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Updated / Edited by	Approved
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Propeller Model Accuracy

1. PURPOSE OF PROCEDURE

The purpose of the procedure is to recommend manufacturing tolerances for model propellers used for cavitation tests. Recommended tolerances for propellers used for propulsion and open water tests are given in ITTC recommended procedure 7.5-01-01-01 “Model Manufacture Ship Models”.

2. FIELD OF APPLICATION

This procedure applies to fixed pitch and controllable pitch propellers, manufactured for cavitation tests. The typical propeller diameter used for cavitation and pressure fluctuation tests is in the range between 180 to 300 mm. The maximum propeller diameter, used in some large test facilities, is in the range up to 600 mm.

3. TERMINOLOGY AND NOMENCLATURE

- Blade section

  The shape of a propeller blade at any radius, when cut by a circular cylinder of which the axis coincides with the shaft axis.

- Camber

  The maximum distance between the mean line and the chord line, measured normal to the chord line.

- 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.

- Fillet

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

- Generator line

  The line formed by the intersection of the pitch helices and the plane containing the shaft axis and the propeller reference line see Figure 1.

- Mean line

  The mean line is the locus of the midpoints between the upper and lower surface of the blade section.

  $$y_S(x) = \tfrac{1}{2}\left(y_{SS}(x) + y_{PS}(x)\right)$$

  For definitions of y_{SS} and y_{PS}, see Figure 4.

- Pitch

  A helix 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.

- Pitch, mean

Weighted value of geometric pitch.

$$P_{\mathrm{m}} = \frac{\int P(r)\times c(r)\times rdr}{\int c(r)\times rdr}$$

- Propeller plane

The plane perpendicular to the shaft axis and passing through the intersection of the generator line and the propeller hub (see Figures 1 and 2).

- Rake

The distance between the propeller plane and the generator line in the direction of the shaft axis.

- Root

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

- Thickness

The thickness of the blade section, generally measured normal to the chord line.

$t(x) = y_{\mathrm{SS}}(x) - y_{\mathrm{PS}}(x)$

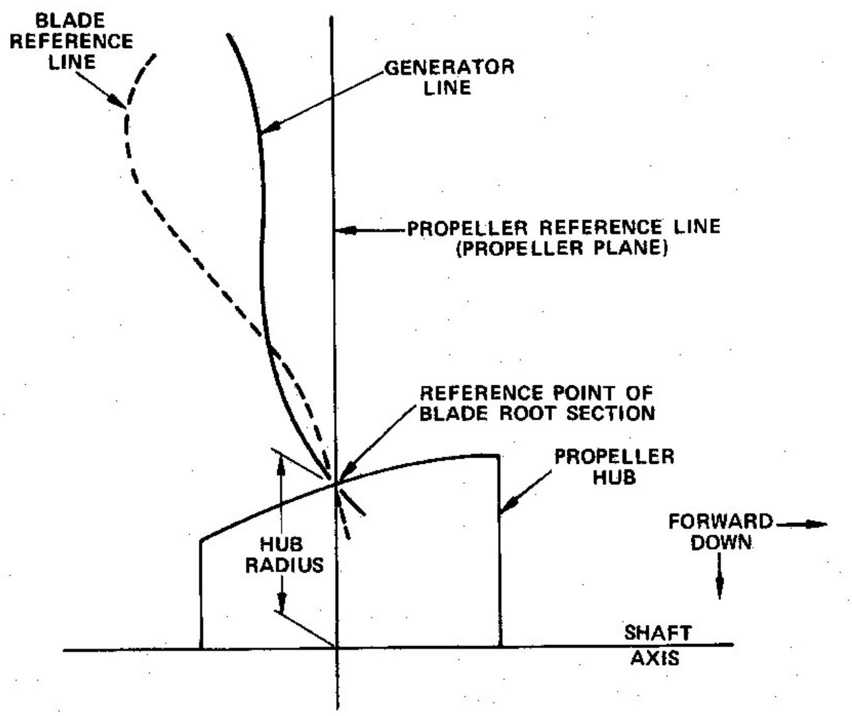

Figure 1: Recommended reference lines (looking to port)
(ITTC – Recommended Procedures 7.5-01-02-01)

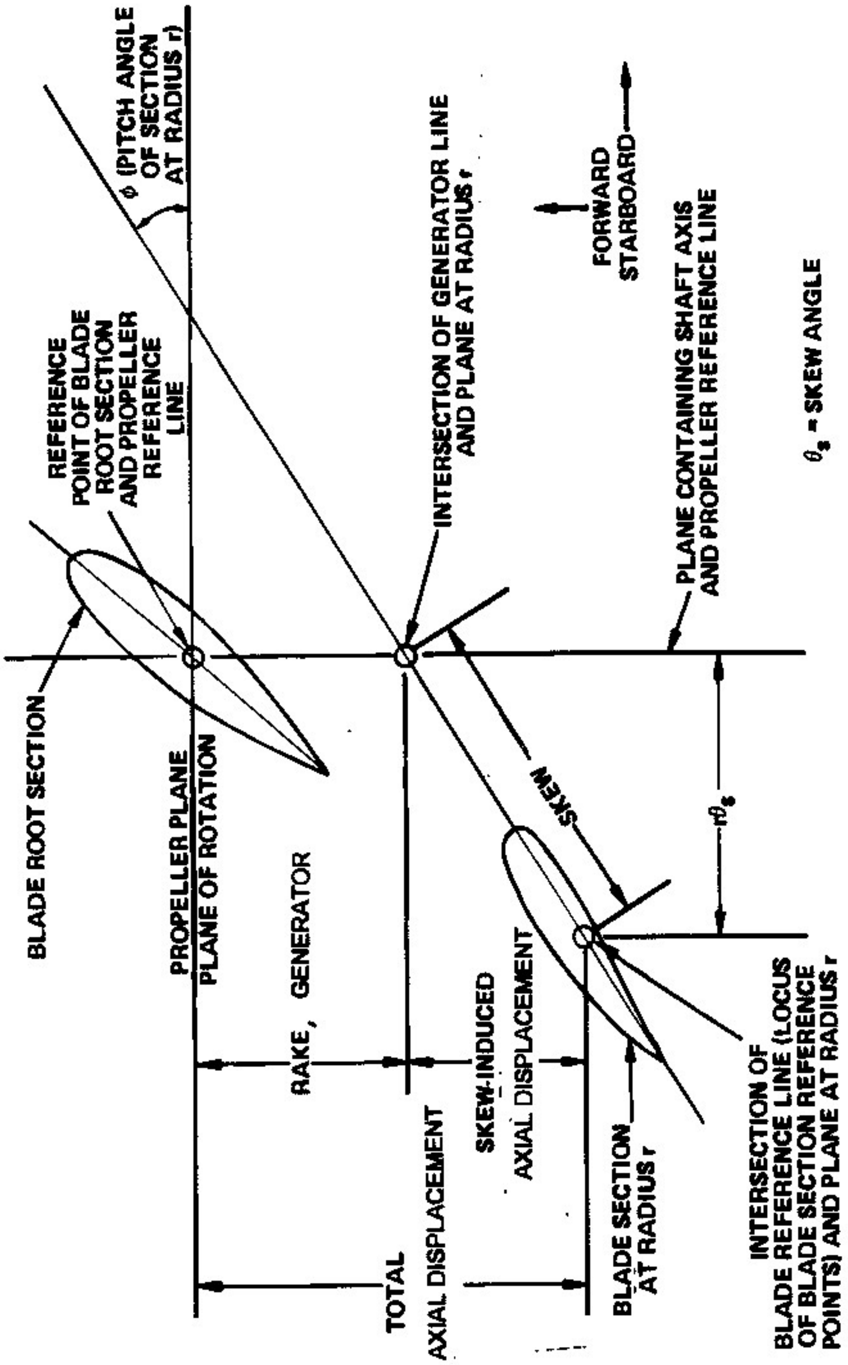

Figure 2: View of unrolled cylindrical sections at blade root and at any radius r of a right-handed propeller (looking down) showing recommended location of propeller plane (ITTC – Recommended Procedures 7.5-01-02-01)

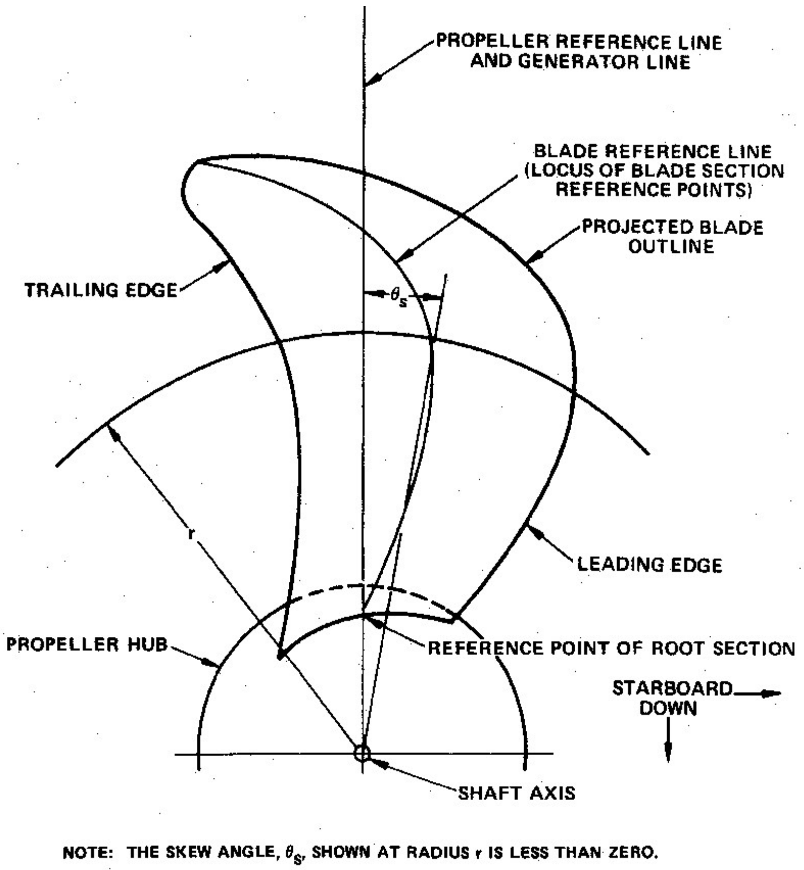

Figure 3: Recommended reference lines (looking forward)
(ITTC – Recommended Procedures 7.5-01-02-01)

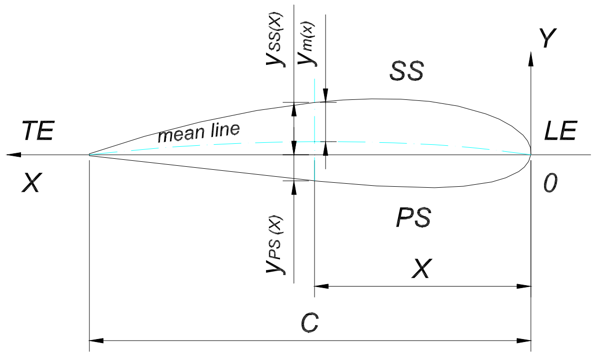

Figure 4: Blade section

4. TOLERANCES

4.1 Diameter

Tolerance for the diameter *D* [mm]:

The diameter should be within ±0.05% of the design diameter with a maximum tolerance of ±0.1 mm.

4.2 Pitch

Tolerance for the pitch *P* [mm]:
a) pitch per blade at each section: ±0.5 % of the design pitch corresponding to the radius at the section

b) mean pitch per blade: ± 0.5 % of the mean design pitch

The pitch should be measured at least at 8 blade sections for each blade.

Section: near the hub – 0.4 *R* – 0.5 *R* – 0.6 *R* – 0.7 *R* – 0.8 *R* – 0.9 *R* - 0.95 *R* – 0.975 *R*

4.3 Chord length of the blade sections

Tolerance for the chord length *c* [mm]:

The chord length should be within ±0.5 % of design length with a maximum tolerance of ±0.2 mm

The lengths of the sections should be measured at the same radii at which the local pitch and blade section offsets are measured.

4.4 Blade section offsets

Tolerance for the blade section offsets y_{SS}, y_{PS} [mm]:

The tolerances of the offsets on the suction side and the pressure side should be in the range of ±0.05 mm.

The blade section offsets should be measured at the same radii at which the pitch is measured. The measurement resolution should be fine enough to define the leading, trailing, and overall section contours.

4.5 Form of blade sections

The leading edges and tip edges require a higher level of accuracy, especially when monitoring cavitation inception. The higher accuracy can be very difficult to manufacture and inspect.

A tolerance within 0.05 mm is recommended for the edge sectional shape (leading, trailing, and tip edge geometry).

The definition of the geometry in the leading edge and tip regions is very important. A greater density of measuring points is required at the leading edge and along the chord and the span in the tip region. Edge gauges or laser sheet equipment should be used where possible, to check the leading edge region.

4.6 Rake

The measuring points for the blade section offsets should be used to check the rake of the blades.

The deviation of the measured rake from the design rake should not be greater than ±0.5% of the propeller diameter.

4.7 Location of blades

Angle between two consecutive blades: The tolerance for the angle between two consecutive blades should be within ± 1°.

4.8 Root area

The root area of the blade, especially the fillet radii and their chord-wise distribution should be checked.

4.9 Surface finish

The model propeller should be polished and inspected for blade surface blemishes, which could affect cavitation performance.

The mean roughness of the blade surface should be in the range of 0.3 - 0.5 μm.

4.10 Pitch adjustment

For controllable pitch propellers, the pitch adjustment of each blade should be checked. For each new pitch ratio, new reference points should be calculated to adjust the correct pitch.

4.11 Documentation

The particulars of the model propeller should be documented in a report and/or included in a test report, and should contain at least the following information:

- Identification (model number or similar)
- Propeller type
- Materials of constructions
- Principal dimensions

Diameter	D	[mm]
Pitch ratio	P/D	[-]
Expanded area ratio	A_E/A_0	[-]
Chord length	c	[mm]
Thickness ratio	t/c	[-]
Hub ratio	d_h/D	[-]
Rake	i_G	[mm]
Skew angle	θ_{EXT}	[°]
Number of blades	Z	
Direction of rotation		

- Tolerances of manufacture
  Accuracies
  Measured inspection data
  Inspection Date

5. REFERENCES

ISO 484/1, Shipbuilding – Ship screw propellers – Manufacturing tolerances – Part 1: Propellers of diameters greater than 2.50 m

ISO 484/2, Shipbuilding – Ship screw propellers – Manufacturing tolerances – Part 2: Propellers of diameters between 0.80 m and 2.50 m inclusive

ITTC Symbols and Terminology List, Version 2002, prepared by the 23rd ITTC Quality Systems Group

Report of the Propulsion Committee, Proceedings of the 23rd ITTC, Volume I, Venice, 2002

Report of the Specialist Committee on Cavitation Induced Pressures, Proceedings of the 23rd ITTC, Volume II, Venice, 2002

ITTC – Recommended Procedures 7.5-01-02-01 Model Manufacture, Propeller Models, Terminology and Nomenclature for Propeller Geometry, 23rd ITTC, 2002

ITTC – Recommended Procedures 7.5-02-03-03.1 Testing and Extrapolation Methods, Propulsion, Cavitation, Model-Scale Cavitation Tests, 23rd ITTC, 2002