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Ships and marine technology — Manoeuvring of ships —

Part 1: General concepts, quantities and test conditions

Navires et technologie maritime — Manoeuvres des navires —
Partie 1: Notions générales, grandeurs et conditions d'essais

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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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 8, *Ships and marine technology*, Subcommittee SC 6, *Navigation and ship operations*.

This second edition cancels and replaces the first edition (ISO 13643-1:2013), of which it constitutes a minor revision with the following changes:

— Table 8, CC-Code VK symbol "*N*" to "*v*";

— Table 8, CC-Code RHOWA symbol "*P*" to "*ρ*";

— Table 8, CC-Code OMN symbol "Ω" was changed to "*ω*";

— 7.9.2, Equations (1) and (2) in the last term Symbol "*φ*" was changed to "*ϕ*";

— 7.9.3, third sentence of the subclause "where as $q = \dot{\theta}$ and $\dot{q} = \ddot{\theta}$ well as $w = \dot{z}$ and $\dot{w} = \ddot{z}$ " was changed to "where $q = \dot{\theta}$ and $\dot{q} = \ddot{\theta}$ as well as $w = \dot{z}$ and $\dot{w} = \ddot{z}$";

— 8.2 "a) stopping test" has been inserted.

A list of all parts in the ISO 13643 series can be found on the ISO website.

Ships and marine technology — Manoeuvring of ships —

Part 1: General concepts, quantities and test conditions

1 Scope

This document applies to manoeuvring tests with surface ships, submarines and models.

This document defines concepts, symbols and test conditions constituting general fundamentals which are to be applied for the description and determination of certain ship manoeuvring characteristics together with the respective test-specific physical quantities contained in ISO 13643-2 to ISO 13643-6.

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.

ISO 19019, *Sea-going vessels and marine technology — Instructions for planning, carrying out and reporting sea trials*

3 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:

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

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

3.1
manoeuvring
all *manoeuvres* (3.2), *manoeuvring tests* (3.3) and tests or other methods, such as computations, simulations, etc. to establish manoeuvring characteristics

Note 1 to entry: Manoeuvring includes measures to maintain cruising conditions under external disturbances.

3.2
manoeuvre
ship operation measures to change course and/or speed, and in case of submarines, depth

Note 1 to entry: Special actions taken, e.g. for casting-off, turning aside or rescuing (person over board), are included.

3.3
manoeuvring test
test conducted with a full-scale ship, submarine or a model to determine and evaluate the manoeuvring characteristics under standardized conditions

Note 1 to entry: Manoeuvring tests are often similar to manoeuvres, but organized in such a manner that, as far as possible, specific manoeuvring characteristics can be measured individually.

3.4
CC-Code
computer compatible symbols introduced by the 14th International Towing Tank Conference

3.5
manoeuvring device
rudder, azimuthing thruster, hydroplane, cycloidal propeller or equivalent system used to *manoeuvre* (3.2) a vessel

4 Axis systems

4.1 General

Axis systems are three-dimensional, orthogonal, right-handed systems. Earth-fixed and ship-fixed axis systems are defined in Tables 1 and 2.

4.2 Earth-fixed axis system

Table 1 — Symbols and their definitions for the earth-fixed axis system

Symbol	CC-Code	SI-Unit	Term	Position	Positive sense
O_0	ORIG0	—	Origin, earth-fixed	Arbitrary, but preferably in the water surface	—
O	ORIG	—	Origin, ship-fixed (moving with the ship)	Preferably according to Table 2	—
x_0	X0	m	—	In the horizontal plane[a]	Arbitrary
y_0	Y0	m	Transverse axis	In the horizontal plane[a]	Right-handed system with x_0, z_0
z_0	Z0	m	Vertical axis	In the direction of gravity	Down
[a] Assuming earth or water surfaces to be plane.					

4.3 Ship-fixed axis system

Table 2 — Symbols and their definitions for the ship-fixed axis system

Symbol	CC-Code	SI-Unit	Term	Position	Positive sense
O	ORIG	—	Origin, ship fixed	For surface ships in CL at the height of DWL at MP For submarines on MA in the lateral plane of B_∇	—
x	X	m	Longitudinal axis	In CL or MA	Forward
y	Y	m	Lateral axis	Perpendicular to CL	Starboard
z	Z	m	Normal axis	In CL	Right-handed system with x and y (under normal cruising conditions down)

5 Position coordinates

Table 3 — Symbols and their definitions for position coordinates of points under consideration

Symbol	CC-Code	SI-Unit	Concept	
			Term	Definition or explanation
x (..)[a]	X (..)[a]	m	Longitudinal position	Distance between point under consideration and origin O measured parallel to the ship's longitudinal axis (see Table 2), positive if point under consideration is forward of origin O.
y (..)[a]	Y (..)[a]	m	Lateral position	Distance between point under consideration and origin O measured parallel to the ship's lateral axis, positive if point under consideration is starboard of origin O.
z (..)[a]	Z (..)[a]	m	Normal position	Distance between point under consideration and origin O measured parallel to the ship's normal axis, positive if point under consideration is below origin O.

[a] (..) = Supplement to symbol/CC-Code by code letters for points under consideration.

Code letters for the following special points:

A antenna (reference point);

B centre of buoyancy (static);

BB bow plane (reference point);

F stabilising fin (reference point);

G centre of gravity;

L lateral area below waterline (centre of area);

LV lateral area above waterline (centre of area);

P propeller (reference point);

R manoeuvring device (reference point);

S stern plane (reference point);

T thruster (reference point).

EXAMPLE z_R resp. ZR: Normal position of manoeuvring device (reference point).

6 Angles

6.1 Angles of flow

6.1.1 Angle of attack

Table 4 — Symbol and definition for the angle of attack

Symbol	CC-Code	SI-Unit	Concept		Axis of rotation	Measurement plane
			Term	Definition or explanation		
α	ALFA	rad[a]	Angle of attack	Angle by which the projection of the direction of heading through the water upon CL has to be turned about lateral axis *y*, such that it coincides with the *x*-axis. $\arctan \frac{w}{u}$ $\arcsin \frac{w}{\sqrt{u^2+w^2}}$	*y*	*xz*

[a] For angles, the unit ° (degree) may be used.

6.1.2 Drift angle

Table 5 — Symbol and definition for the drift angle

Symbol	CC-Code	SI-Unit	Concept		Axis of rotation	Measurement plane
			Term	Definition or explanation		
β	BET	rad[a]	Drift angle	Angle to the principal plane of symmetry from the vector of the ship's speed[b] relative to the water, positive in the positive sense of rotation about the *z*-axis. $\arctan \frac{-v}{u}$ $\arcsin \frac{-v}{\sqrt{u^2+v^2}}$	*z*	*xy*

[a] For angles, the unit ° (degree) may be used.

[b] Reference point for the path through the water within the ship usually is the origin O of the ship-fixed axis system according to Table 2.

6.2 Angles of flow at parts of the ship

The definition of angles of flow at parts of the ship is to follow the definition of the ship's angles of flow as far as possible. Their symbols are to be derived from those in 6.1.1 and 6.1.2 by means of suitable subscripts (for a selection, see Table 3).

EXAMPLE

α_S angle of attack at stern plane (see Table 4).

β_R drift angle at manoeuvring device (see Table 5).

6.3 Eulerian angles

6.3.1 General

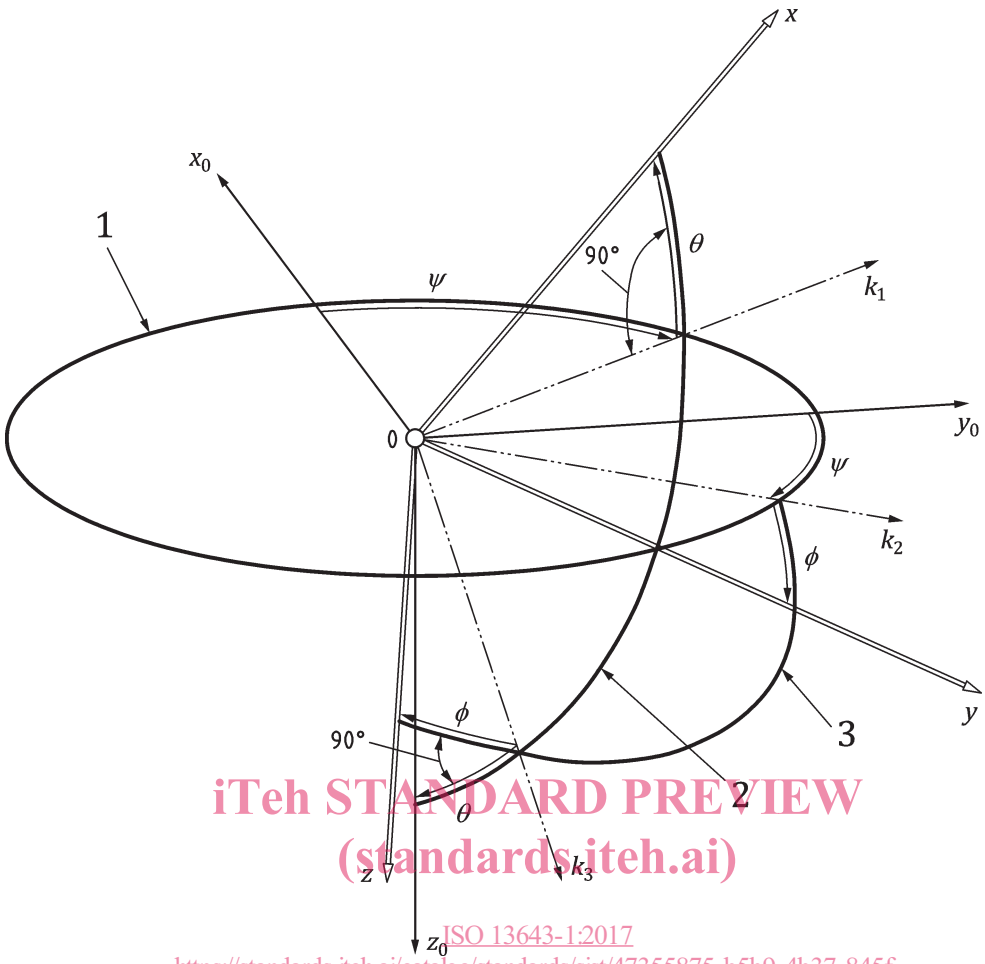
Eulerian angles are described in Figure 1 and Tables 6 and 7.

6.3.2 Nodal axes

In this subclause, the rotational position of two axis systems relative to one another is described by Eulerian angles which are defined with the aid of nodal axes (see Table 6).

Table 6 — Symbols and their definitions for nodal axes

Symbol	Definition or explanation
k_1	Projection of the longitudinal axis x onto the horizontal x_0y_0-plane.
k_2	Positioned with respect to y_0 as k_1 to x_0.
k_3	Projection of vertical axis z_0 onto yz-plane.



Key

1 x_0y_0 plane
2 xz_0 plane
3 xy plane

Figure 1 — Angles between earth-fixed and ship-fixed axis system

6.3.3 Eulerian angles between earth-fixed and ship-fixed axis systems

Table 7 — Symbols and their definitions for angles between earth-fixed and ship-fixed axis systems

Symbol	CC-Code	SI-Unit	Concept		Axis of rotation	Measurement plane
			Term	Definition or explanation		
θ_S	TRIMS	rad[a]	Trim angle	Angle of turn about nodal axis k_2, measured from nodal axis k_1 to x-axis (angle between x-axis and horizontal plane); positive if unit vector in the direction of x-axis has a negative component in the direction of z_0-axis.	k_2	xz_0
θ	TETP	rad[a]	Pitch angle	Definition as for θ_S above; used for oscillatory processes; usually measured relative to mean trim angle.	k_2	xz_0
ϕ_S	HEELANG	rad[a]	Heel (bank) angle	Angle of turn about the x-axis, measured from nodal axis k_2 to y-axis; positive in clockwise direction.	x	yz
ϕ	PHIR	rad[a]	Roll angle	Definition as for ϕ_S above; used for oscillatory processes; usually measured relative to mean heel angle.	x	yz
ψ	PSIH	rad[a]	Heading	Angle of turn about vertical axis z_0, measured from x_0-axis to nodal axis k_1; positive in clockwise direction; usually x_0-direction coincides with north or initial heading.	z_0	x_0y_0
	PSIY	rad[a]	Yaw angle	Definition as above; used for oscillatory processes; usually measured relative to mean heading.	z_0	x_0y_0

[a] For angles, the unit ° (degree) may be used.

7 General quantities

7.1 Physical quantities

Table 8 — Symbols and their definitions for physical quantities

Symbol[a]	CC-Code[a]	SI-Unit	Concept	
			Term	Definition or explanation
F_n	FN	1	Froude number	$\frac{V}{\sqrt{gL}}$
F_{nh}	FH	1	Froude depth number	$\frac{V}{\sqrt{gh}}$
$F_{n\nabla}$	FV	1	Froude displacement number	$\frac{V}{\sqrt{g\nabla^{1/3}}}$
g	G	m s^{-2}	Acceleration due to gravity	—
h	DE	m	Water depth	—
h_m	DEME	m	Mean water depth	During the test
m	MA	kg	Ship's mass	Mass which shall be accelerated for speed changes, but without added mass
n	N	s^{-1}	Rate of revolution, general	—
P	P	W	Power, general	—
R_n	RN	1	Reynolds number	$\frac{V\,L}{\nu}$
s	SP	m	Track length	Measured along ship's track
t	TI	s	Time, general	—
$t°_A$	TEAI	°C	Air temperature	—
$t°_W$	TEWA	°C	Water temperature	—
V	V	m s^{-1} [b]	Ship's speed	Speed through the water; usually given for origin O
W	WT	N	Ship's weight	—
Δ	DISPM	kg	Displacement mass	$\rho\nabla$
Δ_F	DISPF	N	Displacement force	$\rho g\nabla$
ν	VK	m^{2}s^{-1}	Kinematic viscosity	—
ρ	RHOWA	kg m^{-3}	Water density	—
ρ_A	RHOAI	kg m^{-3}	Air density	—
ω	OMN	rad s^{-1}	Angular velocity	—

[a] Symbol and CC-Code can have the additional subscripts S (for ship) or M (for model) if necessary for distinction.

[b] The unit kn, common in the navigation, may be used.

7.2 Geometrical quantities

7.2.1 Symbols for manoeuvring

Table 9 — Symbols and their definitions for geometrical quantities

Symbol	CC-Code	SI-Unit	Concept	
			Term	Definition or explanation
A_C	AC	m^2	Canal cross section	Cross section area of the canal.
A_L	AL	m^2	Lateral area below waterline	Moulded lateral area up to DWL, not including manoeuvring devices, fixed and movable parts of propulsors.
A_{LV}	ALV	m^2	Lateral area above waterline	Lateral area of the ship above DWL, generally without rigging, railings etc.
A_M	AM	m^2	Midship section area	Sectional area of moulded hull parallel to *yz*-plane at MP between BL and DWL.
AP	AP	—	After perpendicular	For surface ships: straight line on CL perpendicular to DWL through its intersection with the moulded stern contour (common practice for naval ships) or through the centreline of manoeuvring device stock (common practice for merchant ships). For submarines with one shaft: straight line perpendicular to MA through the intersection of the aft edge of stern tube with the centreline of the shaft. For submarines with several shafts, AP has to be determined adequately.
A_R	ARU	m^2	Rudder area	For the movable part (including flap); in way of a fixed post, aft of the stock axis only.
A_{RF}	ARF	m^2	Flap area	For the flap movable relative to the rudder, aft of its hinge axis only.
A_{RP}	ARP	m^2	Rudder area in the propeller race	For rudder in neutral position.
A_{RT}	ART	m^2	Total rudder area	$A_R + A_{RX}$
A_{RX}	ARX	m^2	Fixed post area of a rudder	Forward of the stock axis.
A_{SK}	ASK	m^2	Skeg area	For skeg or fixed fin.
A_X	AX	m^2	Maximum transverse section area	Maximum sectional area of moulded hull parallel to the *yz*-plane up to the DWL.
B	B	m	Breadth	Reference breadth of a ship; usually B_{DWL}.
B_{DWL}	BDWL	m	Breadth of design waterline	Maximum moulded breadth of design waterline.
BL	BL	—	Baseline	Line on CL parallel to DWL through the moulded keel line at MP.
B_∇	—	—	Centre of buoyancy of form displacement	Relative to ∇.