INTERNATIONAL STANDARD

ISO 16329

First edition
2003-04-15

Ships and marine technology — Heading control systems for high-speed craft

Navires et technologie maritime — Systèmes de pilotage automatique pour les navires à grande vitesse

Reference number
ISO 16329:2003(E)

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Published in Switzerland

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 16329 was prepared by Technical Committee ISO/TC 8, *Ships and marine technology*, Subcommittee SC 6, *Navigation*.

Ships and marine technology — Heading control systems for high-speed craft

1 Scope

This International Standard specifies the structure, performance, inspection and testing of heading control systems to be installed on board craft operating under the following conditions:

a) *speed exceeding 30 kn and up to 70 kn;*

b) *maximum rate of turn 20°/s;*

c) *normal range of operation between 70°N and 70°S should, as required by chapter 13 of the HSC Code, comply with the minimum performance requirements specified in these standards.*

This International Standard applies to the heading control systems which enable a craft *to keep a preset heading with minimum operation of the* craft's *steering gear*, *within limits related to the* craft's *manoeuvrability in conjunction with* their *sources of heading information.*

This International Standard assumes the use of a conventional arrangement. Where other arrangements are provided, the requirements of this standard should apply insofar as they are applicable, and appropriate justification provided where deviation from the requirements is necessary.

The heading control systems *should, within a speed range of up to 30 knots, comply with resolution A.342(IX), and within a speed range of 30 knots to 70 knots should comply with the requirements of this resolution.*

NOTE 1 All requirements that are extracted from the recommendations of IMO Resolutions [Resolution A.822(19) on performance standards for automatic steering aids for high-speed craft, A.694(17) and A.342(IX)] are printed in italics.

NOTE 2 The heading control system was previously called “automatic steering aids (automatic pilot)”.

NOTE 3 Resolution A.342(IX) represents Resolution A.342(IX) as amended by MSC.64(67), Annex 3.

2 Normative references

The following referenced documents are indispensable for the application 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.

ISO 694, *Ships and marine technology — Positioning of magnetic compasses in ships*

ISO 16328, *Ships and marine technology — Gyro-compasses for high-speed craft*

IEC 60945, *Maritime navigation and radiocommunication equipment and systems — General requirements — Methods of testing and required test results*

IEC 61162 (all parts), *Maritime navigation and radiocommunication equipment and systems — Digital interfaces*

IMO Resolution A.694(17**)**, *General requirements for shipborne radio equipment forming part of the global maritime distress and safety system (GMDSS) and for electronic navigational aids*

IMO Resolution A.822(19)**,** *Performance standards for automatic steering aids (automatic pilots) for high-speed craft*

IMO Resolution MSC.64(67), Annex 3:1997, Amendment to resolution A.342(IX), *Performance standards for heading control systems*

3 Terms and definitions

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

3.1
heading
horizontal direction in which a craft actually points or heads at any instant, expressed in degrees from a reference direction, usually from 000° at the reference direction clockwise through 360°, where 360° becomes identical with 000°

3.2
preset heading
horizontal direction in which a craft is steered or intended to be steered, expressed as the angular direction with respect to north (true/magnetic), from 000° clockwise through 360°, where 360° becomes identical with 000°

3.3
manual steering
method of controlling the steering gear manually

EXAMPLE Using a steering wheel.

3.4
automatic steering
method of controlling the steering gear automatically to enable a craft to keep, or change to, a preset heading by processing the heading information obtained from a heading source, such as a gyro-compass or transmitting magnetic compass, etc.

3.5
change-over device
device for changing-over from automatic to manual steering and vice versa

3.6
automatic-steering device
device which controls automatic steering

3.7
proportional rudder adjustment
adjustment of a component of the total rudder command in proportion to an instantaneous value of the difference between the preset heading and actual heading

3.8
derivative rudder adjustment
counter rudder adjustment
adjustment of a component of the total rudder command which acts to control the rate of turn of the craft

3.9
integral rudder adjustment
adjustment of a component of the total rudder command which is in proportion to the integral value of the heading deviation

3.10
weather adjustment
adjustment which minimizes unnecessary steering motion against yawing caused by waves, swells and wind

3.11
adjustment control
device which changes the characteristics of an automatic steering device, including proportional rudder adjustment, derivative rudder adjustment, integral rudder adjustment and weather adjustment

3.12
operational device
switch, key, knob, etc. which is used for operating a heading control system

3.13
heading-signal processor
unit which processes the heading signal generated by a gyro-compass, magnetic compass, etc., and adapts it before its use by the heading control system

3.14
override function
intentional fast change-over from automatic to temporary manual control

3.15
conning position
place on the bridge with a commanding view providing the necessary information and equipment for the conning officer to carry out his functions

3.16
turn-rate control
method of controlling the rudder of a vessel to perform turns with a preset rate of turn

3.17
turning radius control
method of controlling the rate of turn of a vessel to perform turns with a preset turning radius

4 Performance

4.1 General

4.1.1 *The heading control system* shall *be capable of adapting manually or automatically to different steering characteristics of the* craft *under various speed, weather and loading conditions, and provide reliable operation under prevailing environment and normal operational conditions.*

4.1.2 The heading control system shall *be connected to the gyro-compass if a gyro-compass is provided. Otherwise it* shall *be electronically connected to the magnetic compass*.

4.1.3 *A qualitative description of the effects of the* heading control system *errors due to high speed, accelerations,* heading *changes, sea state, etc., and a qualitative description of corresponding errors in other* navigation system, shall *be provided to the user.* This information shall be provided by the manufacturer.

4.1.4 Heading control systems shall conform to the environmental requirements of IEC 60945 for equipment categories protected from the weather.

4.2 Constituents

A heading control system shall be composed, as a minimum, of the following components (see Figure 1):

a) heading-signal processor (including an indicator of the heading);

b) operational control for preset heading;

c) operational controls for adjustments;

d) automatic steering devices;

e) change-over device (with steering-mode indicator) which is not required to be an integrated part of the heading control system;

f) alarm signalling facilities compliant with the requirements of this International Standard;

g) indicators for steering mode and heading source in use.

4.3 Functional requirements

4.3.1 Introduction

The following requirements shall be fulfilled.

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

4.3.2.1 *Change-over from automatic to manual steering and vice-versa* shall *be possible at any position of the rudder and* shall *be activated by one manual control within 3 seconds.*

4.3.2.2 *Change-over from automatic to manual steering* shall *be possible under any conditions, including any failure in the* heading *control system.*

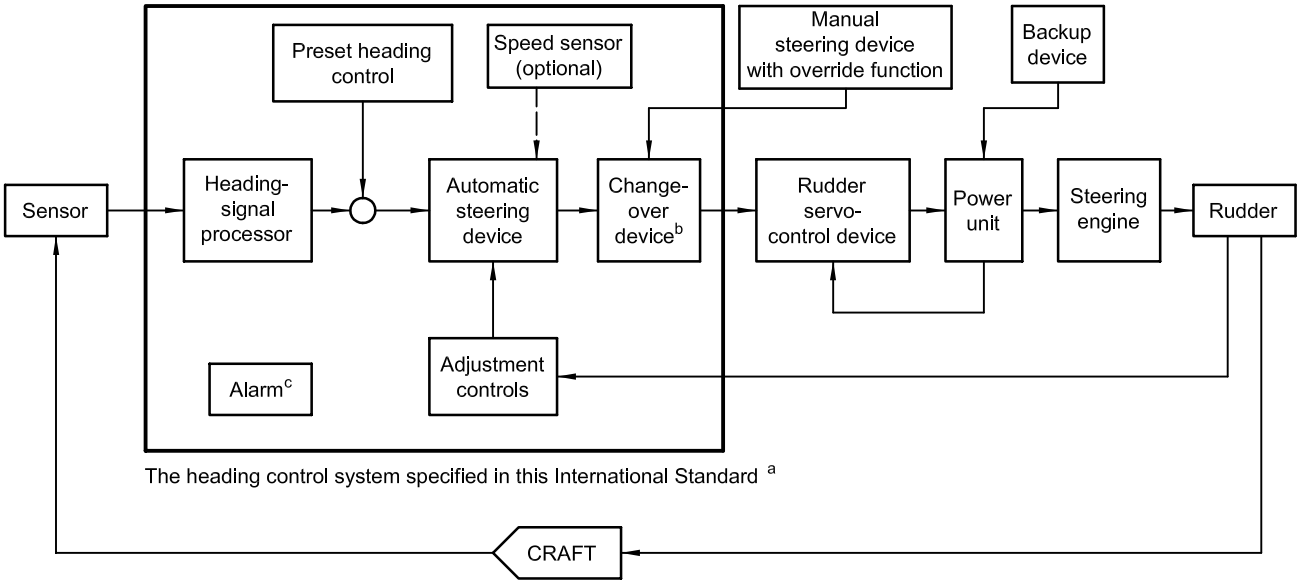
4.3.2.3 *When changing-over from manual to automatic steering, the heading control system (automatic pilot)* shall *take over the actual heading as the preset heading.*

4.3.2.4 Change-over from manual steering with override function to automatic steering shall not be possible without an intended action of the craft's personnel.

4.3.2.5 *Change-over* devices shall *be located close to each other in the immediate vicinity of the* position at which the equipment is normally operated.

4.3.2.6 *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 devices.

4.3.2.7 *The installation* shall *include manual steering with an override function.*



[a] The portion enclosed by the thick line shows the constituent devices of a heading control system which are specified in this International Standard.

[b] The change-over device is not required to be an integrated part of the heading control systems.

[c] Alarm indicating devices may be external units.

Figure 1 — Typical block diagram for heading control systems

4.3.3 Operational controls including adjustment controls

4.3.3.1 *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.*

4.3.3.2 The heading control system shall *be provided with automatic and manually operated controls for operational use to adjust* the system to *the craft's steering performance to take account of the effects of* changing *weather.* The heading control systems may be provided with automatic or manually operated controls for operational use to adjust the system to the craft's steering performance to take account of changing speed and loading conditions.

4.3.3.3 *Adequate illumination* shall *be provided in the equipment or in the craft 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.*

4.3.3.4 *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 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.

4.3.3.5 When changing heading, the clockwise (right-hand side) or counterclockwise (left-hand side) direction of preset heading adjustment shall determine the craft's turning direction.

4.3.3.6 *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.*

4.3.3.7 *Except for the preset heading setting control, the actuation of any other control* shall *not significantly affect the heading of the* craft.

4.3.3.8 *Additional controls at remote positions* shall *comply with the provisions of this standard.*

4.3.4 Rudder angle limitation

Means shall *be incorporated in the equipment to enable* adjustable *rudder angle limitation in the automatic mode of operation. 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.*

4.3.5 Permitted yaw

Means shall *be incorporated to prevent unnecessary activation of the rudder due to normal yaw motion.*

4.3.6 Heading indication accuracy

If there is a heading indication, it shall not deviate from the heading sensor by more than 0,5°.

4.3.7 Preset heading

Any alteration of preset heading shall *not be possible without intended action of the* craft's *personnel.*

4.3.8 Performing turns

4.3.8.1 Basic requirement

The heading control system shall *be able to perform turns within the turning capability of the craft based either on a preset rate of turn or a preset turning radius.*

4.3.8.2 Preset rate of turn

If the heading control system is provided with the function to perform turns with a preset rate of turn, the accuracy of the rate of turn after becoming constant in a turn, shall be within $\pm$ 10 % of its preset value or 3°/min, whichever is the greater, with the craft's normal load condition and in a calm sea which is sufficiently broad and deep to be able to manoeuvre without disturbing the craft's manoeuvrability.

NOTE It is noted that there are some cases where it is not possible to turn at the preset rate, even if steered at the maximum rudder angle, due to the effects of weather, sea state or craft's manoeuvrability.

4.3.8.3 Preset turning radius

If 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 calculated using the data in 4.3.8.2.

NOTE There are some cases where it is not possible to turn at the preset turning radius, even if steered at the maximum rudder angle, due to the effects of weather, sea state or craft's manoeuvrability.

4.3.9 Limiting of overshoot

The heading control system shall include a counter rudder-angle adjustment control or similar system to allow the *change to a preset heading without significant overshoot.*

4.3.10 Power supply

4.3.10.1 A heading control system shall be capable of normal operation when its power supply varies as specified in IEC 60945.

4.3.10.2 *If provision is made for operating equipment from more than one source of electrical energy, arrangements for rapidly changing from one source to the other* shall *be provided but not necessarily incorporated in the equipment.* Means shall be provided to retain the current heading during alteration of the power source.

4.3.11 Alarms and signalling facilities

4.3.11.1 General

The alarm signalling facilities shall *be fitted near the conning position* and easily accessible.

4.3.11.2 Failure or reduction in power

An alarm 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.* The alarm signalling facilities are not required to be an integrated part of the heading control system.

4.3.11.3 System failure

An alarm which is 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.

NOTE The term “heading control system” is shown schematically in Figure 1.

4.3.11.4 Off-heading alarm

An off-heading alarm, 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 preset limit shall be set within a minimum range of 5° to 15°.

NOTE 1 Off-heading is a situation where the craft has deviated from the preset heading.

NOTE 2 The “preset limit” specified in these provisions means an alarm threshold.

4.3.11.5 Heading monitor

If the craft 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. An alarm 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 preset limit shall be set within a minimum range of 5° to 15°.

NOTE The “preset limit” specified in these provisions means an alarm threshold.

4.3.11.6 Indication of heading source

A clear indication of the heading source in use shall *be provided.*

4.3.11.7 Sensor status

The heading control system shall *provide an indication when any input from external sensors used for control is absent* or fails. *The heading control system* shall *also repeat any alarm on the status messages concerning the quality of the input data from its external sensors when they are used for control.*

4.3.12 Transformation error

The heading data supplied to the heading control system shall not deviate by more than 0,5° from the heading sensor.

4.3.13 Heading stability

Under conditions of no disturbance, *within limits related to the craft's manoeuvrability, the* heading control system*, in conjunction with its source of heading information,* shall *enable a craft to keep within ± 2,0° of a preset course.*

The heading stability shall be such that, under conditions of disturbance given in Annex A, the average value of the difference between the preset heading and the heading shall be within ± 3° and the maximum single amplitude of the difference between the preset heading and the heading shall be within 4°.

NOTE The difference is measured by means of the simulator test (see 5.5.4).

4.3.14 Disturbance to the magnetic compass

The disturbance to the magnetic compass caused by the magnetic sensor, if driven and used, shall not be more than 0,5°. This shall be fulfilled on any heading with the power supply of the heading control system switched on or off.

4.3.15 Interfaces

4.3.15.1 *The heading control system* shall *be connected to a suitable source of heading information.*

4.3.15.2 *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.*

4.3.15.3 *The heading control system* shall *provide interface facilities conforming to relevant international interface standards.* Digital serial interfaces shall comply with IEC 61162 as applicable.

4.4 Safety precautions

All safety precautions in the heading control system shall comply with IEC 60945.

5 Type testing

5.1 Testing and required results

The tests shall be carried out in the order given in 5.2 to 5.5. For tests carried out by means of the craft-motion simulators, refer to the specification given in Annex B.

5.2 Magnetic-compass safe-distance test

The determination of magnetic-compass safe distance shall be carried out in accordance with the requirements of ISO 694. All parts of the system and their interconnections shall be considered.

5.3 EMC and environmental test

EMC and environmental testing shall be performed according to IEC 60945.

5.4 Change-over from automatic to manual steering mode

The test for change-over from automatic to manual steering mode shall be carried out as follows.

a) During the mode of automatic steering, turn the steering wheel so that it produces a 0° rudder-angle command.

b) Set the rudder-angle limiter to maximum, then set the preset heading to obtain the maximum rudder angle.

c) Change from automatic steering to manual.

d) Measure the time required from the completion of the mode change-over operation to when the rudder midship command signal is given. This time shall comply with the requirements of 4.3.2.1.

5.5 Control characteristics

5.5.1 General

The following tests shall be carried out using a craft-motion simulator. The simulator described in Annex B shall be the standard simulator to be used for these tests.

5.5.2 Heading-signal transformation accuracy

Set the simulator's craft heading to eight different values and compare them with the heading indicated by the heading control system. This measurement shall be carried out twice for both the clockwise direction and the counterclockwise direction, respectively. The requirements of 4.3.12 shall be complied with.

5.5.3 200° turn

5.5.3.1 This test shall be made by means of the craft-motion simulator as specified in Annex B with l/v = 2. This covers the automatic heading change, without the function of the preset rate of turn or the preset turning radius.

The preset heading control shall be turned right or left to make a 200° heading change according to 4.3.3.4 and 4.3.3.5 and the following shall be checked.

a) When turning the preset heading control clockwise, a right heading change is made and when turning the preset heading control counterclockwise, a left heading change is made. (In each case the heading change is made with respect to the preset direction.)

b) After actuating a heading change, the rudder-angle limiting function is activated.

5.5.3.2 This test shall be made by means of the craft-motion simulator as specified in Annex B with l/v = 2, and the rudder-angle limiter shall be set to maximum. The preset heading control shall be turned right or left to make a 200° heading change. The requirements of 5.5.3.1 a) shall be complied with and the rate of turn or the turning radius respectively shall be within the defined accuracies in 4.3.8.2 and 4.3.8.3. Provided that the preset turning radius is tested, it is ensured that the craft's heading turns with the rate given by the following formula:

$$\dot{\psi}_i = \frac{180}{\pi} \times \frac{v}{r}$$

where

$\dot{\psi}_i$ is the preset rate of turn, in degrees per second;

r is the preset turning radius, in metres;

v is the craft's speed, in metres per second.

This test shall be carried out six times for both directions and with the maximum value, the mean value and the minimum value respectively.

NOTE 1 The horizontal acceleration, a, does not exceed 2,0 m/s^2.

NOTE 2 In this test, the turn rate or the turning radius should be selected so that the horizontal acceleration does not exceed 2,0 m/s^2.

5.5.4 Heading stability

This test shall be made by means of the craft-motion simulator as specified in Annex B with l/v = 2. It shall be tested under the conditions of no disturbance and disturbance as specified in Annex A for more than 10 min, respectively. The requirement of 4.3.13 shall be complied with.

5.5.5 Overshoot

This test shall be made by means of the craft-motion simulator as specified in Annex B with l/v = 2. Change the preset heading from the actual heading by 20° right and left. The overshoot shall not be more than 2°.

6 Fall-back arrangements

In the case of failure of the heading sensor in use or the heading control system itself, the rudder angle immediately before the failure shall be maintained. In the case of a failure of the automatic speed input, if in use, the speed value immediately before the failure shall be used for control. An associated alarm as specified in 4.3.11 shall be given.

7 Marking and identification

Each unit of a heading control system shall *be marked with the following*:

— *identification of the manufacturer;*

— *equipment type number or model identification under which it was type tested;*

— *serial number of the unit;*

— safe distance of magnetic compass (for a unit installed in the bridge).

8 Information

Adequate information shall *be provided to enable the equipment to be properly operated and maintained.*

The information shall include the following.

a) *In the case of equipment so designed that fault diagnosis and repair down to component level are practicable, provide full circuit diagrams, component layouts and a component parts list.*

b) *In the case of equipment containing complex modules in which fault diagnosis and repair down to component level are not practicable, contain sufficient information to enable a defective complex module to be located, identified and replaced. Other modules and those discrete components which do not form part of modules* shall *also meet the requirements of* a) *above*.

c) If the heading control system is provided with functions for rate of turn or turning-radius control, it shall be notified 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 incorrect speed input will lead to incorrect radius control.

Annex A
(normative)

Heading stability test under the conditions of disturbance

This annex specifies the disturbance which is used in the “heading stability test”. The disturbance to be used should be of rectangular waves equivalent to rudder angles. The wave forms are defined in Table A.1.

Table A.1 — Amplitude of wave forms

Time	0	60	120	180	240	360	380	410	440	460
	to	to	to	to	to	to	to	to	to	to
s	60	120	180	240	360	380	410	440	460	600
Amplitude										
(°)	0,0	+ 2,0	0,0	– 2,0	0,0	+ 3,0	0,0	– 3,0	0,0	+ 3,0

Annex B
(normative)

Craft-motion simulator

The following shall be the standard calculation for a craft-motion simulator. The craft manoeuvrability model shall be the K-T (transfer function) model, represented by:

$$\frac{\dot{\psi}}{\delta} = \frac{K}{TS+1}$$

where

$\dot{\psi}$ is the rate of turn of the craft, in degrees per second;

δ is the rudder angle, in degrees;

K is the turning ability constant of the craft, in reciprocal seconds;

T is the time constant of the craft, in seconds;

S is the Laplace operator.

K and T shall be converted from K' and T' as follows:

$$K = \frac{K'}{l/v} \qquad T = T' \times \frac{l}{v}$$

where

K' is the turning ability of the non-dimensional manoeuvrability index; K' = 0,6;

T' is the course-retaining ability of the non-dimensional manoeuvrability index; T' = 0,1;

l is the length of the craft provided with a heading control system, in metres;

v is the speed of the craft provided with a heading control system, in metres per second.

The steering-engine model (transfer function) shall be based on the following expression:

$$\frac{\delta}{\delta^*} = \frac{1}{T_E S+1}$$

where

δ is the rudder angle, in degrees;

δ^* is the actuated rudder angle, in degrees;

T_E is the time constant of the steering engine, in seconds;

S is the Laplace operator.

In this case, the rate of the rudder motion ($d\delta/dt$) shall be equal to, or less than, 15°/s, and T_E shall be equal to 0,1 s.

The bearing resolution and steering-engine model sensitivity shall be as follows:

bearing resolution: 0,1° or less

steering-engine model sensitivity: 0,2° or less

Table B.1 — Examples of L/v_2

Ship's type	Lpp	V_1 kn	V_2 m/s	L/v_2
A	24,5	36	18,52	1,32
B	35,0	32	16,46	2,13
C	26,5[a]	36	18,52	1,43
D	46,0[a]	35	18,0	2,56

[a] These values are not the length between perpendiculars (Lpp). These two values are of overall length.

Annex C
(informative)

Example of heading stability test under the conditions of disturbance

The course-keeping simulation results, obtained when the specified disturbances act, are given for information in this annex. When simulating, the K-T model shown in Annex B as a ship-hull response model, and for the heading control system, a model which has the transfer function shown below were used.

$$\frac{\delta(S)}{e(S)} = K\mathrm{p} + T_{\mathrm{d}}S + \frac{1}{T_{\mathrm{i}}S}$$

where

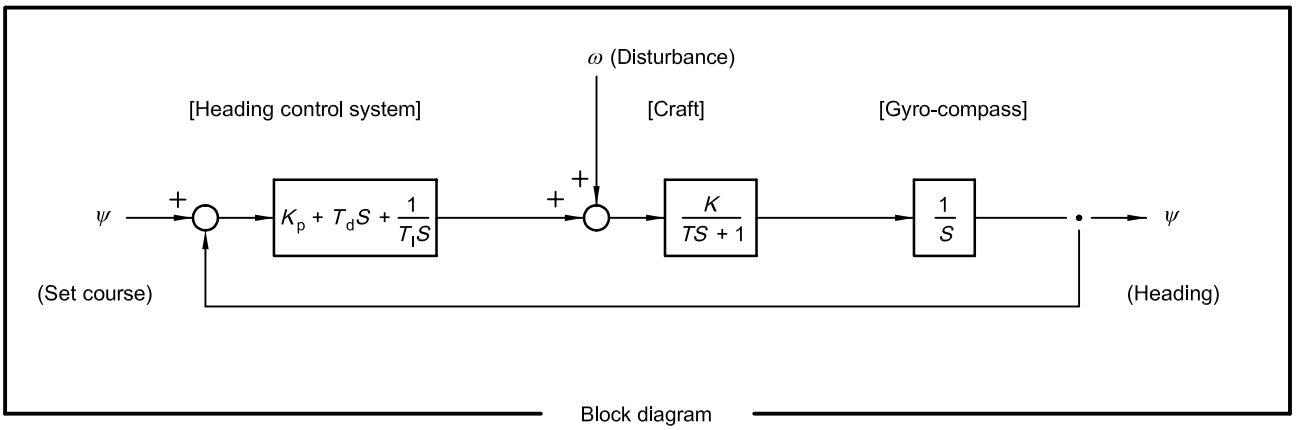
$\delta(S)$ is the rudder angle;

$e(S)$ is the bearing error;

K_{p}, T_{d}, and T_{i} are the parameters of the heading control system;

S is the Laplace operator.

A simulation block diagram and the transfer function which shows the transfer of the disturbance to the ship's bearing are shown in Figure C.1. The parameters of the ship-hull response and the heading control system used for the simulation are shown in Table C.1.



Transfer function

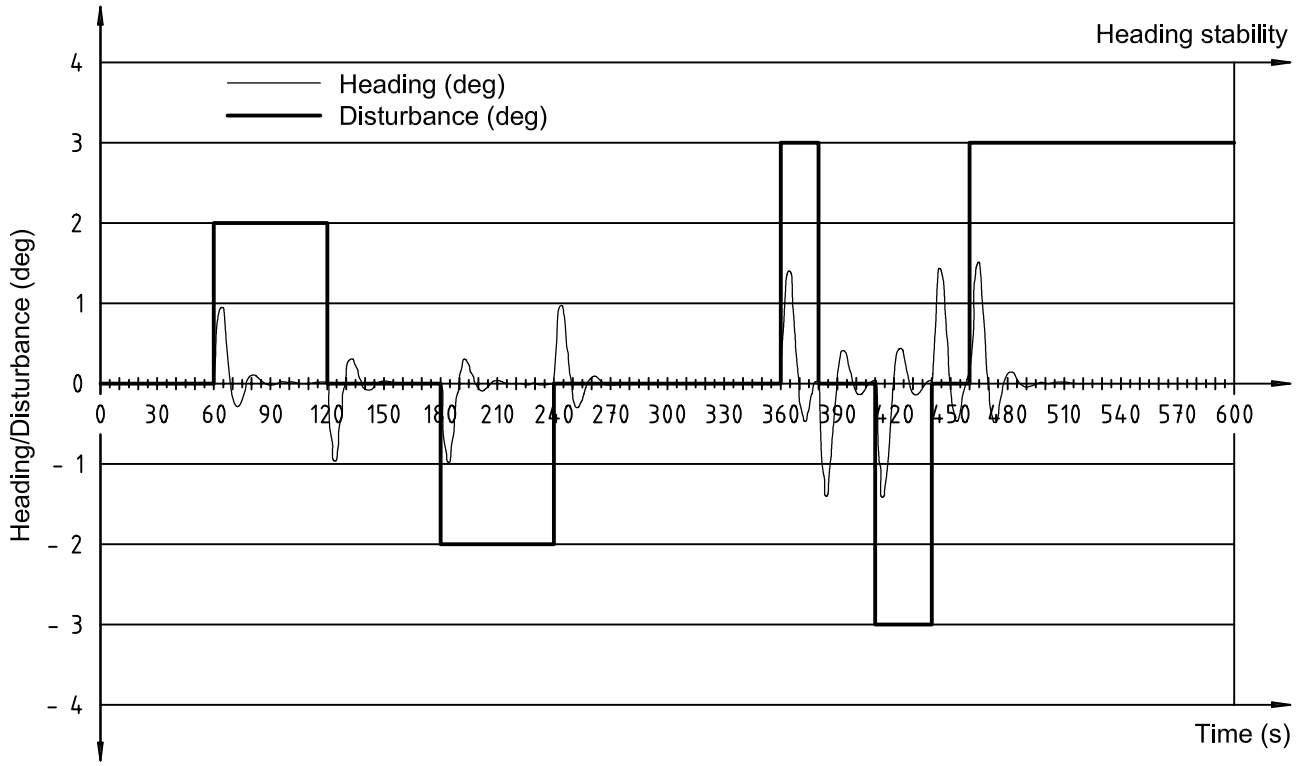
$$\frac{\psi(S)}{\omega(S)} = \frac{S}{(T/K)S^3 + (1/K + T_{\mathrm{d}})S^2 + K_{\mathrm{p}}S + 1/T_{\mathrm{i}}}$$

Figure C.1 — Block diagram and transfer function

Table C.1 — Parameters of ship-hull response and heading control system

Parameter	L/v	K'	T'	K_p	T_d	T_i
Value	2,0	0,6	0,1	1,0	0,194	2,0

The results are shown in Figure C.2.



L/v = 2,0
K' = 0,6
T' = 0,1
K = 0,3
T = 0,2
K_p = 1,0
T_d = 0,194
T_i = 2,0

Figure C.2 — Simulation result

Annex D
(informative)

Equivalent requirements in ISO 16329 and IMO Resolutions

Table D.1

Clause or subclause in this International Standard	Clause or subclause in IMO Res.A.822(19) or IMO Res.A.694(17) or IMO Res. MSC 64(67) annex 3:1997	Clause or subclause in ISO 11674:2000
1	A.822(19), 1.1 and 1.2 and MSC 64(67) annex 3:1997, 2.1	1 [a]
2		2 [a]
3.1		3.6 [a]
3.2		3.11 [a]
3.3		3.9
3.4		3.2 [a]
3.5		3.4
3.6		3.3
3.7		3.12
3.8		3.5
3.9		3.8
3.10		3.15
3.11		3.1 [a]
3.12		3.10
3.13		3.7
3.16		3.14
3.17		3.13 [a]
4.1.1	A.822(19), 2.2 [a] and MSC 64(67) annex 3:1997, 3.1	4.1.1
4.1.2	A.822(19), 2.3	
4.1.3	A.822(19), 2.4	
4.1.4		4.1.2
4.2		4.2
4.3.2.1	A.822(19), 3.1 [a] and MSC 64(67) annex 3:1997, 4.1	4.3.1.1
4.3.2.2	A.822(19), 3.2 and MSC 64(67) annex 3:1997, 4.2	4.3.1.2
4.3.2.3	A.822(19), 3.3 [a] and MSC 64(67) annex 3:1997, 4.3	4.3.1.3 [a]
4.3.2.5	A.822(19), 3.4	
4.3.2.6	A.822(19), 3.5 and MSC 64(67) annex 3:1997, 4.5	4.3.1.5 [a]
4.3.2.7	A.822(19), 3.6	
4.3.3.1	A.694(17), 3.2	4.3.2.1

Table D.1 (*continued*)

Clause or subclause in this International Standard	Clause or subclause in IMO Res.A.822(19) or IMO Res.A.694(17) or IMO Res. MSC 64(67) annex 3:1997	Clause or subclause in ISO 11674:2000
4.3.3.2	A.822(19), 5.1 [a]	
4.3.3.3	A.694(17), 3.3	4.3.2.3
4.3.3.4	A.822(19), 5.2 [a] and MSC 64(67) annex 3:1997, 7.3	4.3.2.5
4.3.3.5		4.3.2.6 [a]
4.3.3.6	MSC 64(67) annex 3:1997, 7.4	4.3.2.7
4.3.3.7	A.822(19), 5.3 [a] and MSC 64(67) annex 3:1997, 7.5	4.3.2.8 [a]
4.3.3.8	A.822(19), 5.4 and MSC 64(67) annex 3:1997, 7.6 [a]	4.3.2.9
4.3.4	A.822(19), 6 and MSC 64(67) annex 3:1997, 3.3	4.3.3
4.3.5	A.822(19), 7 and MSC 64(67) annex 3:1997, 3.4	4.3.4
4.3.6		4.3.5
4.3.7	A.822(19), 3.3 [a] and MSC 64(67) annex 3:1997, 3.5	4.3.6
4.3.8.1	A.822(19), 5.5 [a] and MSC 64(67) annex 3:1997, 3.2	
4.3.8.2		4.3.7 [a]
4.3.8.3		4.3.8 [a]
4.3.9	MSC 64(67) annex 3:1997, 3.6	4.3.9
4.3.10.1		4.3.10.1
4.3.10.2	A.694(17), 4.3	4.3.10.2
4.3.11.1	A.822(19), 4.5	4.3.11.1
4.3.11.2	A.822(19), 4.1 [a] and MSC 64(67) annex 3:1997, 6.1	4.3.11.2
4.3.11.3		4.3.11.3 [a]
4.3.11.4	A.822(19), 4.2 [a] and MSC 64(67) annex 3:1997, 6.2	4.3.11.4
4.3.11.5	A.822(19), 4.3 [a] and MSC 64(67) annex 3:1997, 6.3	4.3.11.5
4.3.11.6	MSC 64(67) annex 3:1997, 6.4	4.3.11.6
4.3.11.7	A.822(19), 4.4 [a] and MSC 64(67) annex 3:1997, 6.5	4.3.11.7
4.3.12		4.3.12 [a]
4.3.13	A.822(19), 2.1	4.3.13 [a]
4.3.14		4.3.14
4.3.15.1	MSC 64(67) annex 3:1997, 8.1	4.3.15.1
4.3.15.2	MSC 64(67) annex 3:1997, 8.2	4.3.15.2
4.3.15.3	A.822(19), 8 and MSC 64(67) annex 3:1997, 8.3 [a]	4.3.15.3 [a]
4.4		4.4
5.1		5.1 [a]
5.2		5.2 [a]
5.3		5.3
5.4		5.4

Table D.1 (*continued*)

Clause or subclause in this International Standard	Clause or subclause in IMO Res.A.822(19) or IMO Res.A.694(17) or IMO Res. MSC 64(67) annex 3:1997	Clause or subclause in ISO 11674:2000
5.5.1		5.5.1 [a]
5.5.2		5.5.2
5.5.3.1		5.5.3.1 [a]
5.5.3.2		5.5.3.2 [a]
5.5.4		5.5.4 [a]
5.5.5		5.5.5 [a]
7	A.694(17), 9	6
8a)	A.694(17), 8.3.1	7a)
8b)	A.694(17), 8.3.2	7b)
8c)		7c)

[a] Differences in text.

Bibliography

[1] IMO Resolution A.210(VII), *Recommendation on steering gear for large ships*

[2] SOLAS 1974, International Convention for the Safety of Life at Sea. Chapter II-1, *Regulations 29 and 30*

[3] SOLAS 1981, Chapter V, *Regulation 19*

[4] ISO 2412:1982, *Shipbuilding — Colours of indicator lights*

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[7] IEC 60092-204:1987, *Electrical installations in ships — Part 204: System design — Electric and electrohydraulic steering gear*

[8] IEC 60092-504:2001, *Electrical installations in ships — Part 504: Special features — Control and instrumentation*

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