Laboratories
R&D Infrastructures for Marine Technology
Technology development through testing and verification

MARINTEK’s laboratory facilities are internationally renowned. Demanding industrial partners and customers from all over the world develop their technology in close cooperation with MARINTEK, partly based on testing and verification in our top class laboratories.

The Norwegian Marine Technology Research Institute (MARINTEK) has more than 70 years of experience in the developing of cost-effective, high performance ships, where model testing in our laboratories constitutes an important element. We have the testing facilities, expertise and analytical tools for developing operationally efficient and safe ship concepts.

Emission to air is the one of the main challenges for the shipping industry, and through our laboratory facilities, we provide technology development for improving energy consumption and reduced emissions. MARINTEK has participated actively in the development of different concepts of ocean energy technology. Extensive research and testing of offshore wind turbines as well as tidal and wave technology is carried out in our laboratories.

For decades MARINTEK has tested, studied and validated different types of marine operations. We have been working with all types of marine operations involving offshore vessels, fixed and floating structures, worldwide. In the developing of the Norwegian Continental Shelf, challenging and harsh conditions have placed tough requirements on various concepts; floating production units, gravity based offshore structures and complete subsea and subsea-to-shore solutions.

A key factor has been the ability to test and verify future solutions in modern laboratories. MARINTEK runs some of the world’s leading laboratory facilities in the field of marine technology development. We have combined laboratory experience with the development of associated numerical tools and software, of which many are in daily use around the world at the operators’ and supply industries’ workbenches. Several of the laboratories are operated by MARINTEK in close cooperation with the Department of Marine Technology at the Norwegian University of Science and Technology (NTNU).

We welcome you to visit MARINTEK and our laboratories in Trondheim, Norway.
Ocean Basin Laboratory

The Ocean Basin Laboratory is used for basic as well as applied research on marine structures and operations. A total environmental simulation including wind, waves and current offers a unique possibility for testing of models in realistic conditions. With a depth of 10 metres and a water surface of 50x80m the Ocean Basin Laboratory is an excellent tool for investigation or existing of future challenges within marine technology.

Applications:
- Seakeeping
- Ship manoeuvring
- Fixed offshore structures
- Shallow water problems
- Mooring and DP systems
- Offshore floating production
- Offshore marine operations
- Subsea systems and operations
- Risers and pipelines
- Energy production from the sea
- Aquaculture

Ocean basin laboratory data
Length: 80 m
Width: 50 m
Depth: 0-10 m
Maximum current velocity in wave surface:
0.25 m/s at 2 m. water depth
0.18 m/s at 5 m. water depth.

Double flap wave maker
Hinged double-flap type.
Regular waves.
Maximum wave height: 0.9 m
Wave periods: 0.8 s and above.
Wave spectra.
Maximum Hs: 0.5 m
TP from 0.7 s and above.

Multi flap wave maker
Hinged single-flap type, 144 individually controlled flaps.
Regular waves:
Maximum wave height: 0.4 m
Wave periods: 0.6 s and above.
Wave spectra:
Shortcrested or longcrested waves of specified direction.
Maximum Hs 0.2 m
TP from 0.7 s and above.

The carriage system follows free running models with no constraints at speed up to 5 m/s at any heading to the waves.

Ship Model Tanks

The main activity of the towing tanks is related to investigation of hydrodynamic performance of ships. This includes resistance, propulsion, seakeeping in head and following seas, and directional stability tests with free running models. The tanks are equipped with two carriages: One for towing up to 10 m/s for traditional calm water tests and a second carriage for seakeeping tests and other tests performed with fixed or free-running models.

Main tests performed in Towing tanks I and III
- Resistance, open water, propulsion tests, 3D wake measurements.
- Seakeeping tests (motions, sea loads, slamming, whipping, active control).
- Manoeuvring (zig-zag tests, Planar Motion Mechanism PMM tests).
- Directional stability tests.
- Crashing tests.
- Dynamic positioning tests.
- Ship-Ship interaction tests.
- Forced motion tests.
- Lifeboat drop tests.
- Measurement of current forces on offshore structures.
- Measurement of forces and moments in six degrees of freedom.
- Measurement of displacement in six degrees of freedom.
- Propeller blade loading measurements.
- Six-component propeller shaft measurements.
- Propeller nozzle loading measurements.
- Tests using yacht dynamometer.
- Various Pod / Azimuth thruster tests.
- High speed video recordings (above and under water).

<table>
<thead>
<tr>
<th>Tank I + III</th>
<th>Tank I</th>
<th>Tank III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length:</td>
<td>260 m</td>
<td>175 m</td>
</tr>
<tr>
<td>Width:</td>
<td>10.5 m</td>
<td>10.5 m</td>
</tr>
<tr>
<td>Depth:</td>
<td>5.6/10.0 m</td>
<td>5.6 m</td>
</tr>
<tr>
<td>Maximum speed:</td>
<td>10 m/sec.</td>
<td>10 m/sec.</td>
</tr>
<tr>
<td>Model size range:</td>
<td>8 m</td>
<td>8 m</td>
</tr>
<tr>
<td>Wave maker:</td>
<td>Double flap</td>
<td>Double flap</td>
</tr>
<tr>
<td>Maximum wave height:</td>
<td>0.9 m</td>
<td>0.9 m</td>
</tr>
<tr>
<td>Wave period range:</td>
<td>0.8-5 sec.</td>
<td></td>
</tr>
</tbody>
</table>
Cavitation Tunnel

The cavitation tunnel is used to investigate the hydrodynamic performance of different types of ship hulls, propellers and other hydrodynamic objects. Propeller induced pressure fluctuations and noise as well as cavitation are investigated by means of measurements and high-speed video observation. Propeller shaft and single propeller blade forces and moments can be measured using advanced in-house developed miniaturized instrumentation, in addition to standard thrust and torque measurements.

Cavitation tunnel data:
- Diameter of working section: 1.20 m.
- Length of working section: 2.08 m.
- Maximum water velocity: 18 m/sec.
- Maximum propeller RPM: 3000.
- Propeller motor power: 50 kW.
- Maximum working pressure: 6.0 atm.abs.
- Minimum working pressure: 0.1 atm.abs./sv to 0.2.
- Impeller motor power: 1150 kW.

Test activities
- Open water tests with propeller (and duct) in axial or oblique flow.
- Behind hull condition with single, twin or triple screw installations.
- Azimuth thrusters.
- Z-drive installations.
- Underwater vehicles (submarines, ROVs etc.).
- Hydrofoils with or without remotely controlled flaps.

Measurements and observations
- Cavitation observation (Documentation by sketches, photos and video recordings).
- Cavitation erosion detection by paint technique.
- Measurements of propeller induced pressure fluctuations in the afterbody.
- Measurements of propeller induced noise.
- Six-component force measurements.

Marine Structures Laboratory

The main activities in the laboratory are the testing of structures, structural components and materials. Typical problems involve fatigue testing, ultimate strength and collapse testing. Experimental work is often combined with analytical or numerical analysis. Small scale testing can be performed to obtain material data and material coefficients to be used in numerical analysis and full scale testing. Dynamic full scale testing is performed for qualification of flexible risers, power cables, umbilicals, hoses and mooring lines. A wide range of structural analysis programs are available for linear and non-linear static and dynamic analyses. These include special programs for fatigue and fracture mechanics analysis, and the collapse behaviour of intact and damaged structures.

Main installations

Actuators:
A range of servohydraulic actuators for static and dynamic testing, from 100 kN load capacity to a maximum load/stroke of 4000 kN/1000 mm.

Control system:
Several computerized systems for multi-actuator control, fatigue load simulation, data logging with on-line reduction and analysis.

Small scale testing:
Modular frame system which can be built to accommodate specimens and structural models with a wide range of shapes and sizes, under uniaxial or multiaxial loading, and with load capacities up to 4000 kN.

Full scale testing:
Dynamic test rigs for static, dynamic and fatigue testing of slender marine structures. The dimension of the test specimen are typically 1.5 m flange to flange, and applied loads include internal pressure, dynamic bending (±30°) and tension (3 000 kN).
Energy-/Machinery Laboratory

The laboratory is amongst the best equipped independent engine laboratories in Scandinavia. Well developed installations with highly specialized experimental equipment, instrumentation and data-acquisition systems, and an experienced staff are crucial assets in provision of professional customized support and accredited services to our clients. We have in-house workshop capabilities for making customized engine components or modifying existing components and systems in order to improve performance.

Facilities
- Test area foundation for rigs, process equipment and full scale set-up.
- Engines and auxiliary machinery.
- Exhaust gas cleaning systems.
- Fuel treatment, and combustion technology.
- Instrumentation for laboratory and on-site use.

Engine research and development
- Diesel engines.
- Dual fuels/gas engines.
- Prototype testing (long term testing).

Exhaust gas cleaning systems research
- Particle matter reduction efficiency.
- Nitrogen oxide reduction efficiency.
- Sulphur oxide reduction efficiency.

Fuel combustion
- Testing of fuels on behalf of oil companies and ship owners.
- Testing of alternative fuels (e.g. LNG, biofuels, hydrogen).

Verification services, basis in measurement competence
- Field measurement of exhaust emissions on ships.
- Field mapping of NOx emissions, gas turbines.
- Verification of efficiency of NOx reduction measures.

Various concept developments and testing
- Comparison studies of instrumentation for equal employment.
- Power and fuel consumption measurements.
- Field measurement of volatile organic compounds (VOC).
- Instrument testing for monitoring separators and offshore valves.
- Ballast water treatment system.

Sloshing Laboratory

For investigating liquid loads in tanks and on custom geometries, MARINTEK has developed a sloshing laboratory with two motion platforms and a drop rig for deterministic water impacts. The motion platforms are custom made for exciting scaled vessel motions.

The 6 DOF vessel motion simulator
Based on vessel motion RAOs and sea-state inputs, the rig can do model scaled motions at a given position on a vessel. Each degree of freedom is independent and can be enabled / disabled accordingly. The rig is electric driven with servo motors from Bosch Rexroth. Static weight of rig and payload is balanced by using two air cylinders with accumulators. Motions applied to the rig is loaded from a pre generated 6 DOF binary file format. This solution makes it possible for clients to easily choose between MARINTEK generated, and their own generated vessel motions as input to the rig.

The 2 DOF vessel motion simulator
The control system of the 2 DOF rig is similar to that of the 6 DOF rig. Based on vessel motion RAOs and sea-state inputs, the rig can do model scaled motions at a given position on a vessel in 2 degrees-of-freedom (typically sway and roll). Each degree of freedom is independent and can be enabled / disabled accordingly. The rig is electric driven with servo motors from Bosch Rexroth. Motions applied to the rig is loaded from a pre generated 2 DOF binary file format. This solution makes it possible for clients to easily choose between MARINTEK generated, and their own generated vessel motions as input to the rig.

The drop rig
The drop rig is a rig specifically designed for studying slamming physics including high-speed measurements and video. The internal measures of the drop tank are: 4000 mm wide, a depth of 283 mm and a height of 1500 mm.

The standard wedge has a total drop weight of approximately 160 kg and the dead rise angle is 10 degrees. The drop height can be varied between 100 mm and 2.25 m from the apex of the wedge to the free surface. Customized wedges can be made for specific projects.
Marine Cybernetics Laboratory

The Marine Cybernetics Laboratory is a wave basin, especially suited for tests of marine control systems, due to the relatively small size and advanced instrumentation package. It is also suitable for more specialized hydrodynamic tests (for example forced motion tests), mainly due to the advanced towing carriage, which has capability for precise movement of models in 6 degrees of freedom. Flow measurements can be performed using Particle Image Velocimetry (PIV) technique.

**Capacities**
- Tank Dimensions: L x B x D = 39 m x 6.45 m x 1.5 m.
- One flap wave maker.
- Carriage towing speed 2 m/s, 6 DOFs forced motions.
- Typical scaling ratios: 50-150.
- Typical ship model lengths: 1-3 m.
- Positioning System measure 6 DOF in Real-Time.

**Experimental Set-ups**
- Propulsor and thruster tests.
- Detailed flow measurements using PIV (Particle Image Velocimetry).
- DP and way-point tracking (wireless control) of ships and semi-submersibles.
- Rapid control prototyping.
- Planar motion mechanism (PMM) and vertical motion mechanism (VMM) tests.
- Calibration of transducers.
- Hardware-In-the-Loop (HIL) Experiment Laboratory.

Circulating Water Tunnel

The new Circulating Water Tunnel (CWT) is a test facility dedicated to optical measurement techniques and flow visualization. The tank’s measurement section is completely transparent and can be operated either with a free surface or the lid closed. Laser-based techniques like PIV (Particle Image Velocimetry) and LDV (Laser Doppler Velocimetry) allow non-intrusive measurements of instantaneous 3D flow fields at high temporal and spatial resolutions. The laboratory is hence especially well-suited for research projects that integrate experimental and computational results. Studies of basic wake hydrodynamics as well as applied cases of marine flows have been successfully performed here.

The CWT is operated by the Department of Marine Technology (NTNU), in co-operation with MARINTEK.

**Capacities**
- Test section: 2,50 x 0,61 x 0,61 m.
- Low turbulence level of 1% of free stream velocity.
- Flow speed from 0,03 to 1 m/s. Also varying flow speed.
- Fixed or free surface.
MARINTEK develops and verifies technological solutions, business and operating concepts for the shipping, marine equipment, ocean energy and petroleum industries. MARINTEK is a company in SINTEF, the largest independent research organization in Scandinavia. Our headquarters and laboratories are located in the Marine Technology Centre in Trondheim, Norway. MARINTEK has subsidiaries in Houston, USA and in Rio de Janeiro, Brazil.