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General Guidelines for Ice Model Testing

1. PURPOSE OF THE PROCEDURE

The purpose of this procedure is to assist in making the test results from different test series and different laboratories more consistent. The ice committee has reviewed the earlier ITTC ice committee reports; this section represents a collection of methods developed during the past years. The following test types are discussed:

- Ship resistance in level ice
- Ship propulsion in level ice
- Manoeuvring of ships in level ice
- Ship tests in deformed ice
- Tests with offshore structures

Some important information is common to all of the above test types.

2. GENERAL GUIDELINES

2.1 Facilities, Ice Conditions and Ship Model

2.1.1 The Facility

Differences in the dimensions and layout of the facility may have some influence on the tests. An important factor is the effect of the basin size on the number of tests that can be run in one ice sheet. The test length, in linear tests, limits this number. This test length should be such that the transients due to entering the testing ice have disappeared. Thus, if the model comes to level ice from open water, the stem must be in the level ice part before the actual test run can start. In this case, the ship should proceed in ice at least two ship lengths (see 15th ITTC). The other factor, which may restrict the test programme, is the vicinity of the basin walls. The level ice sheet may be considered to have infinite extent if the shortest distance from the point of application of any loads to the nearest tank wall is more than three characteristic lengths. The characteristic length is defined as:

$$L_{\mathrm{ch}} = \sqrt[4]{\frac{EH_I^3}{12\left(1-\nu^2\right)\rho_{\mathrm{w}} g}} \tag{1}$$

where E is Young's modulus of ice, H_I is the ice thickness, ν is Poisson's ratio of ice, ρ_w is the density of water and g is the acceleration of gravity.

In resistance tests the basin width "D" where the breadth of the vessel is B, the requirement is:

$$L_{\mathrm{ch_M}} \le \frac{D - B_\mathrm{M}}{6} \tag{2}$$

(subscript $_\mathrm{M}$ refers to model scale).

It is useful to present a layout of the test facility in the model test report. This layout should be used to report how the ice sheet was used in the tests. An example is presented in Fig. 1.

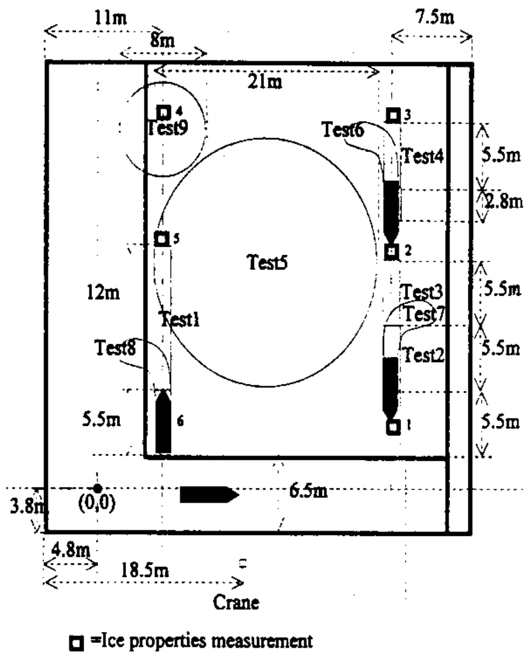

Fig. 1 Description of the use of the ice field in model tests.

2.1.2 Ice Conditions

Ice resistance tests can be performed in different ice conditions such as level ice, newly broken channel, rubble field (old channel) and ridge field. The proper documentation of the tests includes the method by which the model ice field was simulated, the number, time and location of ice thickness, flexural strength and other ice property measurements.

The interval of thickness measurement should be measured about 1 m along the broken track „channel“ in the ice sheet. In level ice, it is recommended to measure the thickness from both sides of the channel. In an old channel or rubble field, the thickness should be measured along two or more straight lines parallel to the ship “or structure in motion“ so that thickness profiles may be presented of the ice formation.

Visible cracks in the ice extending from the broken channel towards the basin walls “or towards open water areas“ should be noted in the report. In the case of presawn ice, in ship resistance tests, the cutting pattern and the size of the ice pieces should be described, see Fig. 2.

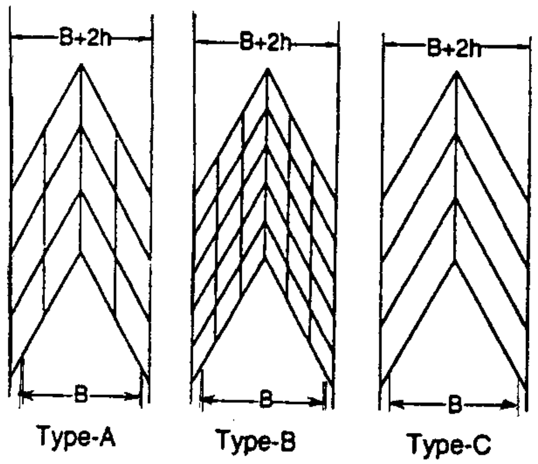

Fig. 2 Patterns of presawn ice field

The breaking pattern of ice, the width and other properties of the broken channel, ice coverage and floe size distribution can be described by photographs and videos after the tests. The use of a clearly visible and readable yardstick on the broken channel or a grid with constant interval is recommended. Numerical data of channel width etc. can be presented in table format. Some facilities perform resistance tests along parallel tracks in the same ice sheet. In these cases, it is possible that cracks from the second channel to a previously broken channel reduce the ice resistance. These resistance points should be ignored. It is important to report how the tests were performed and how the possible ice movement sideways was prevented.

2.1.3 The Model.

It is important to document the ship (or structure) model particulars in detail. A list for the ship model parameters to be reported is given below.

The bow form of the vessel is important in ice breaking. It can be characterized with drawings but in a numerical presentation several bow angles are needed. Fig. 3 presents the recommended definitions of different bow angles. These angles are: φ - stem or buttock angle, β - frame angle and ψ - flare angle.

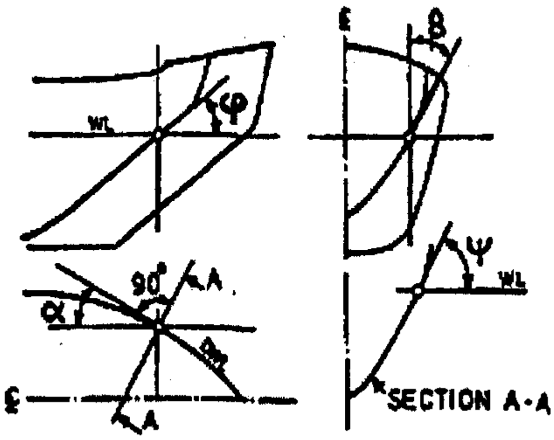

Fig 3 Definitions of bow angles

2.2 Parameters to be taken into account

2.2.1 Ship Model Parameters

Parameter	Priority
Scale ratio	1
Main dimensions	1
Hull lines plan	1
Model draft fore and aft	1
Ice-hull friction coefficient	1
Propeller data	2
Roll and pitch gyradii	2
Trim and inclination angle	2
Geometry of hull appendages	2
A table of bow angles	3
Surface Treatment	3

2.2.2 Level Ice Parameters

Parameter	Priority
Ice thickness	1
Broken channel width	1
Piece size, breaking pattern	1
Model ice type	1
Elastic modulus	1
Flexural strength	1
Compressive strength	1
Underwater photography	1
Ice density	1
Ice crystal structure	2
Fracture toughness	2
Water density	2

3. VALIDATION

3.1 Uncertainty Analysis

Not relevant

3.2 Benchmark Tests

(1) Report of Committee on Ships in Ice-Covered Water (16th 1981 pp. 363-372)

(2) Catalogue of Available Model and Full Scale Test Data (16th 1981 pp. 370-371)

(3) Standard Model Tests (Ice) (17th 1984 pp.591-601)
(a) Model Tests with R-Class Icebreaker
(b) Propulsion Tests
(c) Full Scale Prediction

(4) Reanalysis of Full Scale R-Class Ice-breaker Trial Results (18th 1987 pp.528-531) to Get Reliable Full-Scale R-Class Data CCGS "Pierre Radisson“ and CCGS “Franklin“

(5) Retest of R-Class Icebreaker Model at a Different Friction Level (18th 1987 pp.532-543)

(6) Resistance Tests (18th 1987 pp.532-540)

(7) Self Propulsion Test (18th 1987 pp.540-543)

(8) Comparative Test Program with R-Class Model (19th 1990 pp.526-531)

(9) Comparative Test Program with Basic Offshore Model Structure (19th 1990 pp.534-540)

(10) Repeatability Tests for Quality Control (20th 193 pp.488-490)

(11) Model Propulsion Tests in Ice (21st 1996 pp.252-263)