PROSJEKT OCEAN SPACE CENTRE

REQUIREMENTS FOR TOWING TANK WAVE GENERATION

02	22.10.2021	Issued for enquiry			SF	OJH	SiB
01	16.09.2021	Issued for internal review			SF	OJH	SiB
Version	Date	Text			Prep by	Checked by	Approved by
Project number: **1107305**	**Issued by:** **SB**	**Project name** **Ocean Space Centre**	**Code:** **M**	**Document type:** **Governing document**	**Document code:** **OSC-SB-M-SD-00001**		**Version:** **02**

1 Table of Content

1 Introduction

1.1 Objectives

The existing towing tank in Sintef/NTNU premises at Tyholt in Trondheim shall be shortened down to allow space for the new building for the new Ocean Basin as well as the Seakeeping and Maneuvering Basin. The existing towing tank will later be taken out of service as the new Ocean Basin and Seakeeping and Maneuvering Basin are completed and taken into use. The shortened towing tank shall be equipped with new state of the art wave generation units including electrical motor drives as well as local control system. Scope of delivery shall include detailed engineering, manufacturing, transportation and delivery, installation at site, mechanical completion and commissioning.

The purpose of this document is to specify requirements for the wave generation system in the towing tank.

1.2 Definitions and abbreviations

Definitions:

Company:	Statsbygg, which is the Norwegian government's key advisor in construction and property affairs, building commissioner, property manager and property developer.
Contractor:	Means the party named as such in the Form of Agreement
Subcontractor:	Means a Third Party who has entered into an agreement with the Contractor for the supply of goods or services in connection with the Work.

End-user:	Sintef Ocean and NTNU
Work:	Means all work which Contractor shall perform or cause to be performed in accordance with the Contract
Company Materials:	Means equipment, systems, and/or materials supplied by Company and which are to be incorporated in the Contract Object.

Abbreviations:

GUI	-	Graphical User Interface
HLCC	-	HydroLab Centralized Control
OB	-	Ocean Basin
OSC	-	Ocean Space Centre
PLC	-	Programmable Logic Controller
PTP	-	Precision Time Protocol
SMB	-	Seakeeping and Manoeuvring Basin
WGS	-	Wave Generation System

1.3 Design life and support

The lifetime for the shortened towing tank is limited, but the wave maker should be delivered based on supplier's standards for wave maker lifetime. This is based on the assumption that standard lifetime for a wave maker is more than enough and that modification for less lifetime only complicates the scope and does not provide any significant savings.

Table 1 Estimated wave machine operational profile

	Peak load situation		Average load situation	
Duration	Power %	Hours	Power %	Hours
Day and night	100	12	50	2.5
A week	100	60	50	12.5
One month	80	240	50	50
One year	50	1000	50	600

1.4 Rules and Regulations

All Work shall be in accordance with the latest editions at the time of Contract of all Norwegian Regulations and in particular the following:

- EU machinery directive 2006/42/EC
- Forskrift om maskiner (FM) FOR-2009-05-20-544 (Regulations on machines)
- Forskrift om sikkerhet ved arbeid i og drift av elektriske anlegg (FSE) (Regulations on safety when working in and operating electrical installations)

- Forskrift om elektriske lavspenningsanlegg (FEL) (Regulations on low-voltage electrical systems)

2 Main requirements

2.1 Shortened towing tank specifications

The shorten towing tank will have the following main dimensions:

Water depth:	5.6	m
Tank length:	195	m
Tank width:	10.4	m
Tank freeboard:	0.45	m

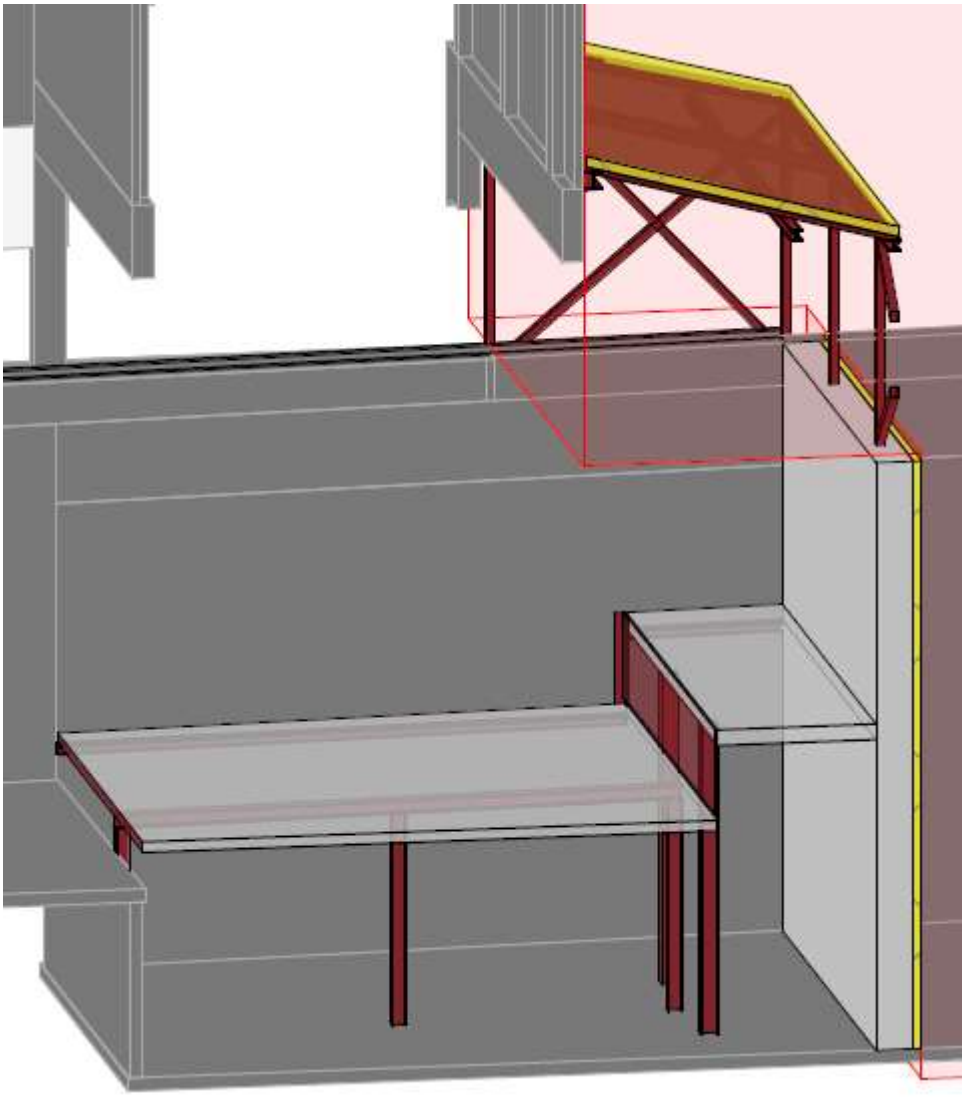

Figure 1 Illustration showing a new end-wall with a shelf for a new wavemaker.

2.2 Wave specifications

The width of the tank is 10.4m. The constant water depth will be adjustable to increase the freeboard but shall be no more than 5.6m and the corresponding freeboard no less than 0.4m. Drawing C-00-B-20-50-001, “Forkorting av slepetank” (Shortening of towing tank) shows the planned construction of the new end wall of the shortened towing tank including “shelf” for installation of new wavemakers.

The wavemaker shall consist of wet back single-hinged flaps with a hinge depth equal to approximately 3.0m when the water depth is 5.6m. The hinge depth shall be adjustable in steps of 0.5m between 3m and 1.5m. The mechanism and final design will be decided together with the supplier. The constant width of the flaps shall be no more than 0.5m. The gap between two consecutive flaps and between the side wall and the adjacent flaps shall be as small as possible, and the effect on wave generation shall be documented by means of either analytical derivations, numerical simulations or experimental results.

The wavemaker shall be able to generate regular waves with a height equal to at least 1.0m, when the water level (freeboard) allows it, with a paddle motion amplitude that should be less than 10deg. The final value will be decided together with the supplier. The wavemaker shall be able to generate regular waves with a period in the range 0.5s-5.0s, the maximum wave height being then determined either by the maximum steepness or the maximum paddle excursion, as shown in Figure 2.

Higher waves can be generated by increasing either the paddle angle or the hinge depth (see Figure 2). However, to maximize the quality of long waves, it is desirable to minimize the paddle angle, and thus increase the hinge depth. In this way, the hydrodynamic response of the wavemaker remains linear and the formation of spurious waves is limited and predictable. Although it is possible to mitigate spurious waves partially (Schäffer, 1996), correction methods do not work for steep waves, for which they may generate even more spurious waves (Fouques et al, 2021).

The actual transfer function and the harmonics amplitudes of the paddle motion shall be documented for this period range.

The wave generation software shall include the possibility of two-dimensional active wave absorption and second order paddle motion correction. It shall be possible to switch these two functionalities on and off separately.

The software interface shall include the possibility to generate waves based on custom-made files consisting of flap motion time series. Corrections related to active absorption may then be switched either on or off. The wavemaker software shall then perform necessary safety checks, including e.g., maximum flap motion amplitude, velocity and acceleration, to prevent excessive loads. Refence is also made to doc. OSC-SB-T-SD-00001, “Requirements for towing tank wave generation control- and safety system”

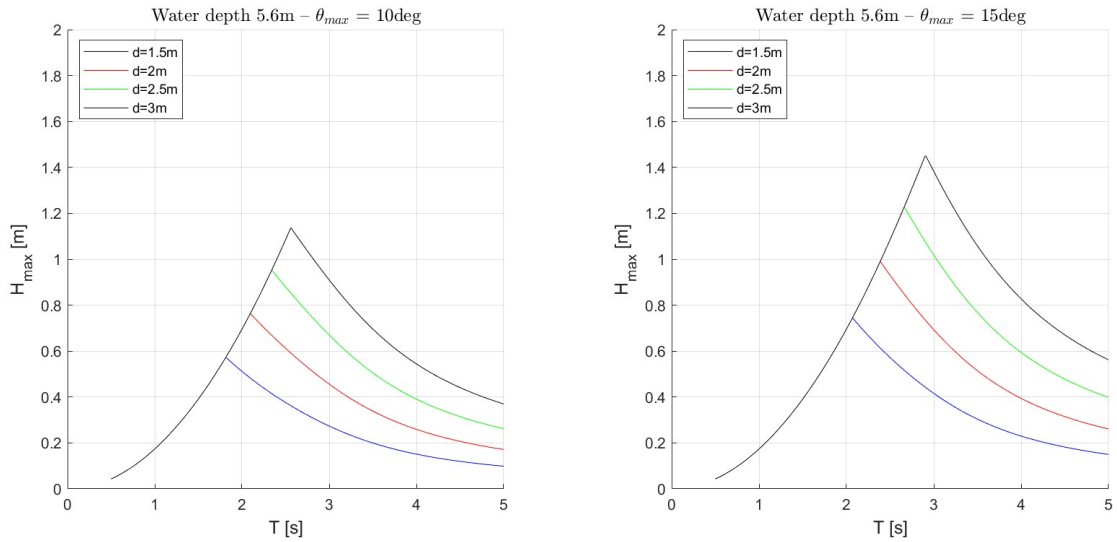

Figure 2: Maximum regular wave heights vs wave period (capacity curves) for various hinge depths d. Left: maximum flap angle 10deg. Right: Maximum flap angle 15deg.

2.3 Wave calibration

Wave calibration is important ensure that the correct waves are generated. This is done by measuring the generated wave and if necessary, correct the input to the wavemaker to meet the target wave specifications. This functionality, including the reading of measured waves and correcting the wave maker input, should preferably be integrated with the local wave generation control system. Additionally, this should also be possible to achieve using the centralized control system described in the control system document.

2.4 Active wave absorption

Active wave absorption is one of the requirements for the wave maker and this functionality should be described with both performance and working principles. The performance is preferably presented as reflection coefficients as function of wave periods, amplitudes and directions.

2.5 Power requirements

The available electrical power on site is 400V AC 3 phase TNS. Electrical power to the new towing tank generators will be provided by EPC K202 from an existing 400V AC distribution board.

Contractor to specify the required rated power for the towing tank wave generators.

2.6 Maintenance, special tools and spare parts

Contractor shall provide detailed maintenance instructions for the delivered equipment/systems. Contractor shall also describe the maintenance and support services he will be able to provide, including remote diagnostics etc.

Contractor shall include in the supply any required special tools, both for assembly/disassembly and for maintenance.

Contractor shall include in his tender documents a list of recommended operational spare parts with pricing.

2.7 Installation and commissioning

Prior to commencement of the installation work, Contractor shall inspect the work site to ensure that the site is ready for performance of the wave generation units installation work.

Contractor shall carry out the installation work of the new towing tank wave generation units as well as the motor drive/control cabinets. Contract shall also perform cabling work between the wave generation units and the motor drive/control cabinets.

Company will provide assistance for transportation and lifting of the wave generation units into position in the shortened towing tank. Necessary temporary lifting equipment, access platforms and scaffolding will also be provided by Company.

Commissioning shall be carried out and documented according to the requirements set forth in document OSC-SB-O-SD-00008, Project completion requirements.

2.8 Training and Documents for operation

Contractor shall document all equipment supplied under this Contract, including that provided by subcontractors, according to the requirements set forth in document OSC-SB-O-SD-00003 Requirements for supplier documentation including DFO.

Contractor shall provide professional training program of the End-user operators and service/maintenance personnel. The program shall cover necessary training to operate and maintain the Contract Object. Contractor's proposed training program shall be submitted to Company for review no later than 60 days prior to scheduled start of the training.

3 References

- OSC-SB-O-SD-00005 Scope of Work description wave generation towing tank
- OSC-SB-T-SD-00001 Requirements for towing tank wave generator control- and safety system
- OSC-SB-O-SD-00003 Requirements for supplier documentation including DFO
- OSC-SB-O-SD-00008 Project completion requirements
- OSC-SG-O-TEG-00001 System diagram, Wave generation for towing tank
- OSC-SB-O-RA-00001 K662-01 Equipment list from dRofus
- C-00-B-20-50-001 “Forkorting av slepetank” (Shortening of towing tank)
- Schäffer H. A. (1996),"Second-order wave maker theory for irregular waves", *Ocean Engineering,* vol. 23, nr. 1, pp. 47-88.
- Fouques S., Laflèche S., Akselsen A. and Sauder T. (2021), “An experimental investigation of nonlinear wave generation by flap wavemakers,” in *40th International Conference on Ocean, Offshore and Arctic Engineering,* OMAE2021-63120, Virtual, Online.