ITTC Quality System Manual

Recommended Procedures and Guidelines

Procedure

Description of Cavitation Appearances

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Disclaimer

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Description of Cavitation Appearances

1. PURPOSE OF PROCEDURE

To ensure description of the appearance of cavitation observed during model-scale cavitation tests is consistent amongst ITTC member organisations.

2. DESCRIPTION OF CAVITATION APPEARANCES

2.1 Introduction

It is standard practice in cavitation testing laboratories to include sketches or photographs of cavitation patterns in test reports. Descriptive terms are used to identify the various types of cavitation observed during tests, typified below, in Figure 1.

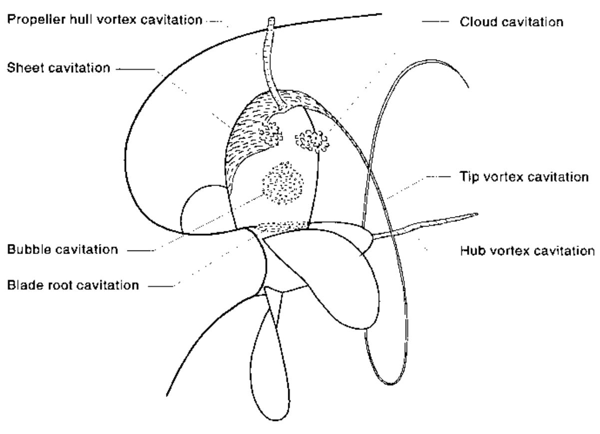

Figure 1 Cavitation types

Description of cavitation appearances should contain information on cavity location, size, structure, and dynamics, as well as proper references to the prevailing flow dynamics. The number of alternative descriptions for cavity structure should be limited to the most commonly used.

2.2 Descriptions

The following descriptive types of cavitation are recommended.

- Cloud
- Sheet
- Streak
- Bubble - large, small
- root
- Vortex - attached, trailing detached, leading edge, propeller-hull, hub

Along with the categories mentioned above, information on cavity location, in particular with regard to propellers, should be specified as follows:

- radial location,
  - fraction of tip radius
  - blade tip
  - root fillet
  - tip (duct) gap
  - hub
- chordwise location,
  - fraction of chord
  - leading edge
  - trailing edge
- suction side (back)
- pressure side (face)
- location in wake

Cavity size should be described in terms of body dimensions if developed cavitation exists, for instance defining the fraction of blade area which is covered by a certain type of cavitation.

Typical examples of cavity types are shown in Fig. 2 through 4. Descriptions of some cavity types are below:

sheet cavitation

- usually thin, smooth, transparent. Initiating near leading edge. Often foamy in appearance.

cloud cavitation

- usually develops from the break-up of unsteady sheet cavitation.

streak cavitation

- special form of bubble cavitation, narrow, usually forming in parallel at isolated roughness spots or imperfections on the blade surface or at the leading edge.

bubble cavitation

- small bubble type cavitation indicative of propellers with new blade sections with no suction peaks at the leading edge at $Re_{0.7R}$ above about 106.
- large bubble type, usually isolated, indicative of $Re_{0.7R}$ less than about 106.

vortex cavitation

- trailing, detached tip vortex cavitation incepts downstream of the blade tip.
- leading edge vortex cavitation occurs along the leading edge, usually at high leading edge loading conditions.
- attached tip vortex cavitation occurs very near the blade tip, often attached to the blade.
- propeller-hull, free vortex extending from hull to propeller disk, at low speed, high loaded conditions.

root cavitation

- thick three dimensional cavitation occurring at the blade root, commonly seen on controllable pitch propellers (CPP).

Figure 2 Leading edge, large bubble and root cavitation

other forms

- hub vortex
- ducted propeller, tip gap leakage vortex
- CPP blade bolt cavitation
- cavitation in separated flow regions, high blade angle of attack, and wake

Cavity dynamics could be categorized as:

- steady,
- periodic,
- unsteady,

- non-periodic,
- transient or travelling,
- intermittent
- unstable

When possible, to complete the description requirements stated above, reference should be made to the type of flow associated with certain cavitation phenomena, e.g.

- laminar boundary layer
- turbulent boundary layer
- steady flow
- unsteady flow
- separated flow
- free vortices
- shear layers
- incoming wake flows (uniform, non-uniform or unsteady)
- ventilated flow.

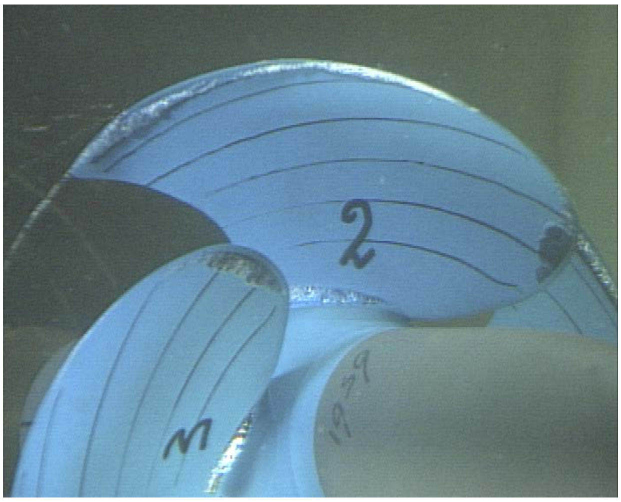

Figure 3 Attached Leading edge tip vortex, leading edge sheet, and root cavitation

All terms listed relate to visual observations only. For other than visual observation techniques (e.g. high speed photography and video, holography, light scattering, Schlieren method, acoustical methods) different terminologies apply. Also, the list should not be regarded as fully comprehensive, but should be extended, if necessary.

What should be avoided is the use of more than one term for the same phenomenon, and descriptions should be as complete as possible.

Figure 4 Small bubble and streak cavitation

Hand drawn sketches of cavitation patterns are often used to describe cavitation in test reports. Schematic patterns are shown below in Figure 5 for various cavitation types.

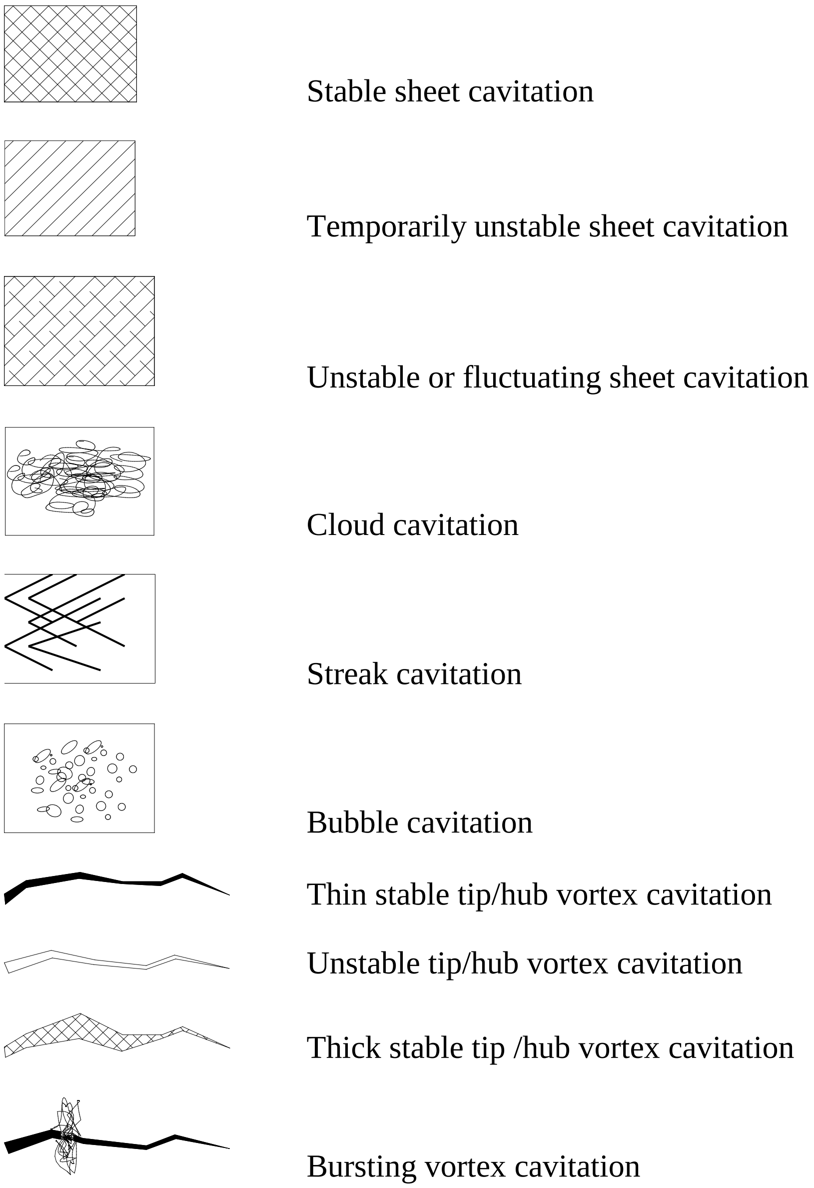

Figure 5. Schematic Patterns for use in Cavitation Hand Sketches

2.3 Non stationary appearance of cavition

A sketch (Figure 6) showing the suction side (and if required the pressure side) of blade at different angular position (every 18° for instance) with the radii of 0.5-0.6-0.7-0.8-0.9-0.95 along with the extension of cavity is often used to describe the changes of cavitation at the operating conditions of the propeller.

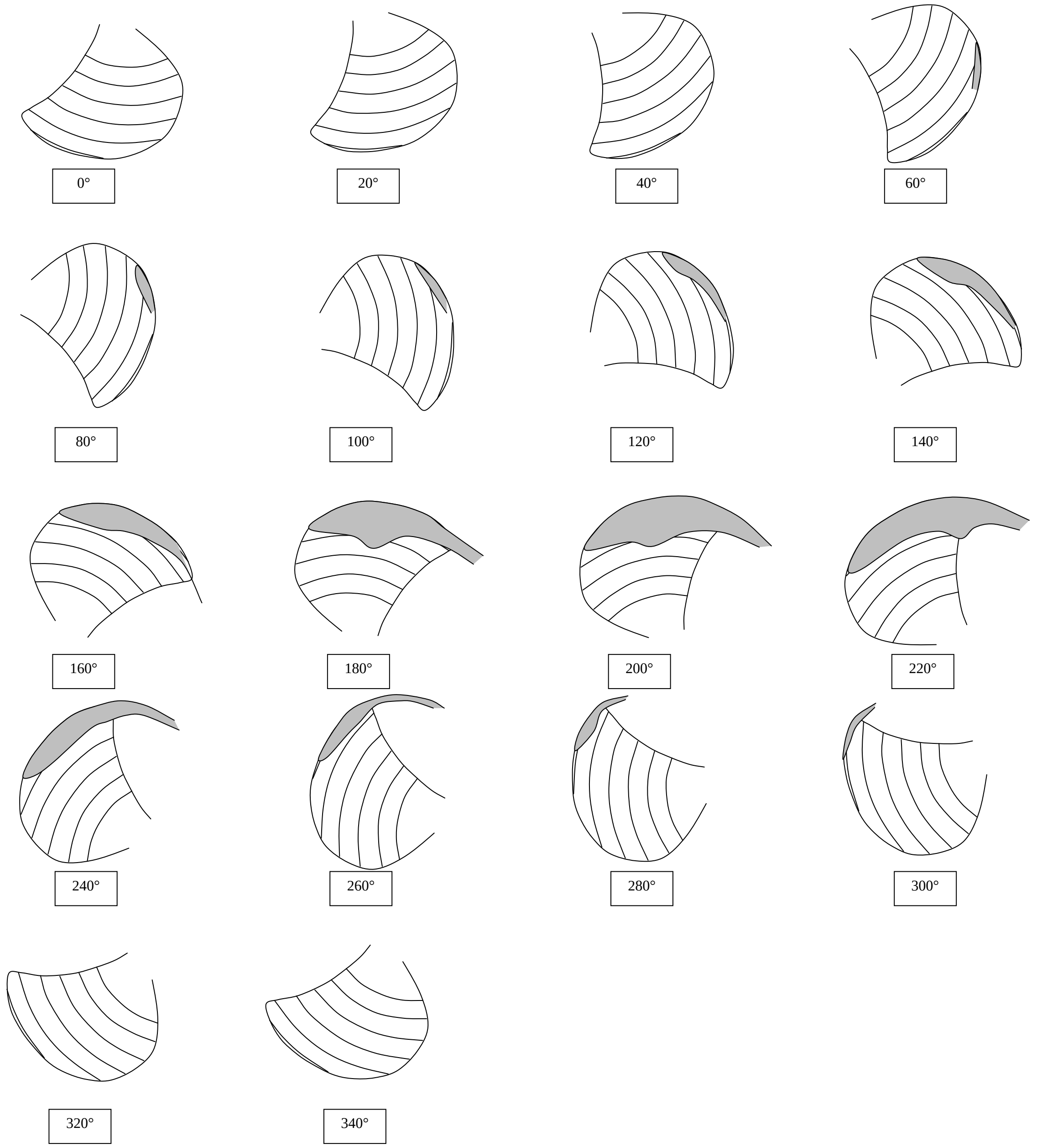

Figure 6 : Suction side cavitation as a function of blade angular position

3. PARAMETERS

3.1 Parameters to be Taken into Account

See sections 2.11, 3.1 and 3.2 of 7.5-02-03-03.1.

3.2 Recommendations of ITTC for Parameters

See sections 3.1 and 3.2 of 7.5-02-03-03.1.

4. VALIDATION

4.1 Benchmark Tests

1) Comparative Propeller Tests (7th l955 pp.129-216)
The Completion of the Full Programme of Tests in One Tunnel

The Tests of At Least One Model Propeller in Each of the Eight Tunnels

The Completion of the Open-Water Tests of All the Model Propellers in Ship Tanks

Measurement of All the Model Propeller, Including Surface Finish Propeller Models from 8 to 18 Inches Diameter at Reynolds' Number from 1.5 to 7.5 million

1.1) Cavitation Tunnel Tests of Series 1 Propellers (7th l955 pp.131-135) Parent Model AEW/C2 (Diameter 9-12-15-18)

1.2) Cavitation Tunnel Tests of Series 2 Propellers (7th l955 pp.135-168)
3-Bladed Propeller; The Developed Blade Area Ratio 0.655,
The Pitch Diameter Ratio 1.333
Constant Ogival Sections with Sharp Leading Edges
The Design Advance Coefficient J=0.925

1.3) Cavitation Tunnel Tests of Series I 12 Inch Propellers and Series III 12 inch Propellers (7th 1955 pp.169 - 189)
Series I: 12 Inch Propeller in All Tunnels
Series III: 12 Inch Propeller in Tunnels
Tunnel Wall Effect: less than 0.14

1.4) Open Water Tests of Model Propellers (7th l955 pp.190 -199)
Series I: Tested in No.2 Ship Tank Haslar
Series II: Tested at Carderock
Series III: Tested at Gothenburg

1.5) Tolerance and Surface Finish of Model Propellers (7th l955 pp.200-216)

2) Cavitation Inception on Head Forms Comparative Experiments (11th l966 pp.170)

2-1) Cavitation Inception on Head Forms ITTC Comparative Experiments
(11th 1966 pp.219-232)

a) Cavitation Number for Cavitation Inception on the Body

b) Cavitation Number when Bubbles are Clearly Visible in the Test Section in Front of the Body i.e. when the Resorption Power of the Tunnel is no Longer Sufficient.

3) 1TTC. Standard Screw Cavitation Tunnel Tests at Brodarski Institute (12th l969 pp. 523-525) 228.6 mm Diameter

4) Nuclei Measurement and "Standard Cavitator" (13th 1972 pp.642-646)
4.1) Air Content- and Nuclei Measurement
4.2) "Standard Cavitator"

5) Comparative Hydrofoil Experiments and Development of a Standard Cavitator
(14th 1975 Vol.2 pp.76-93)

(1) Results of Tests with Three-Dimensional 19-012 and 16-1512 Hydrofoils in Different Cavitation Facilities
(2) Progress in the Development of a 'STANDARD CAVITATOR'

6) Appendix A (Hydrofoils) (15th 1978 pp.340-347)
Foil F: Symmetrical Profiles NACA 19-012
Foil G: Cambered Profiles NACA 19-1512

7) Comparative Tests with the Foil-Head form Combination (16th l981 pp.420-424)

8) Comparative Noise Measurements with the Sydney Express Propeller Model
(16th 1981 pp.447-453)

9) Comparative Tests on Soft Surface Techniques (16th 1981 pp.436-443)
The SSPA Stencil Ink Method, Modified by SRI-MHI Test Procedure

10) Comparative Tests with Foil-Headform Combination (17th 1984 pp.245-248)

11) Comparison of Hull Pressure Amplitudes for Sydney Express Propeller
(17th 1984 pp.248-252)

12) Comparative Erosion Tests with Propeller Model (17th 1984 pp. 252-255)

13) Comparative Noise Measurement with Sydney Express Propeller Model
(17th 1984 pp.255-256)

14) Comparative Cavitation Observations on Propeller with and without Leading Edge Roughness (18th 1987 pp.207 -208)
Model Propeller; NSMB Model 6091, as the '18th ITTC Propeller'

15) Comparison of Propeller-Induced Hull Pressure Measurements for the "SYDNEY EXPRESS" Propeller Models
(18th 1987 pp.209-210)

16) Comparative Noise Measurements with "SYDNEY EXPRESS" Propeller Models (18th 1987 pp.210~-211)

17) Cavitation Nuclei Measurements.
(19th 1990 pp.166-175)

18) Propeller-Induced Hull
(19th 1990 pp.182-187)

19) Further Measurement of Pressure Fluctuation on 'SYDNEY EXPRESS' Propeller (19th 1990 pp.213-219)

20) Joint Bassin d'Essais des Carènes and Cavitation Committee Tests
(20th 1993 pp.206-213)
Measurement of Liquid/Nuclei Distribution Determination of Cavitation Inception Scale Effects. Minimizing the Liquid Tension in a Water Tunnel or Towing Tank.

21) 20th ITTC Comparative Model Measurements (20th 1993 pp.230-231)
Measurements on German Tanker "St. Michaelis" and the "Sydney Express"

21.1) Comparative Measurement of Pressure Fluctuation on the "St Michaelis"
(20th 1993 ~pp.236-240)

22) Measurements of Hull Pressure Fluctuation (21st 1996 pp.65-69)