INTERNATIONAL MARITIME ORGANIZATION

E

SUB-COMMITTEE ON HUMAN ELEMENT, TRAINING AND WATCHKEEPING
5th session
Agenda item 8

HTW 5/8/2
13 April 2018
Original: ENGLISH

REVISION OF THE GUIDELINES ON FATIGUE

Proposed amendments to module 5 (Ship design) of the draft Guidelines on Fatigue

Submitted by the Institute of Marine Engineering, Science and Technology (IMarEST)

SUMMARY

Executive summary:	This document provides comments on the revision of the *Guidance on fatigue mitigation and management* (MSC/Circ.1014), in particular on module 5, and proposes amended text with a view to expediting the completion of this module
Strategic direction, if applicable:	1
Output:	1.23
Action to be taken:	Paragraph 20
Related documents:	MSC 94/18/7; HTW 4/8, HTW 4/WP.3, annex and HTW 4/16, paragraph 8.12

Background

1 The Maritime Safety Committee (MSC), at its ninety-fourth session, following consideration of document MSC 94/18/7 (Australia et al.) included a new output on "Revision of the Guidelines on Fatigue", assigning the Sub-Committee on Human Element, Training and Watchkeeping (HTW) as the coordinating organ.

2 At HTW 4, following the work carried out intersessionally in a correspondence group established at HTW 3, Australia, as coordinator of the Correspondence Groups, reported on the work carried out (HTW 4/8). The report provided draft text for the introduction, six modules and several appendices in the revised guidelines, module 5 of which is contained in the annex. An additional module was proposed by the International Chamber of Shipping (ICS), Cruise Lines International Association (CLIA) and the International Transport Workers' Federation (ITF) in document HTW 4/8/1.

3 A working group was established at HTW 4, the terms of reference of which included review and consideration of documents HTW 4/8 and HTW 4/8/1 respectively, taking into account comments made and decisions taken in plenary, with a view to finalizing the draft Guidelines on Fatigue. While significant progress was made on the introduction and modules 1 and 2, the Group was not able to complete the review of the draft guidelines owing to time constraints.

4 The Sub-Committee invited the Committee to extend the target completion year of the output to 2018 and concurred with the view of the Group that the outcome of HTW 4 (HTW 4/WP.3, annex) should be considered as the basis for further work at the next session, and invited Member States and international organizations to submit relevant proposals to the next session of the Sub-Committee for consideration.

5 The sponsors of this submission participated fully in the work of the HTW 3 Correspondence Group and noting that, while no correspondence group was established at HTW 4 to report at HTW 5, the Sub-Committee invited Member States and international organisations to submit relevant proposals.

Discussion

6 Taking account of the above, this document proposes amendments to the text of module 5 (Ship design) in order to progress the work more effectively. In addition, minor text alterations are proposed for the introduction and module 2 (Fatigue and the Company).

7 IMarEST notes that the Correspondence Group established at HTW 4 proposed that the title of this module be changed from "Fatigue and the ship designer" to "Fatigue and ship design" and the inclusion of a definition of "ship designer" in the introduction, in square brackets. In this document, IMarEST expands on this approach and makes further proposals to clarify this module and to ensure that it is directed to all relevant parties.

8 In this connection, in the original guidance an editorial pattern was followed in so far as each module was addressed to a particular group of "actors", e.g. the Company, the seafarer, the ship designer, etc. While most modules address behavioural matters, e.g. work and rest, this module is unique in so far as it addresses the structure of the vessel and the development of its living and working environments. The change in the title goes some way to acknowledge this, but the subsequent text reverts to directing the module to a specific group of people, e.g. ship designers in the new draft, naval architects in the original.

9 This module recognizes in its opening paragraph that the design principles for fatigue mitigation should be considered early in the design process and IMarEST wholeheartedly agrees with this. However, the concept of directing this module to the ship designer, which is defined in square brackets as "A group of people responsible for the design, layout, and construction of the vessel", does not focus on the aspects of ship design which would influence the mitigation of fatigue; therefore, it will not necessarily provide the best solution.

10 Starting from the contract stage through the development of a design concept, the final design of the delivered vessel will have received input from several sources, including the purchaser/prospective owner, machinery and equipment suppliers, outfitters, etc. We consider it important to direct the module to all who have an influence on the design requirements and not just to those who convert the design inputs into outputs.

11 IMarEST suggests therefore that:

.1 the proposed new title of the module is more appropriate;

.2 the content of the module should be modified slightly to address the design rather than addressing the designer;

.3 a suitable bullet point be added to paragraph 8 of the introduction, which lists when the guidance should be taken into consideration, in order to emphasize that design considerations should be addressed at an early stage. The following text is proposed:

"8.1 contracting for or designing a new ship or a major conversion of an existing ship"; and

.4 paragraph 24 of module 2, which touches on ship design, be modified to address the need to take into consideration module 5 at an early stage. The following text is proposed:

"24. Furthermore, ship design plays an important part in ensuring a healthy shipboard environment (see module 5). As provided in module 5, Companies should specify that the design principles for fatigue mitigation and management should be considered early in the design process."

12 Turning now to some aspects of ship design, during IMarEST's participation in the Correspondence Group, it requested that paragraphs 16 and 17 of module 5 be placed in square brackets for further consideration and IMarEST notes that this was done (HTW 4/8, paragraph 13.6.1). IMarEST's concern over these paragraphs is that they express an opinion, not a fact. They add no value to the overall document and only distract attention from the message that it is intended for. When designing any ship, there is a number of requirements to take into account such as cargo carrying capacity, speed, draught, beam and length limitations, crew numbers, etc., as well as all regulatory and class requirements, which all fit inside a financial model that determines if building the ship is viable or not. The ship designer works to optimize the design so that business performance, safety and environmental protection are balanced in a way that meets the company's appetite for risk, whilst still meeting and, in many cases, exceeding the regulatory and class requirements. This optimization cannot be achieved if the accommodation location is not an integral part of the design process. Every part of a ship's design affects another part and even in the simplest ship, the location of the accommodation and all the services that link to it are an integral part of the design process. IMarEST, therefore, prefers the following text which we believe more correctly captures the encountered problems:

"Crew accommodation is often located in positions likely to be affected by machinery-induced vibration (including cargo transfer systems) and propeller-induced noise and vibration. Steps should be taken early in the design stage to alleviate this. Noise sources internal to the accommodation also need to be considered and noise levels generated by the heating, ventilating and air conditioning (HVAC) systems should be controlled."

13 IMarEST also draws the Sub-Committee's attention to the problem of intermittent noise and vibration and impact noise and proposes the addition of paragraphs to draw attention to this. Intermittent noise and vibration is generally machinery-induced and can be highly disturbing. Where corridors and/or service spaces are located above or adjacent to accommodation, human traffic/activity and the inadvertent dropping of items onto the deck

creates impact noise that again can cause considerable disturbance. In this case provision of sufficient mass and damping in the deck coverings is very important to ensure that energy is not transmitted into the structure; alternatively, accommodation should be isolated from the structure. The text we propose is:

> "Sources of Intermittent machinery-induced noise and vibration caused by machinery stopping and starting on a cyclical or irregular basis should also be considered.
>
> Measures to reduce disturbance from impact noise from human activity in corridors and service spaces above and/or adjacent to accommodation should also be incorporated in the ship design."

14 Paragraph 17 is also a statement that seems to have little evidence to support it. Certainly in passenger ship construction, acoustic insulation and damping is an extremely cost-effective way of making the ship habitable. Any shipyard and ship designer will factor this into the cost of the project to optimize the design as stated previously.

15 The section on ergonomics (paragraphs 23 to 30) is currently based on part of an out-of-date ISO standard, i.e. ISO 6385:1981. Indeed, paragraph 25 is a direct quotation from this standard and retains the imperative "shall". For this reason, the Correspondence Group left some paragraphs in square brackets. While the concepts expressed remain valid, it is questioned whether including just a small part from an out-of-date standard provides satisfactory guidance. IMarEST suggests therefore the deletion of paragraphs 25 and 26. The importance of utilizing ergonomics in the design process is sufficiently highlighted in the remaining paragraphs and a number of significant references are provided at the end of the module. If the Sub-Committee does not agree with this proposed modification, the paragraphs will need some modification, at least to convert the language style into a more advisory one.

16 IMarEST also notes that a definition of Ergonomics/Human Factors has been added to the definitions section in the introduction. No reference is attributed to the text in that section, but the same text is repeated in draft module 5 under "How can ergonomics support the mitigation and management of fatigue on ships?", where a footnote advises that it is the definition provided in the *Guideline of software quality assurance and human-centred design for e-navigation* (MSC.1/Circ.1512). While IMarEST agrees that this definition is reasonable for the purpose of the Guidelines on Fatigue, it should be noted that it is not the same as that given in the current version of the standard ISO 6385:2016, which quotes the definition of its "parent" document ISO 26800:2011. Since the definition is given in the definitions section of the Guidelines on Fatigue and since the protocol of the Guidelines so far is to place all definitions in the introduction, there is no reason to repeat it here. It is suggested, however, that the Sub-Committee replaces the definition given in the introduction with that given in standard ISO 26800:2011 and references the source in a footnote. The definition is:

> "**Ergonomics/human factors**
> Scientific discipline concerned with the understanding of interactions among human and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance."

17 Turning to paragraphs 35.1, 35.2 and 35.3, noise and vibration prediction tools are not used to calculate limits, they are used for "predicting noise levels" and "predicting vibration levels". Similarly, the seakeeping tools are used to predict structural stress levels and velocity and acceleration levels that can affect habitability. The limits are set by requirements specified either in the shipbuilding specification or through regulatory requirements.

18 Finally, IMarEST notes that while the Guidelines rightly concentrate on the mitigation of the causes of fatigue, it has to be recognized that the nature of seafaring and ship operation is such that fatigue is unlikely to be eliminated. Some attention should therefore be given to the mitigation of any degradation in crew performance resulting from fatigue. We have therefore proposed a text change to paragraph 19 thus:

> "19 Additionally, design of control centres such as machinery control room layout, cargo control room layout and the bridge should consider the integration of people with equipment and systems to enhance system resilience to crew fatigue, as well as reducing mental overload and boredom."

19 To facilitate the work of the Sub-Committee, the complete text of module 5 is attached in the annex, with IMarEST's proposed amendments indicated.

Action requested of the Sub-Committee

20 The Sub-Committee is invited to consider the comments in this document and the resulting proposed draft amended text for module 5 set out in the annex and take action as appropriate.

***

ANNEX[*]

GUIDELINES ON FATIGUE
MODULE 5

FATIGUE AND SHIP DESIGN

1 **Module 5** highlights fatigue mitigation measures which may be utilized in the specification and design of ships, their living and working spaces and their machinery installations. **Module 5** contains practical information intended for the **Ship Designer** for improving the conditions on ships. This module highlights principles that the ship designer should consider and includes methods that can be applied in the design process for reducing the risk of fatigue. Module 1 (Fatigue – Causes and Consequences) should be read prior to going through this module.

Companies should specify that the design principles for fatigue mitigation and management should be considered early in the design process.

Why do ship designers need to know about Shipboard fatigue?

2 Fatigue is a hazard that affects safety, health and well-being. This presents a considerable risk to, safety of life, property, health, security and protection of the marine environment. Because seafarers live and work aboard ships – sometimes for an extended period of time, – they may be exposed to conditions that cause fatigue. Therefore, the design, layout and arrangement of working and living areas should be considered as part of mitigating and managing the risk of fatigue on board ships.

"Paragraph 3 deleted by the Correspondence Group"

4 As highlighted in Module 1, inadequate restorative sleep (both quantity and quality) is among the main causes of fatigue and can be affected by the living and working environment onboard. Hence, ship design plays an important role in ensuring that restorative sleep is achieved.

"*(IMarEST proposes to move this paragraph as paragraph 11.4, as indicated below)"*

"Paragraph 5 deleted by the Correspondence Group"

Paragraphs 6 to 10 deleted by the Correspondence Group"

11 Additionally Shipboard ergonomics and the environmental conditions on board are important considerations in ensuring seafarers are provided with the best opportunity to:

"Paragraph 11.1 deleted by the Correspondence Group"

.2 maintain safe levels of alertness and performance during work periods; and

.3 maintain good health and resilience to fatigue through the provision of adequate rest, recreational and exercise facilities; and

[*] Tracked changes are created using "strikeout" for deleted text and "grey shading" to highlight all modifications and new insertions, including deleted text; and they are referred to the annex in document HTW 4/8.

.4 obtain adequate restorative sleep. As highlighted in module 1, inadequate restorative sleep (both quantity and quality) is among the main causes of fatigue and can be affected by the living and working environment on board. ~~Hence, ship design plays an important role in ensuring that restorative sleep is achieved~~.

"Paragraph 12 deleted by the Correspondence Group"

What aspects of ship design can influence fatigue?

13 There are various aspects of fatigue that can potentially be influenced by the design of the living, sleeping and working environment. Excessive noise, heat or cold, light, too much or too little humidity and poor air quality, amongst others, where people live and work can cause fatigue.

"Paragraph 14 deleted by the Correspondence Group"

"Part of paragraph 15 shifted after paragraph 17 by the Correspondence Group"

15 Ships as a whole should be designed for good seakeeping. Sleeping, living, and working areas should be located within the ship to minimise undesired motions, vibrations and noise due to both seakeeping and machinery.

Appropriate noise levels (SOLAS regulation II-1/3-12) support effective communication and reduce mental workload while on duty, and enhance quality of sleep and rest when off duty. Noise and vibration prediction modelling efforts should be done early in the vessel design process to ensure the most effective design and layout for noise and vibration control and mitigation. See also paragraph 44 below, which refers to the Code on noise levels on board ships, which is mandatory for some types and sizes of ships.

~~[~~***16 Accommodation spaces and layout design (Design to promote rest and wellbeing)***

Crew accommodation is often located in positions likely to be affected by machinery-induced noise and vibration (including cargo transfer systems) and propeller-induced noise and vibration. Steps should be taken early in the design stage to alleviate this. Noise sources internal to the accommodation also need to be considered and noise levels generated by the heating, ventilating and air conditioning (HVAC) systems should be controlled.

Sources of intermittent machinery-induced noise and vibration caused by machinery stopping and starting on a cyclical or irregular basis should also be considered.

Measures to reduce disturbance from impact noise from human activity in corridors and service spaces above and/or adjacent to accommodation should be incorporated in the ship design.

~~[Location of crew accommodation is often built around the operation of the ship, with little consideration for crew comfort. This results in accommodation location usually being decided after that of primary functional and structural options (engine, cargo, navigation and lookout). This can lead to vibration and noise exposure. Where ever the accommodation is located care also needs to be taken to control noise levels induced by the heating, ventilating and air conditioning systems (HVAC).~~ Consideration should be given to:

.1 ensuring cabins are cool, quiet, dark and well ventilated;

.2 ~~B~~bunk design, layout and orientation;

.3 ~~M~~mattress, bedding, padding for ship movement, headroom clearance especially upper bunk/deckhead;

.4 ~~I~~insulating and/or isolating sleeping areas;

.5 use of colour and artwork in the cabins could be considered; and

.6 use of acoustic insulation and/or other noise-abatement measures.

Notwithstanding the above, consideration must be given to sounds that must be heard, e.g. fire alarms.~~]~~

~~[17 However it should be noted that insulation is one of the least preferred and most expensive methods of noise mitigation, especially to apply after construction.]~~

17~~a~~ Consideration should be given to providing an accommodation area that is conducive to rest and that it aids in recovery. As far as reasonably practicable, the following should be considered:

.1 ~~D~~design for minimal crew flow in sleeping quarters;

.2 ~~C~~consider laundry, changing, hygiene, privacy;

.3 ~~I~~insulation or isolation from cargo, engine, other disturbances (noise and vibration);

.4 ~~D~~design lighting to support day and night sleep (~~L~~lighting/dimmers and block-out);

.5 ~~V~~ventilation/air quality;

.6 ~~T~~temperature locally adjustable and humidity (design for sleep); and

"Paragraph 17a.7 deleted by the Correspondence Group"

.8 ~~L~~location and layout of Galley & mess room/s.

"Paragraphs 17a.9 and 17a.10 deleted by the Correspondence Group"

It is also important to consider design for recreation and recovery. Aspects to consider include:

a. Range of needs (personality and culture)

b. Privacy and social life;

c. Minimal "housekeeping";

d. Gym/training facilities;

e. Library, media rooms, ease of study.

A. Workplace design (Design for alertness and performance)

18 Workplace design, particularly for tasks that require sustained physical or mental exertion should consider the following aspects:

.1 Design of the workplace and workflow for optimum layout (placement, storage, adjustable, visibility, ease of communication, ease of movement, noise, vibration, temperature, humidity);

"Paragraph 18.2 deleted by the Correspondence Group"

.3 Working position (seated/standing, height, flooring material (shock and balance));

"Paragraph 18.5 deleted by the Correspondence Group"

.6 Usability (displays and controls incorporate ergonomic and task requirements);
[Maintenance (accessibility, coordination, marking, documentation, interlocks, barriers)]
[~~Maintenance – Design for maintainability (access envelopes accounting for required tools and motions, etc.~~)]

"Paragraph 18.7 deleted by the Correspondence Group"

.8 Protection from hazards (e.g. provide suitable hand holds, barriers, signs, stairs and surfaces to allow easy movement in bad weather);
Design lighting for work spaces to support alertness (colour, natural light access, bright light);

"Paragraphs 18.9 and 18.10 deleted by the Correspondence Group"

Maintenance – Design for maintainability (access envelopes accounting for required tools and motions, etc*.)*
"Note: document HTW 4/8 assigns 6bis to this paragraph but the paragraph is not numbered in the draft"

19 Additionally, design of control centres such as machinery control room layout, cargo control room layout and the bridge, should consider the integration of people with equipment and systems to enhance system resilience to crew fatigue, as well as ~~reduce~~ reducing mental overload and boredom.

"Paragraphs 19.1 to 19.5 and paragraph 20 deleted by the Correspondence Group"

How can ergonomics support the mitigation and management of fatigue on ships?

"Paragraphs 21 and 22 deleted by the Correspondence Group"

Ergonomics/human factors is defined as the scientific discipline concerned with the understanding of interactions among human and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being (2.1) and overall system performance

"IMarEST note: SOURCE: standard ISO 26800:2011"

23 Ergonomically designed work systems enhance safety, effectiveness, and efficiency. They support shipboard tasks under all conditions, including situations where people may be fatigued.

~~Ergonomics is defined as the scientific discipline concerned with the application of validated scientific research about people, their abilities, characteristics and limitations to the design of systems they use, environments in which they function and interact, and jobs they perform to improve health, safety, well-being and overall system performance[1].~~
"IMarEST proposes deleting this paragraph and using the latest standard ISO 26800:2011 text. This should replace the definition in the introduction of the Guidelines. If the Sub-Committee prefers the definition to appear in this section of the Guidelines, it is proposed to move it above paragraph 23, as indicated"

24 The ergonomics approach to design is human-centred. This means that all designable components (ship, ship's systems, equipment, service, etc.) are fitted to the characteristics of the intended users, operators or workers (e.g. seafarers, maintainers, etc.) rather than selecting and/or adapting humans to fit the system and/or product. This should be done by consideration of:

.1 the intended target population;

.2 the task, goal or intended outcome of the system, product or service; and

.3 the environment in which the design is to function.

[~~25 Below is a set of general ergonomic principles which can be employed:~~

~~.1 The design of the workspace and work equipment shall take into account constraints imposed by body dimensions, with due regard to the work process.~~

~~.2 The design of the work shall be such as to avoid unnecessary or excessive strain in muscles, joints, ligaments, and in the respiratory and circulatory systems. Strength requirements shall be within physiologically desirable limits. Body movements should follow natural rhythms. Body posture, strength exertion, and body movements should be in harmony with each other.~~

~~.3 The work environment shall be designed and maintained so that physical, chemical and biological conditions have no noxious effect on people but serve to ensure~~

~~[1] As defined in MSC.1/Circ.1512 Guidelines of software quality assurance and human centred design for e-navigation.~~

~~their health, as well as their capacity and readiness to work. Account shall be taken of objectively measurable phenomena and of subjective assessment.~~

~~.4 The design of the work process shall safeguard workers' health and safety, promote their well-being, and facilitate task performance, in particular by avoiding overloading and underloading. This will result in transgressing, respectively the upper or lower limits of the operational range of physiological and/or psychological functions, such as physical or sensory overloading produces fatigue. Conversely, under- loading or monotonous work will diminish vigilance.]~~

~~26 These general principles can be refined into a collection of more specific criteria, which are context-dependent. For example, the first principle (consideration of body dimensions) could be refined in terms of criteria for work-surface height, seating arrangements, space, range for controls, handles etc. The vast majority of ergonomic standards give specific guidance at a low-level of detail. Many of these are tailored for specific industries, some for marine.~~

26 Both the needs and limitations of the end-users (e.g. seafarers, maintenance or repair teams etc.) should be considered during the design of ship systems and equipment. Those with experience and knowledge of the requirements of ship systems and equipment should be consulted, as far as possible, during the design and construction phases of new ships. Early and continued participation and involvement is regarded as an efficient design strategy especially within ergonomics since, in addition to improving the design, it reduces late-stage re-work and increases user acceptance.

27 Ergonomic design is task-oriented, it takes into account differences that can be observed between the designed task and the way the task is actually performed. Activities in performing a task are affected by variations and changes in, for example, context, procedures, equipment, products or materials.

28 The relations between the conditions and demands placed on the seafarer and their response to being exposed to such conditions and their effects need to be considered in the design of ship systems, services, products and tasks in order to avoid impairing effects on the individual. The response to conditions and demands is dependent on individual characteristics (e.g. body size, age, capacities, abilities, skills, etc.).

29 ~~A few standards give~~ Standards are available giving guidance on how to incorporate ergonomics into the design process, e.g. ergonomic principles in the design of work systems. A list of appropriate standards are included in the reference list.

What tools are available for designing/building fatigue resistant ships?

"Paragraph 31 deleted by the Correspondence Group"

32 The application of ergonomic standards and guidance is effective for improving the working environment, particularly those that deal with environmental conditions (such as temperature, [noise], vibration, ventilation, etc.).

33 Computer simulation tools can be used to support ergonomic design. These are increasingly being used to assess both the impact of environmental conditions as well as work and living design ergonomics. Examples include virtual reality and three-dimensional computer aided design. Use of simulation tools is encouraged as they allow early and more

cost effective evaluation of various aspects of design. There are a variety of design tools that can be applied early in the design process to assist the ship designer in ensuring that specified limits are not exceeded. Wherever possible, and if available anthropometric data and standards should be utilised to support ergonomic design.

34 Environmental conditions also extend across structural design, propulsion, hull forms and several other aspects of design. Often, constructional solutions may be employed to improve environmental conditions. For example, the transmission of noise can be reduced by the insertion of acoustic insulation; similarly, structural resilience techniques can be used to alleviate vibration problems.

35 Finite Element Analysis (FEA) and noise and vibration prediction tools are generally more cost effective than post construction noise and vibration mitigation strategies. ~~These tools can be used for:~~

~~Calculating noise limits;~~
~~Calculating vibration limits;~~
~~Calculating seakeeping qualities/quality of ride;~~
~~Analysing ventilation flows; and~~
~~Performing model tests.~~

Similarly, seakeeping tools may be used, together with ship and propeller model testing, to predict velocity and acceleration levels that can affect habitability.

What rules and guidance are available for designing/building a fatigue resistant ship?

36 There are a number of rules, regulations, standards and guidelines designed to enhance environmental shipboard conditions, which can be used by the ship designer to reduce fatigue. This is a developing field and the designer should check for new material.

"Sub-title deleted by the Correspondence Group"

37 Some aspects of crew accommodation, for instance minimum size and acoustic insulation, are subject to regulation such as the International Labour Organization (ILO), Maritime Labour Convention (MLC) 2006. The MLC, 2006 addresses crew accommodation in Title 3 (Accommodation, Recreational Facilities, Food and Catering).

[38 The MLC, 2006 as it relates to habitability, institutes minimum standards of living through the provision of crew accommodation areas that are:

.1 free from hazardous levels of noise and vibration;

.2 provide appropriate levels of lighting and indoor climatic qualities; and

.3 offer improved crew accommodation design.]

[39 The MLC 2006, Guideline B3.1 (Accommodation and recreational facilities) provides more specific guidelines for ship design, covering the following aspects:

.1 ~~V~~ventilation;

.2 ~~H~~heating;

.3 ~~L~~lighting;

.4 ~~S~~sleeping rooms;

.5 ~~M~~mess rooms;

.6 ~~S~~sanitary accommodation;

.7 ~~H~~hospital accommodation; and

.8 ~~P~~prevention of noise and vibration.]

"Note: the Working Group established at HTW 4 left this in square brackets pending a decision on references to ILO. See HTW 4/16, paragraph 8.16."

40 Crew accommodation is also subject to National Standards.

"Sub-title deleted by the Correspondence Group"

41 Some Classification Societies have guidance and optional notations for aspects of environmental conditions (e.g. noise and vibration) for certain ship types (see references). Designers are encouraged to refer to the relevant guidelines.

"Paragraphs 41.1 and 41.2 deleted by the Correspondence Group"

"Paragraphs 42 and 43 deleted by the Correspondence Group"

Noise and Vibration

44 IMO has implemented requirements and resolutions aimed to protect the seafarer from unacceptable levels of noise:

.1 SOLAS Regulation II-1/3-12 (Protection against noise).

.2 ~~Res. MSC. 337(91)~~ Code on noise levels on board ships (resolution MSC.337(91)) (This code is mandatory under regulation II-1/3-12 with entry into force on 1 July 2014).

.3 ~~Resolution A.468(XII) (1981),~~ Code on noise levels on board ships (resolution A.468(XII)) fixes permissible maximum limits of noise depending on the type of space.

In addition relevant ISO/IEC s~~S~~tandards on noise and vibration should be considered throughout the design process (see references).
"Sub-paragraphs .1 to .9 and .1 to .4 shifted to references by the Correspondence Group"

"Paragraphs 45 and 46 deleted by the Correspondence Group"

Working spaces

47 Regulations and standards exist for dealing with improvements to working spaces which may help in reducing fatigue and its effects. These are developed by organizations such as, IMO, ISO/IEC and Classification Societies. Reference to these standards in ship design is encouraged (see reference section).

"Rest deleted and shifted to references by the Correspondence Group"

References

DNV GL Comfort Class: Rules for classification, Ships, Part 6 Additional class notations, Chapter 8 Living and working conditions, Section 1 Comfort Class – COMF. 1. January 2016.

Provisional Rules for Passenger and Crew Accommodation Comfort. Part 7, Chapter 12. February 1999 July 2014. Lloyd's Register of Shipping
Crew Habitability on Ships. American Bureau of Shipping (ABS) (February, 2016).

IMO MSC/Circular.982, Guidelines on Ergonomic criteria for bridge equipment and layout

IMO Resolution A.708(17), Navigation ~~bride~~ bridge visibility and functions, (6 November 1991)

IMO MSC/Circular.834, Guidelines for engine-room layout, design and arrangement.17

LR The human-centred approach – a best practice guide for ship designers, April 2014

Marcus, O., Baur, X., and Schlaich, C., (2010). *Occupational Risks and Challenges of Seafaring.* Journal of Occupational Health, **52**(2010): p. 249-256.

Calhoun, S. R., (2006). *Human Factors in Ship Design: Preventing and Reducing Shipboard Operator Fatigue*, in *Department of Naval Architecture and Marine Engineering*, University of Michigan.

Van Bommel, W. J. M. (2006). *Dynamic Lighting at work- both in level and colour.* in *2nd CIE expert symposium - Lighting and Health* Ottawa: CIE Publication

Jurgens, H. W., Aune, I. A., and Ursula, P., (1990). *International data on anthropometry*, International Labour Office: Geneva, Switzerland.

ASTM, (2013). *Standard Practice for Human Engineering Design for Marine Systems, Equipment, and Facilities*, ASTM International: West Conshohocken, PA.

Noise and vibration references

.1 ISO 2923:1996 Acoustics - Measurement of noise onboard vessels
.2 ISO 1999:2013 Acoustics – Determination of occupational noise exposure and estimation of noise-induced hearing impairment loss
.3 ISO 717-1:2003; ISO 717-2:2013 Acoustics - Rating of sound insulation in buildings and of building elements:
- Part 1: Airborne sound insulation in building and interior elements.
- Part 2: Impact sound insulation.

.4 IEC 61672 Sound level meters - Electroacoustics - Sound level meters
.5 IEC 61260 Electroacoustics - Octave-band and fractional-octave-band filters.
.6 ISO 2041:2009 Mechanical vibration, shock and condition monitoring Vibration and shock vocabulary
.7 ISO 2631 (Series) Mechanical vibration and shock – Evaluation of human exposure to whole-body vibration
.8 ISO 20283 Mechanical vibration - Measurement of vibration on ships.
- Part 2 (2008): Measurement of structural vibration
- Part 3 (2006): Pre-installation vibration measurement of shipboard equipment
- Part 4 (2012): Measurement and evaluation of vibration of the ship propulsion machinery

.9 ISO 6954:2000 Mechanical vibration and shock – Guidelines for the overall measurement, reporting and evaluation of vibration with regard to habitability on passenger and in merchant ships
.10 LR Ship Vibration and Noise, Guidance Notes, Rev 2.1, 2006
.11 NK Noise and Vibration Guideline, July 2011
.12 ABS Noise and Vibration control for inhabited spaces, July 2014
.13 Health and Safety Executive Noise and Vibration, Offshore Technology Report 2001/068 (http://www.hse.gov.uk/research/otopdf/2001/oto01068.pdf)

General ergonomics references

.1 ILO International data on anthropometry. Eds. Jurgens, H., Aune, I. and Pieper, U. Federal Institute for Occupational Safety and Health, Dartmund. Federal Republic of Germany. 92-2-106449-2. Occupational Safety and Health Series: No. 65, (1990).
.2 ISO 26800:2011 Ergonomics – General approach, principles and concepts.
.3 ISO/TS 20646:2014 Ergonomics guidelines for the optimization of musculoskeletal workload.
.4 ISO 6385:2016 Ergonomics principles in the design of work systems.
.5 ISO 9241-110:2006 Ergonomics of human-system interaction – Part 110: Dialogue principles.
ISO 9241-210:2010 Ergonomics of human-system interaction – Part 210: Humancentred design for interactive systems.
ISO TS 18152:2010 Ergonomics of human-system interaction – Specification for the process assessment of human-system issues.
.6 ISO 9241-5:1998 Ergonomic requirements for office work with visual display terminals (VDTs) – Part 5: Workstation layout and postural requirements.
ISO 9241-5:1999 Ergonomic requirements for office work with visual display terminals (VDTs) – Part 6: Guidance on the work environment.
.7 ISO 11064-1:2000 Ergonomic design of control centres – Part 1: Principles for the design of control centers.
.8 ISO 15535:2012 General requirements for establishing anthropometric databases.
.9 ISO 8468:2007 Ships and marine technology – Ship's bridge layout and associated equipment – Requirements and Guidelines.
.10

.11 ABS Guidance Notes on The Application of Ergonomics to Marine Systems (August 2013, updated February 2014)
The Human-Centred Approach A Best Practice Guide for Ship Designers, Lloyd's Register 2014 (available from www.webstore.lr.org Marine/Technical Guides)