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Model Tests on Intact Stability

1 PURPOSE

This procedure is for carrying out experiments on an intact ship model in waves to determine its behaviour in extreme conditions and to establish thresholds for capsizing and extreme motion**.**

2 PARAMETERS

2.1 General Considerations

The size of the model should be appropriate to the size and depth of the tank and type of tests to be conducted to ensure sufficient run length and avoid blockage, reflection and unwanted bottom effects without exceeding the minimum size of 2m. Some indication is also given in chapter 2.1 of Procedure 7.5-02-07-02.1 Sea Keeping Experiments.

3 DESCRIPTION OF PROCEDURE

3.1 Model Design and Construction

The model hull should be complete up to the upper weather deck including forecastle and bulwarks and be sufficiently rigid with a smooth finish. The whole model should be watertight.

The model should be built to scale and should be large enough to contain the necessary instrumentation for propulsion system, steering system, measurement systems, telemetry, and ballast adjustment. A minimum length of 2 metres is recommended, scaled according to Froude's law.

Appendages related to ship motion should be fitted and the report should state which appendages were fitted during the tests.

It is necessary for the free running model to have a steering system, either manual steering or (preferably) an autopilot. The characteristics of the autopilot and the steering system (including rudder rate) are to be clearly stated in the report.

It is necessary for the free running model to have a main propulsion system, including speed and direction control, reduction gear, shafting, propeller(s) and a power supply system. Propulsor characteristics should be stated in the report.

Power may be supplied from rechargeable batteries which reside in the model. Alternatively, power may be supplied to the model from a moving carriage via a non-intrusive umbilical cable. The propulsion system should have the capability to cover the full speed range of the ship.

The model should be ballasted to the appropriate displacement and loading condition for the ship.

Weights should be adjusted to achieve the position of the centre of gravity (GM) and radius of gyration in the transverse and longitudinal directions corresponding to these data on the full scale ship. The method of doing this and the values of radii of gyration in roll,

pitch and yaw should be included in the report. In the absence of more accurate knowledge a value of 0.40*B* should be adopted for the roll radius of gyration and 0.25*L* for both the pitch and yaw radii of gyration. To this end, special care should be taken when testing ferries large passenger ships and any unconventional ship types.

The model should normally be unrestrained. When constraints are applied for particular tests, full details of the restraining system should be reported and care should be taken to avoid any interference that may influence model behaviour.

3.2 Measurements

Model behaviour, attitude and speed, including propulsor and steering system, should be simultaneously measured and recorded as appropriate to the purpose of the test. Where appropriate, it is recommended to determine the model position relative to incident wave system, including the wave elevation amidships. Wave height measurements should be made with wave probes fixed in the tank.

The use of to non-contact measurement systems is recommended when feasible. If it is necessary to attach cables to the model then care should be taken to minimise interference between cables and model.

In order to determine the causality for capsizing, the following main items should be recorded at a sampling rate of at least Hz:

- model speed
- propeller revolutions
- model motions in 6 DOF
- rudder angle
- wave elevation.

In order to ensure accurate operation of instrumentation, calibrations should be carried out and reported, preferably following codes of practice conforming to 9000 procedures.

3.3 Wave Generation

The model test may be carried out in regular, irregular, transient waves or especially designed wave packets. Tests in regular waves should provide adequate data for a range of wavelengths, steepnesses and headings appropriate to the capsize modes being investigated. It is to be noted that the standards recommended by regulatory bodies for wave steepness at the low frequency range are inadequate and their updating should be aimed at.

For tests in irregular waves, due attention should be paid to modelling correctly wave group characteristics. Deriving from ocean wave measurements, a maximum significant wave height of $H_{1/3} = (gTp^2/(2\lambda)) = 0.05$ is recommended, but with extra care taken with models of ships having very large natural roll periods. In the absence of information on specific spectrum data, JONSWAP type spectra should be used. Transient waves and waves packets may be generated at predetermined locations in the tank to investigate specific capsize modes (e.g., breaking waves).

3.4 Preparation

A roll decay test should be carried out to obtain the natural roll period T_ϕ and the damping characteristics of the model in the test condition at zero and non-zero forward speeds if appropriate. Full details of the experiment, including time histories, should be included in the report.

Where appropriate, the speed should be calibrated for smooth water.

3.5 Execution of Test

Prior to the start of the tests datum for all instrumentation used should be established. This should be rechecked after completion of the tests. Particular attention has to be paid to start up transients and the details of the start up condition should be reported.

It should be noted that in the case of following and quartering seas, the model should be situated near the wave maker first. After the wave train propagates enough in the model basin, the model propeller revolutions should be increased to the specified value to achieve the required speed and the steering system activated where appropriate.

In regular waves the number of waves encountered by the model should be large enough to reliably measure the motions of the model leading to capsize. At low encountering frequencies, particularly at high speed in stern quartering seas, it may be necessary to repeat runs starting the model with different initial conditions.

3.6 Report

The test results should be presented as a function of the main ship characteristics, operational and environmental parameters.

4 VALIDATION

All data measurement should conform to the recommendations of the relevant ITTC Procedures regarding uncertainty analysis.

Considering extreme behaviour in regular waves the test should be repeated at least once using the same initial conditions as far as practicable.

Considering extreme behaviour in irregular waves a sufficient number of tests (minimum 10 tests of 30 minutes total effective exposure, full scale, per test) should be undertaken, using different realisations, to ensure that statistical properties of the event being tested are reliable (evidence for the latter should be provided).