

CHRIS J PATTERSON
& JONATHAN D RIDLEY

13

REEDS MARINE ENGINEERING AND TECHNOLOGY

SHIP STABILITY, POWERING AND RESISTANCE

B L O O M S B U R Y

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Chris J Patterson
Jonathan D Ridley



ADLARD COLES NAUTICAL

B L O O M S B U R Y

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For my darling wife Linny
&
For Leanne

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NOMENCLATURE

Symbol	Units	Name
AC	–	Admiralty coefficient
AP	–	Aft perpendicular
AWP	m^2	Waterplane area
b	m	Tank beam
b	m	Compartment beam
B	–	Centre of buoyancy
B	m	Waterline beam of a box shaped vessel
BAR	–	Propeller blade area ratio
BM	m	Vertical position of the metacentre above B
BM	<i>tonne metres</i>	Bending moment
BM_L	m	Vertical position of the longitudinal metacentre above B
B_P	–	Propeller power coefficient
B_{WL}	m	Waterline beam
C_B	–	Block coefficient
C_F	–	Frictional resistance coefficient
C_F	m FOAP	Longitudinal centre of flotation
C_M	–	Amidships area coefficient
C_R	–	Residuary resistance coefficient
C_T	–	Total resistance coefficient
C_W	–	Waterplane area coefficient
d	m	Distance of a mass from the centreline
d	m	Transverse shift in the centre of buoyancy due to bilging in a side compartment
D	m	Draught
D	m	Propeller diameter
D_A	m	Draught at the aft perpendicular
D_B	m	Bilged draught
δ	–	Propeller speed coefficient
Δ	<i>tonnes</i>	Displacement or ship mass including contents
D_F	m	Draught at the forward perpendicular
D_{Heeled}	m	Heeled draught

Symbol	Units	Name
D_I	m	Initial draught
D_{LCF}	m	True mean draught (draught at the LCF)
D_M	m	Mean draught
D_{TMD}	m	True mean draught (draught at the LCF)
DW	–	Subscript used to identify dock water
DWA	mm	Dock water allowance
η_{DUCT}	–	Waterjet duct efficiency
η_H	–	Hull efficiency
η_{JET}	–	Waterjet jet efficiency
η_{JS}	–	Waterjet system efficiency
η_{MI}	–	Engine mechanical efficiency
η_O	–	Propeller open water efficiency
η_P	–	Propeller efficiency
η_{PUMP}	–	Waterjet pump efficiency
η_R	–	Propeller relative rotative efficiency
η_T	–	Transmission efficiency
FC	–	Fuel coefficient
Fn		Froude number
$FOAP$	–	Forward of aft perpendicular
FP	–	Forward perpendicular
FSC	m	Free surface correction (loss in GM due to FSM)
FSM	m^4	Free surface moment (not corrected for fluid density)
FSM	<i>tonne metres</i>	Free surface moment (corrected for fluid density)
FWA	mm	Fresh water allowance
G	m/s^2	Acceleration due to gravity (taken as 9.81 m/s^2)
G	–	Centre of gravity
GM	m	Metacentric height
GM_I	m	Initial metacentric height (at zero heel)
GM_L	m	Longitudinal metacentric height
GZ	m	Righting lever, righting arm, arm of statical stability, lever of statical stability
h	m	Height of a watertight flat or double bottom depth
I or <i>Inertia</i>	m^4	Transverse second moment of area of the waterline measured through the centreline

Symbol	Units	Name
I_{Centroid}	m^4	Second moment of area measured through the centre of a shape
I_{EDGE}	m^4	Second moment of area measured through the edge of the shape
I_{GG}	m^4	Second moment of area measured through the centre of a shape
I_L or $Inertia_L$	m^4	Longitudinal second moment of area of the waterline measured through the LCF
$I_{\text{ROLL AXIS}}$	m^4	Second moment of area of the waterplane measured through the centre of the waterplane
I_{xx} or $I_{x'x'}$, I_{yy} or $I_{y'y'}$	m^4	Second moment of area measured through a point away from centre of a shape
J	–	Propeller advance coefficient
K		The intersection of the centreline and the keel
K_Q	–	Propeller torque coefficient
K_T	–	Propeller thrust coefficient
KB	m	Vertical position of the centre of buoyancy
KM	m	Vertical position of the metacentre above the keel
KM_L	m	Vertical position of the longitudinal metacentre above the keel
KG	m	Vertical position of the centre of gravity
$1 + k$	–	Frictional form factor
l	m	Tank length
l	m	Compartment length
L	m	Waterline length of a box shaped vessel
λ	m	Heeling arm
λ_0	m	Grain heeling arm at 0 degrees
λ_{40}	m	Grain heeling arm at 40 degrees
LBP	m	Length between perpendiculars
LCB	m FOAP	Longitudinal position of the centre of buoyancy
LCF	m FOAP	Longitudinal centre of flotation
LCG	m FOAP	Longitudinal position of the centre of gravity
L_{WL}	m	Waterline length
m	kg	Mass
\dot{m}	kg/s	Mass flowrate
M	–	Metacentre
$MCTC$	tm/cm	Moment to change the trim by 1 cm

Symbol	Units	Name
$MCTC_2$	<i>tm/cm</i>	Used in draught surveys – the MCTC at the corrected midship draught (row 13) plus 0.50 m
$MCTC_1$	<i>tm/cm</i>	Used in draught surveys – the MCTC at the corrected midship draught (row 13) minus 0.50 m
MHM	<i>tonne metres</i>	Mass heeling moment, used in the grain regulations
MSS	<i>tonne metres</i>	Moment of statical stability, or righting moment
μ	–	Compartment permeability
μ	<i>kg/ms</i>	Dynamic viscosity
n	<i>rev/s</i>	Propeller revolution speed
N	<i>rpm</i>	Propeller revolution speed
N	–	Intersection of the line of action of buoyancy and a horizontal line from the keel
∇	<i>m³</i>	Underwater or submerged volume
ν	<i>m²/s</i>	Kinematic viscosity
P_v	<i>Pa</i>	Vapour pressure
P	<i>tonnes</i>	Up-thrust during dry-docking
P	<i>m</i>	Propeller pitch
P_D	<i>W</i>	Delivered power
P_E	<i>W</i>	Effective power
P_{EN}	<i>W</i>	Effective naked power
P_I	<i>W</i>	Installed power
P_S	<i>W</i>	Shaft power
P_T	<i>W</i>	Thrust power
Q	<i>Nm</i>	Propeller torque
r	<i>m</i>	Turn radius
ρ	<i>t/m³</i>	Fluid density
R_F	<i>N</i>	Frictional resistance
R_n	–	Reynold's number
R_R	<i>N</i>	Residuary resistance
R_T	<i>N</i>	Total resistance
s	<i>various</i>	Ordinate spacing when using Simpson's Rule
S	<i>m²</i>	Wetted surface area
SCF	–	Ship correlation factor

Symbol	Units	Name
SF	m^2/t	Stowage factor
SF	<i>tonnes</i>	Shear force
sfc	$kg/kWhr$	Specific fuel consumption
σ	–	Cavitation number
SW	–	Subscript used to identify sea water (taken as $1.025 m^3$)
t	–	Thrust deduction factor
T	N	Propeller thrust
TCB	m	Transverse position of the centre of buoyancy
TCG	m	Transverse position of the centre of gravity
\therefore	–	Mathematical symbol meaning ‘therefore’
θ	<i>degrees</i>	Angle of inclination, list, heel or loll
\sim		Difference between
TPC	t/cm	Tonnes per centimetre immersion
v	$m/s, knots$	Ship speed
v_A	m/s	Advance speed
v_M	m/s	Model speed
v_s	m/s	Ship speed
v_w	m/s	Wake speed
VHM	m^4	Volumetric heeling moment, used in the grain regulations
w	<i>tonnes</i>	Mass of an item of cargo
x	<i>various</i>	Generic term for an unknown variable
Z	–	Number of propeller blades
Z	–	Intersection of the line of action of buoyancy and a horizontal line from the centre of gravity

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