantling draft] : 24,000 M. T
- Service Speed [at 85% MCR,15% SM] :15.50 knots

Data to be analyzed are:

- Angle of View
- Bridge Wing and Working Clearances
- Console and workspace Design
- External Visibility
- Internal Visibility
- Navigational Equipment
- Routes and working Clearances

4.1 Simualtion Results

Using developed program, ships data which has been inputed are to be analized. The results will be obtained by comparing the input data with developed rule and the system will give recommendation after analyzing the ships data.

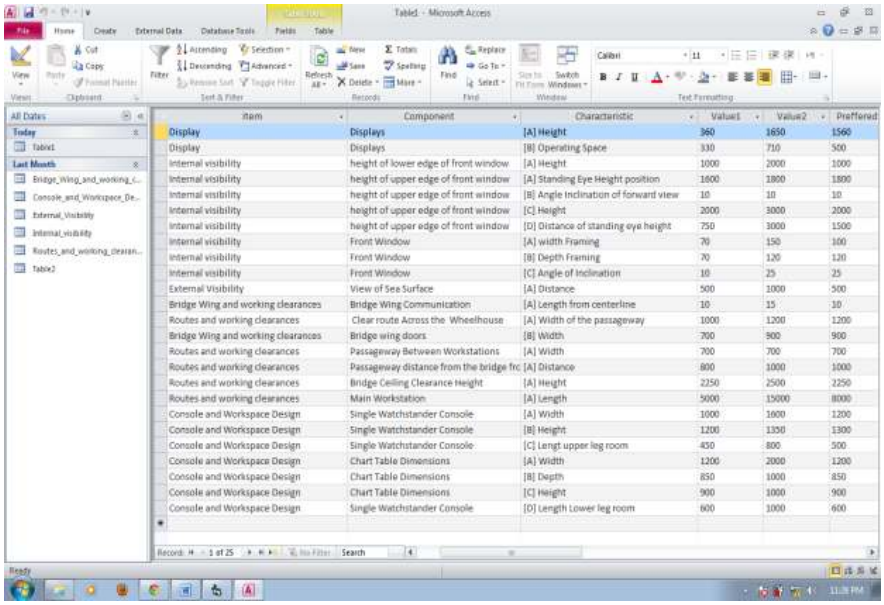
An example that will be analyzed are Console and Workspace Design, where the components insist are:

1) Bridge console
2) Console leg room

1) Single Watch Stander Console Consists of

[A] Height console desktop : 800 mm
[B] Height overall : 1200 mm
[C] Width : 850 mm
[D] Length : 7 m

From obtained data on Bridge Deck arrangement of MT. AA 24000 DWT, the developed program evaluates these properties by matching the knowledge which was build in the developed system and after the evaluation is done the system gives recomendations such as described in Fig. 4.



Item	Component	Characteristic	Value1	Value2	Preffered
Display	Displays	[A] Height	360	1650	1560
Display	Displays	[B] Operating Space	330	710	500
Internal visibility	height of lower edge of front window	[A] Height	1000	2000	1000
Internal visibility	height of upper edge of front window	[A] Standing Eye Height position	1600	1800	1800
Internal visibility	height of upper edge of front window	[B] Angle Inclination of forward view	10	10	10
Internal visibility	height of upper edge of front window	[C] Height	2000	3000	2000
Internal visibility	height of upper edge of front window	[D] Distance of standing eye height	750	1000	1500
Internal visibility	Front Window	[A] width Framing	70	150	100
Internal visibility	Front Window	[B] Depth Framing	70	120	120
Internal visibility	Front Window	[C] Angle of Inclination	10	25	25
External Visibility	View of Sea Surface	[A] Distance	500	1000	500
Bridge Wing and working clearances	Bridge Wing Communication	[A] Length from centerline	10	15	10
Routes and working clearances	Clear route Across the Wheelhouse	[A] Width of the passageway	1000	1200	1200
Bridge Wing and working clearances	Bridge wing doors	[B] Width	700	900	900
Routes and working clearances	Passageway Between Workstations	[A] Width	700	700	700
Routes and working clearances	Passageway distance from the bridge fro	[A] Distance	800	1000	1000
Routes and working clearances	Bridge Ceiling Clearance Height	[A] Height	2250	2500	2250
Routes and working clearances	Main Workstation	[A] Length	5000	15000	8000
Console and Workspace Design	Single Watchstander Console	[A] Width	1000	1600	1200
Console and Workspace Design	Single Watchstander Console	[B] Height	1200	1350	1300
Console and Workspace Design	Single Watchstander Console	[C] Lengt upper leg room	450	800	500
Console and Workspace Design	Chart Table Dimensions	[A] Width	1200	2000	1200
Console and Workspace Design	Chart Table Dimensions	[B] Depth	850	1000	850
Console and Workspace Design	Chart Table Dimensions	[C] Height	900	1000	900
Console and Workspace Design	Single Watchstander Console	[D] Length Lower leg room	600	1000	600

Fig. 3. An example of database

Fig. 4. Validation bridge console program appropriate ergonomic value

Recommendations

Point [A] Height console desktop: Placement of the equipment is in conformity with the rules of ergonomics.

To provide a functional reach from standing position, the height of console desktops above bridge deck surface, equipped with means for operation, should preferably be 800 mm and not less than 750 mm, sloping forward to a height of 950 mm and not less than 900 mm for consoles having a depth of 800 mm from the working position. The height of desktops for frequent use of paper charts for route monitoring from standing position should preferably be 900 mm and not less than 800 mm. To provide easy operation of controls from sitting position, it should be possible to adjust the height of the seat to allow an elbow height 50 mm higher than the console desktop.

Point [B] Height overall: Placement of the equipment is in conformity with the rules of ergonomics.

The top of the consoles should not exceed a height of 1200 mm (47 inches). The consoles forming the front workstations should not be higher than required for efficient use in standing position and should not obstruct the fields of vision over the lower edge windows in front of the workstation from sitting position. The height of the consoles should be 100 mm lower than the horizontal line of sight. maybe accepted for installation at a distance of 350 mm or more from windows with a lower midge of 1000 mm. This console height may also be considered

acceptable even if it interferes with the line of sight from an eye height of 1400 mm, providing the height of the chair can be adjusted to compensate for the interference.

Point [C] Width: Placement of the equipment is in conformity with the rules of ergonomics.

The console should be designed so that from the normal working position, can use all instruments and controls necessary for navigating and maneuvering. The Width of consoles designed for single person operation should not exceed 1200 mm. On a bridge with enclosed bridge wings it should be possible to obtain the view of 360° from inside the bridge area by using two positions, one on each side of the workstation for navigating and maneuvering, not being more than 15 m (49 feet) apart.

Point [D] Length: Placement of the equipment is in conformity with the rules of ergonomics.

The console should be designed so that from the normal working position, can use all instruments and controls necessary for navigating and maneuvering. On a bridge with enclosed bridge wings it should be possible to obtain the view of 360° from inside the bridge area by using two positions, one on each side of the workstation for navigating and maneuvering, not being more than 15 m (49 feet) apart. This guideline may also be applicable for providing the required field of vision within the confines of wheelhouses with a total breath of more than 18 meters.

2) Component: Console leg room

Fig. 5. Results of analysis of leg room console

From the main display interface (Fig. 5) can be seen that there are still some parts of the item are not met with the appropriate value of ergonomics guidelines. So it would appear that the recommendations of these components is able to meet the ergonomic value desired.

Name of Equipment: Console leg room

Recommendations

Point [A] Length of lower leg room: Too narrow, so watch officer did not feel comfortable in operating equipment on the console table. Legs Room become narrow, making the seat should be set slightly back, this would be the distance of watch officer with the equipment becomes more distant, thus affecting the effective operation of the equipment, which is installed in the console and comfort in reaching the equipment, should be added until it reaches between 600-750 mm. Plus approximately 50 mm would be more ergonomic.

The leg room required is governed by the seated working position suiting the user with regard to reach and effective operation of the equipment installed in the consoles, meaning the position of the chair in relation to the front of the console. The reach may be related to equipment installed in both front and side consoles. The upper leg room of the console should have a minimum of 450 mm (18 inches) in depth and the lower leg room a minimum of 600 mm (25 inches) in depth.

Ppoint [B] Length of upper leg room: Too narrow, so watch officer did not feel comfortable in operating the equipment on the console table. Room legs become narrow thus making the seat should be set slightly back, this would be the distance of watch officer with the equipment becomes more distant and thus affects the effectiveness of the operation of equipment that is installed in the console and comfort in reaching the equipment. , should be added until it reaches between 450-550 mm. Plus approximately 100 mm would be more ergonomic.

The leg room required is governed by the seated working position suiting the user with regard to reach and effective operation of the equipment installed in the consoles, meaning the position of the chair in relation to the front of the console. The reach may be related to equipment installed in both front and side consoles. The upper leg room of the console should have a minimum of 450 mm (18 inches) in depth and the lower leg room a minimum of 600 mm (25 inches) in depth.

Value / score ergonomics of leg room console component that has been analyzed is 0.33. where the ergonomic score for the length of the lower leg room is 0.66 because the input value entered is 550 mm which is slightly outside the

range of values determined ergonomics between 600 mm - 750 mm. while the ergonomic score for length of upper leg room is 0 because the calculation is based on input value of 350 mm was far beyond range of recommended value of 450 mm - 550 mm. to obtain the value of component score is 0.33 console leg room taken from the calculation of the average score of the two items lower upper leg room and leg room are analyzed.

3) Component

Adjustable chairs data:

[A] Seat height Width : 700 mm
[B] Seat depth : 450 mm
[C] Seat width : 350 mm
[D] Backrest height : 600 mm
[E] Backrest width : 400 mm
[F] Armrest height : 300 mm
[G] Distance between armrests: 350 mm

Fig. 6. Results of analysis of adjustable chair chemical tanker 24000 DWT Vessel not meet with the rules of ergonomics

From the main display interface such as described in Fig. 6, can be seen that there are still some parts of the item are not met the appropriate value of ergonomic rules. So it would appear that the recommendations of these components are able to meet the ergonomic value desired.

Single Console Watch stander MT. AA CHEMICAL TANKER 24000 DWT not meet ergonomic rules. So that the recommendations that emerge are:

Name of equipment: Adjustable chair

Recommendations:

Point [A] Seat height: Placement of the equipment is in conformity with the rules of ergonomics.

Point [B] Seat depth: Placement of the equipment is in conformity with the rules of ergonomics.

Point [C] Seat width: Placement of the equipment is in conformity with the rules of ergonomics.

Point [D] Backrest height: Too low, watch officer did not feel comfortable because it cannot lean shoulders and head comfortably. So it would quickly lead to fatigue on part of head. High backrest for seat in the navigation deck watch stander higher than seats in general. it is make a point on operator comfort while monitoring surface to sea or to navigate and maneuver vessel, so high backrest are made almost to head height so that body and head reclining comfortably. Should be added until it reached between 750-900 mm and more ergoomics if be added 246 more.

Point [E] Backrest width: Too narrow, watch officer not comfortable in operating the equipment, which is too narrow backrest cannot support the weight of the back perfectly, should be added until it reaches between 450-550 mm and if be added approximately 92 mm would be more ergonomic.

Point [F] Armrest height: Placement of the equipment is in conformity with the rules of ergonomics.

Point [G] Distance between armrests: Placement of the equipment is in conformity with the rules of ergonomics.

Score of adjustable ergonomic chair is 0.79. This value is average score of the ergonomics of each item as follows:

[A] Seat height Width: Recommenddation 100%, Score 1
[B] Seat depth: Recommenddation 100%, Score 1
[C] Seat width: Recommenddation 100%, Score 1
[D] Backrest height: failed, Score 0
[E] Backrest width: Recommenddation 50%, Score 0.5
[F] Armrest height: Recommenddation 100%, Score 1
[G] Distance between armrests: Recommendation 100%, Score 1

4) Placement of Navigational Equipment

The equipment selected for analysis will be provided in the input box to tick (check) in accordance with the location of the equipment on board is analyzed. When the location of the equipment BCC analyzed in accordance with the recommendation Workstation based on ABS Rules, then the name of the equipment will be recommended to be given the green circle. If otherwise not in accordance with the recommendations of the ABS it will be given a recommendation by the red circle in the image code equipment.

Name of equipment: AIS

Place of equipment: Traffic surveillance

AIS Navigational Equipment MT. AA TANKER 24000 DWT already meets the ergonomic rules.

Recommendations:

AIS: Placement of the equipment is in conformity with the rules of ergonomics, laying the proper equipment is in Traffic surveillance. This equipment is used for Traffic surveillance activities - Collision avoidance

Fig. 7a. Navigational equipment validation rules according to the recommendations

The equipment shall be installed in the ship with GT 24000:

- ECDIS backup
- ECDIS all size
- GNSS_GPS
- Heading ctrl. System
- Magnetic compass all size
- Paper chart table
- Pelorus gyro repeater
- Radar ARPA
- Sound reception system all size

5) Equipment applicable for ships of various sizes

Name of equipment: GNSS_GPS
Place of equipment: Maneuvering

GNSS_GPS Equipment applicable for ships of various sizes MT. AA TANKER 24000 DWT not meets ergonomic rules. So that the recommendations that emerge are:

Fig. 7b. GNSS_GPS equipment applicable for ships of various sizes

Recommendations:

GNSS_GPS equipment: Not meet ergonomic rules. Due to a lack of good layed on maneuvering that should be placed at the Navigation.

This equipment is used for Traffic surveillance activities - Collision avoidance and Navigation - Grounding avoidance.

The equipment shall be installed in the ship with GT 24000:

- ECDIS backup
- ECDIS_all size
- GNSS_GPS
- Heading ctrl. System
- Magnetic compass_all size
- Paper chart table
- Pelorus_gyro repeater
- Radar_ARPA
- Sound reception system all size.

5. CONCLUSION

Development of an integrated design of bridge deck based on ergonomics rules has been described in this paper. It is realized that bridge deck is a vast subject, and the approach presented will need improvements for universal

application. Therefore the knowledge bases are built into two parts, one for common knowledge and the other for knowledge accessing. In the common knowledge base each component in the bridge deck is built as a module separately with the other component. These modules represent some general functionality that can be found within many different physical devices.

Finally, developed Program have significant results to analyze design layout of equipment or items in the bridge deck, whether it meets the ergonomic rules or not, and aiming at enhancing bridge room safety and efficiency through design, layout and arrangement.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Calhoun SR. Human factor in ship design. Preventing and Reducing Shipboard Operator Fatigue, Society of Naval Architecture and Marine Engineering Chesapeake Section Meeting, 15th December 2003.
2. Fuchi Masaki, Furusho Masao, Kum Serdar. Analysing of maritime accident by approaching method for minimizing human error. Kobe University, Faculty of Maritime Sciences. Kobe, Japan; 2006.
3. Georgoulis Georgios, Nikitakos Nikitas. Bridge ergonomic and usability of navigational system as a safety and quality feature. University of the Aegean, Korai, Chios; 2009.
4. Kobayashi H. Human factor for safe navigation. Promotion of the Research on Mariners' Characteristics. International Conference on Marine Simulation and Ship Maneuverability (MARSIM 2006), 25-30 June 2006.
5. American Bureau of Shipping. Bridge Design Navigational equipment/system; 2010.
6. American Bureau of Shipping. Ergonomic Design of Navigation Bridges; 2003.
7. ABS Technical Papers. Human factors and ergonomics in safe shipping: The ABS Approach. London; 2002.

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