INTERNATIONAL TOWING TANK CONFERENCE

ITTC Symbols and Terminology List

Version 2024

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Supersedes all previous versions

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Updated by the 30th ITTC Quality Systems Group

ITTC Symbols and Terminology List, Version 2024

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NOTE: bold letters are used to denote vectors
Red colour identifies the additions/modifications of this version of the List

Table of most frequently used acronyms not relating to ITTC Symbols

Acronym	**Definition**
AC	Advisory Council
EC	Executive Council
BIPM	Bureau International des Poids et Mesures
CFD	Computational fluid dynamics
COG	Course over ground
EFD	Experimental fluid dynamics
GNSS	Global navigation satellite system
GPS	Global positioning system
GUM	Guide to the expression of Uncertainty in Measurement
HSMV	High-speed marine vehicle
IMO	International Maritime Organization
ISO	International Organization for Standardization
JCGM	Joint Committee for Guides in Metrology
JCGM-WG1	JCGM Working Group 1
JCGM-WG2	JCGM Working Group 2
LDV	Laser Doppler velocimetry
MSC	Marine Safety Committee
NMI	National Metrology Institute
PIV	Particle imaging velocimetry
SOG	Speed over ground
SPIV	Stereo-PIV
UV	Underwater vehicle
V&V	Verification and validation
VIM	International vocabulary of metrology
VIM	Vortex induced motion
VIV	Vortex induced vibration
WPT	Wind Propulsion Technology

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

1. GENERAL

1.1 Fundamental Concepts

1.1.1 Uncertainty

(The following table follows JCGM 100:2008-Annex J)

a		Half-width of a rectangular distribution	Half-width of a rectangular distribution of possible values of input quantity X_i: $a = (a_+ - a_-) / 2$	
a_+		Upper bound	Upper bound, or upper limit, of input quantity X_i:	
a_-		Lower bound	Lower bound, or lower limit, of input quantity X_i:	
b_+		Upper bound of the deviation	Upper bound, or upper limit, of the deviation of input quantity X_i from its estimate x_i: $b_+ = a_+ - x_i$	
b_-		Lower bound of the deviation	Lower bound, or lower limit, of the deviation of input quantity X_i from its estimate x_i: $b_- = x_i - a_-$	
c_i		Sensitivity coefficient	$c_i = \partial f / \partial x_i$.	1
f		Function	Functional relationship between measurand Y and input quantities X_i on which Y depends, and between output estimate y and input estimates x_i on which y depends.	1
$\partial f / \partial x_i$		Partial derivative	Partial derivative with respect to input quantity X_i of functional relationship f between measurand Y and input quantities X_i on which Y depends, evaluated with estimates x_i for the X_i:	1
k		Coverage factor	Used to calculate expanded uncertainty $U = ku_c(y)$	1
k_p		Coverage factor for probability p	Used for calculation of expanded uncertainty $U_p = k_p u_c(y)$	1
n		Number of repeated observations		1

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
N		Number of input quantities	Number of input quantities X_i on which the measurand Y depends	1
p		Probability; Level of confidence	Level of confidence: $0 \le p \le 1.0$	1
q		Random quantity	Described by a probability distribution	1
$\bar{q}$		Arithmetic mean or average	Of n independent repeated observations q_k of randomly varying quantity q	1
		Estimate of the expectation	Or mean μ_q of the probability distribution of q	1
q_k		k^{th} observation of q	k^{th} independent repeated observation of randomly varying quantity q	1
$r(x_i,x_j)$		Estimated correlation coefficient associated with input estimates	Associated with input estimates x_i and x_j that estimate input quantities X_i and X_j: $r(x_i, x_j) = u(x_i, x_j)/[u(x_i)\ u(x_j)]$	1
$r(\bar{X}_i,\bar{X}_j)$		estimated correlation coefficient of input means $\bar{X}_i$ and $\bar{X}_j$	Determined from n independent pairs of repeated simultaneous observations $X_{i,k}$ $X_{j,k}$ of X_i X_j $r(\bar{X}_i,\bar{X}_j) = s(\bar{X}_i,\bar{X}_j)/[s(\bar{X}_i)s(\bar{X}_j)]$	1
$r(y_i,y_j)$		Estimated correlation coefficient associated with output estimates	With output estimates y_i and y_j when two or more measurands or output quantities are determined in the same measurement	1
$s^2(\bar{q})$		Experimental variance of the mean $\bar{q}$		1
		Estimate of the variance σ^2/n of $\bar{q}$	$s^2(\bar{q}) = s^2(q_k)/n$;	1
		Estimated variance obtained from a Type A evaluation		1
$s(\bar{q})$		Experimental standard deviation of the mean $\bar{q}$	Positive square root of $s^2(\bar{q})$	1

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
		Biased estimator of $\sigma(\bar{q})$	NOTE The sample standard deviation is a biased estimator of the population standard deviation.	
		Standard uncertainty	Obtained from a Type A evaluation	
$s^2(q_k)$		Experimental variance	Determined from *n* independent repeated observations q_k of *q*	1
		Estimate of the variance	Estimate of the variance σ^2 of the probability distribution of *q*	1
$s(q_k)$		Experimental standard deviation	Positive square root of $s^2(q_k)$	1
		Biased estimator of the standard deviation	Biased estimator of the standard deviation σ of the probability distribution of *q*	1
$s^2(\bar{X}_i)$		Experimental variance of input mean $\bar{X}_i$	From mean $\bar{X}_i$, determined from *n* independent repeated observations $X_{i,k}$, of X_i	1
		Estimated variance	Obtained from a Type A evaluation	1
$s(\bar{X}_i)$		Experimental standard deviation of input mean $\bar{X}_i$	Positive square root of $s^2(\bar{X}_1)$	1
		Standard uncertainty	Obtained from a Type A evaluation	1
$s(\bar{q},\bar{r})$		Estimate of covariance of means $\bar{q}$ and $\bar{r}$ that estimate the expectations μ_q and μ_r of two randomly varying quantities *q* and *r*	Determined from *n* independent pairs of repeated simultaneous observations q_k and r_k of *q* and *r*	1
		Estimated covariance	Obtained from a Type A evaluation	1
$s(\bar{X}_i,\bar{X}_j)$		Estimate of the covariance of input means $\bar{X}_i$ and $\bar{X}_j$	Determined from *n* independent pairs of repeated simultaneous observations $X_{i,k}$ and $X_{j,k}$ of X_i and X_j	1
		Estimated covariance	Obtained from a Type A evaluation	1
s_m^2		expected value E[ ] of the variance of mean		1

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
s_{m}		Standard deviation of the mean	Positive square root of s_{m}^2	1
s_p^2		Combined or pooled estimate of variance		1
s_{P}		Pooled experimental standard deviation	Positive square root of s_p^2	1
$t_p(v)$		Inverse Student *t*	Student *t*-distribution for *v* degrees of freedom corresponding to a given probability *p*	1
$t_p(v_{\mathrm{eff}})$		Inverse Student *t* for effective degrees of freedom	Student *t*-distribution for v_{eff} degrees of freedom corresponding to a given probability *p* in calculation of expanded uncertainty U_p	1
$u^2(x_i)$		Estimated variance associated with input estimate x_{i} that estimates input quantity X_{i}	NOTE When x_{i} is determined from the arithmetic mean or average of *n* independent repeated observations, $u^2(x_i) = s^2(\bar{X}_i)$ is an estimated variance obtained from a Type A evaluation.	1
$u(x_i)$		Standard uncertainty of input estimate x_{i} that estimates input quantity X_{i}	Positive square root of $u^2(x_i)$ NOTE When x_{i} is determined from the arithmetic mean or average of *n* independent repeated observations, $u(x_i) = s(\overline{X}_i)$ is a standard uncertainty obtained from a Type A evaluation.	1

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
$u(x_i,x_j)$		Estimated covariance	Associated with two input estimates x_i and x_j that estimate input quantities X_i and X_j NOTE When x_i and x_j are determined from n independent pairs of repeated simultaneous observations, $u(x_i, x_j) = s(\overline{X}_i, \overline{X}_j)$ is an estimated covariance obtained from a Type A evaluation	1
$u(x_i)/\lvert x_i \rvert$		Relative standard uncertainty of output estimate x_i		1
$u(y_i, y_j)$		Estimated covariance	Associated with output estimates y_i and y_j determined in the same measurement	
$u_c^2(y)$		Combined variance	Combined variance associated with output estimate y	1
$u_c(y)$		Combined standard uncertainty	Combined standard uncertainty of output estimate y, equal to the positive square root of $u_c^2(y)$	1
$u_{cA}(y)$		Combined standard uncertainty of output estimate y	Determined from standard uncertainties and estimated covariances obtained from Type A evaluations alone	1
$u_{cB}(y)$		Combined standard uncertainty of output estimate y	Combined standard uncertainty of output estimate y determined from standard uncertainties and estimated covariances obtained from Type B evaluations alone	1
$u_c(y_i)$		Combined standard uncertainty of output estimate y_i	When two or more measurands or output quantities are determined in the same measurement	1
$u_i^2(y)$		Component of combined variance $u_c^2(y)$	Associated with output estimate y generated by estimated variance $u^2(x_i)$ associated with input estimate x_i: $u_i^2(y) \equiv [c_i u(x_i)]^2$	1

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
$u_i(y)$		Component of combined standard uncertainty $u_c(y_i)$ of output estimate y	Generated by the standard uncertainty of input estimate x_i: $u_i(y) \equiv \|c_i\|u(x_i)$	1
$u_c(y)/\|y\|$		Relative combined standard uncertainty of output estimate y		
$[u(x_i)/\|x_i\|]^2$		Estimated relative variance	Estimated relative variance associated with input estimate x_i	
$[u_c(y)/\|y\|]^2$		Relative combined variance	Relative combined variance associated with output estimate y	
$u(x_i, x_j))/\|x_i x_j\|$		Estimated relative covariance	Estimated relative covariance associated with input estimates x_i and x_j	
U		Expanded uncertainty	Expanded uncertainty of output estimate y that defines an interval $Y = y \pm U$ having a high level of confidence, equal to coverage factor k times the combined standard uncertainty $u_c(y)$ of y: $U = k\, u_c(y)$	
U_p		Expanded uncertainty associated to confidence level p	Expanded uncertainty of output estimate y that defines an interval $Y = y \pm U_p$ having a high level of confidence p, equal to coverage factor k_p times the combined standard uncertainty $u_c(y)$ of y: $U_p = k_p\, u_c(y)$	
x_i		Estimate of input quantity X_i	NOTE when x_i is determined from the arithmetic mean or average of n independent repeated observation $x_i = \overline{X_i}$	
X_i		i^{th} input quantity on which measurand Y depends	NOTE X_i may be the physical quantity or the random variable	

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
$\overline{X}_i$		Estimate of the value of input quantity X_i	Equal to the arithmetic mean or average of n independent repeated observation $X_{i,k}$ of X_i	
$X_{i,k}$		k^{th} independent repeated observation of X_i		
y		Estimated of measurand Y		
		Result of a measurement		
		Output estimate		
y_i		Estimate of measurand Y_i	When two or more measurands are determined in the same measurement	
Y		A measurand.		
$\dfrac{\Delta u(x_i)}{u(x_i)}$		Estimated relative uncertainty	Estimated relative uncertainty of standard uncertainty $u(x_i)$ of input estimate x_i	
μ_q		Expectation or mean of the probability distribution	Expectation or mean of the probability distribution of random-varying quantity q	
ν		Degrees of freedom (general)		
ν_i		Degrees of freedom	Degrees of freedom, or effective degrees of freedom of standard uncertainty $u(x_i)$ of input estimate x_i	
ν_{eff}		Effective degrees of freedom	Effective degrees of freedom of $u_c(y)$ used to obtain $t_p(\nu_{eff})$ for calculating expanded uncertainty U_p	
ν_{effA}		Effective degrees of freedom	Effective degrees of freedom of a combined standard uncertainty determined from standard uncertainties obtained from Type A evaluations alone	
ν_{effB}		Effective degrees of freedom	Effective degrees of freedom of a combined standard uncertainty determined from standard uncertainties obtained from Type B evaluations alone	

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
σ^2		Variance of a probability	Variance of a probability distribution of (for example) a randomly-varying quantity q, estimated by $s^2(q_k)$	
σ		Standard deviation of a probability distribution	Equal to the positive square root of σ^2	
		$s(q_k)$ is a biased estimator of σ		
$\sigma^2(\overline{q})$		Variance of $\overline{q}$	Equal to σ^2 / n, estimated by $s^2(\overline{q}) = \frac{s^2(\overline{q_k})}{n}$	
$\sigma(\overline{q})$		Standard deviation of $\overline{q}$	Equal to the positive root of $\sigma^2(\overline{q})$	
		$s(\bar{q})$is a biased estimator of $\sigma(\overline{q})$		
$\sigma^2[s(\overline{q})]$		Variance of experimental standard deviation $s(\overline{q})$ of $\overline{q}$		
$\sigma[s(\overline{q})]$		Standard deviation of experimental standard deviation $s(\overline{q})$ of $\overline{q}$,	Equal to the positive square root of $\sigma^2[s(\bar{q})]$	

1.1.2 Coordinates and Space Related Quantities

Orientation of coordinates

A problem of general interest, the orientation of the axes of coordinate systems, has been treated extensively in the Report of the 17th ITTC Information Committee. The present QS Group recommends that the orientations of the coordinate systems chosen for convenience should be stated explicitly in any case. The coordinate system orientation should not be inferred from the symbols and/or names of the concepts or from national or professional traditions. All sign conventions of related Quantities should be consistent with the orientation chosen.

For ready reference the recommendation of the 17th ITTC Information Committee is quoted in the following.

"In order to adapt ITTC nomenclature to common practice a proposal for a standard coordinate system was published in the newsletter No 7, March 1983, to generate discussion. The response was quite diverse. On the one hand it was suggested that instead of the two orthogonal right handed systems with the positive x-axis forward and the positive z-axis either up- or downward as proposed only one system should be selected, in particular the one with the positive z-axis upwards. On the other hand the attention of the Information Committee was drawn to the fact that in ship flow calculations neither of the two systems proposed is customary. Normally the x-axis is directed in the main flow direction, i.e. backwards, the y-axis is taken positive to starboard and the z-axis is positive upwards. The origin of the co-ordinates in this case is usually in the undisturbed free surface half way between fore and aft perpendicular.

In view of this state of affairs the Information Committee (now Quality System Group - QSG) may offer the following recommendation, if any:

Axes, coordinates

Preferably, orthogonal right handed systems of Cartesian co-ordinates should be used, orientation and origin in any particular case should be chosen for convenience.

Body axes (x,y,z)

Coordinate systems fixed in bodies, ocean platforms, or ships.

For the definition of hull forms and ocean wave properties and the analysis of structural deflections it is customary to take the x-axis positive forward and parallel to the reference or base line used to describe the body's shape, the y-axis positive to port, and the z-axis positive upwards.

For seakeeping and manoeuvrability problems the coordinate system is defined as follows: usually the x-axis as before the y-axis positive to starboard, and the z-axis positive downwards, the origin customarily at the centre of mass of the vehicle or at a geometrically defined position.

For ship flow calculations usually the x-axis positive in the main flow direction, i.e. backwards, the y-axis positive to starboard, and the z-axis positive upwards, the origin customarily at the intersection of the plane of the undisturbed free-surface, the centre plane, and the midship section.

Fixed or space axes (x_0,y_0,z_0)

Coordinate systems fixed in relation to the earth or the water. For further references see ISO Standard 1151/1 ...6: Terms and symbols for flight dynamics.

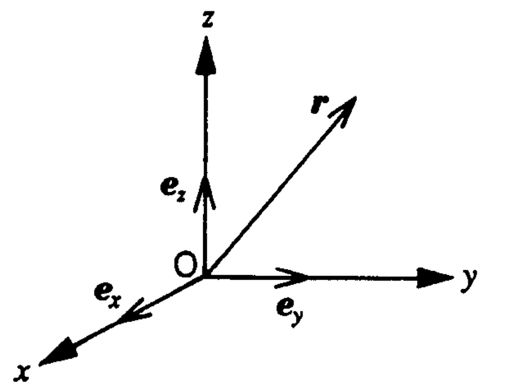
There may be other coordinate systems in use and there is no possibility for the adoption of a single system for all purposes. Any problem requires an adequate coordinate system and transformations between systems are simple, provided that orientations and origins are completely and correctly documented for any particular case."

Origins of coordinates

In seakeeping and manoeuvrability problems customarily the centre of mass of the vehicle is chosen as the origin of the coordinates. This is in most cases not necessarily advantageous, as all the hydrodynamic properties entering the problems are related rather to the geometries of the bodies under investigation. So any geometrically defined point may be more adequate for the purposes at hand.

ISO Standard 31-11 makes the following suggestions

Item No.	Coordinates	Position vector and its differential	Name of coordinate system	Remarks
11-12.1 (-)	x, y, z	$\boldsymbol{r} = x\boldsymbol{e}_x + y\boldsymbol{e}_y + z\boldsymbol{e}_z$ $\mathrm{d}\boldsymbol{r} = \mathrm{d}x\, \boldsymbol{e}_x + \mathrm{d}y\, \boldsymbol{e}_y + \mathrm{d}z\, \boldsymbol{e}_z$	cartesian coordinates	$\boldsymbol{e}_x$, $\boldsymbol{e}_y$ and $\boldsymbol{e}_z$ form an orthonormal right-handed system. See Figure 1.
11-12.2 (-)	ρ, φ, z	$\boldsymbol{r} = \rho\boldsymbol{e}_\rho + z\boldsymbol{e}_z$ $\mathrm{d}\boldsymbol{r} = \mathrm{d}\rho\, \boldsymbol{e}_\rho + \mathrm{d}\varphi\, \boldsymbol{e}_\varphi + \mathrm{d}z\, \boldsymbol{e}_z$	cylindrical coordinates	$\boldsymbol{e}_\rho(\varphi)$, $\boldsymbol{e}_\varphi(\varphi)$ and $\boldsymbol{e}_z$ form an orthonormal right-handed system. See Figures 2 and 3. If $z = 0$, then ρ and φ are the polar coordinates
11-12.3 (-)	r, ϑ, φ	$r = r\boldsymbol{e}_r$; $\mathrm{d}\boldsymbol{r} = \mathrm{d}r\, \boldsymbol{e}_r + r\, \mathrm{d}\vartheta\, \boldsymbol{e}_\theta +$ $r \sin\theta\, \mathrm{d}\varphi\, \boldsymbol{e}_\varphi$	spherical coordinates	$\boldsymbol{e}_r(9, gyp)$, $\boldsymbol{e}_\theta(\theta, \varphi)$ and $\boldsymbol{e}_\varphi(\varphi)$ form an orthonormal right-handed system. See Figures 2 and 4.
NOTE 1 If, exceptionally, a left-handed system is used for certain purposes, this shall be clearly stated to avoid the risk of sign errors.				



The *x*-axis is pointing towards the viewer.

Figure 1 – Right-handed Cartesian coordinate system

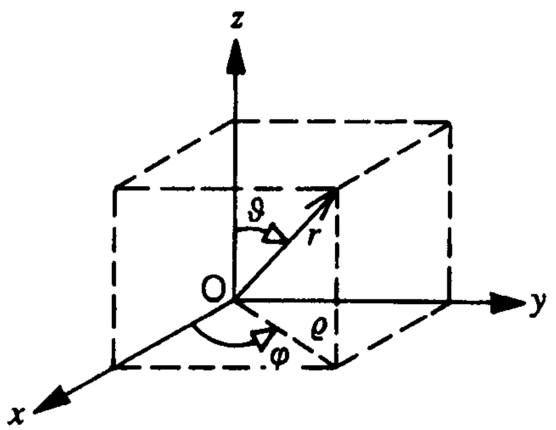


Figure 2 – Oxyz is a right-handed coordinate system

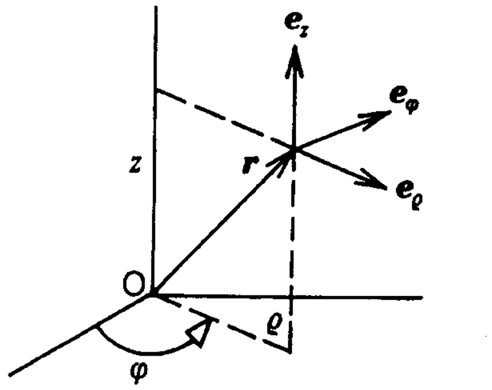


Figure 3 – Right-handed cylindrical coordinates

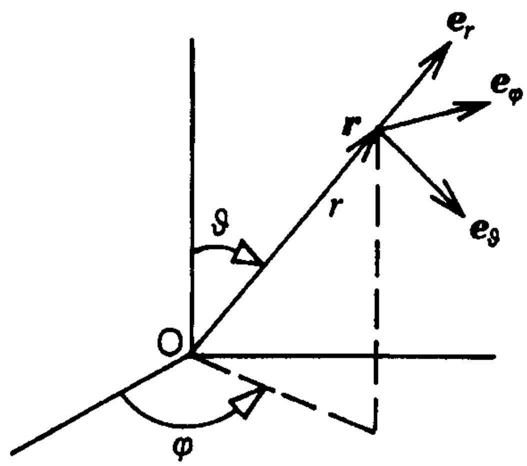


Figure 4 – Right-handed spherical coordinates

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

1.1.2.1 Basic Quantities

s		Any scalar quantity distributed, maybe singularly, in space	$\int ds$	
S^0_{ij}		Zeroth order moment of a scalar quantity	$\int \delta_{ij} ds = \delta_{ij} S$	
S^1_{ij}		First order moment of a scalar quantity, formerly static moments of a scalar distribution	$\int \varepsilon_{ikj} x_k ds$	
S^2_{ij}		Second moment of a scalar quantity, formerly moments of inertia of a scalar distribution	$\int \varepsilon_{kli} x_l \varepsilon_{jkm} x_m ds$	
S_{uv}		Generalized moment of a scalar quantity distributed in space	$S_{ij} = S^0_{ij}$ $S_{i,\,3+j} = S^1{}_{ij}{}^T$ $S_{3+i,\,j} = S^1_{ij}$ $S_{3+i,\,3+j} = S^2_{ij}$	
T_{ij}		Tensor in space referred to an orthogonal system of Cartesian coordinates fixed in the body	$T_{ij}^s + T_{ij}^a$	
T_{ij}^A		Anti-symmetric part of a tensor	$(T_{ij} - T_{ji}) / 2$	
T_{ij}^S		Symmetric part of a tensor	$(T_{ij} + T_{ji}) / 2$	
T_{ij}^T		Transposed tensor	T_{ji}	
$T_{ij}\, v_j$		Tensor product	$\Sigma T_{ij}\, v_j$	
u_i, v_i		Any vector quantities		
$u_i\, v_i$		Scalar product	$u_i v_i$	
$u_i\, v_j$		Diadic product	$u_i v_j$	
$u \times v$		Vector product	$\varepsilon_{ijk} u_j v_k$	
V^0_i , V_i		Zeroth order moments of a vector quantity distributed in space, referred to an orthogonal system of Cartesian coordinates fixed in the body	$\int dv_i$	
V^1_i		First order moments of a vector distribution	$\int \varepsilon_{ijk} x_j dv_k$	
V_u		Generalized vector	$V_i = V^0_i$ $V_{3+i} = V^1_i$	

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
x, x_1 y, x_2 z, x_3		Body axes and corresponding Cartesian coordinates	Right-hand orthogonal system of coordinates fixed in the body	m
x_0, x_{01} y_0, x_{02} z_0, x_{03}		Space axes and corresponding Cartesian coordinates	Right-hand orthogonal system of coordinates fixed in relation to the space	m
x_F, x_{F1} y_F, x_{F2} z_F, x_{F3}		Flow axes and corresponding Cartesian coordinates	Right-hand orthogonal system of coordinates fixed in relation to the flow	m
ε_{ijk}		Epsilon operator	+1 : ijk = 123, 231, 312 1 : ijk = 321, 213, 132 0 : if otherwise	
δ_{ij}		Delta operator	+1 : ij = 11, 22, 33 0 : if otherwise	

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

1.1.3 Time and Frequency Domain Quantities

1.1.3.1 Basic Quantities

a	ADMP	Damping	s^r, in Laplace variable	1/s
f	FR	Frequency		Hz
f_C	FC	Basic frequency in repeating functions	$1 / T_C$	Hz
f_S	FS	Frequency of sampling	$1 / T_S$ period in repeating spectra	Hz
i	I	Imaginary unit	sqrt(-1)	1
I	IM	Imaginary variable		1
j	J	Integer values	$-\infty \ldots +\infty$	1
R	R	Complex variable	$\exp(s\ T_S)$ Laurent transform	
s	S	Complex variable	$a + 2\pi i f$ Laplace transform	1/s
t	TI	Time	$-\infty \ldots +\infty$	s
t_j	TI(J)	Sample time instances	$j\ T_S$	
T_C	TC	Period of cycle	$1 / f_C$ duration of cycles in periodic, repeating processes	s
T_S	TS	Period of sampling	Duration between samples	s
x	x	Values of real quantities	$x(t)$	
X		Real "valued" function		
x_j	X(J)	Variables for samples values of real quantities	$x(t_j) = \int x(t)\delta(t - t_j)dt$	
z	Z	Complex variable		

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

1.1.3.2 Complex Transforms

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
x^{A}		Analytic function	$X^{A}(t) = X(t) + iX^{H}(t)$	
x^{DF}		Fourier transform of sampled function	$X^{DF}(f) = \Sigma x_j exp(-i2\pi fjT_S)$ i.e. periodically repeating $= X(0)/2 + f_S \Sigma X^F(f + jf_S)$ sample theorem: aliasing!	
x^{DL}		Laurent transform of sampled function	$X^{DL}(s) = \Sigma x_j \mathrm{exp}(-sjT_S)$	
x^{F}		Fourier transform	$X^{F}(f) = \int X(t)\mathrm{exp}(-i2\pi ft)dt$ inverse form: $= \int X^F(f)\mathrm{exp}(-i2\pi ft)dt$ if $X(t) = 0$ and a = 0 then $X^F(f)=X^L(f)$	
$x^{F}{}_{j}$		Fourier transform of periodic function	$1/T_C \int X(t)\mathrm{exp}(-i2\pi jt/T_C)dt$ $t = 0 \,..\, T_C$ $X^F = \Sigma x^F{}_j \delta(f - j/T_C)$ inverse form: $X(t) = \Sigma x^F{}_j \mathrm{exp}(-i2\pi fjT_C)$	
x^{H}		Hilbert transform	$X^H(t) = 1/\pi \int X(\tau)/(t - \tau)d\tau$	
x^{HF}		Fourier transform of Hilbert transform	$X^{HF}(f) = X^F(f)(-i \,\mathrm{sgn}\, f)$ $(1/t)^F = -i \,\mathrm{sgn}\, f$	
x^{L}		Laplace transform	$X^L(s) = \int X(t)\mathrm{exp}(-st)dt$ if $X(t<0) = 0$ then $= (X(t)\mathrm{exp}(-at))^F$	
x^{R}		Laurent transform	$X^R(r) = \Sigma x_j r^{-j} = X^{DL}$	
x^{S}		Single-sided complex spectra	$X^S(f) = X^F(f)(1 + \mathrm{sgn}\, f)$ $= X^{AF}$ i.e. = 0 for $f < 0$	
$x^{S}{}_{j}$		Single-sided complex Fourier series	$X^F{}_j(1 + \mathrm{sgn}\, j)$ line spectra	

1.1.3.3 Complex Quantities

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
z^{a}		Amplitude	$\mathrm{mod}(z) = \mathrm{sqrt}(z^{r2}+z^{i2})$	
z^{c}		Real or cosine component	$z^c = \mathrm{real}(z) = z^a\cos(z^p)$	
z^{i}		Imaginary or sine component	$\mathrm{imag}(z) = z^a\sin(z^p) = z^s$	
z^{j}		Conjugate	$z^r - iz^i$	
z^{l}		(Phase) Lag		
z^{p}		Phase	$\mathrm{arc}(z) = \mathrm{arctg}(z^i / z^r)$	
z^{r}		Real or cosine component	$\mathrm{real}(z) = z^a\cos(z^p) = z^c$	
z^{s}		Imaginary or sine component	$z^s = \mathrm{imag}(z) = z^a\sin(z^p)$	

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

1.1.4 Random Quantities and Stochastic Processes

1.1.4.1 Random Quantities

$g^{\mathrm{E}}, g^{\mathrm{M}}, g^{\mathrm{MR}}$		Expected value of a function of a random quantity	$E(g) = \int g(x) f_x(x) dx$ $x = -\infty \dots \infty$	
x, y		Random quantities	$x(\zeta), y(\zeta)$	
x_i, y_i		Samples of random quantities	i = 1... n n : sample size	
$(x^m)^E$		m-th moment of a random quantity	$(x^m)^{\mathrm{E}}$	
$x^{\mathrm{D}}, x^{\mathrm{DR}}, \sigma_x$		Standard deviation of a random quantity	$x^{\mathrm{VR}\ 1/2}$	
x^{DS}, s_x		Sample deviation of a random quantity	$x^{\mathrm{VS}\ 1/2}$, unbiased random estimate of the standard deviation	
$xx^{\mathrm{R}}, xx^{\mathrm{MR}}$, R_{xx}		Auto-correlation of a random quantity	$x\, x^{\mathrm{E}}$	
$xy^{\mathrm{R}}, xy^{\mathrm{MR}}$, R_{xy}		Cross-correlation of two random quantities	$x\, y^{\mathrm{E}}$	
$x^{\mathrm{E}}, x^{\mathrm{M}}, x^{\mathrm{MR}}$, μ_x		Expectation or population mean of a random quantity	$E(x)$	
$x^{\mathrm{A}}, x^{\mathrm{MS}}, m_x$		Average or sample mean of a random quantity	$1/n\ \Sigma\ x_i$, i = 1...n unbiased random estimate of the expectation with $x^{\mathrm{AE}} = x^{\mathrm{E}}$ $x^{\mathrm{VSE}} = x^{\mathrm{V}} / n$	
x^{PD}, f_x		Probability density of a random quantity	$d\, F_x / dx$	
xy^{PD}, f_{xy}		Joint probability density of two random quantities	$\partial^2 F_{xy} / (\partial x\, \partial y)$	
x^{PF}, F_x		Probability function (distribution) of a random quantity		1
xy^{PF}, F_{xy}		Joint probability function (distribution) function of two random quantities		1
$x^{\mathrm{V}}, x^{\mathrm{VR}}$, xx^{VR}		Variance of a random quantity	$x^{2\ \mathrm{E}} - x^{\mathrm{E}\ 2}$	
$x^{\mathrm{VS}}, xx^{\mathrm{VS}}$		Sample variance of a random quantity	$1/(n - 1)\ \Sigma\ (x_i - x^{\mathrm{A}})^2$ i = 1...n unbiased random estimate of the variance $x^{\mathrm{VSE}} = x^{\mathrm{V}}$	
$xy^{\mathrm{V}}, xy^{\mathrm{VR}}$		Variance of two random quantities	$x\, y^E - x^E\, y^E$	

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
ζ		Outcome of a random "ex-periment"		

1.1.4.2 Stochastic Processes

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
g^{MR}		Mean of a function of a random quantity	$M(g(t)) = \lim(1/T \int g(t)dt)$ $t = -T/2 \ldots +T/2$ $T = -\infty \ldots +\infty$	
g^{MS}		Average or sample mean of a function of a random quantity	$A(g(t)) = 1/T \int g(t)dt$ $t = 0 \ldots +T$	
x, y		Stationary stochastic process	$x(\zeta,t), y(\zeta,t)$	
$xx^{\mathrm{C}}, xx^{\mathrm{CR}}, C_{xx}$		Auto-covariance of a stationary stochastic process	$(x(t) - x^{\mathrm{E}})(x(t + \tau) - x^{\mathrm{E}})^{\mathrm{E}}$	
$xy^{\mathrm{C}}, xy^{\mathrm{CR}}, C_{xy}$		Cross-covariance of two stationary stochastic processes	$(x(t) - x^{\mathrm{E}})(y(t + \tau) - y^{\mathrm{E}})^{\mathrm{E}}$	
$xx^{\mathrm{R}}, xx^{\mathrm{RR}}, R_{xx}$		Auto-correlation of a stationary stochastic process	$x(t)x(t + \tau)^{\mathrm{E}} = R_{xx}(\tau)$ $R_{xx}(\tau) = R_{xx}(-\tau)$ if x is ergodic: $R_{xx}(\tau) = x(t)x(t + \tau)^{\mathrm{MR}}$ $R_{xx}(\tau) = \int S_{xx}(\omega)\cos(\omega\tau)d\tau$ $\tau = 0 \ldots \infty$	
xy^{R}, R_{xy}		Cross-correlation of two stationary stochastic processes	$x(t)y(t + \tau)^{\mathrm{E}} = R_{xy}(\tau)$ $R_{yx}(\tau) = R_{xy}(-\tau)$ if x, y are ergodic: $R_{xy}(\tau) = x(t)y(t + \tau)^{\mathrm{MR}}$	
xx^{S}, S_{xx}		Power spectrum or autospectral power density of a stochastic process	xx^{RRSR}	
xy^{S}, S_{xy}		Cross-power spectrum of two stationary stochastic processes	xy^{RRSR}	
τ		Covariance or correlation time		s
ζ		Outcome of a random "ex-periment"		

1.1.4.3 Probability Operators (Superscripts)

A, MS	Average, sample mean
C, CR	Population covariance
CS	Sample covariance
D, DR	Population deviation
DS	Sample deviation

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
E, M, MR		Expectation, population mean		
PD		Probability density		
PF		Probability function		
S		(Power) Spectrum		
SS		Sample spectrum		
R, RR		Population correlation		
RS		Sample correlation		
V, VR		Population variance		
VS		Sample variance		

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

1.1.5 Balances and System Related Concepts

q		Quantity of the quality under consideration stored in a control volume		Q^U
Q		Quality under consideration		Q^U/s
Q^C		Convective flux		Q^U/s
Q^D		Diffusive flux		Q^U/s
Q^F		Total flux across the surface of the control volume	Inward positive!	Q^U/s
Q^M		Molecular diffusion		Q^U/s
Q^P		Production of sources in the control volume		Q^U/s
Q^S		Storage in the control volume, rate of change of the quantity stored	dq / dt	Q^U/s
Q^T		Turbulent diffusion		Q^U/s

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

1.2 Solid Body Mechanics
1.2.1 Inertial and Hydrodynamic Properties
1.2.1.1 Basic Quantities

A_{ij}		Added mass coefficient in *i*th mode due to *j*th motion		
B_{ij}		Damping coefficient in *i*th mode due to *j*th motion		
C_{ij}		Restoring force coefficient in *i*th mode due to *j*th motion		
D^{h}_{uv}		Generalized hydrodynamic damping	$\partial F_u^h / \partial V_v$	
F^{h}_{u}		Generalized hydrodynamic force		
I^{h}_{uv}		Generalized hydrodynamic inertia	$\partial F_u^h / \partial \dot{V}_v$	
I_{L}		Longitudinal second moment of water-plane area	About transverse axis through centre of floatation	m^4
I_{T}		Transverse second moment of water-plane area	About longitudinal axis through centre of floatation	m^4
I_y , I_{yy} , $m^2{}_{22}$, m_{55}		Pitch moment of inertia around the principal axis *y*		kg m^2
I_z , I_{zz} , $m^2{}_{33}$, m_{66}		Yaw moment of inertia around the principal axis z		kg m^2
I_{xy} , I_{12} I_{yz} , I_{23} I_{zx} , I_{31}		Real products of inertia in case of non-principal axes		kg m^2
k_x, k_{xx} k		Roll radius of gyration around the principal axis *x*	$(I_{xx}/m)^{1/2}$	m
k_y, k_{yy}		Pitch radius of gyration around the principal axis *y*	$(I_{yy}/m)^{1/2}$	m
k_z, k_{zz}		Yaw radius of gyration around the principal axis *z*	$(I_{zz}/m)^{1/2}$	m
m		mass		kg
$m^0{}_{ij}$, m_{ij}		Zero-th moments of mass, i.e. inertia distribution, mass tensor	$m_{ij} = m\ \delta_{ij}$	kg
$m^1{}_{ij}$		First moments of mass, i.e. inertia distribution	Alias static moments of mass	kg m
$m^2{}_{ij}$, I_{ij}		Second moments of mass, i.e. inertia distribution	Alias mass moments of inertia	kg m^2

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
M_{uv}		Generalized mass, i. e. generalized inertia tensor of a (rigid) body referred to a body fixed coordinate system	$M_{ij} = M^0_{ij}$ $M_{i,\,3+j} = M^{1\mathrm{T}}_{ij}$ $M_{3+i,\,j} = M^1_{ij}$ $M_{3+i\,,\,3+j} = M^2_{ij}$	

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

1.2.2 Loads

1.2.2.1 External Loads

F_u		Force, generalized, load, in body coordinates	$M^F{}_u = M^M{}_u$ $F_i = F^0{}_i$ $F_{3+i} = F^1{}_i$	N
g_u		Gravity field strength, generalized, in body coordinates	$g_i = g^1{}_i$ $g_{3+i} = 0$	m/s^2
g_i		Gravity field strength, in body coordinates!		m/s^2
K, M_x , $F^1{}_1$, F_4		Moment around body axis x		Nm
M, M_y , $F^1{}_2$, F_5		Moment around body axis y		Nm
N, M_z , $FN^1{}_3$, F_6		Moment around body axis z		Nm
X, F_x , $F^0{}_1$, F_1		Force in direction of body axis x		Nm
Y, F_y , $F^0{}_2$, F_2		Force in direction of body axis y		Nm
Z, F_z , $F^0{}_3$, F_3		Force in direction of body axis z		Nm
G_u		Gravity or weight force, generalized, in body co-ordinates!	$G_u = m_{uv}\, g_v$	N
$G^0 i$, G_i		Gravity or weight force in body coordinates!	$G_i = G^0{}_i = m^0{}_{ij}\, g_j$ $= mg_i$	N
$G^1{}_i$		Gravity or weight moment in body coordinates!	$G_{3+i} = G^1{}_i = \varepsilon_{ikj}\, x_k\, G^0{}_j$ $= m^1{}_{ij}\, g_j$	Nm
q		Load per unit length		N/m
w		Weight per unit length	dW / dx_1	N/m

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

1.2.2.2 Sectional Loads

F^{S}_{u}		Force or load acting at a given planar cross-section of the body, generalized, in section coordinates!	$F^{S}_{i} = F^{S0}_{i}$ $F^{S}_{3+i} = F^{S1}_{i} = M^{B}_{i}$	N Nm
F^{S}_{i}		Shearing force	F^{S0}_{2} , F^{S0}_{3}	N
F^{T}		Tensioning or normal force	F^{S0}_{1}	N
M^{B}_{i}		Bending moment	F^{S1}_{2} , F^{S1}_{3}	Nm
M^{T}		Twisting or torsional moment	F^{S1}_{1}	Nm

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

1.2.3 Rigid Body Motions

1.2.3.1 Motions

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
L		Angular momentum	$L = I\omega\ (= r^2 mv)$	Kg m s^{-1}
P		Linear momentum	$P = m\, v$	Kg m s^{-1}
p , ω_x , $v^0{}_1$, v_4		Rotational velocity around body axis x		rad/s
q , ω_y , $v^0{}_2$, v_5		Rotational velocity around body axis y		rad/s
r , ω_z , $v^0{}_3$, v_6		Rotational velocity around body axis z		rad/s
u , v_x , $v^1{}_1$, v_1		Translatory velocity in the direction of body axis x		m/s
v , v_y , $v^1{}_2$, v_2		Translatory velocity in the direction of body axis y		m/s
w , v_z , $v^1{}_3$, v_3		Translatory velocity in the direction of body axis z		m/s
v_u		Components of generalized velocity or motion relative to body axes	$v_i = v^1{}_i$ $v_{3+i} = v^0{}_i$	m/s rad/s
$\dot{p}$ $\dot{q}$ $\dot{r}$		Rates of change of components of rotational velocity relative to body axes		rad/s^2
$\dot{u}$ $\dot{v}$ $\dot{w}$		Rates of change of components of linear velocity relative to body axes		m/s^2
α		Angular acceleration	$d\omega/dt$	rad/s^2

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

1.2.3.2 Attitudes

α		Angle of attack	The angle of the longitudinal body axis from the projection into the principal plane of symmetry of the velocity of the origin of the body axes relative to the fluid, positive in the positive sense of rotation about the *y*-axis	rad
β		Angle of drift or side-slip	The angle to the principal plane of symmetry from the velocity vector of the origin of the body axes relative to the fluid, positive in the positive sense of rotation about the *z*-axis	rad
γ		Projected angle of roll or heel	The angular displacement about the x_o axis of the principal plane of symmetry from the vertical, positive in the positive sense of rotation about the x_o axis	rad
φ		Angle of roll, heel or list	Positive in the positive sense of rotation about the *x*-axis	rad
θ		Angle of pitch or trim	Positive in the positive sense of rotation about the *y*-axis	rad
ψ		Angle of yaw, heading or course	Positive in the positive sense of rotation about the *z*-axis	rad

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

1.3 Fluid Mechanics
1.3.1 Flow Parameters
1.3.1.1 Fluid Properties

c		Velocity of sound	$(E / \rho)^{1/2}$	m/s
E		Modulus of elasticity		Pa
w		Weight density	ρg (See 1.1.1)	
κ		Kinematic capillarity	σ / ρ	m^3/s^2
μ		Viscosity		kg/ms
ν		Kinematic viscosity	μ / ρ	m^2/s
ρ		Mass density		kg/m^3
σ		Capillarity	Surface tension per unit length	kg/s^2

1.3.1.2 Flow parameters

Bo		Boussinesq number	$V / (g R_H)^{1/2}$	1
Ca		Cauchy number	$V / (E / \rho)^{1/2}$	1
Fr		Froude number	$V / (g L)^{1/2}$	1
Fr_h		Froude depth number	$V / (g h)^{1/2}$	1
Fr_∇		Froude displacement number	$V / (g \nabla^{1/3})^{1/2}$	1
Ma		Mach number	V / c	1
Re		Reynolds number	$V L / \nu$	1
$Re_{0.7}$		Propeller Reynolds number at 0.7 R	$Re_{0.7} = \frac{c_{0.7}\sqrt{V_A^2 + (0.7\pi nD)^2}}{\nu}$	1
St		Strouhal number	$f L / V$	1
Th		Thoma number, Cavitation number	$(p_A - p_V)/q$	1
We		Weber number	$V^2 L / \kappa$	1

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

1.3.1.3 Boundary conditions

k		Roughness height or magnitude	Roughness height, usually in terms of some average	m
k_S		Sand roughness	Mean diameter of the equivalent sand grains covering a surface	m
R_H		Hydraulic radius	Area of section divided by wetted perimeter	m

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

1.3.2 Flow Fields

1.3.2.1 Velocities etc.

e		Density of total flow energy	$\rho V^2 / 2 + p + \rho g h$	Pa
f_i		Mass specific force	Strength of force fields, usually only gravity field g_i	m/s^2
h		Static pressure head	Δz_0 , z_0-axis positive vertical up!	m
H		Total head	$e / w = h + p/w + q/w$	m
p		Pressure, density of static flow energy		Pa
p_0		Ambient pressure in undisturbed flow		Pa
q		Dynamic pressure, density of kinetic flow energy,	$\rho V^2 / 2$	Pa
Q		Rate of flow	Volume passing across a control surface in time unit	m^3/s
S_{H}		Total head loss		m
s^{R}_{ij}		Turbulent or Reynolds stress	$\rho\, v_i v_j^{\mathrm{CR}}$	Pa
s_{ij}		Total stress tensor	Density of total diffusive momentum flux due to molecular and turbulent exchange	Pa
s^{V}_{ij}		Viscous stress		Pa
u, v_x, v_1 v, v_y, v_2 w, v_z, v_3		Velocity component in direction of x, y, z axes		m/s
v_i		Velocity		m/s
V		Velocity	$V = v_i v_i^{1/2}$	m/s
V_0		Velocity of undisturbed flow		m/s
τ_w		Wall shear stress	$\mu\, (\partial U / \partial y)_{y=0}$	Pa

1.3.2.2 Circulation etc.

Γ^{n}		Normalized circulation	$\Gamma / (\pi D V)$ π is frequently omitted	1
I		Induction factor	Ratio between velocities induced by helicoidal and by straight line vortices	1
Γ		Vortex density	Strength per length or per area of vortex distribution	m/s
Γ		Circulation	$\int V\, ds$ along a closed line	m^2/s
Φ		Potential function		m^2/s

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
Ψ		Stream function	ψ = const is the equation of a stream surface	m^3/s

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

1.3.3 Lifting Surfaces

1.3.3.1 Geometry

A		Projected area	$b\ c_M$	m^2
b		Wing or foil span		m
b_F		Flap span		m
c_M		Mean chord length	A / b	m
c_T		Tip chord length		m
c_r		Root chord length		m
f_L		Camber of lower side (general)		m
f_U		Camber of upper side		m
γ		Sweep angle		rad
δ_s		Slat deflection angle		rad
δ		Thickness ratio of foil section (general)	t / c	1
δ_B		Thickness ratio of trailing edge of struts	t_B / c_S	1
δ_F		Camber ratio of mean line (general)	f / c	1
δ_{FL}		Angle of flap deflection		rad
δ_L		Camber ratio of lower side of foil	f_L / c	1
δ_S		Thickness ratio of strut	t_S / c_S	1
δ_{STH}		Theoretical thickness ratio of section	t_S / c_{STH}	1
δ_U		Camber ratio of upper side	f_U / c	1
λ		Taper ratio	c_t / c_r	1
Λ		Aspect ratio	b^2 / A	1

1.3.3.2 Flow angles etc

V_I		Induced velocity		m/s
V_T		Resultant velocity of flow approaching a hydrofoil	Taking vortex induced velocities into account	m/s
α		Angle of attack or incidence	Angle between the direction of undisturbed relative flow and the chord line	rad
α_{EFF}		Effective angle of attack or incidence	The angle of attack relative to the chord line including the effect of induced velocities	rad
α_G		Geometric angle of attack or incidence	The angle of attack relative to the chord line neglecting the effect of induced velocities	rad

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
α_{H}		Hydrodynamic angle of attack	In relation to the position at zero lift	rad
α_{I}		Ideal angle of attack	For thin airfoil or hydrofoil, angle of attack for which the streamlines are tangent to the mean line at the leading edge. This condition is usually referred to as "shock-free" entry or "smooth"	rad
α_0		Angle of zero lift	Angle of attack or incidence at zero lift	rad

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

1.3.3.3 Forces

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
D_{F}		Foil drag	Force in the direction of motion of an immersed foil	N
D_{I}		Induced drag	For finite span foil, the component of lift in the direction of motion	N
D_{INT}		Interference drag	Due to mutual interaction of the boundary layers of intersecting foil	N
D_{P}		Section or profile drag at zero lift	Streamline drag	N
L_{F}		Lift force on foil	$C_L A_{\mathrm{FT}} q$	N
L_0		Lift force for angle of attack of zero	$C_{L0} A_{\mathrm{FT}} q$	N

1.3.3.4 Sectional coefficients

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
C_D		Section drag coefficient		1
$C_{D\mathrm{I}}$		Section induced drag coefficient		1
C_L		Section lift coefficient		1
C_{L0}		Section lift coefficient for angle of attack of zero		1
C_M		Section moment coefficient		1
ε		Lift-Drag ratio	L/D	1

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

1.3.4 Boundary Layers

1.3.4.1 Two-dimensional Boundary Layers

C_f		Skin friction coefficient	$\tau / (\rho\ U_e^2 / 2)$	1
F		Entrainment factor	$1 / (U_e\ dQ / dx)$	1
H		Boundary layer shape parameter	δ^* / Θ	1
H_E		Entrainment shape parameter	$(\delta - \delta^*) / \Theta$	1
p		Static pressure		Pa
P		Total pressure		Pa
Q		Entrainment	$\int_a^b U dy$	m^2/s
Re_{δ^*}		Reynolds number based on displacement thickness	$U_\infty \delta^* / \nu$ or $U_e \delta^* / \nu$	1
Re_θ		Reynolds number based on momentum thickness	$U_\infty \Theta / \nu$ or $U_e \Theta / \nu$	1
u		Velocity fluctuations in boundary layer		m/s
u^s		Root mean square value of velocity fluctuations		m/s
u^+		Non-dimensional distance from surface	U / u_τ	1
u_τ		Shear (friction) velocity	$(\tau / \rho)^{1/2}$	m/s
U_m		Time mean of velocity in boundary layer		m/s
U_i		Instantaneous velocity		m/s
U_∞		Free-stream velocity far from the surface		m/s
U_e		Velocity at the edge of the boundary layer at $y=\delta_{995}$		m/s
ΔU		Velocity defect in boundary layer	$(U_\mathrm{e} - U) / u_\tau$	1
y^+		Non-dimensional distance from the wall	$y\ u_\tau / \nu$	1
β		Equilibrium parameter	$\delta^* / (\tau_w\ dp / dx)$	1
δ_{995}		Thickness of a boundary layer at U=0.995U_e		m
δ^*, δ_1		Displacement thickness of boundary layer	$\int (U_\mathrm{e} - U) / U_\mathrm{e}\ dy$	m
K		von Karman constant	0.41	1
Λ		Pressure gradient parameter	$\delta_{995} / (\nu\ dU_\mathrm{e} / dx)$	1
θ^*, δ^{**}		Energy thickness	$\int (U / U_\mathrm{e}) (1 - U^2 / U_\mathrm{e}^2) dy$	m

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
Θ		Momentum thickness	$\int (U / U_e)(1 - U / U_e) dy$	m
τ_w		Local skin friction	$\mu (\partial U / \partial y)_{y=0}$	Pa

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

1.3.5 Cavitation

1.3.5.1 Flow parameters

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
a_s		Gas content ratio	α / α_S	1
α		Gas content	Actual amount of solved and undissolved gas in a liquid	ppm
α_S		Gas content of saturated liquid	Maximum amount of gas solved in a liquid at a given temperature	ppm
σ		Cavitation number	$(p_A - p_C) / q$	1
σ_I		Inception cavitation number		1
σ_V		Vapour cavitation number	$(p_A - p_V) / q$	1

1.3.5.2 Flow fields

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
D_C		Cavity drag		N
l_C		Cavity length	Stream wise dimension of a fully-developed cavitating region	m
p_A		Ambient pressure		Pa
p_{AC}		Collapse pressure	Absolute ambient pressure at which cavities collapse	Pa
p_{AI}		Critical pressure	Absolute ambient pressure at which cavitation inception takes place	Pa
p_C		Cavity pressure	Pressure within a steady or quasi-steady cavity	Pa
p_{CI}		Initial cavity pressure	Pressure, may be negative, i.e. tensile strength, necessary to create a cavity	Pa
p_V		Vapour pressure of water	At a given temperature!	Pa
U_I		Critical velocity	Free stream velocity at which cavitation inception takes place	m/s
V_L		Volume loss	W_L / w	m^3
W_L		Weight loss	Weight of material eroded from a specimen during a specified time	N/s
δ_C		Cavity height or thickness	Maximum height of a fully-developed cavity, normal to the surface and the stream-wise direction of the cavity	m

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

1.3.5.3 Pumps

H_N		Net useful head of turbo-engines		m
H_U		Total head upstream of turbo-engines		m
Th, σ		Thoma number	$(H_U - p_V / w) / H_N$	1

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

1.4 Environmental Mechanics

1.4.1 Waves

This section is related to Sections 3.1.2 Time and Frequency Domain Quantities and 3.1.3 Random Quantities and Stochastic Processes.

1.4.1.1 Periodic waves

c_W		Wave phase velocity or celerity	$L_W / T_W = \sqrt{g L_W / 2\pi}$ in deep water	m/s
c_{Wi}		Wave phase velocity of harmonic components of a periodic wave	const = c_W for periodic waves in deep water	m/s
c_G		Wave group velocity or celerity	The average rate of advance of the energy in a finite train of gravity waves	m/s
f_W		Basic wave frequency	$1 / T_W$	Hz
f_{Wi}		Frequencies of harmonic components of a periodic wave	$i\, f_W$	Hz
H_W		Wave height	The vertical distance from wave crest to wave trough, or twice the wave amplitude of a harmonic wave. $\eta_C - \eta_T$	m
k, κ		Wave number	$2\,\pi / L_W = \omega^2/g$	1/m
L_W , λ_W		Wave length	The horizontal distance between adjacent wave crests in the direction of advance	m
T_W		Basic wave period	Time between the passage of two successive wave crests past a fixed point. $1 / f_W$	s
μ		Wave direction	The angle between the direction of a component wave and the x_0 axis	rad
η		Instantaneous wave elevation at a given location	z-axis positive vertical up, zero at mean water level;	m
$\eta^{\alpha}{}_i$		Amplitudes of harmonic components of a periodic wave	$\eta^{FS\alpha}$	m
$\eta^{p}{}_i$, ε_i		Phases of harmonic components of a periodic wave	η^{FSp}	rad
η_C		Wave crest elevation		m

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
η_{T}		Wave trough depression	Negative values!	m
ζ		Instantaneous wave depression	z-axis positive vertical down, zero at mean water level	m
ζ_{A}		Wave amplitude	Radius of orbital motion of a surface wave particle	m
ω_{W}, σ		Circular wave frequency	$2\,\pi\,f_{\mathrm{W}} = 2\,\pi\,/\,T_{\mathrm{W}}$	rad/s

1.4.1.2 Irregular waves

H_{d}		Wave height by zero down-crossing	The vertical distance between a successive crest and trough.	m
H_{u}		Wave height by zero up-crossing	The vertical distance between a successive trough and crest	m
$H_{1/3}$		Significant wave height	Average of the highest one third wave heights	m
$T_{1/3d}$		Significant wave period	By downcrossing analysis	s
$T_{1/3u}$		Significant wave period	By upcrossing analysis	s
T_{d}		Wave periods by zero down-crossing	Time elapsing between two successive downward crossings of zero in a record	s
T_{u}		Wave periods by zero up-crossing	Time elapsing between two successive upward crossings of zero in a record	s
η_{C}		Maximum of elevations of wave crests in a record		m
η_{T}		Elevations of wave troughs in a record	Negative values!	m
λ_{d}		Wave length by zero down-crossing	The horizontal distance between adjacent down crossing in the direction of advance	m
λ_{u}		Wave length by zero up-crossing	The horizontal distance between adjacent up crossing in the direction of advance	m

1.4.1.3 Time Domain Analysis

H_{WV}		Wave height estimated from visual observation		m

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
$H_{W1/3}$		Significant wave height. Sum of significant wave height of swell and wind waves	Average of the highest one third wave heights	m
$H_{1/3S}$		Significant wave height of swell	Average of the highest one third wave heights of the swell.	m
$H_{1/3W}$		*(environmental mechanics, waves)* Significant wave height of wind waves.	Average of the highest one third wave heights of the wind waves.	m
$H_{1/3u}$		Zero up-crossing significant wave height	Average of the highest one third zero up-crossing wave heights	m
H_{σ}		Estimate of significant wave height from sample deviation of wave elevation record		m
L_{WV}		Wave length estimated by visual observation	Measured in the direction of wave propagation	m
T_{rt}		Return period	The average interval in years between times that a given design wave is exceeded	
T_R		Duration of record	$1 / f_R$	s
T_S		Sample interval	$1 / f_S$, time between two successive samples	s
T_{WV}		Wave period estimated from visual observation		s

1.4.1.4 Frequency Domain Analysis

b		Bandwidth of spectral resolution	Sampling frequency divided by the number of transform points	Hz
C_r		Average reflection coefficient		1
$C_r(f)$		Reflection coefficient amplitude function		1
f_P		Spectral peak in frequency	Frequency at which the spectrum has its maximum	Hz
f_R		Frequency resolution	$1 / T_R$	Hz
f_S		Sample frequency	$1 / T_S$	Hz

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
H_{m0}		Significant wave height based on zeroth moment for narrow banded spectrum	$4\,(m_0)^{1/2}$	m
H_σ		Estimate of significant wave height from sample deviation of wave elevation record		m
m_n		n-th moment of wave power spectral density	$\int f^n\, S(f) df$	$m^2/\, s^n$
$S_i(f)$, $S_i(\omega)$		Incident wave power spectral density		m^2/Hz
$S_r(f)$, $S_r(\omega)$		Reflected wave power spectral density		m^2/Hz
$S_\eta(f)$, $S_\eta(\omega)$		Wave power spectral density		m^2/Hz
T_P		Period with maximum energy	$2\pi f_P$	s
T_{01}		Average period from zeroth and first moment	m_0/m_1	s
T_{02}		Average period from zeroth and second moment	$(m_0/m_2)^{1/2}$	s

1.4.1.5 Directional Waves

$D_X(f,\theta)$, $D_X(\omega,\mu)$, σ_θ		Directional spreading function	$S(f,\theta)=S(f)D_X(f,\theta)$ where $\int_0^{2\pi} D_X(f,\theta)\, d\theta = 1$	rad
f		Frequency	$2\pi\omega=1/T$	Hz
$S_\zeta\,(\omega,\mu)$ $S_\theta\,(\omega,\mu)$ *etc.*		Two dimensional spectral density		1
$S_\rho(f,\theta)$ $S_\zeta(\omega,\mu)$		Directional spectral density		$m^2/Hz/rad$
θ, μ		Component wave direction		rad
θ_m		Mean or dominant wave direction		rad

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

1.4.2 Wind

1.4.2.1 Basic Quantities

C_{10}		Surface drag coefficient	$(0.08 + 0.065U_{10})10^{-3}$	
F		Fetch length	Distance over water the wind blows	m
t_{d}		Wind duration		s
T_{rt}		Return period	The average interval in years between times that a given wind speed is exceeded	
u_z , u_{zi}		Turbulent wind fluctuations		m/s
U_A, u_*		Wind shear velocity	$C_{10}^{1/2}\, U_{10}$ or $0.71U_{10}^{1.23}$	m/s
U_{10}		Reference mean wind speed at elevation 10 meters above sea surface	$U_{10} = (10/z)^{1/7}\, U_z^A$	m/s
U_z^{A}		Average wind speed at elevation z above the sea surface	$(U_z + u_{zi})^A$ $U_z^A = (z/10)^{1/7}\, U_{10}$ or $U_z^A = U_{10} + U_A \ln(z/10)$	m/s
V_{WR}	AWS	Apparent wind velocity	see section 1.4.1	m/s
V_{WT}	TWS	True wind velocity	see section 1.4.1	m/s
X_{F}		Dimensionless Fetch	gF/U_{10}^2	
z		Height above the sea surface in meters		m
β_{WA}	AWA	Apparent wind angle (relative to vessel course)	see section 2.6	rad
β_{WT}	TWA	True wind angle (relative to vessel course)	see section 2.6	rad
θ_{W}		Wind direction		rad

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

1.4.3 Ice Mechanics

1.4.3.1 Basic Quantities

E_{I}		Modulus of elasticity of ice		Pa
S_{I}		Salinity of ice	Weight of salt per unit weight of ice	1
S_{W}		Salinity of water	Weight of dissolved salt per unit weight of saline water	1
t_{A}		Temperature of air		°C
t_{I}		Local temperature of ice		°C
t_{W}		Temperature of water		°C
δ_{I}		Deflection of ice sheet	Vertical elevation of ice surface	m
ε_{I}		Ice strain	Elongation per unit length	1
$\dot{\varepsilon}_{\mathrm{I}}$		Ice strain rate	$\partial\varepsilon / \partial\tau$	1/s
μ_{I}		Poisson's ratio of ice		1
v_{A}		Relative volume of air	Volume of gas pores per unit volume of ice	1
v_{B}		Relative volume of brine	Volume of liquid phase per unit volume of ice	1
v_0		Total porosity of ice	$v_0 = v_A + v_B$	1
ρ_{I}		Mass density of ice	Mass of ice per unit volume	kg/m^3
ρ_{SN}		Mass density of snow	Mass of snow per unit volume	kg/m^3
ρ_{W}		Mass density of water		kg/m^3
ρ_{Δ}		Density difference	$\rho_{\Delta} = \rho_W - \rho_I$	kg/m^3
σ_{CI}		Compressive strength of ice		Pa
σ_{FI}		Flexural strength of ice		Pa
σ_{TI}		Tensile strength of ice		Pa
τ_{SI}		Shear strength of ice		Pa

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

1.5 Noise

1.5.1 Underwater Noise

d		Distance hydrophone to acoustic centre		m
L_p		Sound pressure level	$L_p = 10\log_{10}\left(\frac{\bar{p}_{rms}^2}{p_{ref}^2}\right)$ dB, $p_{ref} = 1\ \mu\text{Pa}$	
L_s		Underwater sound radiated noise level at a reference distance of 1m	$L_s = L_\mathrm{p} + 20\ \log_{10}\left[\frac{d}{d_{ref}}\right]$ dB, $d_{ref} = 1$ m	
p		Sound pressure		Pa

2. SHIPS IN GENERAL
2.1 Basic Quantities

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
a, a^1		Linear or translatory acceleration	dv / dt	m/s^2
A		Area in general		m^2
B		Breadth		m
C, $F^F{}_2$		Cross force	Force normal to lift and drag (forces)	N
Cc		Cross force coefficient	$C_C = \frac{C}{qA}$	1
D, $F^F{}_1$		Resistance, Drag (force)	Force opposing translatory velocity, generally for a completely immersed body	N
d, D		Diameter		m
E		Energy		J
f		Frequency	$1 / T$	Hz
F, F^0		Force		N
g		Acceleration of gravity	Weight force / mass, strength of the earth gravity field	m/s^2
h		Depth		m
H		Height		m
I		Moment of inertia	Second order moment of a mass distribution	kg m^2
L		Length		m
L, $F^F{}_3$		Lift (force)	Force perpendicular to translatory velocity	N
m		Mass		kg
M, F^1		Moment of forces	First order moment of a force distribution	Nm
M		Momentum		Ns
n, N		Frequency or rate of revolution	Alias RPS (RPM in some propulsor applications)	Hz
P		Power		W
r, R		Radius		m
R, $F^F{}_1$		Resistance (force)	Force opposing translatory velocity	N
s		Distance along path		m
t		Time		s
t		Temperature		K
T		Period	Duration of a cycle of a repeating or periodic, not necessarily harmonic process	s
U		Undisturbed velocity of a fluid		m/s

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
v, V^1		Linear or translatory velocity of a body	ds / dt	m/s
V		Volume		m^3
w		Weight density, formerly specific weight	$dW / dV = \rho g$	N/m^3
W		Weight (force), gravity force acting on a body		N
γ		Relative mass or weight, in English speaking countries called specific gravity	Mass density of a substance divided by mass density of distilled water at 4°C	1
η		Efficiency	Ratio of powers	
ρ		Mass density	dm / dV	kg/m^3
ρ_0		water density for reference water temperature and salt content		kg/m3
ρ_A		Mass density of air	Mass of air per unit volume	kg/m^3
τ		Tangential stress		Pa
λ		Scale ratio	Ship dimension divided by corresponding model dimension	1
σ		Normal stress		Pa
ω		Circular frequency	$2 \pi f$	1/s
ω, V^0		Rotational velocity	$2 \pi n$	rad/s

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

2.2 Geometry and Hydrostatics
2.2.1 Hull Geometry
2.2.1.1 Basic Quantities

A_{BL}		Area of bulbous bow in longitudinal plane	The area of the ram projected on the middle line plane forward of the fore perpendicular	m^2
A_{BT}		Area of transverse cross-section of a bulbous bow (full area port and starboard)	The cross-sectional area at the fore perpendicular. Where the water lines are rounded so as to terminate on the forward perpendicular A_{BT} is measured by continuing the area curve forward to the perpendicular, ignoring the final rounding.	m^2
A_M		Area of midship section	Midway between fore and aft perpendiculars	m^2
A_T		Area of transom (full area port and starboard)	Cross-sectional area of transom stern below the load waterline	m^2
A_V		Area exposed to wind	Area of portion of ship above waterline projected normally to the direction of relative wind	m^2
A_{XV}		Transverse projected area above the waterline including superstructures	Projected area of the ship above the waterline projected on a transversal plane	m^2
A_W		Area of water-plane		m^2
A_{WA}		Area of water-plane aft of midship		m^2
A_{WF}		Area of water-plane forward of midship		m^2
A_X		Area of maximum transverse section		m^2
B		Breadth, moulded, of ship's hull		m
B_M		Breadth, moulded of midship section at design water line		m
B_T		Breadth, moulded of transom at design water line		m
B_{WL}		Maximum moulded breadth at design water line		m

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
B_X		Breadth, moulded of maximum section area at design water line		m
d, T		Draught, moulded, of ship hull		m
d_{KL}		Design drop of the keel line	T_{AD} - T_{FD} alias "keel drag" or "slope of keel"	m
D		Depth, moulded, of a ship hull		m
f		Freeboard	From the freeboard markings to the freeboard deck, according to official rules	m
i_E		Angle of entrance, half	Angle of waterline at the bow with reference to centre plane, neglecting local shape at stem	rad
i_R		Angle of run, half	Angle of waterline at the stern with reference to the centre-plane, neglecting local shape of stern frame	rad
L		Length of ship	Reference length of ship (generally length between the perpendiculars)	m
L_E		Length of entrance	From the forward perpendicular to the forward end of parallel middle body, or maximum section	m
L_{OA}		Length, overall		m
L_{OS}		Length, overall submerged		m
L_P		Length of parallel middle body	Length of constant transverse section	m
L_{PP}		Length between perpendiculars		m
L_R		Length of run	From section of maximum area or after end of parallel middle body to waterline termination or other designated point of the stern	m
L_{WL}		Length of waterline		m
L_{FS}		Frame spacing	used for structures	m
L_{SS}		Station spacing		m
S		Area of wetted surface		m^2

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
t		Taylor tangent of the area curve	The intercept of the tangent to the sectional area curve at the bow on the midship ordinate	1
T, d		Draught, moulded, of ship hull		m
T_{A}, d_{A}		Draught at aft perpendicular		m
T_{AD}		Design draught at aft perpendicular		m
T_{F}, d_{F}		Draught at forward perpendicular		m
T_{FD}		Design draught at forward perpendicular		m
T_H		Draught of the hull	Maximum draught of the hull without keel or skeg	m
T_{M}, d_{M}		Draught at midship	$(T_A + T_F) / 2$ for rigid bodies with straight keel	m
T_{MD}		Design draught at midship	$(T_{AD} + T_{FD}) / 2$ for rigid bodies	m
T_{T}		Immersion of transom	Vertical depth of trailing edge of boat at keel below water surface level	m
∇, V		Displacement volume	$\Delta / (\rho g) = \nabla_{\mathrm{BH}} + \nabla_{\mathrm{AP}}$	m^3
∇_{BH}		Displacement volume of bare hull	$\Delta_{\mathrm{BH}} / (\rho g)$	m^3
∇_{APP}		Displacement volume of appendages	$\Delta_{\mathrm{AP}} / (\rho g)$	m^3
Δ		Displacement force (buoyancy)	$g \rho \nabla$	N
Δ_{BH}		Displacement force (buoyancy) of bare hull	$g \rho \nabla_{\mathrm{BH}}$	N
Δ_{APP}		Displacement force (buoyancy) of appendages	$g \rho \nabla_{\mathrm{AP}}$	N
Δ_m		Displacement mass	$\rho \nabla$	kg
λ		Linear scale of ship model	$\lambda = L_{\mathrm{S}} / L_{\mathrm{M}} = B_{\mathrm{S}} / B_{\mathrm{M}} = T_{\mathrm{S}} / T_{\mathrm{M}}$	1

2.2.1.2 Derived Quantities

B^{C}		R.E. Froude's breadth coefficient	$B / \nabla^{1/3}$	1
C_{B}		Block coefficient	$\nabla / (L B T)$	1
C_{GM}		Dimensionless $\overline{GM}$ coefficient	$\overline{GM} / \nabla^{1/3}$	1
C_{GZ}		Dimensionless $\overline{GZ}$ coefficient	$\overline{GZ} / \nabla^{1/3}$	1

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
C_{KG}		Dimensionless $\overline{KG}$ coefficient	$\overline{KG}/T$	1
C_{IL}		Coefficient of inertia of water plane, longitudinal	$12\, I_L / (B\, L^3)$	1
C_{IT}		Coefficient of inertia of water plane, transverse	$12\, I_T / (B^3\, L)$	1
C_M		Midship section coefficient (midway between forward and aft perpendiculars)	$A_M / (B\, T)$	1
C_P		Longitudinal prismatic coefficient	$\nabla / (A_X\, L)$ or $\nabla / (A_M\, L)$	1
C_{PA}		Prismatic coefficient, after body	$\nabla_A / (A_X\, L / 2)$ or $\nabla_A / (A_M\, L / 2)$	1
C_{PE}		Prismatic coefficient, entrance	$\nabla_E / (A_X\, L_E)$ or $\nabla_E / (A_M\, L_E)$	1
C_{PF}		Prismatic coefficient fore body	$\nabla_F / (A_X\, L / 2)$ or $\nabla_F / (A_M\, L / 2)$	1
C_{PR}		Prismatic coefficient, run	$\nabla_R / (A_X\, L_R)$ or $\nabla_R / (A_M\, L_R)$	1
C_S		Wetted surface coefficient	$S / (V\, L)^{1/2}$	1
C_{VP}		Prismatic coefficient vertical	$\nabla / (A_W\, T)$	1
C_{WA}		Water plane area coefficient, aft	$A_{WA} / (B\, L / 2)$	1
C_{WF}		Water plane area coefficient, forward	$A_{WF} / (B\, L / 2)$	1
C_{WP}		Water plane area coefficient	$A_W / (L\, B)$	1
C_X		Maximum transverse section coefficient	$A_X / (B\, T)$, where B and T are measured at the position of maximum area	1
C_∇		Volumetric coefficient	∇ / L^3	1
f_{BL}		Area coefficient for bulbous bow	$A_{BL} / (L\, T)$	1
f_{BT}		Taylor sectional area coefficient for bulbous bow	A_{BT} / A_X	1
f_T		Sectional area coefficient for transom stern	A_T / A_X	1
M^C		R.E. Froude's length coefficient, or length-displacement ratio	$L / \nabla^{1/3}$	1
S^C		R.E. Froude's wetted surface area coefficient	$\dfrac{S}{\nabla^{\frac{2}{3}}}$	1
T^C		R.E. Froude's draught coefficient	$T / \nabla^{1/3}$	1

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

2.2.1.3 Symbols for Attributes and Subscripts

A		After body		
AP		After perpendicular		
APP		Appendages		
B		Bare hull		
DW		Design waterline		
E		Entry		
F		Fore body		
FP		Fore perpendicular		
FS		Frame spacing		
H		Hull		
RL		Reference Line		
LP		Based on LPP		
LW		Based on LWL		
M		Midships		
PB		Parallel body		
R		Run		
SS		Station spacing		
W		Water plane		
S		Wetted surface		

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

2.2.2 Propulsor Geometry
2.2.2.1 Screw Propellers

A_D		Developed blade area	Developed blade area of a screw propeller outside the boss or hub	m^2
A_E		Expanded blade area	Expanded blade area of a screw propeller outside the boss or hub	m^2
A_0		Propeller Disc Area	$\pi D^2 / 4$	m^2
A_P		Projected blade area	Projected blade area of a screw propeller outside the boss or hub	m^2
a_D		Developed blade area ratio	A_D / A_0	1
a_E		Expanded blade area ratio	A_E / A_0	1
a_P		Projected blade area ratio	A_P / A_0	1
c		Chord length		m
$c_{0.7}$		Chord length	Chord length at r/R=0.7	m
c_{LE}		Chord, leading part	The part of the Chord delimited by the Leading Edge and the intersection between the Generator Line and the pitch helix at the considered radius	m
c_M		Mean chord length	The expanded or developed area of a propeller blade divided by the span from the hub to the tip	m
c_S		Skew displacement	The displacement between middle of chord and the blade reference line. Positive when middle chord is at the trailing side regarding the blade reference line	m
c_{TE}		Chord, trailing part	The part of the Chord delimited by the Trailing Edge and the intersection between the Generator Line and the pitch helix at the considered radius	m
d_h		Boss or hub diameter	$2\ r_h$	m
d_{ha}		Hub diameter, aft	Aft diameter of the hub, not considering any shoulder	m
d_{hf}		Hub diameter, fore	Fore diameter of the hub, not considering any shoulder	m

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
D		Propeller diameter		m
f		Camber of a foil section		m
G_Z		Gap between the propeller blades	$2\ \pi\ r \sin(\varphi)\ /\ z$	m
h_0		Immersion	The depth of submergence of the propeller measured vertically from the propeller centre to the free surface	m
H_{TC}		Hull tip clearance	Distance between the propeller sweep circle and the hull	m
i_G , R_{k}(ISO)		Rake	The displacement from the propeller plane to the generator line in the direction of the shaft axis. Aft displacement is positive rake.	m
i_{S}		Rake, skew-induced	The axial displacement of a blade section which occurs when the propeller is skewed. Aft displacement is positive rake	m
i_{T}		Rake, total	The axial displacement of the blade reference line from the propeller plane $i_{\mathrm{G}} + i_{\mathrm{S}} = c_{\mathrm{S}} \sin\varphi$ Positive direction is aft.	m
l_{h}		Hub length	The length of the hub, including any fore and aft shoulder	m
l_{ha}		Hub length, aft	Length of the hub taken from the propeller plane to the aft end of the hub including aft shoulder	m
l_{hf}		Hub length, fore	Length of the hub taken from the propeller plane to the fore end of the hub including fore shoulder	m
N_{P}		Number of propellers		1
p		Pitch ratio	$P\ /\ D$	1
P		Propeller pitch in general		m
r		Blade section radius		m
r_{h}		Hub radius		m
R		Propeller radius		m
t		Blade section thickness		m

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
t_0		Thickness on axis of propeller blade	Thickness of propeller blade as extended down to propeller axis	m
x_B		Boss to diameter ratio	d_h / D	
x_P		Longitudinal propeller position	Distance of propeller centre forward of the after perpendicular	m
y_P		Lateral propeller position	Transverse distance of wing propeller centre from middle line	m
Z, z		Number of propeller blades		1
z_P		Vertical propeller position	Height of propeller centre above base line	m
α		Angle of inclination of the propeller shaft	Angle between propeller shaft and horizontal	deg
ε, ψ^{bP}		Propeller axis angle measured to body fixed coordinates	Angle between reference line and propeller shaft axis	rad
θ_s		Skew angle	The angular displacement about the shaft axis of the reference point of any blade section relative to the generator line measured in the plane of rotation. It is positive when opposite to the direction of ahead rotation	rad
θ		Angle of rake		rad
θ_{EXT}		Skew angle extent	The difference between maximum and minimum local skew angle	rad
φ		Pitch angle of screw propeller	arctg $(P / (2 \pi R))$	1
φ_F		Pitch angle of screw propeller measured to the face line		1
ψ^{aP}		Propeller axis angle measured to space fixed coordinates	Angle between horizontal plane and propeller shaft axis	rad
τ_B		Blade thickness ratio	t_0 / D	1

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

2.2.2.2 Ducts

A_{DEN}		Duct entry area		m^2
A_{DEX}		Duct exit area		m^2
d_{D}		Propeller tip clearance	Clearance between propeller tip and inner surface of duct	m
f_{D}		Camber of duct profile		m
L_{D}		Duct length		m
L_{DEN}		Duct entry part length	Axial distance between leading edge of duct and propeller plane	m
L_{DEX}		Duct exit length	Axial distance between propeller plane and trailing edge of duct	m
t_{D}		Thickness of duct profile		m
α_{D}		Duct profile-shaft axis angle	Angle between nose-tail line of duct profile and propeller shaft	rad
β_{D}		Diffuser angle of duct	Angle between inner duct tail line and propeller shaft	rad

2.2.2.3 Waterjets (see also section 1.3.5)

A_n, A_6		Nozzle discharge area		m^2
A_s		Cross sectional area at station *s*		m^2
D		Impeller diameter (maximum)		m
D_n		Nozzle discharge diameter		m
H_{ij}		Head between station *i* and *j*		m
H_{JS}		Jet System Head	$\dfrac{P_{\mathrm{JSE}}}{Q_J}$	m
h_{1A}		maximum height of cross sectional area of stream tube at station 1A		m
K_H		Head coefficient:	$\dfrac{gH}{n^2D^5}$	1

2.2.2.4 Pods

A_{PB}		Wetted Surface Area of Pod Main Body		m^2
A_{PBF}		Wetted Surface Area of Bottom Fin		m^2
A_{PS}		Wetted Surface Area of Strut		m^2
C_{BFTC}		Thickness Cord Ratio of Bottom Fin		1
C_{STC}		Thickness Cord Ratio of Strut		1

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
D_{PB}		Maximum Diameter of Pod Body		m
L_{PB}		Length of Pod Main Body		m
L_{PBF}		Length of Bottom Fin	Code length of bottom fin under pod main body	m
L_{PS}		Length of Upper Strut	Code length of strut between forward edge and aft edge	m
T_{PBS}		Bottom Thickness of Strut		m

2.2.2.5 Operators and identifiers

a	absolute (space) reference	(superscript)
b	body axis reference	(superscript)
P	propeller shaft axis	(subscript)
D	Duct	(subscript)

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

2.2.3 Appendage Geometry
Related information may be found in Section 3.3.3 on Lifting Surfaces.
2.2.3.1 Basic Quantities

A_C		Area under cut-up		m^2
A_{FB}		Area of bow fins		m^2
A_{FR}		Frontal area	Projected frontal area of an appendage	m^2
A_{RF}		Projected flap area		m^2
A_R		Lateral rudder area	Area of the rudder, including flap	m^2
A_{RX}		Lateral area of the fixed part of rudder		m^2
A_{RP}		Lateral area of rudder in the propeller race		m^2
A_{RT}		Total lateral rudder area	$A_{RX} + A_{Rmov}$	m^2
A_{FS}		Projected area of stern fins		m^2
A_{SK}		Projected skeg area		m^2
S_{WBK}		Wetted surface area of bilge keels		m^2
c		Chord length of foil section		m
c_M		Mean chord length	A_{RT} / S	m
c_R		Chord length at the root		m
c_T		Chord length at the tip		m
f		Camber of an aerofoil or a hydrofoil	Maximum separation of median and nose-tail line	m
L_F		Length of flap or wedge	Measured in direction parallel to keel	m
t		Maximum thickness of an aerofoil or a hydrofoil	Measured normal to mean line	m
α_{FB}		Bow fin angle		rad
α_{FS}		Stern fin angle		rad
δ_F		Flap angle (general)	Angle between the planing surface of a flap and the bottom before the leading edge	rad
δ_W		Wedge angle	Angle between the planing surface of a wedge and the bottom before the leading edge	rad
δ_{FR}		Flanking rudder angle		rad
δ_{FRin}		Assembly angle of flanking rudders	Initial angle set up during the assembly as zero angle of flanking rudders	rad
δ_R		Rudder angle		rad
δ_{RF}		Rudder-flap angle		rad

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
λ_{R}		Rudder taper	$c_{\mathrm{T}} / c_{\mathrm{R}}$	1
λ_{FR}		Flanking rudder taper		1
Λ_{R}		Rudder aspect ratio	$b_{\mathrm{R}}^2 / A_{\mathrm{RT}}$	1
Λ_{FR}		Flanking rudder aspect ratio		

2.2.3.2 Identifiers for Appendages (Subscripts)

BK	Bilge keel
BS	Bossing
FB	Bow foil
FR	Flanking rudder
FS	Stern foil
KL	Keel
RU	Rudder
RF	Rudder flap
SA	Stabilizer
SH	Shafting
SK	Skeg
ST	Strut
TH	Thruster
WG	Wedge

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

2.2.4 Hydrostatics and Stability

2.2.4.1 Points and Centres (Still under construction)

A		Assumed centre of gravity above keel used for cross curves of stability		
b		Centre of flotation of added buoyant layer or centre of lost buoyancy of the flooded volume		
B		Centre of buoyancy	Centroid of the underwater volume	
F		Centre of flotation of the water plane		
g		Centre of gravity of an added or removed weight (mass)		
G		Centre of gravity of a vessel		
K		Keel reference		
M		Metacentre of a vessel	See subscripts for qualification	
X_{CB} , L_{CB}		Longitudinal centre of buoyancy (LCB)	Longitudinal distance from reference point to the centre of buoyancy, B such as $\mathrm{X}_{\mathrm{MCF}}$ from Midships	m
X_{CF} , L_{CF}		Longitudinal centre of flotation (LCF)	Longitudinal distance from reference point to the centre of flotation, F such as $\mathrm{X}_{\mathrm{MCF}}$ from Midships	m
x_{Cb}		Longitudinal centre of buoyancy of added buoyant layer	Longitudinal distance from reference point to the centre of buoyancy of the added buoyant layer, *b* such as x_{MCb} from Midships	m
x_{Cf}		Longitudinal centre of flotation of added buoyant layer	Longitudinal distance from reference point to the centre of flotation of the added buoyant layer, *f* such as $\mathrm{x}_{\mathrm{MCf}}$ from Midships	m
x_{Cg}		Longitudinal centre of gravity of added weight (mass)	Longitudinal distance from reference to the centre of gravity, *g*, of an added or removed weight (mass) such as $\mathrm{x}_{\mathrm{MCg}}$ from Midships	m

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
X_{CG} , L_{CG}		Longitudinal centre of gravity (LCG)	Longitudinal distance from a reference point to the centre of gravity, G such as X_{MCG} from Midships	m
Y_{CG}		Lateral displacement of centre of gravity (YCG)	Lateral distance from a reference point to the centre of gravity, G	m
Z		Intersection of righting arm with line of action of the centre of buoyancy		
Z_{CB}		Vertical centre of buoyancy	Vertical distance from reference point to the centre of buoyancy, B	m

2.2.4.2 Static Stability levers

$\overline{AB}$		Longitudinal centre of buoyancy from aft perpendicular	Distance of centre of buoyancy from aft perpendicular	m
$\overline{AF}$		Distance of centre of flotation from aft perpendicular		m
$\overline{AG}_{\mathrm{L}}$		Longitudinal centre of gravity from aft perpendicular	Distance of centre of gravity from aft perpendicular	m
$\overline{AG}_{\mathrm{T}}$		Transverse distance from assumed centre of gravity A, to actual centre of gravity G		m
$\overline{AG}_{\mathrm{V}}$		Vertical distance from assumed centre of gravity A, to actual centre of gravity G		m
$\overline{AZ}$		Righting arm based on horizontal distance from assumed centre of gravity A, to Z	Generally tabulated in cross curves of stability	m
$\overline{BM}$		Transverse metacentre above centre of buoyancy	Distance from the centre of buoyancy B to the transverse metacentre M. $\overline{BM} = I_T / \nabla = \overline{KM} - \overline{KB}$	m
$\overline{BM}_L$		Longitudinal metacentre above centre of buoyancy	$\overline{KM}_L - \overline{KB}$	
$\overline{FB}$		Longitudinal centre of buoyancy, L_{CB}, from forward perpendicular	Distance of centre of buoyancy from forward perpendicular	m
$\overline{FF}$		Longitudinal centre of floatation, L_{CF}, from forward perpendicular	Distance of centre of flotation from forward perpendicular	m
$\overline{FG}$		Longitudinal centre of gravity from forward perpendicular	Distance of centre of gravity from forward perpendicular	m
$\overline{GG}_H$		Horizontal stability lever caused by a weight shift or weight addition		m
$\overline{GG}_L$		Longitudinal stability lever caused by a weight shift or weight addition		m

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
$\overline{GG}_1, \overline{GG}_V$		Vertical stability lever caused by a weight shift or weight addition	$\overline{KG}_1 = \overline{KG}_0 + \overline{GG}_1$	m
$\overline{GM}$		Transverse metacentric height	Distance of centre of gravity to the metacentre $\overline{KM} - \overline{KG}$	m
$\overline{GM}_{\mathrm{EFF}}$		Effective transverse metacentric height	$\overline{GM}$ corrected for free surface and/or free communication effects	m
$\overline{GM}_L$		Longitudinal centre of metacentric height	Distance from the centre of gravity G to the longitudinal metacentre M_L $\overline{GM}_L = \overline{KM}_L - \overline{KG}$	m
$\overline{GZ}$		Righting arm or lever	$\overline{GZ} = \overline{AZ} - \overline{AG}_V \ \sin\phi - \overline{AG}_T \cos\varphi$	m
$\overline{GZ}_{\mathrm{MAX}}$		Maximum righting arm or lever		m
$\overline{KA}$		Assumed centre of gravity above moulded base or keel	Distance from the assumed centre of gravity A to the moulded base or keel K	m
$\overline{KB}$		Centre of buoyancy above moulded base or keel	Distance from the centre of buoyancy B to the moulded base or keel K	m
$\overline{KG}$		Centre of gravity above moulded base or keel	Distance from centre of gravity G to the moulded base or keel K	m
$\overline{Kg}$		Vertical centre of gravity of added or removed weight above moulded base or keel	Distance from centre of gravity, g, to the moulded base or keel K	m
$\overline{KM}$		Transverse metacentre above moulded base or keel	Distance from the transverse metacentre M to the moulded base or keel K	m
$\overline{KM}_L$		Longitudinal metacentre above moulded base or keel	Distance from the longitudinal metacentre M_L to the moulded base or keel K	m
l		Longitudinal trimming arm	x_{CG} - x_{CB}	m
t		Equivalent transverse heeling arm	Heeling moment /Δ	m

2.2.4.3 Derived Quantities

C_{GM}		Dimensionless $\overline{GM}$ coefficient	$\overline{GM}/\nabla^{1/3}$	1
C_{GZ}		Dimensionless $\overline{GZ}$ coefficient	$\overline{GZ}\ /\nabla^{1/3}$	1
C_{KG}		Dimensionless $\overline{KG}$coefficient	$\overline{KG}\ /T$	1
C_{MTL}		Longitudinal trimming coefficient	Trimming moment divided by change in trim which approximately equals $\overline{BM}_L / L$	1

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

2.2.4.4 Intact and Damage (Flooded) Stability

C_{MTL}		Longitudinal trimming coefficient	trimming moment divided by change in trim which approximately equals $\overline{BM}_L/L$	1
f		Freeboard	From the freeboard markings to the freeboard deck, according to official rules	m
A_{SI}, I_{AS}		Attained subdivision index	(to be clarified)	1
M_{S}		Moment of ship stability in general	$\Delta \overline{GZ}$ Other moments such as those of capsizing, heeling, etc. will be represented by MS with additional subscripts as appropriate	Nm
m		Ship mass	W / g	kg
$M_{T\mathrm{C}}$		Moment to change trim by one centimetre		Nm/cm
$M_{T\mathrm{M}}$		Moment to change trim by one meter	ΔC_{MTL}	Nm/m
R_{SI}		Required subdivision index		1
t_s, t_{KL}		Static trim	T_{A} - T_{F} - d_{KL}	m
W		Ship weight	$m\ g$	N
z_{SF}		Static sinkage at FP	Caused by loading	m
z_{SA}		Static sinkage at AP	Caused by loading	m
z_{S}		Mean static sinkage	$(z_{\mathrm{SF}} + z_{\mathrm{SA}}) / 2$	m
δ		Finite increment in...	Prefix to other symbol	1
δt_{KL}		Change in static trim		m
Δ		Displacement (buoyant) force	$g\ \rho\ \nabla$	N
Δ_m		Displacement mass	$\rho\ \nabla$	kg
∇		Displacement volume	$\Delta / (\rho g)$	m^3
∇_{fw}		Displacement volume of flooded water	$\Delta f_w / (\rho g)$	m^3
θ_{S}		Static trim angle	$\tan^{-1}((z_{\mathrm{SF}} - z_{\mathrm{SA}}) / L)$	rad
μ		Volumetric permeability	The ratio of the volume of flooding water in a compartment to the total volume of the compartment	1
ϕ		Heel angle		rad
ϕ_{F}		Heel angle at flooding		rad
ϕ_{VS}		Heel angle for vanishing stability		rad

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

2.2.4.5 Symbols for Attributes and Subscripts (under construction)

a	apparent
A, att	attained
d, dyn	dynamic
e, EFF	effective
f	false
KL	keel line
L	longitudinal
MAX	maximum
MTL	longitudinal trimming moment
R, req	required (to be clarified)
s	Static
S, sqt	Sinkage, squat
*T*C	Trim in cm
*T*M	Trim in m
T	transverse
V	vertical
0	Initial
ϕ	at heel angle ϕ
θ	at trim angle θ

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

2.3 Resistance and Propulsion

2.3.1 Hull Resistance
(see also Section 1.4.1 on Waves)

2.3.1.1 Basic Quantities

m		Blockage parameter	Maximum transverse area of model ship divided by tank cross section area	1
R_A		Model-ship correlation allowance	Incremental resistance to be added to the smooth ship resistance to complete the model-ship prediction	N
R_AA		Air or wind resistance		N
R_APP		Appendage resistance		N
R_AR		Roughness resistance		N
R_C		Resistance corrected for difference in temperature between resistance and self-propulsion tests	$R_\mathrm{TM}[(1 + k)\, C_\mathrm{FMC} + C_\mathrm{R}]$ / $[(1 + k)\, C_\mathrm{FM} + C_\mathrm{R}]$ where C_FMC is the frictional coefficient at the temperature of the self-propulsion test	N
R_F		Frictional resistance of a body	Due to fluid friction on the surface of the body	N
R_F0		Frictional resistance of a flat plate		N
R_P		Pressure resistance	Due to the normal stresses over the surface of a body	N
$R_{P\mathrm{V}}$		Viscous pressure resistance	Due to normal stress related to viscosity and turbulence	N
R_R		Residuary resistance	$R_\mathrm{T} - R_\mathrm{F}$ *or* $R_\mathrm{T} - R_\mathrm{F0}$	N
R_RBH		Residuary resistance of the bare hull		N
R_S		Spray resistance	Due to generation of spray	N
R_T		Total resistance	Total towed resistance	N
R_TBH		Total resistance of bare hull		N
R_V		Total viscous resistance	$R_\mathrm{F} + R_{P\mathrm{V}}$	N
R_W		Wave making resistance	Due to formation of surface waves	N
R_WB		Wave breaking resistance	Associated with the breakdown of the bow wave	N
R_WP		Wave pattern resistance		N
S		Wetted surface area, underway	$S_\mathrm{BH} + S_\mathrm{APP}$	m^2
S_0		Wetted surface area, at rest	$S_\mathrm{BH0} + S_\mathrm{APP0}$	m^2
S_APP		Appendage wetted surface area, underway		m^2

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
S_{APP0}		Appendage wetted surface area, at rest		m^2
S_{BH}		Bare Hull wetted surface area, underway		m^2
S_{BH0}		Bare Hull wetted surface area, at rest		m^2
ΔC_{F}		Roughness allowance		1
V		Speed of the model or the ship		m/s
V_{K}		Speed in knots		
V_{WR}		Wind velocity, relative		m/s
$z_{V\mathrm{F}}$		Running sinkage at FP		m
$z_{V\mathrm{A}}$		Running sinkage at AP		m
$z_{V\mathrm{M}}$		Mean running sinkage	$(z_{V\mathrm{F}} + z_{V\mathrm{A}}) / 2$	m
η		Wave Elevation	see 3.4.1	m
θ_V , θ_{D}		Running (dynamic) trim angle	$\tan^{-1}((z_{V\mathrm{F}} - z_{V\mathrm{A}}) / L)$	1
τ_{W}		Local skin friction	see 3.3.4	$\mathrm{N/\ m}^2$

2.3.1.2 Derived Quantities

C_{A}		Incremental resistance coefficient for model ship correlation		1
C_{AA}		Air or wind resistance coefficient	$R_{\mathrm{AA}} / (S\ q)$ $= C_{DA} \frac{\rho_A}{\rho_S} \frac{A_V}{S_S} = -C_X \frac{\rho_A}{\rho_S} \frac{A_V}{S_S}$	1
C_{APP}		Appendage resistance coefficient	$R_{\mathrm{APP}} / (S\ q)$	1
C_D		Drag coefficient	$D / (S\ q)$	1
$C_{D\mathrm{A}}$		Air or wind resistance coefficient, from wind tunnel tests	$= \frac{R_{\mathrm{AA}}}{A_{\mathrm{V}} \frac{1}{2} \rho_{\mathrm{A}} V^2}$	1
C_{F}		Frictional resistance coefficient of a body	$R_{\mathrm{F}} / (S\ q)$	1
C_{F0}		Frictional resistance coefficient of a corresponding plate	$R_{\mathrm{F0}} / (S\ q)$	1
C_p		Local pressure coefficient		1
C_{PR}		Pressure resistance coefficient, including wave effect	$R_P / (S\ q)$	1
$C_{P\mathrm{V}}$		Viscous pressure resistance coefficient	$R_{P\mathrm{V}} / (S\ q)$	1
C_{R}		Residuary resistance coefficient	$R_{\mathrm{R}} / (S\ q)$	1
C_{S}		Spray resistance coefficient	$R_{\mathrm{S}} / (S\ q)$	1

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
C_T		Total resistance coefficient	$R_T / (S\ q)$	1
C_{TL}		Telfer's resistance coefficient	$g\ R\ L / (\Delta V^2)$	1
C_{TQ}		Qualified resistance coefficient	$C_{T\nabla} / (\eta_H\ \eta_R)$	1
$C_{T\nabla}$		Resistance displacement	$R_T / (\nabla^{2/3}\ q)$	1
C_V		Total viscous resistance coefficient	$R_V / (S\ q)$	1
C_W		Wave making resistance coefficient	$R_W / (S\ q)$	1
C_{WP}		Wave pattern resistance coefficient, by wave analysis		1
C_X		Air or wind resistance coefficient, usually from wind tunnel tests	$-R_{AA} / (A_V\ q_R)$	1
C^C		R.E. Froude's resistance coefficient	$1000\ R_T / (\Delta (K^C)^2)$	1
F^C		R.E. Froude's frictional resistance coefficient	$1000\ R_F / (\Delta (K^C)^2)$	1
f		Friction coefficient	Ratio of tangential force to normal force between two sliding bodies	1
k		Three-dimensional form factor on flat plate friction	$(C_V - C_{F0}) / C_{F0}$	1
$k(\theta)$		Wind direction coefficient	C_{AA} / C_{AA0}	1
K^C		R.E. Froude's speed displacement coefficient	$(4\ \pi)^{1/2}\ Fr_\nabla$ or $(4\pi/g)^{1/2} V_K / \nabla^{1/6}$	
K_R		Resistance coefficient corresponding to K_Q, K_T	$R / (\rho\ D^4\ n^2)$	1
q		Dynamic pressure, density of kinetic flow energy,	$\rho\ V^2 / 2$ see 3.3.2	Pa
q_R		Dynamic pressure based on apparent wind	$\rho\ V_{WR}^2 / 2$ see 3.4.2	Pa
S^C		R. E. Froude’s wetted surface coefficient	$\frac{S}{\nabla^{\frac{2}{3}}}$	1
ε		Resistance-displacement ratio in general	R / Δ	1
ε_R		Residuary resistance-displacement ratio	R_R / Δ	1

2.3.1.3 Symbols for Attributes and Subscripts

FW	Fresh water
MF	Faired model data
MR	Raw model data
OW	Open water

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
SF	Faired full scale data			
SR	Raw full scale data			
SW	Salt water			

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

2.3.2 Ship Performance

2.3.2.1 Basic Quantities

A_{XV}		Transverse projected area above the waterline including superstructures	Projected area of the ship above the waterline projected on a transversal plane	m^2
F_{D}		Friction deduction force in self-propulsion test	Towing force applied to a model to correct the model resistance for different *Re* between model and full scale.	N
F_{P}		Force pulling or towing a ship		N
F_{P0}		Pull during bollard test		N
k_S		Roughness height of Hull surface		m
n		Frequency, commonly rate of revolution		Hz
P_{B}		Brake power	Power delivered by prime mover	W
P_{BW}		Brake power in representative sea condition		W
P_{D} , P_{P}		Delivered power, propeller power	$Q\ \omega$	W
$P_{\mathrm{D}T}$		Delivered Power, corrected using correlation factor	$P_{\mathrm{DT}} = C_P \cdot P_{\mathrm{DS}}$	W
P_{E} , P_R		Effective power, resistance power	$R\ V$	W
P_{I}		Indicated power	Determined from pressure measured by indicator	W
P_{S}		Shaft power	Power measured on the shaft	W
P_T		Thrust power	$T\ V_{\mathrm{A}}$	W
Q		Torque	P_{D} / ω	Nm
R_0		Full scale resistance without overload		N
R_{Tw}		Total resistance in wind and waves		N
t_V		Running trim		m
V		Ship speed		m/s
V_{A}		Propeller advance speed	Equivalent propeller open water speed based on thrust or torque identity	m/s

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
V_{ref}		Design ship speed when the ship is in operation in a calm sea condition (no wind and waves)		m/s
V_{w}		Design ship speed when the ship is in operation under the representative sea condition		m/s
z_V		Running sinkage of model or ship		m
ω		Rotational shaft velocity	$2\ \pi\ n$	1/s

2.3.2.2 Derived Quantities

a		Resistance augment fraction	$(T - R_{\mathrm{T}}) / R_{\mathrm{T}}$	1
B_{f}		Bluntness coefficient	7.5-04-01-01.1	1
C_{ADM}		Admiralty coefficient	$\Delta^{2/3}\ V^3 / P_{\mathrm{S}}$	1
$C_{\mathrm{D}\nabla}$		Power-displacement coefficient	$P_D / (\rho\ V^3\ \nabla^{2/3} / 2)$	1
C_N		Trial correction for propeller rate of revolution at speed identity	$n_{\mathrm{T}} / n_{\mathrm{S}}$	1
C_{NP}		Trial correction for propeller rate of revolution at power identity	$P_{\mathrm{DT}} / P_{\mathrm{DS}}$	1
C_P		Trial correction for delivered power		1
f_w		Weather factor, a non-dimensional coefficient indicating the decrease of speed in representative sea conditions	$f_{\mathrm{w}} = \frac{\text{speed in wind and waves}}{\text{speed in calm water}} = \frac{V_{\mathrm{w}}}{V_{\mathrm{ref}}}$	1
K_1		Ship model correlation factor for propulsive efficiency	$\eta_{\mathrm{DS}} / \eta_{\mathrm{DM}}$	1
K_2		Ship model correlation factor for propeller rate revolution	$n_{\mathrm{S}} / n_{\mathrm{M}}$	1
K_{APP}		Appendage correction factor	Scale effect correction factor for model appendage drag applied at the towing force in a self-propulsion test	1
s_V		Sinkage, dynamic	Change of draught, fore and aft, divided by length	1
t_V		Trim, dynamic	Change of the trim due to dynamic condition, divided by length	1
t		Thrust deduction fraction	$(T - R_{\mathrm{T}}) / T$	1

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
w		Taylor wake fraction in general	$(V - V_A) / V$	1
w_F		Froude wake fraction	$(V - V_A) / V_A$	1
w_Q		Torque wake fraction	Propeller speed V_A determined from torque identity	1
w_R		Effect of the rudder(s) on the wake fraction		1
w_T		Thrust wake fraction	Propeller speed, V_A, determined from thrust identity	1
ΔR_{waves}		Added wave resistance		N
ΔR_{wind}		Added wind resistance		N
Δw		Ship-model correlation factor for wake fraction	$w_{T,M} - w_{T,S}$	1
Δw_C		Ship-model correlation factor with respect to $w_{T,S}$ method formula of ITTC 1978 method		1
x		Load fraction in power prediction	$\eta_D P_D / P_E - 1$	1
β		Appendage scale effect factor	Ship appendage resistance divided by model appendage resistance	1
ξ_n		Load variation coefficient of the shaft revolution speed		1
ξ_P		Load variation coefficient of the delivered power		1
ξ_V		Load variation coefficient of the ship speed		1

2.3.2.3 Efficiencies etc.

η_{APP}		Appendage efficiency	P_{Ew0APP} / P_{EwAPP}, R_{TBH} / R_T	1
η_B		Propeller efficiency behind ship	$P_T / P_D = T V_A / (Q \omega)$	1
η_D		Quasi-propulsive efficiency coefficient	$P_E / P_D = P_R / P_P$	1
η_{Did}		Propulsive efficiency in ideal condition, from model test		1
η_G		Gearing efficiency		1
η_H		Hull efficiency	$P_E / P_T = P_R / P_T$ $= (1 - t) / (1 - w)$	1
η_M		Mechanical efficiency of transmission between engine and propeller	P_D / P_B	1

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
η_{O}		Propeller efficiency in open water	$P_T / P_D = T V_A / (Q \omega)$ all quantities measured in open water tests	1
η_{P}		Propulsive efficiency coefficient	P_E / P_B	1
η_{R}		Relative rotative efficiency	η_B / η_O	1
η_{S}		Shafting efficiency	$P_D / P_S = P_P / P_S$	1

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

2.3.3 Propulsor Performance

2.3.3.1 Basic Quantities

A_{O}		Propeller disc area	$\pi D^2 / 4$	m^2
D		Propeller diameter		m
n		Propeller frequency of revolution		Hz
n_{T}		Propeller rate of revolution, corrected using correlation factor	$n_{\mathrm{T}} = C_N \cdot n_{\mathrm{S}}$	1
k_{P}		Roughness height of propeller blade surface		m
q_{A}		Dynamic pressure based on advance speed	$\rho\, V_{\mathrm{A}}^2 / 2$	Pa
q_{S}		Dynamic pressure based on section advance speed	$\rho\, V_{\mathrm{S}}^2 / 2$	Pa
Q_{S}		Spindle torque	About spindle axis of controllable pitch propeller $Q_{\mathrm{S}}=Q_{\mathrm{SC}}+ Q_{\mathrm{SH}}$ positive if it increases pitch	Nm
Q_{SC}		Centrifugal spindle torque		Nm
Q_{SH}		Hydrodynamic spindle torque		Nm
R_{U}		Pod unit resistance	Resistance of a podded drive unit	N
T		Propeller thrust		N
T_{U}		Pod unit thrust	Pod unit resistance subtracted from the propeller thrust	N
T_{D}		Duct thrust of a ducted propeller unit		N
T_{P}		Propeller thrust of a ducted propeller unit		N
T_{T}		Total thrust of a ducted propeller unit		N
$T_{x\mathrm{P}}$		Propeller Thrust along shaft axis		N
$T_{y\mathrm{P}}$		Propeller normal force in y direction in propeller axis		N
$T_{z\mathrm{P}}$		Propeller normal force in z direction in propeller axis		N
V_{A}		Advance speed of propeller		m/s
V_{P}		Mean axial velocity at propeller plane of ducted propeller		m/s

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
V_S		Section advance speed at 0.7 R	$(V_\mathrm{A}^2 + (0.7\, R\, \omega)^2)^{1/2}$	m/s
Y_U		Pod unit side force		N
γ_i		Resistance fraction for one propeller	The portion of the resistance (load fraction, γ_i) that the i^th^ propeller is responsible for	1
ρ_P		Propeller mass density		kg/m^3
τ_i		Thrust deduction sensitivity for one propeller	$\tau_i = 1 + \left(\frac{\Delta F}{\Delta T}\right)_i$	1
ω		Propeller rotational velocity	$2\, \pi\, n$	1/s

2.3.3.2 Derived Quantities

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
B_P		Taylor's propeller coefficient based on delivered horse-power	$n\, P_\mathrm{D}^{½} / V_\mathrm{A}^{2.5}$ with n in revs/min, P_D in horsepower, and V_A in kn (obsolete)	1
B_U		Taylor's propeller coefficient based on thrust horsepower	$n\, P_\mathrm{T}^{½} / V_\mathrm{A}^{2.5}$ with n in revs/min, P_T in horsepower, and V_A in kn (obsolete)	1
C_P		Power loading coefficient	$P_\mathrm{D} / (A_\mathrm{P}\, q_\mathrm{A}\, V_\mathrm{A})$	1
C_{Q*}		Torque index	$Q / (A_\mathrm{P}\, q_\mathrm{S}\, D)$	1
C_{Th}		Thrust loading coefficient, energy loading coefficient	$T / (A_\mathrm{P}\, q_\mathrm{A}) = (T_\mathrm{P} / A_\mathrm{P}) / q_\mathrm{A}$	1
C_{T*}		Thrust index	$T / (A_\mathrm{P}\, q_\mathrm{S})$	1
J		Propeller advance ratio	$V_\mathrm{A} / (D\, n)$	1
J_A , J_H		Apparent or hull advance ra-tio	$V / (D\, n) = V_\mathrm{H} / (D\, n)$	1
J_P		Propeller advance ratio for ducted propeller	$V_\mathrm{P} / (D\, n)$	
J_T , $J_{\mathrm{P}T}$		Advance ratio of propeller determined from thrust iden-tity		1
J_Q , $J_{\mathrm{P}Q}$		Advance ratio of propeller determined from torque identity		1
K_P		Delivered power coefficient	$P_\mathrm{D} / (\rho\, n^3\, D^5) = 2\, \pi\, K_Q$	1
K_Q		Torque coefficient	$Q / (\rho\, n^2\, D^5)$	1
K_SC		Centrifugal spindle torque coefficient	$Q_\mathrm{SC} / (\rho\, n^2\, D^5)$	1
K_SH		Hydrodynamic spindle torque coefficient	$Q_\mathrm{SH} / (\rho\, n^2\, D^5)$	1
K_T		Thrust coefficient	$T / (\rho\, n^2\, D^4)$	1
$K_{T\mathrm{D}}$		Duct thrust coefficient for a ducted propeller unit	$T_\mathrm{D} / (\rho\, n^2\, D^4)$	1

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
K_{TP}		Propeller thrust coefficient for a ducted propeller unit	$T_P / (\rho n^2 D^4)$	1
K_{TQ}		Thrust coefficient achieved by torque identity		1
K_{TT}		Total thrust coefficient for a ducted propeller unit	$K_{TP} + K_{TD}$	1
K_{Q0}		Torque coefficient of propeller converted from behind to open water condition	$K_Q \cdot \eta_R$	1
K_{QT}		Torque coefficient of propeller determined from thrust coefficient identity		1
P_J		Propeller jet power	$\eta_{TJ}\, T\, V_A$	
S_A		Apparent slip ratio	$1 - V / (n P)$	1
S_R		Real slip ratio	$1 - V_A / (n P)$	1
δ		Taylor's advance coefficient	$n D / V_A$ with n in revs/min, D in feet, V_A in kn	1
η_{JP}		Propeller pump or hydraulic efficiency	$P_J / P_D = P_J / P_P$	1
η_{JP0}		Propeller pump efficiency at zero advance speed, alias static thrust coefficient	$T / (\rho \pi / 2)^{1/3} / (P_D D)^{2/3}$	1
η_I		Ideal propeller efficiency	Efficiency in non-viscous fluid	1
η_{TJ}		Propeller jet efficiency	$2 / (1 + (1 + C_{Th})^{1/2})$	1
η_0 , η_{TP0}		Propeller efficiency in open water	$P_T / P_D = T V_A / (Q \omega)$ all quantities measured in open water tests	1
λ		Advance ratio of a propeller	$V_A / (n D) / \pi = J / \pi$	1
τ		Ratio between propeller thrust and total thrust of ducted propeller	T_P / T_T	1

2.3.3.3 Induced Velocities etc.

U_A		Axial velocity induced by propeller		m/s
U_{AD}		Axial velocity induced by duct of ducted propeller		m/s
U_{RP}		Radial velocity induced by propeller of ducted propeller		m/s
U_{RD}		Radial velocity induced by duct of ducted propeller		m/s
U_{AP}		Axial velocity induced by propeller of ducted propeller		m/s

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
U_R		Radial velocity induced by propeller		m/s
U_{TD}		Tangential velocity induced by duct of ducted propeller		m/s
U_{TP}		Tangential velocity induced by propeller of ducted propeller		m/s
U_T		Tangential velocity induced by propeller		m/s
β		Advance angle of a propeller blade section	arctg (V_A / $r\ \omega$)	rad
β_I		Hydrodynamic flow angle of a propeller blade section	Flow angle taking into account induced velocity	rad
β^*		Effective advance angle	arctg (V_A/ (0.7 $R\ \omega$))	rad

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

2.3.4 Unsteady Propeller Forces

2.3.4.1 Basic Quantities

C_{uv}		Generalized stiffness		
D_{uv}		Generalized damping		
F_u		Generalized vibratory force	u = 1,.., 6 u = 1, 2, 3: force u = 4, 5, 6: moment	N N Nm
F_i		Vibratory force	i = 1, 2, 3	N
K_{Fu}		Generalized vibratory force coefficients	According to definitions of K_{Fi} and K_{Mi}	1
K_{Fi}		Vibratory force coefficients	$F_i / (\rho\ n^2\ D^4)$	1
K_{Mi}		Vibratory moment coefficients	$M_i / (\rho\ n^2\ D^5)$	1
K_p		Pressure coefficient	$p / (\rho\ n^2\ D^2)$	1
M_i		Vibratory moment	i = 1, 2, 3	Nm
M_{uv}		Generalized mass		
p		Pressure		Pa
R_u		Generalized vibratory bearing reaction	u = 1,.., 6 u = 1, 2, 3: force u = 4, 5, 6: moment	N N Nm
V_i		Velocity field of the wake	i = 1, 2, 3	m/s
x y z		Cartesian coordinates	Origin O coinciding with the centre of the propeller. The longitudinal x-axis coincides with the shaft axis, positive forward; the trans-verse y-axis, positive to port; the third, z-axis, positive upward	m m m
X a r		Cylindrical coordinates	Cylindrical system with origin O and longitudinal x-axis as defined before; angular a-(attitude)-coordinate, zero at 12 o'clock position, positive clockwise looking forward; r distance measured from the x-axis	m 1 m
δ_u		Generalized vibratory displacement	u = 1,.., 6 u = 1, 2, 3: linear u = 4, 5, 6: angular	m m rad
$\dot{\delta}_u$		Generalized vibratory velocity	u = 1,.., 6 u = 1, 2, 3: linear u = 4, 5, 6: angular	m/s m/s rad/s

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
$\ddot{\delta}_u$		Generalized vibratory acceleration	u = 1,.., 6 u = 1, 2, 3: linear u = 4, 5, 6: angular	m/s^2 m/s^2 rad/s^2

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

2.3.5 Water Jets

C_p		Local pressure coefficient	$(p-p_0)/(\rho\ V^2/2)$	1
C_{Tn}		Thrust loading coefficient:viscous pressure	$\frac{T_{\mathrm{net}}}{\frac{1}{2}\rho U_0^2 A_n}$	1
c_{es}		Energy velocity coefficient at station *s*		1
c_{ms}		Momentum velocity coefficient at station *s*		1
Dp		Pressure differential of flow rate transducer		Pa
E_j		Energy flux at station *j*	$E_j = (\rho/2)\int_{Q_J} V_{Ej}^2 dQ_j$	W
E_s		Total energy flux at station s (kinetic + potential + pressure)	$\iint_{A_s} \rho\left(\frac{1}{2}\boldsymbol{u^2} + \frac{p}{\rho} - g_j x_j\right) u_i n_i dA$	W
$E_{s\xi}$		Total axial (in ξ direction) energy flux at station s	$\iint_{A_s} \rho\left(\frac{1}{2}u_\xi^2 + \frac{p}{\rho} - g_j x_j\right) u_i n_i dA$	W
F_D		Skin friction correction in a self propulsion test carried out at the ship self-propulsion point		N
H_1		Local total head at station 1		m
H_{35}		Mean increase of total head across pump and stator or several pump stages		m
I_{VR}		Intake velocity ratio	VI/V	1
J_{VR}		Jet velocity ratio	VJ/V	1
K_Q		Impeller torque coefficient:	$\frac{Q}{\rho n^2 D^5}$	
K_{QJ}		Flow rate coefficient:	$\frac{Q_J}{nD^3}$	1
$\overline{M}_{is}$		Momentum flux at station *s* in *i* direction	$\iint_{A_s} \rho u_i(u_j n_j) dA$	N
NVR		Nozzle velocity ratio:	$\frac{\overline{u_{6\xi}}}{U_0}$	1
T_{jx}		Jet thrust (can be measured directly in bollard pull condition)		N
n		Impeller rotation rate		Hz

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
n_i		Unit normal vector in *i* direction		1
P_D		Delivered Power to pump impeller		W
P_E		Effective power:	$R_{\mathrm{TBH}} U_0$	W
P_{JSE}		Effective Jet System Power	$Q_J H_{1A7}$	W
P_{PE}		Pump effective power:	$Q_J H_{35}$	W
P_{TE}		Effective thrust power		W
p_0		Ambient pressure in undisturbed flow		Pa
p_s		Local static pressure at station *s*		Pa
Q		Impeller torque		Nm
Q_{bl}		Volume flow rate inside boundary layer		m³/s
Q_J		Volume flow rate through water jet system		m³/s
R_{TBH}		Total resistance of bare hull		N
$T_{\mathrm{jet}x}$		Jet thrust (can be measured directly in bollard pull condition)		N
T_{net}		Net thrust exerted by the jet system on the hull		N
t		Thrust deduction fraction	$(1-t) = \frac{R_{\mathrm{TBH}}}{T_{\mathrm{net}}}$	1
U_0		Free stream velocity		m/s
$\overline{u}_{eis}$		Mean energy velocity in *i* direction at station s	$\sqrt{\frac{1}{Q_J}\iint u_\xi^3 dA}$	m/s
$\overline{u}_{es}$		Mean (total) energy velocity at station *s*	$\sqrt{\frac{1}{Q_J}\iint u^3 dA}$	m/s
u_{is}		Velocity component in *i*-direction at station *s*		m/s
u_s		Velocity at station s		m/s
$u_{7\varphi}$		Local tangential velocity at station 7		*m/s*
w_1		Geometric intake width at station 1		m
$w_{1\mathrm{A}}$		Width of capture area measured over hull surface at station 1A		m

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
z_6		Vertical distance of nozzle centre relative to undisturbed surface		m
ΔM		Change of momentum flux		N
$\Delta \overline{M}_x$		Change in Momentum Flux in x direction		N
η_D		Overall propulsive efficiency:	$\frac{P_E}{P_D}$	1
η_{duct}		Ducting efficiency:	$\frac{P_{\mathrm{JSE}}}{P_{\mathrm{PE}}}$	1
η_{eI}		Energy interaction efficiency:	$\frac{P_{\mathrm{JSE0}}}{P_{\mathrm{JSE}}}$	1
η_I		Ideal efficiency, equivalent to jet efficiency in free stream conditions	$\frac{P_{\mathrm{TE0}}}{P_{\mathrm{JSE0}}}$	1
η_{inst}		Installation efficiency to account for the distorted flow delivered by the jet intake to the pump		1
η_{INT}		Total interaction efficiency:	$\frac{\eta_{\mathrm{eI}}}{\eta_{\mathrm{mI}}}(1-t)$	1
η_{jet}		Momentum or jet efficiency:	$\frac{P_{\mathrm{TE}}}{P_{\mathrm{JSE}}}$	1
η_{JS}		Jet system efficiency:	$\frac{P_{\mathrm{JSE}}}{P_D}$	1
η_{mI}		Momentum interaction efficiency:	$\frac{T_{\mathrm{net0}}}{T_{\mathrm{net}}}$	1
η_P		Pump efficiency	$\frac{P_{\mathrm{PE}}}{P_D}$	1
η_{P0}		Pump efficiency from a pump loop test		1
η_0		Free stream efficiency:	$\eta_P \eta_{\mathrm{duct}} \eta_I$	1
θ_n		Jet angle relative to the horizontal at the nozzle (station 6)		rad
ρ		Mass density of fluid		kg/m³
ζ_{ij}		Energy loss coefficient between station i and j		1
ζ_{13}		Inlet duct loss coefficient:	$\frac{E_3 - E_1}{\frac{1}{2}\rho U_0^2}$	1

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
ζ_{57}		Nozzle duct loss coefficient:	$\dfrac{E_7 - E_5}{\frac{1}{2}\rho \overline{u}_{e6}^2}$	1

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

2.4 Manoeuvrability and Seakeeping

2.4.1 Manoeuvrability

2.4.1.1 Geometrical Quantities

see also Section 1.3.1 and Section 1.3.3

A_{FB}		Projected area of bow fins		m^2
A_{HL}		Lateral area of the hull	The area of the profile of the underwater hull of a ship when projected normally upon the longitudinal centre plane	m^2
A_{LV}		Lateral area of hull above water		m^2
A_{R}		Total lateral area of rudder		m^2
A_{Rmov}		Lateral area of movable part of rudder		m^2
A_{RN}		Nominal lateral area of rudder	$(A_{\mathrm{R}} + A_{\mathrm{Rmov}}) / 2$	m^2
b_{R}		Rudder span	Maximum distance from root to tip	m
b_{RM}		Mean span of rudder		m
C_{AL}		Coefficient of lateral area of ship	$A_{\mathrm{HL}} / (L\ T)$	1
h		Water depth		m
h_{M}		Mean water depth		m
x_{R}		Longitudinal position of rudder axis		m
δ		Rudder angle, helm angle		rad
Λ_{R}		Aspect ratio of rudder	$b_{\mathrm{R}}^2 / A_{\mathrm{R}}$	1

2.4.1.2 Motions and Attitudes

p		Roll velocity, rotational velocity about body x-axis		1/s
q		Pitch velocity, rotational velocity about body y-axis		1/s
r		Yaw velocity, rotational velocity about body z-axis		1/s
$\dot{p}$		Roll acceleration, angular acceleration about body x-axis	dp / dt	1/s^2
$\dot{q}$		Pitch acceleration, angular acceleration about body y-axis	dq / dt	1/s^2
$\dot{r}$		Yaw acceleration, angular acceleration about body z-axis	dr / dt	1/s^2

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
u		Surge velocity, linear velocity along body x-axis		m/s
v		Sway velocity, linear velocity along body y-axis		m/s
w		Heave velocity, linear velocity along body z-axis		m/s
$\dot{u}$		Surge acceleration, linear acceleration along body x-axis	du / dt	m/s^2
$\dot{v}$		Sway acceleration, linear acceleration along body y-axis	dv / dt	m/s^2
$\dot{w}$		Heave acceleration, linear acceleration along body z-axis	dw / dt	m/s^2
V		Linear velocity of origin in body axes		m/s
V_A, V_0		Approach speed		m/s
V_u		Generalized velocity		m/s
$\dot{V}_u$		Generalized acceleration		m/s^2
V_F		Flow or current velocity		m/s
V_{WR}		Relative wind velocity		m/s
V_{WT}		True wind velocity		m/s
ψ		Course angle or heading		rad
χ		Yaw angle		rad
$d_{t\psi}$		Rate of change of course	$d\psi / dt$	rad/s
Ψ_O		Original course		rad
θ		Pitch angle		rad
ϕ		Roll angle		rad

2.4.1.3 Flow Angles etc.

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
α		Pitch angle	Angle of attack in pitch on the hull	rad
β		Drift angle	Angle of attack in yaw on the hull	rad
β_{WR}		Angle of attack of relative wind		rad
δ		Angle of a control surface, rudder angle, helm angle		rad
δ_0		Neutral rudder angle		rad
δ_{EFF}		Effective rudder inflow angle		rad
δ_{FB}		Bow fin angle		rad
δ_{FS}		Stern fin angle		rad
δ_R		Rudder angle		rad
δ_{RO}		Rudder angle, ordered		rad
ψ_C		Course of current velocity		rad

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
ψ_{WA}		Absolute wind direction	see also section 3.4.2, Wind	rad
ψ_{WR}		Relative wind direction		rad

2.4.1.4 Forces and Derivatives

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
K		Roll moment on body, moment about body x-axis		Nm
M		Pitch moment on body, moment about body y-axis		Nm
N		Yaw moment on body, moment about body z-axis		Nm
N_{r}		Derivative of yaw moment with respect to yaw velocity	$\partial N/\partial r$	Nms
$N_{\dot{r}}$		Derivative of yaw moment with respect to yaw acceleration	$\partial N/\partial \dot{r}$	Nms^2
N_v		Derivative of yaw moment with respect to sway velocity	$\partial N/\partial v$	Ns
$N_{\dot{v}}$		Derivative of yaw moment with respect to sway acceleration	$\partial N/\partial \dot{v}$	Nms^2
N_δ		Derivative of yaw moment with respect to rudder angle	$\partial N/\partial \delta$	Nm
Q_{FB}		Torque of bow fin		Nm
Q_{R}		Torque about rudder stock		Nm
Q_{FS}		Torque of stern fin		Nm
X		Surge force on body, force along body x-axis		N
X_{R}		Longitudinal rudder force		N
X_u		Derivative of surge force with respect to surge velocity	$\partial X/\partial u$	Ns/m
$X_{\dot{u}}$		Derivative of surge force with respect to surge acceleration	$\partial X/\partial \dot{u}$	Ns^2/m
Y		Sway force, force in direction of body axis y		N
Y_r		Derivative of sway force with respect to yaw velocity	$\partial Y/\partial r$	Ns
Y_{R}		Transverse rudder force		N
$Y_{\dot{r}}$		Derivative of sway force with respect to yaw acceleration	$\partial Y/\partial \dot{r}$	Ns^2
Y_v		Derivative of sway force with respect to sway velocity	$\partial Y/\partial v$	Ns/m

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
$Y_{\dot{v}}$		Derivative of sway force with respect to sway acceleration	$\partial Y / \partial \dot{v}$	Ns^2/m
Y_δ		Derivative of sway force with respect to rudder angle	$\partial Y / \partial \delta$	N
Z		Heave force on body, force along body z-axis		N

2.4.1.5 Linear Models

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
C_r		Directional stability criterion	$Y_v (N_r - mux_G) - N_v (Y_r - mu)$	N^2s^2
L_b , l_b		Static stability lever	N_v / Y_v	m
L_d , l_d		Damping stability lever	$(N_r - mux_G) / (Y_r - mu)$	m
T		Time constant of the 1st order manoeuvring equation		s
T_1		First time constant of manoeuvring equation		s
T_2		Second time constant of manoeuvring equation		s
T_3		Third time constant of manoeuvring equation		s
K		Gain factor in linear manoeuvring equation		1/s
P_n		P-number, heading change per unit rudder angle in one ship length		1

2.4.1.6 Turning Circles

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
D_C		Steady turning diameter		m
D_C'		Non-dimensional steady turning diameter	D_C / L_{PP}	1
D_0		Inherent steady turning diameter $\delta_R = \delta_0$		m
D_0'		Non-dimensional inherent steady turning diameter	D_0 / L_{PP}	1
l_r		Loop height of r-δ curve for unstable ship		rad/s
l_δ		Loop width of r-δ curve for unstable ship		rad
r_C		Steady turning rate		1/s
r_C'		Non-dimensional steady turning rate	$r_C L_{PP} / U_C$ or $2 L_{PP} / D_C$	m
R_C		Steady turning radius		m
t_{90}		Time to reach 90 degree change of heading		s
t_{180}		Time to reach 180 degree change of heading		s

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
U_{C}		Speed in steady turn		m/s
x_{090}		Advance at 90° change of heading		m
x_{0180}		Advance at 180° change of heading		m
$x_{0\mathrm{max}}$		Maximum advance		m
y_{090}		Transfer at 90° change of heading		m
y_{0180}		Tactical diameter (transfer at 180° change of heading)		m
$y_{0\mathrm{max}}$		Maximum transfer		m
β_{C}		Drift angle at steady turning		rad

2.4.1.7 Zig-Zag Manoeuvres

t_{a}		Initial turning time		s
t_{c1}		First time to check yaw (starboard)		s
t_{c2}		Second time to check yaw (port)		s
t_{hc}		Period of changes in heading		s
t_{r}		Reach time		s
$y_{0\mathrm{max}}$		Maximum transverse deviation		m
δ_{max}		Maximum value of rudder angle		rad
ψ_{S}		Switching value of course angle		rad
ψ_{01}		First overshoot angle		rad
ψ_{02}		Second overshoot angle		rad

2.4.1.8 Stopping Manoeuvres

s_{F}		Distance along track, track reach		m
$x_{0\mathrm{F}}$		Head reach		m
$y_{0\mathrm{F}}$		Lateral deviation		m
t_{F}		Stopping time		s

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

2.4.2 Seakeeping

Related information is to be found in Chapter 3 on General Mechanics in Sections 3.1.2 on Time and Frequency Domain Quantities, 3.1.3 on Stochastic Processes, 3.2.1 on Inertial Properties,, 3.2.2 on Loads, 3.2.3 on Rigid Body Motions, and 3.4.1 on Waves.

2.4.2.1 Basic Quantities

A_{FS}		Projected area of stern fins		m^2
a_i		Attitudes of the floating system	i = 1, 2, 3, e.g. Euler angles of roll, pitch, and yaw, respectively	rad
f		Frequency	$1 / T$	Hz
f_E		Frequency of wave encounter	$1 / T_E$	Hz
f_z		Natural frequency of heave	$1 / T_z$	Hz
f_θ		Natural frequency of pitch	$1 / T_\theta$	Hz
f_φ		Natural frequency of roll	$1 / T_\varphi$	Hz
F_L		Wave excited lateral shear force	Alias horizontal!	N
F_N		Wave excited normal shear force	Alias vertical!	N
M_L		Wave excited lateral bending moment	Alias horizontal!	Nm
M_N		Wave excited normal bending moment	Alias vertical!	Nm
M_T		Wave excited torsional moment		Nm
n_{AW}		Mean increased rate of revolution in waves		1/s
P_{AW}		Mean power increased in waves		W
Q_{AW}		Mean torque increased in waves		Nm
R_{AW}		Mean resistance increased in waves		N
$S_\eta(f)$, $S_{\eta\eta}(f)$, $S_\eta(\omega)$, $S_{\eta\eta}(\omega)$		Wave elevation auto spectral density	see also section 1.4.1, Waves	$m^2 s$
x_i		Absolute displacement of the ship at the reference point	i = 1, 2, 3 :surge, sway, and heave respectively	m
x_u		Generalized displacement of a ship at the reference point	u = 1...6 surge, sway, heave, roll, pitch, yaw	m, rad
T_{AW}		Mean thrust increase in waves		N
T		Wave period		s
T_e		Wave encounter period		s
T_z		Natural period of heave		s

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
T_θ		Natural period of pitch		s
T_φ		Natural period of roll		s
$Y_z(\omega)$, $A_{z\zeta}(\omega)$		Amplitude of frequency response function for translatory motions	$z_a(\omega) / \zeta_a(\omega)$ or $z_a(\omega) / \eta_a(\omega)$	1
$Y_{\theta\zeta}(\omega)$, $A_{\theta\zeta}(\omega)$		Amplitude of frequency response function for rotary motions	$\Theta_a(\omega) / \zeta_a(\omega)$ or $\Theta_a(\omega) / (\omega^2 / (g\zeta_a(\omega)))$	1
Λ		Tuning factor	$\Lambda_z = \frac{\omega_E}{\omega_Z}$ $\Lambda_\theta = \frac{\omega_E}{\omega_\theta}$ $\Lambda_\varphi = \frac{\omega_E}{\omega_\phi}$ Or $\Lambda_Z = \frac{T_Z}{T_E}$ $\Lambda_\theta = \frac{T_\theta}{T_E}$ $\Lambda_\varphi = \frac{T_\phi}{T_E}$	
μ		Wave encounter angle	Angle between ship positive x axis and positive direction of waves (long crested) or dominant wave direction (short crested)	rad

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

2.4.3 Large Amplitude Motions Capsizing

A		Assumed centre of gravity above keel used for cross curves of stability - I99/1.2.4.1		1
$\overline{AB}$		Longitudinal centre of buoyancy from aft perpendicular - I99/1.2.4.2	Distance of centre of buoyancy from aft perpendicular	m
A_{C}		Area of deck available to crew		m^2
$\overline{AF}$		Distance of the centre of flotation from after perpendicular		m
$\overline{AG_L}$		Longitudinal centre of gravity from aft perpendicular	Distance of centre of gravity from aft perpendicular	m
$\overline{AG_T}$		Transverse distance from assumed centre of gravity A to actual centre of gravity G		m
$\overline{AG_V}$		Vertical distance from assumed centre of gravity A to actual centre of gravity G		m
A_{LV}		Lateral area of hull above water		m^2
A_{RL}		Positive area under righting lever curve		m^2
A_{SI} I_{AS}		Attained subdivision index		1
A_{S}		Area of sails in profile according to ISO 8666		m^2
A_{V}		Projected lateral area of the portion of the ship and deck cargo above the waterline - IMO/IS, IMO/HSC'2000		m^2
$\overline{AZ}$		Righting arm based on horizontal distance from assumed centre of gravity A to Z	Generally tabulated in cross curves of stability	m
B		Centre of buoyancy	Centroid of the underwater volume	
B_{CB}		Breadth between centres of buoyancy of side hulls		m

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
$\overline{BM}$		Transverse metacentre above centre of buoyancy	Distance from the centre of buoyancy CB to transverse metacentre M $\overline{BM} = \frac{I_T}{\nabla} = \overline{KM} - \overline{KB}$	m
$\overline{BM}_L$		Longitudinal metacentre above centre of buoyancy	$\overline{BM}_L = \overline{KM}_L - \overline{KB}$	m
b		Centre of flotation of added buoyancy layer or centre of lost buoyancy of the flooded volume		
b		Maximum tank breadth		m
C_{D}		Crew density	Proportion of boat plan needed for crew	
C_H		Height coefficient, depending on the height above sea level of the structural member exposed to the wind		1
C_{Lcpi}		Crew limit	Maximum number of persons on board	
C_{MTL}		Longitudinal trimming coefficient - I99/1.2.4.3	Trimming moment divided by change in trim which approximately equals $\overline{BM}_L/L$	1
C_{s}		Shape coefficient, depending on the shape of the structural member exposed to the wind		1
d		Draught, moulded, of ship hull - I99/1.2.1		m
d		Density coefficient for submerged test weights		1
F		Centre of flotation of the water plane		
F		Wind force - IMO/IS		
f		Freeboard	From the freeboard markings to the freeboard deck, according to official rules	m
$\overline{FB}$		Longitudinal centre of buoyancy, L_{CB}, from forward perpendicular	Distance of centre of buoyancy from forward perpendicular	m
$\overline{FF}$		Longitudinal centre of flotation, L_{CF}, from forward perpendicular	Distance of centre of floatation from forward perpendicular	m

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
$\overline{FG}$		Longitudinal centre of gravity, from forward perpendicular	Distance of centre of gravity from forward perpendicular	m
G		Centre of gravity of a vessel		
g		Centre of gravity of an added or removed weight (mass)		1
$\overline{GG}_1$		Vertical stability lever caused by a weight shift or weight addition	$\overline{KG}_1 = \overline{KG}_0 + \overline{GG}_1$	m
$\overline{GG}_H$		Horizontal stability lever caused by a weight shift or weight addition		m
$\overline{GG}_L$		Longitudinal stability lever caused by a weight shift or weight addition		m
$\overline{GG}_V$		Vertical stability lever caused by a weight shift or weight addition	$\overline{KG}_1 = \overline{KG}_0 + \overline{GG}_1$	m
$\overline{GM}$		Transverse metacentric height	Distance of centre of gravity to the metacentre $\overline{GM} = \overline{KM} - \overline{KG}$ (not corrected for free surface effect)	m
$\overline{GM}_{\text{EFF}}$		Effective transverse metacentric height	$\overline{GM}$ Corrected for free surface and/or free communication effects	m
$\overline{GM_L}$		Longitudinal metacentric height	Distance from the centre of gravity G to the longitudinal metacentre M_{L} $\overline{GM}_L = \overline{KM}_L - \overline{KG}$	m
$\overline{GZ}$		Righting arm or lever	$\overline{GZ} = \overline{AZ} - \overline{AG}_V\ \ sin\,\phi$- $\overline{AG}_T$ cos φ	m
$\overline{GZ}$		Arm of static stability corrected for free surfaces - IMO/table		m
$\overline{GZ}_{\text{MAX}}$		Maximum righting arm or lever		m
h		Maximum tank height		m
h_{CE}		Height of centre of area of A_{SP} above waterline at SSM		m
HL		Heeling lever (due to various reasons) - IMO/HSC'2000		m

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
h_{LP}		Height of waterline above centre of area of immersed profile		m
K		Keel reference		
$\overline{KA}$		Assumed centre of gravity above moulded base of keel	Distance from the assumed centre of gravity A to the moulded base of keel or K	m
$\overline{KB}$		Centre of buoyancy above moulded base of keel	Distance from the centre of buoyancy B to the moulded base of keel or K	m
$\overline{KG}$		Centre of gravity above moulded base of keel	Distance from the centre of gravity G to the moulded base of keel or K	m
$\overline{Kg}$		Vertical centre of gravity of added or removed weight above moulded base of keel	Distance from the assumed centre of gravity, g, to the moulded base of keel or K	m
$\overline{KM}$		Transverse metacentre above moulded base of keel	Distance from the transverse metacentre M to the moulded base of keel or K	m
$\overline{KM_L}$		Longitudinal metacentre above moulded base of keel	Distance from the longitudinal metacentre M_{L} to the moulded base of keel or K	m
k		Roll damping coefficient expressing the effect of bilge keels		1
L		Length of the vessel on the waterline in maximum load condition - IMO/IS		m
l		Arm of dynamic stability corrected for free surfaces - IMO/table		m
l		Longitudinal trimming arm	$X_{\mathrm{CG}} - X_{\mathrm{CB}}$	m
l		Maximum tank length		m
l_{s}		Actual length of enclosed superstructure extending from side to side of the vessel		m
l_{w}		Wind heeling lever		m
M		Metacentre of a vessel	See subscripts for qualification	
m		Ship mass	W/g	kg
M_{C}		Maximum offset load moment due to crew		Nm

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
M_{c}		Minimum capsizing moment as determined when account is taken of rolling		Nm
M_{FS}		Free surface moment at any inclination		Nm
m_{LCC}		Mass in light craft condition		kg
m_{LDC}		Mass in loaded displacement condition according to …		kg
m_{MTL}		Maximum total load (mass)		kg
M_{R}		Heeling moment due to turning		Nm
M_{S}		Moment of ship stability in general	$\Delta\ \overline{GZ}$. Other moments such as those of capsizing, heeling, etc. will be represented by M_{S} with additional subscripts as appropriate.	Nm
m_{SSC}		Mass in standard sailing conditions according to …		kg
M_{TC}		Moment to change trim one centimetre		Nm/cm
M_{TM}		Moment to change trim one meter	$\Delta\ C_{MTL}$	Nm/m
M_{W}		Maximum heeling moment due to wind		Nm
M_{v}		Dynamically applied heeling moment due to wind pressure		Nm
$\overline{OG}$		Height of centre of gravity above waterline		m
P_{V}		Wind pressure		Pa
r		Effective wave slope coefficient		1
R_{SI}		Required subdivision index		1
s		Wave steepness		1
$STIX$		Actual stability index value according to …		1
$\underline{\overline{STIX}}$		Required stability index value, see …		1
T		Equivalent transverse heeling arm	Heeling moment/Δ	m
TL		Turning lever		m
t_{s} t_{KL}		Static trim	T_{A} - T_{F} - d_{KL}	m

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
V v		Tank total capacity		m³
V_0		Speed of craft in the turn - IMO/HSC'2000 Service speed - IMO/IS		m/s
v_W		Wind speed used in calculation		m/s
W		Ship weight	$m\ g$	N
x_CB		Longitudinal centre of floatation of added buoyant layer	Longitudinal distance from reference point to the centre of the added buoyant layer, b	m
X_CB L_CB		Longitudinal centre of buoyancy (L_CB)	Longitudinal distance from reference point to the centre of buoyancy, B	m
X_CF L_CF		Longitudinal centre of flotation (L_CF)	Longitudinal distance from reference point to the centre of flotation, F	m
x_CG		Longitudinal centre of gravity of added weight (mass)	Longitudinal distance from reference point to the centre of gravity, g, of an added or removed weight (mass)	m
X_CG L_CG		Longitudinal centre of gravity (L_CG)	Longitudinal distance from reference point to the centre of gravity, G	m
X_1, X_2		Roll damping coefficients		1
x_D		Distance of down flooding opening from end of boat		m
Y_CG, y_CG		Lateral displacement of centre of gravity (Y_CG)	Lateral distance from a reference point to the centre of gravity, G	m
y_D		Distance of down flooding opening from gunwale		m
y_D'		Distance of down flooding opening off centreline		m
Z		Intersection of righting arm with line of action of the centre of buoyancy		
Z		Vertical distance from the centre of A to the centre of the underwater lateral area or approximately to a point at one half the draught - IMO/IS		m

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
Z, h		Vertical distance from the centre of A to the waterline		m
z_{D}		Height above waterline of down flooding opening		m
z_{SA}		Static sinkage at AP	Caused by loading	m
z_{SF}		Static sinkage at FP	Caused by loading	m
z_S		Mean static sinkage	$(z_{\mathrm{SF}}+z_{\mathrm{SA}})/2$	m
δ		Tank block coefficient		1
δt_{KL}		Change in static trim		m
Δ		Displacement (buoyant) force	$g\ \rho\ \nabla$	N
Δ_m		Displacement mass	$\rho\ \nabla$	kg
∇		Displacement volume	$\Delta\ /\ (\rho g)$	m³
∇_{fw}		Displacement volume of flooded water	$\Delta_{\mathrm{fw}}\ /\ (\rho g)$	m³
ϕ		Heel angle		rad
ϕ_0		Heel angle during offset load tests		rad
$\phi_{0(\mathrm{REQ})}$		Maximum permitted heel angle during …		rad
ϕ_{D}		Actual down flooding angle according to …		rad
$\phi_{\mathrm{D(REQ)}}$		Required down flooding angle, see…		rad
ϕ_{DC}		Down flooding angle to non-quick draining cockpits		rad
ϕ_{DH}		Down flooding angle to any main access hatchway		rad
ϕ_{F}		Heel angle at flooding		rad
ϕ_{GZMAX}		Angle of heel at which maximum righting moment occurs		rad
ϕ_{R}		Assumed roll angle in a seaway		rad
ϕ_{VS}		Heel angle for vanishing stability		rad
ϕ_{W}		Heel angle due to calculation wind		rad
μ		Volumetric permeability	The ratio of the volume of flooding water in a compartment to the total volume of the compartment	1

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
θ_{c}		Capsizing angle under the action of a gust of wind IMO/IS		rad
ϕ_{m}		Heel angle corresponding to the maximum of the statical stability curve		rad
θ_{S}		Static trim angle	$\tan^{-1}((z_{SF}-z_{SA})/L)$	rad
ρ		(Liquid) mass density		kg/m³
ρ_{A}		(Air) mass density		kg/m³
$\rho_{\oslash}$		(Water) mass density		kg/m³

2.4.4 Symbols for Attributes and Subscripts

A	Aft
E	Entrance
F	Fore
R	Run
Z	Heave
θ	Pitch
φ	Roll

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

3. SPECIAL CRAFT

3.1 Planing and Semi-Displacement Vessels

3.1.1 Geometry and Hydrostatics

See also Section 1.2.1, Hull Geometry and Section 1.2.2 Propulsor Geometry

A_P		Planing bottom area	Horizontally projected planing bottom area (at rest), excluding area of external spray strips	m^2
$B_{L\mathrm{CG}}$		Breadth at longitudinal position of the centre of gravity	Breadth over spray strips measured at transverse section containing centre of gravity	m
B_PC		Breadth over chines	Breadth over chines, excluding external spray strips	m
B_PA		Mean breadth over chines	$A_\mathrm{P} / L_\mathrm{P}$	m
B_PT		Transom breadth	Breadth over chines at transom, excluding external spray strips	m
B_PX		Maximum breadth over chines	Maximum breadth over chines, excluding external spray strips	m
L_SB		Total length of shafts and bossings		m
L_PR		Projected chine length	Length of chine projected in a plane parallel to keel	m
β		Deadrise angle of planing bottom	Angle between a straight line approximating body section and the intersection between basis plane and section plane	rad
β_M		Deadrise angle at midship section		rad
β_T		Deadrise angle at transom		rad
ε_SH		Shaft angle	Angle between shaft line and reference line (positive, shaft inclined downwards)	rad

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

3.1.2 Geometry and Levers, Underway

3.1.2.1 Geometry, Underway

d_{TR}		Immersion of transom, underway	Vertical depth of trailing edge of boat at keel below water surface level	m
h_{P}		Wetted height of strut palms (flange mounting)		m
h_{R}		Wetted height of rudders		m
L_{C}		Wetted chine length, underway		m
l_{CP}		Lever of resultant of pressure forces, underway	Distance between centre of pressure and aft end of planing surface	m
L_{K}		Wetted keel length, underway		m
L_{M}		Mean wetted length, underway	$(L_{\mathrm{K}} + L_{\mathrm{C}}) / 2$	m
S_{WHP}		Wetted area underway of planing hull	Principal wetted area bounded by trailing edge, chines and spray root line	m^2
S_{WB}		Wetted bottom area, underway	Area bounded by stagnation line, chines or water surface underway and transom	m^2
S_{WHE}		Wetted hull area, underway	Total wetted surface of hull underway, including spray area and wetted side area, w/o wetted transom area	m^2
S_{WHS}		Area of wetted sides	Wetted area of the hull side above the chine or the design water line	m^2
S_{WS}, S_{S}		Area wetted by spray	Wetted area between design line or stagnation line and spray edge	m^2
α_{B}		Angle of stagnation line	Angle between projected keel and stagnation line in a in plane normal to centre plane and parallel to reference line	rad
α_{BAR}		Barrel flow angle	Angle between barrel axis and assumed flow lines	rad
$\varepsilon_{\mathrm{W}L}$		Wetted length factor	$L_{\mathrm{M}} / L_{\mathrm{WL}}$	1
$\varepsilon_{\mathrm{W}S}$		Wetted surface area factor	S / S_0	1

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
θ_{DWL},		Running trim angle based on design waterline	Angle between design waterline and running waterline (positive bow up)	rad
θ_{S}, θ_0		Static trim angle	Angle between ship design waterline and actual water line at rest (positive bow up) $\tan^{-1}((z_{\mathrm{SF}} - z_{\mathrm{SA}}) / L)$	rad
θ_V , θ_{D}		Running (dynamic) trim angle	Angle between actual water line at rest and running water line (positive bow up) $\tan^{-1}((z_{V\mathrm{F}} - z_{V\mathrm{A}}) / L)$	rad
λ_{W}		Mean wetted length-breadth ratio	$L_{\mathrm{M}} / (B_{L\mathrm{CG}})$	1
τ		Running trim angle based on design waterline	Angle between design waterline and running waterline (positive bow up)	deg
τ_{DWL}		Reference line angle	Angle between the reference line and the design waterline	rad
τ_{R}		Angle of attack relative to the reference line	Angle between the reference line and the running waterline	rad
φ_{SP}		Spray angle	Angle between stagnation line and keel (measured in plane of bottom)	rad
δ_λ		Dimensionless increase in total friction area	Effective increase in friction area length-breadth ratio due to spray contribution to drag	1

3.1.2.2 Levers, Underway

e_{A}		Lever of appendage lift force N_{A}	Distance between N_{A} and centre of gravity (measured normally to N_{A})	m
e_{B}		Lever of bottom normal force N_{B}	Distance between N_{B} and centre of gravity (measured normally to N_{B})	m
$e_{\mathrm{P}N}$		Lever of propeller normal force $N_{\mathrm{P}N}$	Distance between propeller centreline and centre of gravity (measured along shaft line)	m
$e_{\mathrm{P}P}$		Lever of resultant of propeller pressure forces $N_{\mathrm{P}P}$	Distance between N_{PP} and centre of gravity (measured normally to $N_{\mathrm{P}P}$)	m
e_{PS}		Lever of resultant propeller suction forces N_{PS}	Distance between N_{PS} and centre of gravity (measured normal to N_{PS})	m

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
$e_{\mathrm{R}P}$		Lever of resultant of rudder pressure forces $N_{\mathrm{R}P}$	Distance between $N_{\mathrm{R}P}$ and centre of gravity (measured normal to $N_{\mathrm{R}P}$)	m
f_{AA}		Lever of wind resistance R_{AA}	Distance between R_{AA} and centre of gravity (measured normal to R_{AA})	m
f_{AP}		Lever of appendage drag R_{AP}	Distance between R_{AP} and centre of gravity (measured normal to R_{AP})	m
f_{F}		Lever of frictional resistance R_{F}	Distance between R_{F} and centre of gravity (measured normal to R_{F})	m
f_{K}		Lever of skeg or keel resistance R_{K}	Distance between R_{K} and centre of gravity (measured normal to R_{K})	m
f_{R}		Lever of augmented rudder drag ΔR_{RP}	Distance between ΔR_{RP} and centre of gravity (measured normal to ΔR_{RP})	m
f_{S}		Lever of axial propeller thrust	Distance between axial thrust and centre of gravity (measured normal to shaft line)	m
f_{T}		Lever of total resistance R_{T}	Distance between R_{T} and centre of gravity (measured normal to R_{T})	m

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

3.1.3 Resistance and Propulsion

See also Sections 2.3.1 on Hull Resistance

C_{L0}		Lift coefficient for zero deadrise	$\Delta / (B_{CG}^2\ q)$	1
$C_{L\beta}$		Lift coefficient for deadrise surface	$\Delta / (B_{CG}^2\ q)$	1
C_V		Froude number based on breadth	$V / (B_{CG}\ g)^{1/2}$	1
C_Δ		Load coefficient	$\Delta / (B_{CG}^3\ \rho\ g\ )$	1
L_{VHD}		Vertical component of hydrodynamic lift		N
L_{VS}		Hydrostatic lift	Due to buoyancy	N
F_{TA}		Appendage drag force (parallel to reference line)	Drag forces arising from appendages inclined to flow, assumed to act parallel to the reference line	N
F_{TB}		Bottom frictional force (parallel to reference line)	Viscous component of bottom drag forces assumed acting parallel to the reference line	N
F_{TK}		Keel or skeg drag force (parallel to reference line)	Drag forces arising from keel or skeg, assumed to act parallel to the reference line	N
F_{TRP}		Additional rudder drag force (parallel to reference line)	Drag forces arising from influence of propeller wake on the rudder assumed to act parallel to the reference line	N
N_A		Appendage lift force (normal to reference line)	Lift forces arising from appendages inclined to flow, assumed to act normally to reference line	N
N_B		Bottom normal force (normal to reference line)	Resultant of pressure and buoyant forces assumed acting normally to the reference line	N
N_{PP}		Propeller pressure force (normal to reference line)	Resultant of propeller pressure forces acting normally to the reference line	N
N_{PS}		Propeller suction force (normal to reference line)	Resultant of propeller suction forces acting normally to the reference line	N
N_{RP}		Rudder pressure force (normal to reference line)	Resultant of rudder pressure forces acting normally to the reference line	N

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
R_{K}		Keel drag		N
R_{π}		Induced drag	$g\,\rho\,\nabla \tan\tau$	N
R_{PAR}		Parasitic drag	Drag due to inlet and outlet openings	N
$R_{P\mathrm{S}}$		Pressure component of spray drag		N
R_{T}		Total resistance	Total towed resistance	N
R_{VS}		Viscous component of spray drag	$C_{\mathrm{F}}\, S_{\mathrm{WS}}\, q_{\mathrm{S}}$	N
V_{BM}		Mean bottom velocity	Mean velocity over bottom of the hull	m/s
V_{SP}		Spray velocity	Relative velocity between hull and spray in direction of the spray	m/s

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

3.2 Multi-Hull Vessels

3.2.1 Geometry and Hydrostatics

See also Section 2.2.1, Hull Geometry

A_{I}		Strut-hull intersection area		m^2
B_{B}		Box breadth	Breadth of main deck	m
B_{S}		Hull spacing	Distance between hull centre lines	m
B_{TV}		Tunnel width	Minimal distance of the demihulls at the waterline	m
D_{H}		Hull diameter	Diameter of axis symmetric submerged hulls	m
D_{X}		Hull diameter at the longitudinal position "X"		m
H_{DK}		Deck clearance	Minimum clearance of wet deck from water surface at rest	m
H_{SS}		Strut submerged depth	Depth of strut from still water line to strut-hull intersection	m
i_{EI}		Half angle of entrance at tunnel (inner) side	Angle of inner water line with reference to centre line of demihull	rad
i_{EO}		Half angle of entrance at outer side	Angle of outer water line with reference to centre line of demihull	rad
L_{CH}		Length of centre section of hull	Length of prismatic part of hull	m
L_{CS}		Length of centre section of strut	Length of prismatic part of strut	m
L_{H}		Box length	Length of main deck	m
L_{NH}		Length of nose section of hull	Length of nose section of hull with variable diameter	m
L_{NS}		Length of nose section of strut	Length of nose section of strut with variable thickness	m
L_{S}		Strut length	Length of strut from leading to trailing edge	m
L_{SH}		Length of submerged hull		m
t_{S}		Maximum thickness of strut		m

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

3.2.2 Resistance and Propulsion

3.2.2.1 Resistance Components

See also Section 2.3.1 on Hull Resistance

R_{FMH}		Frictional resistance of multi-hull vessel		N
R_{FINT}		Frictional resistance interference correction	$R_{\mathrm{FMH}} - \Sigma R_{\mathrm{F}}$	N
R_{RMH}		Residuary resistance correction of multi-hull	$R_{\mathrm{TMH}} - R_{\mathrm{FMH}}$	N
R_{RI}		Residuary resistance interference correction	$R_{\mathrm{RMH}} - \Sigma R_{\mathrm{R}}$	N
R_{TMH}		Total resistance of multi-hull vessel		N
R_{TI}		Total resistance interference correction	$R_{\mathrm{TMH}} - \Sigma R_{\mathrm{T}}$	N

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

3.3 Hydrofoil Boats

3.3.1 Geometry and Hydrostatics

See Sections 2.2.1 and 2.2.4

A_{F}		Foil area (general)	Foil area in horizontal plane	m^2
A_{FT}		Total foil plane area		m^2
B_{FOA}		Maximum vessel breadth including foils		m
b_{S}		Span of struts		m
b_{ST}		Transverse horizontal distance of struts		m
c_{C}		Chord length at centre plane		m
c_{F}		Chord length of flap		m
c_{M}		Mean chord length		m
c_{S}		Chord length of a strut		m
c_{SF}		Chord length of strut at intersection with foil		m
c_{T}		Chord length at foil tips		m
W_{F}		Weight of foil		N
α_{c}		Geometric angle of twist		rad
θ_{DH}		Dihedral angle		rad
∇_{F}		Foil displacement volume		m^3

3.3.1.1 Geometry, Underway

A_{FE}		Emerged area of foil		m^2
A_{FF}		Submerged area of front foil		m^2
A_{FR}		Submerged area of rear foil		m^2
A_{FS}		Submerged foil area		m^2
A_{FST0}		Submerged foil plan area at take-off speed		m^2
A_{SS}		Submerged strut area		m^2
b_{w}		Foil span wetted		m
$c_{P\mathrm{F}}$		Distance of centre of pressure on a foil or flap from leading edge		m
Fr_L		Froude number based on foil distance	$V / (g\, L_{\mathrm{F}})^{1/2}$	1
Fr_c		Froude number based on chord length	$V / (g\, c_{\mathrm{M}})^{1/2}$	1
h_{CG}		Height of centre of gravity foilborne	Distance of centre of gravity above mean water surface	m
h_{F}		Flight height	Height of foil chord at foil-borne mode above position at rest	m
h_{K}		Keel clearance	Distance between keel and mean water surface foilborne	m

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
l_{F}		Horizontal distance of centre of pressure of front foil to centre of gravity		m
l_{FR}		Horizontal distance between centres of pressure of front and rear foils	$l_{\mathrm{F}} + l_{\mathrm{R}}$	m
l_{R}		Horizontal distance of centre of pressure of rear foil to centre of gravity		m
T_{F}		Foil immersion	Distance between foil chord and mean water surface	m
T_{FD}		Depth of submergence of apex of a dihedral foil	Distance between foil apex and mean water surface	m
T_{FM}		Mean depth of foil submerg-ence		m
α_{IND}		Downwash or induced angle		rad
α_{M}		Angle of attack of mean lift coefficient for foils with twist		rad
α_{S}		Angle of attack for which flow separation (stall) occurs		rad
α_{TO}		Incidence angle at take-off speed		rad

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

3.3.2 Resistance and Propulsion

See also **Section 2.3.1 Hull Resistance**

3.3.2.1 Basic Quantities

D_{F}		Foil drag	Force in the direction of motion of an immersed foil	N
D_{FR}		Drag force on rear foil	$C_{DF}\, A_{\mathrm{FR}}\, q$	N
D_{FF}		Drag force on front foil	$C_{DF}\, A_{\mathrm{FF}}\, q$	N
D_{I}		Induced drag	For finite span foil, the component of lift in the direction of motion	N
D_{INT}		Interference drag	Due to mutual interaction of the boundary layers of intersecting foil	N
D_{P0}		Profile drag for angle of attack equal to zero lift	Streamline drag	N
D_{S}		Spray drag	Due to spray generation	N
D_{ST}		Strut drag		N
D_{W}		Wave drag	Due to propagation of surface waves	N
D_{V}		Ventilation drag	Due to reduced pressure at the rear side of the strut base	N
L_{F}		Lift force on foil	$C_L\, A_{\mathrm{FT}}\, q$	N
L_{FF}		Lift force on front foil	$C_L\, A_{\mathrm{FF}}\, q$	N
L_{FR}		Lift force on rear foil	$C_L\, A_{\mathrm{FR}}\, q$	N
L_0		Profile lift force for angle of attack of zero	$C_{L0}\, A_{\mathrm{FT}}\, q$	N
L_{TO}		Lift force at take off	$C_{L\mathrm{TO}}\, A_{\mathrm{FT}}\, q$	N
M		Vessel pitching moment		Nm

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

3.3.2.2 Derived Quantities

$C_{D\mathrm{F}}$		Drag coefficient of foil	$D_\mathrm{F} / (A_\mathrm{FS}\, q)$	1
$C_{D\mathrm{I}}$		Induced drag coefficient	$D_\mathrm{I} / (A_\mathrm{FS}\, q)$	1
$C_{D\mathrm{INT}}$		Interference drag coefficient	$D_\mathrm{INT} / (A_\mathrm{FS}\, q)$	1
C_{D0}		Section drag coefficient for angle of attack equal to zero	$D_\mathrm{P} / (A_\mathrm{FS}\, q)$	1
$C_{D\mathrm{S}}$		Spray drag coefficient	$D_\mathrm{S} / (A_\mathrm{FS}\, q)$	1
$C_{D\mathrm{VENT}}$		Ventilation drag coefficient	$D_\mathrm{V} / (A_\mathrm{FS}\, q)$	1
$C_{D\mathrm{W}}$		Wave drag coefficient	$D_\mathrm{W} / (A_{FS}\, q)$	1
$C_{L\mathrm{F}}$		Foil lift coefficient	$L_\mathrm{F} / (A_\mathrm{FS}\, q)$	1
C_{L0}		Profile lift coefficient for angle of attack equal to zero	$L_0 / (A_\mathrm{FS}\, q)$	1
$C_{L\mathrm{TO}}$		Lift coefficient at take-off condition	$L_\mathrm{TO} / (A_\mathrm{FS}\, q)$	1
$C_{L\mathrm{X}}$		Slope of lift curve	$dC_L / d\alpha$	1
C_M		Pitching moment coefficient	$M / ((A_\mathrm{FF} + A_\mathrm{FR}) (l_\mathrm{F} - l_\mathrm{R})\, q)$	1
M_F		Load factor of front foil	L_FF / Δ	1
M_R		Load factor of rear foil	L_FR / Δ	1
ε_F		Lift/ Drag ratio of foil	L / D	1

3.4 ACV and SES

3.4.1 Geometry and Hydrostatics

See also Section 1.2.1

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
A_{C}		Cushion area	Projected area of ACV or SES cushion on water surface	m^2
B_{C}		Cushion breadth	SES cushion breadth measured between the side walls	m
B_{WLT}		Total waterline breadth of SES	At the water line	m
H_{CG}		Height of centre of gravity above mean water plane beneath craft		m
h_{BS}		Bow seal height	Distance from side wall keel to lower edge of bow seal	m
H_{SK}		Skirt depth		m
h_{SS}		Stern seal height	Distance from side wall keel to lower edge of stern seal	m
L_{B}		Deformed bag contact length		m
L_{C}		Cushion length		m
L_{E}		Effective length of cushion	A_{C} / B_{C}	m
S_{H0}		Wetted area of side hulls at rest off cushion	Total wetted area of side walls under way on cushion	m^2
S_{SHC}		Wetted area of side hulls under way on cushion	Total wetted area of side walls under way on cushion	m^2
S_{SH}		Wetted area of side hulls under way off cushion	Total wetted area of side walls under way off cushion	m^2
X_{H}, L_{H}		Horizontal spacing between inner and outer side skirt hinges or attachment points to structure	needs clarification	m
X_{S}, L_{S}		Distance of leading skirt contact point out-board or outer hinge of attachment point to structure	needs clarification	m
Z_{H}, H_{H}		Vertical spacing between inner and outer side skirt hinges or attachment points to structure	needs clarification	m
δB_{C}		Increase in cushion breadth due to water contact		m
ε_{WS}		Wetted surface factor	S_{SHC} / S_{SH0}	1
θ_{B}		Bag contact deformation angle		rad

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
θ_{F}		Finger outer face angle		rad
θ_{W}		Slope of mean water plane for surface level beneath cushion periphery		rad
ρ_{A}		*(ACV and SES)* Mass density of air	Mass of air per unit volume	kg/m^3
ζ_{C}		Height of cushion generated wave above mean water plane at leading edge side of the skirt		m

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

3.4.2 Resistance and Propulsion

See also Section 2.3.1 on Hull Resistance

C_{Δ}		Cushion loading coefficient	$\Delta / (g\, \rho_A\, A_C^{3/2})$	1
C_{PR}		Aerodynamic profile drag coefficient	$R_0 / (\rho_A\, V_R^2\, A_C / 2)$	1
C_{WC}		Cushion wave making coefficient		1
p_B		Mean bag pressure		Pa
p_{BS}		Bow seal pressure	Pressure in the bow seal bag	Pa
p_{CE}		Mean effective skirt pressure		Pa
p_{CU}		Cushion pressure	Mean pressure in the cushion	Pa
p_{FT}		Fan total pressure		Pa
p_{LR}		Cushion pressure to length ratio	P_{CU} / L_C	Pa/m
p_{SK}		Skirt pressure in general		Pa
p_{SS}		Stern seal pressure	Pressure in the stern seal bag	Pa
P_{FCU}		Power of lift fan		W
P_{FSK}		Power of skirt fan		W
Q_{BS}		Bow seal air flow rate	Air flow rate to the bow seal	m^3/s
Q_{CU}		Cushion air flow rate	Air flow rate to cushion	m^3/s
Q_{SS}		Stern seal air flow rate	Air flow rate to the stern seal	m^3/s
Q_T		Total air volume flow		m^3/s
Q_{TS}		Total air volume flow of skirt		m^3/s
R_{AT}		Total aerodynamic resistance	$R_M + R_0$	N
R_H		Hydrodynamic resistance	$R_W + R_{WET}$	N
R_M		Intake momentum resistance in general	$\rho_A\, Q_T\, V_A$	N
R_{MCU}		Intake momentum resistance of cushion	$\rho_A\, Q_{CU}\, V_A$	N
R_{ASK}		Intake momentum resistance of skirt	$\rho_A\, Q_{TS}\, V_A$	N
R_{WET}		Resistance due to wetting		N
T_C		Cushion thrust		N

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

3.5 Ice Going Vessels

3.5.1 Resistance and Propulsion

(See Figure 3.4, p 225 and Figure 3.8, p 231 of Vol. 1 of the *Proceedings of the 21st ITTC*)

C_I		Coefficient of net ice resistance	$R_\mathrm{I} / (\rho_I\, g\, h^2\, B)$	1
C_IW		Coefficient of water resistance in the presence of ice	$R_\mathrm{IW} / (S\, q_\mathrm{IW})$	1
F_IN		Normal ice force on a body	Projection of hull - ice interaction force on the external normal	N
F_IT		Tangential ice force on a body	Projection of the hull - ice interaction force on the direction of motion	N
Fr_I		Froude number based on ice thickness	$V / (g\, h_\mathrm{I})^{1/2}$	1
$F_{X\mathrm{I}}$ F_YI F_ZI		Components of the local ice force		N N N
f_ID		Coefficient of friction between surface of body and ice (dynamic)	Ratio of tangential force to normal force between two bodies (dynamic condition)	1
f_IS		Coefficient of friction between surface of body and ice (static)	The same as above (static condition)	1
h_I		Thickness of ice		m
h_SN		Thickness of snow cover		m
K_QIA		Average coefficient of torque in ice	$Q_{IA} / (\rho_\mathrm{W}\, n_{IA}^2\, D^5)$	1
$K_{T\mathrm{IA}}$		Average coefficient of thrust in ice	$T_{IA} / (\rho_\mathrm{W}\, n_{IA}^2\, D^4)$	1
n_IA		Average rate of propeller revolution in ice		Hz
P_DI		Delivered power at propeller in ice	$2\, \pi\, Q_\mathrm{IA}\, n_\mathrm{IA}$	W
Q_IA		Average torque in ice		Nm
R_I		Net ice resistance	$R_\mathrm{IT} - R_\mathrm{IW}$	N
R_IT		Total resistance in ice	Ship towing resistance in ice	N
R_IW		Hydrodynamic resistance in presence of ice	Total water resistance of ship in ice	N
T_IA		Average total thrust in ice		N
η_ICE		Relative propulsive efficiency in ice	$\eta_\mathrm{ID} / \eta_\mathrm{D}$	1

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
η_{ID}		Propulsive efficiency in ice	$R_{\mathrm{IT}}\ V\ /\ (2\ \pi\ n_{\mathrm{IA}}\ Q_{\mathrm{IA}})$	1

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

3.6 Sailing Vessels

3.6.1 Geometry and Hydrostatics

See also Section 2.2.1 on Hull Geometry

A_{J}		Area of jib or genoa		m^2
A_{LK}		Lateral area of keel		m^2
A_{LT}		Total lateral area of yacht		m^2
A_{m}		Area of mainsail		m^2
A_{N}		Normalized sail area		m^2
A_{SP}		Area of spinnaker		m^2
A_{S}, S_A		Sail area in general	$(P\,E + I\,J) / 2$	m^2
A_{WPT}		Representative projected area of WPT		m^2
B_{OA}		Breadth, overall		m
C_{pi} E		Center of pressure for A_i Mainsail base		m
I		Fore triangle height		m
J		Fore triangle base		m
P		Mainsail height		m
L_{EFF}		Effective length for Reynolds Number		m
S_{C}		Wetted surface area of canoe body		m^2
S_{K}		Wetted surface area of keel		m^2
S_{R}		Wetted surface area of rudder		m^2
T_{C}		Draught of canoe body		m
T_{EFF}		Effective draught	$F_{\mathrm{H}} / (\rho V_{\mathrm{B}}^2 R)^5$	m
Z_{CE}		Height of centre of effort of sails above waterline in vertical centre plane		m
∇_{C}		Displaced volume of canoe body		m^3
∇_{K}		Displaced volume of keel		m^3
∇_{R}		Displaced volume of rudder		m^3
Δ_{C}		Displacement force (weight) of canoe body		N
Δ_{K}		Displacement force (weight) of keel		N
Δ_{R}		Displacement force (weight) of rudder		N

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit

3.6.2 Resistance and Propulsion

C_{FU}		Frictional resistance coefficient (upright)	$R_{\mathrm{FU}} / (S\ q)$	1
C_{RU}		Residuary resistance coefficient (upright)	$R_{\mathrm{RU}} / (S\ q)$	1
C_{TU}		Total resistance coefficient (upright)	$R_{\mathrm{TU}} / (S\ q)$	1
C_{WU}		Wave resistance coefficient (upright)		1
$C_{\mathrm{T}\varphi}$		Total resistance coefficient with heel and leeway	$R_{\mathrm{T}\varphi} / (S\ q)$	1
C_{I}		Induced resistance coefficient		1
C_x, C_y, C_z		Force coefficients		1
F_{H}		Heeling force of sails		N
F_{R}		Driving force of sails		N
F_{V}		Vertical force of sails		N
H		Side force		N
L_{HY}		Hydrodynamic lift force		N
R_{AW}		Mean added resistance in waves		N
R_{FU}		Friction resistance (upright)		N
R_{RU}		Residuary resistance (upright)		N
R_{I}		Resistance increase due to side (induced resistance)		N
R_{TU}		Total resistance (upright)		N
$R_{T\varphi}$		Total resistance when heeled	$R_{\mathrm{TU}} + R_{\varphi}$	N
R_{φ} , R_{H}		Resistance increase due to heel (with zero side force)		N
X,Y,Z		Components of resultant force along designated axis		N
V		Vessel velocity		m/s
V	STW	Speed through water in heading direction		m/s
V_{WR}	AWS	Apparent wind velocity		m/s
V_{WT}	TWS	True wind velocity		m/s
V_{mc}		Velocity made good on course		m/s
V_{mg}		Velocity made good to windward (contrary to wind direction)		m/s
β_{L}		leeway angle		rad

ITTC Symbol	Acronym	Name	Definition or Explanation	SI-Unit
β_{WA}	AWA	apparent wind angle (relative to boat course)		rad
β_{WT}	TWA	true wind angle (relative to boat course)		rad
ψ		Heading relative earth		rad

4. BACKGROUND AND REFERENCES

4.1 Symbols and Terminology Group

The tasks of the former Symbols and Terminology Group (SaT) have been handed over to the Quality Systems Group in 2002.

4.2 Description of the List of Symbols

4.2.1 Classification

The prime concern of the QS Group was to revise and try to complement the list of ITTC Standard Symbols sticking to the system for the classification of concepts.

With this regard, the following design requirements and goals have been maintained:

1. a coherent document, meeting the present and possibly the future requirements of the ITTC community in general and particular user groups

2. an open ended matrix structure that can be easily expanded as requirements arise, without the need of restructuring and repetition or too many explicit cross-references

3. minimized departures from the well established and widely accepted previous list of symbols

On the other hand, to facilitate the practical use of the list, a second version in which the symbols are arranged in alphabetic order was prepared. Symbols which have been listed several times in the matrix structured document have been maintained and for each symbol the field in which it is used is given in italic letters prior to the meaning of the symbol.

4.2.2 Structure of the Lists

The concepts related to a given subject area or model are designated by the ITTC Symbol and called by their Name. Their meaning can in principle only be concluded from the context of the model. The logically consistent, so called 'implicit' definition is derived from a definitely defined statement of the model, ideally a generally accepted system or an equivalent, e.g. a drawing.

The problem is that traditionally in lists of symbols, as in dictionaries, these explicit models are missing for various reasons. One reason is that many subject areas under discussion are far from being developed and understood to the extent necessary. A consequence of this situation is that the symbols proposed are not always as coherent as would be necessary for advanced and systematic work, for which explicit models and adequate notations are essential.

The problem under discussion is of course the same in national and international standards. However there is an accepted international standard which deals with the general principles concerning physical quantities, equations, quantity and unit symbols, and coherent unit systems for general use within the various fields of science and technology (ISO 31.

4.2.3 Organization of the matrix structured list

As has been emphasized the development of symbols is a continuing process and as the subject develops, further amendments and additions, as approved by the Conference, will be included in future editions of the list.

In order to avoid any extra problems the symbols are arranged in alphabetical order in each subject area as in previous lists. Continuous page numbering was discarded in earlier versions. The idea was to establish a loose leaf organization as the most appropriate, in view of new draughts to be incorporated.

In view of the tremendous effort which explicit mathematical models, explanations, and sketches take for their preparation, the present QS Group can only follow the former SaT Group and state that the Technical Committees and other interested parties are urged to provide further material for review by the QS Group and future inclusion into the list.

It has been noted that some users dislike the disruption of the list of symbols by lengthy explanations. The present QS Group feels that the subject and the sensible use of the symbols require such explanations, also as the fundamentals of the theory of science and terminology often are not taught to students of naval architecture and marine engineering. However the arrangement has been changed so that these explanations can be visited by using hyperlinks and the list is not disrupted any more.

5. PRINCIPLES OF NOTATION

In Figure 5 the principles of notation in according to ISO 31 are shown.

Symbols representing physical quantities normally are one Latin or Greek letter with Subscripts for further identification. They are written in ***italic*** style letters.

Numbers are normally written in **roman** style letters. For more details, look at the list below or in the Excerpts of ISO 31 below or in standard itself.

Superscripts signify **operators** e.g.

- exponentiation
- the various aspects of complex quantities
- the various aspects of spectra and
- the various aspects of random quantities and stochastic processes e.g. probability operators.

Subscripts signify **identifiers**

- matrix components,
- identifiers tested, e.g. ship S or model M, appendages (App)or the various bodies in a multi-body problem,
- identifiers of coordinate systems and of the reference points, quantities(L_{PP})

Symbols for physical units	italic, one letter, except dimensionless quantities	A (e.g. Area in m²)
Symbols for characteristic numbers	2 letters italic	*Re*, *Fr*
Numbers	roman, generally	10^3
Symbols representing numbers	italic	x_{ij}
Units	roman, lower case unless derived from name	m, Pa
Prefix of units	roman	µm
Symbols for chemical elements	roman	$\mathrm{H_2O}$
Symbols for universal constants	italic	g = 9,80665 m/s²

Superscripts signify **Operators**
Numbers in **roman** (power of *n*)
Symbols representing numbers (n = 1, 2, 3 etc.) in ***italic***

SYMBOLS in *italic*

$$K^{2}_{T\mathrm{M}} \times 10^{n}$$

NUMBERS in roman

Subscripts signify **Identifiers**:
Symbol for **physical quantity** in ***italic*** (T = Thrust)
Other symbols in **roman** (M = Model)

Figure 5

5.1 Excerpts of ISO 31

1 Scope

This part of ISO 31 gives general information about principles concerning physical quantities, equations, quantity and unit symbols, and coherent unit systems, especially the International System of Units, SI.

The principles laid down in this part of ISO 31 are intended for general use within the various fields of science and technology and as a general introduction to the other parts of ISO 31.

2. Quantities and units

2.1 Physical quantity, unit and numerical value

In ISO 31 only physical quantities used for the quantitative description of physical phenomena are treated. Conventional scales, such as the Beaufort scale, Richter scale and colour intensity scales, and quantities expressed as the results of conventional tests, e.g. corrosion resistance, are not treated here, neither are currencies nor information contents.

Physical quantities may be grouped together into categories of quantities which are mutually comparable. Lengths, diameters, distances, heights, wavelengths and so on would constitute such a category. Mutually comparable quantities are called "quantities of the same kind".

If a particular example of a quantity from such a category is chosen as a reference quantity, called the ***unit***, then any other quantity from this category can be expressed in terms of this unit as a product of this unit and a number. This number is called the ***numerical value*** of the quantity expressed in this unit.

In formal treatments of quantities and units, this relation may be expressed in the form

$$A = \{A\} \cdot [A]$$

where A is the symbol for the physical quantity, [A] the symbol for the unit and {A} symbolizes the numerical value of the quantity A expressed in the unit [A]. For vectors and tensors the components are quantities which may be expressed as described above.

If a quantity is expressed in another unit which is *k* times the first unit, then the new numerical value becomes 1/*k* times the first numerical value; the physical quantity, which is the product of the numerical value and the unit, is thus independent of the unit.

REMARK ON NOTATION FOR NUMERICAL VALUES

It is essential to distinguish between the quantity itself and the numerical value of the quantity expressed in a particular unit. The numerical value of a quantity expressed in a particular unit could be indicated by placing braces (curly brackets) around the quantity symbol and using the unit as a subscript. It is, however, preferable to indicate the numerical value explicitly as the ratio of the quantity to the unit.

2.2 Quantities and equations

2.2.1 Mathematical operations with quantities

Two or more physical quantities cannot be added or subtracted unless they belong to the same category of mutually comparable quantities.

Physical quantities are multiplied or divided by one another according to the rules of algebra; the product or the quotient of two quantities, A and B, satisfies the relations

$AB = \{A\}\,\{B\} \cdot [A]\,[B]$

Thus, the product $\{A\}\,\{B\}$ is the numerical value $\{AB\}$ of the quantity AB, and the product [*A*] [*B*] is the unit $[AB]$ of the quantity AB. Similarly, the quotient $\{A!/\{B\})$ is the numerical value $\{A/B\}$ of the quantity A/B, and the quotient [A]/[*B*] is the unit $[A/B]$ of the quantity A/B.

2.2.2 Equations between quantities and equations between numerical values

Two types of equation are used in science and technology: ***equations between quantities***, in which a letter symbol denotes the physical quantity (i.e. numerical value × unit), and ***equations between numerical values***. Equations between numerical values depend on the choice of units, whereas equations between quantities have the advantage of being independent of this choice. Therefore the use of equations between quantities should normally be preferred.

2.2.3 Empirical constants

An empirical relation is often expressed in the form of an equation between the numerical values of certain physical quantities. Such a relation depends on the units in which the various physical quantities are expressed.

An empirical relation between numerical values can be transformed into an equation between physical quantities, containing one or more empirical constants. Such an equation between physical quantities has the advantage that the form of the equation is independent of the choice of the units. The numerical values of the empirical constants occurring in such an equation depend, however, on the units in which they are expressed, as is the case with other physical quantities.

2.2.4 Numerical factors in quantity equations

Equations between quantities sometimes contain ***numerical factors***. These numerical factors depend on the definitions chosen for the quantities occurring in the equations.

EXAMPLE

$$E_k = \frac{1}{2} m v^2$$

2.2.5 Systems of quantities and equations between quantities; base quantities and derived quantities

Physical quantities are related to one another through equations that express laws of nature or define new quantities.

For the purpose of defining unit systems and introducing the concept of dimensions, it is convenient to consider some quantities as mutually independent, i.e. to regard these as ***base quantities***, in terms of which the other quantities can be defined or expressed by means of equations; the latter quantities are called ***derived quantities.***

It is a matter of choice how many and which quantities are considered to be base quantities.

The whole set of physical quantities included in ISO 31 is considered as being founded on seven base quantities: **length L, mass M, time T, electric current I, thermodynamic temperature Θ, amount of substance N and luminous intensity J**.

In the field of mechanics a system of quantities and equations founded on three base quantities is generally used. In ISO 31-3, the base quantities used are length, mass and time.

In the field of electricity and magnetism a system of quantities and equations founded on four base quantities is generally used. In ISO 31-5, the base quantities used are length, mass, time and electric current.

In the same field, however, systems founded on only three base quantities, length, mass and time, in particular the "Gaussian" or symmetric system, have been widely used. (See ISO 31-5:1992, annex A.)

2.2.6 Dimension of a quantity

Any quantity Q can be expressed in terms of other quantities by means of an equation. The expression may consist of a sum of terms. Each of these terms can be expressed as a product of powers of base quantities $A, B, C, \ldots$ from a chosen set, sometimes multiplied by a numerical factor ξ, i.e. $\xi A^{\alpha} B^{\beta} C^{\gamma} \ldots$, where the set of exponents ($\alpha, \beta, \gamma \ldots$) is the same for each term.

The ***dimension*** of the quantity Q is then expressed by the dimensional product

$$\dim Q = \mathrm{A}^{\alpha}\mathrm{B}^{\beta}\mathrm{C}^{\gamma} \ldots$$

where A, B, C, ... denote the dimensions of the base quantities $A, B, C, \ldots$, and where $\alpha, \beta, \gamma \ldots$ are called the ***dimensional exponents***.

A quantity all of whose dimensional exponents are equal to zero is often called a ***dimensionless* quantity**. Its dimensional product or dimension is $\mathrm{A}^0\,\mathrm{B}^0\,\mathrm{C}^0 \ldots = 1$. Such a quantity *of* ***dimension one*** *is* expressed as a number.

In the system founded on the seven base quantities length, mass, time, electric current, thermodynamic temperature, amount of substance and luminous intensity, the base dimensions may be denoted by L, M, T, I, O, N and J respectively and the dimension of a quantity Q becomes in general

$$\dim Q = L^{\alpha} M^{\beta} T^{\gamma} I^{\delta} \Theta^{\varepsilon} N^{\zeta} J^{\eta}.$$

EXAMPLES

Quantity	**Dimension**
velocity	LT^{-1}
angular velocity	T^{-1}
force	LMT^{-2}
energy	$\mathrm{L}^2\mathrm{MT}^{-2}$
relative density	1

2.3 Units

2.3.1 Coherent unit systems

Units might be chosen arbitrarily, but making an independent choice of a unit for each quantity would lead to the appearance of additional numerical factors in the equations between the numerical values.

It is possible, however, and in practice more convenient, to choose a system of units in such a way that the equations between numerical values have exactly the same form (including the numerical factors) as the corresponding equations between the quantities. A unit system defined in this way is called ***coherent*** with respect to the system of quantities and equations in question. The SI is such a system. The corresponding system of quantities is given in ISO 31-1 to ISO 31-10 and in ISO 31-12 and ISO 31-13.

For a particular system of quantities and equations, a coherent system of units is obtained by first defining units for the base quantities, the ***base units***. Then for each derived quantity, the definition of the corresponding ***derived unit*** in terms of the base units is given by an algebraic expression obtained from the dimensional product (see 2.2.6) by replacing the symbols for the base dimensions by those of the base units. In particular, a quantity of dimension one acquires the unit 1. In such a coherent unit system no numerical factor other than the number 1 ever occurs in the expressions for the derived units in terms of the base units.

2.3.2 SI units and their decimal multiples and sub-multiples

The name *International System of Units* (Système International d'Unités), with the international abbreviation SI was adopted by the 11th *General Conference on Weights and Measures* (Conférence Générale des Poids et Mesures, CGPM) in 1960.

This system includes
- base units
- derived units including supplementary units

which together form the coherent system of *SI units.*

2.3.2.1 Base units

The seven base units are listed in Table 1.

Table 1 - SI base units

Base quantity	SI base unit	
	Name	Symbol
length	metre	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd

2.3.2.2 Derived units including supplementary units

The expressions for the coherent derived units in terms of the base units can be obtained from the dimensional products by using the following formal substitutions:

$L \rightarrow m$ $I \rightarrow A$
$M \rightarrow kg$ $\Theta \rightarrow K$
$T \rightarrow s$ $N \rightarrow mol$
$J \rightarrow cd$

In 1960, the CGPM classified the SI units radian, rad, and steradian, sr, for plane angle and solid angle respectively as "supplementary units".

In 1980, the *International Committee for Weights and Measures* (Comité International des Poids et Mesures, CIPM) decided to interpret the class of supplementary units in the SI as a class of dimensionless derived units for which the CGPM allows the freedom of using or not using them in expressions for SI derived units.

Although, as a consequence of this interpretation, the coherent unit for plane angle and for solid angle is the number 1, it is convenient to use the special names radian, rad, and steradian, sr, instead of the number 1 in many practical cases.

Table 2 - SI derived units with special names, including SI supplementary units

Derived quantity	SI derived unit		
	Special name	Symbol	Expressed in terms of SI base units and SI derived
plane angle	radian	rad	1 rad = 1 m/m = 1
solid angle	steradian	sr	1 sr = 1 m^2 /m^2 = 1
frequency	hertz	Hz	1 Hz = 1 s^{-1}
force	newton	N	1 N = 1 kg . m/s^2
pressure, stress	pascal	Pa	1 Pa = 1 N/m^2

energy, work, quantity of heat	joule	J	1 J = 1 N - m
power, radiant flux	watt	W	1 W = 1 J/s
electric charge, quantity of electricity	coulomb	C	1 C = 1 A - s
electric potential, potential difference, tension, electromotive force	volt	V	1 V = 1 W/A
capacitance	farad	F	1 F = 1 C/V
electric resistance	ohm	S2	1Ω = 1 V/A
electric conductance	siemens	S	1 S = 1 Ω-'
magnetic flux	weber	Wb	1 Wb = 1 V . s
magnetic flux density	tesla	T	1 T = 1 Wb/m^2
inductance	henry	H	1 H = 1 Wb/A
Celsius temperature	degree Celsius')	°C	1 °C = 1 K
luminous flux	lumen	Im	1 lm = 1 cd . sr
illuminance	lux	Ix	1 lx = 1 lm/m^2
1) Degree Celsius is a special name for the unit kelvin for use in stating values of Celsius temperature. (See also ISO 31-4:1992, items 4-1.a and 4-2.a.)			

EXAMPLES

Quantity	Symbol for SI unit expressed in terms of the seven base units (and the supplementary units in some cases)
velocity	m/s
angular velocity	rad/s or s-'
force	kg . m/s^2
energy	kg . m^2/s^2
relative density	1

For some of the SI derived units, special names and symbols exist; those approved by the CGPM are listed in tables 2 (and 3).
It is often of advantage to use special names and symbols in compound expressions for units.

2.3.2.3 SI prefixes

In order to avoid large or small numerical values, decimal multiples and sub-multiples of the SI units are added to the coherent system within the framework of the SI. They are formed by means of the prefixes listed in Table 4.

Table 4 - Sl prefixes

Factor	Prefix	
	Name	Symbol
10^{24}	yotta	Y
10^{21}	zetta	z
10^{18}	exa	E
10^{15}	peta	P
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10	deca	da
10^{-1}	deci	d
10^{-2}	centi	c

10^{-3}	milli	m
10^{-6}	micro	µ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a
10^{-21}	zepto	z
10^{-24}	yocto	y

For information about the use of the prefixes, see 3.2.4.

The SI units and their decimal multiples and submultiples formed by use of the prefixes are specially recommended.

2.3.3 The unit one

The coherent SI unit for any quantity of dimension one is the unit one, symbol 1. It is generally not written out explicitly when such a quantity is expressed numerically.
EXAMPLE

Refractive index $n = 1{,}53 \times 1 = 1{,}53$

In the case of certain such quantities, however, the unit 1 has special names that could be used or not, depending on the context.

EXAMPLES
Plane angle $\alpha = 0{,}5$ rad = 0,5 ,
Solid angle $\Omega = 2{,}3$ sr = 2,3

Decimal multiples and sub-multiples of the unit one are expressed by powers of 10. They shall not be expressed by combining the symbol 1 with a prefix.

In some cases the symbol % (per cent) is used for the number 0,01.
NOTES
3 In some countries the symbol %o ("per mill", or per thousand) is used for the number 0,001. This symbol should be avoided.
4 Since per cent and per mill are numbers it is in principle meaningless to speak about percentage by mass or percentage by volume. Additional information, such as % (m/m) or % (V/V), should not therefore be attached to the unit symbol. The preferred way of expressing a mass fraction is: "the mass fraction is 0,67" or "the mass fraction is 67 %", and the preferred way of expressing a volume fraction is: "the volume fraction is 0,75" or "the volume fraction is 75 %". Mass and volume fractions can also be expressed in the form 5 µg/g or 4,2 ml/m3.

Abbreviations such as ppm, pphm and ppb shall not be used.

2.3.4 Other unit systems and miscellaneous units

The CGS system of mechanical units is a coherent system the base units of which are centimetre, gram and second for the three base quantities length, mass and time.

In practice this system was enlarged by adding the kelvin, the candela and the mole as base units for the base quantities thermodynamic temperature, luminous intensity and amount of substance.

Units used in electricity and magnetism have been defined in the CGS system in several ways depending on the system of quantities and equations chosen. The "Gaussian" or symmetric CGS system, coherent with the "Gaussian" or symmetric system of quantities and equations founded on three base quantities, has been widely used. For further information on this system, see ISO 31-5:1992, Annex A.

The special names and symbols for derived CGS units such as dyne, erg, poise, stokes, gauss, oersted and maxwell shall not be used together with the Sl.

Table 5 - Units used with the SI

Quantity	**Unit**		
	Name	**Symbol**	**Definition**
time	minute hour day	min h d	1 min= 60s 1 h = 60 min 1 d = 24 h

plane angle	degree minute second	° ' "	1 ° = (π/180)rad = (n/l80) rad 1' = (1/60)° 1" = (1/60)'
volume	litre	I, L [1]	$1l = 1\ dm^3$ = 1 dm
mass	tonne[2]	t	$1\ t = 10^3$ kg
[1] The two symbols for litre are on an equal footing. The CIPM will, however, make a survey on the development of the use of the two symbols in order to see if one of the two may be suppressed. [2] Also called the metric ton in the English language.			

Table 6 - Units used with the SI, whose values in SI units are obtained experimentally

Quantity	Unit		
	Name	**Symbol**	**Definition**
energy	electronvolt	eV	The electronvolt is the kinetic energy acquired by an electron in passing through a potential difference of 1 volt in vacuum: 1 eV ≈ 1,602 177 $\times 10^{-19}$ J.
mass	unified atomic mass unit	u	The unified atomic mass unit is equal to (1 /12) of the mass of an atom of the nuclide ^{12}C: 1u ≈ 1,660 540 $\times 10^{-27}$kg.

In other parts of ISO 31, the special names for the derived CGS units are given in informative annexes which are not integral parts of the standards.

There are certain units outside the SI which are recognized by the CIPM as having to be retained for use together with the SI, e.g. minute, hour and electronvolt. These units are given in Tables 5 and 6.

Other coherent systems of units have been defined, e.g. a system based on the units foot, pound and second and a system based on the units metre, kilogram-force and second.

Apart from these, other units have been defined which do not belong to any coherent system, e.g. the atmosphere, **the nautical mile** and the curie.

3 Recommendations for printing symbols and numbers

3.1 Symbols for quantities

3.1.1 Symbols

The symbols for physical quantities are generally single letters of the Latin or Greek alphabet, sometimes with subscripts or other modifying signs. These **symbols** are printed in ***italic*** (sloping) type (irrespective of the type used in the rest of the text).

The symbol is not followed by a full stop except for normal punctuation, e.g. at the end of a sentence.

NOTES

5 Symbols for quantities are given in ISO 31-1 to ISO 31-10 and in ISO 31-12 and ISO 31-13.

6 Notations for vectorial and other non-scalar quantities are given in ISO 31-11, on mathematical signs and symbols.

7 Exceptionally, symbols made up of two letters are sometimes used for combinations of dimension one of quantities (e.g. Reynolds number, *Re*). If such a two-letter symbol appears as a factor in a product, it is recommended that it be separated from the other symbols.

3.1.2 Rules for the printing of subscripts

When, in a given context, different quantities have the same letter symbol or when, for one quantity, different applications or different values are of interest, a distinction can be made by use of subscripts.

The following principles for the printing of subscripts are recommended:

A subscript that represents a symbol for a physical quantity is printed in italic (sloping) type.

Other subscripts are printed in roman (upright) type.

EXAMPLES

Upright subscripts		**Sloping subscripts**	
$\boldsymbol{C}_\mathrm{g}$	(*g* gas)	C_p	(*p*: pressure)
$\mathrm{g_n}$	(n: normal)	$\sum_n a_n \delta_n$	(*n:* running number)
μ_r	(r: relative)	$\sum_x a_x b_x$	(*x:* running number)
$\boldsymbol{E}_\mathbf{k}$	(k: kinetic)	g_{ik}	(*i, k:* running numbers)
χ_e	(e: electric)	p_x	(*x*:*x*-coordinate)
$T_{1/2}$	(1/2: half)	l_λ	(λ wavelength)

NOTES

8 Numbers as subscripts should be printed in roman (upright type. However, letter symbols representing numbers are generally printed in italic (sloping) type.

3.1.3 Combination of symbols for quantities; elementary Operations with quantities

When symbols for quantities are combined in a product, this process of combination may be indicated in one of the following ways:

$ab,\ a\ b,\ a\cdot\bullet\ b,\ a\times b$

NOTES

10 In some fields, e.g. in vector analysis, distinction is made between $\boldsymbol{a}\cdot\bullet\ \boldsymbol{b}$ and $\boldsymbol{a} \times \boldsymbol{b}$.

11 For multiplication of numbers, see 3.3.3.

12 In systems with limited character sets a dot on the line may be used instead of a half-high dot.

Division of one quantity by another may be indicated in one of the following ways:
$\frac{a}{b}$ a/b or by writing the product of $\boldsymbol{a}$ and $\boldsymbol{b}^{-1}$,

e.g. $a\cdot\cdot\ b^{-1}$

3.2 Names and symbols for units

3.2.1 International symbols for units

When international symbols for units exist, they, and no other, shall be used. They shall be printed in roman (**upright**) type (irrespective of the type used in the rest of the text), shall remain unaltered in the plural shall be written without a final full stop (period) except for normal punctuation, e.g. at the end of a sentence.

Any attachment to a unit symbol as a means of giving information about the special nature of the quantity or context of measurement under consideration is incorrect.

EXAMPLE

$U_\mathrm{max} = 500$ V (not $U = 500\ \mathrm{V_{max}}$)

The unit symbols shall in general be printed in lower case letters except that the first letter is printed in upper case when the name of the unit is derived from a proper name.

EXAMPLES

m	metre
s	second
A	ampere
Wb	weber

3.2.2 Combination of symbols for units

When a compound unit is formed by multiplication of two or more units, this should be indicated in one of the following ways:

N·m, N m

NOTES

13 In systems with limited character sets a dot on the line may be used instead of a half high dot.

14 The latter form may also be written without a space, provided that special care is taken when the symbol for one of the units is the same as the symbol for a prefix.

EXAMPLE
mN means millinewton, not metre newton.

When a compound unit is formed by dividing one unit by another, this should be indicated in one of the following ways:

$\frac{m}{s}$ m/s m·s^{-1}

A solidus (/) shall not be followed by a multiplication sign or a division sign an the same line unless parentheses are inserted to avoid any ambiguity. In complicated cases negative powers or parentheses shall be used.

3.2.3 Printing of symbols for units

No recommendation is made or implied about the font of upright type in which symbols for units are to be printed.

NOTE 15 In this series of publications the font used in such cases is generally that of the associated text, but this does not constitute a recommendation.

3.2.4 Printing and use of prefixes

Symbols for prefixes should be printed in roman (upright) type without a space between the symbol for the prefix and the symbol for the unit. Compound prefixes shall not be used.

EXAMPLE

Write nm (nanometre) for 10^{-9} m, not mμm.

The symbol of a prefix is considered to be combined with the single unit symbol to which it is directly attached, forming with it a new symbol (for a decimal multiple or sub-multiple) which can be raised to a positive or negative power, and which can be combined with other unit symbols to form symbols for compound units (see 3.2.2).

EXAMPLES
1cm^3 = (10^{-2}m)^3=10^{-6} m^3
1 μs^{-1}= (10^{-6} s)$^{-1}$ = 10^6 s^{-1}
1 kA/m = (10^{3}A)/m = 10^3 A/m

NOTE 16 For historical reasons the name of the base unit or mass, the kilogram, contains the name of the SI prefix ,"kilo". Names of the decimal multiples and sub-multiples of the unit of mass are formed by adding the prefixes to the word “gram” e.g. milligram (mg) instead of microkilogram (μkg).

3.3 Numbers

3.3.1 Printing of numbers

Numbers should generally be printed in roman (upright) type.

To facilitate the reading of numbers with many digits, these may be separated into suitable groups, preferably of three, counting from the decimal sign towards the left and the right; the groups should be separated by a small space, and never by a comma or a point, or by any other means.

3.3.2Decimal sign

The decimal sign is a comma on the line.

If the magnitude of the number is less than unity, the decimal sign should be preceded by a zero.

NOTE 17 In documents in the English language. a dot is often used instead of a comma. If a dot is used, it should be on the line. In accordance with an ISO Council decision, the decimal sign is a comma in ISO documents.

3.3.3 Multiplication of numbers

The sign for multiplication of numbers is a cross (×) or a dot half-high (·).

NOTES
18 If a dot half-high is used as the multiplication sign, a comma should be used as the decimal sign. If a dot is used as the decimal sign, a cross should be used as the multiplication sign.
19. In ISO documents, the dot is not used directly between numbers to indicate multiplication.

3.4 Expressions for quantities

The symbol of the unit shall be placed after the numerical value in the expression for a quantity, leaving a space between the numerical value and the unit symbol. It should be noted that, in accordance with this rule, the symbol °C for degree Celsius shall be preceded by a space when expressing a Celsius temperature.

The only exceptions to this rule are for the units degree, minute and second for plane angle, in which case there shall be no space between the numerical value and the unit symbol.

If the quantity to be expressed is a sum or a difference of quantities then either parentheses shall be used to combine the numerical values, placing the common unit symbol after the complete numerical value, or the expression shall be written as the sum or difference of expressions for the quantities.

EXAMPLES

l = 12 m - 7 m= (12 - 7) m = 5m
t = 28.4 °C ± 0,2 °C = (28,4 ± 0,2) °C
(not 28,4 ± 0,2 °C)
λ.=220 × (1 ± 0,02) W/(m·K)

3.5 Symbols for chemical elements and nuclides

Symbols for chemical elements shall be written in roman (upright) type (irrespective of the type used in the rest of the text). The symbol is not followed by a full stop except for normal punctuation, e.g. at the end of a sentence.

EXAMPLES

H He C Ca

A complete list of the symbols for the chemical elements is given in ISO 31-8:1992, annex A, and 150 31-9:1992, annex A.

The attached subscripts or superscripts specifying a nuclide or molecule shall have the following meanings and positions.

The nucleon number (mass number) of a nuclide is shown in the left superscript position, e.g.
^{14}N

The number of atoms of a nuclide in a molecule is shown in the right subscript position, e.g.
$^{14}N_2$

The proton number (atomic number) may be indicated in the left subscript position, e.g.
$_{64}Gd$

If necessary, a state of ionization or an excited state may be indicated in the right superscript position.

EXAMPLES

State of ionization:	Na^+
	PO_4^{3-} or $(PO_4)^{3-}$
Electronic excited state:	$He^{*\bullet}$, $N0^{*\bullet}$
Nuclear excited state:	$^{110}Ag^{*\bullet}$, $^{110}Ag^m$

3.6 Mathematical signs and symbols

Mathematical signs and symbols recommended for use in the physical sciences and technology are given in 1S031-11.

3.7 Greek alphabet (upright and sloping types)

alpha	Α	a	*Α*	*a*
beta	Β	β	*Β*	*β*
gamma	Γ	γ	*Γ*	*γ*
delta	Δ	δ	*Δ*	*δ*
epsilon	Ε	ε	*Ε*	*ε*
zeta	Ζ	ζ	*Ζ*	*ζ*
eta	Η	η	*Η*	*η*
theta	Θ	θ, ϑ	*Θ*	*θ, ϑ*
iota	Ι	ι	*Ι*	*ι*
kappa	Κ	κ	*Κ*	*κ*
lambda	Λ	λ	*Λ*	*λ*
mu	Μ	μ	*Μ*	*μ*
nu	Ν	ν	*Ν*	*ν*
xi	Ξ	ξ	*Ξ*	*ξ*
omicron	Ο	ο	*Ο*	*ο*
pi	Π	π	*Π*	*π*
rho	Ρ	ρ	*Ρ*	*ρ,*
sigma	Σ	σ	*Σ*	*σ*
tau	Τ	τ	*Τ*	*τ*
upsilon	Υ	υ	*Υ*	*υ*
phi	Φ	φ	*Φ*	*φ*
chi	Χ	χ	*Χ*	*χ*
psi	Ψ	ψ	*Ψ*	*ψ*
omega	Ω	ω	*Ω*	*ω*

5.2 Computer Symbols

Wherever possible the symbols in the second column of the tables have been chosen so that their meaning is readily apparent. They have been constructed from the CCITT International Telegraph Alphabet, restricted character set. They are therefore suitable for use in a wide range of situations e. g.: Telex messages, letters, computer printouts etc.

To ensure that the symbols can be used in a wide range of programming languages they currently have been kept to less than six characters long. The symbols should be used as defined, and, in accordance with modern programming practice, should have their type explicitly declared before use. The following rules were applied in the derivation of the symbols:

1. Only upper case letter A - Z and digits 0 - 9 have been used.
2. Formerly Greek letters have been spelled out, if necessary in abbreviated form or with changed spelling. This practice is considered obsolete.
3. The Froude 'circular' symbols are defined by the prefix CIRC.
4. All symbols start with a letter.
5. Qualifiers and operators, preferably two characters, are currently suffixed to the main symbol line, without spacing.
6. No one computer compatible symbol should be used for different concepts in a given context. This goal has not been completely achieved for the whole list. Ad hoc solutions have been attempted but discarded as unsatisfactory.
7. Since the computer compatible symbols have been proposed as the basis of attribute names for data exchanges, the above rules will probably be further developed in the near future.

A final remark on the Computer Symbols: in the computer, the letter O and figure 0 (zero) have fundamentally different meanings, but owing to their resemblance they can be easily confused. Thus it is necessary to distinguish rigorously between them. As a matter of fact there are contradictory conventions being widely used.

5.3 Documentation

5.3.1 ITTC Documents

1. International Towing Tank Conference, Standard Symbols 1971, BSRA Technical Memorandum No.400, August 1971.
2. International Towing Tank Conference, Standard Symbols 1976. BSRA T.M. No.500, 1976.
3. ITTC Dictionary of Ship Hydrodynamics. RINA Maritime Technology Monograph No.6, 1978.
4. Translation of Overall Index of Titles of Dictionary of Ship Hydrodynamics., Vol. 1: CETENA, Genova, 1984,
   Vol. 2: University of Tokyo, 1984.
5. Bibliography and Proposed Symbols on Hydrodynamic Technology as Related Model Tests of High Speed Marine Vehicles. Prep. by 17th ITTC High-Speed Marine Vehicle Committee. SPPA Maritime Research and Consulting. Rep. No.101, 1984.

5.3.2 Translations

A number of translations of the List of ITTC Standard Symbols into languages other than English have been made including French, German, Italian, Japanese, Russian, Spanish and Chinese. For obvious reasons these translations are no longer up-to-date as the present accepted list in English and the Russian one.

1. French Translation of ITTC Standard Symbols 1971., Association Francaise de Normalisation (AFNOR).
2. International vereinbarte Buchstabensymbole und Bezeichnungen auf dem Gebiet der Schiffshydrodynamik. Collatz, G. Schiff und Hafen 27 (1975) No.10.
3. Italian Translation of ITTC Standard Symbols 1971. Luise E. Appendix II, Report of Presentation Committee.
   Proceedings 14th ITTC, Vol. 4, Ottawa 1975.
4. Japanese Translation of ITTC Standard Symbols. Transactions of the Society of Naval Architects of Japan, No.538, April 1974.
5. Russian Translation of ITTC Standard Symbols 1971. Brodarski Institute Publication No.28, Zagreb 1974.
6. Simbolos Internacionales en Arquitectura Naval. Asociacion de Investigacion de la Construccion Naval,
   Publication 7/75, Juli 1975, Madrid.
7. Report of Information Committee, Proc. 17th ITTC, Göteborg 1984.
8. Chinese Translation of ITTC Standard Symbols. China Ship Scientific Research Centre, Wuxi.

5.3.3 Other References

Apart from the organizations represented on the ITTC these symbols have been recommended for use in technical writing on naval architecture by a number of organizations concerned with marine matters including The Royal Institution of Naval Architects, the American Society of Naval Architects and Marine Engineers and the American, British, Canadian, Australian, and Italian Navies. Where possible, the symbols for Section 3.4.1, Waves are consistent with the IAHR/PIANC List of Sea State Parameters, Supplement to Bulletin No 52, January 1986.

In 1985 the Draught International Standard ISO/DIS 7463 Shipbuilding - Symbols for Computer Applications - has been published. The symbols are based on the list approved by the ITTC in Ottawa 1975 and a related list produced by the ISSC in 1974, inconsistencies having been removed. The ISO/TC8/SC15 has been notified that major changes of the ITTC Symbols are under discussion. Subsequently processing of ISO/DIS 7463 has not been postponed, but the standard has been published as ISO 7463 in 1990.