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COMMENTS OF THE PROPULSION COMMITTEE OF 22nd ITTC

Several of the symbols and definitions used in 1975 differ from the symbols in the 1996 version of ITTC Symbols and Terminology List. These changes were made to the Dictionary. The keywords "angular blade position", "effective pitch ratio", "pitch setting", "propulsor", "rope guard" and "skew angle extent" were added to the Dictionary. The note was added that the strength criteria of some classification societies use other definitions for rake as given in this terminology. The keywords "singing" and "skew-back" were deleted from the Dictionary.

The 14th ITTC (1975, vol. 3, pp. 473-476) published notations for "Nomenclature Relating to Unsteady Propeller Forces". This nomenclature presents a definition for the positive directions of global reference frame. For propeller geometry it is convenient to define a local rotating reference frame (e.g. Carlton, 1994, pp. 29-46). The fact that there are many different local reference frames in use (e.g. Smith & Slater, 1988), can cause confusion or errors when transferring data for comparative calculations or for other purposes. Another similar problem is that particular lengths, angles, velocities, angular velocities, etc. are, in some cases, given pre-selected positive values irrespective of the positive co-ordinate directions of the reference frame.

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14th ITTC 1975 Vol. 3 pp473-476 Vol.4 pp 518-541; 18th ITTC 1987 Vol. 1 pp141-142, Vol. 2 pp 99-100; Updated 25th ITTC Propulsion Committee	14th ITTC 1975 and 18th ITTC 1987 and 25th ITTC
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Terminology and Nomenclature for Propeller Geometry

1 PURPOSE

To ensure that the terms and definitions of propeller geometry are properly defined.

2 ITTC DICTIONARY OF SHIP HYDRODYNAMICS – PROPELLER SECTION

Active rudder
See Rudder, active.

Advance angle (of a propeller blade section)
See Angle, advance.

Advance coefficient (J)[-]
A parameter relating the speed of advance of the propeller, V_A, to the rate of rotation, n, given by: $J = V_A/nD$, where D is the propeller diameter.

Advance coefficient in terms of ship speed (J_V)[-]
$J_V = V/nD$
The advance coefficient in terms of ship speed, V, is also called apparent advance coefficient.

Advance coefficient, Taylor's (δ)[-]
A parameter defined as:
$\delta = nD/V_A = 101.27/J$
where n is the rate of propeller rotation in revolutions per minute, D is the propeller diameter in feet, and V_A is the speed of advance in knots.

Advance ratio (λ)[-]
A non-dimensional speed parameter relating the speed of advance, V_A, and the rotational tip speed, πnD, given by:
$\lambda = V_A/\pi nD = J/\pi$ where J is the advance coefficient.

Analysis pitch
See Pitch, analysis.

Angle, advance (of a propeller blade section) (ß)[-]
The inflow angle to a propeller blade section determined by the rotational speed, ω, the axial velocity of the fluid, V_x, and the tangential velocity of the fluid, V_θ, according to the equation:
$$\beta = \tan^{-1}\{V_X(r,\theta)/[\omega r - V_\theta(r,\theta)]\}$$
The induced velocities are not included in the determination of the advance angle.
(see Figure 1).

Angle, advance (β^*)[-]
A propeller inflow angle defined by the equation:
$$\beta^* = \tan^{-1}(V_A/0.7\pi nD)$$
where V_A is the speed of advance, n is the rate of rotation, and D is the propeller diameter.

Angle, hydrodynamic flow (β_I)[-]
The inflow angle to a propeller blade section including the axial and tangential induced velocities given by the equation (see Figure 1):
$$\beta_I = \tan^{-1}\{[V_X(r,\theta) + U_A(r)]/[\omega r - V_\theta(r,\theta) - U_T(r)]\}$$

Angle, shaft [-]
The angle(s) made by a shaft axis with the centre-plane and the base plane of a ship.

Angle of attack (α)[-]
The angle between the direction of undisturbed relative flow and the chord line (See Figure 1).

Angle of attack, effective (α_E)[-]
The angle of attack relative to the chord line including the induced velocities (See Figure 1).

Angle of attack, geometric (α_G)[-]
The angle of attack relative to the chord line of a section neglecting the induced velocities (See Figure 1).

Angle of attack, ideal (α_I)[-]
A term used in the two-dimensional theory of thin airfoils to denote that angle of attack for which the stagnation point is at the leading edge. This condition is usually referred to as "shock-free" entry or "smooth" entry.

Angle of incidence
Synonymous with Angle of attack.

Angle of zero lift (α_0)[-]
The angle of attack relative to the chord line for which the lift is zero.

Angular blade position (θ)[-]
Angular co-ordinate of key blade relative to fixed ship.

Area, developed (A_D)[L²]
An approximation to the surface area of the propeller equal to the area enclosed by an outline of a blade times the number of blades. The outline of a blade is constructed by laying off, at each radius r, the chord length along an arc whose radius of curvature, r_1, is equal to the radius of curvature of the pitch helix given by $r_1 = r/\cos^2 \phi$ where ϕ is the pitch angle at that radius. The outline is formed by the locus of the end points of the chord lines laid out in the above manner.

Area, disc (A_0)[L²]
The area of the circle swept out by the tips of the blades of a propeller of diameter D

$$A_0 = \pi D^2 / 4$$

Area, expanded (A_E)[L²]
An approximation to the surface area of the propeller equal to the area enclosed by an outline of a blade times the number of blades. The outline of a blade is constructed by laying off at each radius r, the chord length along a straight line. The outline is formed by the locus of the end points of the chord lines laid out in the above manner.

Area, projected (A_P)[L²]
The area enclosed by the outline of the propeller blades outside the hub projected onto a plane normal to the shaft axis. The outline is constructed by laying off, along each radius r, the extremities of each section as determined in a view along the shaft axis. The locus of the end points of the chord lines laid out in the above manner is the required outline.

Axial displacement, skew induced
The amount of axial displacement of a blade section which results when skew-back is used (see Figure 2). It is the distance, measured in the direction of the shaft axis, between the generator line and the blade reference line and is given by $r\theta_S \tan\phi$, where r is the local ra-

dius, θ_S is the local skew angle, and ϕ is the local pitch angle. It is positive when the generator line is forward of the blade reference line.

Axial induced velocity
See Induced velocity, axial.

Back (of blade)
The side of a propeller blade which faces generally in the direction of ahead motion. This side of the blade is also known as the suction side of the blade because the average pressure there is lower than the pressure on the face of the blade during normal ahead operation. This side of the blade corresponds to the upper surface of an airfoil or wing.

Blade area ratio [-]
A term used to denote the ratio of either the developed or expanded area of the blades to the disc area. The terms expanded area ratio or developed area ratio are recommended in order to avoid ambiguity.

Blade section
Most commonly taken to mean the shape of a propeller blade at any radius, when cut by a circular cylinder whose axis coincides with the shaft axis.

Blade section reference point
See Reference point, blade section.

Blade thickness fraction (t_0/D)[-]
If the maximum thickness of the propeller blades varies linearly with radius, then this variation of thickness may be imagined to extend to the axis of rotation. The hypothetical thickness at the axis of rotation, to, divided by the diameter, is known as the blade thickness fraction or blade thickness ratio. If the thickness does not vary linearly with radius, then the blade thickness fraction is not uniquely defined.

Bollard pull F_{P0} [ML/T²]
The pull force exerted by a ship at zero ship speed. It is the sum of the propeller thrust and the interaction force on the hull.

Boss
See Hub.

Camber (f)[L]
Sea Mean Line

Camber, maximum (f_M)[L]
The maximum separation of the mean line and the nose-tail line.

Camber ratio [-]
The maximum camber divided by the chord length, f_M/c.

Cap, propeller
See Cone, propeller.

Centrifugal spindle torque
See Spindle torque, centrifugal.

Chord (c) [L]
The length of the chord line. Sometimes used synonymously with chord line.

Chord length, mean (c_m)[L]
The quotient obtained by dividing the expanded or developed area of a propeller blade by the span from the hub to the tip.

Chord line
The straight line connecting the extremities of the mean line. The length of this line is called

the chord length or simply the chord. It passes through, or nearly through, the fore and aft extremities of the section; synonymous with nose-tail line.

Cone, propeller
The conical-shaped cover placed over the after or forward end of the propeller shaft for the purpose of protecting the nut and forming a hydrodynamic fairing for the hub; also known as a propeller fairwater or a propeller cap.

Contra rotating propeller
See Propeller Types.

Cycloidal propeller
See Propeller Types.

Developed area
See Area, developed.

Developed area ratio [-]
The ratio of the developed area of the propeller blades to the disc area.

Ducted propeller
See Propeller Types.

Effective angle of attack
See Angle of attack, effective.

Effective pitch
See Pitch, effective.

Emergence, tip [L]
The vertical distance from the top of the propeller tip circle to the at-rest water surface when the tips are exposed.

Expanded area
See Area, expanded.

Expanded area ratio [-]
The ratio of the expanded area of the blades to the disc area.

Face (of blade)
The side of the propeller blade which faces downstream during ahead motion. This side of the blade is also known as the pressure side because the average pressure on the face of the blade is higher than the average pressure on the back of the blade during normal operations. The face corresponds to the lower surface of an airfoil or wing.

Face pitch
See Pitch, face.

Fillet
The transition region (fairing) between the propeller hub and the blades at the blade root.

Gap (G_Z)[L]
The distance between the chord lines of two adjacent propeller blade sections at the same radius, r, measured normal to the chord. This distance is given by the formula:

$$G_Z = (2\pi r \sin\phi)/(Z)$$

where r is the radius in question, ϕ is the pitch angle of the chord line at radius r (geometric pitch), and Z is the number of blades.

Generator line
The line formed by the intersection of the pitch helices and the plane containing the shaft axis and the propeller reference line. The distance from the propeller plane to the generator line in the direction of the shaft axis is called the rake. The generator line, the blade reference line, and the propeller reference line each intersect the shaft axis at the

same point when extended thereto. Because of ambiguities which can arise in so extending the generator line and blade reference line when non-linear distributions of rake and skew angle are used, these lines can be defined to each originate at the reference point of the root section (see Figure 2). The rake and skew angle of the root section will thus be defined to be zero and the propeller plane will pass through the reference point of the root section.

Geometric angle of attack
See Angle of attack, geometric.

Geometric pitch
See Pitch, geometric.

Hub
The central portion of a screw propeller to which the blades are attached and through which the driving shaft is fitted; also known as the boss.

Hub diameter (d_h)[L]
The diameter of the hub where it intersects the generator line.

Hub ratio [-]
The ratio of the diameter of the hub to the maximum diameter of the propeller, d_h/D.

Hydrodynamic flow angle
See Angle, hydrodynamic flow.

Hydrodynamic pitch
See Pitch, hydrodynamic.

Hydrodynamic pitch angle
Synonymous with hydrodynamic flow angle. See Angle, hydrodynamic flow

Hydrodynamic spindle torque
See Spindle torque, hydrodynamic.

Hydrofoil
A structure externally similar to an airplane wing designed to produce lift and which operates in water.

Hydrofoil section
The cross-section shape of a hydrofoil.

Ideal angle of attack
See Angle of attack, ideal.

Immersion (h_0)[L]
The depth of submergence of the propeller measured vertically from the shaft axis to the free surface.

Immersion ratio [-]
The depth of submergence of the propeller axis divided by the propeller diameter.

Inboard rotation
A propeller which is not located on the centreline of the ship is said to have inboard rotation if the blades move toward the centreline as they pass the upper vertical position. The opposite direction of rotation is called outboard rotation.

Induced velocity, axial (U_A)[L/T]
The change in the velocity component in the direction parallel to the propeller axis due to the presence of the propeller but not including any change in the wake field due to propeller/hull interactions (see Figure 1).

Induced velocity, tangential (U_T)[L/T]
The change in the velocity component in the tangential direction due to the presence of the propeller but not including any change in the

wake field due to propeller/hull interactions (see Figure 1).

Induced velocity, radial (U_R)[L/T]
The change in the velocity component in the radial direction due to the presence of the propeller but not including any change in the wake field due to propeller/hull interactions.

Kort nozzle
See Propeller Types (ducted).

Left handed (propeller)
A propeller which rotates in the counter clockwise direction when viewed from astern.

Lift (*L*) [ML/T^2]
The fluid force acting on a body in a direction perpendicular to the motion of the body relative to the fluid.

Mean chord length
See Chord length, mean.

Mean line
The mean line is the locus of the midpoint between the upper and lower surface of an airfoil or hydrofoil section. The thickness is generally measured in the direction normal to the chord rather (see Figure 3) than normal to the mean line (see Figure 4). The maximum distance between the mean line and the chord line, measured normal to the chord line, is called the camber. The term camber line is often used synonymously with mean line.

Mean pitch
See Pitch, mean.

Mean width ratio [-]
Mean expanded or developed chord of one blade divided by the propeller diameter; equal to the inverse of one half of the aspect ratio for a wing.

Median line
Synonymous with generator line.

Nominal pitch
See Pitch, nominal.

Nose-tail line
Synonymous with chord line.

Nozzle
The duct portion of a ducted propeller; synonymous with duct or shroud.

Ogival section
A type of airfoil or hydrofoil section having a straight face, a circular arc or parabolic back, maximum thickness at the mid chord, and relatively sharp leading and trailing edges.

Outboard rotation
A propeller which is not located on centreline of the ship is said to have outboard rotation if the blades move away from the centreline as they pass the upper vertical position. The opposite direction of rotation is called inboard rotation.

Pitch (*P*)[L]
A helical path is generated by a point moving at a uniform velocity, V, along an axis while at the same time rotating about that axis at a uniform angular velocity, ω, at a distance, r, from the axis. The distance travelled along the axis in one revolution is called the pitch, P, of the helix. The angle between the path and a plane normal to the axis is called the pitch angle, ϕ (see Figure 2a).

Pitch, analysis
Advance per revolution at zero thrust as determined experimentally.

Pitch, effective
Weighted value of geometric pitch when pitch is not constant. Both the radius and the thrust distribution (if known) have been used as weighting factors. Effective refers also to the advance coefficient where K_T is zero (i.e. ”no-thrust” pitch).

Pitch, face
The pitch of the helix generated by a line parallel to the face of the blade. Used only for flat-faced sections where offsets are defined from a face reference line.

Pitch, geometric (nose-tail pitch)
The pitch of the helix generated by the nose-tail line (chord line). It is equal to the face pitch if the setback of the leading and trailing edges of the section are equal.

Pitch, hydrodynamic
The pitch of the streamlines passing the propeller including the velocities induced by the propeller at a radial line passing through the mid-chord of the root section. See Angle, hydrodynamic flow.

Pitch, mean
1) Generally synonymous with effective pitch.
2) The pitch of a constant pitch propeller which would produce the same thrust as a propeller with radially varying pitch when placed in the same flow.

Pitch, nominal
Synonymous with face pitch. (See Pitch, face).

Pitch, variable
A propeller blade for which the pitch is not the same at all radii is said to have variable pitch or varied pitch. A propeller which has the same pitch at all radii is said to be a constant pitch propeller.

Pitch angle(ϕ)[-]
In the case of a propeller, the angle between the chord line of the section at radius r and a plane normal to the shaft axis is called the pitch angle of the propeller at that radius, ϕ. This is generally known as the geometric pitch (see Figure 1).

Pitch ratio [-]
The ratio of the pitch to the diameter of the propeller. Generally, the face pitch or geometric pitch at the 70 percent radius is used to compute the pitch ratio. Any measure of pitch can be used with the diameter to form a pitch ratio.

Pitch setting [-]
In CPP context pitch setting is defined as the angle of the nose tail line of the blade at the radius 0.7. In other words, the pitch setting is the actual pitch angle at the 0.7 radius.

Plane of rotation
See Propeller plane.

Power coefficient (K_P)[-]
The delivered power at the propeller, P_D, expressed in coefficient form:

$$K_P = P_D / \rho n^3 D^5$$

where ρ is the mass density of the fluid, n is the rate of propeller rotation, and D is the diameter of the propeller.

Power coefficient, Taylor's delivered power (B_P)[ML^{-3}]$^{1/2}$
The horsepower absorbed by the propeller, P_D, expressed in coefficient form:

$$B_P = n(P_D)^{\frac{1}{2}} / V_A^{\frac{5}{2}}$$

where n is revolutions per minute and V_A is the speed of advance in knots.

Power coefficient, Taylor's thrust power (B_U)[ML^{-3}]$^{1/2}$
The thrust horsepower delivered by the propeller, P_T, expressed in coefficient form:

$$B_U = n\left(P_T\right)^{\frac{1}{2}} / V_A^{\frac{5}{2}}$$

where n is revolutions per minute and V_A is the speed of advance in knots.

Power loading coefficient (C_P)[-]
The power absorbed by the propeller, P_D, expressed in coefficient form:

$$C_P = P_D / \left[\frac{1}{2}\rho V_A^3\left(\pi D^2/4\right)\right]$$

where ρ is the fluid density, V_A is the speed of advance, and D is the propeller diameter.

Power loading coefficient, ship speed (C_{PS})[-]

$$C_{PS} = P_D / \left[\frac{1}{2}\rho V^3\left(\pi D^2/4\right)\right]$$

This coefficient may be defined in terms of ship speed V and is then denoted by the symbol C_{PS}.

Pressure side
The side of the propeller blade having the greater mean pressure during normal ahead operation. This is synonymous with the face of the blade and analogous to the lower surface of a wing.

Projected area
See Area, projected.

Projected area ratio [-]
The ratio of the projected area to the disc area.

Propeller
The most common form of propulsor is the screw propeller, which basically consists of a central hub and a number of blades extending out radially from the hub. Lift is generated by the blades when the propeller is rotated. One component of the lift force produces the desired thrust and the other component creates torque which must be overcome by the engine to sustain rotation.

Propeller plane
The plane normal to the shaft axis and passing through the intersection of the generator line and the shaft axis when the generator line is thereto extended; also called the plane of rotation (see Figure 2). It is recommended that the plane be defined instead to contain the propeller reference line, i.e., contain the reference point of the root section, in order to avoid the ambiguities which can arise when non-linear distributions of rake and skew are used.

Propeller Types
The basic screw propeller may be described as fixed pitch, subcavitating, open (unducted), and fully submerged. Variations on this basic type are listed below.

Adjustable-pitch propeller - A propeller whose blades can be adjusted to different pitch settings when the propeller is stopped.

Contra-rotating propeller - Two propellers rotating in opposite directions on coaxial shafts.

Controllable-pitch propeller - A propeller having blades which can be rotated about a radial axis to change the pitch of the blades while the propeller is operating. This allows full power to be absorbed for all loading conditions. If the pitch can be adjusted to the extent that reverse thrust can be achieved without reversing the direction of rotation of the shaft then the propeller is sometimes called a controllable-reversible pitch propeller.

Cycloidal propeller - A propeller consisting of a flat disc set flush with the under surface of the vessel with a number of vertical, rudder-like blades projecting from it. The disc revolves about a central axis and each of the blades rotates about its own vertical axis. The axis of each blade traces a cycloidal path. The blade motion can be varied so as to produce a net thrust in any desired direction - ahead, astern, or athwartships. It is used where excellent manoeuvrability is required.

Ducted propeller - A propeller with a short duct mounted concentrically or nearly concentrically with the shaft. The duct, or nozzle is shaped so as to control the expansion or contraction of the slipstream in the immediate vicinity of the propeller. In one form (the Kort nozzle) the flow is accelerated, whereas in the other form (pump jet) the flow is decelerated.

Ring propeller - A propeller with a very short duct attached to the tips of the blades and rotating with the propeller; also called a banded propeller.

Steerable ducted propeller - A ducted propeller in which the duct can be pivoted about a vertical axis so as to obtain a steering effect.

Supercavitating propeller - A propeller designed to operate efficiently at very low cavitation numbers where a fully developed cavity extends at least to the trailing edge of the blade. The blade sections of such propellers have relatively sharp leading edges for more efficient supercavitating operation and thick trailing edges for strength.

Surface-Piercing propeller - A propeller of the supercavitating ventilated type designed to operate with only a portion of the full disc area immersed. These propellers are considered for application to high speed vehicles such as surface effect ships where the appendage drag associated with the shafts and struts of a fully submerged propeller would result in a considerable increase in resistance. Also known as partially-submerged, or surface, or interface propellers.

Tandem propeller - Two propellers fitted to the same shaft, one behind the other, and rotating as one.

Transcavitating propeller – A propeller that has a hybrid blade section designs: the inner portion of the blade is designed as a supercavitating section while the outer portion of the blade is designed as a subcavitating section.

Ventilated propeller - A propeller of the supercavitating type, but with provision to introduce air into the cavities in order to achieve fully developed, stable cavities at lower speeds than would otherwise be possible.

Vertical axis propeller - Synonymous with cycloidal propeller.

Propulsor
Most generally, any device which produces thrust to propel a vehicle.

Pumpjet
See Propeller Types (ducted).

Race, propeller
The accelerated, turbulent column of water forming the outflow from a screw propeller.

Radial induced velocity
See Induced velocity, radial.

Radius (*r*)[L]
Radius of any point on a propeller.

Radius, maximum (*R*)[L]
Maximum radial extent of a blade section measured from the propeller centre line.

Rake (i_G)[L]
The displacement, i_G, from the propeller plane to the generator line in the direction of the shaft axis. Aft displacement is considered positive rake (see Figure 2). The rake at the blade tip, or the rake angle are generally used as measures of the rake. The strength criteria of some classification societies use other definitions for rake. See also keyword "reference point, blade section".

Rake angle (θ)[-]
The rake angle for a straight generator line can be defined by:

$$\theta = \tan^{-1}\left[i_G(R)/R\right].$$

Another definition of the rake angle is:

$$\theta = \tan^{-1}\left[i_G(R)/(R-r_h)\right].$$

See also keyword "reference point, blade section".

Rake, total axial displacement (i_T)[L]
The sum of the rake and the skew-induced axial displacement.

Reference line, blade
The locus of the reference points of the blade sections (see Figure 2). Sometimes used synonymously with generator line.

Reference line, propeller
The straight line, normal to the shaft axis, which passes through the reference point of the root section (see Figure 2). It lies in the plane containing the shaft axis and the generator line.

Reference point, blade section
The point on the pitch helix to which the blade section offsets is referred. It is usually the mid-point of the chord line. The point of maximum thickness and the location of the spindle axis for controllable-pitch propellers, as well as other points, are also used as blade section reference points.

Right handed (propeller)
A propeller which rotates in the clockwise direction when viewed from astern.

Root
The part of the propeller blade adjacent to the propeller hub.

Rope Guard
Shaped plate (or piece in model scale) attached to the stern tube boss of a ship which extends from the boss to towards the propeller

leaving a small gap between the two. Rope guards are usually of cylindrical or conical shape.

Rudder, active
A propulsion device installed in the rudder for ship manoeuvring at low or zero speed.

Screw propeller
See Propeller.

Shaft inclination
See Angle, shaft

Setback [L]
The displacement of the leading edge or trailing edge of a propeller blade section from the face pitch datum line when the section shape is referenced to that line; also called wash-back or wash-up. The setback ratio is the set-back divided by the chord length.

Shock free entry
See Angle of attack, ideal.

Shroud
The duct portion of a ducted propeller concentric or nearly concentric with the axis of rotation of the propeller blades. In some cases the duct may be rotated about a vertical axis to provide steering forces; Synonyms: duct, nozzle.

Skew [L]
The displacement of any blade section along the pitch helix measured from the generator line to the reference point of the section (see Figure 2). Positive skew-back is opposite to the direction of ahead motion of the blade section. The skew definition pertains to mid-chord skew, unless specified otherwise. See also keyword "reference point, blade section".

Skew angle (θ_S)[-]
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 (see Figure 2). It is positive when opposite to the direction of ahead rotation. This angle is the same as the warp.

Skew angle extent (θ_{EXT})[-]
The difference between maximum and minimum local skew angle.

Skew-back [L]
Also called skew.

Skew-induced axial displacement
See Axial displacement, skew-induced.

Slipstream
See Race.

Span (b)[L]
The distance from tip to tip of a hydrofoil. The distance from root to tip in the semi-span.

Spindle axis
The axis about which a controllable-pitch propeller blade is rotated to achieve a change in pitch.

Spindle torque (Q_S)[ML^2/T^2]
The torque acting about the spindle axis of a controllable-pitch propeller blade resulting from the hydrodynamic and centrifugal forces exerted on the blade. This torque is positive if it tends to rotate the blade toward a higher positive pitch.

$$Q_S = Q_{SC} + Q_{SH}$$

Spindle torque, centrifugal (Q_{SC})[ML²/T²]
The torque acting about the spindle axis of a controllable pitch propeller blade resulting from the centrifugal forces exerted on the blade. This torque is positive if it tends to rotate the blade toward a higher positive pitch.

Spindle torque, hydrodynamic (Q_{SH}) [ML²/T²]
The torque acting about the spindle axis of a controllable pitch propeller blade resulting from the hydrodynamic forces exerted on the blade. This torque is positive if it tends to rotate the blade toward a higher positive pitch.

Spindle torque coefficient, centrifugal (K_{SC}) [-]
The centrifugal spindle torque, Q_{SC}, expressed in coefficient form:

$$K_{SC} = Q_{SC}/\rho_P n^2 D^5$$

where ρ_P is the mass density of the propeller blade material, n is the rate of propeller rotation, and D is the propeller diameter.

Spindle torque coefficient, hydrodynamic (K_{SH}) [-]
The hydrodynamic spindle torque, Q_{SH}, expressed in coefficient form:

$$K_{SH} = Q_{SH} / \rho n^2 D^5$$

where ρ is the mass density of the fluid, n is the rate of propeller rotation, and D is the propeller diameter.

Spindle torque index, hydrodynamic (K^*_{SH}) [-]
The hydrodynamic spindle torque, Q_{SH}, expressed in coefficient form:

$$K^*_{SH} = Q_{SH} / \left\{ \frac{1}{2} \rho \left[V_A^2 + (0.7\pi nD)^2 \right] (\pi D^3/4) \right\}$$

where ρ is the density of the fluid, V_A is the speed of advance, n is the rate of propeller rotation, and D is the diameter. This form of the spindle torque coefficient is useful when presenting propeller spindle torque characteristics over a range of advance coefficients extending from zero ($V_A = 0$) to infinity ($n = 0$). Usually presented as a function of $\beta^* \equiv \tan^{-1}\left[V_A / (0.7\pi nD) \right]$

Stacking line
Synonymous with generator line; also used to denote the blade reference line.

Static thrust coefficient
See Thrust coefficient, static.

Steerable ducted propeller
See Propeller Types.

Suction side
The low pressure side of a propeller blade; synonymous with the back of the propeller blade; analogous to the upper surface of a wing.

Supercavitating propeller
See Propeller Types.

Surface-piercing propeller
See Propeller Types.

Tangential induced velocity
See Induced velocity, tangential.

Taylor's advance coefficient
See Advance coefficient, Taylor's.

Taylor's power coefficients (B_U,B_P)
See Power coefficient, Taylor's.

Thickness, (t)[L]
The thickness of a propeller blade section, generally measured normal to the chord line (see Figure 3). In NACA definition thickness is set perpendicular to camber line (see Figure 4).

Thickness ratio [-]
The ratio of the maximum thickness, t_M, of a hydrofoil/propeller blade section to the chord length, c, of that section.

Thrust (T)[ML/T²]
The force developed by a screw propeller in the direction of the shaft.

Thrust breakdown
The phenomenon of loss of thrust due to excessive cavitation on a sub-cavitating type propeller. The torque absorbed by the propeller is affected similarly and is called torque breakdown. Both the thrust and torque coefficients may increase slightly above non-cavitating values near the initial inception of cavitation. In general, the changes in thrust and torque are such that propeller efficiency is reduced.

Thrust coefficient (K_T)[-]
The thrust, T, produced by propeller expressed in coefficient form:
$K_T = T/\rho n^2 D^4$
where ρ is the mass density of the fluid, n is the rate of propeller rotation, and D is the propeller diameter.

Thrust coefficient, static (η_{JPO})[-]

A figure of merit for comparing the relative performance of propulsion devices at zero speed of advance given by the equation:

$$\eta_{JPO} = T / \left[(\rho\pi/2)^{\frac{1}{3}} (P_D D)^{\frac{2}{3}} \right] = K_T / \left[\pi (K_Q)^{\frac{2}{3}} .2^{\frac{1}{3}} \right]$$

Thrust index (C_T*)[-]
The thrust, T, produced by the propeller expressed in coefficient form:

$$C_T^* \equiv T / \left\{ \frac{1}{2} \rho \left[V_A^2 + (0.7\pi nD)^2 \right] (\pi D^2/4) \right\}$$

where ρ is the density of the fluid, V_A is the speed of advance, n is the rate of rotation and D is the propeller diameter. This form of the thrust coefficient is useful when presenting propeller thrust characteristics over a range of advance coefficients from zero ($V_A = 0$) to infinity ($n = 0$). Usually presented as a function of β^* where $\beta^* = -\tan^{-1}[V_A/(0.7\pi nD)]$.

Thrust loading coefficient (C_{Th})[-]
The thrust, T, produced by the propeller expressed in coefficient form:

$$C_{Th} = T / \left[(\rho/2) V_A^2 (\pi D^2/4) \right] = (K_T/J^2)(8/\pi)$$

where ρ is the density of the fluid, V_A is the speed of advance, and D is the propeller diameter.

Thrust loading coefficient, ship speed(C_{TS})[-]
The symbol C_{TS} is used when this coefficient is based on ship speed instead of speed of advance.

$$C_{TS} = T / \left[(\rho/2) V^2 (\pi D^2/4) \right]$$

Thruster
A propulsion device for zero or low speed manoeuvring of vessels.

Torque (Q)[ML²/T²]
The torque delivered to the propeller aft of all bearings.

Torque breakdown
See Thrust breakdown.

Torque coefficient (K_Q)[-]
The torque, Q, delivered to the propeller expressed in coefficient form:
$K_Q = Q/(\rho n^2 D^5)$
where ρ is the density of the fluid, n is the rate of propeller rotation, and D is the propeller diameter.

Torque index (C_Q*)[-]
The torque, Q, absorbed by the propeller expressed in coefficient form:

$$C_Q^* \equiv Q / \left\{ \frac{1}{2} \rho \left[V_A^2 + (0.7\pi nD)^2 \right] \left(\pi D^3 / 4 \right) \right\}$$

where ρ is the density of the fluid, V_A is the speed of advance, n is the rate of propeller rotation, and D is the diameter. This form of the torque coefficient is useful when presenting propeller torque characteristics over a range of advance coefficients extending from zero ($V_A = 0$) to infinity ($n = 0$). Usually presented as a function
$\beta^* = -\tan^{-1}[V_A/(0.7\pi nD)]$.

Total rake
See Rake, total.

Transcavitating propeller
See Propeller Types.

Variable pitch
See Pitch, variable.

Velocity, induced
See Induced velocity (axial, tangential, and radial).

Ventilated propeller
See Propeller Types.

Vertical-axis propeller
Synonymous with cycloidal propeller. See Propeller Types.

Warp
Synonymous with skew angle.

Washback
See Setback.

Waterjet
A form of propulsion in which water is taken into the hull of the ship by means of ducting and energy is imparted to the water with a pump. The water is then ejected astern through a nozzle.

Windmilling
The rotation of a propeller caused by flow past the propeller without power being applied to the propeller shaft. This action may take place while the ship is moving under its own momentum, while it is being towed, or while it is being propelled by other means of propulsion.

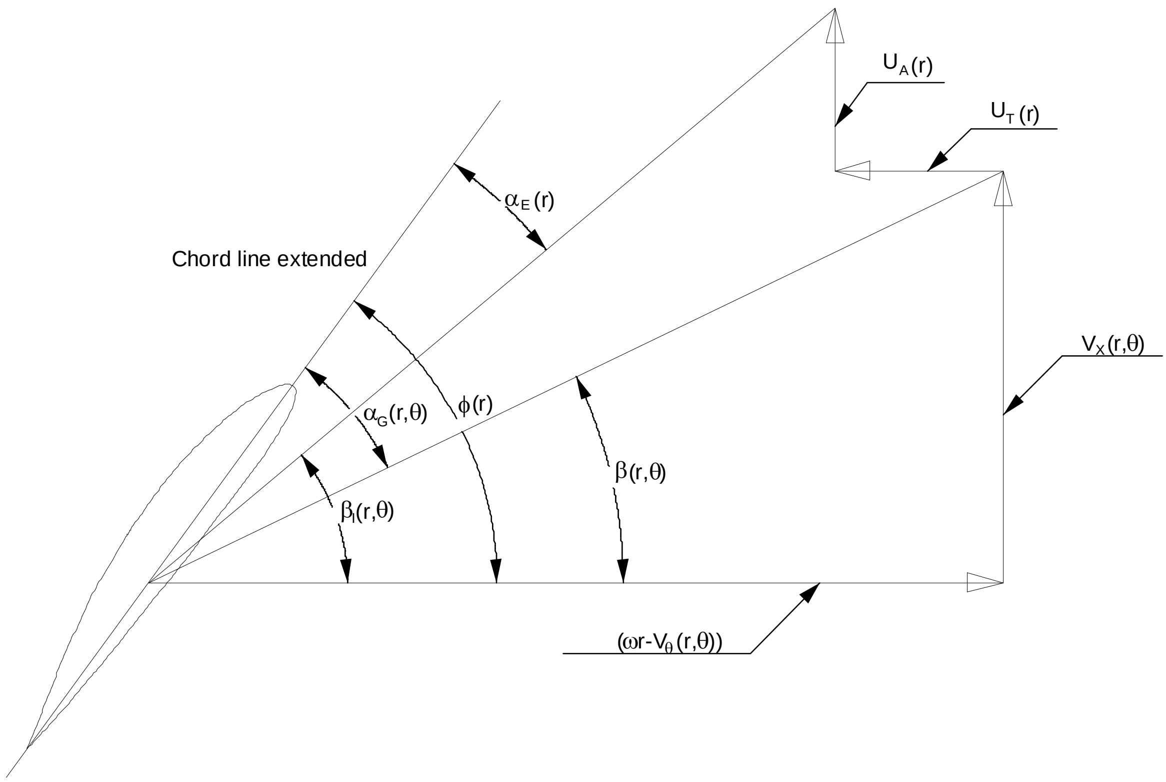
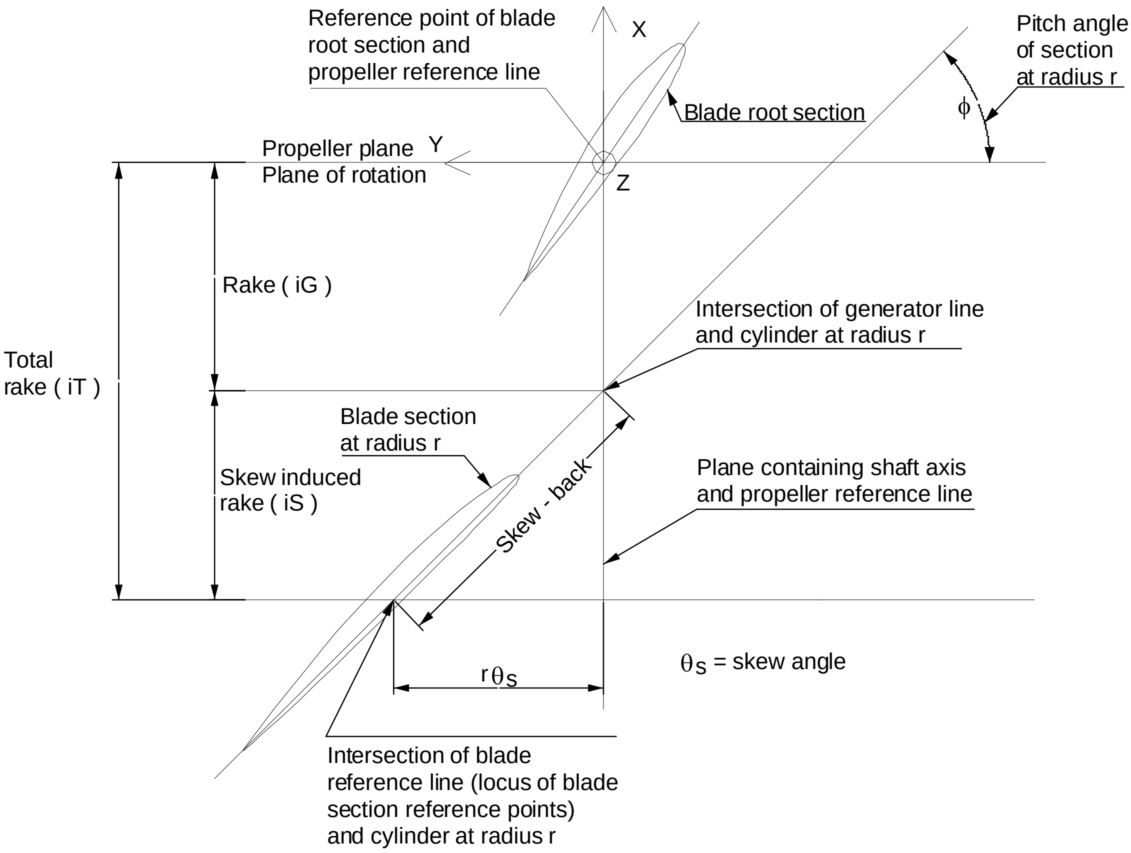


Figure 1 Typical velocity diagram for a propeller blade section at radius *r*. Note diagram is drawn with all quantities positive and the velocity vectors representing the velocity of the propeller blade section elative to the fluid.


Reference point of blade root section and propeller reference line
X
Pitch angle of section at radius r
ϕ
Blade root section
Propeller plane Plane of rotation
Y
Z
Rake (iG)
Total rake (iT)
Intersection of generator line and cylinder at radius r
Blade section at radius r
Skew induced rake (iS)
Skew - back
Plane containing shaft axis and propeller reference line
rθs
θs = skew angle
Intersection of blade reference line (locus of blade section reference points) and cylinder at radius r

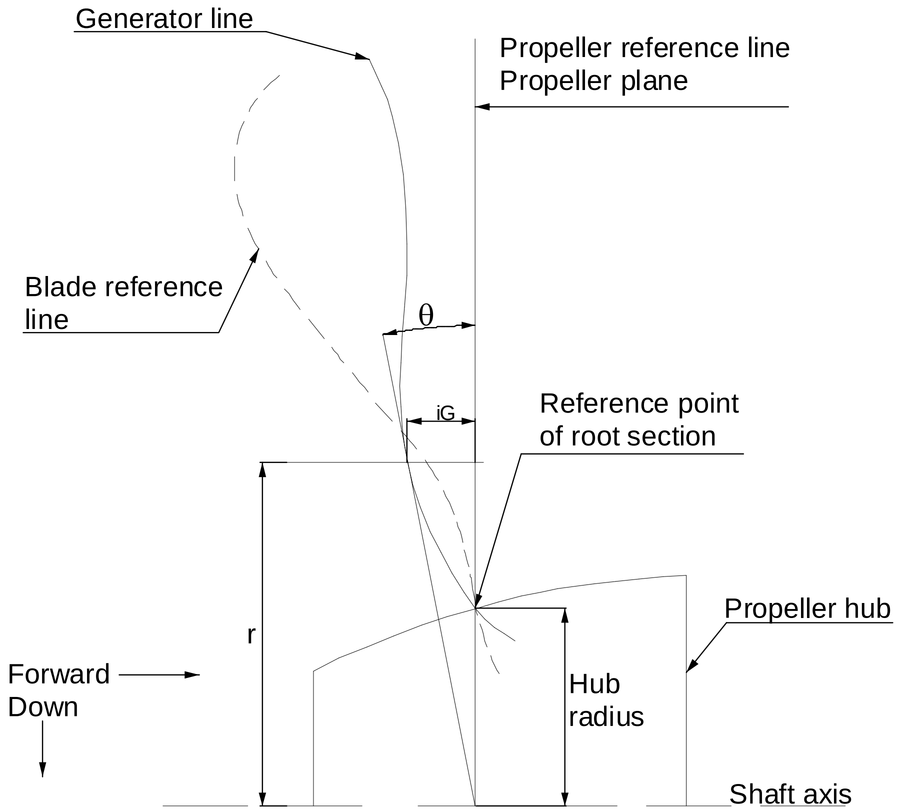


Figure 2b Diagram showing recommended reference lines (looking to port)

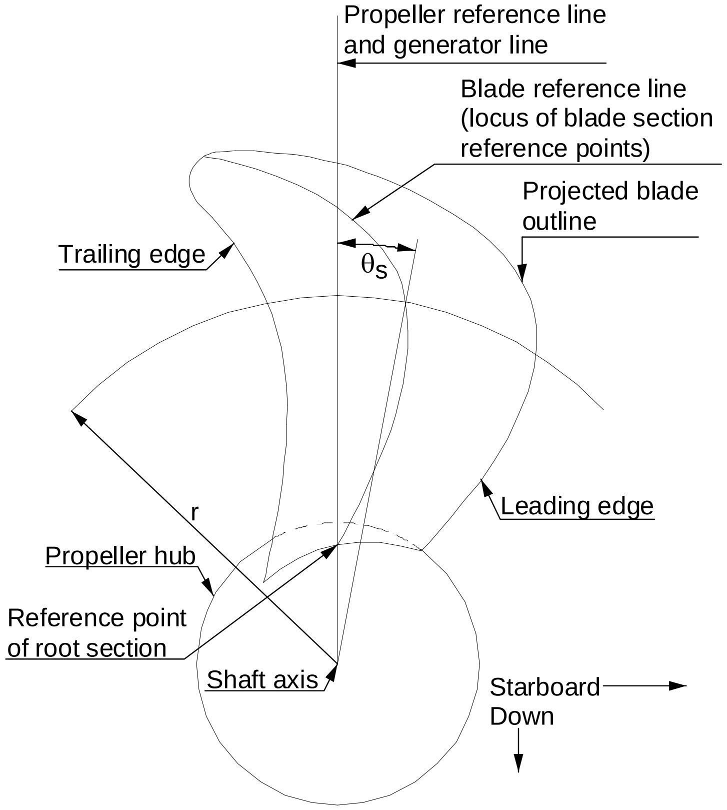


Figure 2c Diagram showing recommended reference lines (looking forward)

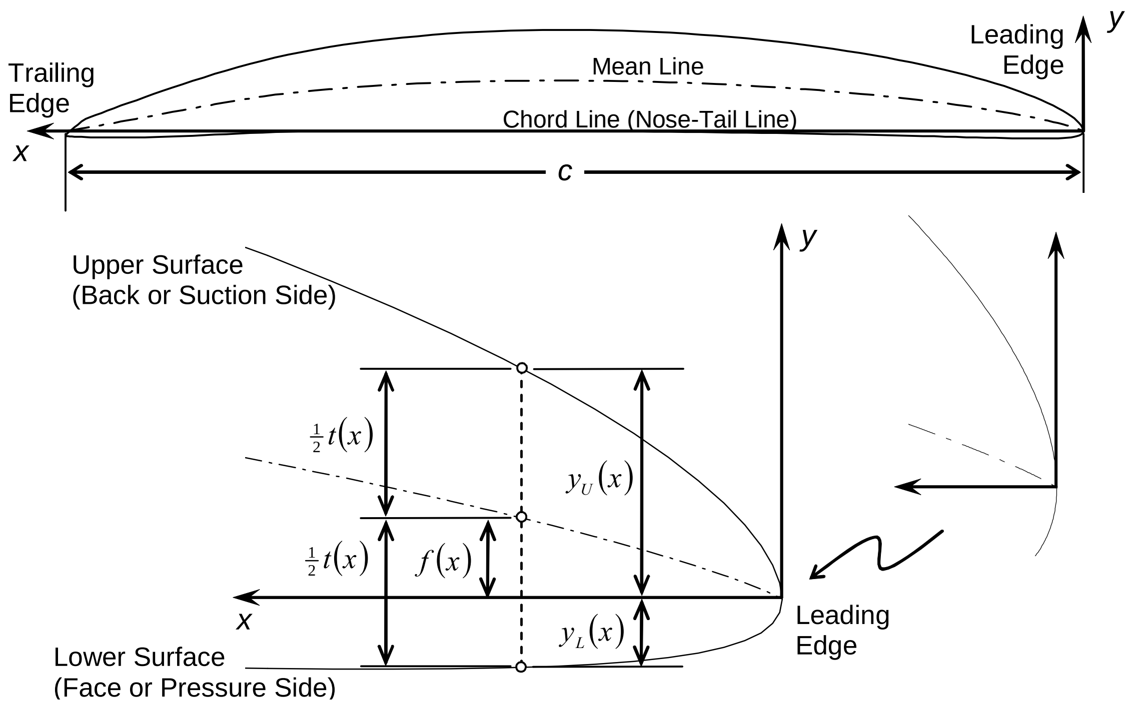


Figure 3. Definition of expanded cylindrical blade section geometry - thickness normal to chord line.

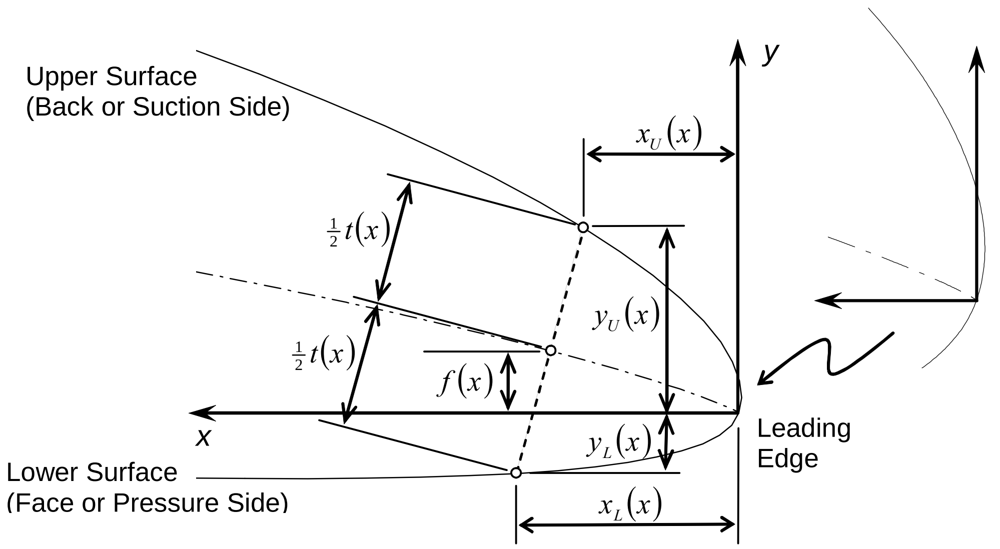


Figure 4. Definition of expanded cylindrical blade section geometry with thickness added normal to mean line.