ITTC Quality System Manual

Recommended Procedures and Guidelines

Guideline

Guideline for Model Tests of Multi-Bodies in Close Proximity

7.5	Process Control
7.5-02	Testing and Extrapolation Methods
7.5-02-07	Loads and Responses
7.5-02-07-03	Ocean Engineering
7.5-02-07-03.11	Guideline for Model Tests of Multi-Bodies in Close Proximity

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Table of Contents

Guideline for Model Tests of Multi-Bodies in Close Proximity

1. PURPOSE OF GUIDELINE

The purpose of this guideline is to ensure that model tests of stationary multi-bodies (at least two floating/fixed bodies) in close proximity are conducted according to the best available techniques and to provide an indication of where improvements in techniques might be made.

The primary procedure for a multi-body model test is similar to that for a single body as described in Procedure 7.5-02-07-03.1 Offshore Structure Platform Experiments. Therefore, the present guideline is to ensure that any compromises, inherent in a particular multi-body interaction model test, are identified and their effect on the measured results is understood.

In general, multi-body interaction model tests are usually performed when the safe operations of offshore platforms and vessels, such as side-by-side offloading and offshore installation involving multiple vessels / platforms, may be compromised, and/or for validation studies.

The main objective of an experiment with multi-bodies in close proximity is to measure positions and motions of the models, free surface elevations in the gap, global loads, and lines tensions/fender loads if present.

2. DESCRIPTION OF THE TEST PROCEDURE

Model tests of multi-bodies are subject to wave, current, and wind in terms of environmental conditions. In addition to environmental conditions, model tests are often carried out at operational conditions to assess the operational limits of the multi-body configuration. Floating multi-bodies could be moored or dynamically positioned.

2.1 Model test agenda and matrix

Before planning the tests, a statement of the test objectives and a test matrix are required. Judicious use of computational tools can help to reduce the extent of the test matrix.

2.2 Multi-body models

Models should be scaled according to Froude’s law. The scale ratio is often based on basin dimensions, the relative positions of models and the footprint of mooring systems if present. For dynamically positioned bodies, the characteristics of thrusters should also be taken into account when determining the scale ratio according to Procedure 7.5-02-07-03.6 Dynamic Positioning Systems Model Test Experiments.

For bodies with mooring lines/risers, full-length line models are preferred, but if basin dimensions and model scale require shortening or truncation, this should be done according to Procedure 7.5-02-07-03.4 Active Hybrid Model Tests of Floating Offshore Structures with Mooring Lines or Procedure 7.5-02-07-03.5 Passive Hybrid Model Tests of Floating Offshore Structures with Mooring Lines.

2.3 Ballasting and loading

Ballasting and loading will be performed for each model individually, and follows the same procedure and guidelines as given in Procedure 7.5-02-07-03.1 Floating Offshore Platform Experiments.

2.4 Instrumentation and measurement systems

Multi-body tests may show high frequency phenomena, especially in the gap. For example, the resonance frequency in the gap could be two or three times of the wave frequency of interest for some multi-body configurations. The sampling rate of the measurement system has to be sufficiently high to capture these phenomena.

It is recommended to use a motion measurement system which will not influence the body motions and to provide a synchronised measurement of motions. Optical tracking systems are preferred for multi-body model tests. Care must be taken to ensure that the interference of the motion measurement system due to the presence of multiple bodies are minimized (this could be due to one model blocking the camera view).

It is also recommended to use in-line force measurement transducers with a minimum influence on the line tension according to Procedure 7.5-02-07-03.5 Passive Hybrid Model Tests of Floating Offshore Structures with Mooring Lines.

The wave probes should have adequately high resolution to measure the high-frequency wave elevations in the gap, and they should be sufficiently small to avoid any disturbance of the free surface and interference/clashing with the bodies.

A full synchronisation of all the equipment is recommended, including wave, current and wind generators, and data acquisition systems.

2.5 Calibration

The nonlinear behaviour of fenders, transfer/mooring lines and hoses should be modelled and calibrated according to the prototype specifications and Procedure 7.5-02-07-03.14 Floating Offshore Structure Model Construction.

More details on calibrations of environments and equipment including moorings/risers and thrusters can be found in Procedure 7.5-02-07-03.1 Floating Offshore Platform Experiments.

2.6 Test procedure and data acquisition

2.6.1 Pre-test considerations

Before each run, measurements should be checked to ensure the residual body motions and wave elevations are sufficiently small.

2.6.2 Data analysis

Data analysis should be presented in both time series and frequency domain. Details on the analysis procedures can be found in Procedure 7.5-02-07-03.13 Analysis Procedure for Model Tests in Regular Wave and 7.5-02-07-03.13 Analysis Procedure for Model Tests in Irregular Waves.

2.6.3 Presentation of results

Results can be presented in dimensional or non-dimensional form. Dimensional results can be in model scale or full scale, however, this must be clearly documented. Typical results follow the results as presented in Procedure 7.5-02-07-03.1 Floating Offshore Platform Experiments, and in addition may include the following when considering multiple bodies:

- 6DOF rigid body motions;
- Relative body motions;
- Accelerations at specified locations;
- Free surface elevations in the gap;
- Free surface elevations in other locations;
- Tensions in lines (mooring lines, offloading lines, hoses, etc.);
- Fender loads;
- Wave conditions;
- Wind velocity;

- Current velocity.

3. PARAMETERS

Most parameters are the same as those for a single body model test. Details on the parameters can be found in Procedure 7.5-02-07-03.1 Floating Offshore Platform Experiments, including:

- test conditions;
- models dimensions;
- basin dimensions;
- wave calibration;
- wave periods and heights;
- wave headings;
- current calibration;
- wind calibration;
- mooring calibration;
- measuring equipment;
- test duration;
- number of repeat runs;
- use of different gauges.

3.1 Scaling

Multi-body model tests may involve several similitude laws such as geometrical and dynamic similitudes. The linkages between bodies need to be modelled according to their mechanical properties, for example, the stiffness of the fender and hoses.

It is critical to scale the gap width. The gap needs to be large enough to avoid possible effects due to water surface tension, such as capillary waves and meniscus. It should also be noted that the damping effects of fenders and the viscous effects are affected by the gap width.

3.2 Model geometry

The models have to be as detailed as possible if their elements influence the physical phenomena or they are important to the measurements. These elements include appendages, fenders, offloading hoses, hawsers, cables, articulated arms, connecting bridges, thrusters, and mooring lines/risers if present.

3.3 Body-to-body connection systems

If multi-bodies are connected, inertial properties, motions, loads and extensions of connecting systems, such as body-to-body mooring lines and connecting bridges, should be modelled.

3.4 Fenders

Fenders are needed if contacts occur between bodies. In this case, the stiffness and damping of fenders, including their nonlinear behaviour, has to be accurately modelled by using rubber type, polymer elements or mechanical systems. Fenders should also be calibrated before the tests.

If a fender affects the flow in the gap, its geometry should also be modelled as accurately as possible.

Details on the fender modelling can be found in Procedure 7.5-02-07-03.14 Floating Offshore Structure Model Construction.

3.5 Offloading systems

For offloading systems such as hoses and articulated arms, their stiffness and lumped mass distribution should be modelled, and in-line tensions may be measured.

3.6 Other structures

A structure should be modelled if it has a substantial effect on the motion of or the load on one (or more) body. Examples include a superstructure or topside under wind loading and subsea structures in the splash zone.

3.7 Environmental parameters

Wind, waves and current are of main importance to the behaviour of multi-bodies in close proximity, especially shielding and shadowing effects. Details on these parameters can be found in Procedure 7.5-02-07-03.1 Floating Offshore Platform Experiments.

4. UNCERTAINTY ANALYSIS

Many parameters cause uncertainties in multi-body model tests. Details on the sources of uncertainties can be found in the work of Qiu et al. (2014).

Furthermore, uncertainty analysis should be performed in accordance with Procedure 7.5-02-01-01 Guide to the Expression of Un-certainty in Experimental Hydrodynamics.

5. REFERENCES

Qiu, W., Sales, J.J., Lee, D., Lie, H., Magarovskii, V., Mikami, T., Rousset, J.M., Sphaier, S., and Wang, X., 2014. "Uncertainties Related to Predictions of Loads and Responses for Ocean and Offshore Structures", Ocean Engineering, Vol. 86, pp. 58-67.

Qiu, W., Rousset, J.M., Peng, H., Horel, B., 2017. "Benchmark Tests of Two Body Interaction in Waves", Proceedings of the ASME 36th International Conference on Ocean, Offshore and Arctic Engineering, Trondheim, Norway.