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Ships and marine technology — Automatic pilots

Navires et technologie maritime — Pilotes automatiques

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 11674, which is a Technical Report of type 2, was prepared by Technical Committee ISO/TC 8, *Ships and marine technology*, Subcommittee SC 6, *Navigation*.

Following the fifth meeting of ISO/TC 8/SC 18, *Navigational instruments and systems,* held in October 1990 in Tokyo, the proposal for standardization of automatic pilots was approved. Then, IEC/TC 80, *Marine navigational and radiocommmunication equipment and systems,* proposed that International Standards for automatic pilots should be developed jointly by ISO and IEC and this was subsequently accepted by both secretariats.

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The working draft, ISO/WD 11674, was aimed at satisfying the provisions contained in IMO resolution A.342(IX), *Recommendation on performance standards for automatic pilots.* The final committee draft, ISO/CD 11674, was circulated for voting by both and was accepted as a DIS.

The fortieth session of the NAV Subcommittee of IMO, held in September 1994, considered an amendment to the resolution A.342(IX). Hence, the ISO Central Secretariat and the Secretariat of ISO/TC 8/SC 6, *Navigation* (renamed and reorganized since 1995), agreed that the current document be published as a Technical Report of type 2.

At a later date ISO/TC 8/SC 6 will develop International Standards on automatic pilots, which will conform to the amended version of the IMO resolution which is expected to be made at the forty-second session of the NAV Subcommittee in July 1996.

This document is being issued in the Technical Report (type 2) series of publications (according to subclause G.3.2.2 of part 1 of the ISO/IEC Directives, 1995) as a "prospective standard for provisional application" in the field of navigational instruments because there is an urgent need for guidance on how standards in this field should be used to meet an identified need.

This document is not to be regarded as an "International Standard". It is proposed for provisional application so that information and experience of its use in practice may be gathered. Comments on the content of this document should be sent to the ISO Central Secretariat.

A review of this Technical Report (type 2) will be carried out not later than three years after its publication with the options of: extension for another three years; conversion into an International Standard; or withdrawal.

Annexes A and B of this Technical Report are for information only.

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Ships and marine technology — Automatic pilots

1 Scope

This Technical Report specifies the structure, performance, inspection and testing of automatic pilots to be installed on board ships of 1 600 tonnes gross tonnage and upwards.

It applies to the automatic pilots which enable a ship, when navigating in accordance with the current regulations, *to keep a preset course with minimum operation of the* ship's *steering gear, within limits related to the* ship's *manœuvrability, in conjunction with their source of heading information.*

NOTE 1 All requirements that are extracted from the recommendations of IMO Resolutions [A.342(IX) and A.694(17)] are printed in italics.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Technical Report. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Technical Report are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO/R 694:1968, *Positioning of magnetic compasses in ships.*

IEC 945:1994, *Marine navigational equipment — General requirements — Methods of testing and required test results.*

IEC 1162-1:1995, *Maritime navigation and radiocommunication equipment and systems — Digital interfaces — Part 1: Single talker and multiple listeners.*

3 Definitions

For the purposes of this Technical Report, the following definitions apply.

3.1 course: Horizontal direction in which a ship is steered or intended to be steered, expressed as the angular direction with respect to north, usually from 000° at north, clockwise through 360°. Strictly, the term applies to the direction through the water, not the direction actually covered over the ground. Differs from heading.

3.2 heading: Horizontal direction in which a ship actually points or heads at any instant, expressed in angular units from a reference direction, usually from 000° at the reference direction clockwise through 360°.

3.3 manual steering: Method of controlling the steering gear manually, for example using a steering-wheel.

3.4 automatic steering: Method of controlling the steering gear automatically to keep a ship's heading, processing the heading information which is obtained by a gyrocompass or magnetic compass.

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 adjustment device: Device which changes the characteristics of an automatic steering device, including proportional rudder adjustment, derivative rudder adjustment, integral rudder adjustment and weather adjustment.

3.8 operating device: Switch, heading set device, etc. which is used for operating an automatic pilot.

3.9 proportional rudder adjustment: Adjustment of a component of the total rudder command in proportion to an instantaneous value of the difference between the preset course and heading.

3.10 derivative rudder adjustment: Adjustment of a component of the total rudder command which acts to control the rate of turn of the ship.

3.11 integral rudder adjustment: Adjustment of a component of the total rudder command so that an integral value of the difference between the course and heading becomes zero.

3.12 weather adjustment: Adjustment which minimizes unnecessary steering motion against yawing caused by waves, swells and wind.

3.13 heading signal processor: Unit which processes the heading signal generated by a gyrocompass, magnetic compass, etc., and adapts it before its use by the automatic pilot.

3.14 non follow-up steering: Method of controlling the steering gear (moving the rudder) as long as a steering lever is activated.

3.15 follow-up steering: Method of controlling the steering gear (moving the rudder) to an angle set on a follow-up steering unit.

4 Performance

4.1 General

4.1.1 *An automatic pilot* shall *be capable of adapting to different steering characteristics of the* ship *under various weather and loading conditions.*

4.1.2 *An automatic pilot shall provide reliable operation under prevailing environmental and normal operational conditions.*

4.1.3 An automatic pilot shall conform to clause 3 of IEC 945:1994, clause 3, class B bridge-mounted equipment.

4.2 Constituents

An automatic pilot shall be composed, as a minimum, of the following devices (see figure 1):

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

b) course setting control (which can be set to any direction);

c) automatic steering device;

d) adjustment and operating device;

e) change-over device (with steering mode indicator);

f) alarm signalling facilities which indicate a deviation from the preset heading and failure in the power supply.

4.3 Requirements for function

The following requirements shall be fulfilled.

4.3.1 Changing over from automatic to manual steering and vice versa

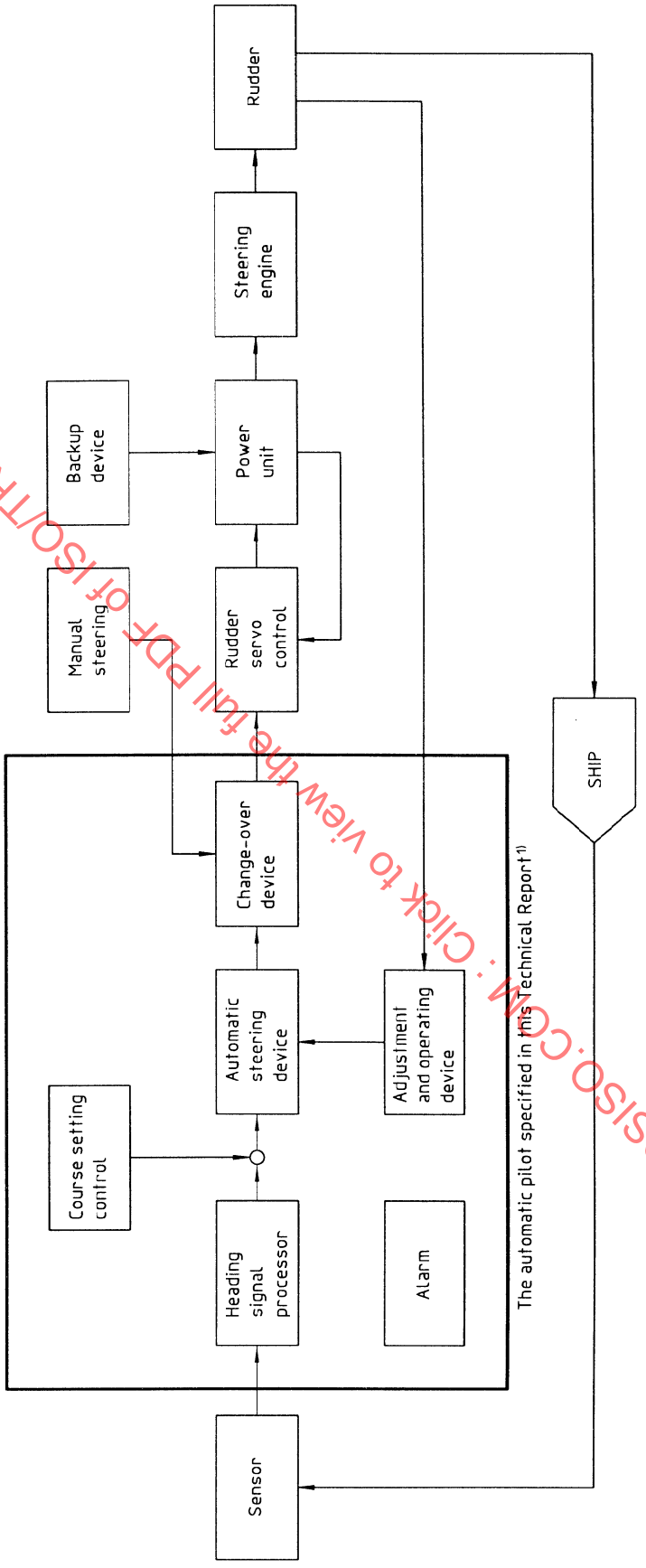
4.3.1.1 *Changing over from automatic to manual steering and vice versa* shall *be possible at any rudder position and be effected by one, or at the most two manual controls, within a time lag of 3 seconds.*

4.3.1.2 *Changing over from automatic to manual steering* shall *be possible under any conditions, including any failure in the automatic* pilot including any power failure.

4.3.1.3 *When changing over from manual to automatic steering, the automatic pilot* shall *be capable of bringing the* ship *to the preset course.* At this time, no alteration of the current heading shall be possible without intended action of the ship's personnel.

4.3.1.4 *Change-over* devices shall *be located close to each other in the immediate vicinity of the main steering position.*

4.3.1.5 *Adequate indication* shall *be provided to show which method of steering is in operation at a particular moment.* This indicator shall be fitted at the main steering unit.



1) Portion enclosed by the thick line shows the constituent devices of an automatic pilot which are specified in this Technical Report.

Figure 1 — Control devices for automatic pilots

4.3.2 Operational controls and adjustment controls

4.3.2.1 *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.*

4.3.2.2 *The number of operational* and adjustment *controls* shall *be minimized as far as possible and they* shall *be designed to preclude inadvertent operation.* The number of operational controls, their design and manner of functioning, location, arrangement and size shall provide for simple, quick and effective operation. The controls shall be arranged in a manner which minimizes the chance of inadvertent operation.

4.3.2.3 *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.*

4.3.2.4 *Unless features for automatic adjustments are incorporated in the installation, the automatic pilot* shall *be provided with adequate* adjustment *controls for operational use to adjust effects due to weather and the ship's steering performance.*

4.3.2.5 An *automatic pilot* shall *be designed in such a way as to ensure altering course to starboard by turning the course setting control clockwise. Normal alterations of course* shall *be possible by one* control *only of the course setting control.* Requirements shall be made by means of the design and the construction of the course setting control to preclude unintended alteration of heading.

4.3.2.6 When changing course 180° away from the ship's heading, the clockwise or counterclockwise direction of course change shall determine the ship's turning direction. The turning angle of the course setting control shall be proportional to the effected change of the course.

4.3.2.7 *Except for the course setting control, the actuation of any other control* shall *not significantly affect the course of the* ship.

4.3.2.8 *Additional controls at remote positions* shall *comply with the provisions of* this Technical Report.

4.3.3 Rudder angle limitation

4.3.3.1 *Means* shall *be incorporated in the equipment to enable rudder angle limitation in the automatic* steering *mode of operation. Means* shall *also be available to indicate when the angle of limitation has been reached* or when the signal to get to the angle of limitation has been given.

4.3.3.2 The rudder angle of limitation in the automatic steering mode of operation shall be capable of being set.

4.3.4 Countermeasure to yawing

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

4.3.5 Heading indication accuracy

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

4.3.6 Power supply

4.3.6.1 An automatic pilot shall be capable of normal operation under the following variation of the appropriate power supply.

AC	variation from nominal voltage:	± 10 %
AC	variation from nominal frequency:	± 6 %
DC	variation from nominal voltage	
	mains supplies:	+ 10 % − 20 %
	battery supplies:	+ 30 % − 10 %

4.3.6.2 *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.

4.3.7 Alarm signalling facilities

4.3.7.1 Course monitor

4.3.7.1.1 *A course monitor* shall *be provided which actuates an adequate "off-course" audible alarm signal after a course deviation of a preset amount.* The preset amount shall be set within a minimum range of 5° to 15° using increments of 2° max.

NOTE 2 Off-course is a situation where the ship has deviated from the course.

4.3.7.1.2 *The information required to actuate the course monitor* shall *be provided from an independent source.*

NOTE 3 The information required is heading data provided from a source independent of the steering reference.

4.3.7.2 Power source failure alarm

4.3.7.2.1 *Alarm signals, both audible and visual,* shall *be provided in order to indicate failure or a reduction in the power supply to the automatic pilot or course monitor, which would affect the safe operation of the equipment.*

4.3.7.2.2 *The alarm signalling facilities* shall *be fitted near the steering position.*

4.3.8 Transformation error

The heading data supplied to the automatic pilot shall not deviate by more than 0,5° from the compass heading.

4.3.9 Heading stability

The heading stability shall be such that, under conditions of no disturbance, the average value of the difference between the preset direction and the heading is within ± 1° and the maximum single amplitude is within 1,5°.

4.3.10 Digital interface

Digital interfaces with other items of equipment shall comply with IEC 1162-1.

4.4 Safety precautions

4.4.1 *As far as is practicable, accidental access to dangerous voltages* shall *be prevented. All parts and wiring in which the direct or alternating voltages or both (other than radio frequency voltages) combine to give a peak voltage greater than 55 V shall be protected against accidental access and* shall *be isolated automatically from all sources of electrical energy when the protective covers are removed. Alternatively, the equipment* shall *be so constructed that access to such voltages may only be gained after having used a tool for this purpose, such as spanner or screwdriver, and warning labels* shall *be prominently displayed both within the equipment and on protective covers.*

4.4.2 *Means* shall *be provided for earthing exposed metallic parts of the equipment but this* shall *not cause any terminal of the source of electrical energy to be earthed.*

5 Type testing

The following type tests shall be carried out in the order given below.

5.1 Structure test

The structure of an automatic pilot shall be subjected to the following tests.

a) Installation shall be such that the distance between the centre of a magnetic compass and the casing of the automatic pilot is 70 cm.

b) The difference between a magnetic compass indication with an automatic pilot installed and an indication without it shall be not more than ± 5°.

c) With the positioning of a), the difference of the magnetic compass indication between when the automatic pilot power source is turned on and when turned off shall be not more than ± 1°.

5.2 Environmental tests

5.2.1 Vibration

The vibration test shall be carried out in accordance with the requirements of IEC 945:1994, 4.4.7.

5.2.2 Dry heat cycle

The dry heat cycle test shall be carried out in accordance with the requirements of IEC 945:1994, 4.4.2.1.

5.2.3 Damp heat cycle

The damp heat cycle test shall be carried out in accordance with the requirements of IEC 945:1994, 4.4.3.1.

5.2.4 Low temperature cycle

The low temperature cycle test shall be carried out in accordance with the requirements of IEC 945:1994, 4.4.4.1 and 4.4.4.3.

5.3 Power supply

5.3.1 Power supply variation

The power supply variation test shall be carried out in accordance with the requirements of IEC 945:1994, 4.3.1. The requirements of 4.3.6.1 shall be complied with.

5.3.2 Power supply failure

The power supply failure test shall be carried out by turning off the power supply to the automatic pilot while the power supply of the alarm unit remains on. The requirements of 4.3.7.2 shall be complied with.

5.4 Interference

5.4.1 Conducted interference

The conducted interference test shall be carried out in accordance with the requirements of IEC 945:1994, 4.5.3.

5.4.2 Radiated interference

The radiated interference test shall be carried out in accordance with the requirements of IEC 945:1994, 4.5.4.

5.5 Immunity to electromagnetic environment

Immunity tests shall be carried out in accordance with the requirements of IEC 945:1994, annex A.

5.6 Acoustic noise

The acoustic noise test shall be carried out in accordance with the requirements of IEC 945:1994, 4.5.7.

5.7 Compass safe distances

The determination of compass safe distances shall be carried out in accordance with the requirements of ISO/R 694:1968, method B.

5.8 Automatic to manual steering mode change-over

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

a) During the mode of automatic steering, turn the steering wheel so that the position of the wheel is at 0° to the rudder angle command.

b) 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 4.3.1.1.

5.9 Control characteristic

The following tests shall be carried out using a ship motion simulator. The simulator described in 5.9.4 shall be the standard simulator to be used for these tests.

5.9.1 Heading signal transformation accuracy

Set the simulator's ship heading at 8 bearing points and then measure the heading indicated by the automatic pilot. This measurement shall be carried out twice for both the clockwise direction and the counter clockwise direction respectively. The requirements of 4.3.8 shall be complied with.

NOTE 4 This test is not required for systems which require the heading data to be directly supplied by means of a digital signal from a gyrocompass or a magnetic compass.

5.9.2 180° turn

With regard to the ship's manœuvrability model, the following test shall be carried out with:

$$l/v = 30$$

where

l is the length of the ship, in metres;

v is the ship speed, in metres per second.

The heading set device shall be turned right or left to make 180° heading change according to 4.3.2.6 and the following shall be checked.

a) When turning the course setting control clockwise, a right heading change is made and when turning the course setting control counter clockwise, 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.

5.9.3 Heading stability

With regard to the ship's manœuvrability model, the following test shall be carried out with:

$$l/v = 30$$

where

l is the length of the ship, in metres;

v is the ship speed, in metres per second.

10 min after switching on the automatic pilot, maintain for 10 min the automatic heading while maintaining conditions of no disturbance. The requirements of 4.3.9 shall be complied with.

5.9.4 Ship motion simulator

The following shall be the standard for a ship motion simulator. The ship manœuvrability 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 ship, in degrees per second;

δ is the rudder angle, in degrees;

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

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

S is the Laplace operator, in reciprocal seconds.

K and T shall be converted from K′ and T′ as follows;

$$K = K'/(l/v)$$

$$T = T'(l/v)$$

where

K' is the turning ability of the non-dimensional manœuvrability index; $K' = 1$;

T' is the course retaining ability of the non-dimensional manœuvrability index; $T' = 1$;

l is the length of the ship provided with an automatic pilot, in metres;

v is the speed of the ship provided with an automatic pilot, 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;

$\delta *$ 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 reciprocal seconds.

In this case, the rate of the rudder motion ($d\delta/dt$) shall be equal to, or less than, 3 degrees per second, and T_E shall be equal to 2,5 seconds.

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

6 Marking

Each unit of an automatic pilot 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.*

7 Information

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

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,* and

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.*