CTO S.A.

CENTRUM TECHNIKI OKRĘTOWEJ S.A.

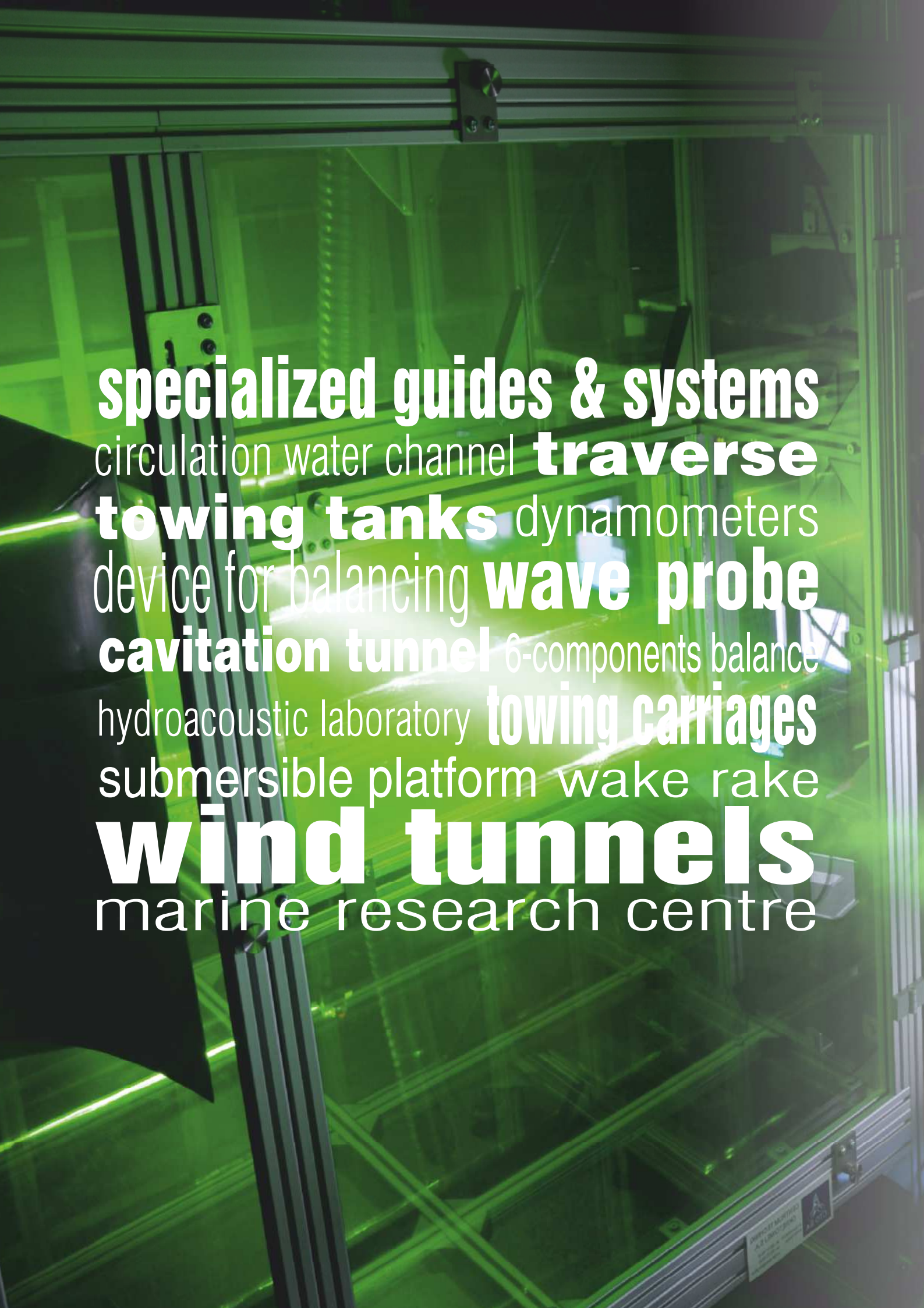
SHIP DESIGN AND RESEARCH CENTRE S.A.

Research facilities
tailored design, manufacture,
delivery, launching and training

Gdańsk

POLAND

www.cto.gda.pl


specialized guides & systems
circulation water channel traverse
towing tanks dynamometers
device for balancing wave probe
cavitation tunnel 6-components balance
hydroacoustic laboratory towing carriages
submersible platform wake rake
wind tunnels
marine research centre

INTRODUCTION

Ship Design and Research Centre S.A. (CTO) has long-standing experience in the field of operating own research equipment. Since 1973, the company has been a member of the International Towing Tank Conference (ITTC). The CTO operates in accordance with Quality Management System ISO 9001:2008 certified by LRQA.

Conducting advanced research enables us to look at the process of research and measuring equipment design from the user's point of view, better understand our Clients' needs as well as properly select technical and operational characteristics of the designed equipment.

We offer comprehensive solutions including Client's needs analysis, feasibility and profitability studies, initial and conceptual designs, research laboratories organisation, basic technical designs and detailed engineering, manufacturing and functional testing of research equipment, training based on using our own research facilities, comparative inter-laboratory tests of benchmark models, elaborating research procedures and supervision over entire project until the stage of full equipment commissioning and implementation.

In particular, our competences include:

- designing, manufacturing, delivering and commissioning of facilities and equipment for conducting applied research connected with the marine technology, particularly model tests of vessels (towing tanks equipment, cavitation tunnels, circulating water channels, subsonic wind tunnels),
- designing and manufacturing measuring equipment used in the experimental fluid and solid mechanics including dynamometers and equipment measuring physical fields,
- modernisation of research equipment including towing tanks and cavitation tunnels and their equipment.

The company's offer covers transfer of knowledge and high technologies, particularly in the field of the use and operation of research facilities and measuring equipment for marine applied research.

We are at your disposal when the selection as well as design and manufacture of equipment customised to particular research and technological needs is concerned.

We are looking forward to doing business with you!

DEEP-WATER TOWING TANK

Description

Deep-water towing tank is a primary research facility of any Ship Model Basin worldwide. Its principal purpose is to conduct ship model test concerning ship hull resistance and propulsion systems.

The results of those model tests are used for elaboration of a ship propulsion prediction – which determines key decisions during the design of any ship.

The deep-water towing tank is a large reinforced concrete construction filled with fresh water. The typical approximate dimensions of a deep-water towing tank are as follows: length - 300 m, breadth - 14 m, depth - 6 m. The primary equipment of the deep-water towing tank includes:

- precise, adjustable railways,
- self propelled movable towing carriage of precisely adjustable and controlled speed, the typical maximum carriage speed is 10 ÷ 12 m/s,
- computer controlled wave maker and wave absorber, capable to generate regular or irregular waves,

- a set of measuring equipment, integrated with a towing carriage and computer control system,
- a water filtering system.

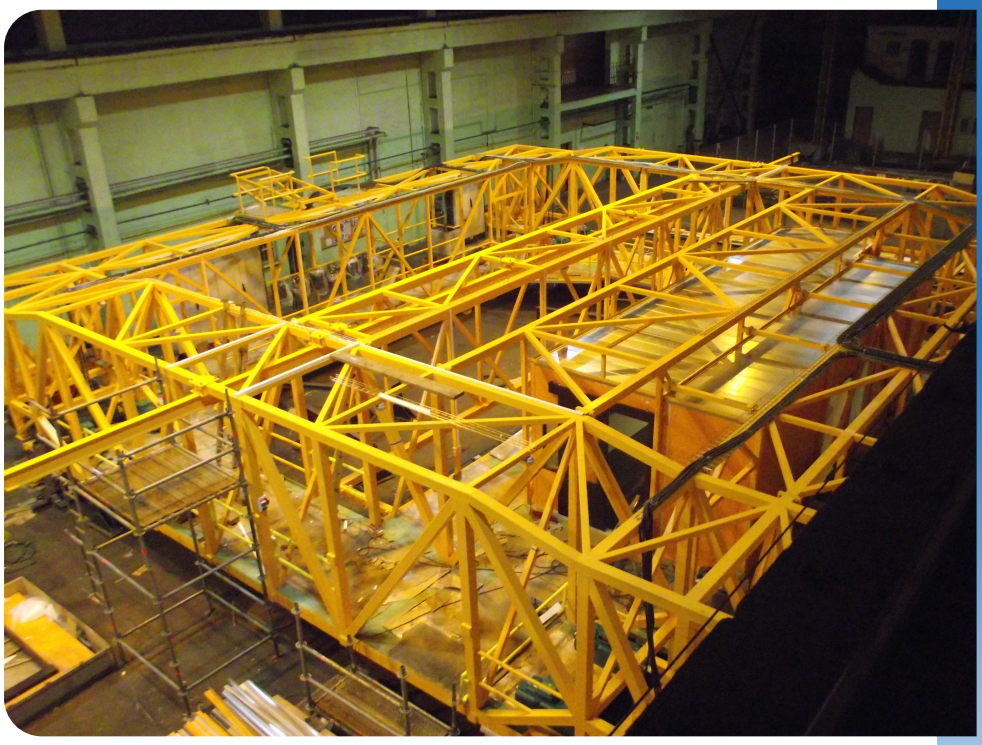
The use of the deep-water towing tank is not only limited to the marine applications. It is also a convenient facility for model tests of devices used for conversion of renewable energy obtained from the sea, tests of interaction of moving objects with free surface (for example simulation of the emergency landing of an aircraft on the water), tests of coatings reducing friction resistance of ship hulls and general hydrodynamic tests.

TOWING CARRIAGE FOR DEEP-WATER TOWING TANK

Description

A precisely manufactured platform moving on rails at both sides of the towing tank is a device allowing for conduction of various model tests of ships, floating structures, propulsors as well as general hydrodynamic experiments under conditions of deep water:

- hull resistance,
- ship propulsion,
- open water propeller characteristics (including both screw propellers as well as unconventional propulsors like ducted propellers, azimuthing propulsors, waterjets),
- wake measurements,
- streak line visualisation,
- velocity field measurements,
- seakeeping properties of ships and floating structures sailing both in the regular or irregular waves,
- free oscillations and stability tests of ships,
- captive manoeuvrability model tests of ships conducted with the use of planar motion mechanism.



Example technical specification

- Brief construction description: precisely machined steel construction, welded and bolted, thoroughly anticorrosion secured,
- Overall length (along the axis of the towing tank): 16.0 m,
- Overall width: 15.0 m,
- Overall height: 3.5 m,
- Weight of the carriage: 50 t,
- Carriage velocity range: 0 ÷10 m/s,
- Maximum carriage acceleration: +/- 1 m/s^2
- Drive system: 4 x 2 wheels with DC electric motor each,
- Control system: FC computer based system,
- Power requirements: 8 x 56.2 kW 600V = abt 450kW continuous power.

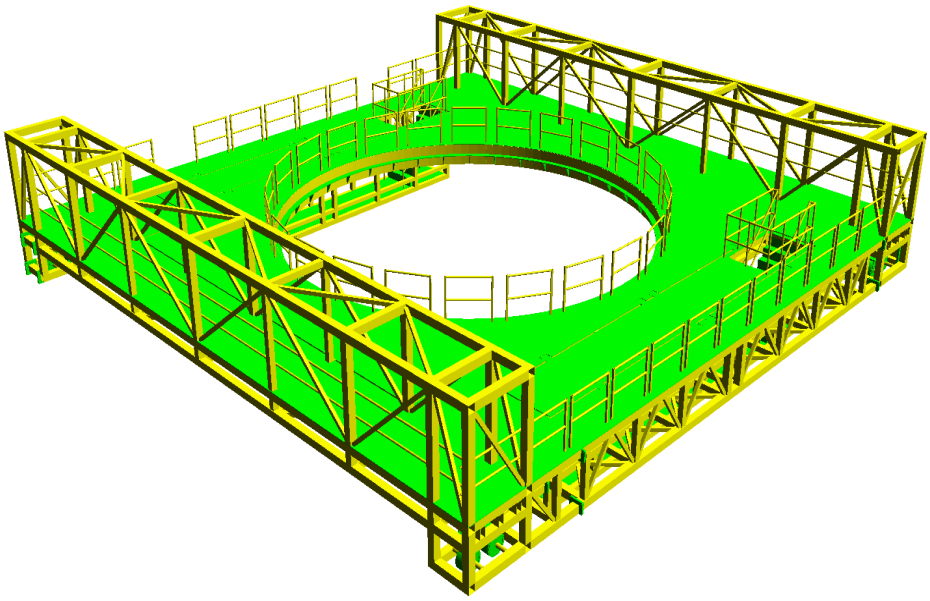
TOWED CARRIAGE

Description

Towed carriage serves auxiliary purposes when offshore constructions model tests are conducted in the deep-water towing tank.

In particular the carriage is intended to:

- accommodate the research personnel,
- assembly off-shore constructions models,
- installing anchor system simulators,
- installing probes for waves measurements,
- installing the wind generator,
- installing wind speed meters,
- installation of various measuring equipment,
- conduct measurements.



Example technical specification

- Brief construction description: steel construction, welded and bolted, corrosion protected,
- Length (along the axis of the tank): 15.5 m,
- Width: 15.5 m,
- Maximum height from the track: 3.2 m,
- Diameter of the turntable: 9.0 m,
- Weight: 55 t.

SUBMERSIBLE PLATFORM FOR OFFSHORE CONSTRUCTIONS MODEL TESTS

Description

The platform is intended for model testing various offshore constructions. It cooperates with the auxiliary towed carriage (see page 6). The immersion of the working space of the platform is controlled. The working deck of the example platform presented below can be lifted 150 mm above the water level and submerged up to 10 m below this level. Its lifting capacity is up to 2000 kg.

The tested objects are placed or anchored at the working deck of the platform. Additionally the working deck of the platform can be rotated around vertical axis. The platform moves vertically thanks to hydraulic lifting system. The movement of the platform is controlled using a portable control panel connected to a cable from the power supplying switchboard or remotely from the auxiliary towed carriage. Movement of the platform is signalled visually and audibly.

The following model tests can be conducted using the submersible platform:

- model tests of drilling platforms in waves and wind,
- model tests various types of offshore wind mills support structures,
- model tests of FPSO vessels,
- model tests of renewable energy devices in marine environment.

Example technical specification

- Diameter of the rotating platform (working deck): 6.0 m,
- Speed of platform vertical movement: 0.5 ÷2.0 cm/s,
- Total working stroke of hydraulic cylinders: 10.15 m (4.0 m + 6.15 m),
- The oil pressure in the hydraulic system: 10 ÷ 16 MPa,
- Pump pressure supply system: hydraulic power pack,
- Pump output power supply: 22 kW,
- Power requirements: 3x380 V/50 Hz,
- Diameter of the well: 7.5 m,
- Depth of the well: 10.0 m.

SHALLOW WATER TOWING TANK

Description

The principal aim of the shallow water towing tank is to carry out the model test of ships which operation may be affected by the sea or river bottom.

The shallow water towing tank is also a reinforced concrete construction filled with fresh water. Usually the water level in the tank can be altered. The typical approximate dimensions of a deep water towing tank are as follows: length - 200 m, breadth - 10 m, maximum depth - 3 m.

The primary equipment of the shallow water towing tank includes:

- precise, adjustable railways,
- self propelled movable towing carriage of precisely adjustable and controlled speed, the typical maximum carriage speed is 4 ÷ 6 m/s, equipped with a platform of adjustable elevation,
- computer controlled wave maker and wave absorber,
- a set of measuring equipment, integrated with a towing carriage and computer control system,
- a water filtering system.

Practical application of such the tests results takes place in design of ships of inland navigation and in the tests of the ocean ships in conditions of inland navigation in shallow water, for example, while approaching restricted waters, harbours, river mouths or straits.

TOWING CARRIAGE FOR SHALLOW WATER TOWING TANK

Description

Towing carriage for the shallow water tank is a device allowing conduction of standard model tests of ships under shallow water conditions:

- hull resistance,
- ship propulsion tests,
- captive manoeuvrability model tests of ships conducted with the use of planar motion mechanism,
- wash wave measurements,
- model tests to investigate ship hull-sea bottom interaction.

The towing carriage is designed to operate when water depth in the tank is varied as it is equipped with an adjustable level working platform.

Example technical specification

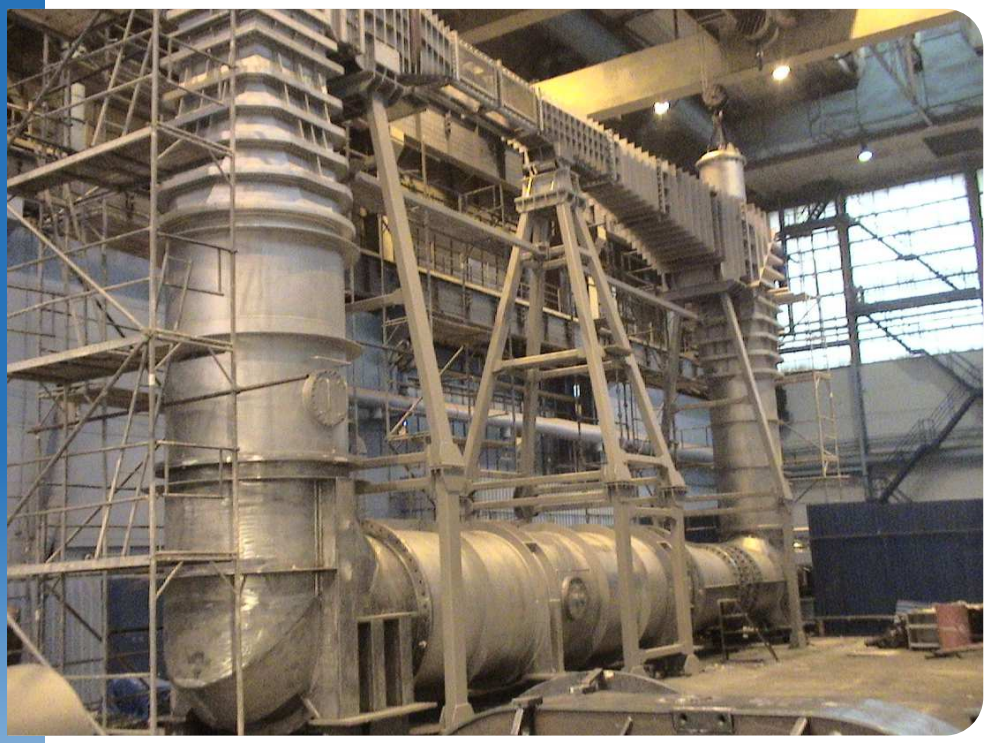
- Brief construction description - precisely machined steel construction, welded and bolted, thoroughly anticorrosion secured,
- Overall length (along the axis of the towing tank): 12.0 m,
- Overall width: 11.0 m,
- Overall height: 3.0 m,
- Weight of the carriage: 32 t,
- Carriage velocity range: 0 ÷ 5 m/s,
- Maximum carriage acceleration: +/- 1 m/s^2,
- Drive system: 4 x wheels with DC electric motor each,
- Control system: FC computer based system,
- Power requirements: 4 x 32.1 kW 600 V = abt 128 kW continuous power.

CAVITATION TUNNELS

Description

Cavitation Tunnel is a basic research facility for cavitation model tests of ship propulsors. The experiments are conducted usually in simulated behind conditions however in uniform velocity field as well. According to the dimensions of the test section the entire ship hull model or dummy hull model equipped with wire screens are placed in the tunnel to simulate the wake. Both above ways of testing are recommended by ITTC.

Cavitation tunnel is a vertically oriented, closed steel loop, filled entirely with water. The tunnel is composed of precisely manufactured sections which connections are enough tight to allow for facility operation under vacuum conditions. The upper part of the loop consists of contraction, test section and diffuser as well as contains precisely manufactured honeycombs and elbows with turning vanes. The bottom, return duct contains an impeller pump.

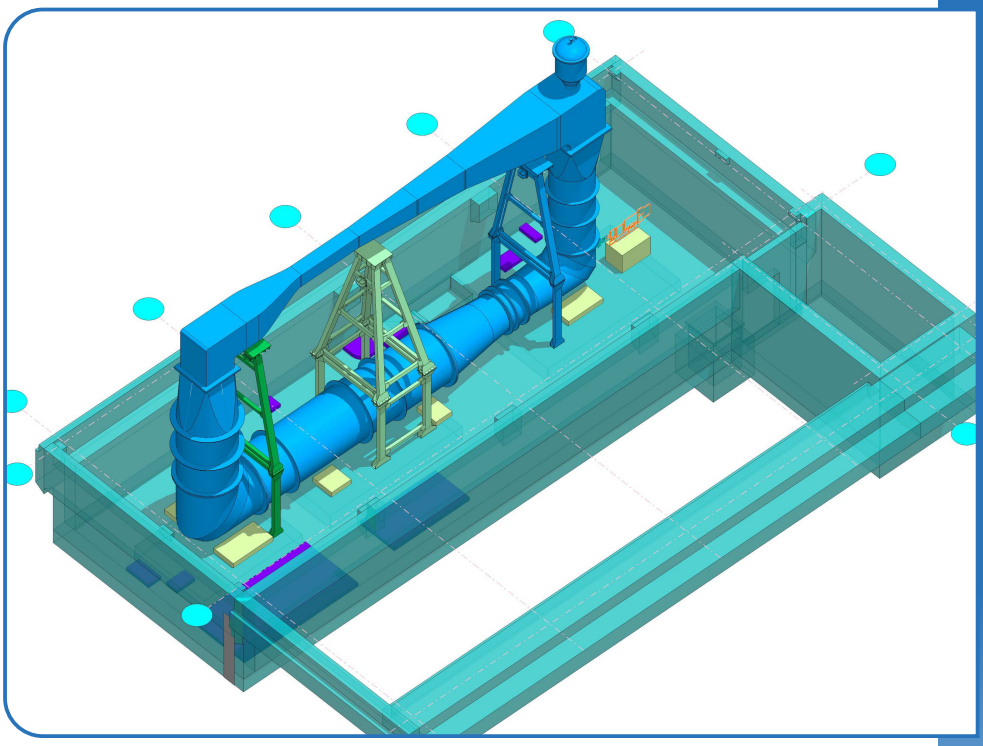


The axial pump drive and control allows precise, practically continuous adjustment of the flow velocity in the test section of the tunnel. The facility is usually equipped with dissolved oxygen content measuring system and vacuum system for continuous adjustment of the pressure inside the tunnel. Optionally cavitation tunnel may be equipped with the systems for quick water degassing, microbubbles generation and cavitation nuclei measurement.

The following set of standard model tests and research works is conducted in a cavitation tunnel:

- cavitation model tests of propellers in a uniform velocity field including cavitation inception and hydrodynamic characteristics,
- cavitation model tests of propellers, rudders and appendages in a simulated behind conditions,
- cavitation observations with stroboscopic lighting and high speed video recording,

- cavitation erosion model tests,
- measurements of pressure pulses generated by the propeller model,
- hydroacoustic investigations,
- pressure and velocity fields measurements, including LDA or PIV methods,
- fundamental research on cavitation phenomena, including: cavitation inception, dynamics of various cavitation forms, investigation of correlation between cavitation and hydroacoustic emission, studies of the impact of flow parameters on cavitation.



Example technical specification of a small cavitation tunnel

- Test section dimensions (W x H x L): 0.5 x 0.5 x 2.5 m,
- Overall length of the tunnel: 16.0 m,
- Overall height of the tunnel: 8.0 m,
- Maximum flow velocity in the empty test section: 12 m/s,
- Power requirements: 80 kW.

Example technical specification of a medium test section cavitation tunnel

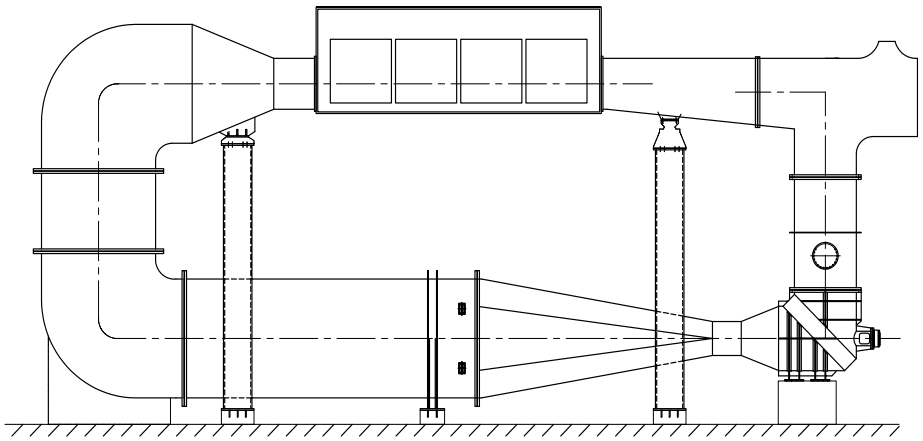
- Test section dimensions (W x H x L): 1.2 x 1.0 x 4.0 m,
- Overall length of the tunnel: 29.0 m,
- Overall height of the tunnel: 12.0 m,
- Maximum flow velocity in the empty test section: 15 m/s,
- Power requirements: 750 kW.

CIRCULATING WATER CHANNEL (CWC)

Description

The multipurpose Circulating Water Channel is a closed, vertical, plane type facility. From the functionality point of view, the multipurpose CWC combines together selected features and hydrodynamic testing capabilities of a towing tank, flume tank, and wind tunnel. Hydrodynamic testing facilities like circulating water channels are customized in accordance with the detailed needs, requirements and expectations of their users.

The test section of the CWC is equipped with large PERSPEX windows along both side walls and a bottom wall. The flow measurements and observations are conducted through the test section windows therefore the maximum possible size of them is considered as the highest priority.



The proposed CWC is intended to conduct model tests of ships, propellers and off-shore structures. The construction and operational characteristics of CWC allows in particular for conduction of the following hydro- and aerodynamic experiments:

- model tests of ship hull resistance,
- model tests of open water screw propellers,
- investigation of the pressure and velocity fields in the flow around a ship hull model,
- visualization of the flow around a ship hull model,
- model tests of offshore structures subjected to the interaction of current, waves and wind,
- general hydro- and aerodynamic research involving a flow fields investigation, flow visualization, validation of the results of numerical computations and many others.

Example technical specification

- Test section dimensions (W x H x L): 2 x 1.5 x 4.5 m,
- Overall length of the channel: 15.0 m,
- Overall height of the channel: 6.0 m,
- Maximum flow velocity in the empty test section: 2 m/s,
- Drive system: parallel arranged two axial pumps,
- Optional equipment: wave maker, wind generator, dynamometers, wake survey devices, wave probes, LDA, PIV, pressure transducers.

HYDROACOUSTIC LABORATORY

Description

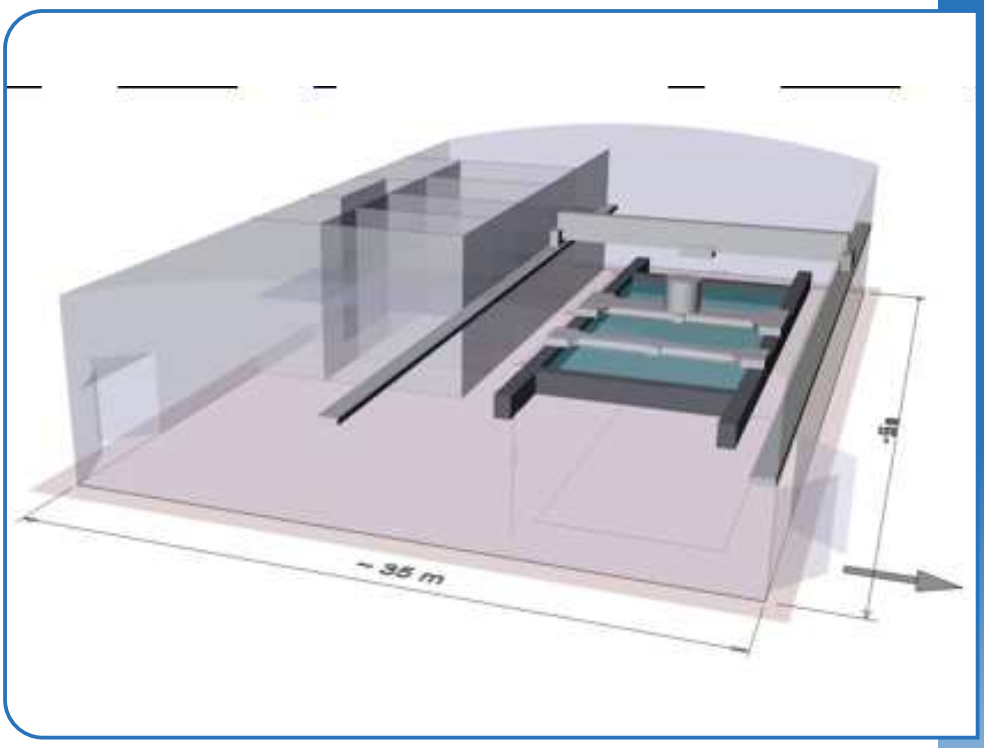
The principal facility of the laboratory is the hydroacoustic basin. The main aim of hydroacoustic basin is calibration of various measuring devices (hydrophones, pressure transducers).

The following tests can be also carried out in the hydroacoustic basin:

- hydroacoustic stations for target indicating,
- radio-hydroacoustic air buoy,
- hydroacoustic devices for short-range and mid-range detection,
- tests of communication devices,
- measurement of submerged acoustic barriers, etc.

The main equipment of hydroacoustic tank:

- dismountable acoustic insulations of the tank,
- full acoustic insulation from the ground and from building structure,
- two movable platforms,



- rail gantry of 3 t capacity, supplied with operational platform,
- remote control console,
- pressure chamber and it`s equipment.

Example technical specification

- Dimensions of the tank:
  - Width: 12.0 m,
  - Length: 25.0 m,
  - Depth: 10.5 m (10.0 m to water level),
  - Scope of frequency: 2÷ 500 kHz.

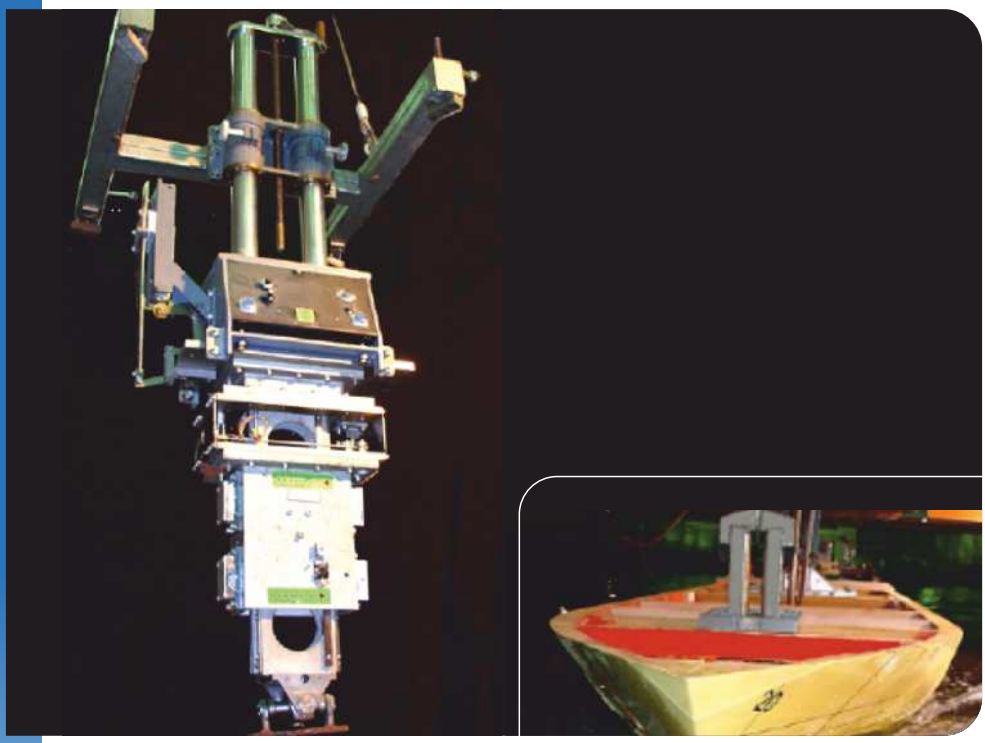
DYNAMOMETER OPN

Description

Dynamometer OPN is a measuring device used for standard hydrodynamic model tests conducted in towing tank or circulating water channel. Depending on particular version, the dynamometer OPN can be used for resistance, propulsion or seakeeping model tests of ships.

Standard version of OPN is equipped with vertical, adjustable column, which allows for handy fitting the dynamometer to the currently tested hull model as well as force and sinkage electric converters. Pitching converters can be added as an option.

OPN-R allows for selection of optimal dynamometer version considering the range of resistance force measurement and weight of towed model.



Reinforced construction of OPN-S is adjusted for resistance tests of high speed vessels, planning boats and for the purpose of seakeeping tests.

Technical specification

Version	OPN-R100	OPN-R200	OPN-R700	OPN-S600
Measuring range of the resistance	± 100 N	± 200 N	± 400 N	± 600 N
Measuring system of the resistance measurement	Strain gauge - full bridge			
Measuring range of the sinkage	± 200 mm			
Measuring system of the sinkage	Lineal displacement sensor			
Range of initial, vertical* dynamometer's position	0 ÷ 450 mm			
Measuring range of pitching	± 5 deg		± 10 deg	
Measuring system of the pitching	Angle displacement sensor			
Device weight	App. 200 kg			
Maximum model weight**	3000 kg			1000 kg

* Option

** Maximum acceleration ragne ± 0.5 m/s^2

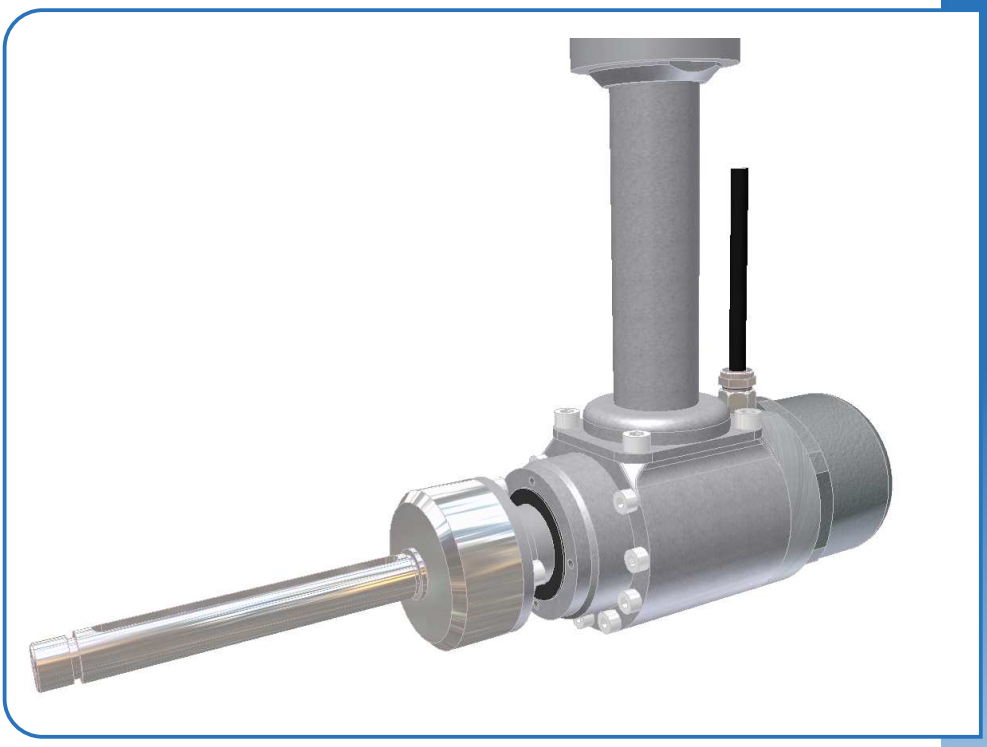
POD DYNAMOMETER

Description

The device installed inside the POD housing as a part of the modelled propulsion system is intended for thrust and torque measurements generated on the POD propeller (instead of the entire POD unit). The dynamometer can be applied as a part of the measuring system for podded vessels model testing as well as for open water POD propulsors model tests.

Main features:

- measurements based on strain gauges,
- housing made of aluminium and stainless steel,
- signal transmission via rings or radio,
- compact design, intended to be installed inside POD housing/side thrusters,
- possible adjustment of the distance between vertical POD axis of rotation and front end of the propeller shaft,
- standard analogue output signal.



The device is provided together with a calibration certificate.

Example technical specification

Thrust (maximum)	500 N
Torque (maximum)	20 Nm
Propeller mass (maximum)	3 kg
Propeller shaft diameter	Ø 16 mm

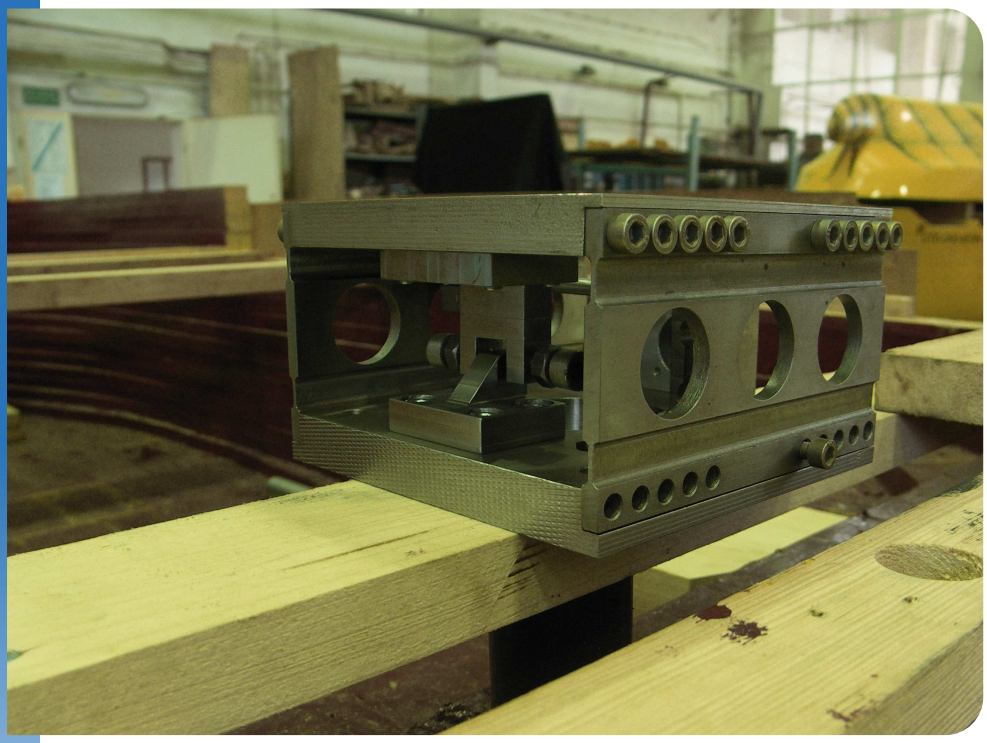
RUDDER DYNAMOMETER FOR OPEN WATER RUDDER TEST

Description

The rudder dynamometer for open water rudder tests is an element of the towing carriage equipment and is used for measurements of torque and longitudinal/transverse force components generated on a rudder model during tests in the towing tank. The dynamometer can be used to measure rudder forces behind the hull model as well. Its structure and measuring range corresponds to the characteristics of the research models used in model testing of ships.

Characteristic features:

- compact design,
- casing made of corrosion resistant material,
- measurements based on strain gauges,
- analogue output signal.



The device is provided together with a calibration certificate.

Example technical specification

Measuring range	2 axis
Fx	300 N
Fy	500 N

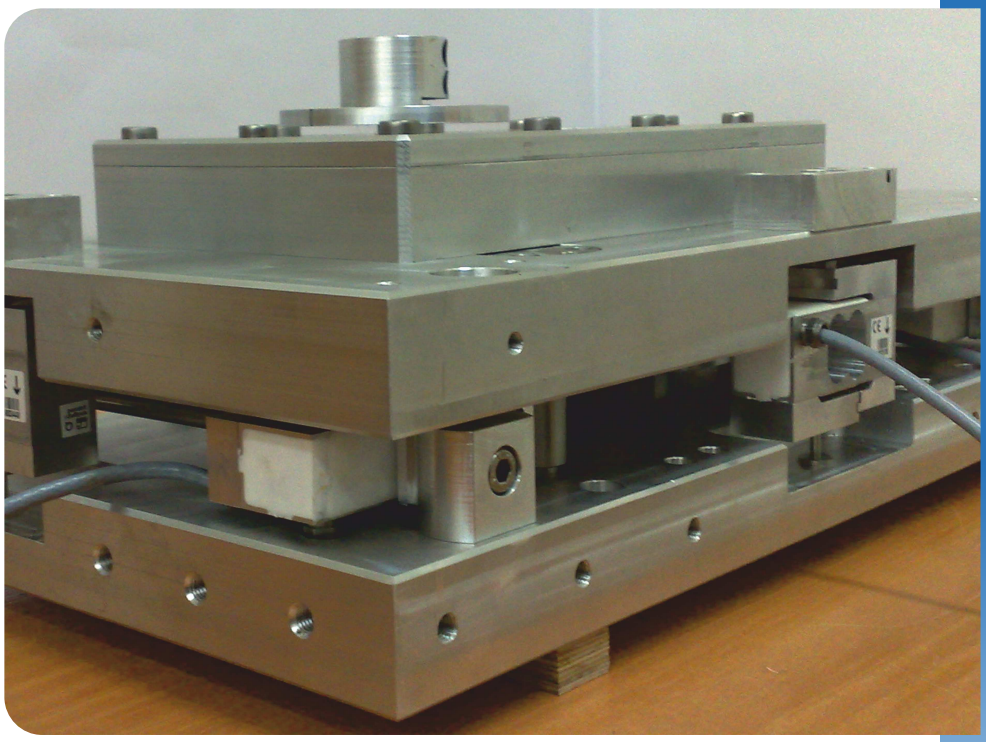
6-COMPONENTS BALANCE

Description

The 6-components balance is a general application device for measurements of 3 force and 3 moment components. It can be used as an element of the measuring stands or systems in towing tanks, cavitation tunnels or wind tunnels (e.g.: loading measurements in yachts' model tests or measurements of the forces generated on PODs' housings).

Characteristic features:

- mesurements based on strain gauges,
- made of corrosion-resistant material,
- compact design (to be used as a component of more sophisticated measuring systems),
- analog output signal.



The device is provided including basic calibration set and the calibration certificate.

Example technical specification

Fx	400 kg
Fy	400 kg
Fz	1200 kg
Qx	300 kGm
Qy	300 kGm
Qz	200 kGm
Diameter of platform	2.2 m

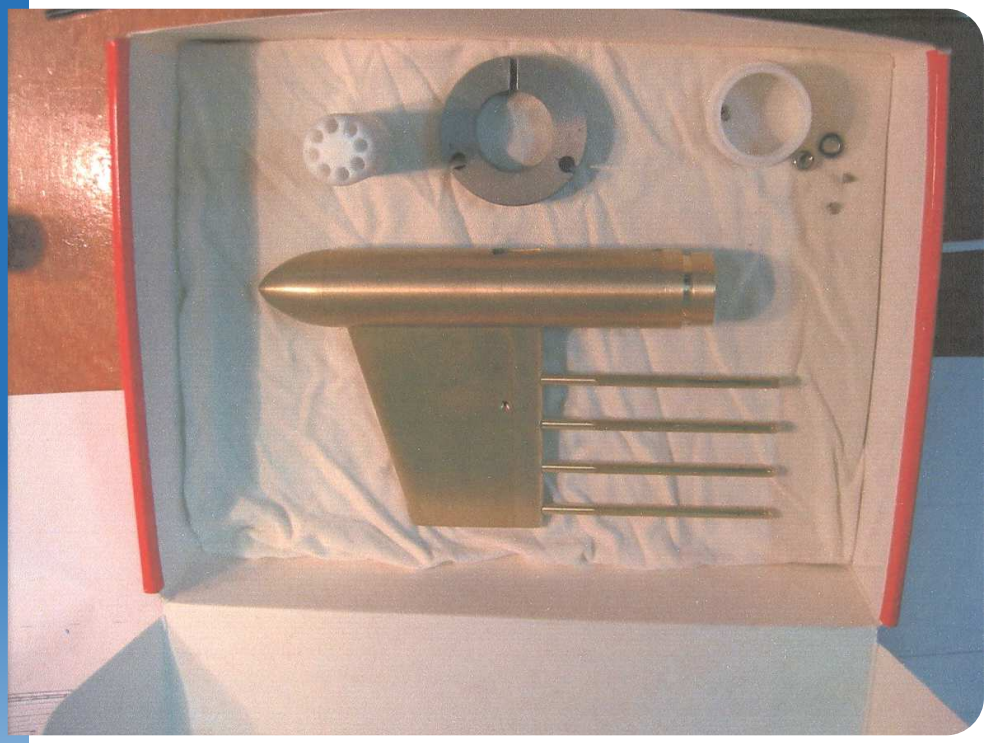
WAKE RAKE - A SET OF PITOT (PRANDTL) PROBES

Description

Description

The wake rake is dedicated to the measurements of the wake axial component in a propeller disk. The device, has the form of a comb and consists of the number of Pitot tubes. Modification of the measuring radii is achieved through replacement of the comb, while the angular position of the comb can be adjusted using the tube installed inside the propeller shaft (used also for outlets of the pressure tubes).

The measurements are made with pressure pick-ups and the results are recorded by means of a PC equipped with dedicated converter card.



Example technical specification

Range of measuring radius	40 ÷ 160 mm
Range of flow velocity	from 0.5 to 6.0 m/s

WAKE SURVEY DEVICE

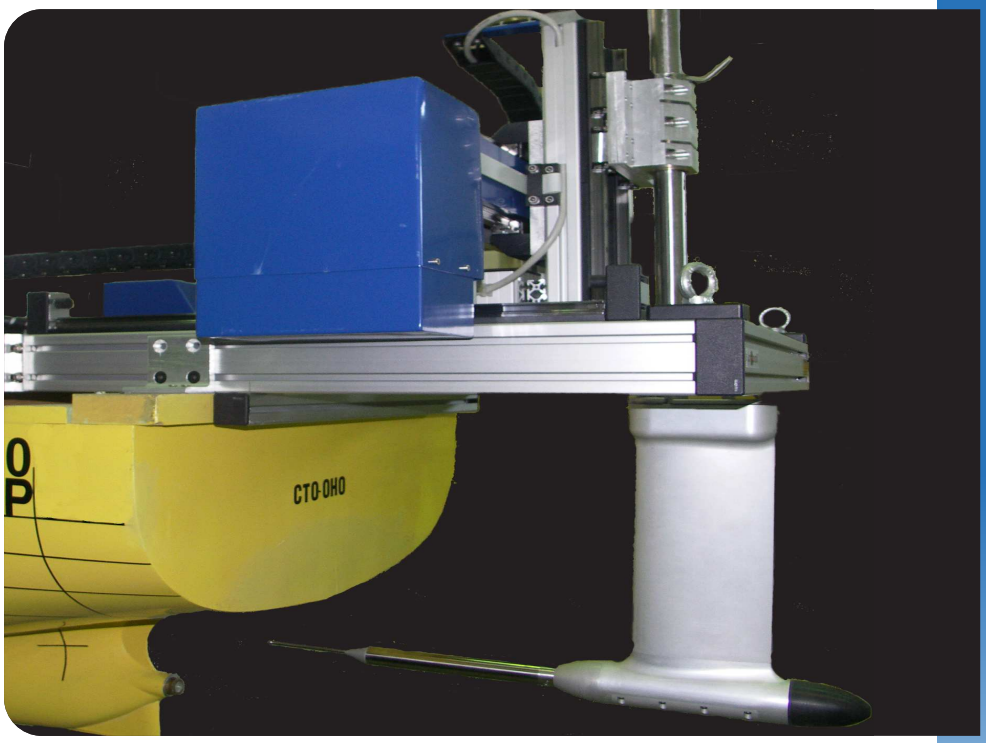
Description

Wake survey device is a measurement system designed for three-dimensional velocity field determination behind the ship model, particularly in propeller disc. It can also be used for velocity determination in many other flows.

The system for water velocity determination is based on the pressure measurement using 5-hole spherical probe and associated precise, piezoelectric pressure pick-ups.

The positioning system of the probe is digitally controlled. It allows for arbitrary planning of the probe trajectory.

Due to the system technical parameters such as: accuracy of the probe positioning, high resolution of the position sensors and pressure measurement as well as considerably short time of the measurement, the wake survey device is particularly useful for determination of nominal wake field in the towing tank practice.



Technical specification

Velocity measurement range	0.5 ÷ 6.0 m/s
Working envelope	X-axis 300 mm; Y-axis 300 mm; Z-axis 300 mm
Axis traverse rate	rapid rate up to 18 m/s; work rate up to 10 m/s
Axis motors	stepping motors for all axes
Control system	based on the PC control with induction sensor limit on each axis
Probe type	spherical, 5-hole
Pressure sensor type	Keller
Software	set of programs dedicated for system preparation and monitoring as well as measurement results processing

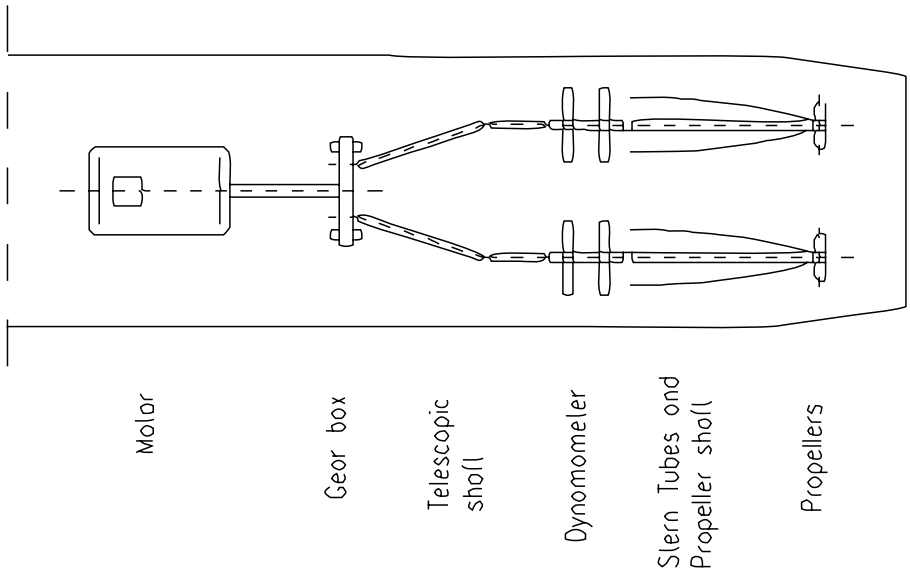
The device can be provided in either in 2D standard (measurement in Y-Z plane) or 3D standard. Technical specification as well as the software can be adjusted to the individual Customer preferences.

SHIP MODEL POWER TRANSMISSION SYSTEM

Description

The AC drive motors are equipped with encoder which allows the operator to adjust motor shaft revolutions trough the control unit. The adjustable-length telescopic shafts with couplings shall be used as the drive transmission to self-propulsion dynamometers.

In order to arrange the connection with dynamometers the claw couplings are provided. In case of twin screw propulsion the gear box driving two outputs from single motor shaft shall be used. The propulsion shall be driven trough shaft lines coming through the stern tube fitted with low friction bearings and watertight seal.



Technical specification

Standard ship model propulsion set consists of:

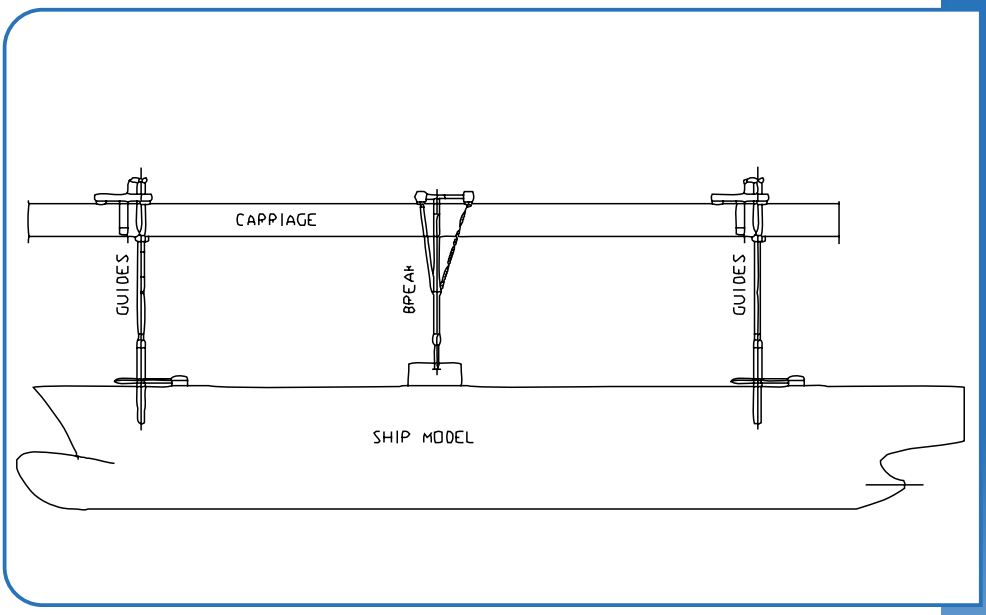
- AC electric motor 1 kW or 3 kW with built-in encoder and control unit,
- telescopic shafts with couplings on both ends,
- distribution gear box to be used with twin propellers systems and output driven in opposite directions,
- claw couplings compatible with range of K&R dynamometres,
- shaft lines:
  - propeller model shaft diameter 13 mm,
  - stem tube diameter 32 mm,
  - bearings and seals provided.

GUIDES FOR SHIP MODEL

Description

Model guides consist of two parts. The rollers build on the steel frame shall be mounted on a hull model in its plane of symmetry. The vertical forks shall be located on the towing carriage using the supporting brackets. The longitudinal and vertical position of forks shall be adjusted in such a way that the natural motions of the model at speed are not restricted.

The brake consist of pneumatically driven clamps mounted on the towing carriage. Their longitudinal and vertical position shall be adjusted according to the model size and position. Clamps are usually closed on the wooden plank mounted on the model. The force required to hold the model is provided by springs. In order to release the clamps the pneumatic actuator controlled trough the electro-valve shall be turned on by the operator.



Standard set required to set up the model for test consists of:

- Model guides (2 pieces) type CTO-MG,
- Model break -electro-pneumatic type CTO-MB.

Example technical specification

Maximum vertical displacement of the hull model	+/- 300 mm
Maximum longitudinal displacement of the hull model	+/- 200 mm
Vertical adjustment of the fork	600 mm
Maximum displacement of the hull model	4000 kg
Maximum length of the hull model	10.0 m

HYDROFOIL MODEL GUIDES AND DYNAMIC COMPENSATION SYSTEM

Description

Model guides

The model guides are used to restrict the model motions in certain directions and eliminate unwanted forces acting on the measuring equipment, namely the resistance dynamometer. During model runs in resistance and self-propulsion tests the model plane of symmetry should coincide with the plane of symmetry of the towing tank. Therefore the model sway and yaw relative to the towing carriage should be eliminated. This way the influence of the side force and yaw moment on the resistance dynamometer is eliminated or greatly reduced. It is achieved by application of model guides.

The guides do not exert unbalanced static vertical forces so that the model weight and centre of gravity are not affected. During the tests in waves no external dynamic (interia) forces should be exerted on the model. Since the hydrofoil models have small displacement the movable parts of the guides are lightweight.

The stiffness of guides is sufficient to minimize lateral deflection (static or oscillatory). Their position is adjustable to allow various model size. The guides enable dynamic model sinkage/rise and trimming with minimum friction. During the tests in waves the guides do not restrict pitch and heave motions of the model. Due to the construction of the resistance dynamometer the guides allow limited model surge. Also limited roll is allowed. The guides ensure smooth model movement.

Dynamic compensation system

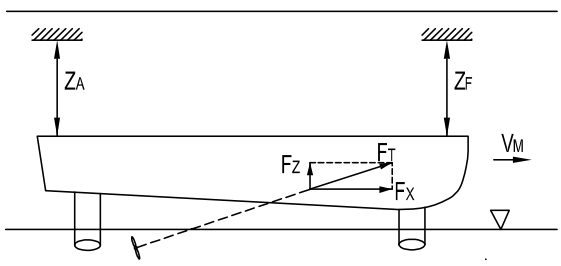
During the resistance test the model is towed with a constant speed V_m. For a fast vessel the propulsors' thrust compared to the ship's displacement is significant thus it may influence the ship's attitude (sinkage/rise and trim)which in turn may affect the resistance. Therefore to assure the test conditions equivalent to the conditions reproduced in a self-propulsion test the tow force should be applied alongside the propeller shafts. As the model speed varies its attitude changes and the direction of the equivalent tow force F_t does not stay constant. For this reason a compensation mechanism is used to keep this force in line with the required direction. The system operates automatically and real-time. The horizontal tow force F_x and the vertical displacements at a model bow Z_f and stern Z_a are the input to the system. The vertical displacements are used to determine the model/s dynamic trim and sinkage/rise.

The calculated necessary vertical force F_z is applied to the model during the runs in real time by an electric actuator.

Example dimensions of model

Lenght of model (L_{max})	4.0 m
Mass of model (M)	600 kg
Draught increase (AT)	~ 0.5 m

Diagram of the dynamic compensation system



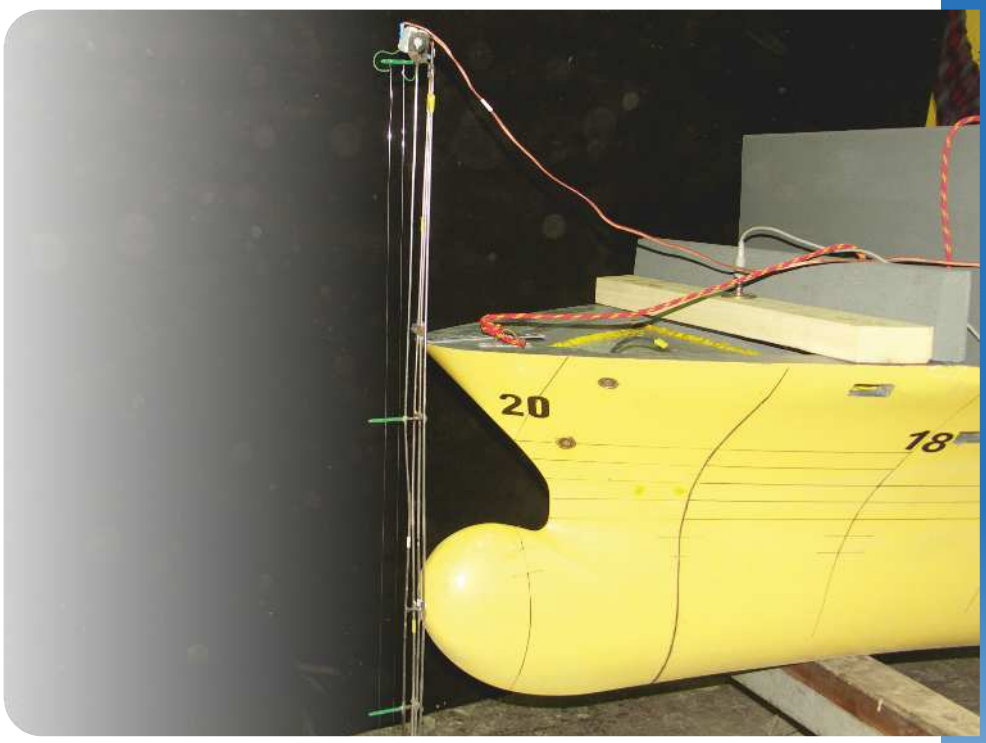
WAVE PROBE

Description

Wave probe is dedicated to measurements of the wave height in the towing tank. The device is sine-wave powered with the properly adjusted amplitude. The output signal is proportional to the actual immersion of the probe.

Its structure consists of two cords insulated one from another mounted on a supporting frame.

Measuring range of the probe as well as its accuracy depends on its design and dimensions of the components



Example technical specification

Probe type	resistance
Range of probe resistance	50 ÷ 500 Ω
Output signal	voltage
Maximum range of voltage output signal	+/- 10 V
Frequency band	up to 20 Hz
Power supply	AC
Example range	+/- 300 mm

DEVICE FOR BALANCING SHIP MODELS

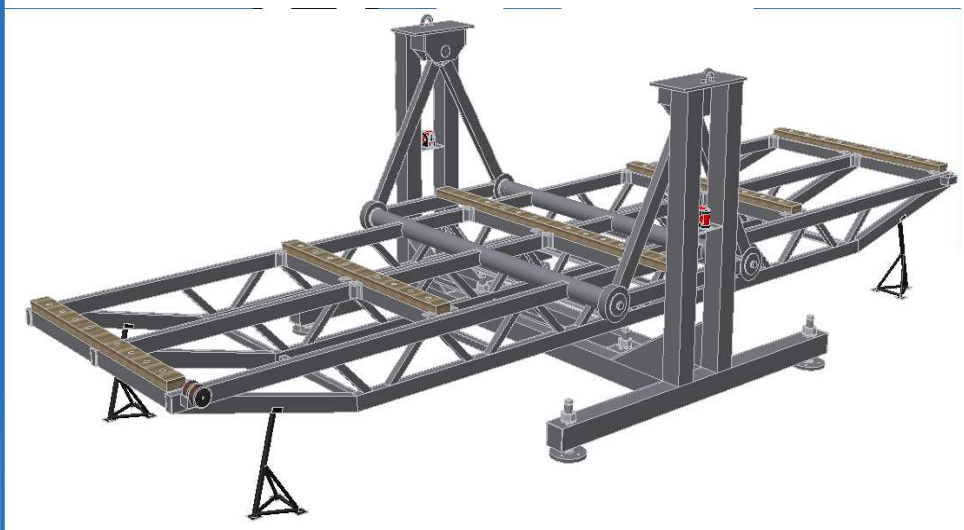
Description

The device is a compact and light-weight construction, which enables determination of the moment of inertia as well as the centre of gravity for a ship model. The correct and accurate determination of the above mentioned quantities is necessarily required as the preparation for the manoeuvrability and sea keeping model test.

Device for balancing ship models can be equipped with a manual or an automatic system for inclination angle measuring. The automatic system coupled with dedicated software considerably reduces the time of model preparation for test. Depending on a size, device enables balancing objects in the length range: 1 ÷ 10 m.

Device consists of the following items:

- platform for ship model placement with adjustable suspension (for adjustment of the axis of rotation),
- platform support with adjustable flanges allowing for the device levelling,



- laser pointer for projection of rotation axis at the model side,
- manual system for determination of the platform inclination angle consisting of laser pointer and the screen,
- automatic system for determination of the platform inclination angle consisting of electronic inclinometer and the software (to be used with a PC).

The design, manufacture and measuring equipment of a device for balancing ship models suits individual customer requirements.

Example technical specification

Device type	WM-500
Platform lenght	6.2 m
Platform breadth	2.63 m
Support height	1.75 m
Maximum model mass	1300 kg
Maximum width of hull model	2.0 m
Maximum length of hull model	10.0 m

HULL MODEL LIFTING AND TRANSPORT TRAVERSE

Description

The traverse is used to transport hull models with overhead travelling crane. Due to the usual hull model length the use of the traverse is necessary both at model manufacture phase as well as during the model preparation for the test. The traverse is also used to revolve the hull models.

Characteristic features:

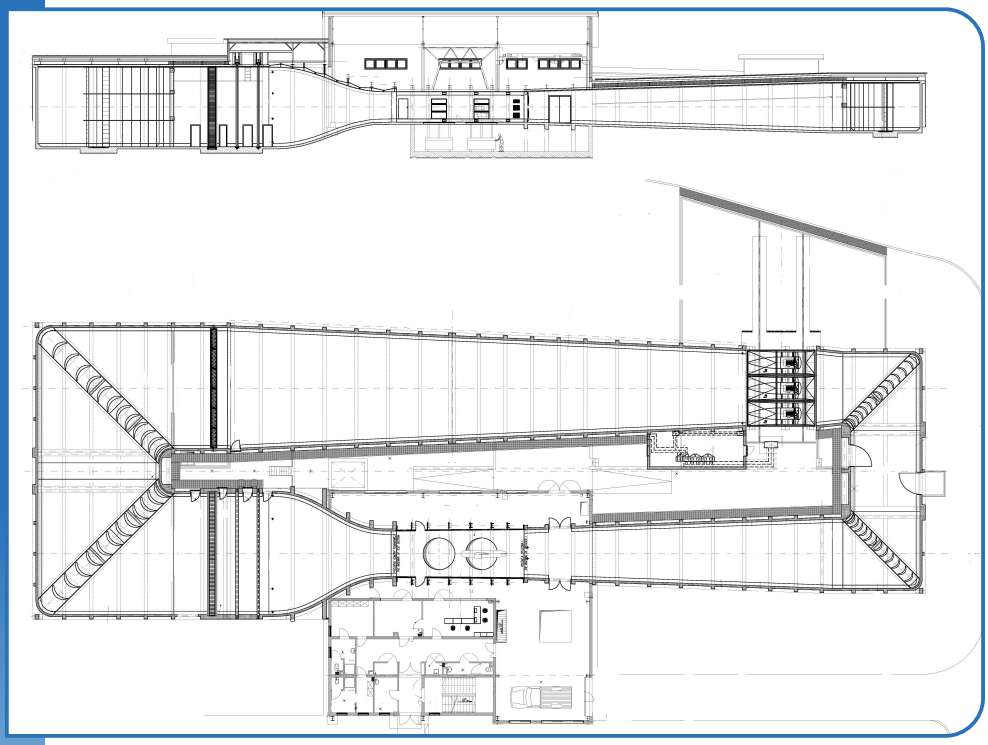
- welded steel construction,
- anticorrosive protected,
- enables revolving (inc. locking mechanism) the hull model,
- equipped with detachable soft polymer transport belts,
- adjustable length: 2.0 ÷ 5.0 m,
- maximum load: 4000 kg.

CLOSED CIRCUIT LARGE LOW SPEED WIND TUNNEL

Description

A low speed wind tunnel (LSWT) is a research facility which allows for controlled simulation of the air flow around a tested object (or set of objects) and determination of aerodynamic load acting on it. The scaled model of real object or its part is the most often tested physical sample. As long as the size of the test section is sufficient to accommodate full scale object (i.e. the blockage coefficient is acceptable as well as the tested object wake does not affect the operation of the LSWT) then such objects as passenger cars, motorcycles, antennas, solar panels, sportsmen or small remotely operated aircrafts are tested.

The considered wind tunnel is a horizontal closed, return, rectangular, solid wall circuit. The test section is a closed jet type with solid walls. The drive unit of the tunnel is composed of 6 parallel, identical, single stage axial fans. The static pressure in the test section is balanced with the ambient static pressure (atmospheric).



LSWT is used for model testing and prototype examination with respect to the following:

- Interaction of the wind with the above water part of ships and offshore structures (mainly drilling rigs) as well as other marine structures,
- Aerodynamics and flow around surface transport vehicles like cars, trucks, buses, racing cars, motorcycles, trains,
- Aerodynamics of aircrafts and helicopters,
- Aerodynamics of the renewable energy (wind, sunlight) facilities,
- Interaction of the wind on buildings, groups of buildings, transport infrastructure (bridges, airports, sea ports, etc.).

Example technical specification

Overall length between the axes: 72.0 m,
Overall width between the axes: 15.6 m,
Test section type: closed,
Test section dimensions (H x W x L): 2.83 x 4.24 x 12.00 m,
Maximum air flow velocity: 50 m/s,
Drive system: six identical single stage axial fans arranged parallel,
Power requirements: 965 kW.

MULTIPURPOSE SUBSONIC WIND TUNNEL

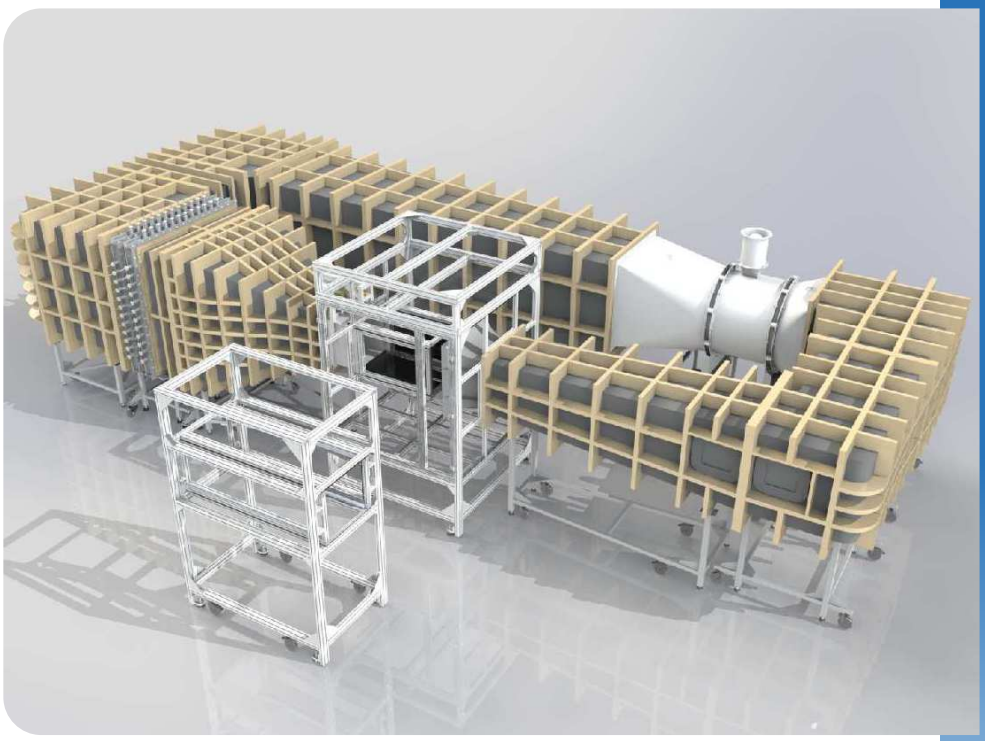
Description

The considered wind tunnel is a horizontal return, closed circuit. The air flow in the tunnel is generated by a single stage axial fan. The static pressure in the test section is balanced with the ambient atmosphere.

The tunnel is equipped with two exchangeable test sections:

- closed test section with transparent walls,
- semi-open test section with Eiffel chamber.

Except the general aerodynamic testing the tunnel is intended to conduct detailed flow measurements. Therefore the steady motion of the air in the test section can be maintained starting from 0.1 m/s. The construction of both test sections enables the application of a 3D PIV measuring system.
Due to the considerable maximum air speed the tunnel works with a heat exchanger and a cooler enabling conduction long-term testing in stable conditions.



The most significant feature of the multipurpose subsonic wind tunnel is a precise air flow rate control system, starting from the lowest achievable values. Additionally, the tunnel is equipped with a gust generator enabling periodic variation of the air flow rate in the test section.

Example technical specification

- External dimensions of the tunnel (H x W x L): 2.3 x 4.1 x 9.8 m ,
- Dimensions of the closed test section (H x W x L): 0.5 x 0.5 x 1.5 m,
- Dimensions half-open test section with the Eiffel chamber (H x W x L): 1.5 x 1.5 x 1.44 m,
- Range of the steady air flow rate: 0.1 ÷ 60 m/s,
- Intensity of turbulence: < 0,5%,
- Adjustable, stable temperature,
- Static pressure: ambient.

OPEN CIRCUIT EDUCATIONAL WIND TUNNEL

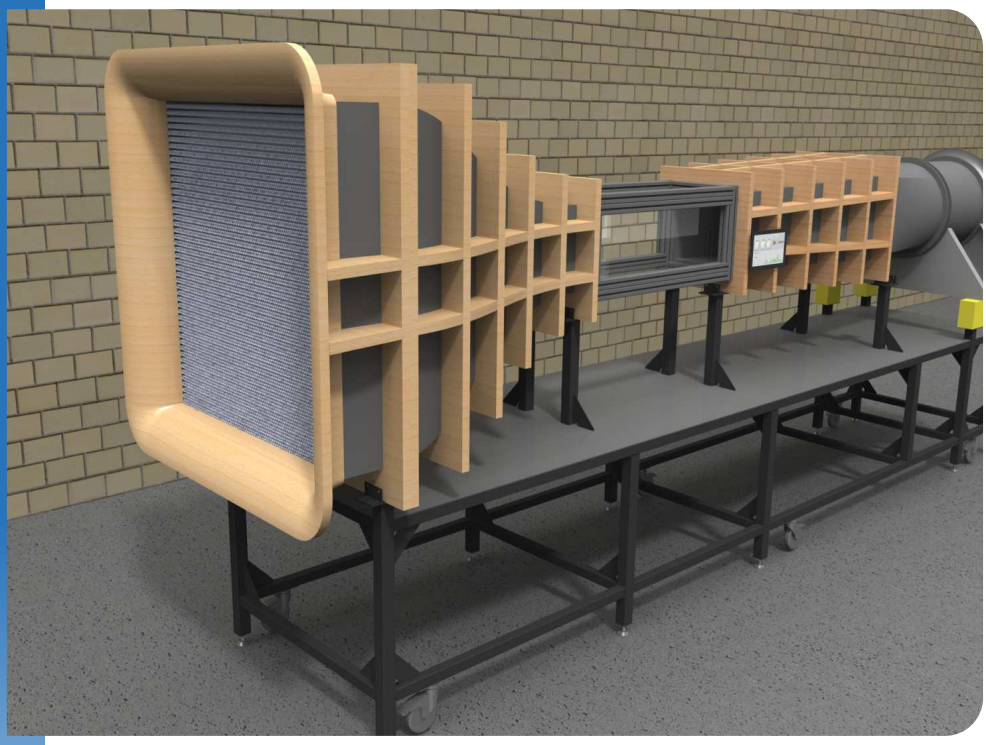
Description

A handy wind tunnel is an excellent educational facility to teach experimental fluid dynamics. Simple experiments with various models enable efficient understanding of flow principles. The tunnel is equipped with portable support construction allowing its easy and safe transport.

The tunnel is an open circuit facility, oriented in a horizontal plane. Its construction is safe and easy to maintain. The measuring equipment can be customized according to the User requirements, however the basic set includes a Pitot tube, pressure transducers and two component balance to measure drag and lift forces.

The tunnel is equipped with:

- honeycomb - a precise flow straightener assuring the best quality of the flow,
- contraction section,



- easy access test section that allows flow visualization and measurements,
- diffuser,
- single stage axial fan driven by electric motor with smoothly adjusted revolutions,
- safety screens protecting vital tunnel components against accidental damage,
- integrated control desk,
- measuring equipment for flow velocity, pressure and forces recording.
- forces.

Example technical specification

- Overall dimensions of the tunnel (H x W x L): 2.1 x 1.1 x 6.3 m,
- Dimensions of the test section (H x W x L): 0.3 x 0.3 x 0.9 m,
- Maximum air flow velocity: 40 m/s,
- Itensity of turbulence: < 0,5%,
- Fan diameter: 0.5 m,
- Required power: 5.5 kW.

TRANSONIC CASCADE WIND TUNNEL

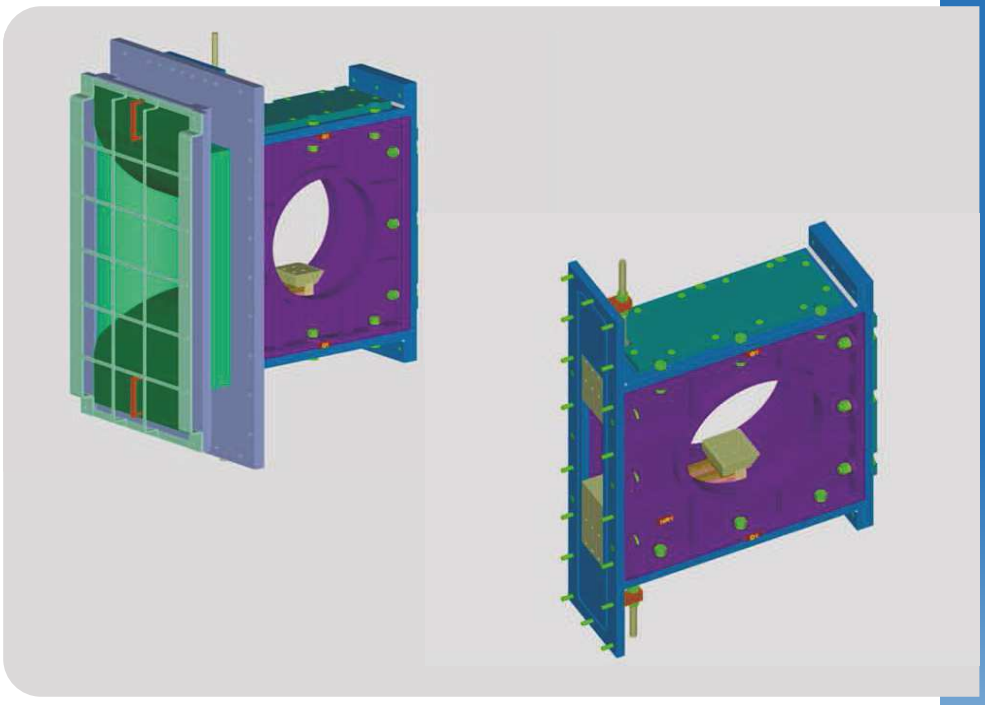
Description

The transonic cascade wind tunnel is an open circuit facility. It is used for the study and visualization of the air flow through a vane cascade in transonic flow conditions. Air is drawn directly from the laboratory room or from the elastic container and after passing through the test section and control valve moves into the vacuum vessel.
The test section of the facility can be operated in two modes: turbine and compressor.

The open transonic wind tunnel consists of several independent, exchangeable sections:

- an elastic air reservoir,
- inlet nozzle section,
- the measuring chamber with a mechanism allowing controlled setting the position of the vane cascade for turbine and compressor configuration,
- the valve controlling the air flow rate.

The elastic air reservoir is mounted on a frame. The design of the intake manifold allows for the adjustment of the flow channel cross-section. The air reservoir is equipped with



a hatch for its inspection and alternating the position of the inlet nozzle when changing the configuration of the tests section.

The test section has tightly fitted window covers made of high quality optical glass providing required insight into the flow. The vanes cascades are attached to the windows. The construction enables controlled setting of the vanes' angle of attack. Windows are mounted in easily removable panels which allows test parameters inside the test section to be changed without its dismantling.

Example technical specification

- Dimensions of the compressor mode channel (H x W x L): 2.1 x 1.0 x 2.3 m,
- Dimensions of the turbine mode channel (H x W x L): 2.0 x 1.0 x 2.4 m,
- Width of the inlet channel and the test section: 0.1 m,
- Adjustable cross-section of the inlet channel: 22000 ÷ 32000 mm^2,
- Windows with optical glass,
- Range of the vanes' angle of attack: +/- 15°,
- Control valve with variable throat area that determines the flow rate in the test section,
- Elastic air storage volume: 60 m^3.

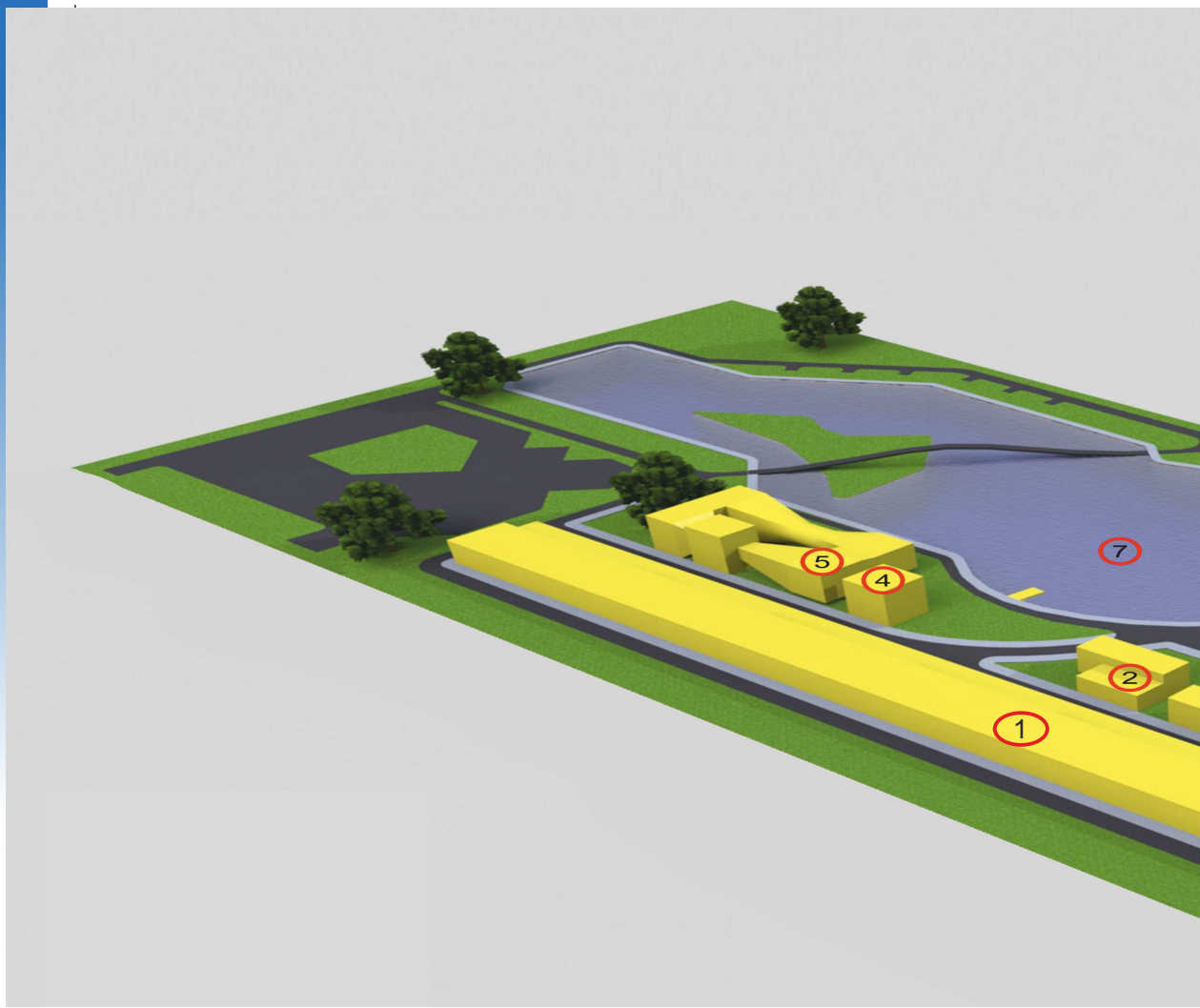
MARINE RESEARCH CENTRE

Description

The Research Centre is a complex of complementary, modern research facilities fully equipped with measuring equipment. Its main purpose is to carry out scientific applied research, which results find practical implementation in various branches of marine industry. Among the purposes of the described below research centre the basic research as well as training and education should be mentioned.

In particular the facilities and equipment of the Research Centre allows for conduction of a scientific research in the following fields of knowledge:

- ship hydromechanics, flow of incompressible fluids, free surface flow, two – phase flow and mutual interaction of fluid and flowed objects. The principal utilization of the research infrastructure concerns model tests of ships, ship propulsors, offshore constructions, facilities exploiting renewable sources of energy in marine environment, other various hydraulic engineering systems;
- acoustics (including underwater acoustics) – in scope of the tests of characteristics of sources of sound, sound propagation in various complex environments, sound absorption in materials and constructions;
- material science – in scope of resistance of modern multi-component materials and constructions against extreme environment conditions: high temperatures, corrosion environment.

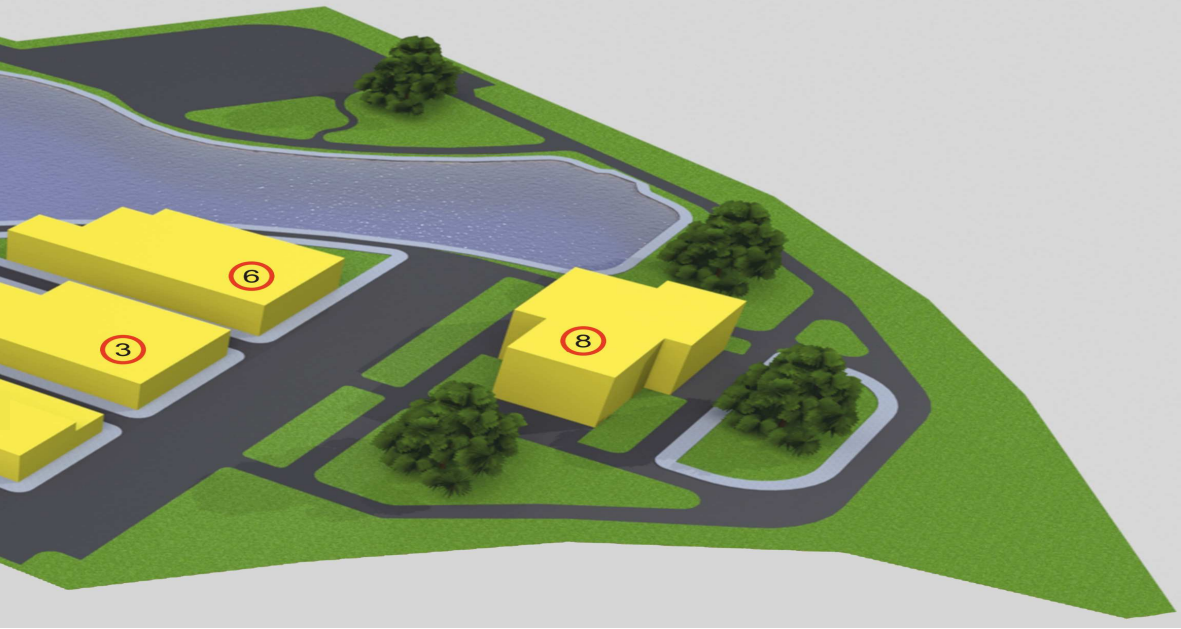


MARINE RESEARCH CENTRE

The Marine Research Centre is intended to serve as an independent research support for national marine industry, additionally creating the development opportunities for other various industry branches, like construction and energy industry. To meet the research & development needs of marine industry, the main purposes of the Research Centre are defined as follows:

- to provide an applied research support for ship design offices, shipyards (also repair shipyards), manufacturers of marine equipment and shipowners in the field of design of merchant ships, warships and off- shore constructions - in particular to elaborate predictions concerning vessels performance during their operation on the basis of model tests results and numerical computations;
- to conduct applied research and development works in scope of hydromechanics, aerodynamics, structure mechanics and hydraulic engineering - in particular with regard to the phenomena specific for the operation of vessels and floating or off-shore structures;
- to enable education and training in the field of experimental and numerical hydromechanics for the students of Naval Architecture and Ocean Engineering faculties of Technical Universities in End-used country;
- to conduct general research works in scope of analytical, experimental computational fluid dynamics, solid body mechanics, acoustics (including underwater acoustics), corrosion, fire resistance and advanced material properties.

1. Deep and Shallow Water Towing Tanks
2. High Speed Cavitation Tunnel
3. Model Production and Equipping Workshop
4. Model Storage Room
5. Large Low Speed Wind Tunnel
6. Large Cavitation Tunnel
7. Open Water Test Station
8. Office Buildings Complex



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