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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 8, *Ships and marine technology*, Subcommittee SC 6, *Navigation and ship operations*.

This third edition cancels and replaces the second edition (ISO 11674:2006), which has been technically revised.

The main changes compared to the previous edition are as follows.

— Clause 1: The bridge alert management (BAM) requirement was added.

— Clause 2: The referenced documents such as related to BAM were added.

— Clause 3: Along with renewal of the overall structure of the document, the terms, definitions and abbreviated terms were also updated.

— Clause 4: The IMO performance requirements that were defined in each clauses were summarized in Clause 4. In addition, Clause 4 was classified into Operational requirements (4.2), Functional requirements (4.3), and Control performance requirements (4.4) and the corresponding tests are specified in Clause 6, Clause 7 and Clause 8.

— 4.3.4, 7.4, Annex B: Because the HCS becomes the BAM compliant equipment, alerts with a standard alert identifier, BAM requirements, test methods, communication procedures, and other requirements regarding implementation were added.

— Clause 5: To harmonize with IEC 62065:2014, the test procedure positively utilizing the ship motion simulator of IEC 62065:2014 and the required test results were specified.

— Annex A: In connection with the change in Clause 8, the use of IEC 62065:2014 ship models and wave disturbances for the HCS performance test was specified.

— The IEC 61162 interface requirements specified in the main body of this document were transferred to Annex C, and details were specified.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Ships and marine technology — Heading control systems

1 Scope

This document specifies the minimum operational, functional and performance requirements, as well as methods of testing and the corresponding required test results, for heading control systems installed on board ships conforming to performance standards adopted by IMO Resolution MSC.64(67), Annex 3.

In addition, it takes into account parts of IMO resolution A.694(17) to which IEC 60945 is associated.

Also it takes into account IMO resolution MSC.302(87) on bridge alert management (BAM).

In this document, the ship models of simulators used for performance testing are based on those from ships with a combined system of propeller propulsion and conventional rudder, with a speed range of up to 30 knots.

The test results are considered also to be valid for ships with multiple parallel operated rudders.

NOTE The text in this document that is identical to that in IMO Resolution A.342(IX), as amended by IMO Resolution MSC.64(67) Annex 3, and IMO Resolution A.694(17), is printed in italics.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61162-1, *Maritime navigation and radiocommunication equipment and systems — Digital interfaces — Part 1: Single talker and multiple listeners*

IEC 61162-2, *Maritime navigation and radiocommunication equipment and systems — Digital interfaces — Part 2: Single talker and multiple listeners, high-speed transmission*

IEC 61162-450, *Maritime navigation and radiocommunication equipment and systems — Digital interfaces — Part 450: Multiple talkers and multiple listeners — Ethernet interconnection*

IEC 62288, *Maritime navigation and radiocommunication equipment and systems — Presentation of navigation-related information on shipborne navigational displays — General requirements, methods of testing and required test results*

IEC 62065:2014, *Maritime navigation and radiocommunication equipment and systems — Track control systems — Operational and performance requirements, methods of testing and required test results*

IEC 62923-1:2018, *Maritime navigation and radiocommunication equipment and systems — Bridge alert management — Part 1: Operational and performance requirements, methods of testing and required test results*

IEC 62923-2, *Maritime navigation and radiocommunication equipment and systems — Bridge alert management — Part 2: Alert and cluster identifiers and other additional features*

IMO Resolution MSC.302(87), *Performance standards for bridge alert management*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp/

— IEC Electropedia: available at http://www.electropedia.org/

3.1.1
adjustment control
control which changes the characteristics of an automatic *heading* (3.1.7) control unit

3.1.2
back-up navigator
individual, generally an officer, designated by the ship master to be on call if assistance is needed on the bridge

[SOURCE: IMO Resolution MSC.74(69), Annex 2:1998, para 4]

3.1.3
change-over control
function for changing over from automatic to *manual steering* (3.1.10) and vice versa

3.1.4
central alert management
CAM
functionality for the management of the presentation of alerts on the *CAM-HMI* (3.1.5), the communication of alert states between CAM-HMI and navigational systems and sensors

Note 1 to entry: The functions may be centralized or partly centralized in subsystems and interconnected via a standardized alert-related communication.

[SOURCE: IMO Resolution MSC.302(87):2010, Appendix 1]

3.1.5
central alert management HMI
CAM-HMI
human machine interface for centralized presentation and handling of alerts on the bridge

[SOURCE: IMO Resolution MSC.302(87):2010, Appendix 1]

3.1.6
central alert management system
CAM system
combined functionality of *CAM* (3.1.4) and *CAM-HMI* (3.1.5)

[SOURCE: IEC 62923-1:2018, 3.1.18]

3.1.7
heading
direction in which the longitudinal axis of the ship is pointed, defined by the angle between the meridian through its position and the fore-and-aft line of the ship, expressed in angular units from true north

Note 1 to entry: The heading is expressed in degrees from true north 000° clockwise through 360°, where 360° becomes identical to 000°.

3.1.8
heading changing
function of the *heading* (3.1.7) control unit to change a ship's heading towards the altered *preset heading* (3.1.14) by taking the rudder order within the rudder limit, while if possible turning with a preset turn rate or with a preset turning radius, within limits related to the ship's manoeuvrability

3.1.9
heading keeping
function of the *heading* (3.1.7) control unit to keep a ship's heading at the *preset heading* (3.1.14) by taking the rudder order within the rudder limit, within limits related to the ship's manoeuvrability

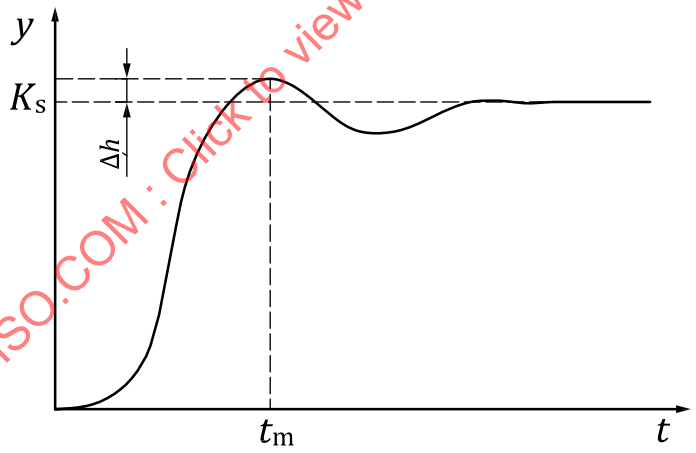
3.1.10
manual steering
method of controlling the steering gear manually

EXAMPLE Using a steering wheel.

3.1.11
off-heading
situation in *heading keeping* (3.1.9), where the ship's *heading* (3.1.7) has deviated from the *preset heading* (3.1.14) beyond a preset limit

3.1.12
overshoot
occurrence of a ship's *heading* (3.1.7) response exceeding the *preset heading* (3.1.14) during *heading changing* (3.1.8), when the preset heading is given as a step input to the HCS

Note 1 to entry: See Figure 1.



Key

Δh absolute value of overshoot
y ship's heading response relative to the previous preset heading during heading changing
k_s change of the preset heading
t_m time when ship's heading response reached the maximum value after exceeding k_s
t time

Figure 1 — Overshoot

3.1.13
power supply
connection point of the HCS to the electrical system on board

Note 1 to entry: A power supply is an external interface to the HCS and may include any AC or DC voltage as defined by the manufacturer. A HCS may have multiple power supplies.

3.1.14
preset heading
direction in which a ship is steered or intended to be steered as entered into the *heading* (3.1.7) control system

Note 1 to entry: Preset heading is expressed as the angular direction in degrees from true north 000° clockwise through 360°, where 360° becomes identical to 000°.

3.1.15
single operator action
one manual control
procedure achieved by no more than one hard-key or soft-key action, excluding any necessary cursor movements, or voice actuation using programmed codes

[SOURCE: IMO Resolution MSC.302(87):2010, Appendix 1]

3.1.16
steering gear control system
SGCS
function that calculates and provides commands to the rudder actuator(s) to achieve the rudder angle according to the rudder order provided

3.1.17
total power failure
absence of sufficient electrical voltage on all power supplies of the EUT

3.1.18
turning-radius control
method of controlling the rate of turn of a ship to perform turns with a preset turning radius through the water

3.1.19
turn rate control
method of controlling the rudder of a ship to perform turns with a preset turn rate

3.1.20
undershoot
occurrence that during *heading changing* (3.1.8), the ship's *heading* (3.1.7) has never reached the *preset heading* (3.1.14) and the difference between the preset heading and the heading is not within the specified range from the preset heading before/at specified time t_u

Note 1 to entry: See 4.4.3.1.

3.1.21
waypoint
geographic position together with its associated data

[SOURCE: IEC 62065:2014, 3.1.43]

3.2 Abbreviated terms

BAM bridge alert management

BNC back-up navigator call

BNWAS bridge navigational watch alarm system

CAM central alert management

CAM-HMI central alert management-human machine interface

CCW	counterclockwise
CW	clockwise
EUT	equipment under test
HCS	heading control system
HMI	human machine interface
OOW	officer of the watch
ROT	rate of turn
SDME	speed and distance measuring equipment
SGCS	steering gear control system
SPD	speed of ship
TCS	track control system
UID	user input device

4 Requirements

4.1 General

[IMO Resolution MSC.64(67), Annex 3, para 2.1] *Within limits related to the ship's manoeuvrability the heading control system, in conjunction with* their sources *of heading information,* shall *enable a ship to keep a preset heading with minimum operation of the ship's steering gear.*

[IMO Resolution MSC.64(67), Annex 3, para 2.3] *A turn rate control or a turning-radius control for performing turns may be provided.*

NOTE The above IMO requirement (para 2.3) is interpreted as follows.

When the HCS performs the heading changing according to the preset heading, *a turn rate* (constant) *control for performing turns* can *be provided* by setting either the maximum desired preset turn rate or the maximum desired preset turning radius. (See IMO Resolution MSC.64(67), Annex 3, para 3.2).

[IMO Resolution MSC.64(67), Annex 3, para 3.1] *The heading control system* shall *be capable of adapting manually or automatically to different steering characteristics of the ship under various speed, weather and loading conditions, and provide reliable operation under prevailing environment and normal operational conditions.*

A heading control system (HCS) shall be composed, as a minimum, of the following components (see Figure 2).

— 4 components of HCS, in addition to an external heading monitor ([a] in Figure 2):

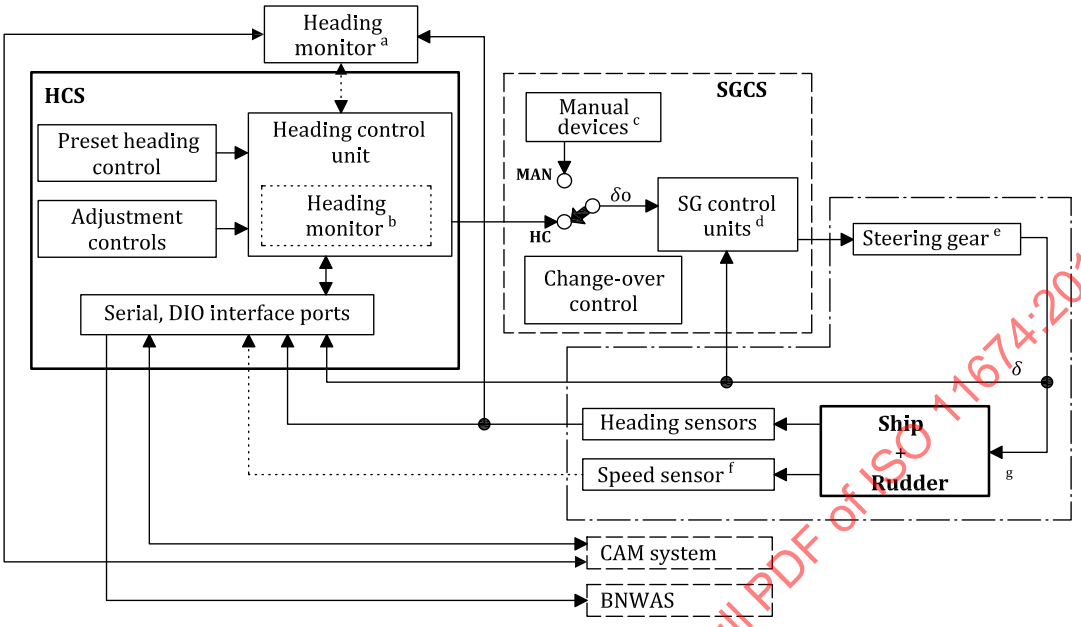
  preset heading control, adjustment controls, serial/DIO interface ports, heading control unit.

— The heading control unit includes the following functions:

  adjustment of control parameters (automatic/manual), heading keeping, display and indication of mandatory/relevant information, alert management. If possible, heading changing with preset turn rate or with preset turning radius. If applicable, automatic adaption control to ship speed (change) and/or disturbances, an internal heading monitor ([b] in Figure 2).

— The alert management includes the following functions:

alert activation, alert presentation, alert handling, alert communication with CAM system, self-diagnostic function to notify OOW.



Key

δo rudder order

δ actual rudder angle

a In case the heading monitor is (a function of) an external device. (e.g. heading information system composed of multiple heading sensors and heading distribution unit).

b In case the heading monitor is an internal function of the heading control unit.

c Manual devices for example include a steering wheel and steering UIDs installed on the bridge.

d Plural SG control units are usually installed to drive hydraulic power units of steering gear.

e Steering gear usually includes the plural hydraulic power units.

f When the HCS utilizes speed information for automatic heading control adaptation.
For example: an autopilot adaptive to speed; a HCS with turning-radius control.

g When a ship simulator is used for test, the part surrounded by a dash-dotted line is replaced by IEC 62065:2014 ship motion simulator.

NOTE 1 During the tests, the CAM system can be replaced by a CAM simulator.

NOTE 2 During the tests, the BNWAS can be replaced by a simulator.

NOTE 3 Dotted line: equipment/function is optional.

NOTE 4 Dashed line: not part of the system to be tested in this document.

Figure 2 — Typical block diagram for a heading control system installed on the bridge

4.2 Operational requirements

4.2.1 Change-over from automatic to manual steering and vice versa

[IMO Resolution MSC.64(67), Annex 3, para 4.1] *Change-over from automatic to manual steering and vice versa* shall be *possible at any position of the rudder and* shall *be effected by* single operator action (i.e. *one manual control*) *within 3 seconds.*

[IMO Resolution MSC.64(67), Annex 3, para 4.2] *Change-over from automatic to manual steering* shall *be possible under any conditions including any failure in the heading control system.*

[IMO Resolution MSC.64(67), Annex 3, para 4.3] *When changing-over from manual to automatic steering, the heading control system* shall *take over the actual heading as the preset heading.*

[IMO Resolution MSC.64(67), Annex 3, para 4.4] *There* shall *be a single change-over control which* shall *be located in such a position that it is easily accessible to the officer of the watch.*

The installation manual or drawings shall hold a requirement for the change-over control to be installed in a position in which *it is easily accessible to the officer of the watch*.

[IMO Resolution MSC.64(67), Annex 3, para 4.5] *Adequate indication* shall *be provided to show which method of steering is in operation* at a particular moment. This indicator shall be fitted near the change-over control.

NOTE The word 'automatic' means heading control, it does not include track control.

4.2.2 Operational controls including adjustment controls

[IMO Resolution A.694(17), para 3.2] *All operational controls* shall *permit normal adjustments to be easily performed and* shall *be easy to identify from the position at which the equipment is normally operated. Controls not required for normal operation* shall *not be readily accessible.*

[IMO Resolution A.694(17), para 3.3] *Adequate illumination* shall *be provided in the equipment or in the ship to enable identification of controls and facilitate reading of indicators at all times. Means* shall *be provided for dimming the output of any equipment light source which is capable of interfering with navigation.*

For a required external light source and/or dimming of external light sources, a requirement should be stated in the installation manual or drawings.

[IMO Resolution MSC.64(67), Annex 3, para 7.1] *The number of operational controls* shall *be such that easy and safe operation can be achieved. The controls* shall *be designed* and arranged *to preclude inadvertent operation.* Their manner of functioning, location and size shall provide for simple, quick and effective operation.

[IMO Resolution MSC.64(67), Annex 3, para 7.2] *Unless features for automatic adjustment are incorporated in the installation, the heading control system* shall *be provided with adequate controls to adjust* its performance *to effects due to weather and the ship's steering performance*.

[IMO Resolution MSC.64(67), Annex 3, para 7.3] *The heading control system* shall *be designed in such a way as to ensure altering the preset heading to starboard by turning the heading setting control clockwise or tilting it to the right-hand side.* Turning the control counterclockwise or tilting it to the left-hand side shall effect a similar alteration to port. *Normal alterations of heading* shall *be possible by one adjustment only of the preset heading control.* Requirements shall be made by means of the design and the construction of the preset heading control to preclude unintended alteration of heading. When changing heading, the clockwise or counterclockwise direction of the preset heading control shall determine the ship's turning direction.

[IMO Resolution MSC.64(67), Annex 3, para 7.4] *Where remote control stations are provided, facilities for the delegation of control to the remote station and unconditional return of control* shall *be incorporated in the master station.*

[IMO Resolution MSC.64(67), Annex 3, para 7.5] *Except for the preset heading setting control, the actuation of any other control* shall *not significantly affect the heading of the ship.*

[IMO Resolution MSC.64(67), Annex 3, para 7.6] *Additional controls at remote positions* shall *comply with the provisions of this* document.

4.2.3 Manual change-over from track control to heading control

[IMO Resolution MSC.64(67), Annex 3, para 2.2] *The heading control system may work together with a track control system adjusting its heading for drift.*

The manufacturer shall declare if the HCS is able to work together with a track control system.

NOTE The HCS is able to work together with a TCS, for example, if it can accept heading commands from a track control system.

[IMO Resolution MSC.64(67), Annex 3, para 5.1] *If the heading control system works as part of a track control system, then when switching from track control to heading control, the actual heading should be taken as the preset heading.*

[IMO Resolution MSC.64(67), Annex 3, para 5.2] *Any switching back to track control shall not be possible without intended action of the ship's personnel.*

4.3 Functional requirements

4.3.1 Rudder angle limitation

[IMO Resolution MSC.64(67), Annex 3, para 3.3] *Means* shall *be incorporated in the equipment to enable adjustable rudder angle limitation in the automatic mode. Means* shall *also be available to indicate when the angle of limitation has been commanded or reached. When other means of directional control are used the requirements of this* subclause shall *appropriately apply.*

NOTE The word 'automatic' means heading control, it does not include track control.

4.3.2 Heading monitor

[IMO Resolution MSC.64(67), Annex 3, para 6.3] *If the ship is required to carry two independent compasses, a heading monitor* shall *be provided to monitor the actual heading information from independent heading sources. The heading monitor is not required to be an integrated part of the heading control system.*

4.3.3 Interfaces

[IMO Resolution MSC.64(67), Annex 3, para 8.1] *The heading control system* shall *be connected to a suitable source of heading information.*

[IMO Resolution MSC.64(67), Annex 3, para 8.2] *The heading control system* shall *be connected to a suitable source of speed information when it is used in a turning radius mode or when any control parameters are automatically adapted to speed.*

For the connection of a suitable source of heading information and, if applicable, speed information, a requirement should be stated in the installation manual or drawings.

[IMO Resolution MSC.64(67), Annex 3, para 8.3] *If a heading control system is capable of digital serial communication with the ship's navigation system, the interface facilities* shall *comply with the relevant international marine interface standards* IEC 61162-1, IEC 61162-2 and/or IEC 61162-450 as applicable.

The IEC 61162-1 sentences for transmitting and receiving data for the heading control system are specified in Tables C.1 and C.2 and shall be supported. (See Annex C.)

4.3.4 Alert management

4.3.4.1 General

The general presentation, handling and communication for alerts shall comply with the requirements stated in IMO Resolution MSC.302(87), in IEC 62923-1:2018, Module A — Presentation and handling of alerts on the bridge, and Module C — Interfacing, and in IEC 62923-2, as a minimum.

The alerts with standard alert identifiers for heading control system are specified in Table B.1.

NOTE 1 In clause 7.4, these alerts are independently verified one by one by using IEC 62065:2014 ship motion simulator, CAM simulator, change-over control.

NOTE 2 Alert titles and alert description texts in Table B.1 and used in the body text of this document are not mandatory alert titles and alert description texts, but are to be regarded as guidance. Alert titles and alert description texts used in the body text of this document are therefore indicated between single quotation marks (‘ ’).

Manufacturer of heading control system shall declare the EUT function type for BAM compliance test.

NOTE 3 According to the EUT function type, the relevant test set-up and test items are specified in BAM test standards. Refer to the following clauses in IEC 62923-1:2018: 4.2, EUT function types; 5, Test methods; 6, Module A - Presentation and handling of alerts on the bridge; 8, Module C - Interfacing.

4.3.4.2 Failure and alert status of the heading sensor in use for control (‘Lost HDG control’ alert)

The heading information used by the HCS can be based on a single heading sensor or optionally can be based on multiple heading sensors.

In case the HCS is (can be) connected to multiple sensors (not integrated into an INS), the situation that heading information has failed or is unavailable means that all connected heading sensors fail or are unavailable at the same time.

If heading information has failed or is unavailable while heading control is active, then:

a) ‘Lost HDG control’ alarm shall be activated, giving advice to the OOW to switch to manual control.

   The actual rudder angle shall be maintained (i.e. stay in position), where the rudder angle shall be set to a fixed angle in such a way that:

   — if the ship’s heading is controlled to keep the preset heading, the actual heading shall be approximately maintained;

   — if the ship’s heading is controlled during turn, the actual rate of turn shall be approximately maintained.

   [SOURCE: IEC 62065:2014, 5.5.3]

b) When the HCS has been switched to manual steering by the operator, with or without acknowledgement of the ‘Lost HDG control’ alarm, this alarm shall be terminated (this alarm is changed to normal state and therefore removed from both HMI of the HCS and CAM-HMI automatically).

   After being switched to manual steering, for example a ‘HCS unavailable’ caution indicating that ‘HCS unavailable due to missing heading inputs’ could be activated.

c) When the ‘Lost HDG control’ alarm is not acknowledged by OOW within 30 s, and this alarm has not been terminated, a BNC shall be activated by giving appropriate signal to BNWAS (see IEC 62616).

   The BNC to the BNWAS is de-activated after the HCS has been switched to manual steering or the ‘Lost HDG control’ alarm has been acknowledged.

If the HCS is connected to multiple sensors (not integrated into an INS), and only the heading sensor selected for automatic heading control use (i.e. the primary heading sensor) has failed or is unavailable while another sensor is still available, the following shall be done:

— in case that the HCS does an automatic change of heading sensors, a caution shall be activated. (e.g. the 'HDG in fallback' caution, '<GYRO 1> lost, HC continues normally. Automatic switched over to <GYRO 2>');

— in case that the HCS does not do an automatic change of heading sensors, the same alerts shall be activated as in a), b) and c) above;

— when the operator switches the active steering mode from heading control to manual steering, but the primary heading sensor is not switched to another sensor manually, for example a 'HCS unavailable' caution indicating that '<GYRO1>lost, HCS unavailable. Select <GYRO2> immediately' could be activated.

4.3.4.3 'Off-heading' alert

[IMO Resolution MSC.64(67), Annex 3, para 6.2] *An off-heading alert, both audible with mute function and visual* shall *be provided when the actual heading information deviates from the preset heading beyond a preset limit.* The minimum range of the preset limit shall be 5° to 15°.

When this alert is activated, the alert priority shall be warning.

If 'Off-heading' warning is not acknowledged by the OOW within 30 s, the alert priority shall change from warning to alarm. 'Off-heading' warning is removed from the display and 'Off-heading' alarm is activated newly.

4.3.4.4 Alert detected by heading monitor ('Doubtful heading' alert)

[IMO Resolution MSC.64(67), Annex 3, para 6.3] *An alert both audible with mute function and visual* shall *be provided when the heading information in use deviates from the second heading source beyond a preset limit.* The minimum range of a preset limit shall be 5° to 15°.

This alert shall be the 'Doubtful heading' warning listed in Table B.1, and, if the heading monitor is part of the HCS, doubtful heading data shall be clearly indicated.

NOTE Although the detection device/function (alert source) is called 'heading monitor', IEC 62923-2 on bridge alert management advices to provide a functional title such as "Doubtful heading".

4.3.4.5 Failure and alert status of speed sensor in use for control ('No SPD adaptive' alert)

If the HCS utilizes speed information for automatic adjustment of control parameters, the following alert is applicable.

If the speed information has failed or is unavailable, but heading control is still available by using e.g. the last plausible speed or manual speed input:

a) 'No SPD adaptive' caution indicating that the 'Speed adaptive control is not available due to no speed inputs' shall be activated during heading control;

b) when the HCS has been switched to manual steering by the operator, the 'No SPD adaptive' caution shall be terminated.

4.3.4.6 'Low speed' alert

In case that the HCS utilizes speed information during heading control, the following 'Low speed' alert is applicable.

If the speed through the water in the fore/aft direction is lower than a predefined limit necessary for steering the ship during heading control (minimum manoeuvring speed for heading control due to the effectiveness of the rudder), a 'Low speed' warning shall be given.

4.3.4.7 Failure or reduction in the power supply to the HCS or heading monitor ('HCS power fail' alert)

[IMO Resolution MSC.64(67), Annex 3, para 6.1] *An alert both audible with mute function and visual* shall *be provided in order to indicate failure or a reduction in the power supply to the heading control system or heading monitor, which would affect the safe operation of the equipment.*

When the HCS has multiple power supplies, and thus remains in operation after failure of one power supply due to the presence of another power supply, the HCS shall on failure of one power supply raise a 'HCS power fail' alert of priority caution with an appropriate alert description text, e.g. 'HCS is working normally by switching to another power supply automatically'.

In case of total power failure to the HCS, the HCS shall provide a status signal (e.g. by normally closed contact) to enable external equipment to raise the appropriate alert.

In case the heading monitor is not included in the HCS (see Figure 2), the same requirements apply for the heading monitor as for the HCS.

4.3.4.8 System failure ('HCS fault' alert)

An alert, both audible with mute function and visual, shall be provided in order to indicate any malfunction of the heading control system which would affect the safe operation of the equipment.

The HCS shall provide an alert indicating the system failure ('HCS fault') as appropriate for the HCS.

4.3.5 Mandatory displayed information

When heading control is performed, the following items shall be displayed at least on user request in the heading control system:

— ship's heading and its source name in use for control;

— preset heading;

— active steering mode;

— alerts activated by heading control system;

— rudder limit indication, when an angle of rudder limit has been set; and

— indication when a rudder order, or an actual rudder angle, has reached or exceeded the set angle of rudder limit.

4.4 Control performance requirements

4.4.1 General

The heading control system shall facilitate both heading keeping and heading changing.

The control performance tests shall be performed by using ship motion simulator.

NOTE Refer to the following for ship motion simulators:

IEC 62065:2014, Annex H, H.4, Simulation of sea state, and Annex I, Ship model specification.

4.4.2 Heading keeping function under wave disturbance

[IMO Resolution MSC.64(67), Annex 3, para 3.4] *Means* shall *be incorporated to prevent unnecessary activation of the rudder due to normal yaw motion.*

The heading control system shall be able to successfully perform the tests in 8.1.1, within the accuracy requirements specified in 8.1.2 and Table A.1.

NOTE Different requirements are given for each ship model.

4.4.3 Heading changing function

4.4.3.1 General

[IMO Resolution MSC.64(67), Annex 3, para 3.2] *The heading control system* shall *be able to perform turns, within the turning capability of the ship, based either on a preset turning radius or a preset rate of turn.*

NOTE 1 Regarding the heading changing with a preset turn rate or a preset turning radius, the ship's rate of turn constant control is not always realized due to the heading changing angle (set as a preset heading), the ship's condition (ship's manoeuvrability, speed, loading condition etc.), environmental conditions, and/or other settings such as a rudder limit, a preset turning radius, a preset turn rate.

[IMO Resolution MSC.64(67), Annex 3, para 3.5] *Any alteration of the preset heading* shall *not be possible without intended action of the ship's personnel.*

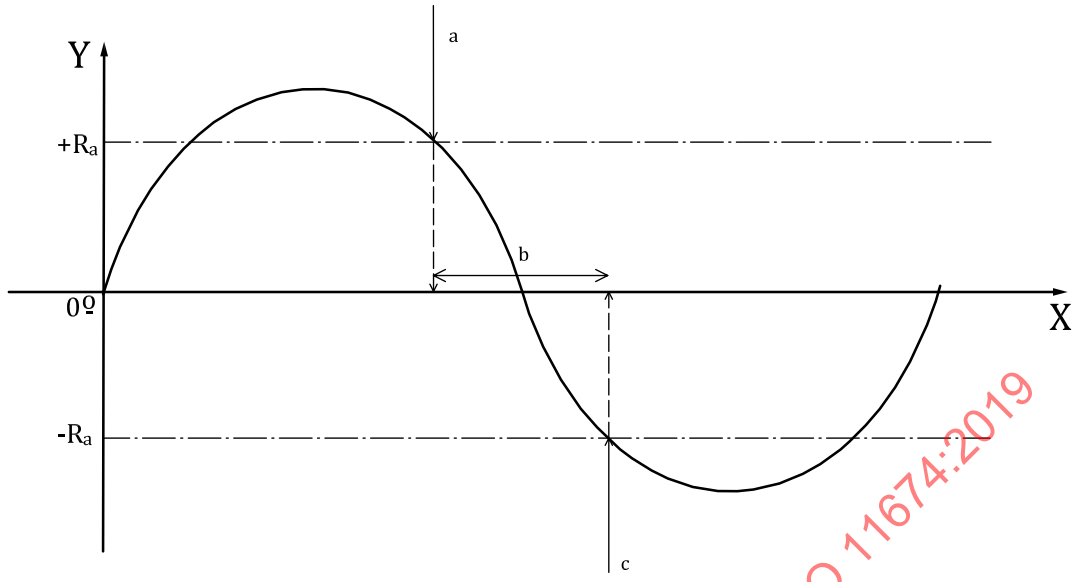
[IMO Resolution MSC.64(67), Annex 3, para 3.6] *The heading control system* shall *allow the change to a preset heading without significant overshoot or* undershoot.

The heading changing performance shall enable a ship's heading to follow the altered preset heading by taking the rudder to not more than the rudder limit, if possible, with a preset turn rate or with a preset turning radius within limits related to the ship's manoeuvrability.

The HCS shall demonstrate that the heading changing results (see 8.2.2.2, 8.2.3.3, 8.2.4.3, 8.2.5.2 and 8.2.6.2) satisfy the following three requirements, in addition to the requirement stated in each of 4.4.3.2 to 4.4.3.5 clauses:

— heading overshoot shall be equal to or less than OVR1 in Table A.2 (under no disturbance) respectively OVR2 in Table A.3 (under sea state 5);

— the rudder angle shall stay in the band between +Ra and –Ra. Rudder angle (Ra) means Ra2 in Table A.2, and Ra3 in Table A.3, respectively. If the HCS creates a first peak (in order to set up turn rate) and/or a counter rudder peak (in order to eliminate rate of turn) then these peaks shall be excluded from the +Ra and –Ra band consideration. A first peak ends when the rudder angle has passed the first maximum amplitude at the moment the rudder angle enters within the band between +Ra and -Ra. A counter rudder peak starts at the last increment of the rudder angle where the rudder angle reaches beyond the band between +Ra and -Ra. (See Figure 3);



Key

X time

Y rudder angle

a Start (after max. first band entry).

b 'Band evaluation' period. Not all systems will show such 'perfect' response – ripples are possible.

c End (last increment max. first beyond band).

Figure 3 — Band evaluation period during heading changing

— before or at t_u, as specified in Table A.2 (under no disturbance) or Table A.3 (under sea state 5), the ship's heading shall be reached at least once within ±1,0° (in case heading changing angle is larger than 5°) or ±0,5° (in case heading changing angle is equal to or less than 5°) from the preset heading.

NOTE 2 The times t_u to judge undershoot are specified in Table A.2 and Table A.3 for each ship model being tested in certain conditions (see 8.2.1 NOTE).

The requirements for heading changing in 4.4.3.2 to 4.4.3.4 apply for conditions of no disturbance.

4.4.3.2 Small heading changing

In case the heading control system is provided with the function to perform turns with a preset turn rate or preset turning radius, the equipment shall be able to successfully perform the small heading changing tests of 8.2.2, within the three accuracy requirements defined in 4.4.3.1.

NOTE During the tests of 8.2.2 it is not required to actually reach the preset turn rate or preset turning radius setpoints.

4.4.3.3 Heading changing with preset turn rate

In case that the heading control system is provided with the function to perform turns with a preset turn rate, the accuracy of the rate of turn after becoming constant in a turn shall be within ±10 % of its preset value or 3°/min, whichever is the greater, under no wave disturbance (see 8.2.3).

NOTE The heading changing angle and the preset turn rate for this test are selected so that the heading response has a constant rate of turn for 10 s as a minimum.

4.4.3.4 Heading changing with preset turning radius

In case that the heading control system is provided with the function to perform turns with a preset turning radius, the accuracy of the radius after becoming constant in a turn shall be verified by the preset turn rate corresponding to preset turning radius specified in Table A.2 (see 8.2.4).

See A.5 b) for the relation between *r*, *V* and *R*, and see 4.4.3.3 for the accuracy of the rate of turn.

NOTE The heading changing angle and the preset turning radius for this test are selected so that the heading response has a constant rate of turn for 10 s as a minimum.

4.4.3.5 Heading changing under wave disturbance

The three requirements in 4.4.3.1 shall apply for the test in 8.2.6 (see A.4).

4.5 Display

The visual display of the HCS shall comply with the requirements of IEC 62288.

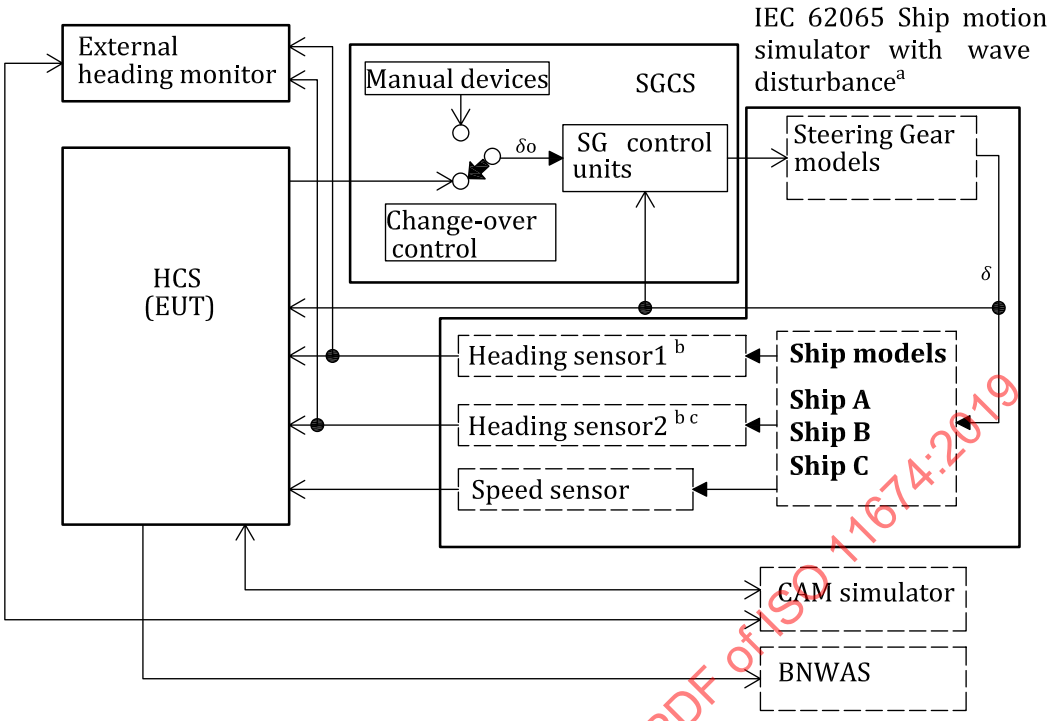
5 Set-up

5.1 General

All the tests in this document are intended to be executed in a laboratory environment with the IEC 62065:2014 ship motion simulator, a BNWAS simulator and the IEC 62923-1:2018 CAM simulator.

A typical test set-up is shown in Figure 4.

Prepare the test environment (see Figure 4) including the necessary simulators and install the interfaces to the EUT. Verify that the 3 ship classes described in 5.2 are available in the simulator.



Key

δo rudder order

δ actual rudder angle

The solid square box means a device, function or units and the EUT.

The dashed square box means an application, software based on PC hardware.

If an actual SGCS is not available:

— the manual device may be a potentiometer that outputs a voltage signal corresponding to the rudder order of manual steering device;

— the change-over control may be a toggle switch; and

— the SG control unit can be omitted and the switched rudder order is directly connected to ship motion simulator.

In case the heading monitor is a function of an external device as specified in Figure 2. The sentences from heading sensor 1 and heading sensor 2 are then also input to such an external Heading monitor.

[a] Ship models of IEC 62065:2014 Ship motion simulator are used for the following tests.

For the operational tests and functional tests, ship B is used.

For the performance test, ship A, ship B and Ship C are used.

For the alerts with a standard alert identifiers in Annex B, ship A is used.

[b] For example, heading sensor 1 is used for control as a primary sensor, and heading sensor 2 is used for reference as a secondary sensor. (e.g. for a heading monitor). On failure of the primary sensor, the EUT may switch over primary use to another available heading sensor.

[c] In case the EUT supports two independent heading sensors.

Figure 4 — Typical test set-up for heading control system and the external heading monitor

5.2 Ship motion simulator and starting condition

Using the ship motion simulator, the ship's manoeuvrability shall be simulated for:

— ship class A: ferry, 30 kn;

— ship class B: container ship, 25 kn; and

— ship class C: tanker, 10 kn.

The parameters of classes A, B and C are specified in Annex I, Table I.5 of IEC 62065:2014.

Regarding the disturbances, only the wave disturbance model representing sea states (Annex H, H.4 of IEC 62065:2014) is used for the functional tests and the performance tests of the EUT.

The starting conditions of every ship model are as follows.

— Starting conditions of ship A:

  <ship motion simulator>

  Initial heading: 180°; Initial speed: 20 kn; Active steering mode: Manual; No wave disturbance; Manual rudder order: 0°; Rudder limit: 35°; steering bias: 0°.

  <HCS>

  Set HCS control gains and parameters to be optimal for ship A.

— Starting conditions of ship B:

  <ship motion simulator>

  Initial heading: 180°; Initial speed: 20 kn; Active steering mode: Manual; No wave disturbance; Manual rudder order: 0°; Rudder limit: 35°; steering bias: 0°.

  <HCS>

  Set HCS control gains and parameters to be optimal for ship B.

— Starting conditions of ship C:

  <ship motion simulator>

  Initial heading: 180°; Initial speed: 10 kn; Active steering mode: Manual; No wave disturbance; Manual rudder order: 0°; Rudder limit: 35°; steering bias: 0°.

  <HCS>

  Set HCS control gains and parameters to be optimal for ship C.

The ship models of the IEC 62065:2014 ship motion simulator are used for the following tests:

— for operational testing and functional testing except alert management, ship B is used;

— for control performance testing, ship A, ship B and ship C are used; and

— for alert management testing (the test of alerts with a standard alert identifier as listed in Annex B), ship A is used.

6 Tests of operational requirements

6.1 Change-over from automatic to manual steering and vice versa — Method of testing and required test results

See 4.2.1.

During the heading changing test under wave disturbance in 8.2.6, confirm by observation that the EUT comply with the requirements of 4.2.1.

6.2 Operational controls including adjustment controls — Method of testing and required test results

See 4.2.2.

Refer to the manufacturer's documentation on operational controls and adjustment controls.

Confirm by inspection of the manufacturer's documentation that the EUT meets the requirements of 4.2.2.

6.3 Manual change-over from track control to heading control

6.3.1 Application

See 4.2.3.

This test is only required for heading control systems that can work together with track control systems (for the purpose of this test, this is described as 'HCS as part of a TCS', becoming one EUT, together called 'TCS').

6.3.2 Method of testing and required test results

Refer to the manufacturer's documentation. Determine if the EUT can work as part of a TCS.

If the EUT can work as part of a TCS, either

a) confirm by inspection of documented evidence that the TCS including the EUT complies with IEC 62065:2014, 5.1.1.14 and 6.4.6.6;

   or

b) perform the following procedures.

   Setup the TCS so that the TCS includes the EUT as specified in the manufacturer's documentation.

   1) Plan WP1 waypoint and WP2 waypoint in the route for track control so that the first leg course over ground becomes 180° and the leg length between WP1 and WP2 becomes 1,0 NM (nautical mile).

   2) Start simulation of ship B under ship B starting conditions on WP1 position.

   3) Change the active steering mode from manual to heading control and simulate sea state 5 (wave disturbance).

      Monitor for 1 min if the EUT enables a ship's heading to keep the preset heading and the rudder is fluctuated.

   4) Start track control on the straight leg.

   5) At 1 min after the track control started, change the active steering mode from track control to heading control.

      Confirm by observation that the EUT takes the actual heading as the preset heading and enables a ship's heading to keep the preset heading by taking the rudder amplitude not more than Ra1 in Table A.1 under sea state 5.

      Confirm by analytical evaluation that it is not possible to switch back to track control without intended action of the ship's personnel.

   6) Stop the simulation.

6.4 Display test

See 4.5.

If the EUT provides a visual display, confirm by inspection of documented evidence that the EUT complies with IEC 62288.

7 Tests of functional requirements

7.1 Rudder angle limitation

See 4.3.1.

7.1.1 Method of testing

Perform the following procedures (see A.6. and Figure A.10).

a) Start simulation of ship B under ship B starting conditions, change the active steering mode from manual to heading control.

b) At 1 min after the heading control starts, simulate sea state 8 (wave disturbance).

NOTE The scaling factor of sea state 8 is specified at A.5 a).

c) Monitor for 10 min that the EUT keeps the ship's heading to preset heading (180°) and that the rudder is fluctuated by more than 5°.

d) Change the rudder limit to 5°.

Monitor for 10 min that the maximum rudder angle is restricted to 5° port and starboard sides.

e) Remove the wave disturbance.

Monitor the ship's heading and rudder responses until their fluctuations are reduced considerably.

f) Alter the preset heading from 180° to 200° so as to start heading changing to starboard side.

g) Monitor the ship's heading and the rudder angle until 2 min after the ship's heading has once reached within ±1,0° from the preset heading.

h) Change the active steering mode from heading control to manual.

i) Stop the simulation.

7.1.2 Required test results

Confirm by observation that the EUT is able to restrict the maximum rudder angle to 5° to both port and starboard sides under sea state 8 during heading keeping.

Confirm by observation that the EUT is able to follow the ship's heading to preset heading (200°), whilst restricting maximum rudder angle to 5° to starboard side during heading changing.

Confirm by observation that means are available to indicate when the angle of rudder limitation has been commanded or reached.

7.2 Heading monitor

See 4.3.2, 4.3.4.4.

If the EUT has a heading monitor as an internal function, the test in 7.4.4 is performed.

7.3 Interfaces

See 4.3.3.

7.3.1 Method of testing

Refer to the manufacturer's documentation specified in IEC 61162.

Regarding the check of alert communication messages and sentences, a CAM simulator may be used.

7.3.2 Required test results

Confirm by observation that the sentences supported by the EUT include those in Table C.1, Table C.2 and C.2 of Annex C.

Confirm by observation that the EUT supports all optional sentences as declared by manufacturer.

Confirm by analytical evaluation that the available interfaces comply with IEC 61162-1, IEC 61162-2 and/or IEC 61162-450 and that for alert management at least the interfaces specified in IEC 62923-1:2018 are available.

7.4 Alert management

7.4.1 Basic test for alert management

See 4.3.4.1.

Confirm by inspection of documented evidence that the EUT complies with IEC 62923-1:2018, Module A and Module C, and with IEC 62923-2.

See Annex B.

Subclauses 7.4.2 to 7.4.8 give the tests for the functional alerts specified in Table B.1.

7.4.2 'Lost HDG control' alert and escalation to BNWAS

See 4.3.4.2.

7.4.2.1 Method of testing

Perform the following procedures from a) to i).

a) Start simulation of ship A under ship A starting conditions, change active steering mode from manual to heading control.

b) After the preset heading from 180° to 210°.

c) During the heading change, disable all heading sensor input.

   Do not acknowledge the 'Lost HDG control' alarm for at least 30 s.

d) After the 'Lost HDG control' alarm has been escalated to BNC for BNWAS, acknowledge this alarm at HMI of the EUT.

e) Switch to manual steering.

f) Restore heading sensor input and switch to heading control.

g) When the ship's heading is near the preset heading for 2 min, tag all heading sensor inputs as 'invalid'. Do not acknowledge the 'Lost HDG control' alarm.

h) Within 30 s switch to manual steering.

i) Restore all heading inputs as ‘valid’.

When the EUT obtains input from multiple heading sensors and is able to automatically switch from the actually selected heading sensor to an alternative heading sensor in failure situations, also perform the following tests.

Connect the EUT to multiple heading sensors.

j) Switch to heading control.

k) Remove the input from the heading sensor in use.

l) Restore all connected heading sensor inputs.

m) Tag the input from the heading sensor in use as ‘invalid’.

n) Restore ‘valid’ tags on the input of all connected heading sensors.

7.4.2.2 Required test results

For 7.4.2.1 a) to n), confirm by observation that the EUT reacts as required in 4.3.4.2.

7.4.3 ‘Off-heading’ alert

See 4.3.4.3.

7.4.3.1 Method of testing and required test results

NOTE The following test is performed during heading keeping by setting a steering bias larger than the rudder limit of the EUT to the ship motion simulator.

a) Start simulation of ship A under ship A starting conditions.

b) Change the rudder limit to 5° and set the preset off-heading limit to 5°.

c) Change the active steering mode from manual to heading control.

d) Set the steering bias of the ship motion simulator to 8° starboard.

   1) Monitor that the rudder order is fixed to 5° port and that the ship’s heading is increasing to CW.

   2) Monitor until the ship’s heading exceeds 185°.

   3) Confirm by observation that the ‘Off-heading’ warning, as required in 4.3.4.3 and Table B1, is activated.

e) Do not acknowledge the ‘Off-heading’ warning for at least 30 s.

   1) Confirm by observation that this warning is escalated to alarm as specified in 4.3.4.3 and Table B1.

   2) Acknowledge this alarm at HMI of the EUT.

   3) Confirm by observation that the alert state is changed from “active - unacknowledged” to “active - acknowledged”.

f) Set the steering bias of the ship motion simulator to 0°.

   1) Monitor until the ship’s heading becomes below 185° and is settled to 180°.

2) Confirm by observation that the alert state is changed from “active acknowledged” to “normal” and it is removed from HMI of the EUT and CAM system simulator after the ship’s heading becomes below 185°.

g) Change the active steering mode from heading control to manual.

h) Stop the simulation.

7.4.4 Alert detected by the heading monitor (‘Doubtful heading’ alert)

See 4.3.4.4.

7.4.4.1 Method of testing and required test results

NOTE This test uses the two simulated heading sensor outputs generated by the ship motion simulator. The simulator can be set to add an offset to each of these values to simulate a deviation between the two outputs.

a) Start simulation of ship A under ship A starting conditions.

b) Change the active steering mode from manual to heading control.

c) Set the preset limit of heading monitor alert to 5°.

d) Add an offset of 6° to the heading sensor used for monitoring so that the heading difference between two heading sensors becomes more than 5°.

Confirm by observation that the ‘Doubtful heading’ warning, as required in 4.3.4.4 and as specified in Table B.1, is activated.

e) Acknowledge this alert at HMI of the EUT.

Confirm by observation that the alert state is changed from “active - unacknowledged” to “active - acknowledged”.

f) After 30 s, change the offset of the heading sensor used for monitoring back to 0°.

Confirm by observation that the alert is removed from the display.

g) Stop the heading output of the heading sensor used for monitoring.

Confirm by observation that the ‘Doubtful heading’ warning is activated once more.

h) Do not acknowledge this warning and restart the input of the heading sensor used for monitoring.

Confirm by observation that the alert state is changed from “active - unacknowledged” to “rectified - unacknowledged”.

i) Acknowledge the ‘rectified - unacknowledged’ alert.

Confirm by observation that the alert state is changed from “rectified - unacknowledged” to “normal” and the alert is removed from the display.

j) Tag the input from the heading sensor used for monitoring as ‘invalid’.

Confirm by observation that the ‘Doubtful heading’ warning is activated once more.

k) Change the active steering mode from heading control to manual.

Confirm by observation that the alert state is changed from “active - unacknowledged” to “normal” and the alert is removed from the display.

l) Restore ‘valid’ tags on the input of the heading sensor used for monitoring.

m) Stop the simulation.

7.4.5 'No SPD adaptive' alert

7.4.5.1 Applicability

If the EUT utilizes speed information for automatic adjustment of control parameters, the following alert test is applicable.

See 4.3.4.5.

7.4.5.2 Method of testing and required test results

In case the EUT is able to use input of speed information for the automatic adjustment of control parameters, perform the following test. However, in case heading control fails when no speed input is available, the 'Lost HDG control' test (7.4.2) shall be performed using failure of speed input in addition to the failure of heading input.

a) Start simulation of ship A under ship A starting conditions.

b) Change the active steering mode from manual to heading control.

c) Stop the input of speed information to the EUT.

   Confirm by observation that the 'No SPD adaptive' caution, as required in 4.3.4.5 and as specified in Annex B, is activated.

d) Alter the preset heading from 180° to 195°.

   Confirm by observation that heading changing is possible without continuous speed input to the EUT.

e) Restart the input of speed information.

   Confirm by observation that the alert is removed from the display.

f) After approximately 30 s, make the status of the speed information input 'invalid'.

   Confirm by observation that the 'No SPD adaptive' caution is activated once more.

g) Alter the preset heading from 195° to 180°.

   Confirm by observation that heading changing is possible without continuous speed input to the EUT.

h) Make the status of speed information input 'valid'.

   Confirm by observation that the alert is removed from the display.

i) Change the active steering mode from heading control to manual.

j) Stop the simulation.

7.4.6 'Low speed' alert

See 4.3.4.6.

7.4.6.1 Method of testing and required test result

Perform the following procedures.

a) Start simulation of ship A under ship A starting conditions.

b) Change the active steering mode from manual to heading control.

c) Reduce the ship's speed below the minimum manoeuvring speed for heading control.

Confirm by observation that the 'Low speed' warning, as required in 4.3.4.6 and as specified in Table B.1, is activated.

d) Acknowledge the alert.

Confirm by observation that the alert state is changed from "active - unacknowledged" to "active - acknowledged".

e) Return the ship's speed input to the starting conditions.

Confirm by observation that the alert is removed from the display.

f) Stop the simulation.

7.4.7 Failure or reduction in the power supply to the EUT or an external heading monitor ('HCS power fail' alert)

See 4.3.4.7.

In case that the EUT is a heading monitor that is not included in the HCS, replace the term "EUT" with the term "external heading monitor" and perform the same tests in 7.4.7.1 and 7.4.7.2 for the external heading monitor.

NOTE Regarding the alert activated by the external heading monitor, an appropriate alert title and description text are provided by the manufacturer instead of 'HCS power fail'.

EXAMPLE 'EX HM power fail'.

7.4.7.1 Method of testing and required test result for total power failure

The tests for reporting power failure are dependent on the power supply configuration for which the EUT is designed (e.g. single power source, multiple power sources).

In case that the EUT has only one power supply, only the following test applies.

In case that the EUT has multiple power supplies, the test in 7.4.7.2 applies as well for the situation of total power failure.

Connect power to the power supply/supplies of the EUT.

a) Set the EUT to heading control.

b) Remove all power to the EUT.

In case the EUT blacks out due to power failure, confirm by observation that the EUT provides a status signal output as specified in 4.3.4.7.

Optionally, the EUT may activate an 'HCS power failure' alert of an appropriate priority.

7.4.7.2 Additional method of testing and required test result for multiple power supplies

In case that the EUT has multiple power supplies, the following tests additionally apply.

Connect power to all power supplies of the EUT.

Set the EUT to heading control.

a) Remove power to one power supply of the EUT.

Confirm by observation that the EUT remains in operation and that it provides a 'HCS power fail' caution, indicating loss of power supply redundancy.

b) Restore power to all power supplies.

c) Subsequently repeat a) and b) until all power supplies of the EUT have been tested.

7.4.8 System failure of EUT or an external heading monitor ('HCS fault' alert)

See 4.3.4.8.

7.4.8.1 Method of testing

Perform the following procedures.

a) Refer to the EUT alert list in the manufacturer's documentation.

b) Select an alert representing a system failure.

c) Create a spurious fault that triggers the selected alert.

7.4.8.2 Required test results

Confirm by inspection of the manufacturer's documentation that an alert representing a system failure is provided. (e.g. 'HCS fault' alert).

Confirm by observation that an alert with an appropriate alert title and description text is activated by the heading control system as specified in the manufacturer's documentation.

7.5 Mandatory displayed information — Method of testing and required test results

See 4.3.5.

This test method is covered in the control performance test of heading changing (see 8.2).

During the test of 8.2, confirm by observation that the mandatory information (see 4.3.5) is available, at least on operator request.

8 Tests of control performance

8.1 Heading keeping test under wave disturbance

See 4.4.2.

8.1.1 Method of testing

For every ship model A, B, C of the ship motion simulator, perform a heading keeping test under sea state 5 (wave disturbance) for 30 min, as specified in this document.

Perform the following procedures (see Figure A.1, Figure A.2 and Figure A.3).

a) Start simulation of ship A under ship A starting conditions.

   Change the active steering mode from manual to heading control.

b) Input sea state 5 (wave disturbance) at 1 min after the heading control starts.

c) Monitor the ship's heading and the rudder angle for 30 min.

d) Remove the wave disturbance.

   Change the active steering mode from heading control to manual.

e) Stop the simulation.

f) Start simulation of ship B under ship B starting conditions.

g) Repeat procedures from b) up to e).

h) Start simulation of ship C under ship C starting conditions.

i) Repeat procedures from b) up to e).

8.1.2 Required test results

Confirm by observation that the maximum amplitude of the difference between the ship's heading and the preset heading is equal to or less than AMP1 in Table A.1, and that the maximum allowed rudder angle does not exceed Ra1 in Table A.1 for each ship model.

8.2 Heading changing test

8.2.1 Application

The test of 8.2.2 is applicable to any HCS.

In case that the EUT supports heading changing with a preset turn rate, the additional test in 8.2.3 by using ship A is performed (see 8.2.3 and Figure A.5).

In case that the EUT supports heading changing with a preset turning radius, the additional test in 8.2.4 by using ship A is performed (see 8.2.4 and Figure A.6).

The 200° heading changing test is performed under no wave disturbance by using ship A (see 4.2.2 [IMO Resolution MSC.64(67), Annex 3, para 7.3], 8.2.5 and Figure A.11).

The 30° heading changing tests are performed under wave disturbance (sea state 5) by using ship A, ship B and ship C (see 8.2.6 and Figure A.7, Figure A.8, Figure A.9).

NOTE In these tests, undershoot is judged by the time t_u specified in Table A.2, Table A.3. See 4.4.3.1 for details on t_u.

8.2.2 Small heading changing test

8.2.2.1 Method of testing

Perform the following procedures.

a) Start simulation of ship A under ship A starting conditions.

b) In case that the EUT supports the heading changing with preset turn rate, set the EUT so as to execute the heading changing with the preset turn rate of 40°/min.

In case that the EUT supports the heading changing with preset turning radius, set the EUT so as to execute the heading changing with the preset turning radius of 926 m (0,5 NM).

Change the active steering mode from manual to heading control.

Monitor that the ship's heading is kept near 180° for 1 min.

c) Alter the preset heading from 180° to 182° so as to start heading changing to starboard side.

Monitor the ship's heading and the rudder angle until 2 min after the ship's heading has once reached within ±0,5° from the preset heading.

d) Alter the preset heading from 182° to 180° so as to start heading changing to port side.

Monitor the ship's heading and the rudder angle until 2 min after the ship's heading has once reached within ±0,5° from the preset heading.

e) Alter the preset heading from 180° to 185° so as to start heading changing to starboard side.

Monitor the ship's heading and the rudder angle until 2 min after the ship's heading has once reached within ±0,5° from the preset heading.

f) Alter the preset heading from 185° to 180° so as to start heading changing to port side.

Monitor the ship's heading and the rudder angle until 2 min after the ship's heading has once reached within ±0,5° from the preset heading.

g) Change the active steering mode from heading control to manual.

h) Stop the simulation.

8.2.2.2 Required test results

Confirm by observation that the heading changing performance of the EUT complies with the requirement in 4.4.3.2.

8.2.3 Heading changing test with preset turn rate

8.2.3.1 Application

In case that the EUT supports heading changing with a preset turn rate, the following test is performed.

8.2.3.2 Method of testing

Perform the following procedures.

a) Start simulation of ship A under ship A starting conditions.

b) Set the EUT so as to execute heading changing with the preset turn rate of 20°/min.

Change the active steering mode from manual to heading control.

Monitor that the ship's heading is kept near 180° for 1 min.

c) Alter the preset heading from 180° to 210° so as to start heading changing to starboard side.

Monitor the ship's heading and the rudder angle until 2 min after the ship's heading has once reached within ±1,0° from the preset heading.

d) Alter the preset heading from 210° to 180° so as to start heading changing to port side.

Monitor the ship's heading and the rudder angle until 2 min after the ship's heading has once reached within ±1,0° from the preset heading.

e) Set the EUT so as to execute heading changing with the preset turn rate of 40°/min.

f) Repeat these test procedures from c) up to d).

g) Set the EUT so as to execute heading changing with the preset turn rate of 60°/min.

h) Alter the preset heading from 180° to 240° so as to start heading changing to starboard side.

Monitor the ship's heading and the rudder angle until 2 min after the ship's heading has once reached within ±1,0° from the preset heading.

i) Alter the preset heading from 240° to 180° so as to start heading changing to port side.

Monitor the ship's heading and the rudder angle until 2 min after the ship's heading has once reached within ±1,0° from the preset heading.

j) Change the active steering mode from heading control to manual.

k) Stop the simulation.

8.2.3.3 Required test results

Confirm by observation that the heading changing performance of the EUT complies with the three requirements in 4.4.3.1 and the requirement in 4.4.3.3.

8.2.4 Heading changing test with preset turning radius

8.2.4.1 Application

In case that the EUT supports heading changing with a preset turning radius, the following test is performed.

8.2.4.2 Method of testing

Perform the following procedures.

a) Start simulation of ship A under ship A starting conditions.

b) Set the EUT so as to execute heading changing with the preset turning radius of 1 852 m (1,0 NM).

Change the active steering mode from manual to heading control.

Monitor that the ship's heading is kept near 180° for 1 min.

c) Alter the preset heading from 180° to 210° so as to start heading changing to starboard side.

Monitor the ship's heading and the rudder angle until 2 min after the ship's heading has once reached within ±1,0° from the preset heading.

d) Alter the preset heading from 210° to 180° so as to start heading changing to port side.

Monitor the ship's heading and the rudder angle until 2 min after the ship's heading has once reached within ±1,0° from the preset heading.

e) Set the EUT so as to execute heading changing with the preset turning radius of 926 m (0,5 NM).

f) Repeat these test procedures from c) up to d).

g) Set the EUT so as to execute heading changing with the preset turning radius of 555 m (0,3 NM).

h) Alter the preset heading from 180° to 240° so as to start heading changing to starboard side.

Monitor the ship's heading and the rudder angle until 2 min after the ship's heading has once reached within ±1,0° from the preset heading.

i) Alter the preset heading from 240° to 180° so as to start heading changing to port side.

Monitor the ship's heading and the rudder angle until 2 min after the ship's heading has once reached within ±1,0° from the preset heading.

j) Change the active steering mode from heading control to manual.

k) Stop the simulation.

8.2.4.3 Required test results

Confirm by observation that the heading changing performance of the EUT complies with the three requirements in 4.4.3.1 and the requirement in 4.4.3.4.

8.2.5 200° heading changing test

8.2.5.1 Method of testing

Perform the following procedures.

a) Start simulation of ship A under ship A starting conditions.

b) Set the EUT so as to execute the heading changing with the preset turn rate of 60°/min or the preset turning radius of 555 m (0,3 NM).

   Change the active steering mode from manual to heading control.

   Monitor that the ship's heading is kept near 180° for 1 min.

c) Alter the preset heading CW from 180° to 020° so as to start heading changing to starboard side.

   Monitor the ship's heading, the actual rate of turn and the rudder angle until 2 min after the ship's heading has once reached within ±1,0° from the preset heading.

d) Alter the preset heading CCW from 020° to 180° so as to start heading changing to port side.

   Monitor the ship's heading, the actual rate of turn and the rudder angle until 2 min after the ship's heading has once reached within ±1,0° from the preset heading.

e) Change the active steering mode from heading control to manual.

f) Stop the simulation.

8.2.5.2 Required test results

See 4.2.2, 4.4.3.1, 4.4.3.3 and 8.2.3.

Confirm by observation that the heading changing performance of the EUT complies with the three requirements in 4.4.3.1 and confirm by observation that:

— when turning the preset heading control CW, a heading changing to starboard is made; and

— when turning the preset heading control CCW, a heading changing to port is made.

8.2.6 Heading changing test under wave disturbance

8.2.6.1 Method of testing

This test is performed by using ship A, ship B and ship C of the ship motion simulator.

Perform the following procedures.

a) Start simulation of ship A under ship A starting conditions.

b) Set the EUT so as to execute heading changing with the preset turn rate or the preset turning radius of the corresponding ship in Table A.3.

c) Change the active steering mode from manual to heading control.

d) Input sea state 5 (wave disturbance) at 1 min after the heading control starts.

Monitor for 2 min the ship's heading and the rudder angle applied.

e) Alter the preset heading from 180° to 210° so as to start heading changing to starboard side.

Monitor the ship's heading, the actual rate of turn and the rudder angle until 5 min after the ship's heading has once reached within ±1,0° from the preset heading.

f) Alter the preset heading from 210° to 180° so as to start heading changing to port side.

Monitor the ship's heading, the actual rate of turn and the rudder angle until 5 min after the ship's heading has once reached within ±1,0° from the preset heading.

g) Remove wave disturbance from the simulation.

Change the active steering mode from heading control to manual.

h) Stop the simulation.

i) Start simulation of ship B under ship B starting conditions.

j) Repeat procedures from b) up to h).

k) Start simulation of ship C under ship C starting conditions.

l) Repeat procedures from b) up to h).

8.2.6.2 Required test results

Confirm by observation that the heading changing performance of the EUT complies with the requirement in 4.4.3.5.

9 Information

Adequate information shall be provided to enable the equipment to be properly operated and maintained. The information, which is to be provided by the manufacturer, shall include the following.

a) If the heading control system is provided with functions for rate of turn or turning-radius control, it shall be clearly stated that the preset values may not be reached under certain conditions of weather, sea, speed, load, draft, trim, etc. Furthermore, it shall be pointed out that an incorrect speed input will lead to an incorrect radius control.

b) There shall be a direct and unambiguous relation between the adjustment controls and the behaviour of the rudder upon both heading error and heading rate. The operating manual shall hold sufficient explanation to the operator on the operation and effect of the controls, including default settings and guidance in which situation which control should be used in what manner.

c) When using input signals other than controls, the operating manual shall hold sufficient explanation of the effect of an input signal.

Annex A
(normative)

Use of IEC 62065 ship models and wave disturbances for the HCS performance tests

A.1 General

For the HCS performance tests under disturbances and to establish harmonization with IEC 62065:2014, this revised document introduces the same ship models (specified in Annex I) and the same wave disturbances (specified in Annex H) of IEC 62065:2014.

As specified in IEC 62065:2014, Annex I, Formula I.19, the wave disturbance turning moment related to the wave height is input to the yaw response model.

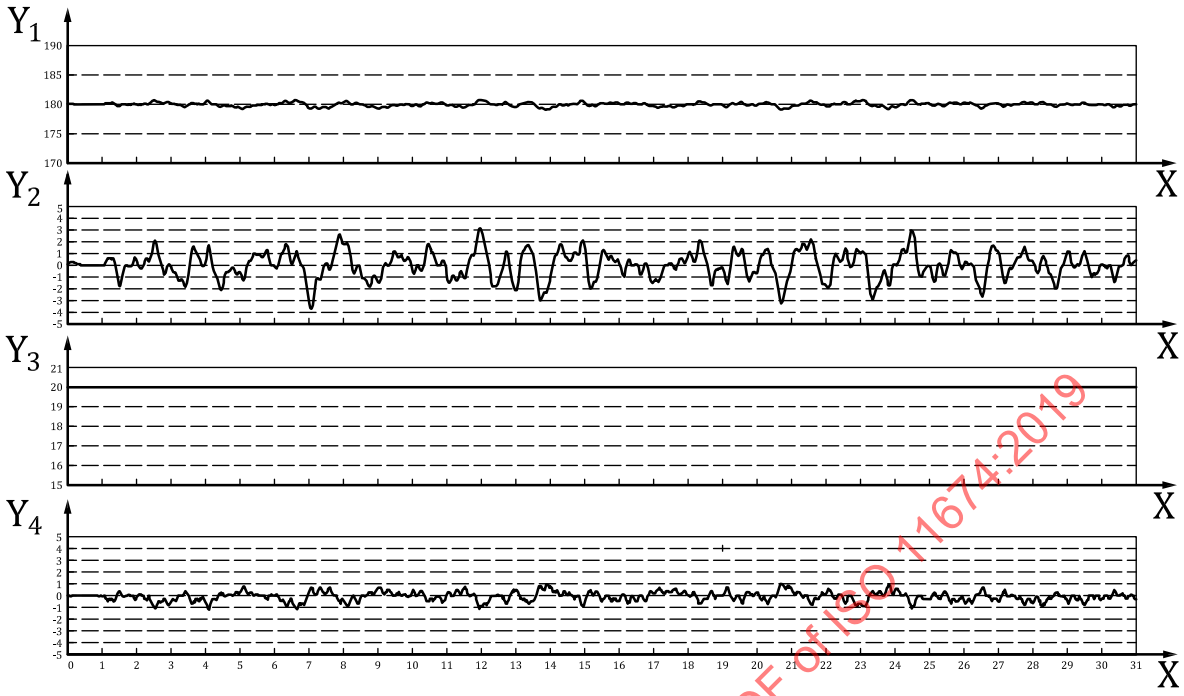
Figures A.1 to A.10 show examples of heading keeping test results under sea state 5, and of heading changing test results both under no disturbance and in sea state 5, using the ship A, ship B and ship C.

A.2 Heading keeping examples under sea state 5

Table A.1 shows the allowable heading amplitude (AMP1) and the allowed rudder amplitude (Ra1) during heading keeping test under sea state 5 for each ship model (see 8.1).

Table A.1 — Allowable heading amplitude (AMP1) and allowed rudder amplitude (Ra1)

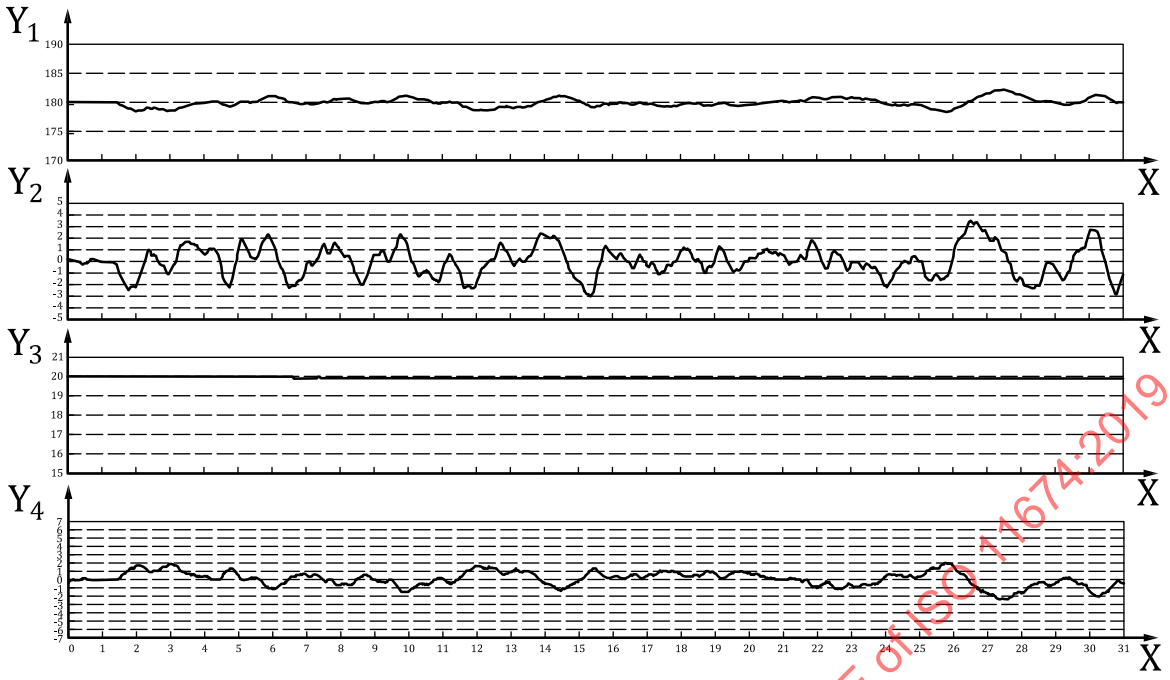
Ship model	AMP1	Ra1
ship A	2,5°	5°
ship B	4,0°	7°
ship C	5,0°	12°



Key

X time [min]
Y_1 heading [°]
Y_2 ROT [°/min]
Y_3 speed [kn]
Y_4 rudder [°]

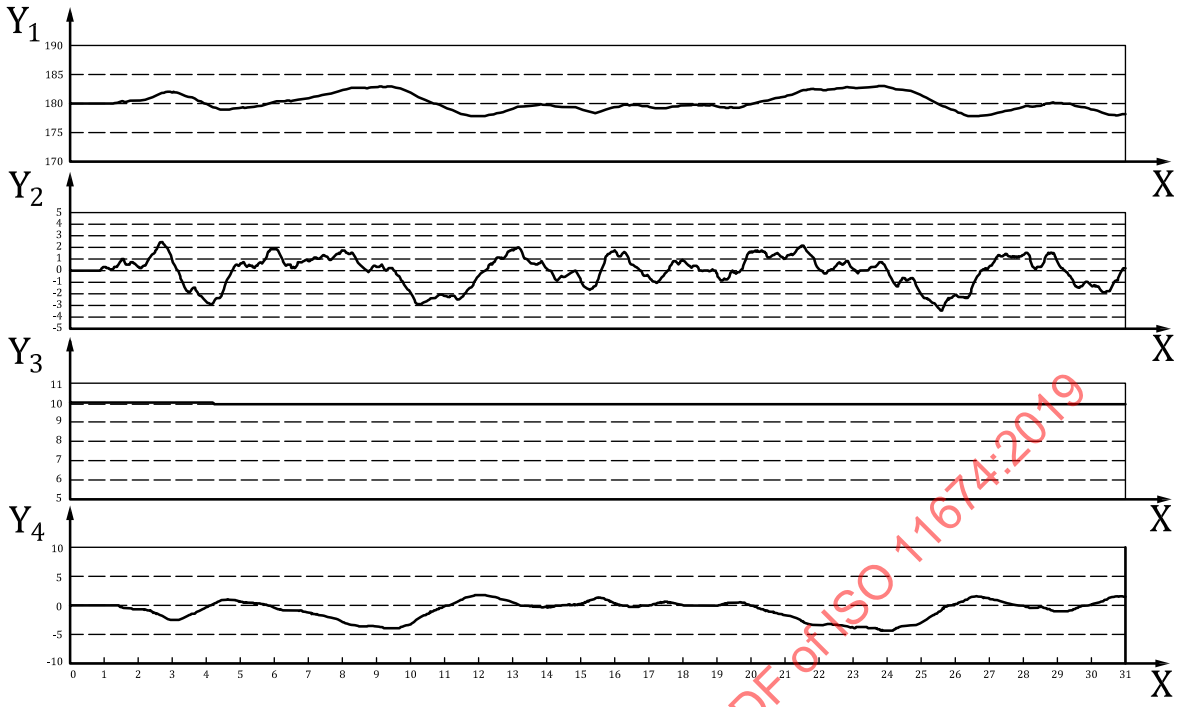
Figure A.1 — Ship A example — Sea state 5 (Ra1 = 5°)



Key

X time [min]
Y_1 heading [°]
Y_2 ROT [°/min]
Y_3 speed [kn]
Y_4 rudder [°]

Figure A.2 — Ship B example — Sea state 5 (Ra1 = 7°)



Key

X time [min]
Y_1 heading [°]
Y_2 ROT [°/min]
Y_3 speed [kn]
Y_4 rudder [°]

Figure A.3 — Ship C example — Sea state 5 (Ra1 = 12°)

A.3 Heading changing examples under no disturbance (30°, 60° heading changing, 2°, 5° heading changing by using ship A)

Table A.2 provides the maximum allowable limit (OVR1) for overshoot amplitude, the allowed rudder amplitude (Ra2) and t_u for undershoot judgement applied for ship A.

Preset turn rate or preset turning radius is specified in Table A.2, see also A.5 b).

NOTE The initial turn rate comparable to preset turning radius in Table A.2 is as follows.

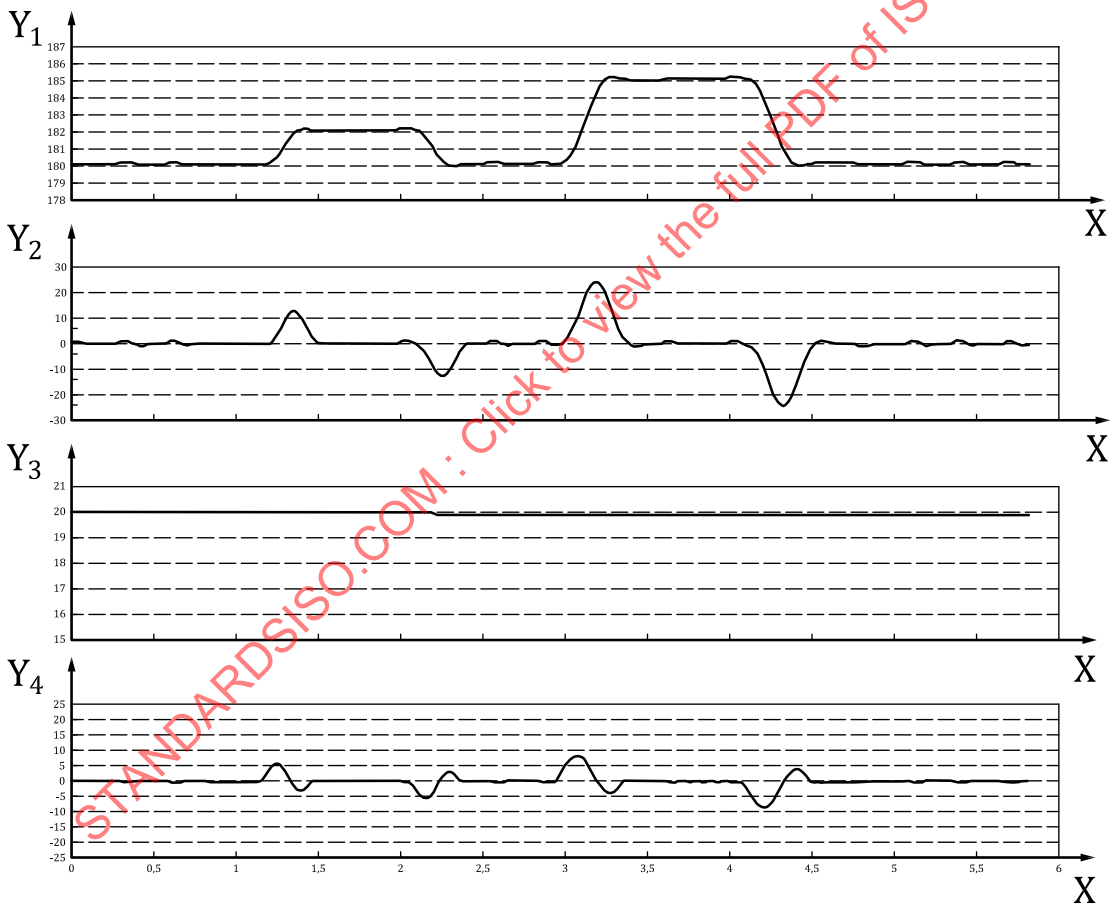
1 852 m → 19,1°/min. 926 m → 38,2°/min. 555 m → 63,7°/min.

Table A.2 — Maximum allowable limit (OVR1) for overshoot amplitude, other allowed limits (Ra2, t_u) and preset parameters

Ship model (heading changing angle)	OVR1	Ra2	Preset turn rate	Preset turning radius	t_u	Initial speed
ship A (2°)	0,5°	3,0°	40°/min.	926 m	40 s	20 kn
ship A (5°)		5,0°		(0,5 NM)	60 s	

Table A.2 *(continued)*

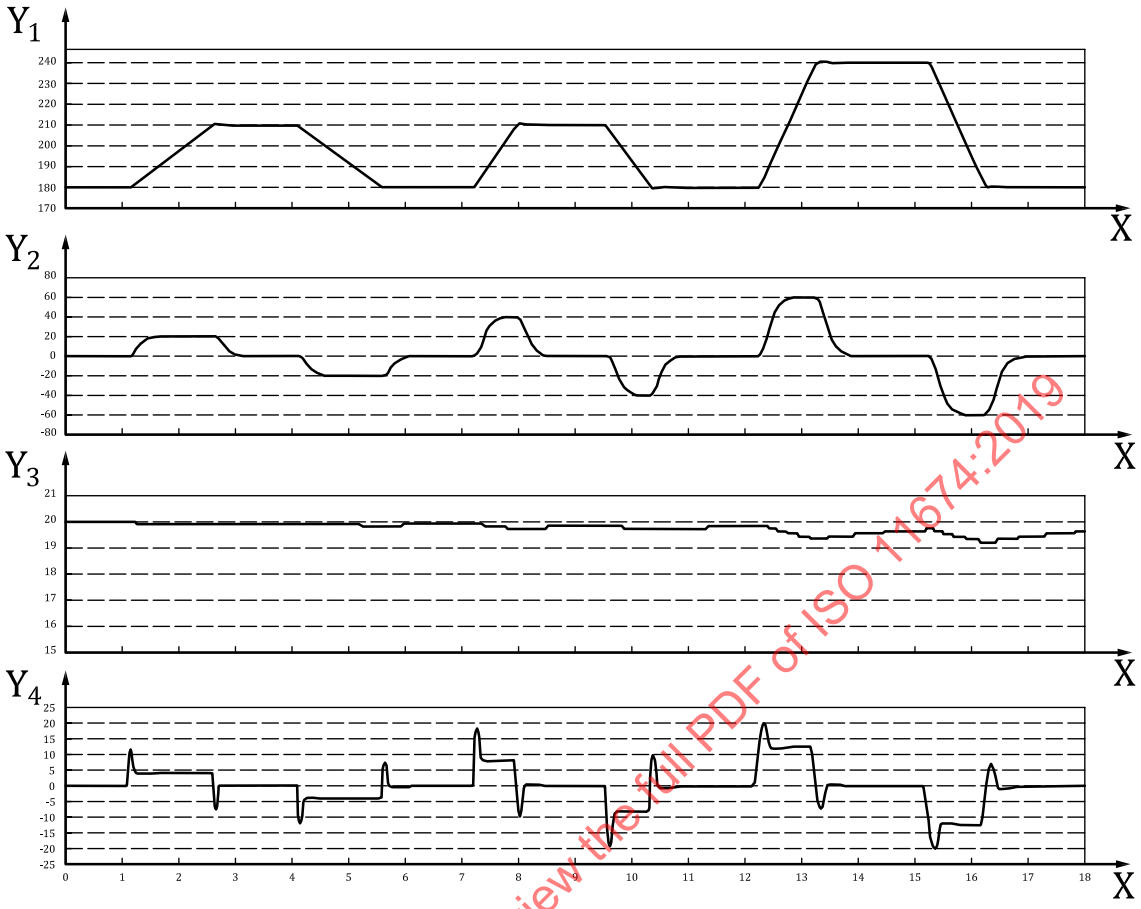
Ship model (heading changing angle)	OVR1	Ra2	Preset turn rate	Preset turning radius	t_u	Initial speed
ship A (30°)	1,5°	6,5°	20°/min.	1 852 m (1,0 NM)	150 s	20 kn
		11,0°	40°/min.	926 m (0,5 NM)	100 s	
ship A (60°)		16,0°	60°/min.	555 m (0,3 NM)	120 s	
ship A (200°)	1,5°	16,0°	60°/min.	555 m (0,3 NM)	240 s	20 kn



Key

X time [min]
Y_1 heading [°]
Y_2 ROT [°/min]
Y_3 speed [kn]
Y_4 rudder [°]

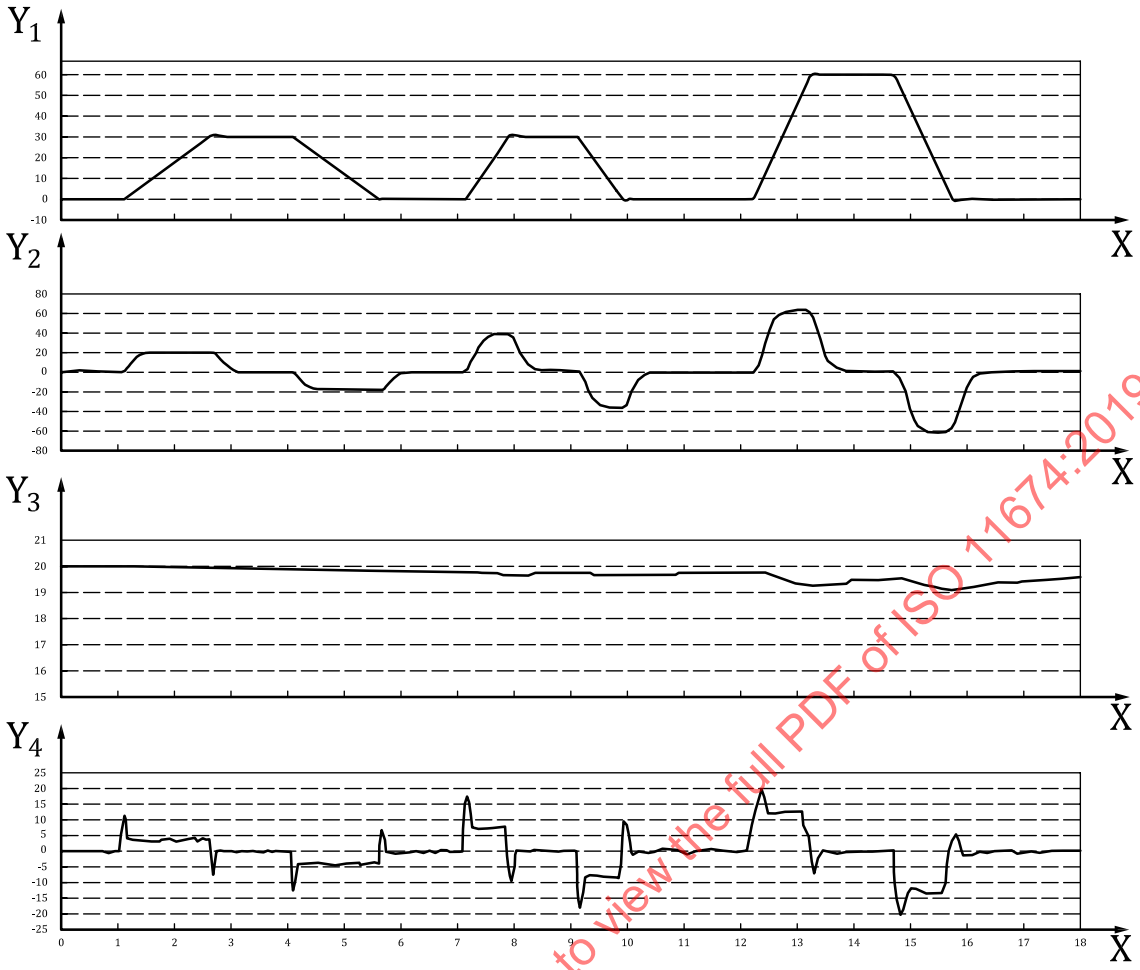
Figure A.4 — Ship A example — Small heading changing test with preset turn rate of 40°/min (preset heading: 180° →182°→180°→185°→180°)



Key

X time [min]
Y_1 heading [°]
Y_2 ROT [°/min]
Y_3 speed [kn]
Y_4 rudder [°]

Figure A.5 — Ship A example — 30°, 60° heading changing test with preset turn rates (preset turn rate: 20°/min, 40°/min, 60°/min)



Key

X time [min]
Y_1 heading [°]
Y_2 ROT [°/min]
Y_3 speed [kn]
Y_4 rudder [°]

Figure A.6 — Ship A example — 30°, 60° heading changing with preset turning radiuses (preset turning radius: 1 852 m, 926 m, 555 m)

A.4 Ship A example —30° heading changing under sea state 5

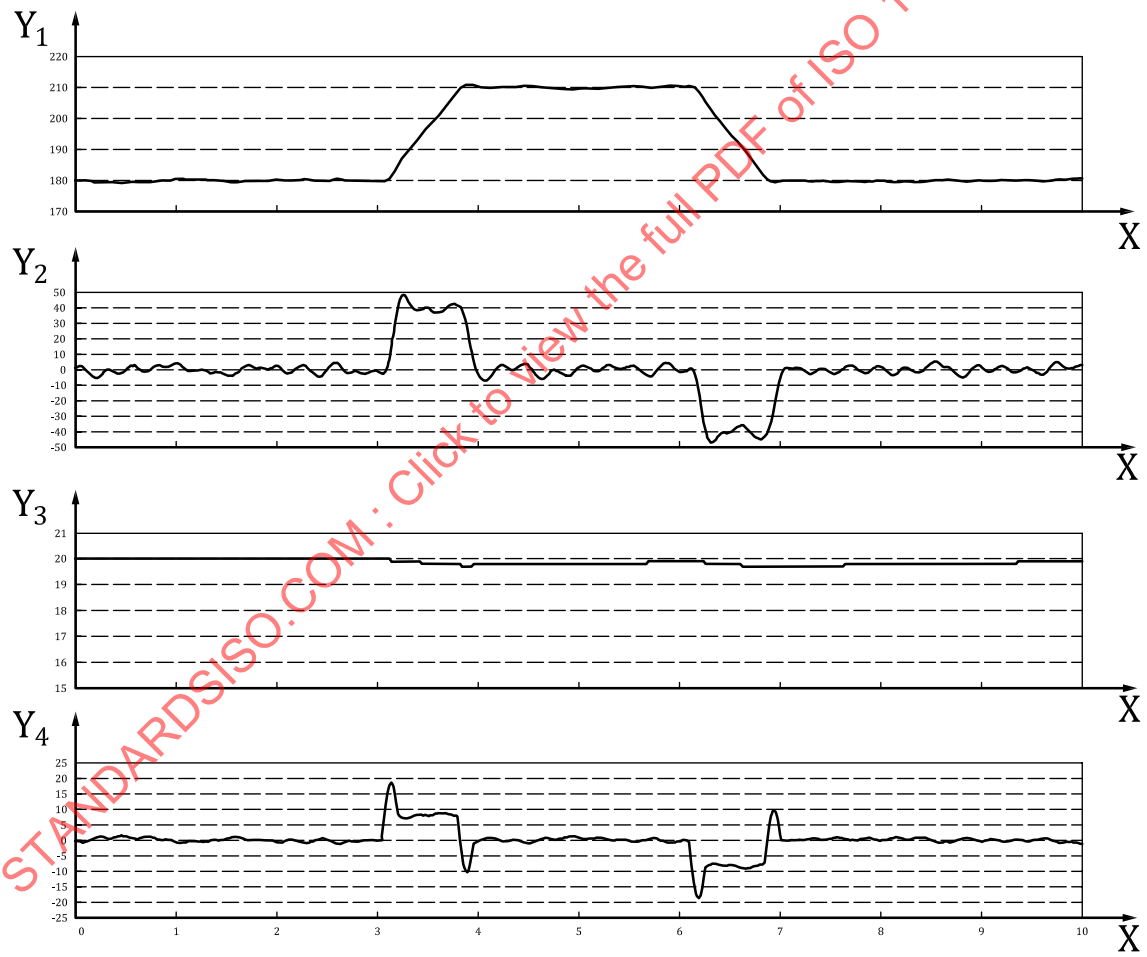
Table A.3 provides the maximum allowable limit (OVR2) for overshoot amplitude, the allowed rudder amplitude (Ra3) and t_u for undershoot judgement applied for each ship model.

Preset turn rate or preset turning radius is specified in Table A.3 and A.5 b).

Table A.3 — Maximum allowable limit (OVR2) for overshoot amplitude, other allowed limits (Ra3, t_u) and preset parameters

Ship model	OVR2	Ra3	Preset turn rate	Preset turning radius	t_u	Initial speed
ship A	2,5°	14°	40 °/min	926 m (0,5 NM)	100 s	20 kn
ship B	3,5°	15°	15 °/min	2 357 m (1,27 NM)	180 s	20 kn
ship C	5,0°	20°	8 °/min	2 210 m (1,19 NM)	420 s	10 kn

Every figure includes the turns to CW and CCW direction.



Key

X time [min]
Y_1 heading [°]
Y_2 ROT [°/min]
Y_3 speed [kn]
Y_4 rudder [°]

Figure A.7 — Ship A example — 30° heading changing under sea state 5