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Ships and marine technology — Manoeuvring of ships —

Part 6: Model test specials

Navires et technologie maritime — Manoeuvres des navires —

Partie 6: Spécificités des essais sur modèle

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ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
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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 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 13643-6:2013), of which it constitutes a minor revision with the following changes:

— in 3.6 $xy\psi$-carriage was inserted;

— in Table 1 "DNDPDYS" row, the symbol was changed from "$N_{\phi\mathrm{dyn}}$" to "$N'_{\phi\mathrm{dyn}}$";

— in Table 1 "DYDVTS" row, the SI-unit was changed from "—" to "1";

— in Equation (20) "ρ_{w}" was changed to "ρ";

— in 7.3 paragraph 3, "moments" was changed to "motions".

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

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Ships and marine technology — Manoeuvring of ships —

Part 6:
Model test specials

1 Scope

This document defines symbols and terms and provides guidelines for the conduct of tests to determine the hydrodynamic forces and moments due to prescribed motions under a planar-motion, a circular-motion or an oblique towing or flow system for models of surface ships and submarines. It also defines symbols and terms and provides guidelines for the conduct of tests in a wind tunnel. It is intended to be read in conjunction with ISO 13643-1.

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 13643-1, *Ships and marine technology — Manoeuvring of ships — Part 1: General concepts, quantities and test conditions*

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 http://www.iso.org/obp

3.1
planar motion test
manoeuvring test to determine the hydrodynamic forces and moments as functions of lateral velocity and acceleration as well as of angular velocity and acceleration about the z-axis or the y-axis, respectively

3.2
circular motion test
manoeuvring test to determine the hydrodynamic forces and moments as a function of the angular velocity for surface ships primarily about the z-axis, for submarines primarily about the z-axis, as well as the y-axis

3.3
oblique towing or flow test
manoeuvring test to determine the forces and moments as a function of the drift angle and of the manoeuvring device angle and, in the case of submarines, the angle of attack and hydroplane deflections, in a towing tank, a circulating water tunnel, or a wind tunnel

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3.4
wind tunnel test
test to determine the aerodynamic forces and moments acting upon the above-water portion of the ship as a function of the relative wind

Note 1 to entry: A wind tunnel may also be used for the underwater hull.

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

3.6
***xyψ*-carriage**
sub carriage (secondary towing system) to the towing carriage that allows a differential longitudinal, a transverse and a rotational motion of the model in the horizontal plane

4 Test-related physical quantities

Test-related physical quantities are according to Table 1. General quantities and concepts are according to ISO 13643-1.

Table 1 — Test-related physical quantities

Symbol	CC-code	SI-unit	Concept	
			Term	Definition or explanation
A_{LV}	ALV	m^2	Lateral area above waterline	(see ISO 13643-1)
A_{XV}	AXV	m^2	Transverse projected area of ship above waterline	Projected cross section area above DWL, generally without rigging, railings, etc.
AP	AP	—	After perpendicular	(see ISO 13643-1)
a_0	A0PMM	m	Displacement amplitude of the model movement	—
C	CWI	N	Cross force	Force perpendicular to relative wind direction
C_C	CC	1	Cross force coefficient	$2C / (\varrho_A V_{WRA}^2 A_{LV})$
C_D	CD	1	Drag coefficient	$2D / (\varrho_A V_{WRA}^2 A_{LV})$
C_{DAX}	CDAX	1	Drag coefficient	$2D / (\varrho_A V_{WRA}^2 A_{XV})$, relative to cross section
C_K	CK	1	Roll-moment coefficient	$2K / (\rho_A V_{WRA}^2 A_{LV} L_{OA})$
C_N	CN	1	Coefficient of moment about *z*-axis	$2N / (\varrho_A V_{WRA}^2 A_{LV} L_{OA})$
C_X	CX	1	Longitudinal-force coefficient	$2X / (\varrho_A V_{WRA}^2 A_{LV})$
C_{XAX}	CXAX	1	Longitudinal-force coefficient	$2X / (\varrho_A V_{WRA}^2 A_{XV})$, relative to cross section
C_Y	CY	1	Lateral-force coefficient	$2Y / (\varrho_A V_{WRA}^2 A_{LV})$

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Table 1 *(continued)*

Symbol	CC-code	SI-unit	Concept	
			Term	Definition or explanation
D	DWI	N	Drag	Force in direction in which relative wind blows
DWL	DWL	—	Design waterline	(see ISO 13643-1)
FP	FP	—	Fore perpendicular	(see ISO 13643-1)
F_T	FTWI	N	Resultant force	$\sqrt{C^2+D^2}$ and $\sqrt{X^2+Y^2}$, respectively
F_n	FN	1	Froude number	(see ISO 13643-1)
F_{n0}	FN0	1	(Reference) Froude number	$V_0 / \sqrt{gL}$
$\overline{GM}$	GM	m	Metacentric height	(see ISO 13643-1)
H_{LM}	HLM	m	Mean height of lateral area above design waterline	A_{LV}/L_{OA}
I_{xx}	IXX	kg m^2	Moment of inertia of the model about x-axis	(see ISO 13643-1)
I_{yy}	IYY	kg m^2	Moment of inertia of the model about y-axis	(see ISO 13643-1)
I_{zx}	IZX	kg m^2	Product of inertia of the model	(see ISO 13643-1)
I_{zz}	IZZ	kg m^2	Moment of inertia of the model about z-axis	(see ISO 13643-1)
K	MX	N m	Roll moment	Moment about x-axis Relative to ship-fixed axis system
$K_{\phi stat}$	DKDPST	N m rad^{-1} [a]	—	$\frac{\partial K}{\partial \phi}\Big\vert_{V=0}$ from static test or calculation
K'	MXS	1	Non-dimensional roll moment	Especially for submarines: $\frac{K}{\frac{\rho}{2}L^3V^2}$ where $K(u, v, w, p, q, r, \dot{v}, \dot{w}, \dot{p}, \dot{q}, \dot{r}, \phi, \theta)$
				For surface ships only: $\frac{K}{\frac{\rho}{2}L^3V_0^2}$ where $K(V_0, \Delta u, v, w, p, q, r, \dot{v}, \dot{w}, \dot{p}, \dot{q}, \dot{r}, \phi, \theta)$
K'_{in}	MXINS	1	In-phase part of non-dimensional roll moment	$\frac{2}{nT}\int_t^{t+nT} K'(t)\sin\omega t\, dt$
K'_{out}	MXOUTS	1	Quadrature part of non-dimensional roll moment	$\frac{2}{nT}\int_t^{t+nT} K'(t)\cos\omega t\, dt$

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Table 1 *(continued)*

Symbol	CC-code	SI-unit	Concept	
			Term	Definition or explanation
K'_p	DKDPS	1	—	$\frac{\partial K'}{\partial p'}\Big\vert_{K'=\hat{K}'_0}$
$K'_{\dot{p}}$	DKDPTS	1	—	$\frac{\partial K'}{\partial \dot{p}'}\Big\vert_{K'=\hat{K}'_0}$
$K'_{\dddot{p}}$	DKDP3TS	1	—	$\frac{\partial K'}{\partial \dddot{p}'}\Big\vert_{K'=\hat{K}'_0}$
K'_r	DKDRS	1	Slope through zero of K' versus r'	$\frac{\partial K'}{\partial r'}\Big\vert_{K'=\hat{K}'_0}$
$K'_{\dot{r}}$	DKDRTS	1	—	$\frac{\partial K'}{\partial \dot{r}'}\Big\vert_{K'=\hat{K}'_0}$
K'_v	DKDVS	1	Slope through zero of K' versus v'	$\frac{\partial K'}{\partial v'}\Big\vert_{K'=\hat{K}'_0}$
$K'_{\dot{v}}$	DKDVTS	1	—	$\frac{\partial K'}{\partial \dot{v}'}\Big\vert_{K'=\hat{K}'_0}$
$\hat{K}'_{pq}$	MXPQS	1	Non-dimensional coefficient used in representing K' as a function of p' q'	—
$\hat{K}'_r$	MXRS	1	Non-dimensional coefficient used in representing K' as a function of F_{n0} r'	(for surface ships only)
$\hat{K}'_{ur}$	MXURS	1	Non-dimensional coefficient used in representing K' as a function of u' r'	(especially for submarines)
$\hat{K}'_{uu}$	MXUUS	1	Non-dimensional coefficient used in representing K' as a function of u'^2	(especially for submarines)
$\hat{K}_{uu\delta R}$	MXUUDRS	1	Non-dimensional coefficient used in representing K' as a function of u'^2 δ_R	(especially for submarines)
$\hat{K}_{uu\delta\delta\delta R}$	MXUUDR3S	1	Non-dimensional coefficient used in representing K' as a function of $u'^2 \delta_R^3$	(especially for submarines)
$\hat{K}'_{uv}$	MXUVS	1	Non-dimensional coefficient used in representing K' as a function of u' v'	(especially for submarines)
$\hat{K}_{uv\delta R}$	MXUVDRS	1	Non-dimensional coefficient used in representing K' as a function of u' v' δ_R	(especially for submarines)
$\hat{K}'_v$	MXVS	1	Non-dimensional coefficient used in representing K' as a function of F_{n0} v'	(for surface ships only)
$\hat{K}'_{vvv}$	MXV3S	1	Non-dimensional coefficient used in representing K' as a function of $v' \vert v' \vert \sqrt{v'^2 + w'^2}\, F_{n0}$	(for surface ships only)

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Table 1 *(continued)*

Symbol	CC-code	SI-unit	Concept	
			Term	Definition or explanation
$\hat{K}'_{v\|v\|}$	MXVVAS	1	Non-dimensional coefficient used in representing K' as a function of $v'\sqrt{v'^2 + w'^2}$	—
$\hat{K}'_{v\delta R}$	MXVDRS	1	Non-dimensional coefficient used in representing K' as a function of $F_{n0}\, v'\, \delta_R$	(for surface ships only)
$\hat{K}'_{wp}$	MXWPS	1	Non-dimensional coefficient used in representing K' as a function of $w'\, p'$	—
$\hat{K}'_{wr}$	MXWRS	1	Non-dimensional coefficient used in representing K' as a function of $w'\, r'$	—
$\hat{K}'_{\Delta u}$	MXDUS	1	Non-dimensional coefficient used in representing K' as a function of $\Delta u'$	(for surface ships only)
$\hat{K}'_{\Delta uv}$	MXDUVS	1	Non-dimensional coefficient used in representing K' as a function of $\Delta u'\, v'$	(for surface ships only)
$\hat{K}'_{\Delta\Delta u}$	MXDU2S	1	Non-dimensional coefficient used in representing K' as a function of $(\Delta u')^2$	(for surface ships only)
$\hat{K}'_{\delta R}$	MXDRS	1	Non-dimensional coefficient used in representing K' as a function of $F_{n0}{}^2\, \delta_R$	(for surface ships only)
$\hat{K}'_{\delta\delta\delta R}$	MXDR3S	1	Non-dimensional coefficient used in representing K' as a function of $F_{n0}{}^2\, \delta_R^3$	(for surface ships only)
$\hat{K}'_0$	MX0S	1	Non-dimensional coefficient used in representing K' when angle of attack α, drift angle β, manoeuvring device, and plane angles are zero	—
$\hat{K}'_\phi$	MXOPHS	1	Non-dimensional oscillatory roll coefficient	—
L	L	m	Model length	Reference length (see ISO 13643-1)
L_{OA}	LOA	m	Length overall	Length between the most aft and most forward points of the ship, permanent outfit included, measured parallel to DWL
M	MY	N m	Moment about y-axis	Relative to ship-fixed axis system
MA	MAX	—	Main axis	(see ISO 13643-1)
$M_{\theta stat}$	DMDTST	N m rad^{-1} [a]	—	$\frac{\partial M}{\partial \theta}\Big\|_{V=0}$ from static test or calculation

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Table 1 *(continued)*

Symbol	CC-code	SI-unit	Concept	
			Term	Definition or explanation
M'	MYS	1	Non-dimensional moment about y-axis	Especially for submarines $\frac{M}{\frac{\rho}{2} L^3 V^2}$ where $M\ (u, v, w, p, q, r, \dot{v}, \dot{w}, \dot{p}, \dot{q}, \dot{r}, \phi, \theta)$
				For surface ships only: $\frac{M}{\frac{\rho}{2} L^3 V_0^2}$ where $M\ (V_0, \Delta u, v, w, p, q, r, \dot{v}, \dot{w}, \dot{p}, \dot{q}, \dot{r}, \phi, \theta)$
M'_{in}	MYINS	1	In-phase part of non-dimensional moment about y-axis	$\frac{2}{nT} \int_t^{t+nT} M'(t) \sin\omega t \, dt$
M'_{out}	MYOUTS	1	Quadrature part of non-dimensional moment about y-axis	$\frac{2}{nT} \int_t^{t+nT} M'(t) \cos\omega t \, dt$
M'_q	DMDQS	1	Slope through zero of M' versus q'	$\frac{\partial M'}{\partial q'} \Big\vert_{M'=\hat{M}'_0}$
$M'_{\dot{q}}$	DMDQTS	1	—	$\frac{\partial M'}{\partial \dot{q}'} \Big\vert_{M'=\hat{M}'_0}$
$M'_{\dddot{q}}$	DMDQ3TS	1	—	$\frac{\partial M'}{\partial \dddot{q}'} \Big\vert_{M'=\hat{M}'_0}$
M'_w	DMDWS	1	Slope through zero of M' versus w'	$\frac{\partial M'}{\partial w'} \Big\vert_{M'=\hat{M}'_0}$
$M'_{\dot{w}}$	DMDWTS	1	—	$\frac{\partial M'}{\partial \dot{w}'} \Big\vert_{M'=\hat{M}'_0}$
M'_θ	DMDTHS	rad^{-1} [a]	—	$\frac{\partial M'}{\partial \theta} \Big\vert_{M'=\hat{M}'_0}$
$\hat{M}'_{pp}$	MYPPS	1	Non-dimensional coefficient used in representing M' as a function of p'^2	—
$\hat{M}'_{pr}$	MYPRS	1	Non-dimensional coefficient used in representing M' as a function of $p'\ r'$	—

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Table 1 *(continued)*

Symbol	CC-code	SI-unit	Concept	
			Term	Definition or explanation
$\hat{M}'_{q}$	MYQS	1	Non-dimensional coefficient used in representing M' as a function of $u'\,q'$	—
$\hat{M}'_{q\lvert q\rvert}$	MYQQAS	1	Non-dimensional coefficient used in representing M' as a function of $q'\lvert q'\rvert$	—
$\hat{M}'_{\lvert q\rvert\delta S}$	MYQADSS	1	Non-dimensional coefficient used in representing M' as a function of $u'\lvert q'\rvert\delta_S$	—
$\hat{M}'_{rr}$	MYRRS	1	Non-dimensional coefficient used in representing M' as a function of r'^2	—
$\hat{M}'_{uu}$	MYUUS	1	Non-dimensional coefficient used in representing M' as a function of u'^2	—
$\hat{M}'_{vp}$	MYVPS	1	Non-dimensional coefficient used in representing M' as a function of $v'\,p'$	—
$\hat{M}'_{vr}$	MYVRS	1	Non-dimensional coefficient used in representing M' as a function of $v'\,r'$	—
$\hat{M}'_{w}$	MYWS	1	Non-dimensional coefficient used in representing M' as a function of $u'\,w'$	—
$\hat{M}'_{ww}$	MYWWS	1	Non-dimensional coefficient used in representing M' as a function of $\lvert w'\rvert\sqrt{v'^2 + w'^2}$	—
$\hat{M}'_{w\lvert w\rvert}$	MYWWAS	1	Non-dimensional coefficient used in representing M' as a function of $w'\sqrt{v'^2 + w'^2}$	—
$\hat{M}'_{\lvert w\rvert}$	MYWAS	1	Non-dimensional coefficient used in representing M' as a function of $u'\lvert w'\rvert$	—
$\hat{M}'_{\lvert w\rvert q}$	MYWAQS	1	Non-dimensional coefficient used in representing M' as a function of $q'\sqrt{v'^2 + w'^2}$	—
$\hat{M}'_{\delta B}$	MYDBS	1	Non-dimensional coefficient used in representing M' as a function of $u'^2\,\delta_B$	—
$\hat{M}'_{\delta S}$	MYDSS	1	Non-dimensional coefficient used in representing M' as a function of $u'^2\,\delta_S$	—
$\hat{M}'_{0}$	MY0S	1	Non-dimensional coefficient used in representing M' when angle of attack α, drift angle β, manoeuvring device, and plane angles are zero	—
$\tilde{M}'_{\theta}$	MYOTHS	1	Non-dimensional oscillatory coefficient about y-axis	—
m	MA	kg	Model mass	—

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Table 1 *(continued)*

Symbol	CC-code	SI-unit	Concept	
			Term	Definition or explanation
N	MZ	N m	Moment about *z*-axis	Relative to ship-fixed axis system
$N'_{\phi\mathrm{dyn}}$	DNDPDYS	rad^{-1} [a]	—	$\left.\frac{\partial N'}{\partial \phi}\right\|_{N'=\hat{N}'_0} - \frac{N_{\phi\,\mathrm{stat}}}{\frac{\rho}{2} L^3 V^2}$
$N_{\phi\mathrm{stat}}$	DNDPST	N m rad^{-1} [a]	—	$\left.\frac{\partial N}{\partial \phi}\right\|_{V=0}$ from static test or calculation
N'	MZS	1	Non-dimensional moment about *z*-axis	Especially for submarines: $\frac{N}{\frac{\rho}{2} L^3 V^2}$ where $N\,(u, v, w, p, q, r, \dot{v}, \dot{w}, \dot{p}, \dot{q}, \dot{r}, \phi, \theta)$
				For surface ships only: $\frac{N}{\frac{\rho}{2} L^3 V_0^2}$ where $N\,(V_0, \Delta u, v, w, p, q, r, \dot{v}, \dot{w}, \dot{p}, \dot{q}, \dot{r}, \phi, \theta)$
N'_{in}	MZINS	1	In-phase part of non-dimensional moment about *z*-axis	$\frac{2}{nT}\int_t^{t+nT} N'(t)\sin\omega t\,dt$
N'_{out}	MZOUTS	1	Quadrature part of non-dimensional moment about *z*-axis	$\frac{2}{nT}\int_t^{t+nT} N'(t)\cos\omega t\,dt$
N'_p	DNDPS	1	—	$\left.\frac{\partial N'}{\partial p'}\right\|_{N'=\hat{N}'_0}$
$N'_{\dot{p}}$	DNDPTS	1	—	$\left.\frac{\partial N'}{\partial \dot{p}'}\right\|_{N'=\hat{N}'_0}$
$N'_{\dddot{p}}$	DNDP3TS	1	—	$\left.\frac{\partial N'}{\partial \dddot{p}}\right\|_{N'=\hat{N}'_0}$
N'_r	DNDRS	1	Slope through zero of N' versus r'	$\left.\frac{\partial N'}{\partial r'}\right\|_{N'=\hat{N}'_0}$

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Table 1 *(continued)*

Symbol	CC-code	SI-unit	Concept	
			Term	Definition or explanation
$N'_{\dot{r}}$	DNDRTS	1	—	$\frac{\partial N'}{\partial \dot{r}'}\Big\vert_{N'=\hat{N}'_0}$
N'_{v}	DNDVS	1	Slope through zero of N' versus v'	$\frac{\partial N'}{\partial v'}\Big\vert_{N'=\hat{N}'_0}$
$N'_{\dot{v}}$	DNDVTS	1	—	$\frac{\partial N'}{\partial \dot{v}'}\Big\vert_{N'=\hat{N}'_0}$
$\hat{N}'_{pq}$	MZPQS	1	Non-dimensional coefficient used in representing N' as a function of p' q'	—
$\hat{N}'_{qr}$	MZQRS	1	Non-dimensional coefficient used in representing N' as a function of q' r'	—
$\hat{N}'_{r}$	MZRS	1	Non-dimensional coefficient used in representing N' as a function of F_{n0} r'	(for surface ships only)
$\hat{N}'_{r\vert r\vert}$	MZRRAS	1	Non-dimensional coefficient used in representing N' as a function of $r'\vert r'\vert$	—
$\hat{N}'_{r\delta\delta R}$	MZRDDS	1	Non-dimensional coefficient used in representing N' as a function of $F_{n0} r' \delta_R^2$	(for surface ships only)
$\hat{N}'_{\vert r\vert\delta R}$	MZRADS	1	Non-dimensional coefficient used in representing N' as a function of $F_{n0} \vert r' \vert \delta_R$	(for surface ships only)
$\hat{N}'_{ur}$	MZURS	1	Non-dimensional coefficient used in representing N' as a function of u' r'	(especially for submarines)
$\hat{N}'_{ur\delta\delta R}$	MZURDDS	1	Non-dimensional coefficient used in representing N' as a function of $u' r' \delta_R^2$	(especially for submarines)
$\hat{N}'_{u\vert r\vert\delta R}$	MZURADS	1	Non-dimensional coefficient used in representing N' as a function of $u' \vert r' \vert \delta_R$	(especially for submarines)
$\hat{N}'_{uu}$	MZUUS	1	Non-dimensional coefficient used in representing N' as a function of u'^2	(especially for submarines)
$\hat{N}'_{uu\delta R}$	MZUUDS	1	Non-dimensional coefficient used in representing N' as a function of u'^2 δ_R	(especially for submarines)
$\hat{N}'_{uu\delta\delta\delta R}$	MZUUD3S	1	Non-dimensional coeffi cient used in representing N' as a function of $u'^2 \delta_R^3$	(especially for submarines)
$\hat{N}'_{uv}$	MZUVS	1	Non-dimensional coefficient used in representing N' as a function of u' v'	(especially for submarines)

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Table 1 *(continued)*

Symbol	CC-code	SI-unit	Concept	
			Term	Definition or explanation
$\hat{N}'_{v}$	MZVS	1	Non-dimensional coefficient used in representing N' as a function of v'	(for surface ships only)
$\hat{N}'_{vq}$	MZVQS	1	Non-dimensional coefficient used in representing N' as a function of $v'\ q'$	—
$\hat{N}'_{vrr}$	MZVRRS	1	Non-dimensional coefficient used in representing N' as a function of $F_{n0}\ v'\ r'^2$	(for surface ships only)
$\hat{N}'_{vvr}$	MZVVRS	1	Non-dimensional coefficient used in representing N' as a function of $F_{n0}\ v'^2\ r'$	(for surface ships only)
$\hat{N}'_{vvv}$	MZV3S	1	Non-dimensional coefficient used in representing N' as a function of $v'^2\sqrt{v'^2+w'^2}\,F_{n0}$	(for surface ships only)
$\hat{N}'_{v\lvert v\rvert}$	MZVVAS	1	Non-dimensional coefficient used in representing N' as a function of $v'\sqrt{v'^2+w'^2}$	—
$\hat{N}'_{v\lvert r\rvert}$	MZVARS	1	Non-dimensional coefficient used in representing N' as a function of $r'\sqrt{v'^2+w'^2}$	—
$\hat{N}'_{wp}$	MZWPS	1	Non-dimensional coefficient used in representing N' as a function of $w'\ p'$	—
$\hat{N}'_{wr}$	MZWRS	1	Non-dimensional coefficient used in representing N' as a function of $w'\ r'$	—
$\hat{N}'_{\Delta u}$	MZDUS	1	Non-dimensional coefficient used in representing N' as a function of $\Delta u'$	(for surface ships only)
$\hat{N}'_{\Delta uv}$	MZDUVS	1	Non-dimensional coefficient used in representing N' as a function of $\Delta u'\ v'$	(for surface ships only)
$\hat{N}'_{\Delta\Delta u}$	MZDU2S	1	Non-dimensional coefficient used in representing N' as a function of $(\Delta u')^2$	(for surface ships only)
$\hat{N}'_{\delta R}$	MZDRS	1	Non-dimensional coefficient used in representing N' as a function of $F_{n0}^2\ \delta_R$	(for surface ships only)
$\hat{N}'_{\delta\delta\delta R}$	MZDR3S	1	Non-dimensional coefficient used in representing N' as a function of $F_{n0}^{\ 2}\ \delta_R^{\ 3}$	(for surface ships only)
$\hat{N}'_{0}$	MZ0S	1	Non-dimensional coefficient used in representing N' when angle of attack α, drift angle β, manoeuvring device, and plane angles are zero	—

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Table 1 *(continued)*

Symbol	CC-code	SI-unit	Concept	
			Term	Definition or explanation
$\hat{N}'_{\phi}$	MZOPHS	1	Non-dimensional oscillatory coefficient about *z*-axis	—
n	N	1	—	Number of periods used in Fourier integral
	NWI	1	Exponent	—
p	OMX	rad s^{-1} [a]	Roll velocity	$-V/R \sin\theta_S$ Angular velocity about *x*-axis
p'	OXS	1	Non-dimensional roll velocity	$p\,L/V_0$
$\dot{p}$	OXRT	rad s^{-2} [a]	Roll acceleration	Angular acceleration about *x*-axis
$\dot{p}'$	OXRTS	1	Non-dimensional roll acceleration	$\dot{p}L^2 / V_0^2$
$\dddot{p}$	OXR3T	rad s^{-4} [a]	3rd derivative of roll velocity	—
$\dddot{p}'$	OXR3TS	1	Non-dimensional 3rd derivative of roll velocity	$\dddot{p}L^4 / V_0^4$
q	OMY	rad s^{-1} [a]	Angular velocity about *y*-axis	$V/R \sin\phi_S \cos\theta_S$ Relative to ship-fixed axis system
q'	OYS	1	Non-dimensional angular velocity about *y*-axis	$q\,L/V_0$
$\dot{q}$	OYRT	rad s^{-2} [a]	Angular acceleration about *y*-axis	Relative to ship-fixed axis system
$\dot{q}'$	OYRTS	1	Non-dimensional angular acceleration about *y*-axis	$\dot{q}L^2 / V_0^2$
$\dddot{q}$	OYR3T	rad s^{-4} [a]	3rd derivative of angular velocity about *y*-axis	—
$\dddot{q}'$	OYR3TS	1	Non-dimensional 3rd derivative of angular velocity about *y*-axis	$\dddot{q}L^4 / V_0^4$
R	RCM	m	Circular motion radius	—
R_{nA}	RNA	1	Reynolds number	$V_{WRA}\,L_{OA}/\nu_A$
R_{n0}	RN0	1	(Reference) Reynolds number	$V_0\,L/\nu$
r	OMZ	rad s^{-1} [a]	Angular velocity about *z*-axis	$V/R \cos\phi_S \cos\theta_S$ Relative to ship-fixed axis system
r'	OZS	1	Non-dimensional angular velocity about *z*-axis	$r\,L/V_0$
$\dot{r}$	OZRT	rad s^{-2} [a]	Angular acceleration about *z*-axis	Relative to ship-fixed axis system
$\dot{r}'$	OZRTS	1	Non-dimensional angular acceleration about *z*-axis	$\dot{r}L^2 / V_0^2$
T	TIP	s	Period of oscillation	—
u	VX	m s^{-1} [b]	Longitudinal velocity	$V \cos\theta_S \cos\beta$ Relative to ship-fixed axis system
u_0	VX0	m s^{-1}	Longitudinal reference velocity	—
u'	VXS	1	Non-dimensional velocity in direction of *x*-axis	u/V_0

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