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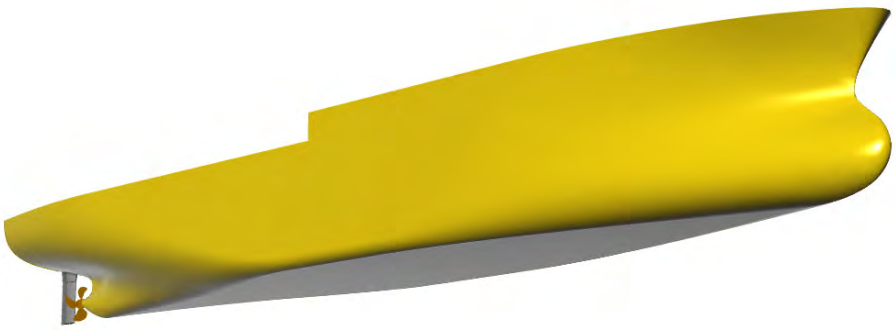
Report

Calm Water performance tests, SOBC-1 (SINTEF Ocean Bulk Carrier no.1)

On behalf of SINTEF Ocean

Author(s)
Hans Jørgen Rambech



SINTEF Ocean AS
Ship & Ocean Structures
August 25, 2021

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Report

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1.0	August 25, 2021

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Hans Jørgen Rambech

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ABSTRACT
This report presents the results from the calm water performance model test with design propeller for the 1:32.000 scaled hull model of SOBC-1 on behalf of SINTEF Ocean.

Both the hull lines, propeller design and rudder design is made by SINTEF Ocean.

Resistance and propulsion tests have been conducted for two draughts as well as 3D wake tests at 15 knots for both draughts, T_{AP}/T_{FP}= 7.50/5.40 (WL1) and T_{AP}/T_{FP}= 11.00/11.00 (DWL).

All tests were performed in Sintef Oceans' towing tank in May 2021.

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Hans Jørgen Rambech	xxxxxxxx	S.Anders Alterskjær

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VERSION	DATE	VERSION DESCRIPTION
1.0	2021-08-15	First version, complete report.

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Contents

1 CONCLUSIONS

1.1 Calm Water Performance

The speed for brake power of $P_B = 5000$ kW are given in Table 1.

Table 1: Performance Predictions

Water Line	Draught (m) T_{AP}/T_{FP}	$P/D_{(0.7R)}$ (-)	Brake Power (kW)	Speed (kn)	N (RPM)
Ballast Water Line, WL1	7.50/5.40	0.97	5000 kW	14.86	73.4
Design Water Line, DWL	11.00/11.00	0.97	5000 kW	14.35	73.6

A mechanical efficiency $\eta_m = 0.97$ is used. The effect of air resistance is included in the predictions, which are valid for trial condition with a clean hull and propeller in calm water of temperature 15 C with density 1025.9 kg/m^3. Added resistance for 0.35m high bilge keels with length 0.3 x LPP is included.

1.2 3D Wake test

3D wake is measured at the propeller plane for both ballast and design waterlines at 15 knots ship speed. The results are presented in the enclosure sections.

The 3D wake measurements shows acceptable values and gradients typical for such vessel and propulsion system with an axial peak value of about 0.60 at the propeller tip. The wake is in general assessed as satisfactorily. As a general comment to the measurrements, higher axial wake is measured in ballast condition compared to the loaded design condition. Identical trend is observed on the effective wake measurements from the propulsion test with higher effective wake in ballast condition. All this is according to previous experiences for such full bodied single screw vessel types.

2 INTRODUCTION

This report presents the results from the calm water performance model test with design propeller for the 1:32.000 scaled hull model of SOBC-1 on behalf of SINTEF Ocean.

Resistance and propulsion tests have been conducted for two draughts as well as 3D wake tests at 15 knots for both draughts, T_{AP}/T_{FP}= 7.50/5.40 (WL1) and T_{AP}/T_{FP}= 11.00/11.00 (DWL).

Both the hull lines and propeller design is made by SINTEF Ocean. The hull design, propeller design and rudder design were developed in NAPA software (Hull) and Rhino (Propeller and Rudder) throughout the winter 2020/2021. The project number used for this task was 302005859-1: GM Demo Case SOShip (2020-2021), which is a sub-project of the 302005859 GM Grønn Skipsfart (2020-2021) project.

All tests were performed in Sintef Oceans' towing tank in May 2021.

Unless otherwise specified, all results in this report refer to full scale values.

The documentation is delivered on electronic format, containing all photos and report.

3 HULL MODEL SPECIFICATIONS

The reported tests are performed with a hull model denoted M3246 manufactured according to drawings provided internally by SINTEF Ocean. The drawings presented in Table 2 were used for production of the hull model and design propulsion units.

The following have been produced:

- Hull model
- Rudder and head box
- Complete CP Propeller including hub and 4 blades.
- Dummy hub used during resistance tests, and for the zero polynoms prior to the open water tests and self-propulsion test
- Rotating cone used during the open water test.
- 2 Hub caps, one used during propulsion and one for the open water test

The hull model, rudder and propeller hub and blades were produced based on drawings, which are located on the location:

`\\Tegnekontor\Skrogmodeller\M3246A SOSHIP\FINAL`

The NAPA design files are located there as well. The following files are used for model production:

Table 2: Drawings for model production

Drawing	From	Date
m3246a_final.3dm	Internal SINTEF Ocean	11.01.2021
.	”	.
.	”	.

The hull model is produced of Divinycell and wood reinforcements at a scale of 1:32.000. In order to stimulate turbulent flow, a trip wire was located at station 19 on the hull. There are no thruster tunnels on the hull model.

The hull model is equipped with an design open propeller, denoted P1608 in the Sintef Ocean system. The design rudder and head box is 3D printed by a sub-contractor (.....Levanger). The design propeller with associated parts are manufactured at Sintef Ocean. Propulsor data is provided in enclosure E-4.1.

The calm water performance tests is undertaken with no bilge keels installed on the hull model. Resistance allowance for 0.35m high bilge keels with length 0.3 x LPP is included. Lines plan, body plan, lines fore and lines aft are shown in the enclosures E-1.1 to E-1.4

4 PERFORMED MODEL TESTS

Table 3: Performed model tests

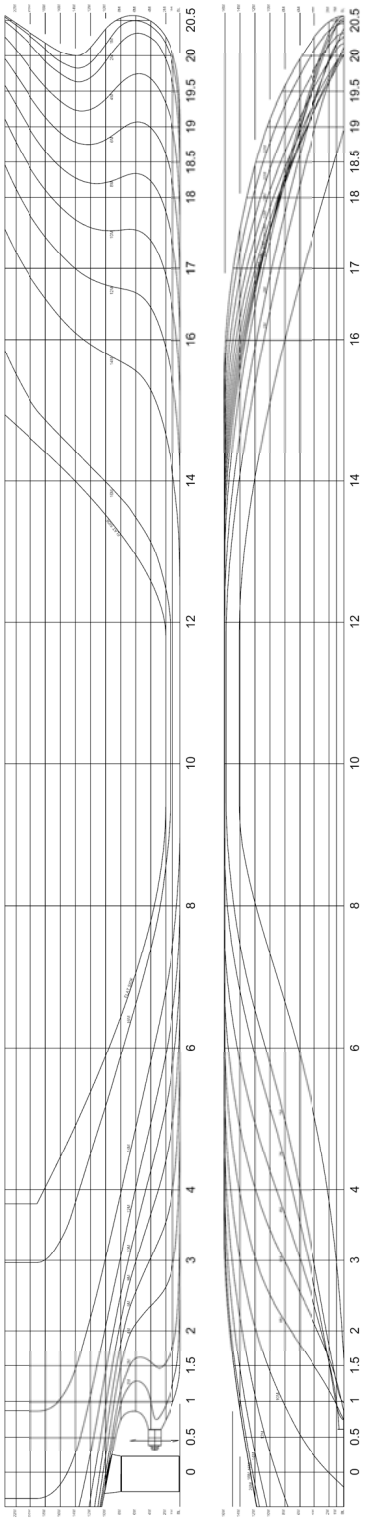
Type of test	Draught T_{AP}/T_{FP} (m)	Ship speed (Knots)	Results in encls.	Photos in encls.
Resistance, WL1	7.50/5.40	7 - 17	E-5	-
Propulsion, WL1	7.50/5.40	7 - 17	E-6	E-6.8 - E-6.12
Resistance, DWL	11.00/11.00	7 - 17	E-7	-
Propulsion, DWL	11.00/11.00	7 - 17	E-8	E-8.8 - E-8.12
3D Wake, WL1	7.50/5.40	15	E-9	-
3D Wake, DWL	11.00/11.00	15	E-10	-
Propeller Open Water Tests, n=14.0 Hz			E-4	

Explanation of the various tests described in Table 3 can be found in the appendices.

E-1 DRAWINGS

REFERENCE M3246

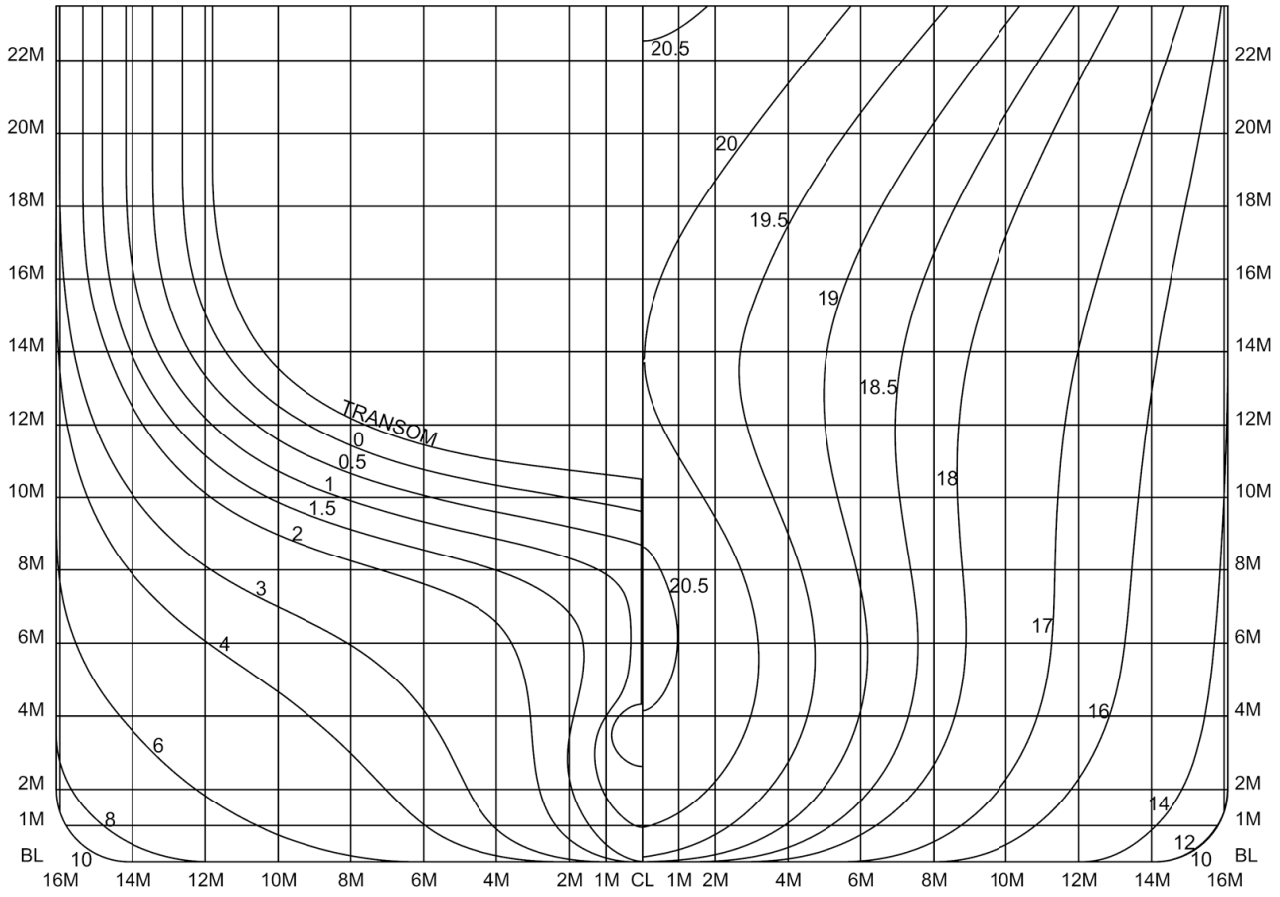
E-1.1 Linesplan



E-1 DRAWINGS

REFERENCE M3246

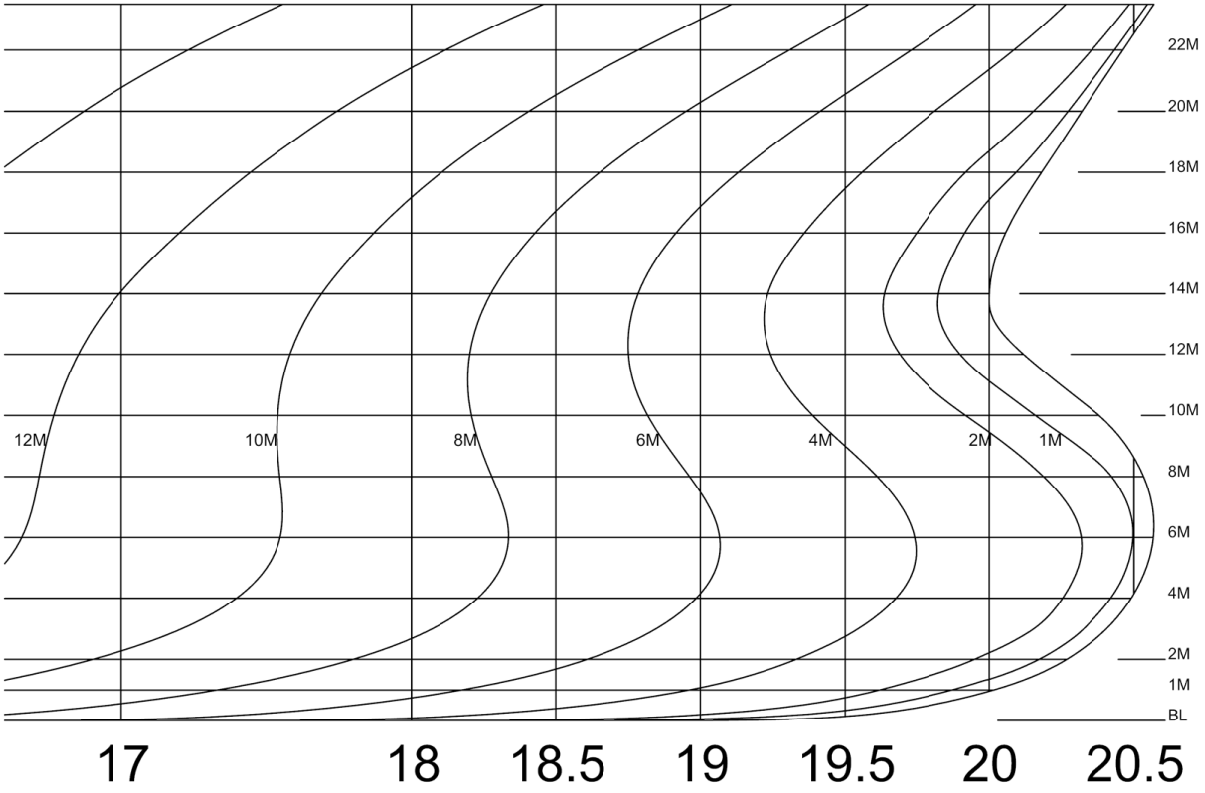
E-1.2 Bodyplan

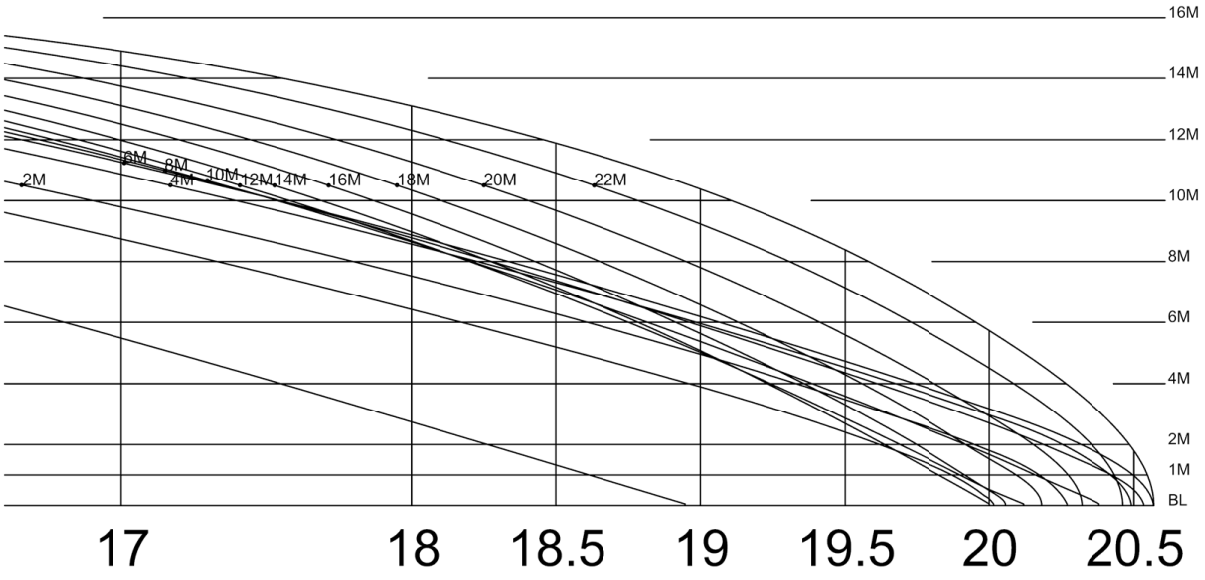


E-1 DRAWINGS

REFERENCE M3246

E-1.3 Lines Fore

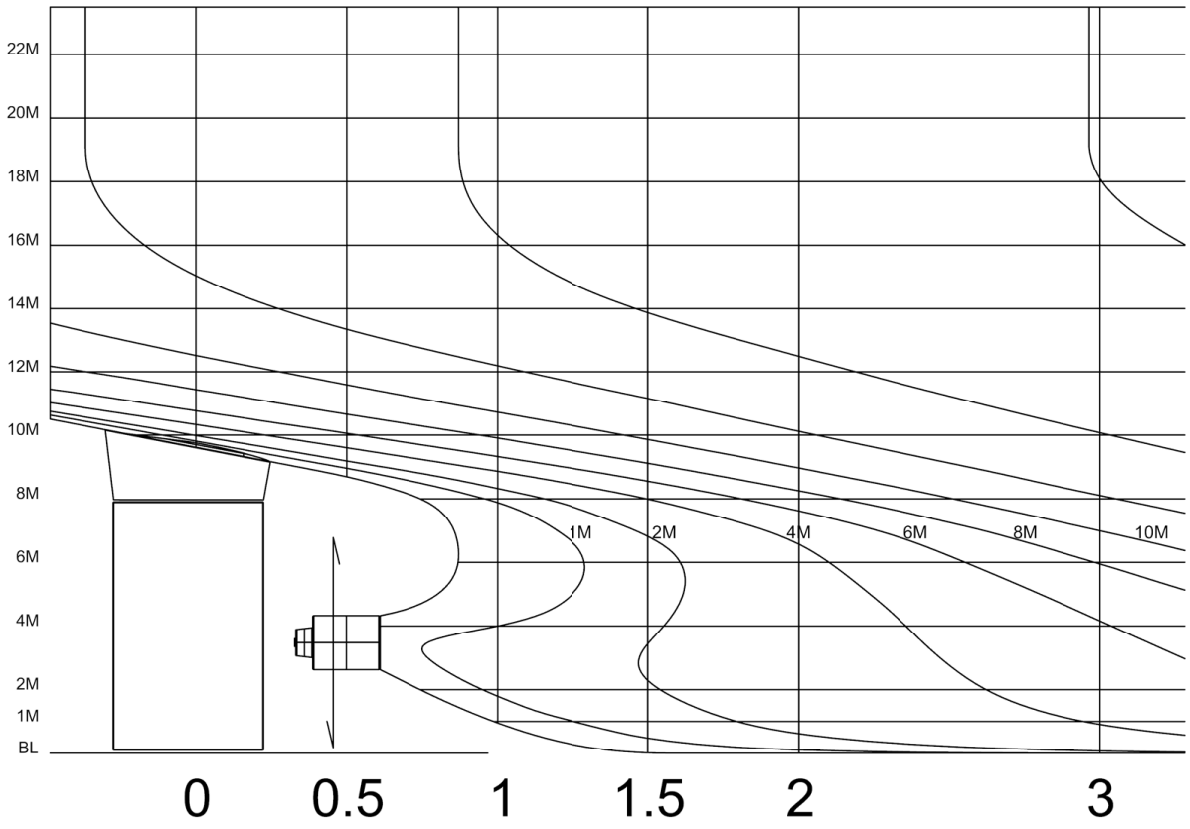


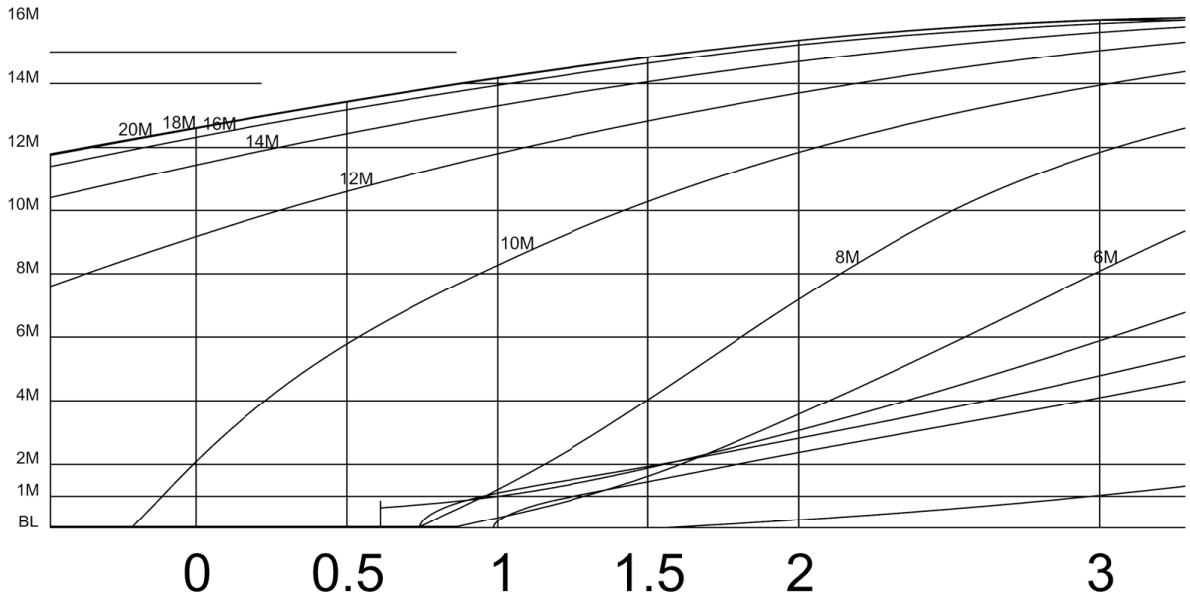


E-1 DRAWINGS

REFERENCE M3246

E-1.4 Lines Aft





E-2 PRINCIPAL HULL DATA - WL1

E-2.1 Principal Hull Data Report (including model scale data)

REFERENCE M3246

HULL MODEL NO.: M3246A Model Scale: 32.000
Loading condition: WL 1
Draught AP/FP: 7.500 / 5.400 [m]
Setup: m3246a1s5

	Symbol	Unit	SHIP	MODEL
Length overall	L_{OA}	[m]	200.002	6.250
Length on designed waterline	L_{WL}	[m]	187.385	5.856
Length betw. perp.	L_{PP}	[m]	190.000	5.938
Breadth moulded	B	[m]	32.205	1.006
Breadth waterline	B_{WL}	[m]	32.200	1.006
Depth to 1st deck	D	[m]	23.502	0.734
Draught at $L_{PP}/2$	T	[m]	6.450	0.202
Draught at FP	T_{FP}	[m]	5.400	0.169
Draught at AP	T_{AP}	[m]	7.500	0.234
Trim (pos. aft)	t	[m]	2.100	0.066
Rake of keel		[m]	0.000	0.000
Rise of floor		[m]	0.000	0.000
Bilge radius		[m]	2.000	0.062
Water density	ρ_s	[kg/m^3]	1025.87	998.82
Shell plating thickness		[mm]	2.00	0
Shell plating in % of displ.		[%]	0.40	0.00
Volume displacement	∇	[m^3]	26400.1	0.806
Displacement	Δ	[t]	27191.3	0.805
Prismatic coefficient*	C_P	[-]	0.6644	0.6644
Block coefficient*	C_B	[-]	0.6690	0.6690
Block coefficient based on L_{WL}	C_{BLW}	[-]	0.6784	0.6784
Midship section coefficient	C_M	[-]	1.0070	1.0070
Longitudinal C.B. from $L_{PP}/2$	LCB	[m]	4.016	0.126
Longitudinal C.B. from $L_{PP}/2$*	LCB	[% L_{PP}]	2.114	2.114
Longitudinal C.B. from AP	LCB	[m]	99.016	3.094
Wetted surface of naked hull	S_{BH}	[m^2]	6322.41	6.174
Wetted surface	S	[m^2]	6322.41	6.174
Wetted surf. of transom stern	A_T	[m^2]	0.00	0.000

Remarks: *Refers to L_{PP}
Hydrostatic corrections included
C_{BLW}, is based on naked hull displacement
Appendages: Rudder and Headbox.
Turbulence stimulator: Trip Wire at Station 19.

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E-2 PRINCIPAL HULL DATA - WL1

E-2.2 Hydrostatic Corrections Report

HULL MODEL No.: M3246A
Loading condition: WL 1
Draught AP/FP: 7.500 / 5.400 [m]
Setup: m3246a1s1

HYDROSTATIC CORRECTIONS

	S [m^2]	Vol [m^3]	LCB [m]
From hydrostatics	6242.64	26378.168	99.098
Naked hull corrections:			
Transom	0.00	0.000	0.000
Rudder	79.76	21.919	0.210
Rudder box	0.00	0.000	0.000
Naked hull	6322.41	26400.088	99.016
Appendices:			
Bilge Keels (2)	79.80	0.000	95.000
Sum appendices (model corrections)	0.00	0.000	0.000
Appended hull (model corrections)	6322.41	26400.088	99.016

(1)-Only in model scale; (2)-Only in full scale; (3)-Both

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E-3 PRINCIPAL HULL DATA - DWL

E-3.1 Principal Hull Data Report (including model scale data)

REFERENCE M3246

HULL MODEL NO.: M3246A Model Scale: 32.000
Loading condition: Design WL
Draught AP/FP: 11.000 / 11.000 [m]
Setup: m3246a0s11

	Symbol	Unit	SHIP	MODEL
Length overall	L_{OA}	[m]	200.002	6.250
Length on designed waterline	L_{WL}	[m]	196.942	6.154
Length betw. perp.	L_{PP}	[m]	190.000	5.938
Breadth moulded	B	[m]	32.205	1.006
Breadth waterline	B_{WL}	[m]	32.200	1.006
Depth to 1st deck	D	[m]	23.502	0.734
Draught at $L_{PP}/2$	T	[m]	11.000	0.344
Draught at FP	T_{FP}	[m]	11.000	0.344
Draught at AP	T_{AP}	[m]	11.000	0.344
Trim (pos. aft)	t	[m]	0.000	0.000
Rake of keel		[m]	0.000	0.000
Rise of floor		[m]	0.000	0.000
Bilge radius		[m]	2.000	0.062
Water density	ρ_s	[kg/m^3]	1025.87	998.82
Shell plating thickness		[mm]	2.00	0
Shell plating in % of displ.		[%]	0.40	0.00
Volume displacement	∇	[m^3]	48956.7	1.494
Displacement	Δ	[t]	50424.0	1.492
Prismatic coefficient*	C_P	[-]	0.7308	0.7308
Block coefficient*	C_B	[-]	0.7275	0.7275
Block coefficient based on L_{WL}	C_{BLW}	[-]	0.7018	0.7018
Midship section coefficient	C_M	[-]	0.9955	0.9955
Longitudinal C.B. from $L_{PP}/2$	LCB	[m]	4.329	0.135
Longitudinal C.B. from $L_{PP}/2$*	LCB	[% L_{PP}]	2.279	2.279
Longitudinal C.B. from AP	LCB	[m]	99.329	3.104
Wetted surface of naked hull	S_{BH}	[m^2]	8576.74	8.376
Wetted surface	S	[m^2]	8576.74	8.376
Wetted surf. of transom stern	A_T	[m^2]	1.82	0.002

Remarks: *Refers to L_{PP}
Hydrostatic corrections included
C_{BLW}, is based on naked hull displacement
Appendages: Rudder and Headbox.
Turbulence stimulator: Trip Wire at Station 19.

ShipX (RepGen version 2.0.22) 05-Aug-2021 11:13:06

E-3 PRINCIPAL HULL DATA - DWL

E-3.2 Hydrostatic Corrections Report

HULL MODEL No.: M3246A
Loading condition: DWL - Design waterline
Draught AP/FP: 11.000 / 11.000 [m]
Setup: m3246a0s6

HYDROSTATIC CORRECTIONS

	S [m^2]	Vol [m^3]	LCB [m]
From hydrostatics	8485.26	48927.625	99.388
Naked hull corrections:			
Transom Area	-1.82	0.000	0.000
Rudder	79.76	21.919	0.120
Rudder box	13.53	7.172	0.000
Naked hull	8576.74	48956.715	99.329
Appendices:			
Bilge keels (2)	79.80	0.000	95.000
Sum appendices (model corrections)	0.00	0.000	0.000
Appended hull (model corrections)	8576.74	48956.715	99.329

(1)-Only in model scale; (2)-Only in full scale; (3)-Both

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E-4 OPEN WATER TEST

REFERENCE M3246

E-4.1 Open Water Test Report (model scale results)

PROPELLER MODEL No.: P1608 Model Scale: 32.000

	Symbol	Unit	SHIP	MODEL
Propeller diameter	D	[mm]	6750	210.94
Pitch ratio at r/R = 0.7	$P/D_{0.7}$	[-]	0.970	0.970
Blade area ratio	A_E/A_0	[-]	0.483	0.483
Number of blades	Z	[-]	4	4
Chord/Diameter ratio	$c/D_{0.7R}$	[-]	0.3209	0.3209
Thickness/Chord ratio	$t/C_{0.7R}$	[-]	0.0324	0.0324
Hub diameter ratio	d/D	[-]	0.252	0.252
TEST CONDITIONS				
Propeller revolutions	n	[Hz]		14.00
Water temperature	T	[°C]		16.00
Average Reynolds no. at 0.7R	R_n	[-]		$0.41 \cdot 10^6$

No scaling is applied to the results

J (-)	K_T (-)	K_Q (-)	η_0 (-)	K_T/J^2 (-)
0.000	0.466	0.0632	0.000	
0.100	0.430	0.0586	0.117	42.977
0.200	0.390	0.0537	0.231	9.739
0.300	0.345	0.0484	0.340	3.836
0.400	0.298	0.0430	0.441	1.863
0.500	0.253	0.0378	0.533	1.013
0.600	0.209	0.0326	0.612	0.580
0.700	0.166	0.0272	0.679	0.338
0.800	0.117	0.0214	0.700	0.184
0.900	0.062	0.0144	0.612	0.076
1.000	0.002	0.0064	0.048	0.002
1.100	-0.065	-0.0024	4.780	-0.054

Setup: Open water test file:
p1608s2 p1608a0_frip_2 (Ci)

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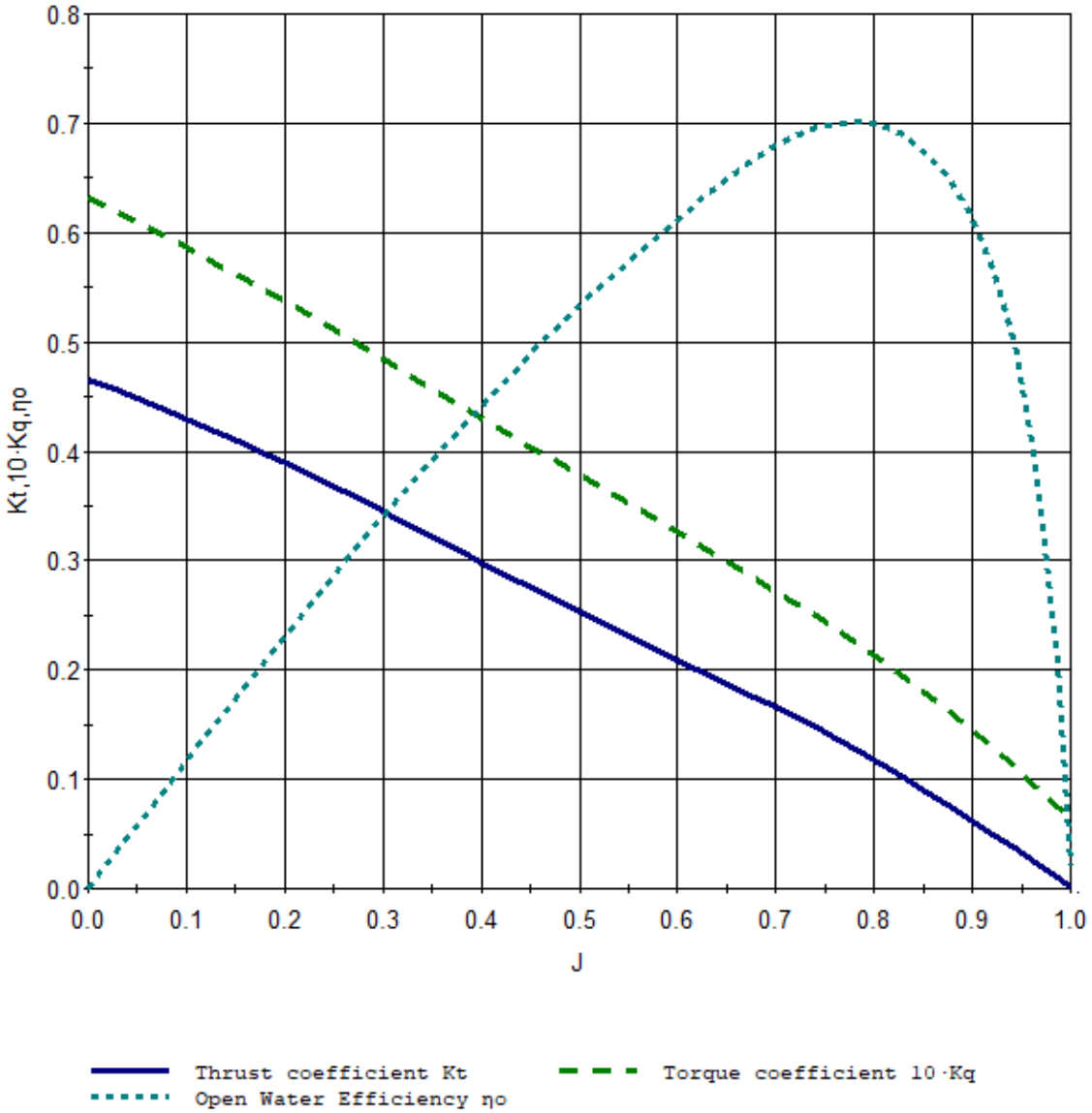
E-4 OPEN WATER TEST

E-4.2 Open Water Diagram Plot NO SCALING APPLIED

REFERENCE M3246

PROPELLER MODEL No.: P1608
NO SCALING APPLIED



Pitch ratio = 0.970
Smoothing method: (Ci) Interpolating cubic spline
Setup: p1608s2

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E-5 RESISTANCE TEST, WL1

REFERENCE M3246

E-5.1 Resistance Test Report

HULL MODEL No.: M3246A Model Scale: 32.000
Loading condition: WL 1
Draught AP/FP: 7.500 / 5.400 [m]

	Symbol	Unit	SHIP	MODEL
Length betw. perp.	L_{PP}	[m]	190.000	5.938
Length on waterline	L_{WL}	[m]	187.385	5.856
Breadth waterline	B_{WL}	[m]	32.200	1.006
Draught at $L_{PP}/2$	T	[m]	6.450	0.202
Wetted surface	S	[m^2]	6322.41	6.174
Wetted surf. of transom stern	A_T	[m^2]	0.00	0.000
Transv. proj. area above WL	A_V	[m^2]	846.00	0.571
Volume displacement	∇	[m^3]	26400.09	0.806
Block coefficient	C_{BLW}	[-]	0.678	0.678

1+k	= 1.0743	Tankwater temp. [°C]	= 16.2
$C_{AAM} \cdot 10^3$	= 0.0958		

V_S [knots]	V_M [m/s]	F_N [-]	R_{NM} $\cdot 10^{-6}$	R_{TM} [N]	C_{TM} $\cdot 10^3$	C_{FM} $\cdot 10^3$	C_{AppM} $\cdot 10^3$	C_{BDM} $\cdot 10^3$	C_R $\cdot 10^3$
7.00	0.637	0.084	3.380	5.132	4.107	3.657	0.000	0.000	0.083
7.50	0.682	0.090	3.621	5.828	4.063	3.609	0.000	0.000	0.090
8.00	0.728	0.096	3.863	6.602	4.045	3.565	0.000	0.000	0.120
8.50	0.773	0.102	4.104	7.449	4.043	3.524	0.000	0.000	0.161
9.00	0.818	0.108	4.346	8.362	4.048	3.487	0.000	0.000	0.207
9.50	0.864	0.114	4.587	9.338	4.057	3.451	0.000	0.000	0.254
10.00	0.909	0.120	4.828	10.370	4.067	3.419	0.000	0.000	0.298
10.50	0.955	0.126	5.070	11.454	4.074	3.388	0.000	0.000	0.338
11.00	1.000	0.132	5.311	12.585	4.078	3.359	0.000	0.000	0.374
11.50	1.046	0.138	5.553	13.765	4.081	3.332	0.000	0.000	0.406
12.00	1.091	0.144	5.794	15.042	4.096	3.306	0.000	0.000	0.449
12.50	1.137	0.150	6.035	16.462	4.131	3.282	0.000	0.000	0.510
13.00	1.182	0.156	6.277	17.988	4.174	3.258	0.000	0.000	0.578
13.50	1.228	0.162	6.518	19.571	4.211	3.236	0.000	0.000	0.639
14.00	1.273	0.168	6.760	21.242	4.250	3.215	0.000	0.000	0.700
14.50	1.319	0.174	7.001	23.040	4.297	3.195	0.000	0.000	0.769
15.00	1.364	0.180	7.243	24.938	4.346	3.175	0.000	0.000	0.839
15.50	1.410	0.186	7.484	26.904	4.391	3.157	0.000	0.000	0.904
16.00	1.455	0.192	7.725	29.005	4.443	3.139	0.000	0.000	0.975
16.50	1.501	0.198	7.967	31.340	4.514	3.122	0.000	0.000	1.064
17.00	1.546	0.204	8.208	34.007	4.614	3.106	0.000	0.000	1.182

Setup: Towing test:
m3246a1s1 m3246a1_slep_1 (Cs)

ShipX (RepGen version 2.0.22) 05-Aug-2021 11:03:15

E-5 RESISTANCE TEST, WL1

E-5.2 Appendage Resistance Report (model) FOR PROPULSION ANALYSIS

REFERENCE M3246

HULL MODEL No.: M3246A Model Scale: 32.000
Loading condition: WL 1
Draught AP/FP: 7.500 / 5.400 [m]

Appendix	Wetted surface	Flow length	Form f. k	Wake w
1 Bilge Keels	0.000	0.000	0.200	0.100
2	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000

Wetted hull surface 6322.4 [m²]
Note! All coeff. are made non-dimensional wrt. the wetted hull surf.

Tankwater temp. [°C] = 16.20 Kin. visc. ν_m [m²/s] = $1.10 \cdot 10^{-6}$

V_S [knots]	V_M [m/s]	$C_{AppM}{}^1 \cdot 10^3$	$C_{AppM}{}^2 \cdot 10^3$	$C_{AppM}{}^3 \cdot 10^3$	$C_{AppM}{}^4 \cdot 10^3$	$C_{AppM}{}^5 \cdot 10^3$	$C_{AppM}{}^6 \cdot 10^3$	$C_{AppM} \cdot 10^3$
7.00	0.637	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7.50	0.682	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8.00	0.728	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8.50	0.773	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9.00	0.818	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9.50	0.864	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10.00	0.909	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10.50	0.955	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11.00	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11.50	1.046	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12.00	1.091	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12.50	1.137	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13.00	1.182	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13.50	1.228	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14.00	1.273	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14.50	1.319	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15.00	1.364	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15.50	1.410	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16.00	1.455	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16.50	1.501	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17.00	1.546	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Setup: Towing test:
m3246a1s1 m3246a1_slep_1 (Cs)

ShipX (RepGen version 2.0.22) 05-Aug-2021 11:03:15

E-5 RESISTANCE TEST, WL1

REFERENCE M3246

E-5.3 Appendage Resistance Report (ship)

HULL MODEL No.: M3246A Model Scale: 32.000
Loading condition: WL 1
Draught AP/FP: 7.500 / 5.400 [m]

Appendix	Wetted surface	Flow length	Form f. k	Wake w	Roughness m
1 Bilge Keels	79.8	57.0	0.200	0.100	0.0
2	0.0	0.0	0.000	0.000	0.0
3	0.0	0.0	0.000	0.000	0.0
4	0.0	0.0	0.000	0.000	0.0
5	0.0	0.0	0.000	0.000	0.0
6	0.0	0.0	0.000	0.000	0.0
Wetted hull surface	6322.4 [m²]				

Note! All coeff. are made non-dimensional wrt. the wetted hull surf.

Seawater temp. [°C] = 15.00 Kin. visc. ν_s [m²/s] = $1.19 \cdot 10^{-6}$

V_S [knots]	V_M [m/s]	$C_{AppS}{}^1 \cdot 10^3$	$C_{AppS}{}^2 \cdot 10^3$	$C_{AppS}{}^3 \cdot 10^3$	$C_{AppS}{}^4 \cdot 10^3$	$C_{AppS}{}^5 \cdot 10^3$	$C_{AppS}{}^6 \cdot 10^3$	$C_{AppS} \cdot 10^3$
7.00	0.637	0.024	0.000	0.000	0.000	0.000	0.000	0.024
7.50	0.682	0.024	0.000	0.000	0.000	0.000	0.000	0.024
8.00	0.728	0.024	0.000	0.000	0.000	0.000	0.000	0.024
8.50	0.773	0.024	0.000	0.000	0.000	0.000	0.000	0.024
9.00	0.818	0.024	0.000	0.000	0.000	0.000	0.000	0.024
9.50	0.864	0.023	0.000	0.000	0.000	0.000	0.000	0.023
10.00	0.909	0.023	0.000	0.000	0.000	0.000	0.000	0.023
10.50	0.955	0.023	0.000	0.000	0.000	0.000	0.000	0.023
11.00	1.000	0.023	0.000	0.000	0.000	0.000	0.000	0.023
11.50	1.046	0.023	0.000	0.000	0.000	0.000	0.000	0.023
12.00	1.091	0.023	0.000	0.000	0.000	0.000	0.000	0.023
12.50	1.137	0.022	0.000	0.000	0.000	0.000	0.000	0.022
13.00	1.182	0.022	0.000	0.000	0.000	0.000	0.000	0.022
13.50	1.228	0.022	0.000	0.000	0.000	0.000	0.000	0.022
14.00	1.273	0.022	0.000	0.000	0.000	0.000	0.000	0.022
14.50	1.319	0.022	0.000	0.000	0.000	0.000	0.000	0.022
15.00	1.364	0.022	0.000	0.000	0.000	0.000	0.000	0.022
15.50	1.410	0.022	0.000	0.000	0.000	0.000	0.000	0.022
16.00	1.455	0.022	0.000	0.000	0.000	0.000	0.000	0.022
16.50	1.501	0.022	0.000	0.000	0.000	0.000	0.000	0.022
17.00	1.546	0.022	0.000	0.000	0.000	0.000	0.000	0.022

Setup: Towing test:
m3246a1s1 m3246a1_slep_1 (Cs)

ShipX (RepGen version 2.0.22) 05-Aug-2021 11:03:16

E-5 RESISTANCE TEST, WL1

REFERENCE M3246

E-5.4 Ship Resistance Coefficients Report

HULL MODEL No.: M3246A Model Scale: 32.000
Loading condition: WL 1
Draught AP/FP: 7.500 / 5.400 [m]

	Symbol	Unit	SHIP	MODEL
Length betw. perp.	L_{PP}	[m]	190.000	5.938
Length on waterline	L_{WL}	[m]	187.385	5.856
Breadth waterline	B_{WL}	[m]	32.200	1.006
Draught at $L_{PP}/2$	T	[m]	6.450	0.202
Wetted surface	S	[m^2]	6322.41	6.174
Wetted surf. of transom stern	A_T	[m^2]	0.00	0.000
Transv. proj. area above WL	A_V	[m^2]	846.00	0.571
Volume displacement	∇	[m^3]	26400.09	0.806
Block coefficient	C_{BLW}	[-]	0.678	0.678

1+k	= 1.0743	Correlation coef $\cdot 10^3$	= -0.1300
$C_{AAS} \cdot 10^3$	= 0.1349	Seawater temp. [°C]	= 15.0

V_S [knots]	V_M [m/s]	F_N [-]	R_{NS} $\cdot 10^{-9}$	C_R $\cdot 10^3$	C_{FS} $\cdot 10^3$	C_{VS} $\cdot 10^3$	C_{BDS} $\cdot 10^3$	C_{AppS} $\cdot 10^3$	C_{TS} $\cdot 10^3$
7.00	0.637	0.084	0.568	0.083	1.644	1.795	0.000	0.024	1.907
7.50	0.682	0.090	0.609	0.090	1.629	1.797	0.000	0.024	1.916
8.00	0.728	0.096	0.650	0.120	1.616	1.797	0.000	0.024	1.946
8.50	0.773	0.102	0.690	0.161	1.604	1.798	0.000	0.024	1.988
9.00	0.818	0.108	0.731	0.207	1.592	1.799	0.000	0.024	2.034
9.50	0.864	0.114	0.771	0.254	1.581	1.799	0.000	0.023	2.081
10.00	0.909	0.120	0.812	0.298	1.571	1.800	0.000	0.023	2.126
10.50	0.955	0.126	0.853	0.338	1.561	1.800	0.000	0.023	2.167
11.00	1.000	0.132	0.893	0.374	1.552	1.800	0.000	0.023	2.202
11.50	1.046	0.138	0.934	0.406	1.544	1.801	0.000	0.023	2.235
12.00	1.091	0.144	0.974	0.449	1.536	1.801	0.000	0.023	2.277
12.50	1.137	0.150	1.015	0.510	1.528	1.801	0.000	0.022	2.339
13.00	1.182	0.156	1.056	0.578	1.520	1.801	0.000	0.022	2.406
13.50	1.228	0.162	1.096	0.639	1.513	1.801	0.000	0.022	2.467
14.00	1.273	0.168	1.137	0.700	1.507	1.801	0.000	0.022	2.528
14.50	1.319	0.174	1.177	0.769	1.500	1.801	0.000	0.022	2.597
15.00	1.364	0.180	1.218	0.839	1.494	1.801	0.000	0.022	2.667
15.50	1.410	0.186	1.259	0.904	1.488	1.801	0.000	0.022	2.732
16.00	1.455	0.192	1.299	0.975	1.482	1.801	0.000	0.022	2.802
16.50	1.501	0.198	1.340	1.064	1.477	1.801	0.000	0.022	2.892
17.00	1.546	0.204	1.380	1.182	1.471	1.801	0.000	0.022	3.010

Setup: Towing test:
m3246a1s1 m3246a1_slep_1 (Cs)

ShipX (RepGen version 2.0.22) 05-Aug-2021 11:03:16

E-5 RESISTANCE TEST, WL1

REFERENCE M3246

E-5.5 Ship Resistance Report

HULL MODEL No.: M3246A Model Scale: 32.000
Loading condition: WL 1
Draught AP/FP: 7.500 / 5.400 [m]

	Symbol	Unit	SHIP	MODEL
Length betw. perp.	L_{PP}	[m]	190.000	5.938
Length on waterline	L_{WL}	[m]	187.385	5.856
Breadth waterline	B_{WL}	[m]	32.200	1.006
Draught at $L_{PP}/2$	T	[m]	6.450	0.202
Wetted surface	S	[m^2]	6322.41	6.174
Wetted surf. of transom stern	A_T	[m^2]	0.00	0.000
Transv. proj. area above WL	A_V	[m^2]	846.00	0.571
Volume displacement	∇	[m^3]	26400.09	0.806
Block coefficient	C_{BLW}	[-]	0.678	0.678

1+k	= 1.0743	Correlation coef $\cdot 10^3$	= -0.1300
$C_{AAS} \cdot 10^3$	= 0.1349	Seawater temp. [°C]	= 15.0

V_S [knots]	V_M [m/s]	F_N [-]	R_{TS} [kN]	P_E [kW]	C_{ADX} [-]	Trim [deg]	Sinkage AP [m]	Sinkage FP [m]
7.00	0.637	0.084	80.21	288.9	143.34	0.007	-0.051	-0.029
7.50	0.682	0.090	92.50	356.9	142.70	0.006	-0.056	-0.035
8.00	0.728	0.096	106.90	439.9	140.48	0.006	-0.062	-0.041
8.50	0.773	0.102	123.26	539.0	137.54	0.006	-0.068	-0.047
9.00	0.818	0.108	141.42	654.8	134.40	0.006	-0.075	-0.054
9.50	0.864	0.114	161.20	787.8	131.37	0.006	-0.082	-0.061
10.00	0.909	0.120	182.46	938.6	128.60	0.006	-0.089	-0.068
10.50	0.955	0.126	205.01	1107.4	126.19	0.006	-0.097	-0.076
11.00	1.000	0.132	228.69	1294.1	124.15	0.006	-0.106	-0.084
11.50	1.046	0.138	253.63	1500.5	122.35	0.006	-0.114	-0.093
12.00	1.091	0.144	281.43	1737.4	120.06	0.006	-0.123	-0.102
12.50	1.137	0.150	313.62	2016.7	116.91	0.006	-0.133	-0.112
13.00	1.182	0.156	348.96	2333.8	113.64	0.006	-0.143	-0.122
13.50	1.228	0.162	385.87	2679.8	110.83	0.006	-0.154	-0.134
14.00	1.273	0.168	425.31	3063.2	108.14	0.006	-0.164	-0.145
14.50	1.319	0.174	468.67	3496.0	105.26	0.006	-0.176	-0.157
15.00	1.364	0.180	515.02	3974.3	102.51	0.005	-0.188	-0.170
15.50	1.410	0.186	563.30	4491.7	100.08	0.005	-0.199	-0.183
16.00	1.455	0.192	615.74	5068.2	97.56	0.004	-0.211	-0.198
16.50	1.501	0.198	675.69	5735.5	94.54	0.003	-0.224	-0.214
17.00	1.546	0.204	746.48	6528.4	90.84	0.002	-0.236	-0.229

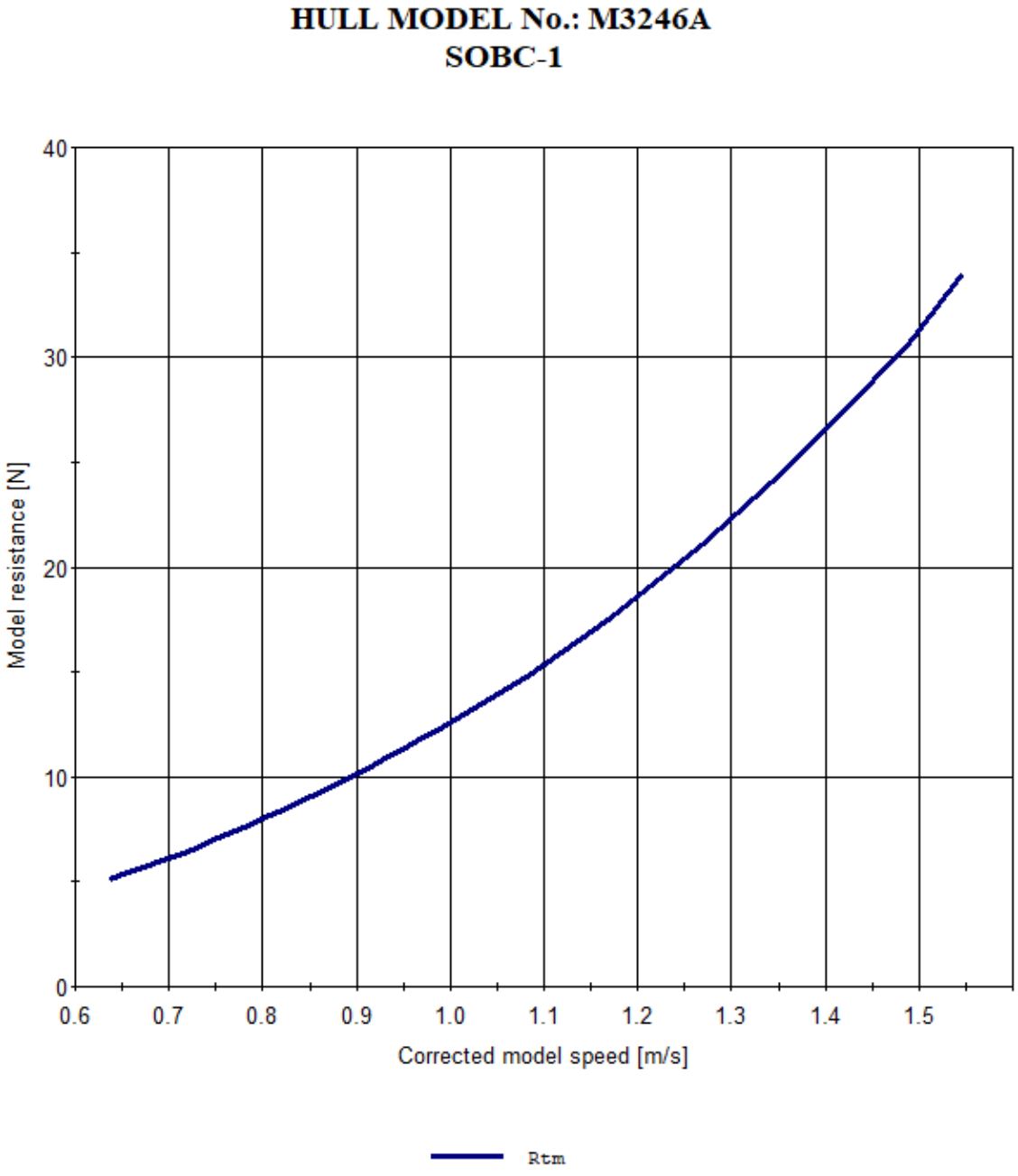
Setup: Towing test:
m3246a1s1 m3246a1_slep_1 (Cs)

ShipX (RepGen version 2.0.22) 05-Aug-2021 11:03:16

E-5 RESISTANCE TEST, WL1

REFERENCE M3246

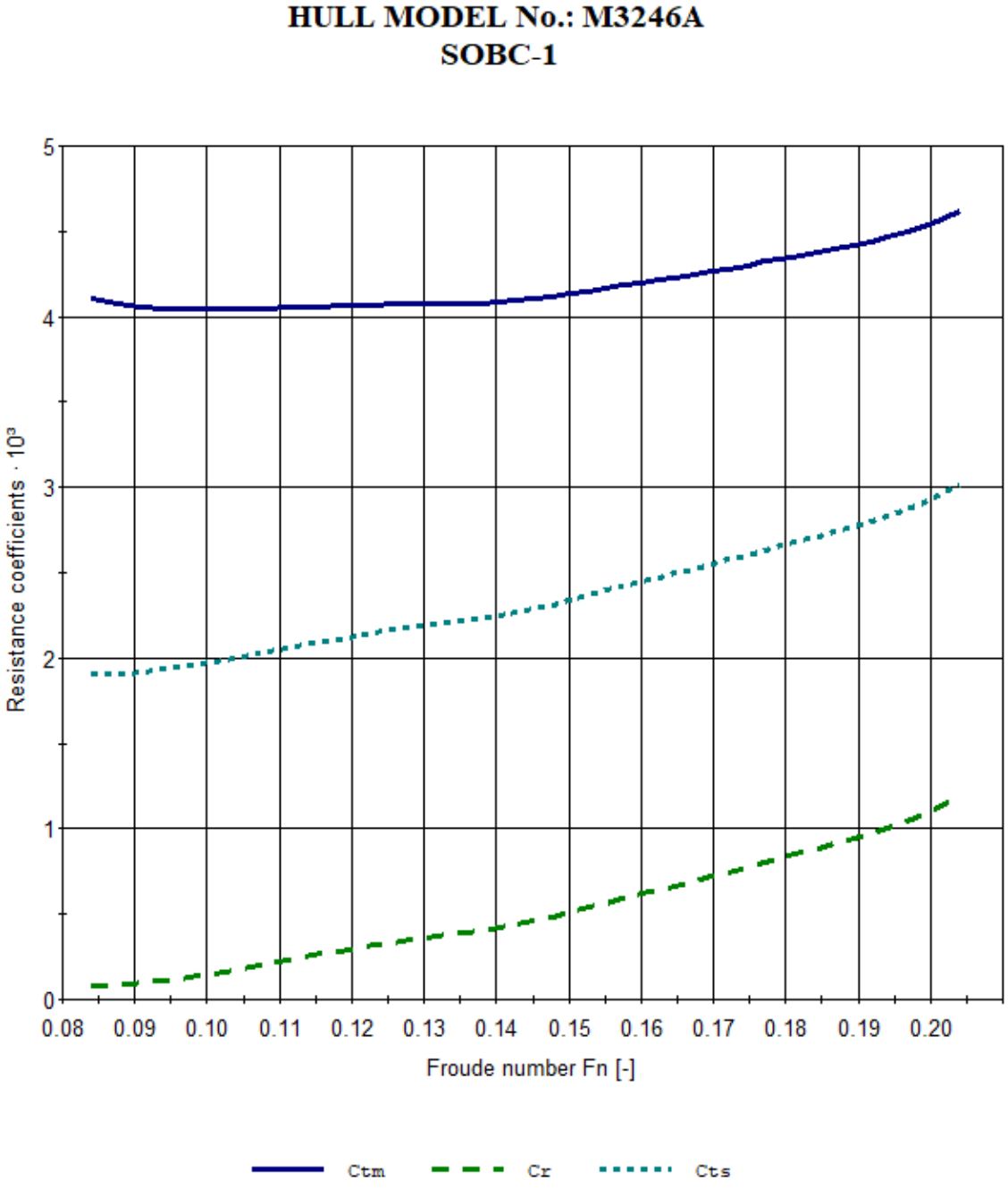
E-5.6 Model Resistance Plot



E-5 RESISTANCE TEST, WL1

REFERENCE M3246

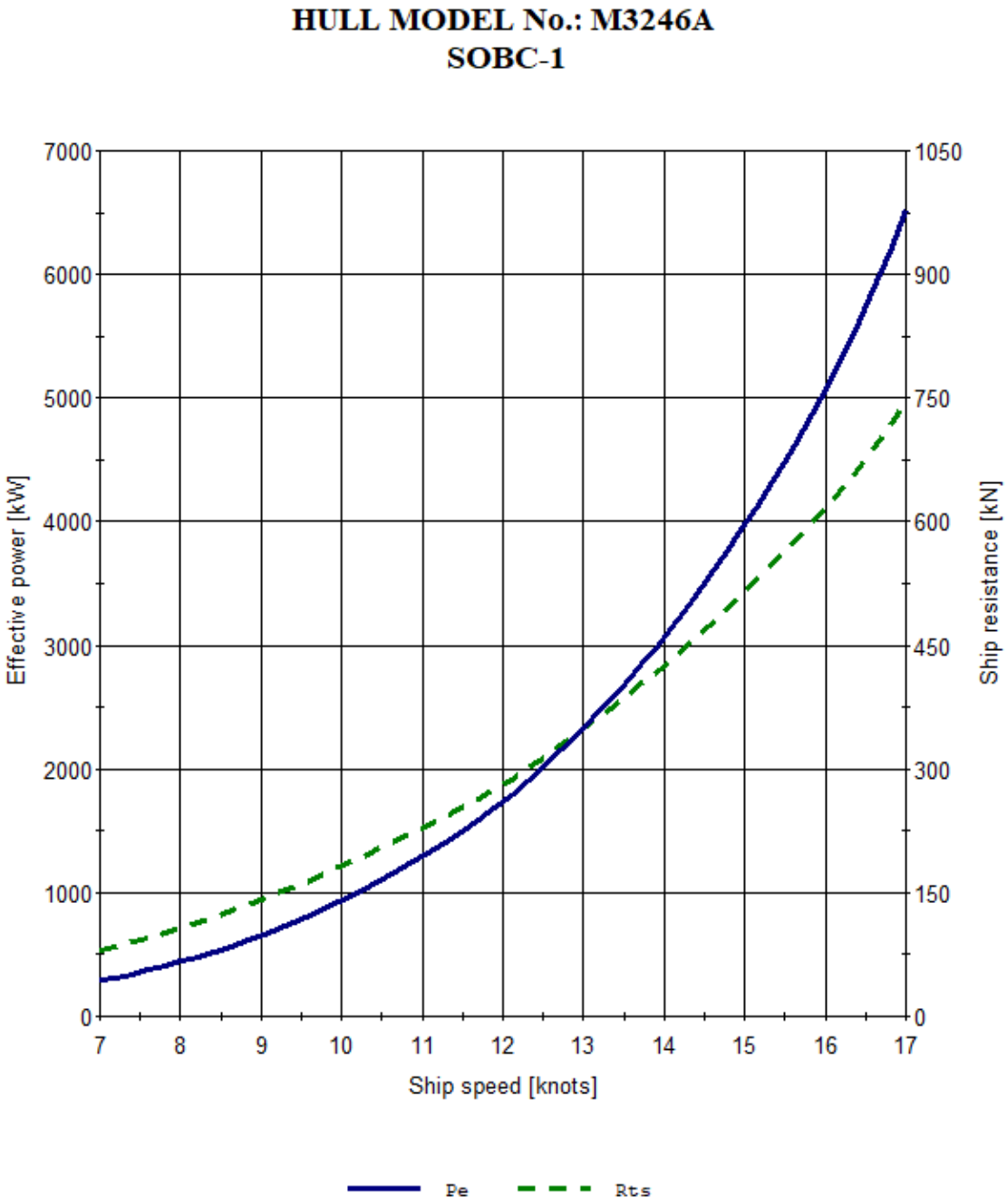
E-5.7 Resistance Coefficients Plot



E-5 RESISTANCE TEST, WL1

REFERENCE M3246

E-5.8 Ship Resistance And Effective Power Plot



E-6 PROPULSION TEST, WL1

E-6.1 Propulsion Test Report (average)

HULL MODEL No.: M3246A Model Scale: 32.000
Loading condition: WL 1
Draught AP/FP: 7.500 / 5.400 [m]

Propeller model	**P1608**
Number of propellers	1
Direction of rotation	Right
Propeller diameter (ship)[mm]	6750
Pitch ratio (P/D)	0.970
Expanded blade area ratio	0.483
Number of blades	4
Open water test ref.	a0.2 (Ci)

Tank water temp. [°C] = 16.20

V_S [knots]	V_M [m/s]	n_M [Hz]	J [-]	K_Q [-]	K_{Ttot} [-]	J_0 [-]	K_{Q0} [-]
7.00	0.637	2.716	1.111	0.0287	0.182	0.662	0.0293
7.50	0.682	2.908	1.112	0.0289	0.184	0.658	0.0294
8.00	0.728	3.115	1.107	0.0292	0.185	0.655	0.0296
8.50	0.773	3.334	1.099	0.0296	0.187	0.652	0.0298
9.00	0.818	3.563	1.089	0.0299	0.188	0.648	0.0300
9.50	0.864	3.800	1.078	0.0302	0.189	0.645	0.0302
10.00	0.909	4.043	1.066	0.0304	0.191	0.642	0.0303
10.50	0.955	4.288	1.056	0.0305	0.192	0.639	0.0305
11.00	1.000	4.534	1.046	0.0307	0.194	0.635	0.0307
11.50	1.046	4.777	1.038	0.0308	0.196	0.630	0.0310
12.00	1.091	5.016	1.031	0.0309	0.198	0.626	0.0312
12.50	1.137	5.249	1.027	0.0309	0.199	0.623	0.0314
13.00	1.182	5.490	1.021	0.0309	0.200	0.620	0.0315
13.50	1.228	5.754	1.012	0.0310	0.202	0.615	0.0318
14.00	1.273	6.030	1.001	0.0312	0.204	0.611	0.0320
14.50	1.319	6.303	0.992	0.0316	0.206	0.607	0.0322
15.00	1.364	6.578	0.983	0.0319	0.207	0.603	0.0324
15.50	1.410	6.868	0.973	0.0320	0.209	0.600	0.0326
16.00	1.455	7.171	0.962	0.0321	0.210	0.597	0.0328
16.50	1.501	7.483	0.951	0.0322	0.213	0.592	0.0330
17.00	1.546	7.801	0.939	0.0326	0.215	0.585	0.0334

Setup:	Towing (Res. Calc):	Towing (Prop.an.):	Propulsion:
m3246a1s5	m3246a1s1 (Cs)	m3246a1s1 (Cs)	m3246a1_prop_1 (Cs)

ShipX (RepGen version 2.0.22) 05-Aug-2021 11:03:22

E-6 PROPULSION TEST, WL1

E-6.2 Propulsive Coefficients Report (propulsor 1 of 1)

REFERENCE M3246

HULL MODEL No.: M3246A Model Scale: 32.000
Loading condition: WL 1
Draught AP/FP: 7.500 / 5.400 [m]

	SHIP	MODEL
Propeller model	**P1608**	**P1608**
Number of propellers	1	1
Direction of rotation	Right	Right
Propeller diameter [mm]	6750	210.94
Pitch ratio (P/D)	0.970	0.970
Expanded blade area ratio	0.483	0.483
Number of blades	4	4
Open water test ref.	a0.2 (Ci)	a0.2 (Ci)

Tank water temp. [°C] = 16.20

|<----------Model----------|<----------Ship----------|

V_S [kn]	w_M [-]	η_O [-]	η_H [-]	η_D [-]	t [-]	η_R [-]	w_S [-]	η_O [-]	η_H [-]	η_D [-]
7.00	0.405	0.656	1.389	0.929	0.173	1.019	0.301	0.682	1.182	0.822
7.50	0.408	0.654	1.418	0.944	0.160	1.018	0.297	0.684	1.194	0.831
8.00	0.409	0.652	1.438	0.949	0.150	1.013	0.292	0.685	1.202	0.834
8.50	0.407	0.650	1.447	0.947	0.142	1.008	0.289	0.685	1.207	0.833
9.00	0.404	0.647	1.447	0.939	0.138	1.003	0.287	0.684	1.208	0.829
9.50	0.401	0.645	1.439	0.928	0.138	1.000	0.286	0.682	1.208	0.823
10.00	0.398	0.643	1.426	0.915	0.141	0.998	0.287	0.679	1.205	0.817
10.50	0.395	0.640	1.409	0.902	0.148	0.999	0.290	0.676	1.201	0.811
11.00	0.393	0.637	1.390	0.888	0.157	1.002	0.295	0.672	1.196	0.805
11.50	0.393	0.634	1.372	0.876	0.167	1.006	0.301	0.667	1.191	0.800
12.00	0.393	0.631	1.367	0.873	0.170	1.011	0.303	0.664	1.190	0.799
12.50	0.393	0.629	1.380	0.882	0.163	1.016	0.300	0.663	1.196	0.806
13.00	0.393	0.627	1.394	0.892	0.154	1.021	0.296	0.662	1.202	0.813
13.50	0.392	0.623	1.390	0.890	0.154	1.026	0.297	0.659	1.202	0.813
14.00	0.390	0.620	1.380	0.879	0.158	1.027	0.298	0.655	1.200	0.807
14.50	0.388	0.617	1.376	0.867	0.158	1.021	0.298	0.651	1.199	0.798
15.00	0.386	0.614	1.373	0.857	0.157	1.016	0.297	0.648	1.199	0.790
15.50	0.383	0.612	1.363	0.849	0.159	1.018	0.297	0.645	1.196	0.785
16.00	0.380	0.609	1.351	0.841	0.162	1.022	0.297	0.641	1.192	0.781
16.50	0.378	0.606	1.343	0.834	0.164	1.025	0.297	0.636	1.189	0.776
17.00	0.377	0.601	1.344	0.826	0.163	1.023	0.297	0.631	1.191	0.769

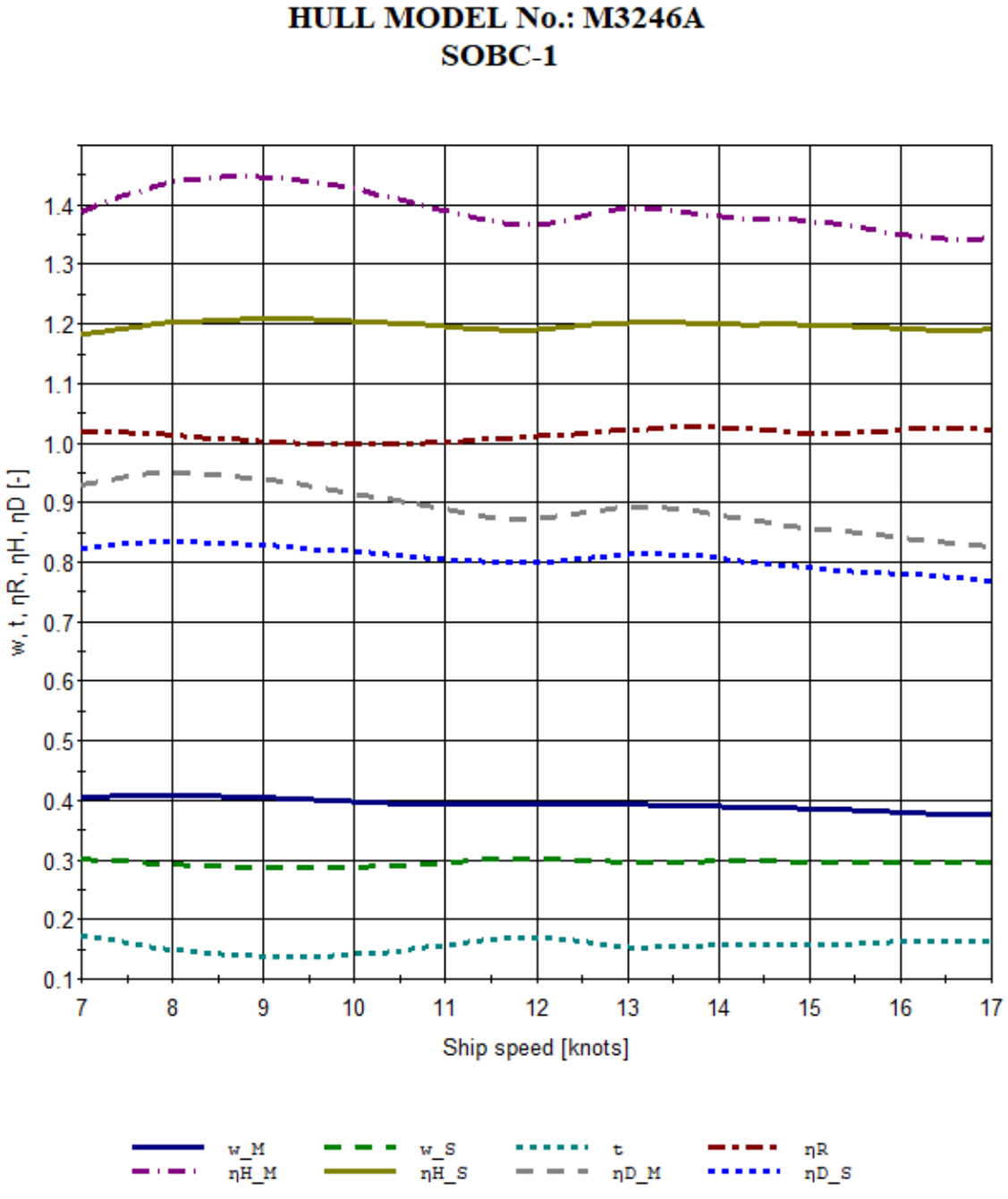
Setup:	Towing (Res. Calc):	Towing (Prop.an.):	Propulsion:
m3246a1s5	m3246a1s1 (Cs)	m3246a1s1 (Cs)	m3246a1_prop_1 (Cs)

ShipX (RepGen version 2.0.22) 05-Aug-2021 11:03:23

E-6 PROPULSION TEST, WL1

REFERENCE M3246

E-6.3 Propulsive Coefficients Plot (propulsor 1 of 1)



E-6 PROPULSION TEST, WL1

REFERENCE M3246

E-6.4 Performance Prediction Report

HULL MODEL No.: M3246A Model Scale: 32.000
Loading condition: WL 1
Draught AP/FP: 7.500 / 5.400 [m]

Propeller model	**P1608**
Number of propellers	1
Direction of rotation	Right
Propeller diameter (ship)[mm]	6750
Pitch ratio (P/D)	0.970
Expanded blade area ratio	0.483
Number of blades	4
Open water test ref.	a0.2 (Ci)

Predicted speed: 14.86 knots at 5000.00 kW

Predicted prop. RPM	73.4
Mech. efficiency	0.970
Seawater temp. [°C]	15.00

V_S [kn]	N [RPM]	P_B [kW]	C_{ADM} [-]	Trim [deg]	Sinkage AP	[m] FP
7.0	31.7	362.3	117.82	0.003	-0.017	-0.009
7.5	34.0	442.4	118.66	0.006	-0.085	-0.067
8.0	36.4	543.7	117.19	0.007	-0.123	-0.100
8.5	38.9	667.4	114.51	0.007	-0.136	-0.114
9.0	41.4	814.7	111.36	0.006	-0.133	-0.114
9.5	44.0	986.6	108.15	0.004	-0.120	-0.107
10.0	46.6	1183.9	105.12	0.002	-0.104	-0.098
10.5	49.1	1407.2	102.38	-0.000	-0.092	-0.092
11.0	51.7	1656.9	99.97	-0.001	-0.091	-0.095
11.5	54.2	1934.1	97.86	-0.002	-0.104	-0.111
12.0	56.8	2241.3	95.94	-0.002	-0.120	-0.127
12.5	59.6	2580.5	94.19	-0.002	-0.123	-0.130
13.0	62.4	2960.6	92.35	-0.001	-0.126	-0.130
13.5	65.3	3399.0	90.08	0.001	-0.144	-0.140
14.0	68.2	3915.0	87.22	0.003	-0.168	-0.156
14.5	71.2	4519.1	83.95	0.004	-0.185	-0.170
15.0	74.2	5189.0	80.94	0.004	-0.195	-0.182
15.5	77.3	5901.7	78.52	0.004	-0.206	-0.194
16.0	80.4	6693.3	76.16	0.004	-0.219	-0.207
16.5	83.8	7622.8	73.34	0.004	-0.235	-0.222
17.0	87.3	8757.7	69.81	0.005	-0.254	-0.238

Setup:	Towing (Res. Calc):	Towing (Prop.an.):	Propulsion:
m3246a1s5	m3246a1s1 (Cs)	m3246a1s1 (Cs)	m3246a1_prop_1 (Cs)

ShipX (RepGen version 2.0.22) 05-Aug-2021 11:03:23

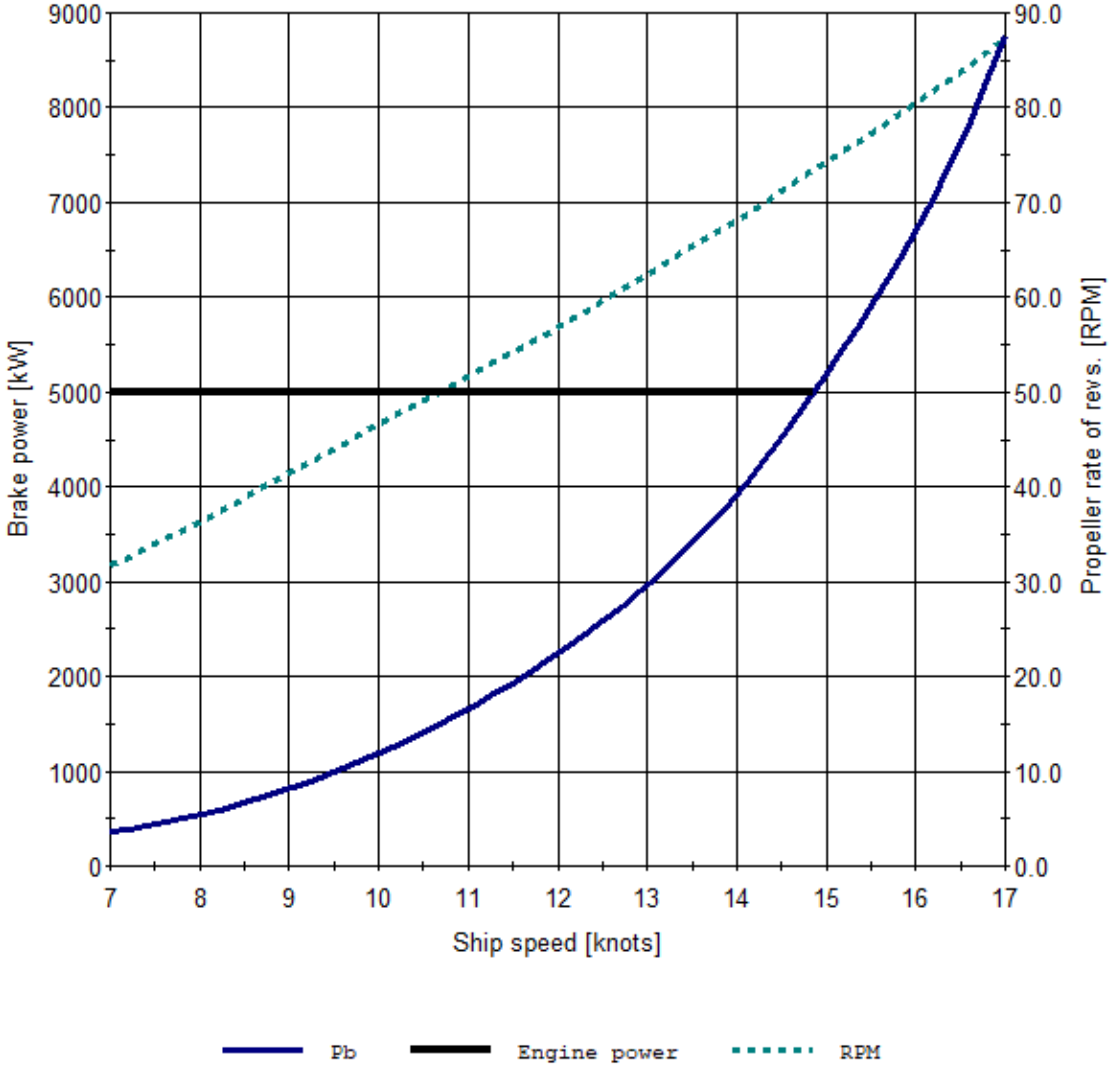
E-6 PROPULSION TEST, WL1

REFERENCE M3246

E-6.5 Performance Prediction Plot

HULL MODEL No.: M3246A
SOBC-1

Predicted speed: 14.86 knots at 5000.0 kW and 73.4 RPM



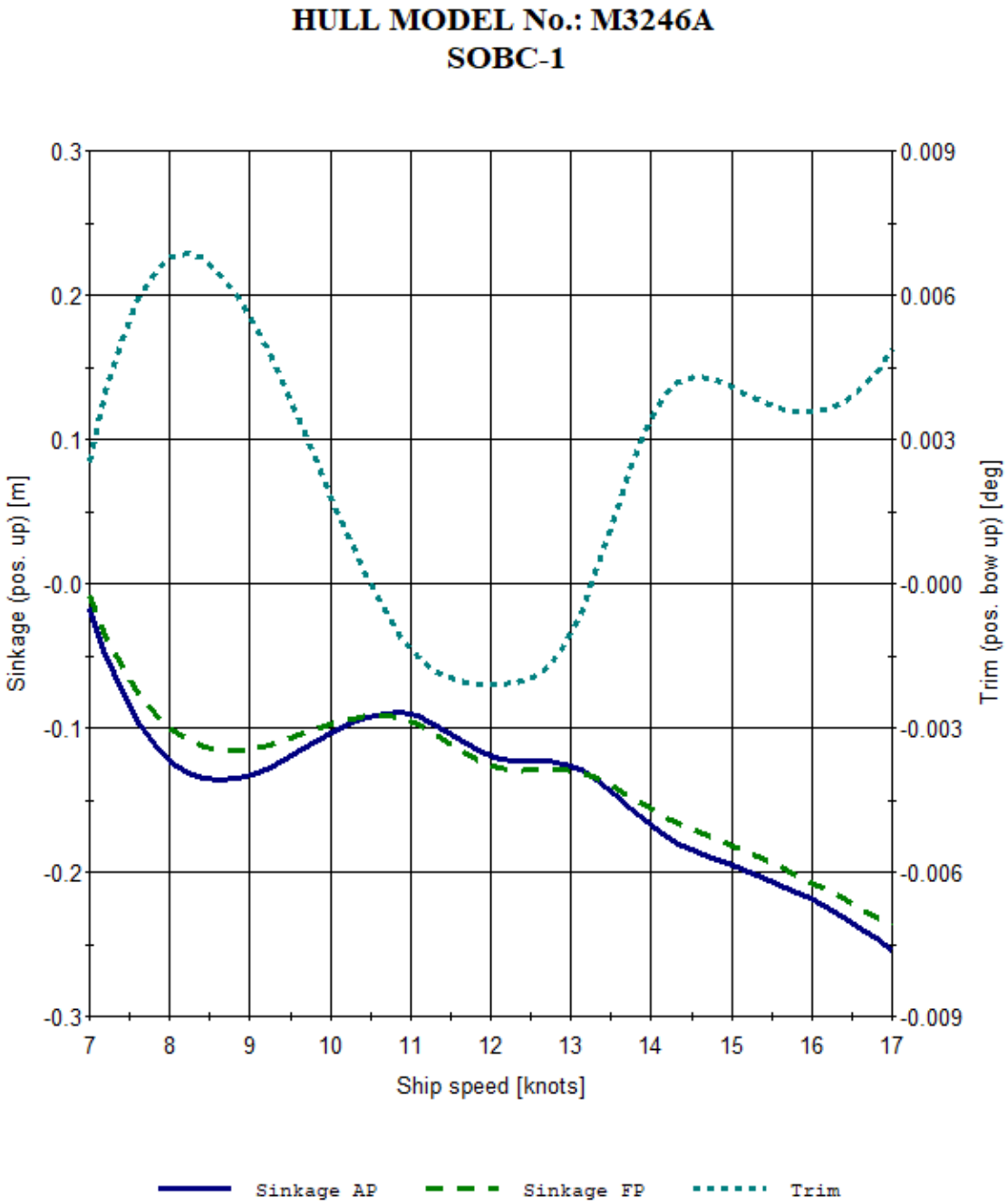
The RPM presented is the average RPM for all propulsors.
Smoothing method: (Cs) Cubic spline
Setup: m3246a1s5

ShipX (RepGen version 2.0.22) 05-Aug-2021 11:03:24

E-6 PROPULSION TEST, WL1

REFERENCE M3246

E-6.6 Sinkage And Trim Plot



E-6 PROPULSION TEST, WL1

E-6.7 Propulsion Test Setup

```
 HULL MODEL No.:      M3246A                                    Model Scale:  32.000
 Loading condition:   WL 1
 Draught AP/FP:       7.500 / 5.400 [m]
 Setup ID:            m3246a1s5

Specification of test data files:

Test type           Setup     Sm.  File name:

Propulsion test:    m3246a1s5 (Cs) \\sintef.no\ocean\organisasjon\Teknisk\HydroLab\Vogna\StdReg\PropData\m3246a1_pr

    Zero torque:              (Cs) \\sintef.no\ocean\organisasjon\Teknisk\HydroLab\Vogna\StdReg\PropData\m3246a1_pr

    Zero thrust:              (Cs) \\sintef.no\ocean\organisasjon\Teknisk\HydroLab\Vogna\StdReg\PropData\m3246a1_pr

Towing test:        m3246a1s1 (Cs) \\sintef.no\ocean\organisasjon\Teknisk\HydroLab\Vogna\StdReg\SlepData\m3246A1_sl

App. trim corr.:              (Cs) file not given
OPW test:           p1608s2   (Ci) \\sintef.no\ocean\organisasjon\Teknisk\HydroLab\Vogna\StdReg\FripData\p1608a0_fr

    Zero torque:              (Av) \\sintef.no\ocean\organisasjon\Teknisk\HydroLab\Vogna\StdReg\FripData\p1608a0_fr

    Zero thrust:              (Cs) \\sintef.no\ocean\organisasjon\Teknisk\HydroLab\Vogna\StdReg\FripData\p1608a0_fr

Specification of Propulsion Test Analysis:
Number of propulsors:         1
Thrust deduction:             Apply same thrust deduction for all propulsors
Sea margin:                   0.00\%
Propulsor:                    Position:                  Main Propeller
                              Scaling of wake fraction:  Conv. single screw
                              Scaling method, propeller: No scaling
Position of aft sinkage measurement point (model scale):      0.743 m
Position of fwd sinkage measurement point (model scale):      4.664 m

Specification of Towing Test Analysis:
Blockage correction:          on
Appendage scaling:            Appended - Scaling based on ITTC'57 and given appendix data
Hull roughness (default):     150.0 µ

Environment:

                              Model      Ship  Unit

Water temperature:             16.20     15.00  [°C]
Salinity:                       0.00      3.50  [%]
Density:                      998.82   1025.87  [kg/m^3]
Kinematic viscosity:            1.103     1.187  [·10^-6m^2/s]

                    ShipX (RepGen version 2.0.22) 05-Aug-2021 11:03:28
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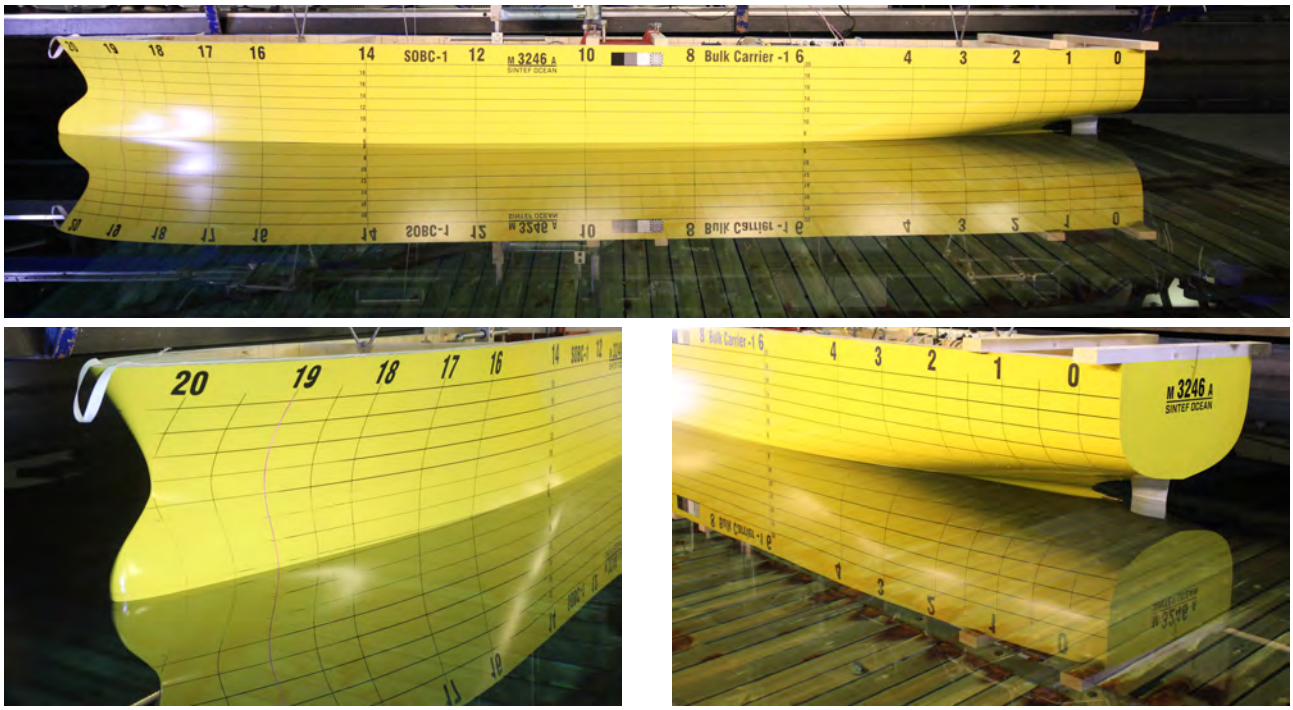
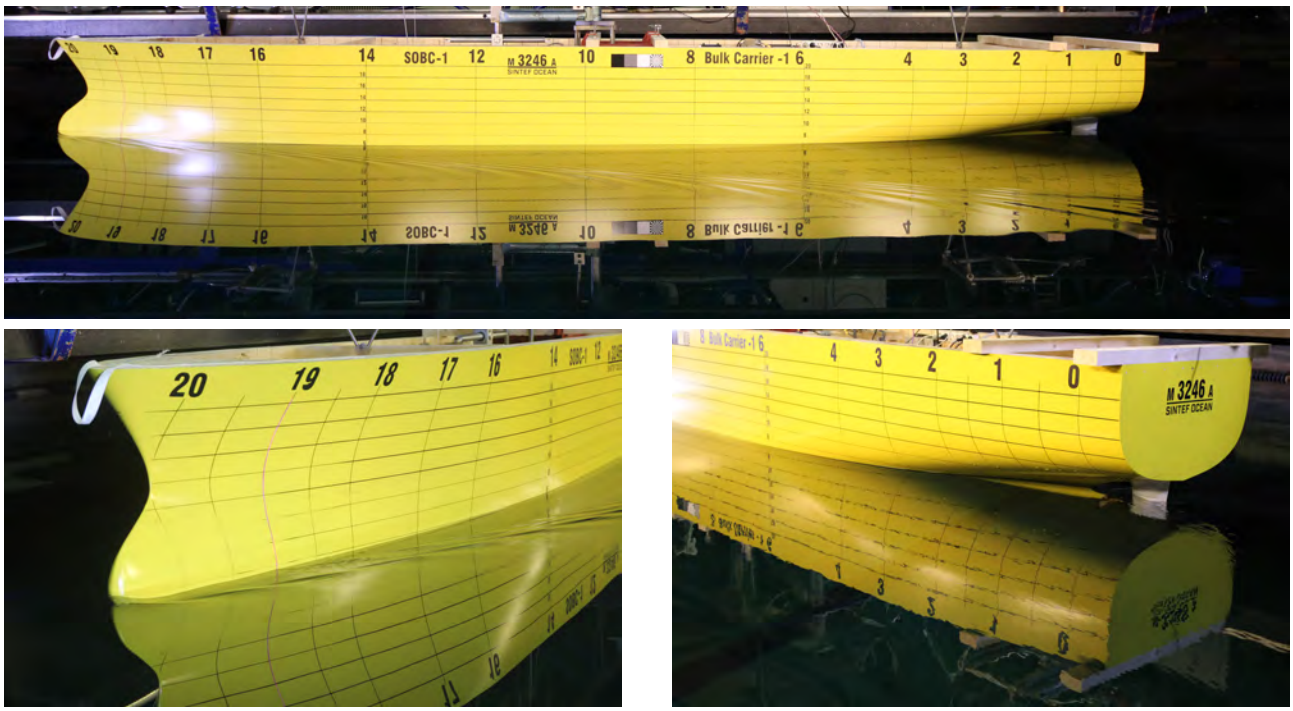
E-6 PROPULSION TEST, WL1

REFERENCE M3246

E-6.8 Wave Profiles 0.0kn and 7.0kn



Wave Profiles 0.0kn

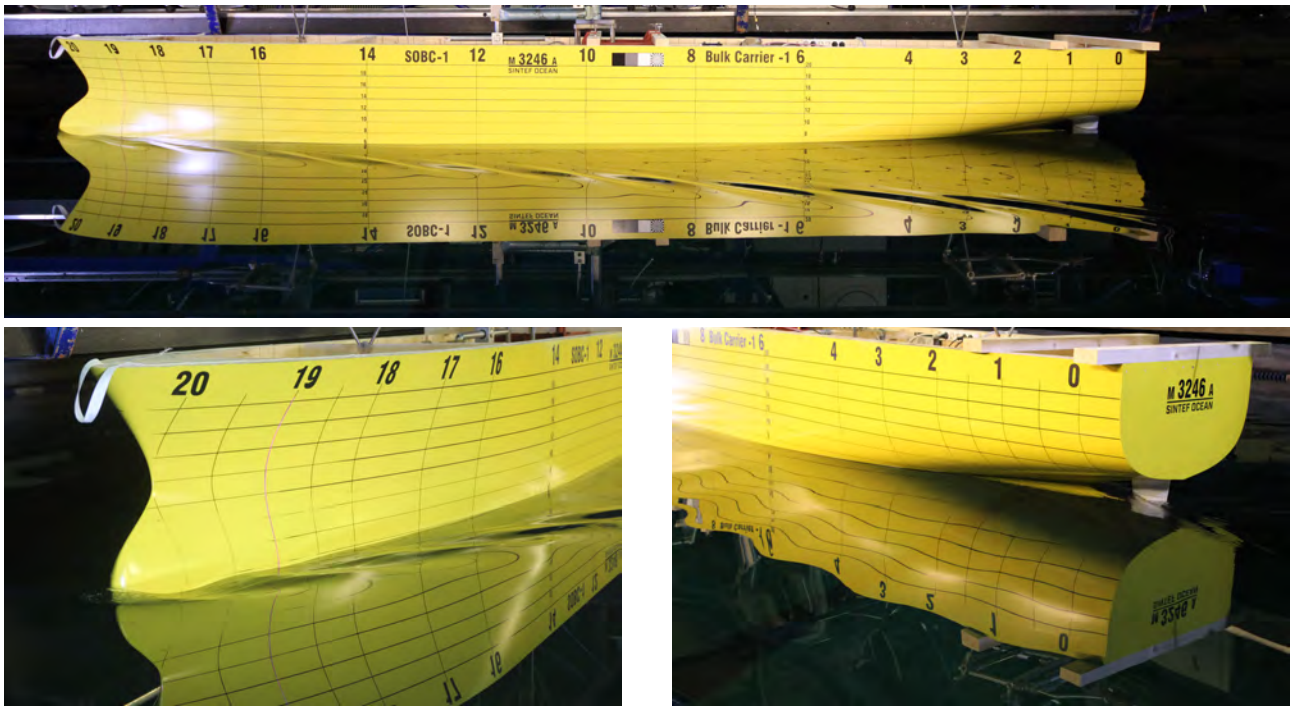


Wave Profiles 7.0kn

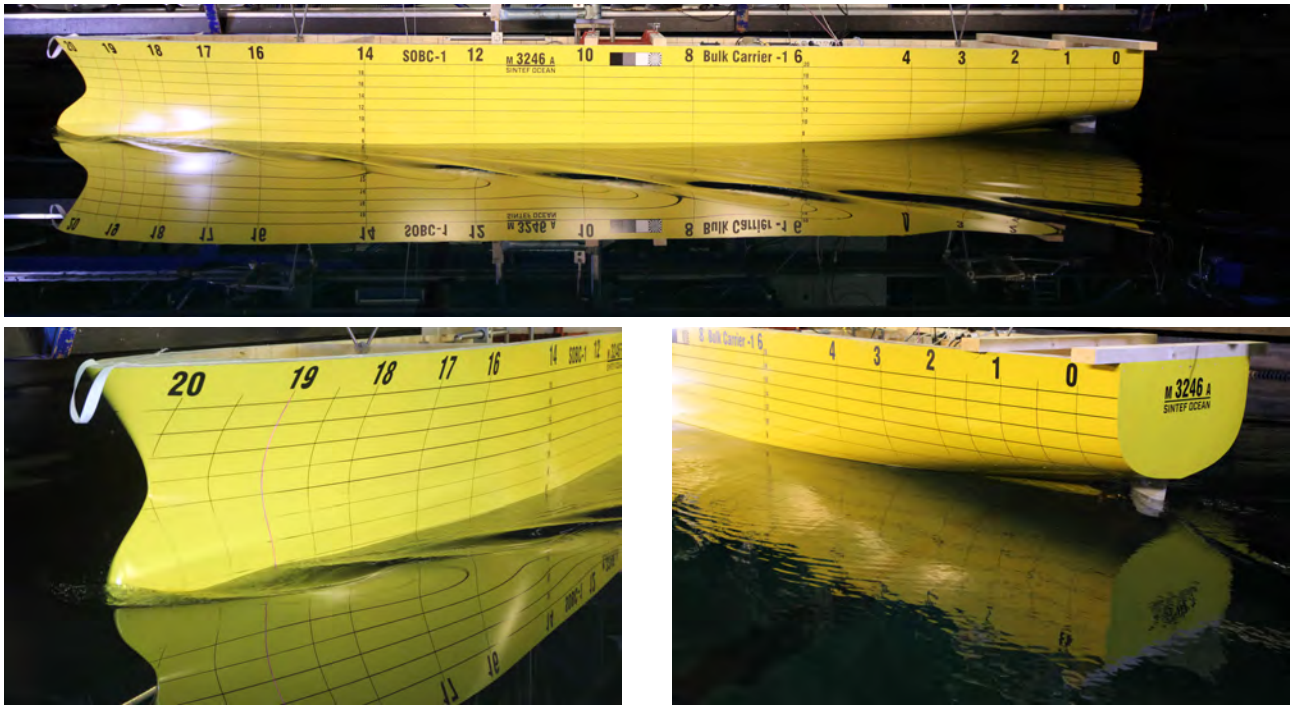
E-6 PROPULSION TEST, WL1

REFERENCE M3246

E-6.9 Wave Profiles 9.0kn and 11.0kn



Wave Profiles 9.0kn

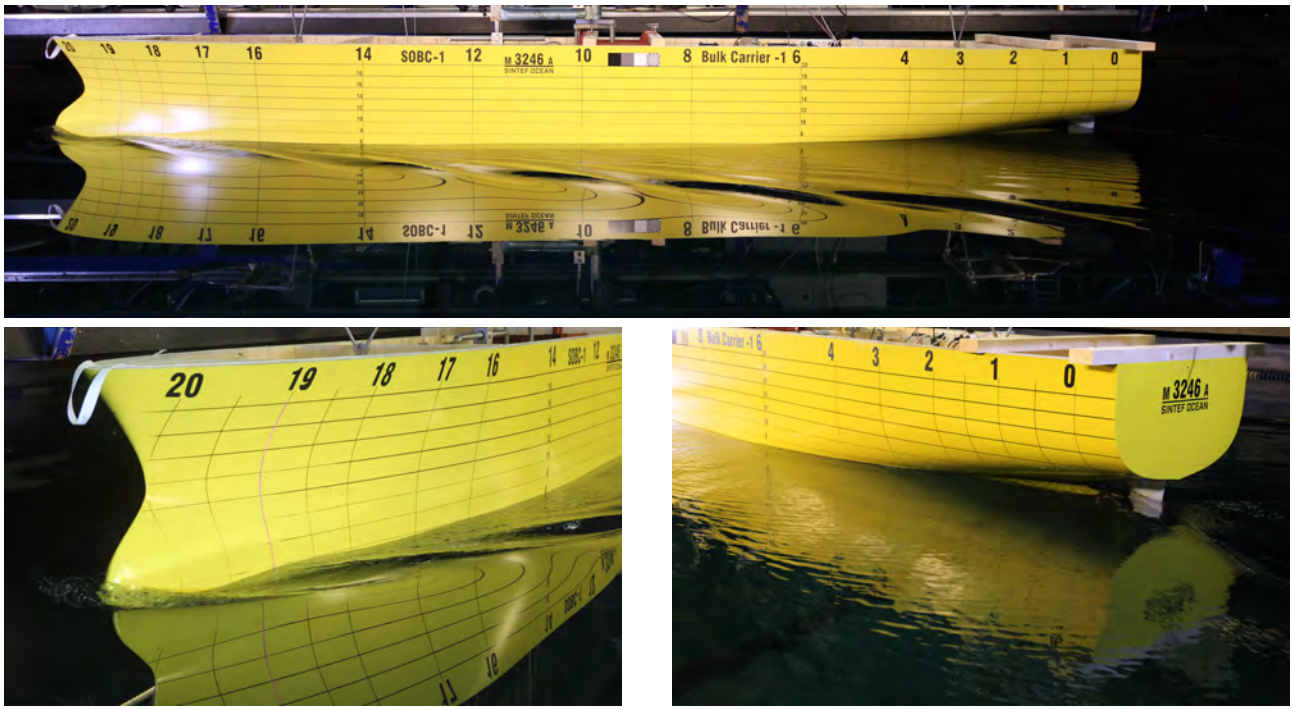


Wave Profiles 11.0kn

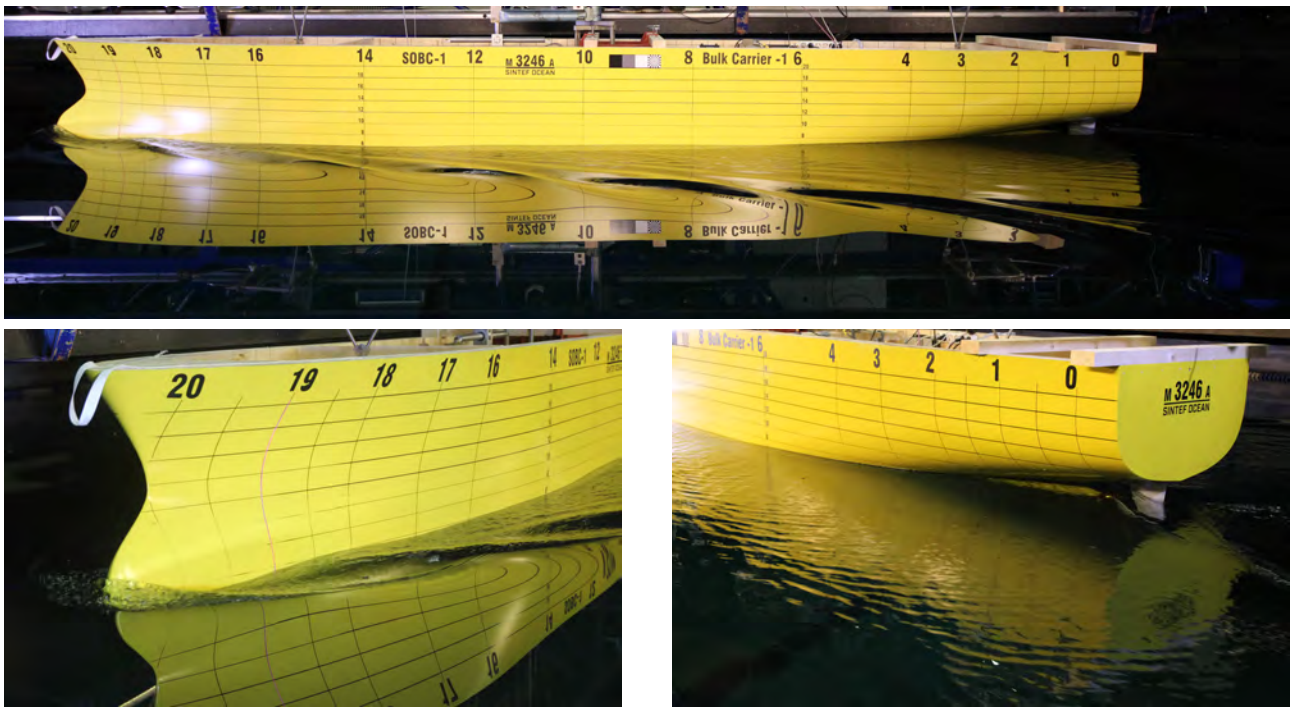
E-6 PROPULSION TEST, WL1

REFERENCE M3246

E-6.10 Wave Profiles 12.0kn and 13.0kn



Wave Profiles 12.0kn

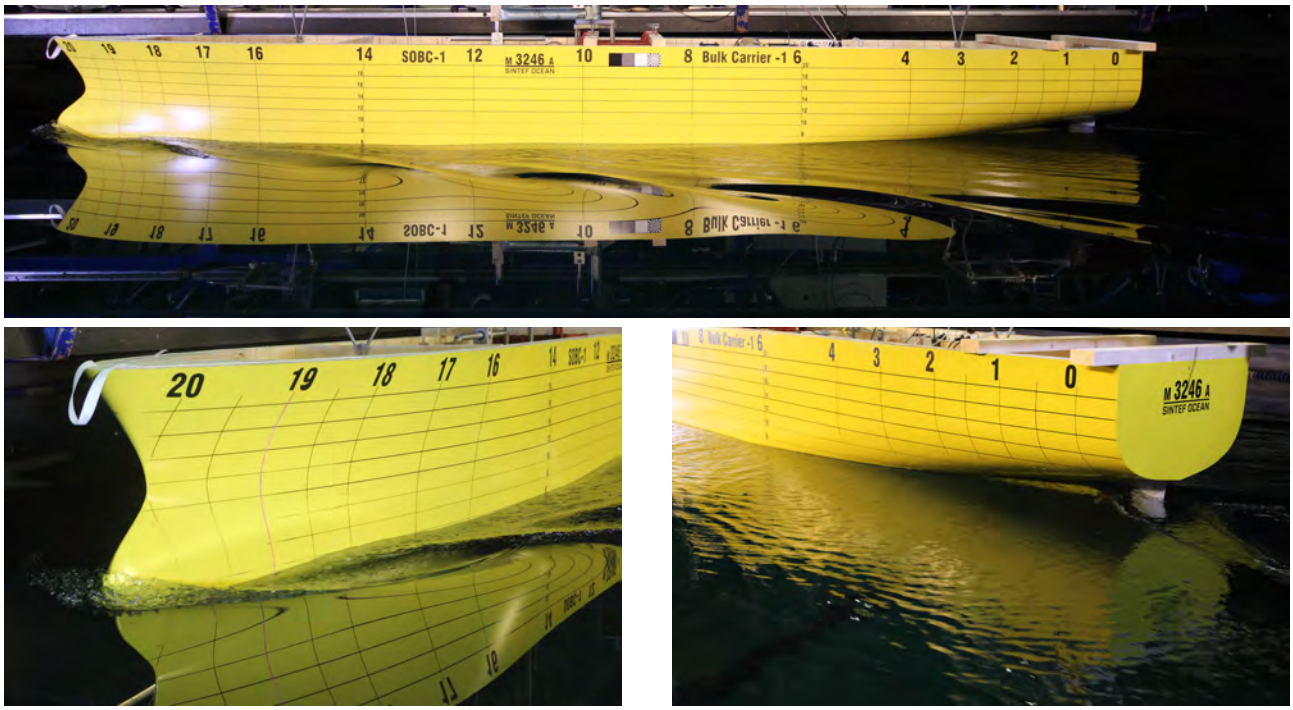


Wave Profiles 13.0kn

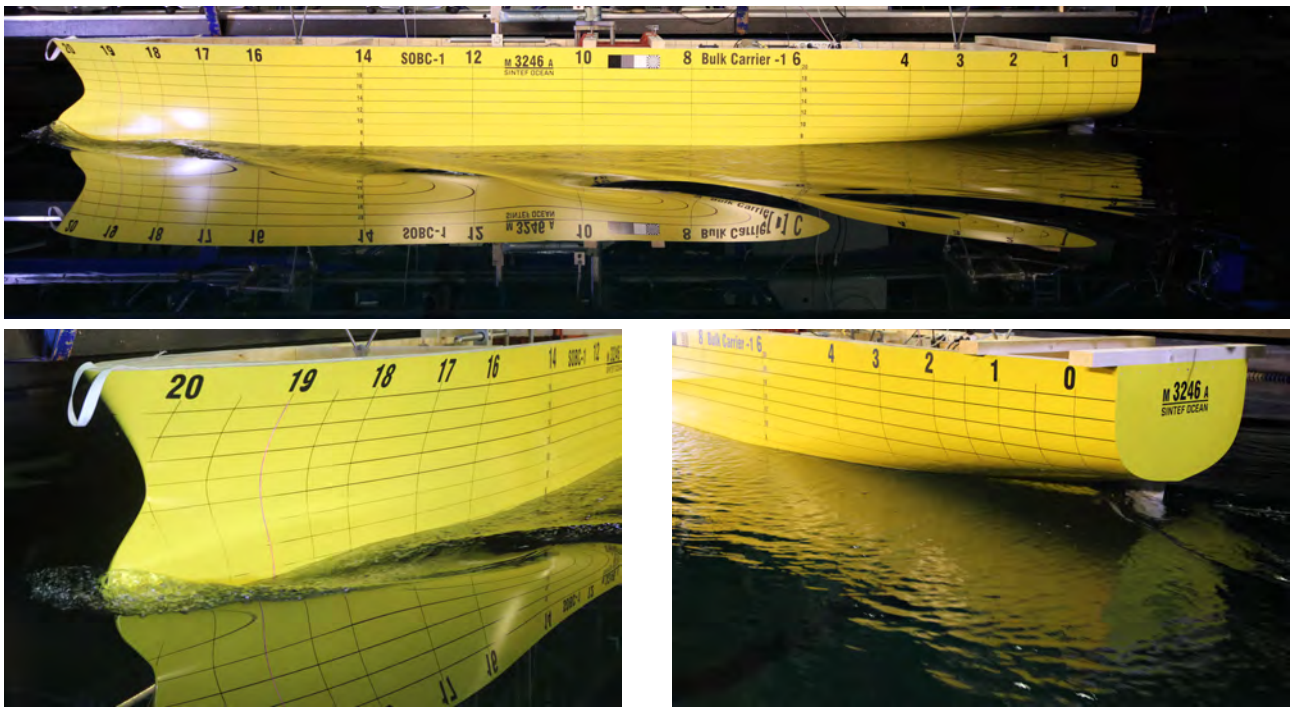
E-6 PROPULSION TEST, WL1

REFERENCE M3246

E-6.11 Wave Profiles 14.0kn and 15.0kn



Wave Profiles 14.0kn

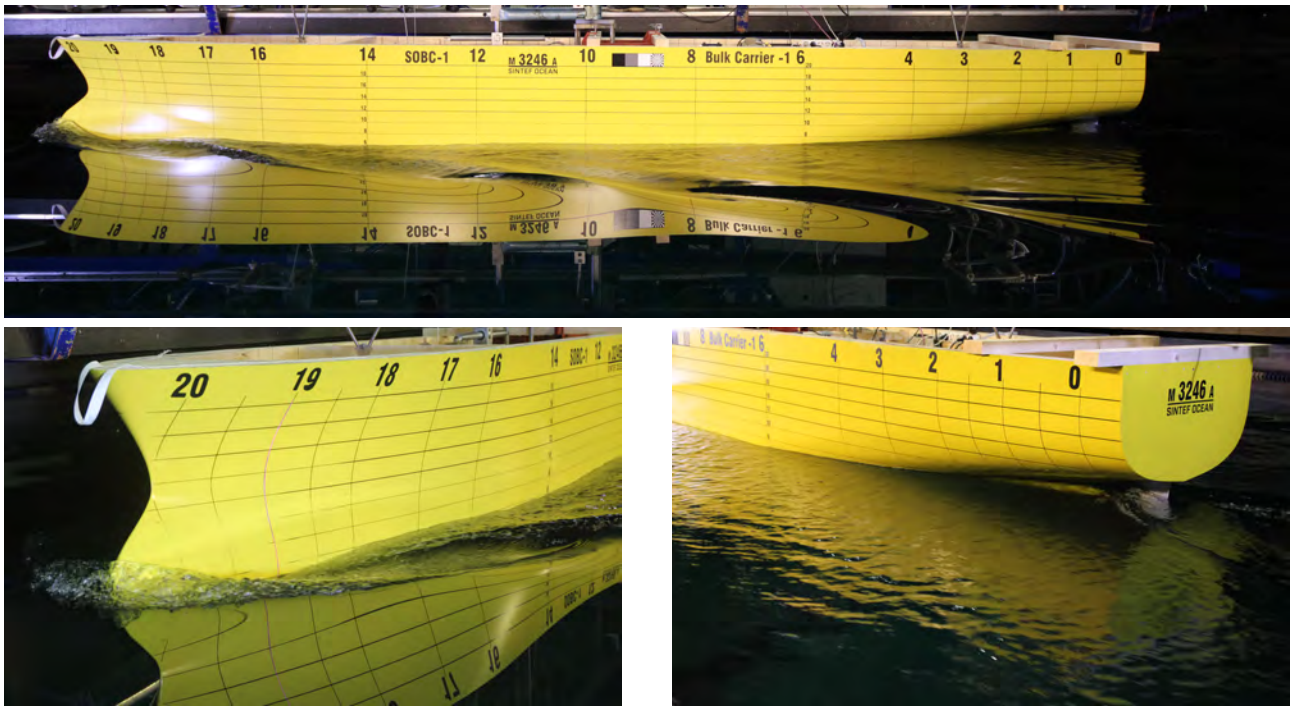


Wave Profiles 15.0kn

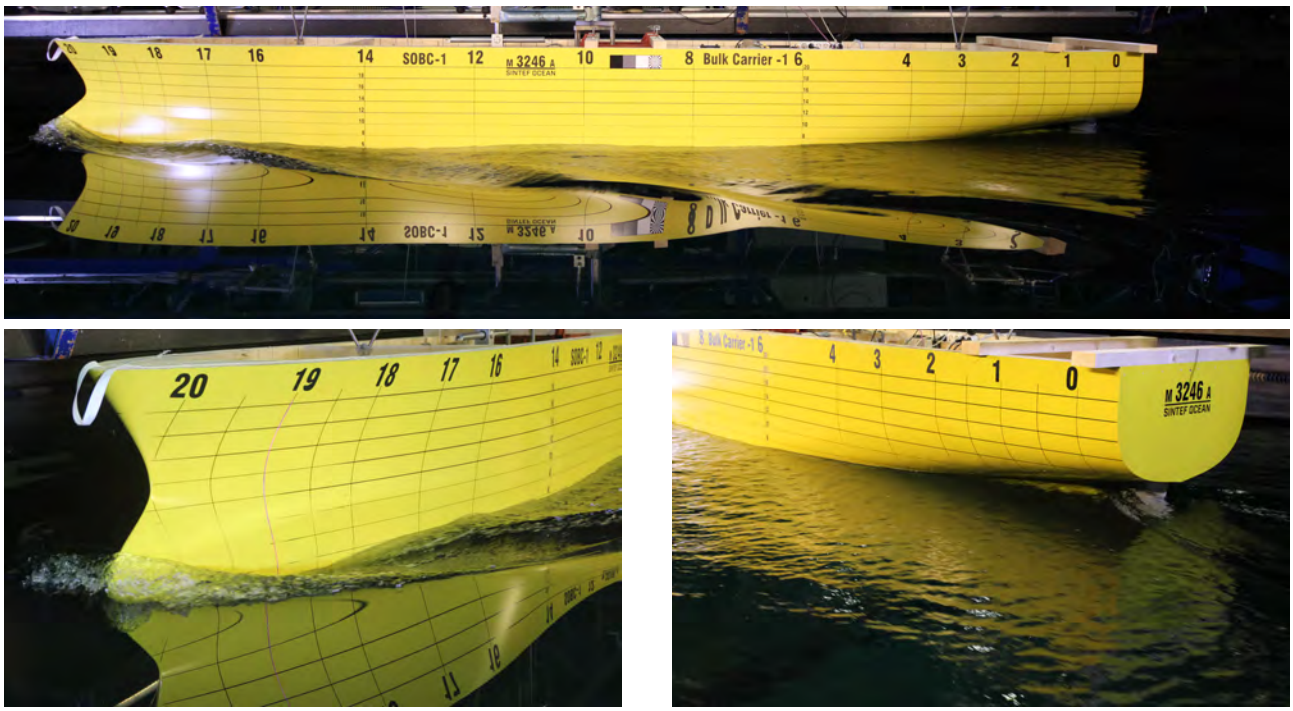
E-6 PROPULSION TEST, WL1

REFERENCE M3246

E-6.12 Wave Profiles 16.0kn and 17.0kn



Wave Profiles 16.0kn



Wave Profiles 17.0kn

E-7 RESISTANCE TEST, DWL

REFERENCE M3246

E-7.1 Resistance Test Report

HULL MODEL No.: M3246A Model Scale: 32.000
Loading condition: DWL - Design waterline
Draught AP/FP: 11.000 / 11.000 [m]

	Symbol	Unit	SHIP	MODEL
Length betw. perp.	L_{PP}	[m]	190.000	5.938
Length on waterline	L_{WL}	[m]	196.942	6.154
Breadth waterline	B_{WL}	[m]	32.200	1.006
Draught at $L_{PP}/2$	T	[m]	11.000	0.344
Wetted surface	S	[m^2]	8576.74	8.376
Wetted surf. of transom stern	A_T	[m^2]	1.82	0.002
Transv. proj. area above WL	A_V	[m^2]	700.00	0.393
Volume displacement	∇	[m^3]	48956.71	1.494
Block coefficient	C_{BLW}	[-]	0.702	0.702

1+k	= 1.1208	Tankwater temp. [°C]	= 16.2
$C_{AAM} \cdot 10^3$	= 0.0486		

V_S [knots]	V_M [m/s]	F_N [-]	$R_{NM} \cdot 10^{-6}$	R_{TM} [N]	$C_{TM} \cdot 10^3$	$C_{FM} \cdot 10^3$	$C_{AppM} \cdot 10^3$	$C_{BDM} \cdot 10^3$	$C_R \cdot 10^3$
7.00	0.637	0.082	3.552	6.663	3.930	3.622	0.000	0.001	-0.179
7.50	0.682	0.088	3.806	7.582	3.896	3.575	0.000	0.001	-0.160
8.00	0.728	0.094	4.060	8.562	3.867	3.531	0.000	0.002	-0.141
8.50	0.773	0.100	4.313	9.598	3.840	3.491	0.000	0.002	-0.123
9.00	0.818	0.105	4.567	10.686	3.813	3.454	0.000	0.002	-0.108
9.50	0.864	0.111	4.821	11.819	3.785	3.420	0.000	0.002	-0.097
10.00	0.909	0.117	5.075	13.007	3.760	3.387	0.000	0.002	-0.087
10.50	0.955	0.123	5.328	14.273	3.742	3.357	0.000	0.002	-0.070
11.00	1.000	0.129	5.582	15.639	3.736	3.329	0.000	0.002	-0.045
11.50	1.046	0.135	5.836	17.121	3.742	3.302	0.000	0.002	-0.008
12.00	1.091	0.140	6.090	18.693	3.752	3.276	0.000	0.002	0.030
12.50	1.137	0.146	6.343	20.315	3.758	3.252	0.000	0.002	0.063
13.00	1.182	0.152	6.597	21.998	3.763	3.229	0.000	0.002	0.093
13.50	1.228	0.158	6.851	23.815	3.777	3.207	0.000	0.002	0.133
14.00	1.273	0.164	7.104	25.772	3.801	3.186	0.000	0.002	0.180
14.50	1.319	0.170	7.358	27.799	3.822	3.166	0.000	0.002	0.223
15.00	1.364	0.176	7.612	30.118	3.869	3.147	0.000	0.002	0.292
15.50	1.410	0.181	7.866	32.921	3.961	3.129	0.000	0.002	0.404
16.00	1.455	0.187	8.119	36.038	4.069	3.112	0.000	0.002	0.532
16.50	1.501	0.193	8.373	39.246	4.167	3.095	0.000	0.002	0.648
17.00	1.546	0.199	8.627	42.543	4.255	3.078	0.000	0.002	0.755

Setup: Towing test:
m3246a0s6 m3246a0_slep_1 (Cw)

ShipX (RepGen version 2.0.22) 05-Aug-2021 11:13:07

E-7 RESISTANCE TEST, DWL

E-7.2 Appendage Resistance Report (model) FOR PROPULSION ANALYSIS

REFERENCE M3246

HULL MODEL No.: M3246A Model Scale: 32.000
Loading condition: DWL - Design waterline
Draught AP/FP: 11.000 / 11.000 [m]

Appendix	Wetted surface	Flow length	Form f. k	Wake w
1 Bilge keels	0.000	0.000	0.200	0.100
2	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000

Wetted hull surface 8576.7 [m²]
Note! All coeff. are made non-dimensional wrt. the wetted hull surf.

Tankwater temp. [°C] = 16.20 Kin. visc. ν_m [m²/s] = $1.10 \cdot 10^{-6}$

V_S [knots]	V_M [m/s]	$C_{AppM}{}^1 \cdot 10^3$	$C_{AppM}{}^2 \cdot 10^3$	$C_{AppM}{}^3 \cdot 10^3$	$C_{AppM}{}^4 \cdot 10^3$	$C_{AppM}{}^5 \cdot 10^3$	$C_{AppM}{}^6 \cdot 10^3$	$C_{AppM} \cdot 10^3$
7.00	0.637	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7.50	0.682	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8.00	0.728	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8.50	0.773	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9.00	0.818	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9.50	0.864	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10.00	0.909	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10.50	0.955	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11.00	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11.50	1.046	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12.00	1.091	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12.50	1.137	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13.00	1.182	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13.50	1.228	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14.00	1.273	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14.50	1.319	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15.00	1.364	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15.50	1.410	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16.00	1.455	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16.50	1.501	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17.00	1.546	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Setup: Towing test:
m3246a0s6 m3246a0_slep_1 (Cw)

ShipX (RepGen version 2.0.22) 05-Aug-2021 11:13:08

E-7 RESISTANCE TEST, DWL

REFERENCE M3246

E-7.3 Appendage Resistance Report (ship)

HULL MODEL No.: M3246A Model Scale: 32.000
Loading condition: DWL - Design waterline
Draught AP/FP: 11.000 / 11.000 [m]

Appendix	Wetted surface	Flow length	Form f. k	Wake w	Roughness m
1 Bilge keels	79.8	57.0	0.200	0.100	0.0
2	0.0	0.0	0.000	0.000	0.0
3	0.0	0.0	0.000	0.000	0.0
4	0.0	0.0	0.000	0.000	0.0
5	0.0	0.0	0.000	0.000	0.0
6	0.0	0.0	0.000	0.000	0.0
Wetted hull surface	8576.7 [m²]				

Note! All coeff. are made non-dimensional wrt. the wetted hull surf.

Seawater temp. [°C] = 15.00 Kin. visc. ν_s [m²/s] = $1.19 \cdot 10^{-6}$

V_S [knots]	V_M [m/s]	$C_{AppS}{}^1 \cdot 10^3$	$C_{AppS}{}^2 \cdot 10^3$	$C_{AppS}{}^3 \cdot 10^3$	$C_{AppS}{}^4 \cdot 10^3$	$C_{AppS}{}^5 \cdot 10^3$	$C_{AppS}{}^6 \cdot 10^3$	$C_{AppS} \cdot 10^3$
7.00	0.637	0.018	0.000	0.000	0.000	0.000	0.000	0.018
7.50	0.682	0.018	0.000	0.000	0.000	0.000	0.000	0.018
8.00	0.728	0.018	0.000	0.000	0.000	0.000	0.000	0.018
8.50	0.773	0.017	0.000	0.000	0.000	0.000	0.000	0.017
9.00	0.818	0.017	0.000	0.000	0.000	0.000	0.000	0.017
9.50	0.864	0.017	0.000	0.000	0.000	0.000	0.000	0.017
10.00	0.909	0.017	0.000	0.000	0.000	0.000	0.000	0.017
10.50	0.955	0.017	0.000	0.000	0.000	0.000	0.000	0.017
11.00	1.000	0.017	0.000	0.000	0.000	0.000	0.000	0.017
11.50	1.046	0.017	0.000	0.000	0.000	0.000	0.000	0.017
12.00	1.091	0.017	0.000	0.000	0.000	0.000	0.000	0.017
12.50	1.137	0.017	0.000	0.000	0.000	0.000	0.000	0.017
13.00	1.182	0.016	0.000	0.000	0.000	0.000	0.000	0.016
13.50	1.228	0.016	0.000	0.000	0.000	0.000	0.000	0.016
14.00	1.273	0.016	0.000	0.000	0.000	0.000	0.000	0.016
14.50	1.319	0.016	0.000	0.000	0.000	0.000	0.000	0.016
15.00	1.364	0.016	0.000	0.000	0.000	0.000	0.000	0.016
15.50	1.410	0.016	0.000	0.000	0.000	0.000	0.000	0.016
16.00	1.455	0.016	0.000	0.000	0.000	0.000	0.000	0.016
16.50	1.501	0.016	0.000	0.000	0.000	0.000	0.000	0.016
17.00	1.546	0.016	0.000	0.000	0.000	0.000	0.000	0.016

Setup: Towing test:
m3246a0s6 m3246a0_slep_1 (Cw)

ShipX (RepGen version 2.0.22) 05-Aug-2021 11:13:08

E-7 RESISTANCE TEST, DWL

REFERENCE M3246

E-7.4 Ship Resistance Coefficients Report

HULL MODEL No.: M3246A Model Scale: 32.000
Loading condition: DWL - Design waterline
Draught AP/FP: 11.000 / 11.000 [m]

	Symbol	Unit	SHIP	MODEL
Length betw. perp.	L_{PP}	[m]	190.000	5.938
Length on waterline	L_{WL}	[m]	196.942	6.154
Breadth waterline	B_{WL}	[m]	32.200	1.006
Draught at $L_{PP}/2$	T	[m]	11.000	0.344
Wetted surface	S	[m^2]	8576.74	8.376
Wetted surf. of transom stern	A_T	[m^2]	1.82	0.002
Transv. proj. area above WL	A_V	[m^2]	700.00	0.393
Volume displacement	∇	[m^3]	48956.71	1.494
Block coefficient	C_{BLW}	[-]	0.702	0.702

1+k	= 1.1208	Correlation coef $\cdot 10^3$	=	-0.1300
$C_{AAS} \cdot 10^3$	= 0.0823	Seawater temp. [°C]	=	15.0

V_S [knots]	V_M [m/s]	F_N [-]	R_{NS} $\cdot 10^{-9}$	C_R $\cdot 10^3$	C_{FS} $\cdot 10^3$	C_{VS} $\cdot 10^3$	C_{BDS} $\cdot 10^3$	C_{AppS} $\cdot 10^3$	C_{TS} $\cdot 10^3$
7.00	0.637	0.082	0.597	-0.179	1.633	1.861	0.002	0.018	1.654
7.50	0.682	0.088	0.640	-0.160	1.619	1.862	0.002	0.018	1.674
8.00	0.728	0.094	0.683	-0.141	1.606	1.863	0.002	0.018	1.694
8.50	0.773	0.100	0.725	-0.123	1.593	1.864	0.002	0.017	1.713
9.00	0.818	0.105	0.768	-0.108	1.582	1.864	0.002	0.017	1.728
9.50	0.864	0.111	0.811	-0.097	1.571	1.865	0.002	0.017	1.739
10.00	0.909	0.117	0.853	-0.087	1.561	1.865	0.002	0.017	1.750
10.50	0.955	0.123	0.896	-0.070	1.552	1.866	0.002	0.017	1.767
11.00	1.000	0.129	0.939	-0.045	1.543	1.866	0.002	0.017	1.793
11.50	1.046	0.135	0.981	-0.008	1.534	1.866	0.002	0.017	1.829
12.00	1.091	0.140	1.024	0.030	1.526	1.866	0.002	0.017	1.868
12.50	1.137	0.146	1.067	0.063	1.518	1.866	0.002	0.017	1.901
13.00	1.182	0.152	1.110	0.093	1.511	1.866	0.002	0.016	1.931
13.50	1.228	0.158	1.152	0.133	1.504	1.866	0.002	0.016	1.970
14.00	1.273	0.164	1.195	0.180	1.497	1.866	0.002	0.016	2.017
14.50	1.319	0.170	1.238	0.223	1.491	1.866	0.002	0.016	2.060
15.00	1.364	0.176	1.280	0.292	1.485	1.866	0.002	0.016	2.129
15.50	1.410	0.181	1.323	0.404	1.479	1.866	0.002	0.016	2.241
16.00	1.455	0.187	1.366	0.532	1.473	1.866	0.002	0.016	2.369
16.50	1.501	0.193	1.408	0.648	1.468	1.866	0.002	0.016	2.485
17.00	1.546	0.199	1.451	0.755	1.462	1.866	0.002	0.016	2.591

Setup: Towing test:
m3246a0s6 m3246a0_slep_1 (Cw)

ShipX (RepGen version 2.0.22) 05-Aug-2021 11:13:09

E-7 RESISTANCE TEST, DWL

REFERENCE M3246

E-7.5 Ship Resistance Report

HULL MODEL No.: M3246A Model Scale: 32.000
Loading condition: DWL - Design waterline
Draught AP/FP: 11.000 / 11.000 [m]

	Symbol	Unit	SHIP	MODEL
Length betw. perp.	L_{PP}	[m]	190.000	5.938
Length on waterline	L_{WL}	[m]	196.942	6.154
Breadth waterline	B_{WL}	[m]	32.200	1.006
Draught at $L_{PP}/2$	T	[m]	11.000	0.344
Wetted surface	S	[m^2]	8576.74	8.376
Wetted surf. of transom stern	A_T	[m^2]	1.82	0.002
Transv. proj. area above WL	A_V	[m^2]	700.00	0.393
Volume displacement	∇	[m^3]	48956.71	1.494
Block coefficient	C_{BLW}	[-]	0.702	0.702

1+k	= 1.1208	Correlation coef $\cdot 10^3$	= -0.1300
$C_{AAS} \cdot 10^3$	= 0.0823	Seawater temp. [°C]	= 15.0

V_S [knots]	V_M [m/s]	F_N [-]	R_{TS} [kN]	P_E [kW]	C_{ADX} [-]	Trim [deg]	Sinkage AP [m]	Sinkage FP [m]
7.00	0.637	0.082	94.38	339.9	183.88	-0.026	-0.013	-0.098
7.50	0.682	0.088	109.63	423.0	181.72	-0.031	-0.012	-0.114
8.00	0.728	0.094	126.24	519.5	179.56	-0.036	-0.011	-0.131
8.50	0.773	0.100	144.06	629.9	177.63	-0.042	-0.010	-0.150
9.00	0.818	0.105	162.96	754.5	176.04	-0.048	-0.009	-0.170
9.50	0.864	0.111	182.75	893.2	174.91	-0.056	-0.007	-0.192
10.00	0.909	0.117	203.77	1048.3	173.81	-0.063	-0.006	-0.215
10.50	0.955	0.123	226.77	1225.0	172.19	-0.071	-0.004	-0.239
11.00	1.000	0.129	252.54	1429.1	169.70	-0.079	-0.002	-0.263
11.50	1.046	0.135	281.64	1666.2	166.31	-0.087	-0.000	-0.288
12.00	1.091	0.140	313.14	1933.1	162.87	-0.096	0.001	-0.316
12.50	1.137	0.146	345.79	2223.6	160.04	-0.106	0.004	-0.347
13.00	1.182	0.152	379.91	2540.7	157.55	-0.117	0.008	-0.380
13.50	1.228	0.158	418.01	2903.1	154.42	-0.128	0.011	-0.415
14.00	1.273	0.164	460.26	3314.9	150.82	-0.140	0.014	-0.451
14.50	1.319	0.170	504.30	3761.8	147.66	-0.153	0.019	-0.489
15.00	1.364	0.176	557.69	4303.5	142.89	-0.167	0.025	-0.529
15.50	1.410	0.181	626.82	4998.2	135.75	-0.181	0.029	-0.570
16.00	1.455	0.187	705.99	5811.1	128.43	-0.195	0.033	-0.612
16.50	1.501	0.193	787.73	6686.5	122.41	-0.210	0.040	-0.658
17.00	1.546	0.199	871.96	7625.8	117.39	-0.228	0.049	-0.709

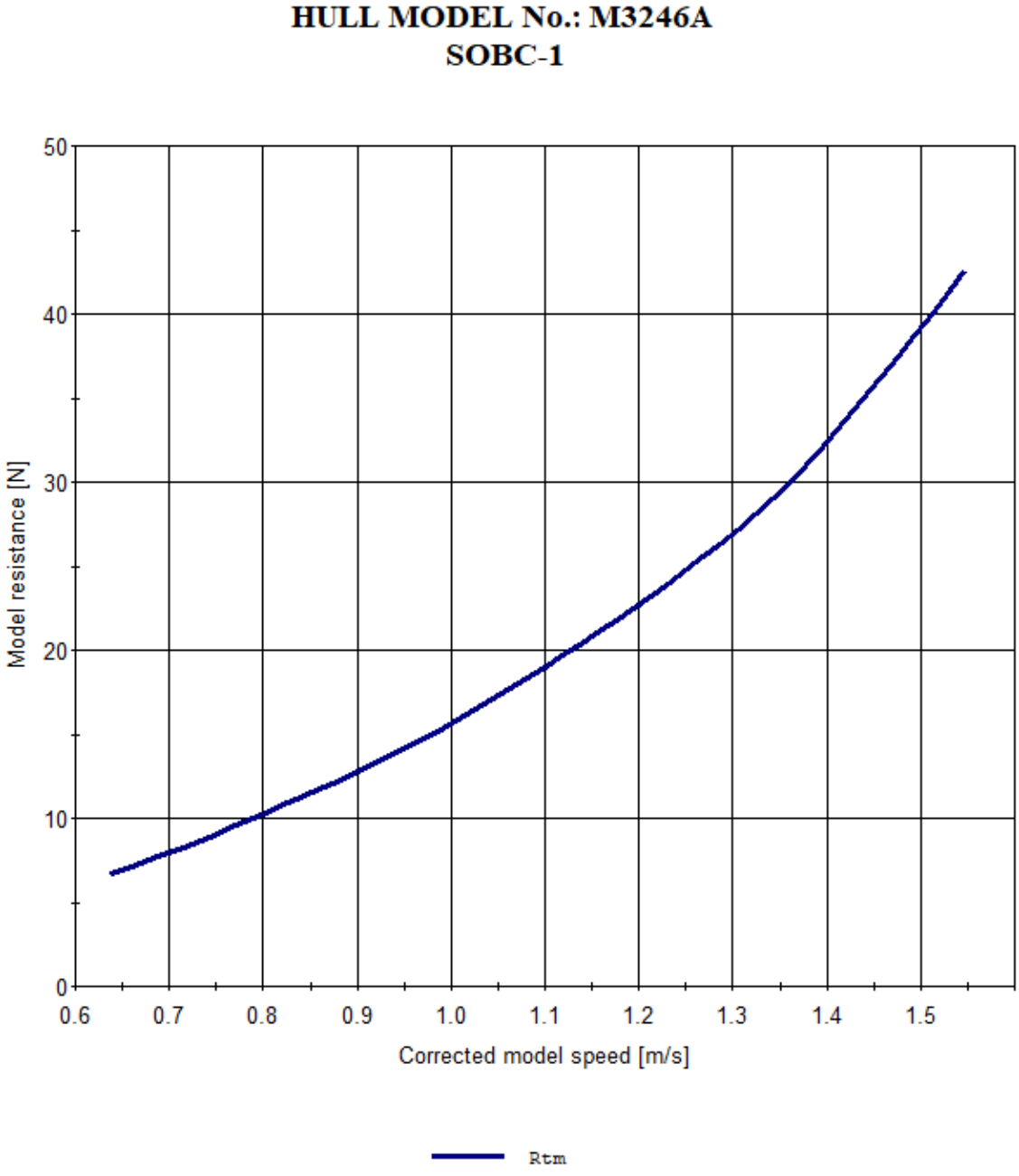
Setup: Towing test:
m3246a0s6 m3246a0_slep_1 (Cw)

ShipX (RepGen version 2.0.22) 05-Aug-2021 11:13:09

E-7 RESISTANCE TEST, DWL

REFERENCE M3246

E-7.6 Model Resistance Plot



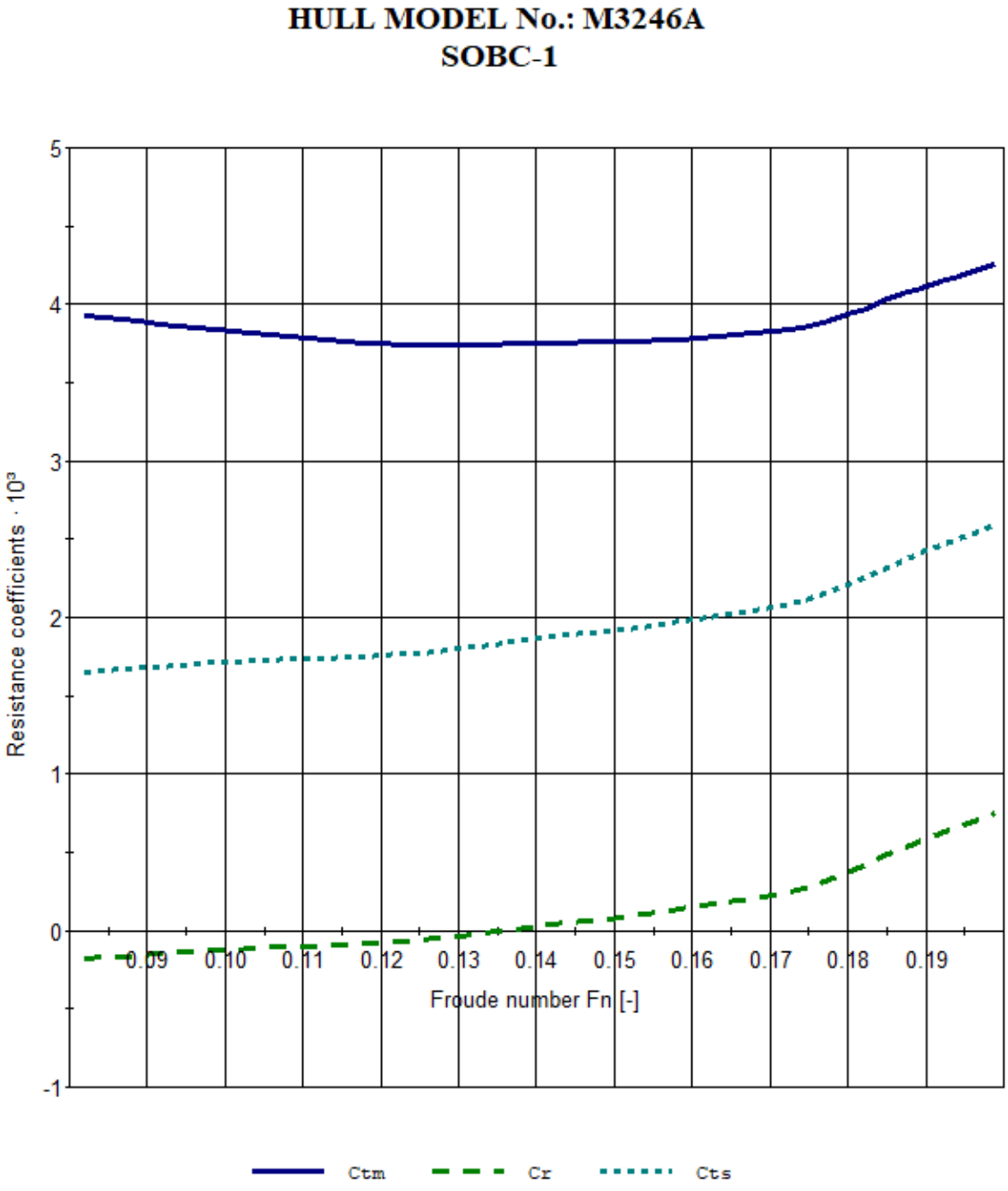
Smoothing method: (Cw) Cubic spline - anti wiggle
Model speed is corrected due to blockage effects
Setup: m3246a0s6

ShipX (RepGen version 2.0.22) 05-Aug-2021 11:13:09

E-7 RESISTANCE TEST, DWL

REFERENCE M3246

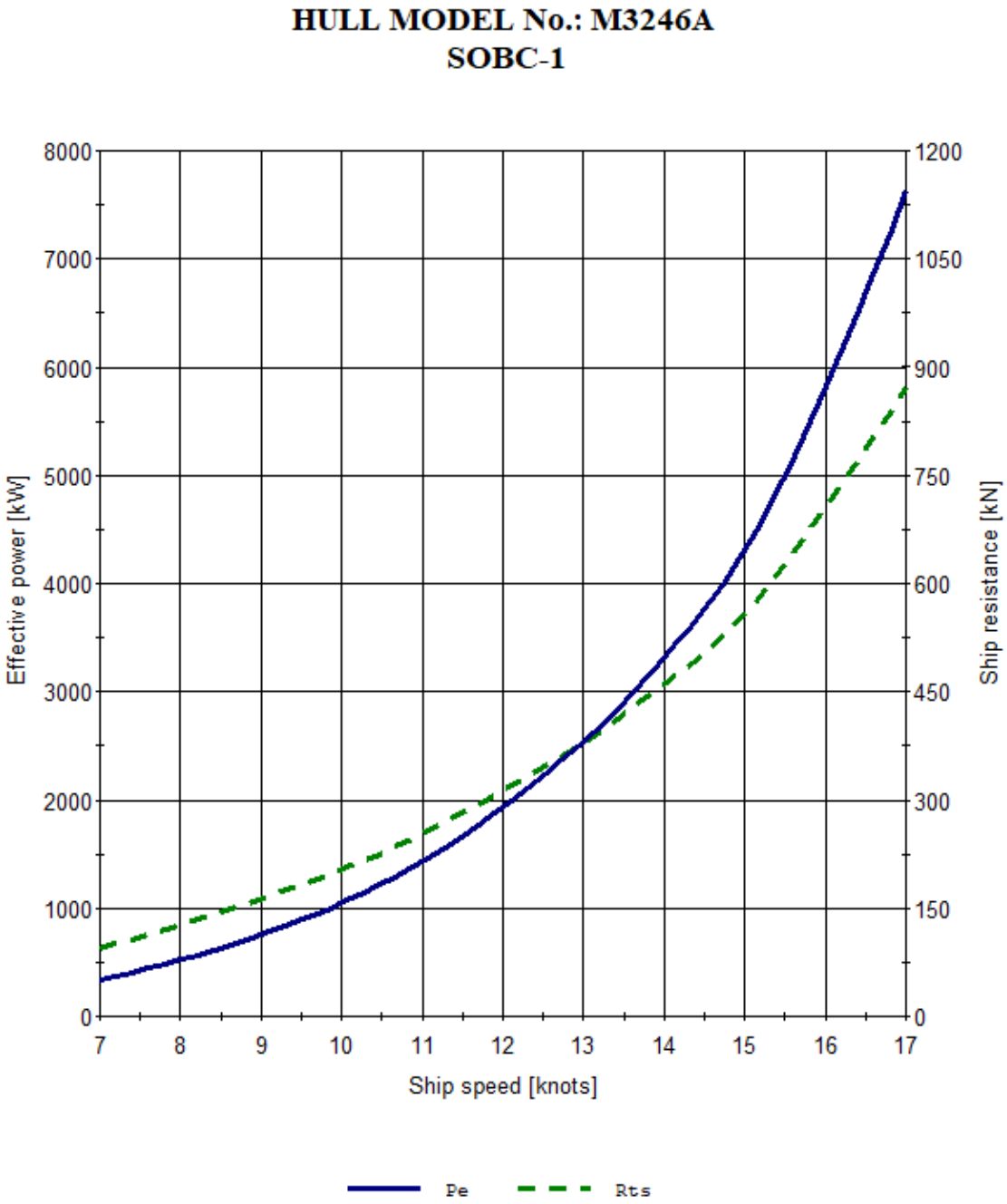
E-7.7 Resistance Coefficients Plot



E-7 RESISTANCE TEST, DWL

REFERENCE M3246

E-7.8 Ship Resistance And Effective Power Plot



Smoothing method: (Cw) Cubic spline - anti wiggle
Setup: m3246a0s6

ShipX (RepGen version 2.0.22) 05-Aug-2021 11:13:10

E-8 PROPULSION TEST, DWL

E-8.1 Propulsion Test Report (average)

HULL MODEL No.: M3246A Model Scale: 32.000
Loading condition: DWL - Design waterline
Draught AP/FP: 11.000 / 11.000 [m]

Propeller model	**P1608**
Number of propellers	1
Direction of rotation	Right
Propeller diameter (ship)[mm]	6750
Pitch ratio (P/D)	0.970
Expanded blade area ratio	0.483
Number of blades	4
Open water test ref.	a0.2 (Ci)

Tank water temp. [°C] = 16.20

V_S [knots]	V_M [m/s]	n_M [Hz]	J [-]	K_Q [-]	K_{Ttot} [-]	J_0 [-]	K_{Q0} [-]
7.00	0.637	3.083	0.979	0.0298	0.185	0.655	0.0296
7.50	0.682	3.304	0.979	0.0301	0.186	0.654	0.0297
8.00	0.728	3.527	0.978	0.0300	0.185	0.656	0.0296
8.50	0.773	3.751	0.977	0.0299	0.184	0.658	0.0294
9.00	0.818	3.979	0.975	0.0298	0.183	0.660	0.0293
9.50	0.864	4.211	0.973	0.0297	0.182	0.662	0.0293
10.00	0.909	4.448	0.969	0.0296	0.182	0.662	0.0293
10.50	0.955	4.692	0.965	0.0296	0.183	0.661	0.0293
11.00	1.000	4.943	0.959	0.0297	0.184	0.658	0.0295
11.50	1.046	5.202	0.953	0.0298	0.185	0.655	0.0296
12.00	1.091	5.466	0.947	0.0299	0.187	0.651	0.0298
12.50	1.137	5.730	0.941	0.0300	0.188	0.649	0.0300
13.00	1.182	5.990	0.936	0.0301	0.189	0.647	0.0301
13.50	1.228	6.244	0.932	0.0302	0.189	0.646	0.0301
14.00	1.273	6.499	0.929	0.0303	0.190	0.644	0.0302
14.50	1.319	6.768	0.924	0.0303	0.192	0.639	0.0305
15.00	1.364	7.070	0.915	0.0306	0.195	0.632	0.0309
15.50	1.410	7.421	0.901	0.0313	0.198	0.625	0.0313
16.00	1.455	7.793	0.885	0.0320	0.201	0.617	0.0317
16.50	1.501	8.153	0.872	0.0323	0.205	0.609	0.0321
17.00	1.546	8.501	0.862	0.0322	0.208	0.601	0.0325

Setup:	Towing (Res. Calc):	Towing (Prop.an.):	Propulsion:
m3246a0s11	m3246a0s6 (Cw)	m3246a0s6 (Cw)	m3246a0_prop_1 (Cc)

ShipX (RepGen version 2.0.22) 05-Aug-2021 11:13:11

E-8 PROPULSION TEST, DWL

E-8.2 Propulsive Coefficients Report (propulsor 1 of 1)

REFERENCE M3246

HULL MODEL No.: M3246A Model Scale: 32.000
Loading condition: DWL - Design waterline
Draught AP/FP: 11.000 / 11.000 [m]

	SHIP	MODEL
Propeller model	**P1608**	**P1608**
Number of propellers	1	1
Direction of rotation	Right	Right
Propeller diameter [mm]	6750	210.94
Pitch ratio (P/D)	0.970	0.970
Expanded blade area ratio	0.483	0.483
Number of blades	4	4
Open water test ref.	a0.2 (Ci)	a0.2 (Ci)

Tank water temp. [°C] = 16.20

|<----------Model----------|<----------Ship----------|

V_S [kn]	w_M [-]	η_O [-]	η_H [-]	η_D [-]	t [-]	η_R [-]	w_S [-]	η_O [-]	η_H [-]	η_D [-]
7.00	0.330	0.652	1.171	0.758	0.216	0.992	0.290	0.663	1.105	0.727
7.50	0.331	0.651	1.170	0.752	0.217	0.987	0.292	0.661	1.105	0.721
8.00	0.329	0.652	1.180	0.758	0.208	0.984	0.286	0.663	1.109	0.724
8.50	0.326	0.654	1.193	0.768	0.196	0.984	0.279	0.666	1.115	0.730
9.00	0.323	0.656	1.204	0.777	0.184	0.984	0.272	0.669	1.120	0.737
9.50	0.320	0.656	1.209	0.782	0.178	0.986	0.267	0.670	1.122	0.742
10.00	0.317	0.656	1.208	0.783	0.175	0.988	0.265	0.670	1.123	0.743
10.50	0.315	0.656	1.204	0.782	0.176	0.990	0.265	0.669	1.122	0.744
11.00	0.314	0.654	1.200	0.779	0.177	0.993	0.265	0.667	1.121	0.743
11.50	0.313	0.652	1.197	0.777	0.178	0.996	0.266	0.665	1.120	0.741
12.00	0.312	0.649	1.194	0.773	0.179	0.998	0.266	0.662	1.119	0.739
12.50	0.310	0.647	1.189	0.769	0.180	0.999	0.266	0.660	1.118	0.736
13.00	0.309	0.646	1.187	0.766	0.179	0.998	0.265	0.658	1.117	0.734
13.50	0.307	0.646	1.196	0.770	0.171	0.997	0.261	0.659	1.122	0.736
14.00	0.307	0.644	1.211	0.779	0.161	0.999	0.256	0.659	1.128	0.743
14.50	0.308	0.641	1.214	0.784	0.160	1.008	0.257	0.656	1.130	0.747
15.00	0.309	0.636	1.211	0.778	0.163	1.010	0.259	0.651	1.130	0.742
15.50	0.306	0.630	1.210	0.762	0.160	0.999	0.257	0.645	1.130	0.728
16.00	0.303	0.625	1.210	0.748	0.156	0.989	0.253	0.640	1.130	0.715
16.50	0.302	0.619	1.213	0.747	0.154	0.995	0.252	0.634	1.132	0.714
17.00	0.302	0.613	1.218	0.754	0.151	1.010	0.251	0.629	1.134	0.721

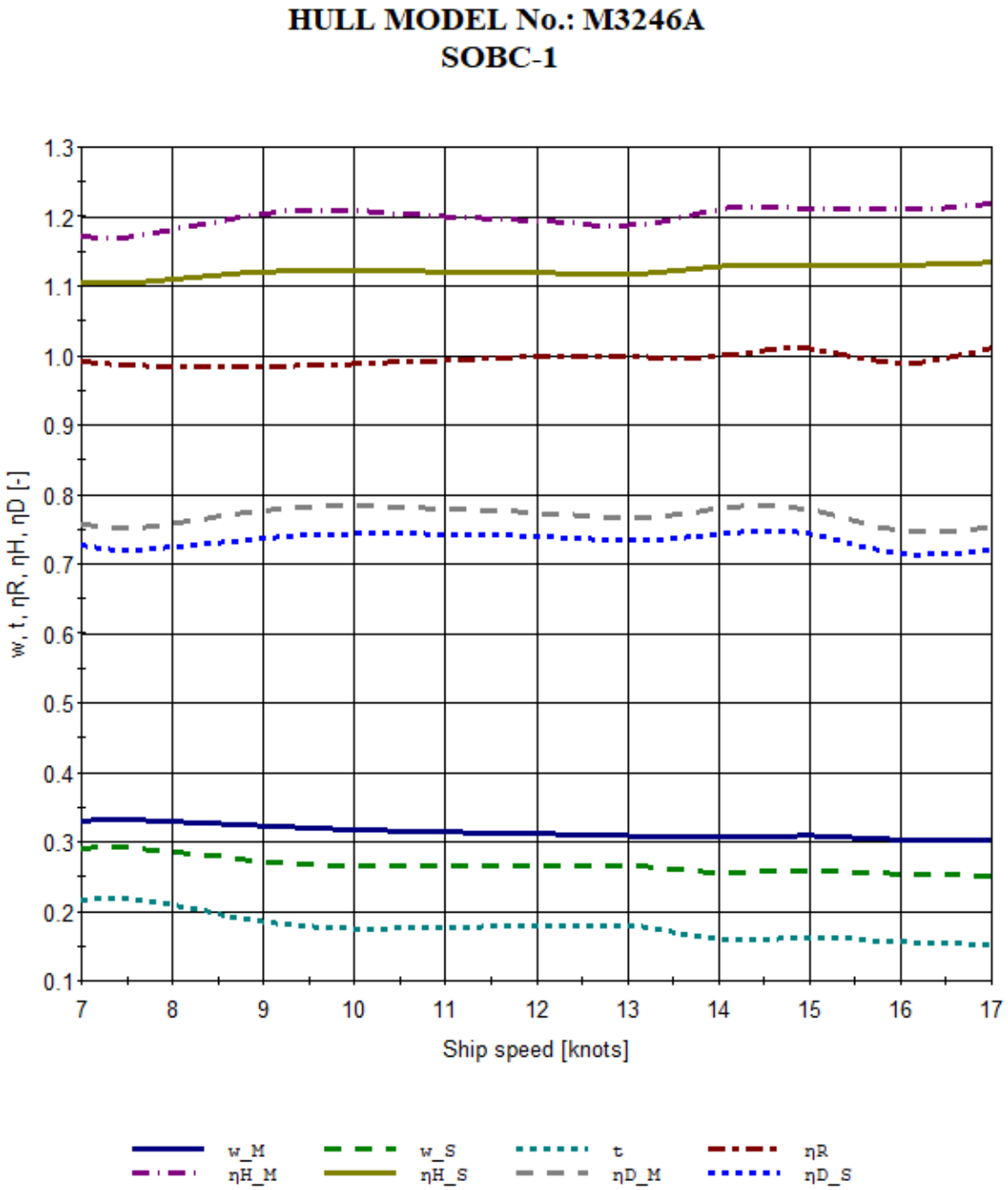
Setup:	Towing (Res. Calc):	Towing (Prop.an.):	Propulsion:
m3246a0s11	m3246a0s6 (Cw)	m3246a0s6 (Cw)	m3246a0_prop_1 (Cc)

ShipX (RepGen version 2.0.22) 05-Aug-2021 11:13:12

E-8 PROPULSION TEST, DWL

REFERENCE M3246

E-8.3 Propulsive Coefficients Plot (propulsor 1 of 1)



Smoothing method: (Cc) Cubic spline - preserves concavity
Setup: m3246a0s11

ShipX (RepGen version 2.0.22) 05-Aug-2021 11:13:12

E-8 PROPULSION TEST, DWL

REFERENCE M3246

E-8.4 Performance Prediction Report

HULL MODEL No.: M3246A Model Scale: 32.000
Loading condition: DWL - Design waterline
Draught AP/FP: 11.000 / 11.000 [m]

Propeller model	**P1608**
Number of propellers	1
Direction of rotation	Right
Propeller diameter (ship)[mm]	6750
Pitch ratio (P/D)	0.970
Expanded blade area ratio	0.483
Number of blades	4
Open water test ref.	a0.2 (Ci)

Predicted speed: 14.35 knots at 5000.00 kW

Predicted prop. RPM	73.6
Mech. efficiency	0.970
Seawater temp. [°C]	15.00

V_S [kn]	N [RPM]	P_B [kW]	C_{ADM} [-]	Trim [deg]	Sinkage AP [m]	FP
7.0	33.8	482.3	133.59	-0.032	0.008	-0.097
7.5	36.3	605.0	130.99	-0.037	0.005	-0.118
8.0	38.9	740.1	129.95	-0.043	0.002	-0.139
8.5	41.5	889.4	129.70	-0.048	-0.000	-0.160
9.0	44.0	1055.5	129.74	-0.054	-0.002	-0.182
9.5	46.6	1241.6	129.71	-0.061	-0.003	-0.204
10.0	49.1	1453.7	129.21	-0.068	-0.004	-0.228
10.5	51.8	1698.6	128.02	-0.075	-0.003	-0.252
11.0	54.4	1983.6	126.04	-0.084	-0.001	-0.278
11.5	57.2	2316.8	123.31	-0.093	0.002	-0.306
12.0	60.1	2695.2	120.43	-0.103	0.007	-0.336
12.5	62.9	3112.5	117.87	-0.115	0.012	-0.368
13.0	65.7	3567.3	115.69	-0.127	0.018	-0.402
13.5	68.6	4064.6	113.70	-0.139	0.025	-0.438
14.0	71.6	4600.8	112.03	-0.152	0.030	-0.473
14.5	74.5	5192.2	110.29	-0.163	0.033	-0.509
15.0	77.8	5975.2	106.10	-0.174	0.033	-0.544
15.5	81.6	7081.3	98.78	-0.188	0.031	-0.591
16.0	85.7	8376.8	91.85	-0.204	0.031	-0.646
16.5	89.6	9651.0	87.43	-0.220	0.035	-0.694
17.0	93.4	10907.1	84.61	-0.234	0.041	-0.735

Setup:	Towing (Res. Calc):	Towing (Prop.an.):	Propulsion:
m3246a0s11	m3246a0s6 (Cw)	m3246a0s6 (Cw)	m3246a0_prop_1 (Cc)

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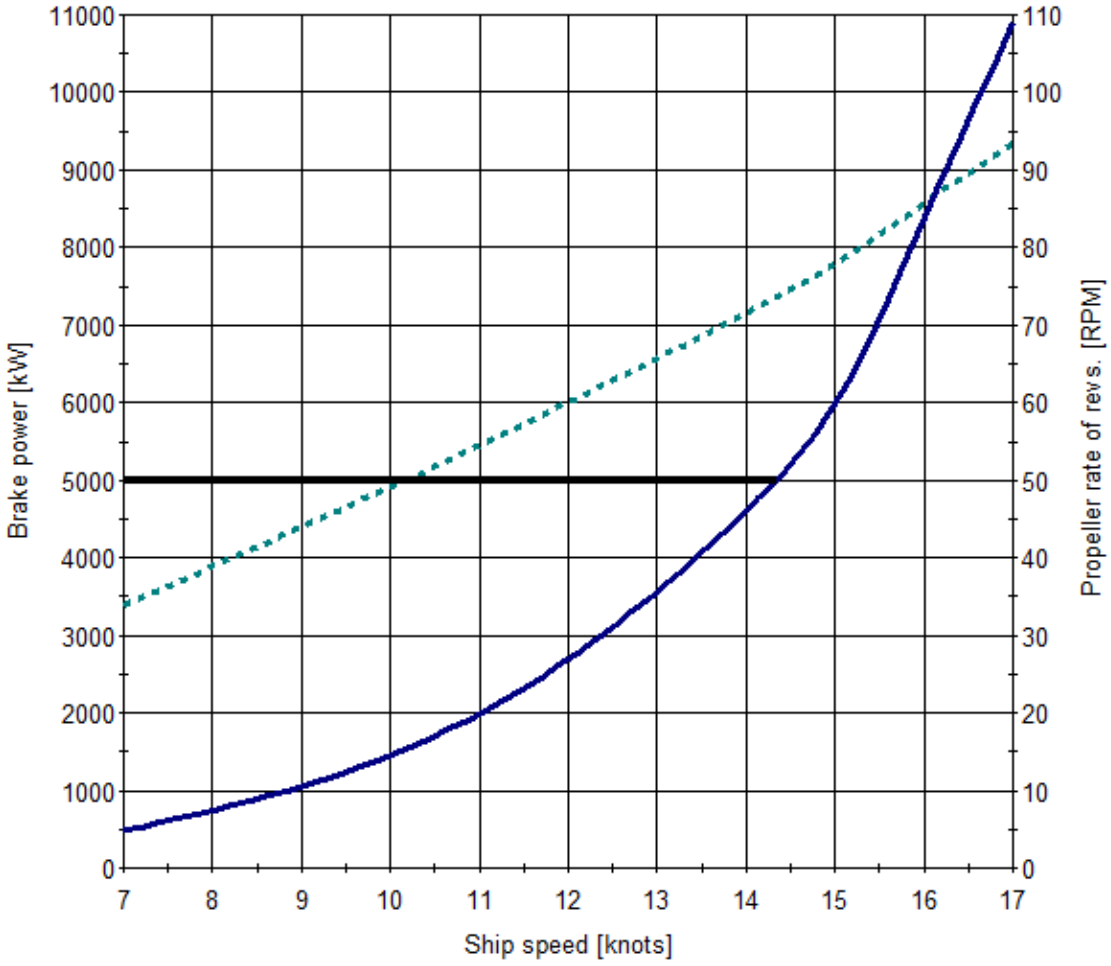
E-8 PROPULSION TEST, DWL

E-8.5 Performance Prediction Plot

HULL MODEL No.: M3246A
SOBC-1

Predicted speed: 14.35 knots at 5000.0 kW and 73.6 RPM



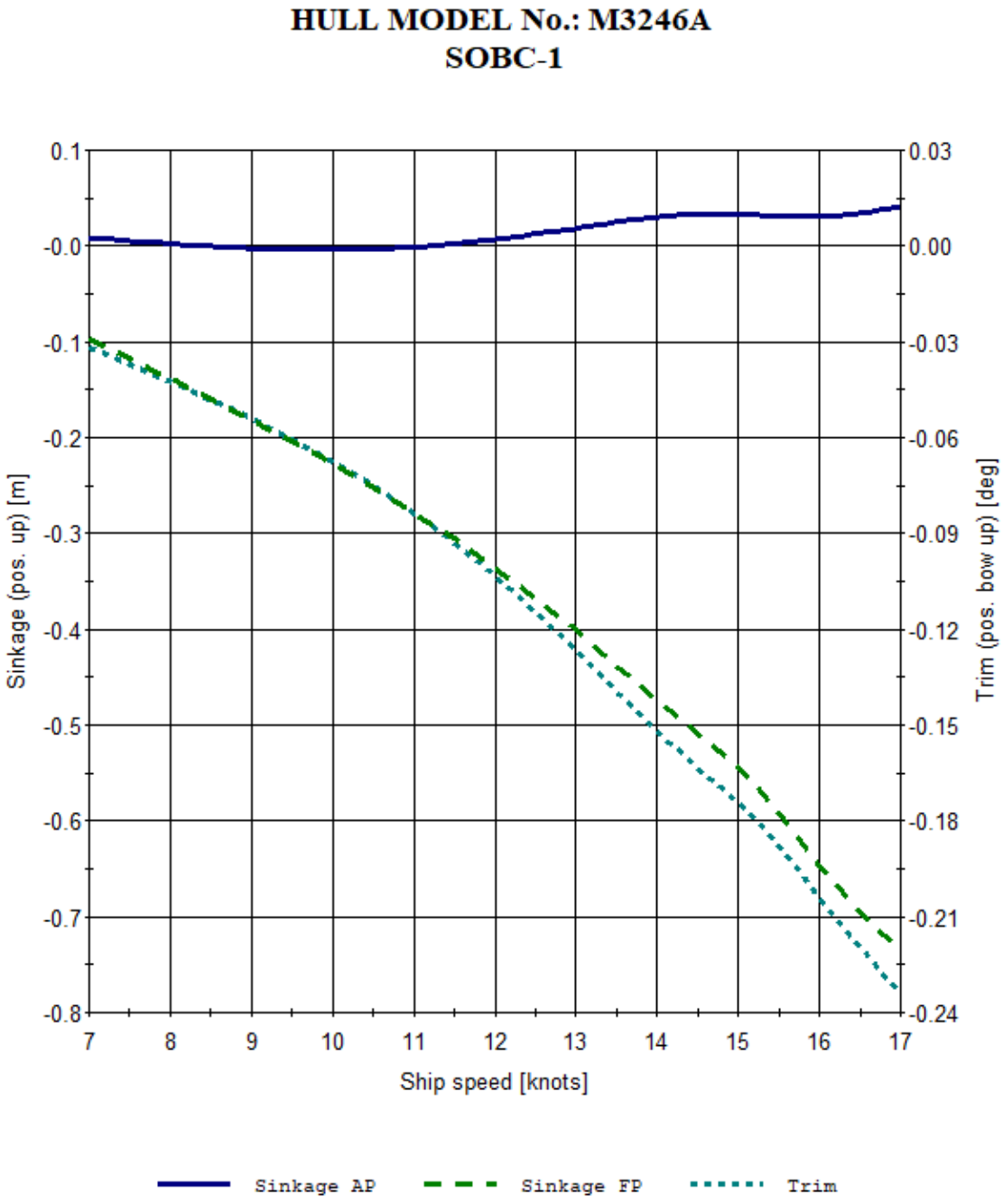
The RPM presented is the average RPM for all propulsors.
Smoothing method: (Cc) Cubic spline - preserves concavity
Setup: m3246a0s11

ShipX (RepGen version 2.0.22) 05-Aug-2021 11:13:13

E-8 PROPULSION TEST, DWL

REFERENCE M3246

E-8.6 Sinkage And Trim Plot



Smoothing method: (Cc) Cubic spline - preserves concavity
Setup: m3246a0s11

ShipX (RepGen version 2.0.22) 05-Aug-2021 11:13:13

E-8 PROPULSION TEST, DWL

E-8.7 Propulsion Test Setup

```
 HULL MODEL No.:      M3246A                                    Model Scale:  32.000
 Loading condition:   DWL - Design waterline
 Draught AP/FP:       11.000 / 11.000 [m]
 Setup ID:            m3246a0s11

Specification of test data files:

Test type           Setup     Sm.  File name:

Propulsion test:    m3246a0s11(Cc) \\sintef.no\ocean\organisasjon\Teknisk\HydroLab\Vogna\StdReg\PropData\m3246a0_pr

    Zero torque:               (Cw) \\sintef.no\ocean\organisasjon\Teknisk\HydroLab\Vogna\StdReg\PropData\m3246a0_pr

    Zero thrust:               (Cw) \\sintef.no\ocean\organisasjon\Teknisk\HydroLab\Vogna\StdReg\PropData\m3246a0_pr

Towing test:        m3246a0s6 (Cw) \\sintef.no\ocean\organisasjon\Teknisk\HydroLab\Vogna\StdReg\SlepData\m3246A0_sl

App. trim corr.:           (Cw) file not given
OPW test:           p1608s2   (Ci) \\sintef.no\ocean\organisasjon\Teknisk\HydroLab\Vogna\StdReg\FripData\p1608a0_fr

    Zero torque:               (Av) \\sintef.no\ocean\organisasjon\Teknisk\HydroLab\Vogna\StdReg\FripData\p1608a0_fr

    Zero thrust:               (Cs) \\sintef.no\ocean\organisasjon\Teknisk\HydroLab\Vogna\StdReg\FripData\p1608a0_fr

Specification of Propulsion Test Analysis:
Number of propulsors:         1
Thrust deduction:             Apply same thrust deduction for all propulsors
Sea margin:                   0.00\%
Propulsor:                    Position:                  Main Propeller
                              Scaling of wake fraction:  Conv. single screw
                              Scaling method, propeller: No scaling
Position of aft sinkage measurement point (model scale):      0.743 m
Position of fwd sinkage measurement point (model scale):      4.664 m

Specification of Towing Test Analysis:
Blockage correction:          on
Appendage scaling:            Appended - Scaling based on ITTC'57 and given appendix data
Hull roughness (default):     150.0 µ

Environment:

                              Model      Ship  Unit

Water temperature:             16.20     15.00  [°C]
Salinity:                       0.00      3.50  [%]
Density:                      998.82   1025.87  [kg/m^3]
Kinematic viscosity:            1.103     1.187  [·10^-6m^2/s]

                ShipX (RepGen version 2.0.22) 05-Aug-2021 11:13:14
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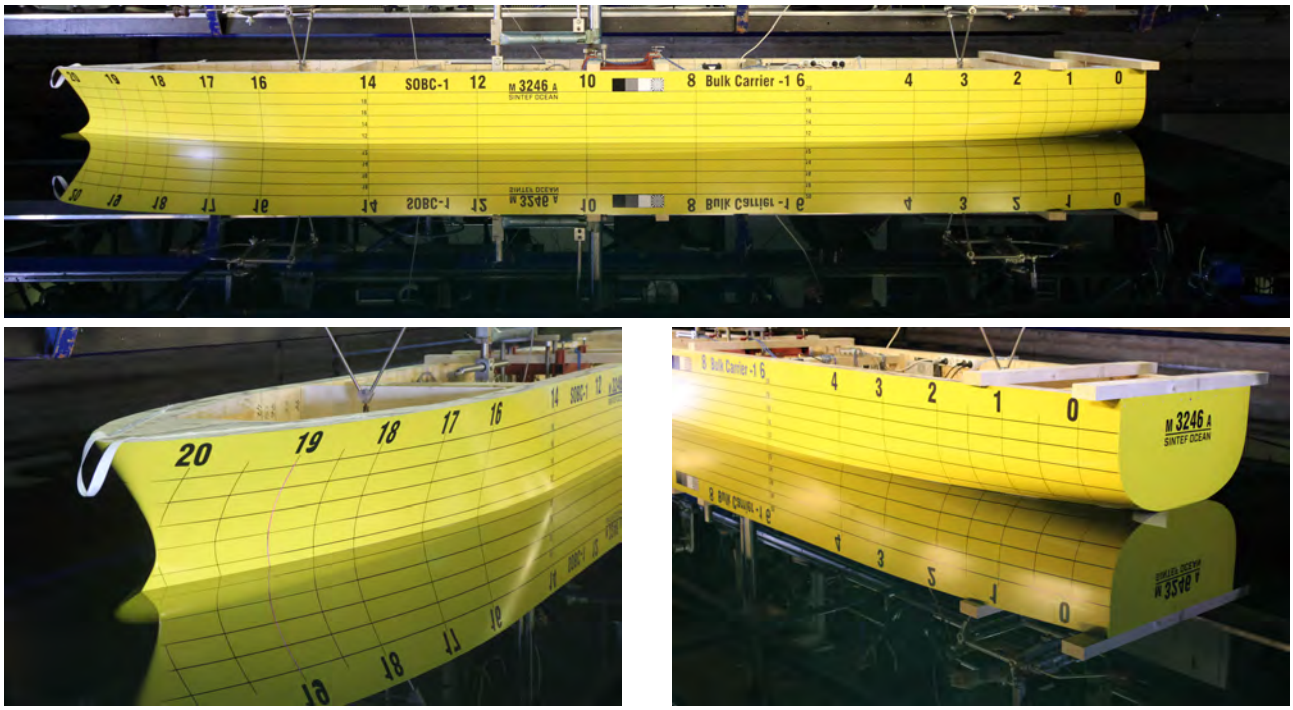
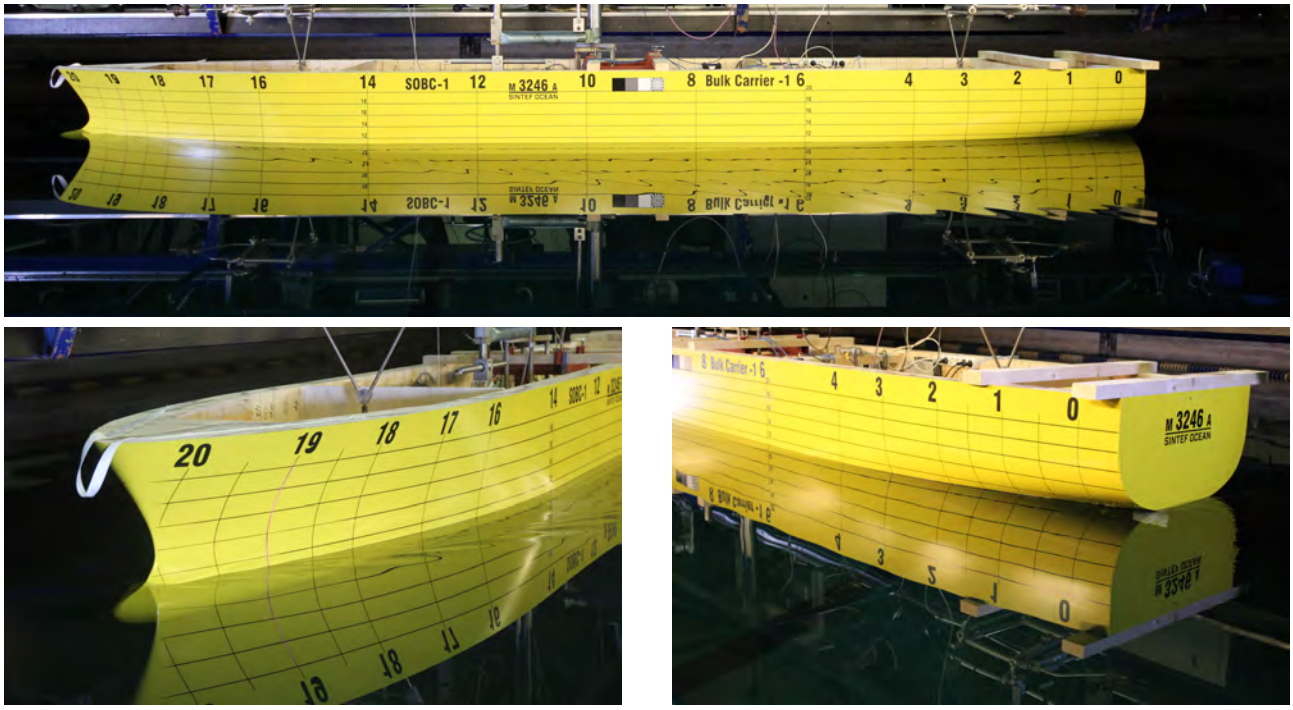
E-8 PROPULSION TEST, DWL

REFERENCE M3246

E-8.8 Wave Profiles 0.0kn and 7.0kn



Wave Profiles 0.0kn

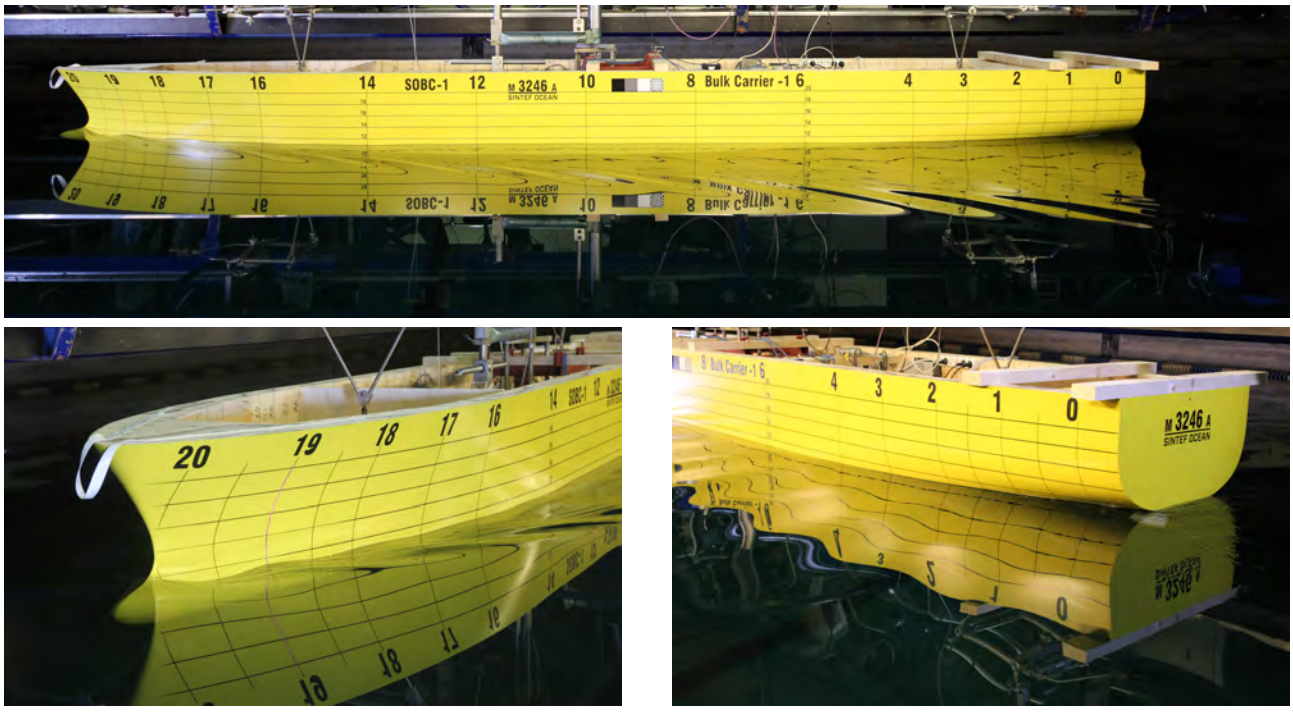


Wave Profiles 7.0kn

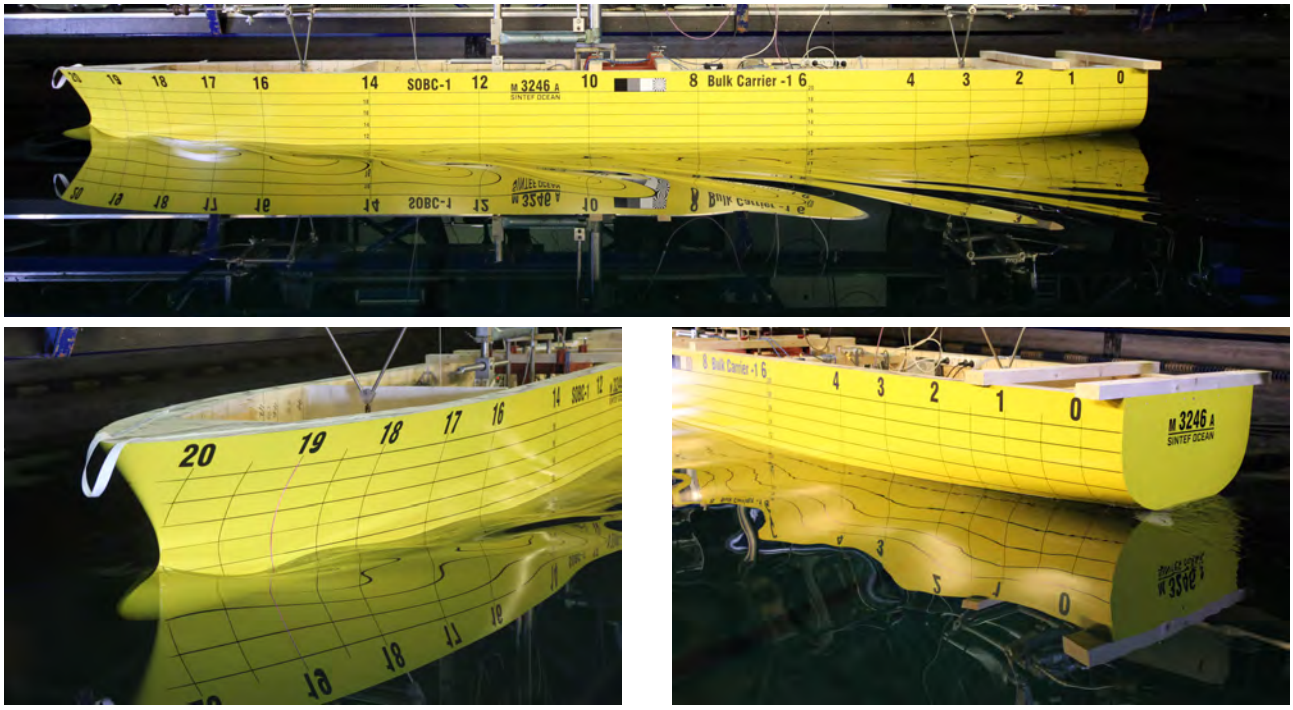
E-8 PROPULSION TEST, DWL

REFERENCE M3246

E-8.9 Wave Profiles 9.0kn and 11.0kn



Wave Profiles 9.0kn

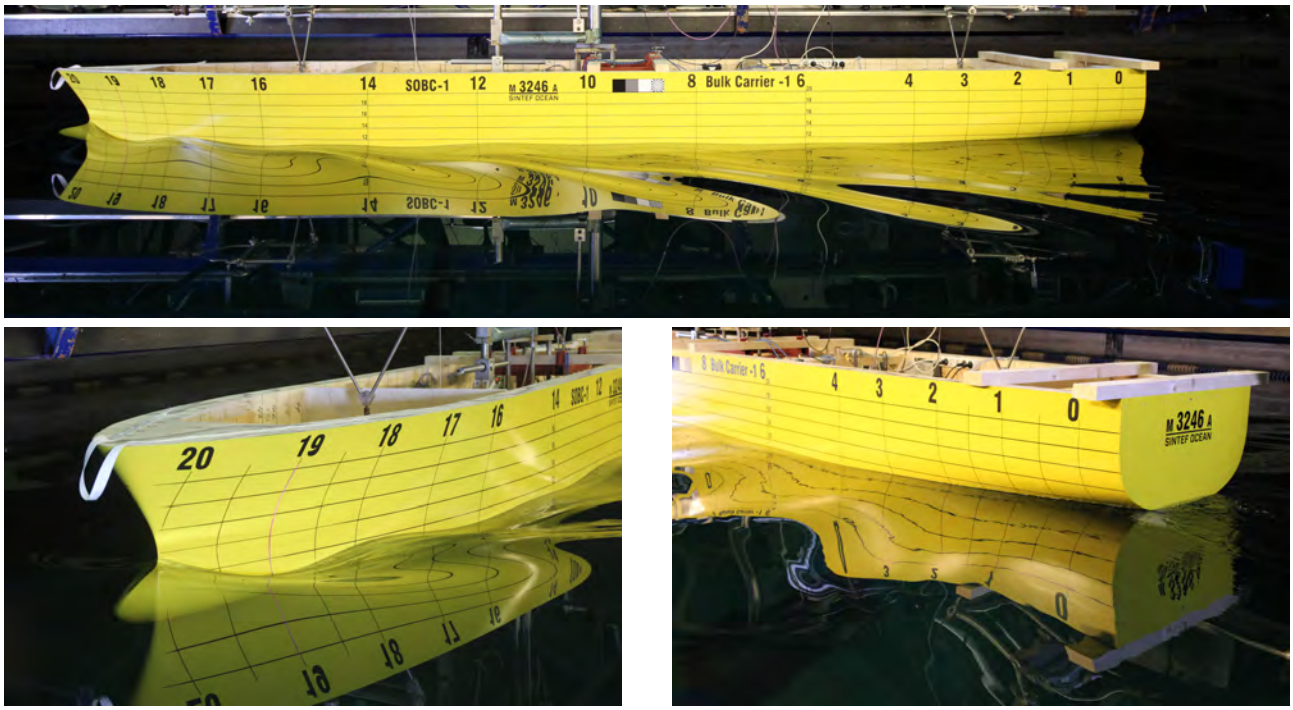


Wave Profiles 11.0kn

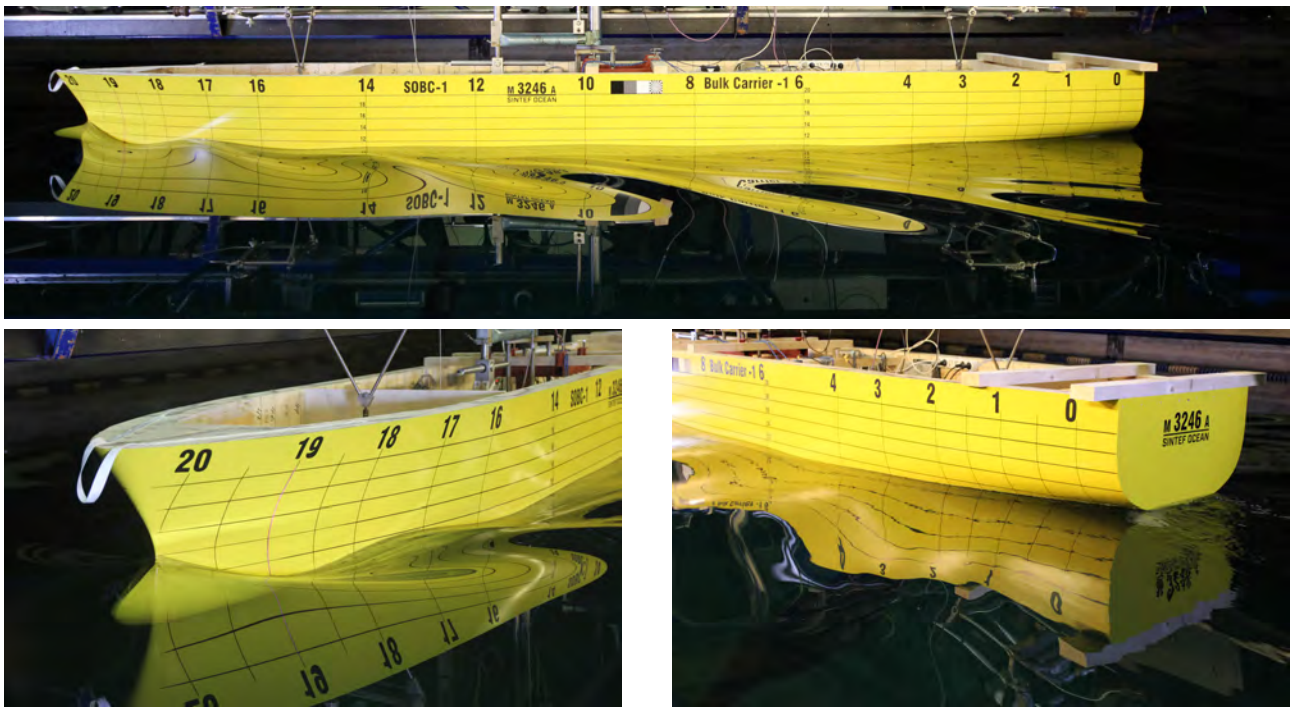
E-8 PROPULSION TEST, DWL

REFERENCE M3246

E-8.10 Wave Profiles 13.0kn and 14.0kn



Wave Profiles 13.0kn

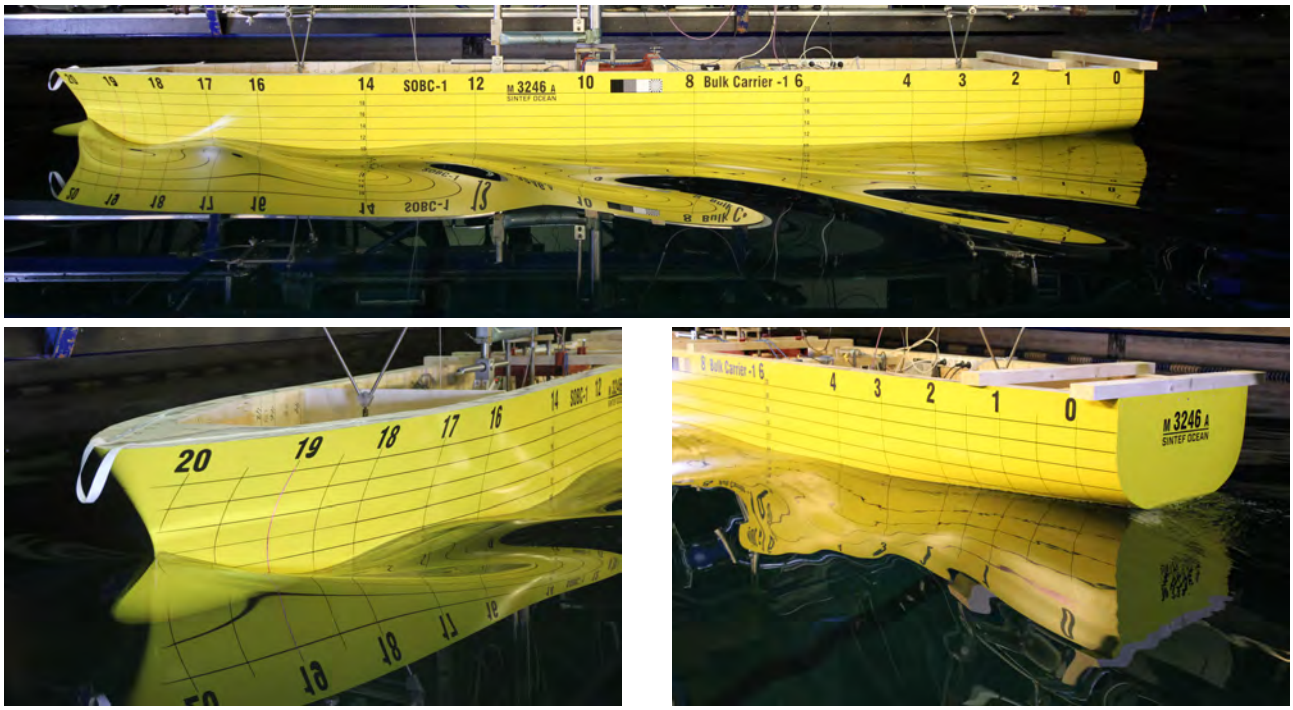


Wave Profiles 14.0kn

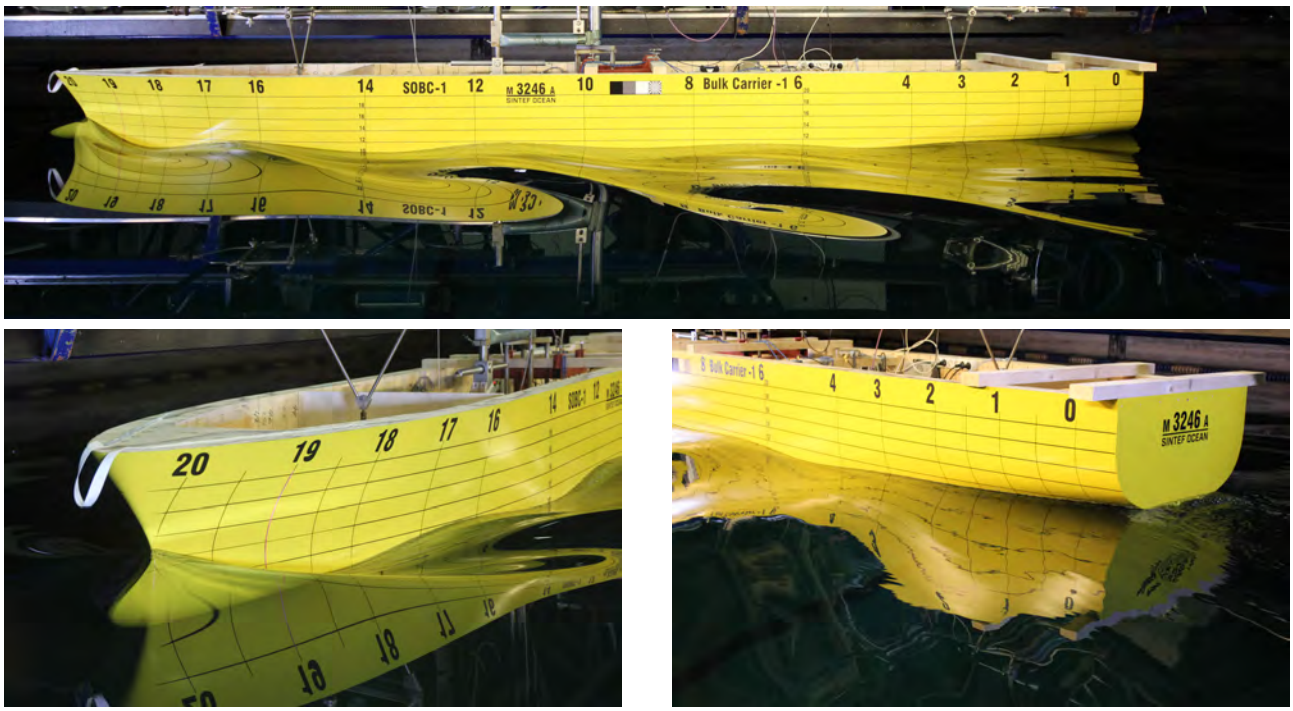
E-8 PROPULSION TEST, DWL

REFERENCE M3246

E-8.11 Wave Profiles 15.0kn and 16.0kn



Wave Profiles 15.0kn

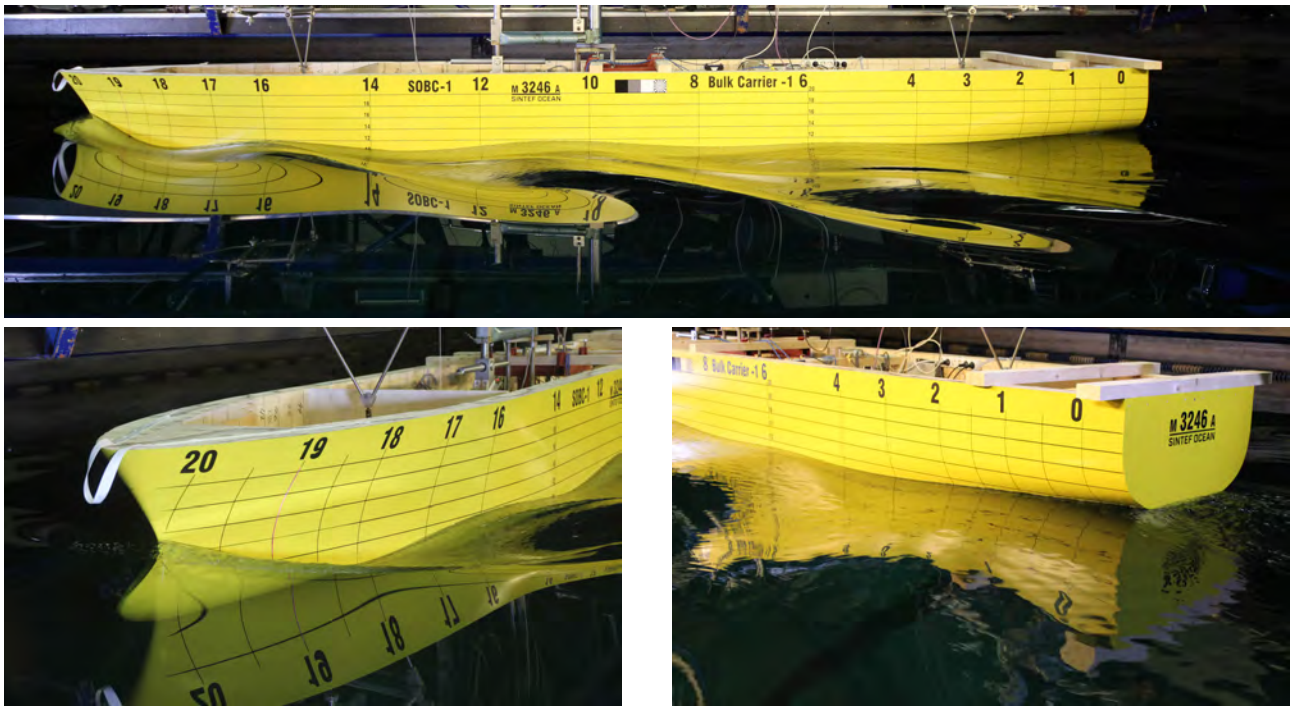


Wave Profiles 16.0kn

E-8 PROPULSION TEST, DWL

REFERENCE M3246

E-8.12 Wave Profiles 17.0kn



Wave Profiles 17.0kn

E-9 3D WAKE TEST - WL1

REFERENCE M3246

E-9.1 WAKE MEASUREMENTS RESULTS (Page 1 of 2)

SOBC-1

HULL MODEL NO.: M3246A Model Scale: 32.000
Loading condition: WL 1
Draught AP/FP: 7.500 / 5.400 [m]
Description: Untitled

Angle	R/R0= 0.398			R/R0= 0.503			R/R0= 0.702			R/R0= 0.901		
[deg]	w_ax	w_t	w_r	w_ax	w_t	w_r	w_ax	w_t	w_r	w_ax	w_t	w_r
0.0	0.601	-0.018	-0.304	0.512	0.053	-0.394	0.392	-0.077	-0.480	0.619	-0.012	-0.271
5.0	0.616	-0.018	-0.296	0.519	-0.031	-0.398	0.591	-0.036	-0.284	0.612	-0.067	-0.210
10.0	0.569	0.038	-0.288	0.591	-0.033	-0.315	0.613	-0.023	-0.250	0.562	-0.066	-0.181
15.0	0.615	0.078	-0.262	0.588	0.017	-0.276	0.581	-0.015	-0.222	0.554	-0.055	-0.165
20.0	0.609	0.085	-0.233	0.597	0.056	-0.245	0.557	-0.009	-0.201	0.522	-0.069	-0.155
30.0	0.598	0.127	-0.172	0.580	0.074	-0.186	0.496	-0.004	-0.170	0.468	-0.080	-0.124
45.0	0.591	0.202	-0.117	0.573	0.116	-0.132	0.486	-0.001	-0.128	0.351	-0.097	-0.115
60.0	0.622	0.247	-0.075	0.587	0.118	-0.068	0.524	-0.016	-0.075	0.343	-0.101	-0.086
75.0	0.578	0.284	-0.039	0.604	0.126	-0.034	0.530	-0.036	-0.069	0.325	-0.122	-0.072
90.0	0.600	0.272	0.013	0.616	0.143	0.002	0.585	-0.041	0.004	0.229	-0.104	-0.041
120.0	0.430	0.446	0.166	0.546	0.249	0.132	0.504	-0.057	-0.012	0.164	-0.092	-0.029
150.0	0.713	0.169	-0.069	0.675	0.163	0.036	0.466	-0.006	-0.032	0.150	-0.051	-0.019
160.0	0.666	0.063	-0.082	0.689	0.103	0.017	0.468	0.013	-0.023	0.142	-0.041	-0.016
170.0	0.709	-0.004	-0.075	0.681	0.080	0.012	0.563	0.022	-0.014	0.192	-0.012	-0.018
175.0	0.691	-0.017	-0.089	0.698	0.060	-0.007	0.560	0.015	0.006	0.172	-0.009	-0.023
180.0	0.703	0.029	-0.059	0.644	-0.019	-0.008	0.540	0.028	0.023	0.172	-0.008	-0.013
185.0	0.685	-0.079	-0.077	0.697	0.002	0.002	0.489	-0.018	-0.016	0.197	-0.005	-0.015
190.0	0.691	-0.110	-0.057	0.666	-0.073	0.035	0.476	-0.008	-0.011	0.149	0.014	-0.022
200.0	0.720	-0.109	-0.039	0.705	-0.100	0.062	0.470	0.008	0.011	0.121	0.029	-0.029
210.0	0.734	-0.169	0.013	0.506	-0.149	0.065	0.463	0.022	0.017	0.113	0.043	-0.022
240.0	0.606	-0.274	0.128	0.660	-0.104	0.091	0.409	0.049	0.002	0.111	0.094	-0.027
270.0	0.539	-0.317	0.062	0.645	-0.087	0.028	0.466	0.037	-0.010	0.243	0.121	-0.028
285.0	0.597	-0.273	0.012	0.601	-0.122	0.007	0.496	0.029	0.006	0.239	0.126	-0.039
300.0	0.613	-0.246	-0.056	0.598	-0.132	-0.031	0.472	0.015	-0.054	0.305	0.121	-0.057
315.0	0.629	-0.209	-0.101	0.554	-0.113	-0.095	0.472	0.018	-0.093	0.334	0.118	-0.064
330.0	0.607	-0.181	-0.173	0.585	-0.092	-0.154	0.498	-0.007	-0.125	0.425	0.082	-0.103
340.0	0.607	-0.148	-0.215	0.580	-0.095	-0.234	0.537	0.009	-0.181	0.489	0.054	-0.121
345.0	0.634	-0.094	-0.223	0.610	-0.067	-0.215	0.573	-0.002	-0.192	0.514	0.063	-0.143
350.0	0.521	-0.108	-0.299	0.570	-0.074	-0.299	0.586	-0.009	-0.243	0.569	0.028	-0.176
355.0	0.575	-0.030	-0.297	0.562	-0.018	-0.297	0.562	0.000	-0.303	0.602	0.030	-0.237
360.0	0.601	-0.018	-0.304	0.512	0.053	-0.394	0.392	-0.077	-0.480	0.619	-0.012	-0.271
Mean=	0.610	0.002	-0.048	0.606	0.013	-0.038	0.499	-0.001	-0.066	0.276	0.001	-0.065

Wake Analysis 1.3 : 2021-05-26 Measurement date: 26-May-2021 14:34:04

E-9 3D WAKE TEST - WL1

REFERENCE M3246

E-9.2 WAKE MEASUREMENTS RESULTS (Page 2 of 2)

SOBC-1

HULL MODEL NO.: M3246A Model Scale: 32.000
Loading condition: WL 1
Draught AP/FP: 7.500 / 5.400 [m]
Description: Untitled

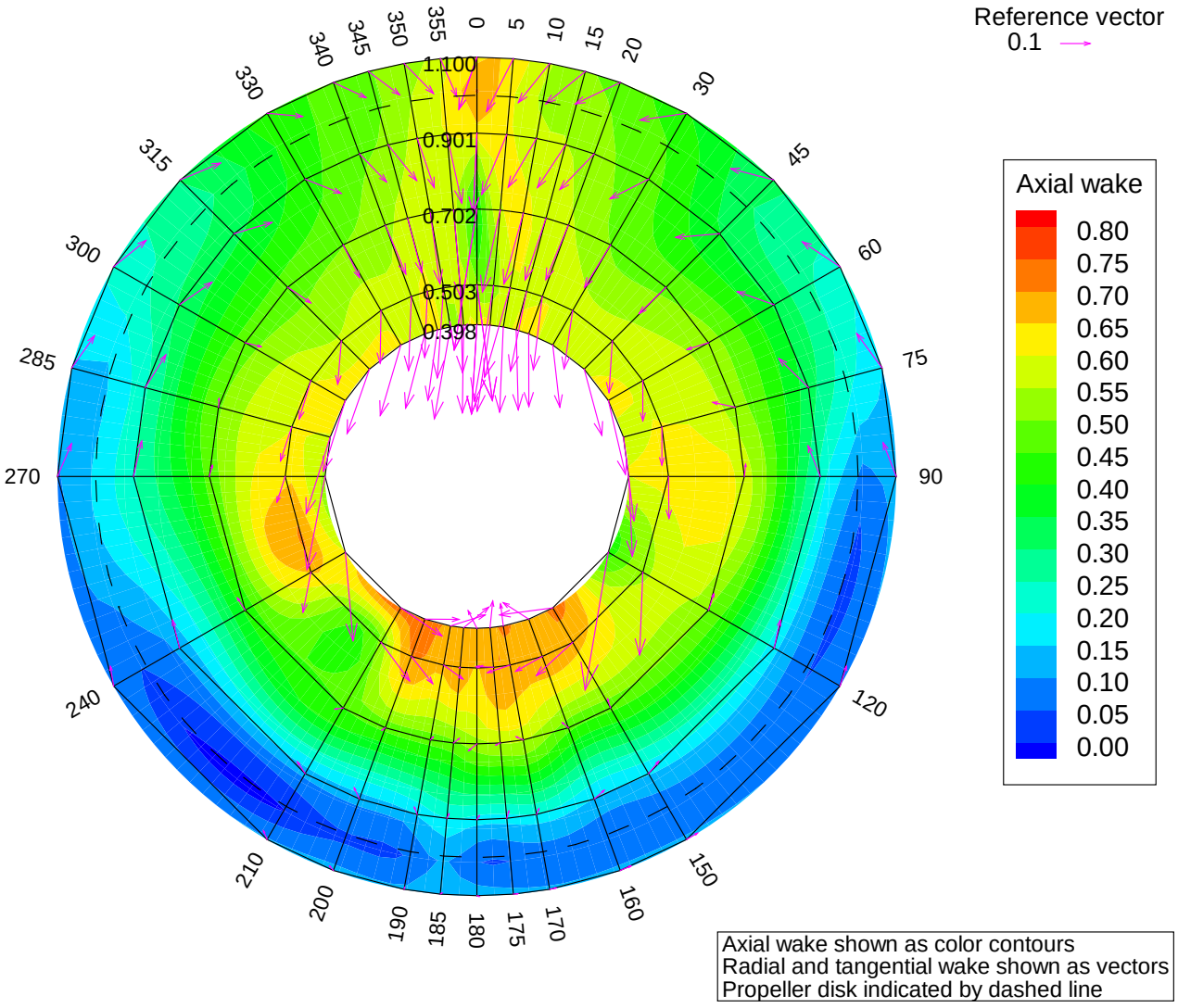
Angle [deg]	R/R0= 1.100 w_ax	w_t	w_r
0.0	0.638	-0.061	-0.177
5.0	0.636	-0.075	-0.187
10.0	0.555	-0.082	-0.149
15.0	0.508	-0.102	-0.142
20.0	0.484	-0.119	-0.121
30.0	0.406	-0.126	-0.100
45.0	0.314	-0.130	-0.076
60.0	0.226	-0.138	-0.068
75.0	0.149	-0.135	-0.053
90.0	0.117	-0.115	-0.045
120.0	0.097	-0.069	-0.015
150.0	0.106	-0.043	0.000
160.0	0.108	-0.039	-0.001
170.0	0.105	-0.022	-0.001
175.0	0.112	-0.015	0.000
180.0	0.123	-0.008	0.003
185.0	0.116	-0.005	-0.003
190.0	0.107	-0.001	-0.007
200.0	0.114	0.017	-0.009
210.0	0.105	0.026	-0.019
240.0	0.093	0.063	-0.024
270.0	0.095	0.111	-0.048
285.0	0.145	0.125	-0.046
300.0	0.210	0.133	-0.051
315.0	0.303	0.138	-0.057
330.0	0.423	0.099	-0.070
340.0	0.469	0.087	-0.087
345.0	0.497	0.083	-0.105
350.0	0.521	0.081	-0.118
355.0	0.578	0.045	-0.133
360.0	0.638	-0.061	-0.177
Mean=	0.216	-0.007	-0.049

Wake Analysis 1.3 : 2021-05-26 Measurement date: 26-May-2021 14:34:04

E-9 3D WAKE TEST - WL1

REFERENCE M3246

E-9.3 WAKE DISTRIBUTION

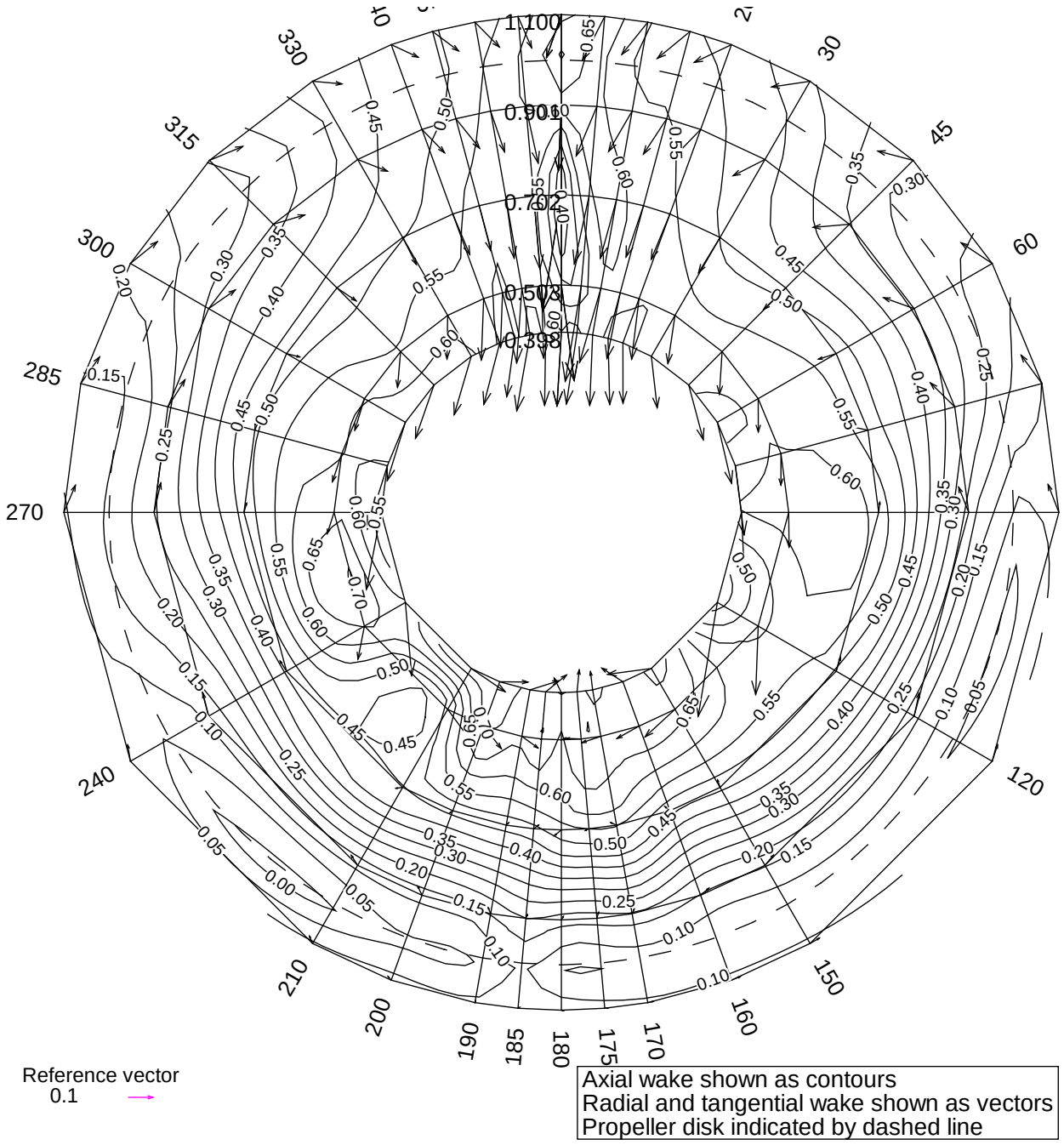


Wake Analysis 1.3 : 2021-05-26 Measurement date: 26-May-2021 14:34:04

E-9 3D WAKE TEST - WL1

REFERENCE M3246

E-9.4 WAKE DISTRIBUTION CONTOURS



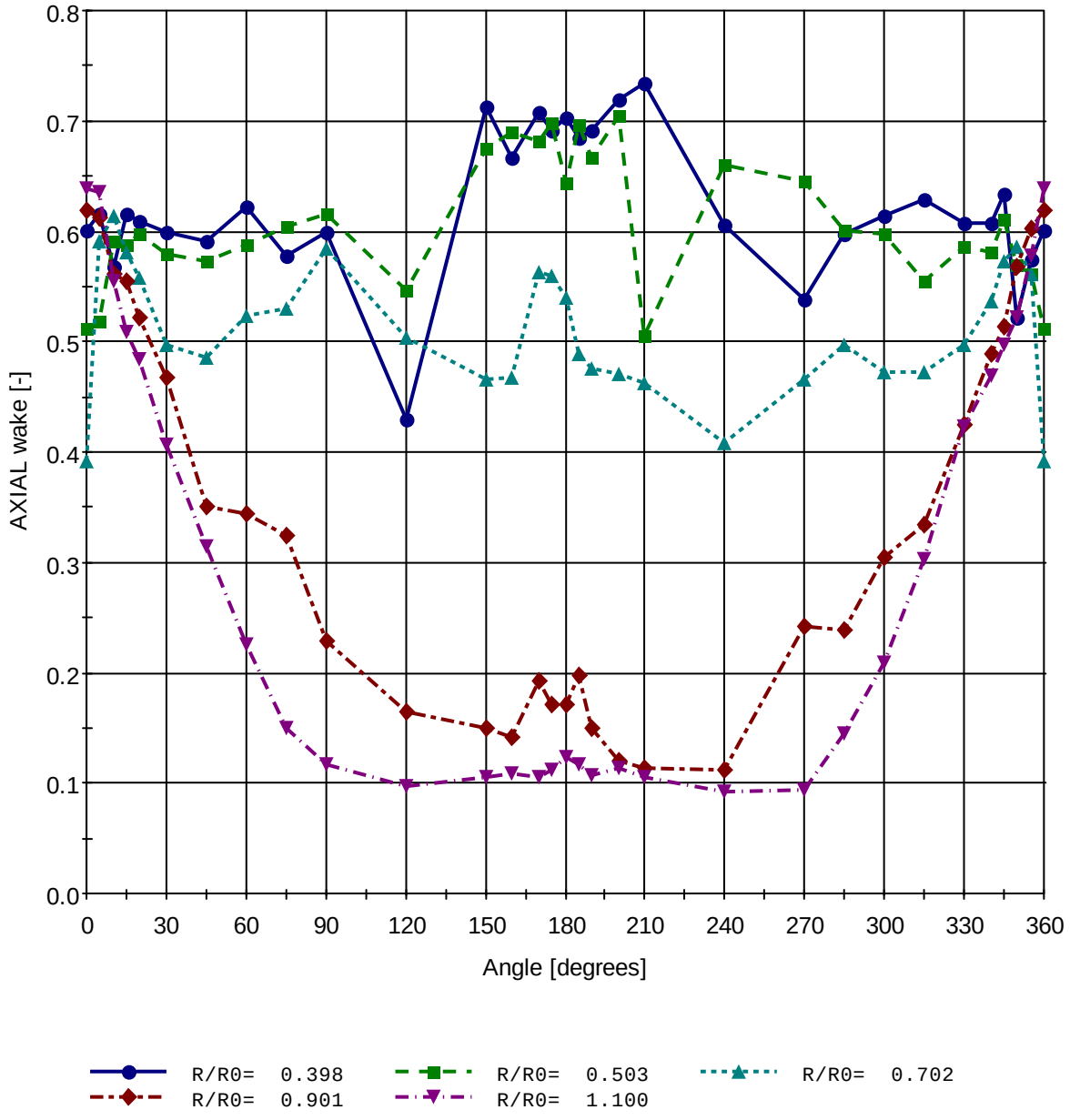
Wake Analysis 1.3 : 2021-05-26 Measurement date: 26-May-2021 14:34:04

E-9 3D WAKE TEST - WL1

REFERENCE M3246

E-9.5 AXIAL WAKE

HULL MODEL No.: M3246A
SOBC-1



Description: Untitled
Measurement date: 26-May-2021 14:34:04

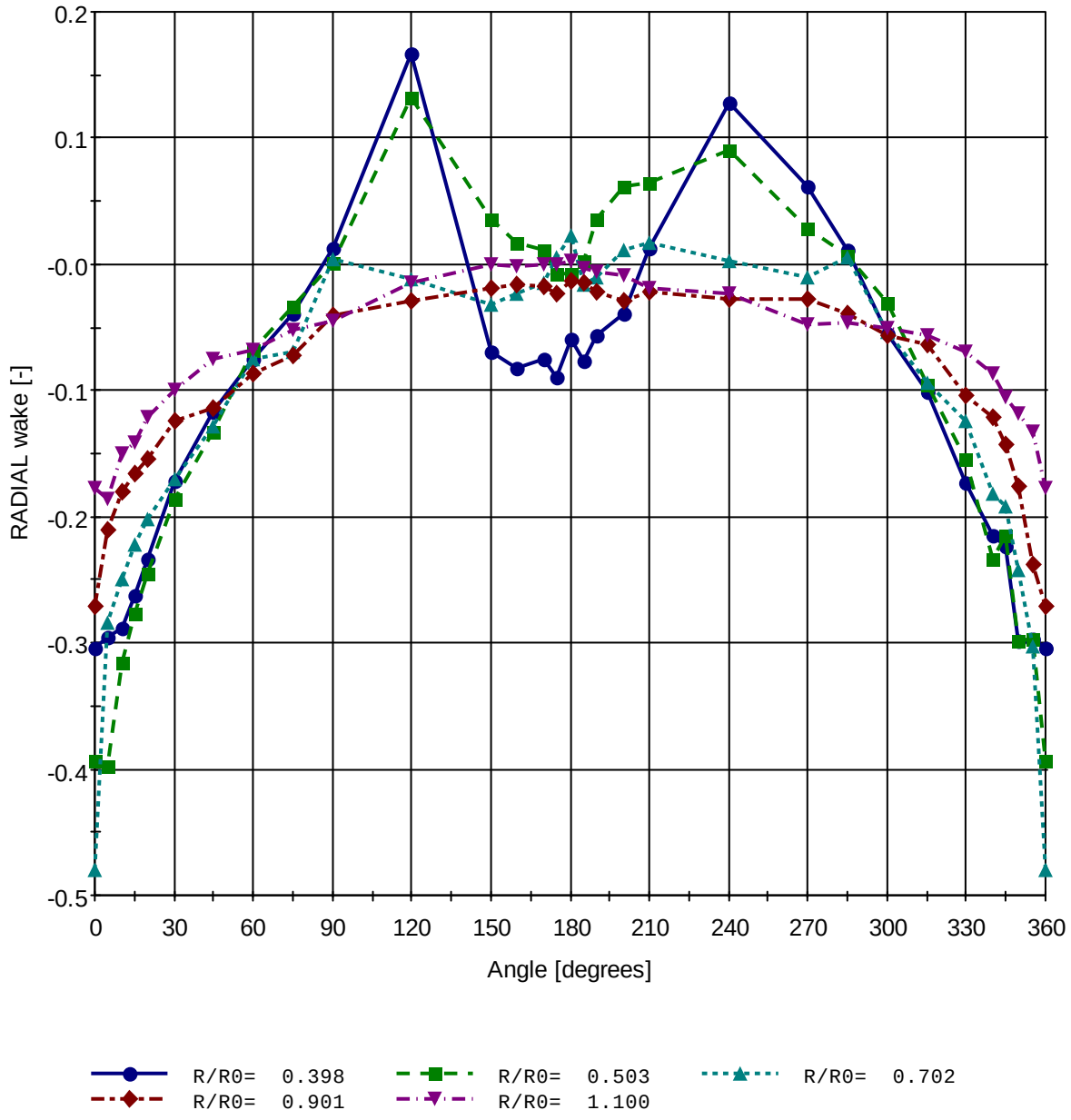
Wake Analysis 1.3 : 2021-05-26

E-9 3D WAKE TEST - WL1

REFERENCE M3246

E-9.6 RADIAL WAKE

HULL MODEL No.: M3246A
SOBC-1



Description: Untitled
Measurement date: 26-May-2021 14:34:04

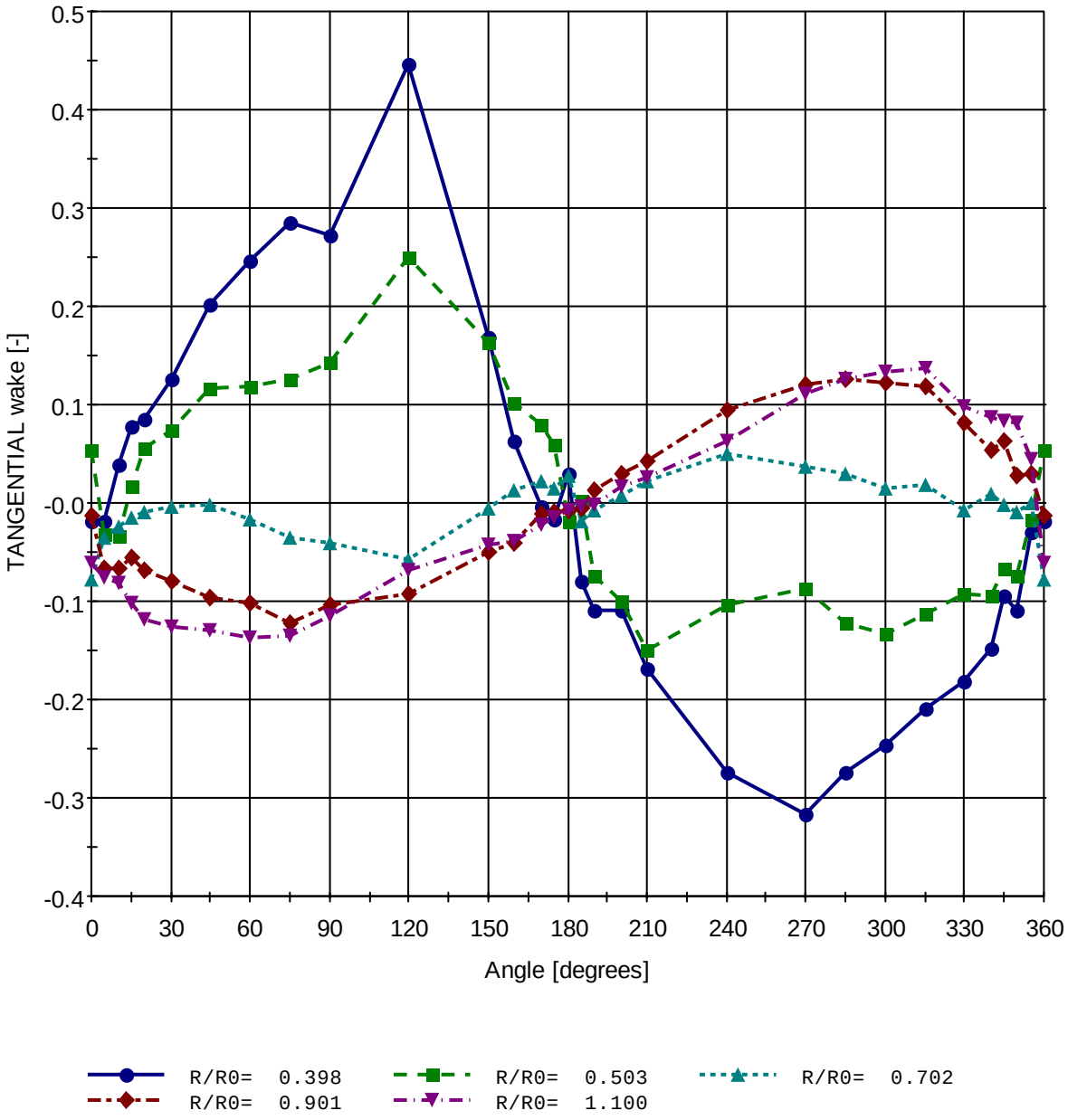
Wake Analysis 1.3 : 2021-05-26

E-9 3D WAKE TEST - WL1

REFERENCE M3246

E-9.7 TANGENTIAL WAKE

HULL MODEL No.: M3246A
SOBC-1



Description: Untitled
Measurement date: 26-May-2021 14:34:04

Wake Analysis 1.3 : 2021-05-26

E-9 3D WAKE TEST - WL1

E-9.8 HARMONIC ANALYSIS OF AXIAL WAKE (Page 1 of 3)

REFERENCE M3246

SOBC-1

HULL MODEL NO.: M3246A Model Scale: 32.000
Loading condition: WL 1
Draught AP/FP: 7.500 / 5.400 [m]
Description: Untitled

Radius: 0.40
MEAN VALUE : 0.609

IHARM	A	B	C	PHASE
1	-0.038	-0.017	0.041	204.052
2	0.055	0.011	0.056	11.757
3	-0.048	0.002	0.048	177.655
4	-0.008	-0.005	0.009	211.569
5	0.035	0.007	0.035	11.576
6	-0.015	0.007	0.017	154.813
7	0.003	-0.012	0.012	282.632
8	0.014	0.001	0.014	4.476
9	-0.004	0.005	0.007	130.126
10	-0.005	-0.013	0.014	249.904
11	0.002	-0.001	0.003	332.874
12	-0.001	-0.004	0.004	251.711
13	0.005	0.000	0.005	356.034
14	-0.002	0.002	0.003	139.348

Radius: 0.50
MEAN VALUE : 0.598

IHARM	A	B	C	PHASE
1	-0.031	-0.003	0.032	185.528
2	-0.008	-0.002	0.009	196.350
3	-0.009	0.034	0.035	105.369
4	0.012	-0.035	0.037	289.642
5	-0.021	0.020	0.029	137.398
6	0.005	0.019	0.020	76.192
7	-0.015	-0.019	0.024	232.314
8	-0.008	0.027	0.028	106.941
9	0.003	-0.005	0.006	301.580
10	-0.012	0.009	0.015	140.943
11	0.004	-0.001	0.005	347.130
12	-0.010	0.001	0.010	172.566
13	0.002	0.006	0.007	70.188
14	-0.002	0.000	0.002	192.622

Wake Analysis 1.3 : 2021-05-26 Measurement date: 26-May-2021 14:34:04

E-9 3D WAKE TEST - WL1

E-9.9 HARMONIC ANALYSIS OF AXIAL WAKE (Page 2 of 3)

REFERENCE M3246

SOBC-1

HULL MODEL NO.: M3246A Model Scale: 32.000
Loading condition: WL 1
Draught AP/FP: 7.500 / 5.400 [m]
Description: Untitled

Radius: 0.70
MEAN VALUE : 0.492

IHARM	A	B	C	PHASE
1	0.013	0.037	0.039	71.237
2	-0.008	-0.012	0.014	238.393
3	-0.020	-0.005	0.021	193.605
4	0.019	0.003	0.019	9.525
5	-0.017	0.013	0.022	141.666
6	-0.020	0.005	0.021	165.677
7	-0.014	0.022	0.026	122.334
8	-0.011	0.012	0.016	133.833
9	-0.013	0.024	0.027	117.964
10	-0.017	0.007	0.018	156.863
11	-0.005	0.015	0.015	107.462
12	-0.008	0.009	0.012	131.558
13	0.002	0.008	0.008	75.653
14	-0.003	0.006	0.007	113.174

Radius: 0.90
MEAN VALUE : 0.285

IHARM	A	B	C	PHASE
1	0.205	0.000	0.205	359.957
2	0.069	-0.017	0.071	346.383
3	0.019	0.005	0.019	14.821
4	0.029	-0.022	0.036	322.495
5	0.008	-0.007	0.010	319.545
6	0.008	0.006	0.010	37.776
7	-0.003	0.003	0.004	131.895
8	-0.008	-0.010	0.013	232.693
9	0.000	0.002	0.002	99.250
10	0.003	-0.005	0.006	300.348
11	0.007	-0.001	0.007	348.681
12	-0.002	-0.003	0.003	231.595
13	0.001	0.000	0.001	340.520
14	-0.002	0.003	0.003	128.505

Wake Analysis 1.3 : 2021-05-26 Measurement date: 26-May-2021 14:34:04

E-9 3D WAKE TEST - WL1

E-9.10 HARMONIC ANALYSIS OF AXIAL WAKE (Page 3 of 3)

REFERENCE M3246

SOBC-1

HULL MODEL NO.: M3246A Model Scale: 32.000
Loading condition: WL 1
Draught AP/FP: 7.500 / 5.400 [m]
Description: Untitled

Radius: 1.10
MEAN VALUE : 0.228

IHARM	A	B	C	PHASE
1	0.208	-0.015	0.208	355.805
2	0.120	-0.024	0.122	348.737
3	0.034	-0.013	0.036	339.133
4	0.012	-0.003	0.013	344.849
5	0.009	-0.003	0.010	339.553
6	0.009	-0.005	0.010	330.432
7	0.007	-0.003	0.008	335.462
8	0.007	-0.002	0.008	341.941
9	0.004	-0.005	0.006	312.467
10	0.002	-0.007	0.007	282.886
11	0.000	-0.004	0.004	267.514
12	0.000	-0.005	0.005	268.457
13	0.000	-0.001	0.001	242.620
14	0.000	-0.003	0.003	271.069

Wake Analysis 1.3 : 2021-05-26 Measurement date: 26-May-2021 14:34:04

E-9 3D WAKE TEST - WL1

E-9.11 HARMONIC ANALYSIS OF RADIAL WAKE (Page 1 of 3)

REFERENCE M3246

SOBC-1

HULL MODEL NO.: M3246A Model Scale: 32.000
Loading condition: WL 1
Draught AP/FP: 7.500 / 5.400 [m]
Description: Untitled

Radius: 0.40
MEAN VALUE : -0.052

IHARM	A	B	C	PHASE
1	-0.132	0.001	0.132	179.737
2	-0.117	0.026	0.120	167.399
3	0.028	-0.013	0.031	334.853
4	-0.021	0.025	0.033	130.303
5	-0.022	-0.001	0.022	181.852
6	0.010	-0.011	0.015	314.000
7	-0.001	0.012	0.012	97.248
8	-0.001	-0.006	0.006	255.665
9	0.002	-0.002	0.003	312.836
10	0.000	-0.002	0.002	280.329
11	0.000	0.000	0.000	265.926
12	0.001	0.001	0.001	31.130
13	0.001	-0.001	0.001	315.526
14	0.001	0.001	0.001	42.670

Radius: 0.50
MEAN VALUE : -0.048

IHARM	A	B	C	PHASE
1	-0.171	0.008	0.171	177.272
2	-0.098	0.009	0.098	174.740
3	-0.010	0.000	0.010	180.367
4	-0.031	0.025	0.040	140.145
5	-0.016	-0.001	0.016	184.143
6	-0.001	0.004	0.004	100.267
7	-0.007	0.007	0.010	135.578
8	-0.008	0.006	0.010	142.446
9	-0.001	-0.001	0.002	227.114
10	-0.005	0.003	0.006	148.353
11	-0.002	0.001	0.002	162.589
12	-0.003	0.007	0.007	117.772
13	0.001	0.003	0.003	74.206
14	0.002	0.007	0.007	76.392

Wake Analysis 1.3 : 2021-05-26 Measurement date: 26-May-2021 14:34:04

E-9 3D WAKE TEST - WL1

E-9.12 HARMONIC ANALYSIS OF RADIAL WAKE (Page 2 of 3)

REFERENCE M3246

SOBC-1

HULL MODEL NO.: M3246A Model Scale: 32.000
Loading condition: WL 1
Draught AP/FP: 7.500 / 5.400 [m]
Description: Untitled

Radius: 0.70
MEAN VALUE : -0.081

IHARM	A	B	C	PHASE
1	-0.134	-0.001	0.134	180.280
2	-0.085	0.014	0.086	170.617
3	-0.049	0.003	0.049	176.540
4	-0.022	0.021	0.031	136.955
5	-0.030	0.016	0.034	151.578
6	-0.027	0.008	0.028	162.315
7	-0.015	0.019	0.024	128.702
8	-0.008	0.018	0.019	113.427
9	-0.011	0.015	0.019	126.811
10	-0.011	0.007	0.013	147.156
11	-0.008	0.011	0.013	125.116
12	-0.002	0.007	0.007	102.731
13	0.000	0.011	0.011	92.486
14	0.001	0.003	0.003	73.473

Radius: 0.90
MEAN VALUE : -0.071

IHARM	A	B	C	PHASE
1	-0.079	-0.003	0.079	181.963
2	-0.041	-0.002	0.041	182.179
3	-0.022	0.006	0.023	165.575
4	-0.014	0.007	0.016	153.597
5	-0.013	0.010	0.016	142.982
6	-0.011	0.006	0.013	150.970
7	-0.005	0.007	0.009	128.384
8	-0.004	0.005	0.006	134.747
9	-0.005	0.006	0.008	131.706
10	-0.003	0.004	0.004	123.762
11	-0.001	0.004	0.004	102.699
12	0.001	0.003	0.003	70.285
13	0.000	0.003	0.003	84.379
14	0.000	0.001	0.001	107.714

Wake Analysis 1.3 : 2021-05-26 Measurement date: 26-May-2021 14:34:04

E-9 3D WAKE TEST - WL1

E-9.13 HARMONIC ANALYSIS OF RADIAL WAKE (Page 3 of 3)

REFERENCE M3246

SOBC-1

HULL MODEL NO.: M3246A Model Scale: 32.000
Loading condition: WL 1
Draught AP/FP: 7.500 / 5.400 [m]
Description: Untitled

Radius: 1.10
MEAN VALUE : -0.053

IHARM	A	B	C	PHASE
1	-0.060	0.004	0.060	176.131
2	-0.019	-0.007	0.020	200.620
3	-0.016	0.003	0.016	169.992
4	-0.013	0.002	0.013	169.424
5	-0.008	0.003	0.009	156.758
6	-0.004	0.002	0.004	148.917
7	-0.005	0.003	0.006	153.730
8	-0.001	0.003	0.003	114.115
9	0.000	0.002	0.002	99.641
10	0.000	0.002	0.002	96.939
11	0.000	0.002	0.002	86.032
12	0.000	0.000	0.000	62.575
13	0.001	0.000	0.001	28.063
14	0.001	-0.001	0.001	322.066

Wake Analysis 1.3 : 2021-05-26 Measurement date: 26-May-2021 14:34:04

E-9 3D WAKE TEST - WL1

E-9.14 HARMONIC ANALYSIS OF TANGENTIAL WAKE (Page 1 of 3)

REFERENCE M3246

SOBC-1

HULL MODEL NO.: M3246A Model Scale: 32.000
Loading condition: WL 1
Draught AP/FP: 7.500 / 5.400 [m]
Description: Untitled

Radius: 0.40
MEAN VALUE : 0.003

IHARM	A	B	C	PHASE
1	0.012	0.323	0.323	87.948
2	-0.028	-0.043	0.052	236.829
3	0.024	0.000	0.024	359.082
4	-0.011	0.027	0.029	113.246
5	-0.007	-0.023	0.024	253.274
6	0.022	-0.006	0.023	345.309
7	-0.008	0.007	0.011	139.910
8	-0.002	-0.008	0.008	257.403
9	-0.001	-0.002	0.002	243.226
10	-0.002	-0.006	0.007	256.087
11	-0.005	0.007	0.009	124.885
12	-0.005	-0.005	0.007	223.286
13	-0.004	0.007	0.008	119.167
14	-0.003	-0.007	0.007	244.254

Radius: 0.50
MEAN VALUE : 0.015

IHARM	A	B	C	PHASE
1	0.002	0.165	0.165	89.166
2	-0.025	-0.036	0.044	234.695
3	0.040	0.029	0.050	35.820
4	-0.007	-0.012	0.014	239.082
5	-0.005	-0.008	0.009	239.004
6	0.013	-0.006	0.014	334.034
7	0.007	-0.009	0.011	310.652
8	0.002	-0.010	0.011	278.859
9	0.007	-0.010	0.012	303.736
10	-0.003	-0.009	0.010	250.413
11	0.004	-0.006	0.007	302.273
12	-0.004	-0.007	0.008	238.028
13	0.003	-0.003	0.005	314.226
14	0.000	-0.003	0.003	277.000

Wake Analysis 1.3 : 2021-05-26 Measurement date: 26-May-2021 14:34:04

E-9 3D WAKE TEST - WL1

E-9.15 HARMONIC ANALYSIS OF TANGENTIAL WAKE (Page 2 of 3)

REFERENCE M3246

SOBC-1

HULL MODEL NO.: M3246A Model Scale: 32.000
Loading condition: WL 1
Draught AP/FP: 7.500 / 5.400 [m]
Description: Untitled

Radius: 0.70
MEAN VALUE : -0.004

IHARM	A	B	C	PHASE
1	-0.019	-0.033	0.039	239.821
2	-0.003	0.015	0.015	100.173
3	-0.013	0.012	0.017	137.566
4	-0.012	-0.004	0.012	200.802
5	-0.006	0.009	0.011	124.053
6	-0.008	-0.001	0.008	185.890
7	-0.004	0.005	0.006	127.245
8	-0.003	0.002	0.004	150.033
9	-0.003	0.006	0.007	118.973
10	-0.003	0.003	0.004	135.727
11	0.000	0.005	0.005	94.524
12	0.001	0.001	0.001	53.379
13	0.001	0.001	0.002	56.540
14	0.000	-0.001	0.001	266.019

Radius: 0.90
MEAN VALUE : 0.001

IHARM	A	B	C	PHASE
1	-0.013	-0.118	0.119	263.891
2	-0.010	-0.011	0.015	226.449
3	-0.004	-0.001	0.004	188.747
4	-0.002	0.001	0.002	161.772
5	-0.001	0.002	0.002	119.290
6	0.001	-0.001	0.002	333.017
7	0.003	-0.001	0.003	334.607
8	0.003	0.000	0.003	8.248
9	0.000	0.001	0.001	102.552
10	-0.001	0.000	0.001	186.664
11	0.002	0.000	0.002	14.692
12	0.001	0.002	0.003	60.302
13	0.004	0.001	0.004	16.741
14	0.002	0.003	0.004	50.787

Wake Analysis 1.3 : 2021-05-26 Measurement date: 26-May-2021 14:34:04

E-9 3D WAKE TEST - WL1

E-9.16 HARMONIC ANALYSIS OF TANGENTIAL WAKE (Page 3 of 3)

REFERENCE M3246

SOBC-1

HULL MODEL NO.: M3246A Model Scale: 32.000
Loading condition: WL 1
Draught AP/FP: 7.500 / 5.400 [m]
Description: Untitled

Radius: 1.10
MEAN VALUE : -0.009

IHARM	A	B	C	PHASE
1	-0.018	-0.121	0.122	261.434
2	-0.019	-0.038	0.042	243.310
3	-0.009	-0.006	0.011	217.031
4	-0.007	0.001	0.007	172.898
5	-0.007	-0.001	0.007	189.565
6	-0.003	0.002	0.003	149.573
7	-0.002	0.002	0.003	141.803
8	-0.002	0.003	0.004	118.135
9	-0.002	0.006	0.006	104.845
10	-0.001	0.006	0.006	97.859
11	0.002	0.007	0.007	75.096
12	0.003	0.005	0.006	61.799
13	0.004	0.004	0.006	44.398
14	0.004	0.002	0.004	24.032

Wake Analysis 1.3 : 2021-05-26 Measurement date: 26-May-2021 14:34:04

E-10 3D WAKE TEST - DWL

REFERENCE M3246

E-10.1 WAKE MEASUREMENTS RESULTS (Page 1 of 2)

SOBC-1

HULL MODEL NO.: M3246A Model Scale: 32.000
Loading condition: DWL - Design waterline
Draught AP/FP: 11.000 / 11.000 [m]
Description: DWL-15 kn

Angle	R/R0= 0.398			R/R0= 0.503			R/R0= 0.702			R/R0= 0.901		
[deg]	w_ax	w_t	w_r	w_ax	w_t	w_r	w_ax	w_t	w_r	w_ax	w_t	w_r
0.0	0.569	-0.005	-0.356	0.548	-0.005	-0.384	0.387	0.004	-0.503	0.641	0.003	-0.222
5.0	0.537	0.026	-0.351	0.577	0.008	-0.343	0.625	-0.036	-0.266	0.623	-0.037	-0.215
10.0	0.616	0.043	-0.248	0.603	0.006	-0.271	0.586	-0.023	-0.240	0.544	-0.056	-0.161
15.0	0.590	0.082	-0.277	0.617	0.034	-0.261	0.612	0.000	-0.191	0.546	-0.075	-0.135
20.0	0.650	0.112	-0.207	0.645	0.045	-0.185	0.561	-0.021	-0.139	0.481	-0.079	-0.112
30.0	0.682	0.120	-0.137	0.662	0.058	-0.117	0.609	-0.018	-0.084	0.500	-0.094	-0.047
45.0	0.676	0.144	-0.060	0.697	0.068	-0.046	0.560	-0.047	-0.050	0.317	-0.161	-0.020
60.0	0.659	0.163	0.007	0.718	-0.003	-0.024	0.518	-0.125	-0.043	0.160	-0.180	-0.015
75.0	0.685	0.128	0.042	0.678	-0.011	0.011	0.345	-0.086	-0.043	0.116	-0.170	-0.023
90.0	0.696	0.105	0.063	0.647	-0.018	-0.023	0.206	-0.114	-0.059	0.083	-0.137	-0.037
120.0	0.714	0.095	-0.022	0.523	0.016	-0.044	0.141	-0.064	-0.062	0.088	-0.069	-0.056
150.0	0.662	0.042	-0.006	0.524	-0.001	-0.045	0.114	-0.016	-0.085	0.088	-0.034	-0.062
160.0	0.705	0.035	0.008	0.443	0.027	-0.078	0.103	-0.020	-0.073	0.093	-0.024	-0.063
170.0	0.578	0.018	-0.087	0.470	0.045	-0.079	0.187	0.004	-0.083	0.089	-0.009	-0.060
175.0	0.611	-0.021	-0.071	0.491	0.030	-0.049	0.203	0.006	-0.086	0.090	-0.004	-0.061
180.0	0.627	-0.012	-0.058	0.540	0.017	-0.041	0.219	0.006	-0.075	0.090	0.004	-0.064
185.0	0.624	-0.005	-0.068	0.503	0.011	-0.059	0.177	-0.006	-0.086	0.088	0.008	-0.061
190.0	0.597	0.007	-0.064	0.506	0.001	-0.058	0.176	0.023	-0.077	0.093	0.012	-0.059
200.0	0.558	-0.069	-0.067	0.505	-0.029	-0.032	0.124	0.020	-0.085	0.093	0.027	-0.060
210.0	0.670	-0.053	-0.014	0.484	-0.034	-0.065	0.107	0.029	-0.090	0.083	0.040	-0.060
240.0	0.711	-0.048	0.004	0.559	0.032	-0.044	0.134	0.087	-0.071	0.091	0.081	-0.051
270.0	0.724	-0.063	0.055	0.641	0.003	0.021	0.196	0.140	-0.052	0.090	0.131	-0.036
285.0	0.658	-0.146	0.043	0.647	0.009	0.023	0.378	0.135	-0.055	0.105	0.172	-0.014
300.0	0.691	-0.127	0.018	0.700	-0.037	0.044	0.511	0.106	-0.014	0.280	0.171	-0.004
315.0	0.670	-0.152	-0.044	0.680	-0.073	-0.005	0.617	0.027	0.002	0.373	0.143	0.016
330.0	0.654	-0.140	-0.119	0.616	-0.085	-0.104	0.579	-0.001	-0.065	0.412	0.115	-0.037
340.0	0.609	-0.117	-0.201	0.626	-0.078	-0.171	0.557	-0.005	-0.127	0.467	0.070	-0.082
345.0	0.583	-0.117	-0.275	0.636	-0.059	-0.216	0.567	0.002	-0.164	0.500	0.063	-0.119
350.0	0.600	-0.090	-0.249	0.589	-0.049	-0.281	0.576	-0.009	-0.198	0.530	0.037	-0.141
355.0	0.604	-0.044	-0.271	0.601	-0.047	-0.290	0.586	0.012	-0.286	0.577	0.046	-0.191
360.0	0.569	-0.005	-0.356	0.548	-0.005	-0.384	0.387	0.004	-0.503	0.641	0.003	-0.222
Mean=	0.665	0.003	-0.048	0.595	-0.002	-0.065	0.324	0.003	-0.084	0.211	0.000	-0.055

Wake Analysis 1.3 : 2021-05-26 Measurement date: 26-May-2021 14:11:41

E-10 3D WAKE TEST - DWL

REFERENCE M3246

E-10.2 WAKE MEASUREMENTS RESULTS (Page 2 of 2)

SOBC-1

HULL MODEL NO.: M3246A Model Scale: 32.000
Loading condition: DWL - Design waterline
Draught AP/FP: 11.000 / 11.000 [m]
Description: DWL-15 kn

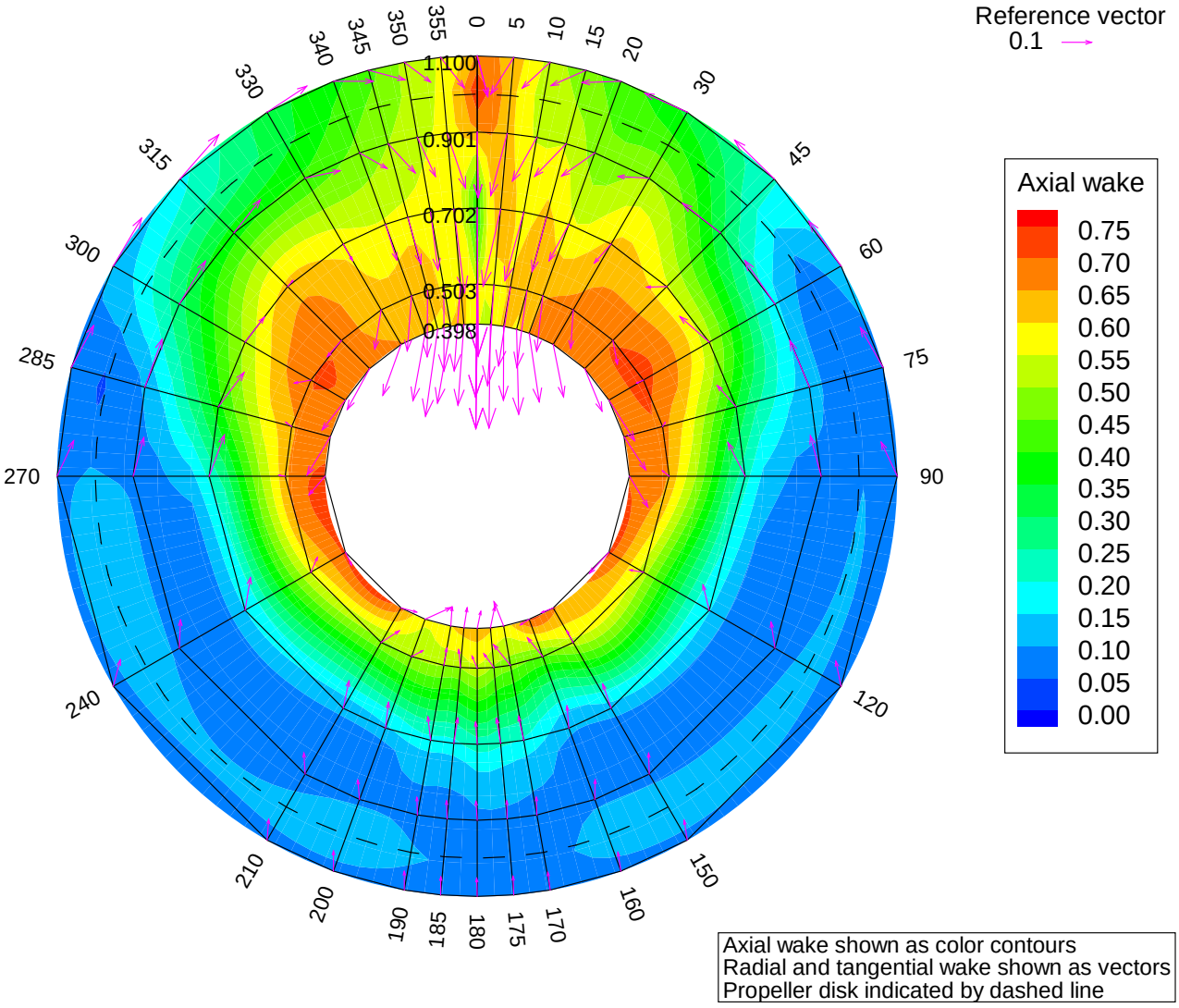
Angle [deg]	R/R0= 1.100 w_ax	w_t	w_r
0.0	0.658	0.036	-0.138
5.0	0.627	-0.067	-0.131
10.0	0.535	-0.078	-0.103
15.0	0.469	-0.101	-0.081
20.0	0.429	-0.122	-0.049
30.0	0.338	-0.157	-0.016
45.0	0.203	-0.188	-0.002
60.0	0.132	-0.186	-0.019
75.0	0.082	-0.150	-0.040
90.0	0.081	-0.116	-0.055
120.0	0.083	-0.065	-0.058
150.0	0.089	-0.025	-0.063
160.0	0.086	-0.012	-0.063
170.0	0.086	-0.003	-0.060
175.0	0.088	-0.003	-0.063
180.0	0.087	0.002	-0.061
185.0	0.091	0.004	-0.061
190.0	0.089	0.011	-0.062
200.0	0.087	0.023	-0.064
210.0	0.087	0.031	-0.064
240.0	0.084	0.066	-0.065
270.0	0.084	0.120	-0.056
285.0	0.084	0.157	-0.037
300.0	0.105	0.189	-0.002
315.0	0.183	0.199	0.013
330.0	0.324	0.161	0.009
340.0	0.387	0.126	-0.046
345.0	0.431	0.112	-0.064
350.0	0.514	0.076	-0.082
355.0	0.554	0.071	-0.109
360.0	0.658	0.036	-0.138
Mean=	0.172	0.003	-0.049

Wake Analysis 1.3 : 2021-05-26 Measurement date: 26-May-2021 14:11:41

E-10 3D WAKE TEST - DWL

REFERENCE M3246

E-10.3 WAKE DISTRIBUTION

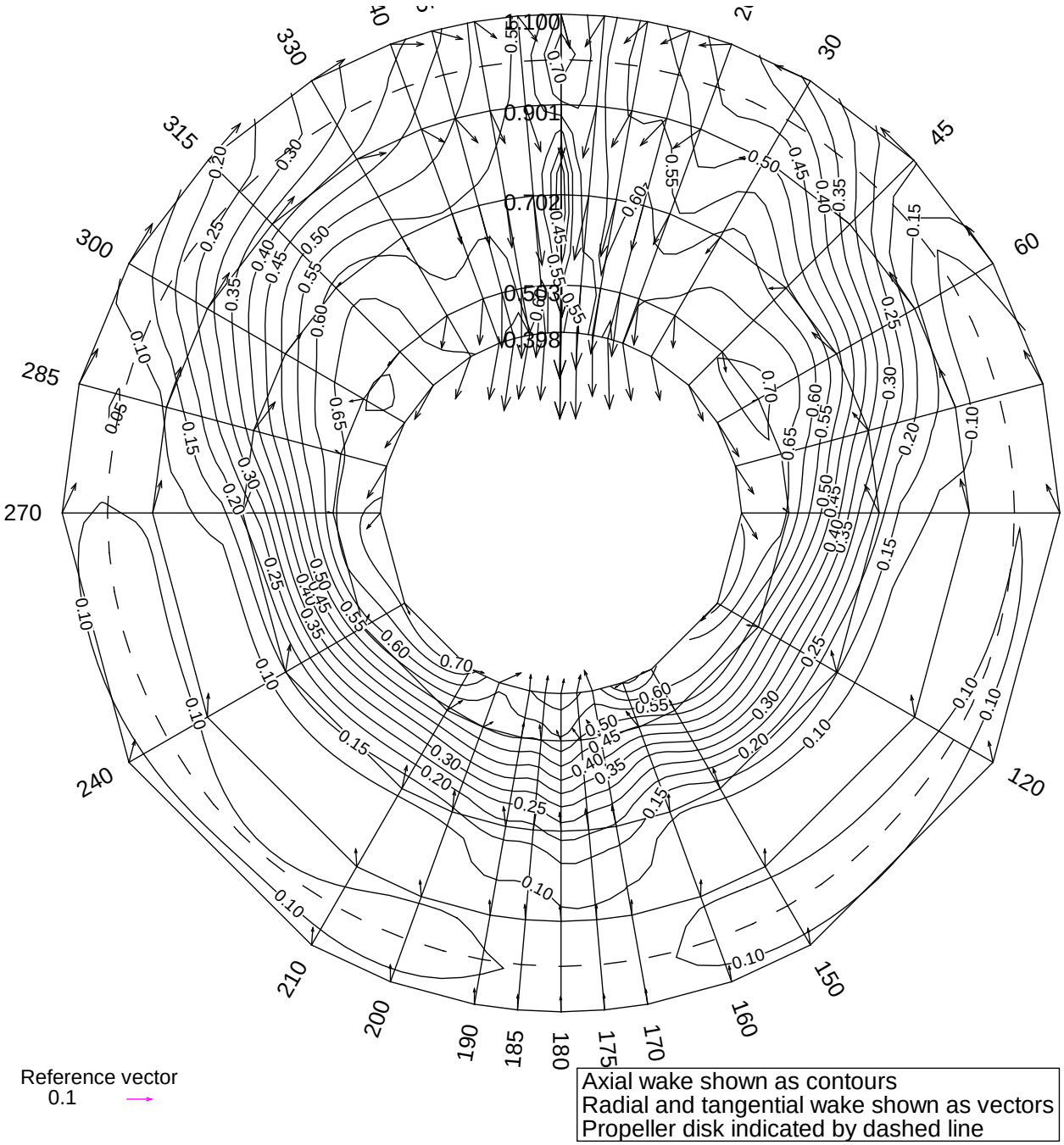


Wake Analysis 1.3 : 2021-05-26 Measurement date: 26-May-2021 14:11:41

E-10 3D WAKE TEST - DWL

REFERENCE M3246

E-10.4 WAKE DISTRIBUTION CONTOURS



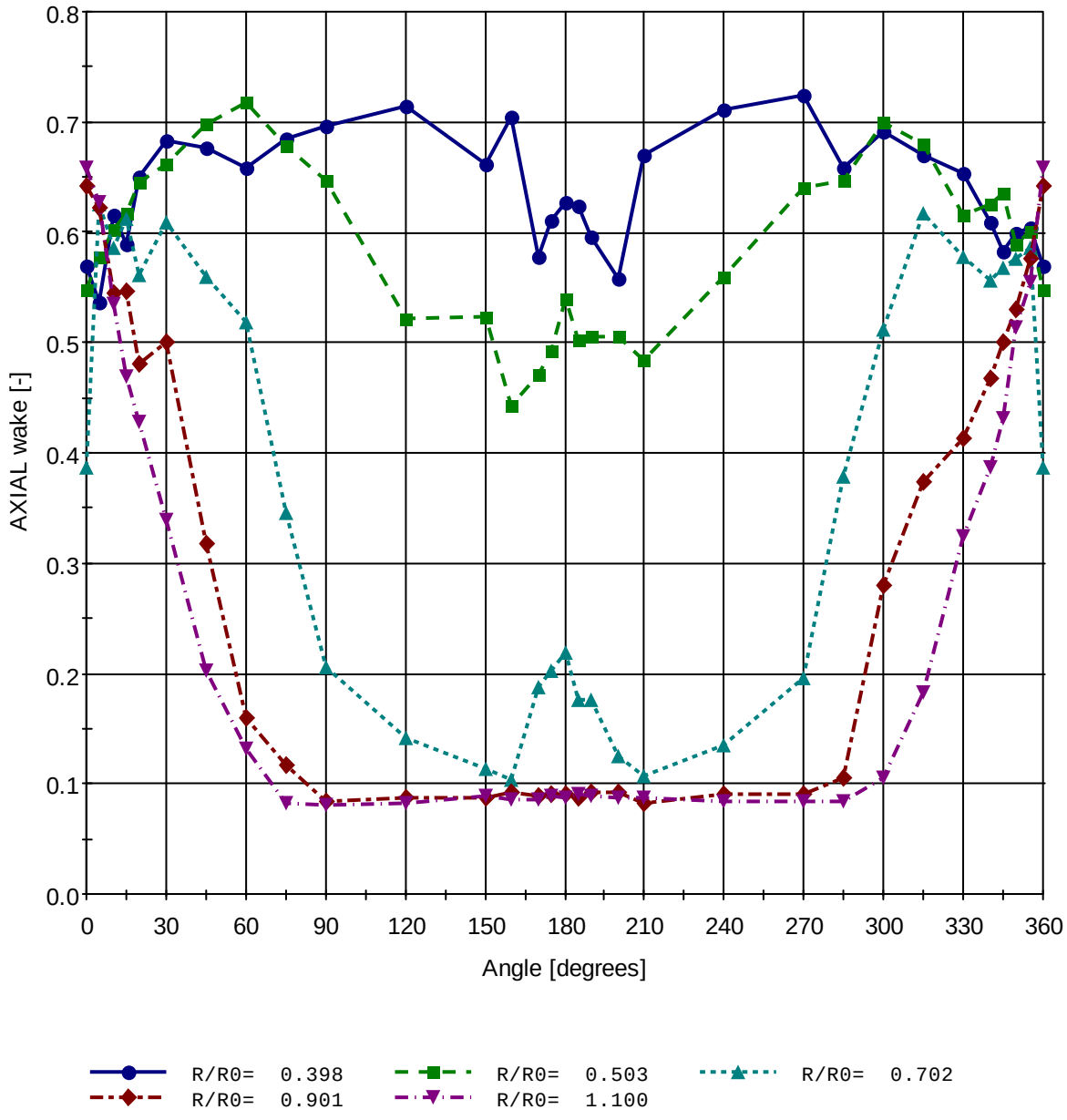
Wake Analysis 1.3 : 2021-05-26 Measurement date: 26-May-2021 14:11:41

E-10 3D WAKE TEST - DWL

REFERENCE M3246

E-10.5 AXIAL WAKE

HULL MODEL No.: M3246A
SOBC-1



Description: DWL-15 kn
Measurement date: 26-May-2021 14:11:41

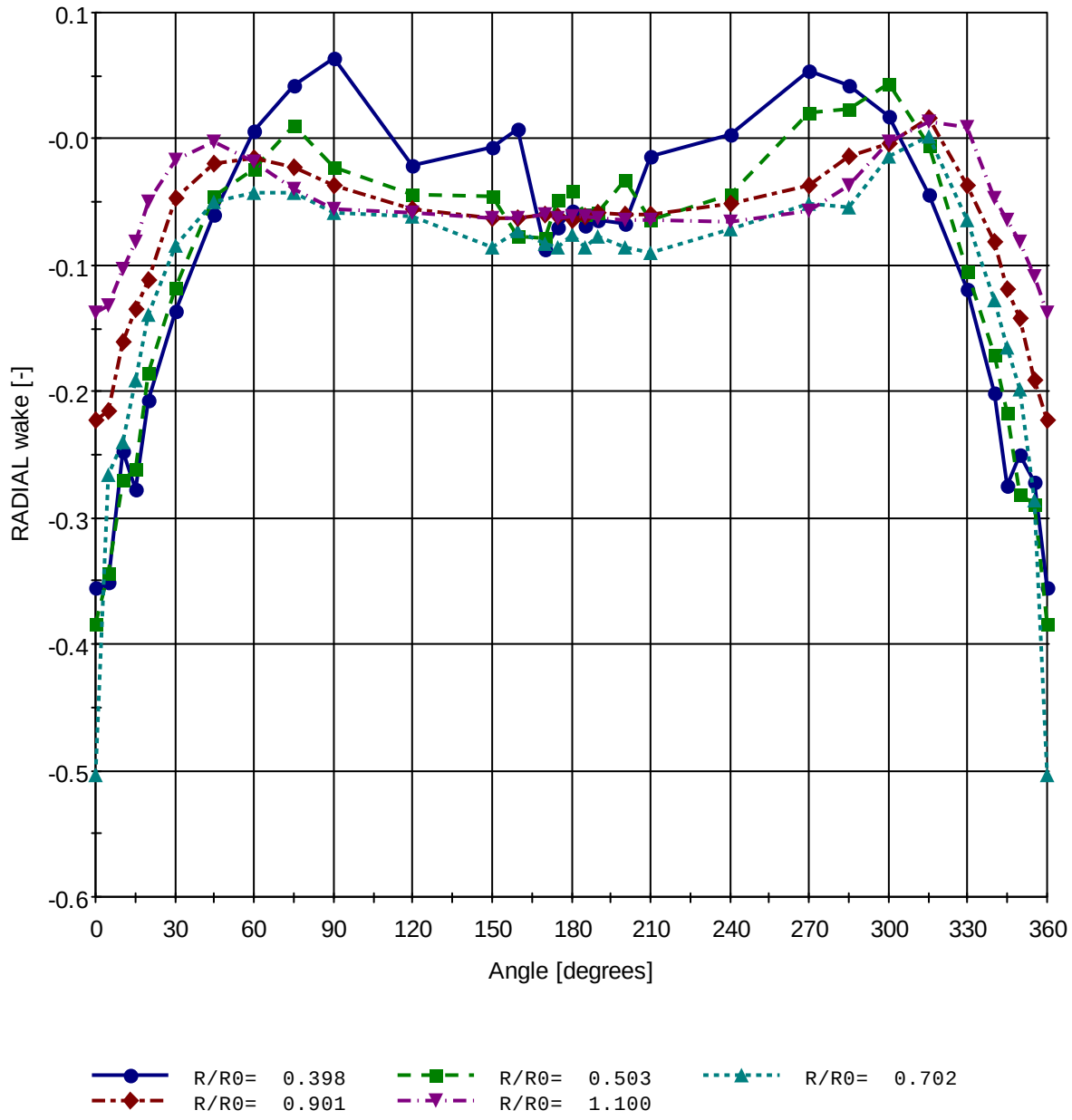
Wake Analysis 1.3 : 2021-05-26

E-10 3D WAKE TEST - DWL

REFERENCE M3246

E-10.6 RADIAL WAKE

HULL MODEL No.: M3246A
SOBC-1



Description: DWL-15 kn
Measurement date: 26-May-2021 14:11:41

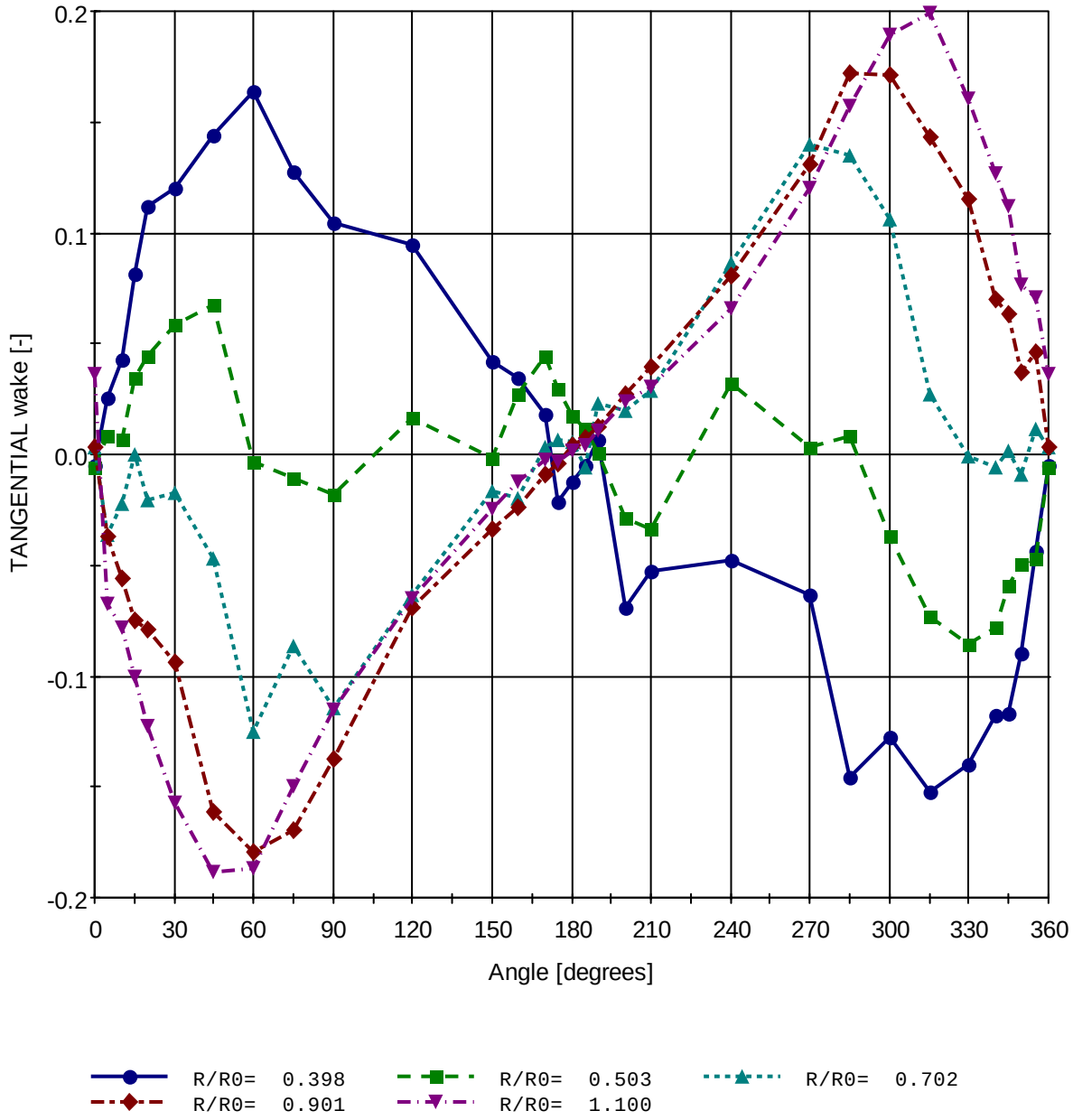
Wake Analysis 1.3 : 2021-05-26

E-10 3D WAKE TEST - DWL

REFERENCE M3246

E-10.7 TANGENTIAL WAKE

HULL MODEL No.: M3246A
SOBC-1



Description: DWL-15 kn
Measurement date: 26-May-2021 14:11:41

Wake Analysis 1.3 : 2021-05-26

E-10 3D WAKE TEST - DWL

E-10.8 HARMONIC ANALYSIS OF AXIAL WAKE (Page 1 of 3)

REFERENCE M3246

SOBC-1

HULL MODEL NO.: M3246A Model Scale: 32.000
Loading condition: DWL - Design waterline
Draught AP/FP: 11.000 / 11.000 [m]
Description: DWL-15 kn

Radius: 0.40
MEAN VALUE : 0.664

IHARM	A	B	C	PHASE
1	-0.016	-0.002	0.016	187.515
2	-0.050	0.018	0.053	159.843
3	0.011	0.002	0.011	11.042
4	-0.022	0.009	0.024	157.963
5	-0.004	0.017	0.018	104.192
6	-0.013	-0.003	0.013	193.529
7	0.007	0.005	0.008	36.889
8	-0.008	-0.007	0.011	220.700
9	-0.007	0.000	0.007	183.115
10	0.012	0.003	0.012	13.119
11	-0.010	-0.004	0.011	201.362
12	0.009	-0.005	0.010	332.034
13	-0.010	0.002	0.010	171.124
14	0.006	-0.005	0.008	321.439

Radius: 0.50
MEAN VALUE : 0.594

IHARM	A	B	C	PHASE
1	0.072	-0.002	0.072	358.255
2	-0.055	0.020	0.058	160.451
3	-0.035	0.018	0.039	152.929
4	-0.008	-0.001	0.008	189.979
5	-0.006	0.001	0.006	171.442
6	0.008	0.009	0.012	50.486
7	-0.013	-0.009	0.016	213.267
8	0.003	0.001	0.003	26.181
9	-0.013	0.011	0.017	140.483
10	-0.001	-0.002	0.002	245.629
11	0.000	0.005	0.005	88.914
12	-0.001	-0.004	0.004	260.670
13	0.002	0.003	0.004	56.851
14	0.000	-0.001	0.001	265.696

Wake Analysis 1.3 : 2021-05-26 Measurement date: 26-May-2021 14:11:41

E-10 3D WAKE TEST - DWL

E-10.9 HARMONIC ANALYSIS OF AXIAL WAKE (Page 2 of 3)

REFERENCE M3246

SOBC-1

HULL MODEL NO.: M3246A Model Scale: 32.000
Loading condition: DWL - Design waterline
Draught AP/FP: 11.000 / 11.000 [m]
Description: DWL-15 kn

Radius: 0.70
MEAN VALUE : 0.320

IHARM	A	B	C	PHASE
1	0.240	-0.025	0.242	354.139
2	0.029	-0.012	0.031	337.812
3	-0.091	0.030	0.096	161.671
4	-0.041	0.025	0.049	148.514
5	-0.016	0.012	0.020	143.960
6	0.008	-0.003	0.009	339.272
7	-0.021	0.018	0.028	139.232
8	-0.004	0.007	0.008	120.693
9	-0.013	0.012	0.018	137.307
10	-0.009	0.005	0.010	150.572
11	-0.004	0.016	0.017	103.866
12	-0.002	0.013	0.013	97.883
13	0.001	0.011	0.011	87.285
14	-0.005	0.009	0.010	117.371

Radius: 0.90
MEAN VALUE : 0.224

IHARM	A	B	C	PHASE
1	0.225	-0.032	0.227	351.896
2	0.123	-0.030	0.127	346.351
3	0.035	-0.003	0.035	355.585
4	0.002	0.013	0.014	82.777
5	0.004	0.011	0.012	70.217
6	0.013	-0.007	0.014	331.145
7	0.004	-0.021	0.022	279.299
8	-0.001	-0.016	0.016	264.651
9	0.005	-0.007	0.008	306.125
10	0.010	0.000	0.010	359.387
11	0.007	-0.001	0.007	350.930
12	0.002	0.001	0.002	21.414
13	-0.002	0.002	0.003	134.998
14	-0.003	0.002	0.004	143.420

Wake Analysis 1.3 : 2021-05-26 Measurement date: 26-May-2021 14:11:41

E-10 3D WAKE TEST - DWL

E-10.10 HARMONIC ANALYSIS OF AXIAL WAKE (Page 3 of 3)

REFERENCE M3246

SOBC-1

HULL MODEL NO.: M3246A Model Scale: 32.000
Loading condition: DWL - Design waterline
Draught AP/FP: 11.000 / 11.000 [m]
Description: DWL-15 kn

Radius: 1.10
MEAN VALUE : 0.187

IHARM	A	B	C	PHASE
1	0.183	-0.014	0.184	355.533
2	0.134	-0.021	0.136	351.002
3	0.074	-0.019	0.076	345.699
4	0.032	-0.013	0.035	337.744
5	0.014	-0.009	0.016	328.031
6	0.009	-0.005	0.011	330.863
7	0.009	-0.006	0.011	327.904
8	0.007	-0.006	0.009	321.454
9	0.003	-0.007	0.008	296.069
10	0.002	-0.008	0.008	284.520
11	0.001	-0.006	0.006	278.782
12	0.001	-0.004	0.004	279.823
13	0.000	-0.001	0.001	280.460
14	0.000	0.000	0.000	318.142

Wake Analysis 1.3 : 2021-05-26 Measurement date: 26-May-2021 14:11:41

E-10 3D WAKE TEST - DWL

E-10.11 HARMONIC ANALYSIS OF RADIAL WAKE (Page 1 of 3)

REFERENCE M3246

SOBC-1

HULL MODEL NO.: M3246A Model Scale: 32.000
Loading condition: DWL - Design waterline
Draught AP/FP: 11.000 / 11.000 [m]
Description: DWL-15 kn

Radius: 0.40
MEAN VALUE : -0.057

IHARM	A	B	C	PHASE
1	-0.090	0.004	0.090	177.576
2	-0.116	0.025	0.118	167.858
3	-0.045	0.011	0.046	166.561
4	-0.019	0.005	0.020	165.251
5	-0.001	0.012	0.012	94.107
6	-0.020	0.007	0.021	159.501
7	0.002	0.004	0.004	68.364
8	-0.003	0.007	0.007	117.359
9	-0.007	0.003	0.007	158.852
10	0.004	0.004	0.006	39.296
11	-0.007	-0.002	0.007	194.245
12	0.006	-0.002	0.006	340.080
13	-0.005	0.001	0.005	170.776
14	0.003	-0.004	0.005	306.369

Radius: 0.50
MEAN VALUE : -0.076

IHARM	A	B	C	PHASE
1	-0.073	-0.006	0.074	184.815
2	-0.102	0.011	0.103	174.020
3	-0.064	0.027	0.070	157.115
4	-0.027	0.015	0.031	150.259
5	-0.017	0.006	0.018	159.370
6	-0.004	0.017	0.017	102.172
7	-0.013	-0.001	0.013	185.541
8	-0.006	0.003	0.006	151.104
9	-0.004	0.004	0.005	137.473
10	0.000	0.002	0.002	82.419
11	0.000	0.004	0.004	90.455
12	-0.002	-0.003	0.004	241.445
13	0.000	0.001	0.001	90.674
14	0.001	-0.004	0.005	279.262

Wake Analysis 1.3 : 2021-05-26 Measurement date: 26-May-2021 14:11:41

E-10 3D WAKE TEST - DWL

E-10.12 HARMONIC ANALYSIS OF RADIAL WAKE (Page 2 of 3)

REFERENCE M3246

SOBC-1

HULL MODEL NO.: M3246A Model Scale: 32.000
Loading condition: DWL - Design waterline
Draught AP/FP: 11.000 / 11.000 [m]
Description: DWL-15 kn

Radius: 0.70
MEAN VALUE : -0.100

IHARM	A	B	C	PHASE
1	-0.063	0.000	0.063	179.605
2	-0.087	0.008	0.087	175.043
3	-0.074	0.018	0.077	166.170
4	-0.054	0.021	0.058	158.351
5	-0.041	0.025	0.048	148.986
6	-0.022	0.018	0.029	140.217
7	-0.020	0.015	0.025	143.643
8	-0.019	0.013	0.023	146.375
9	-0.014	0.013	0.019	137.693
10	-0.007	0.015	0.017	116.125
11	-0.005	0.011	0.012	116.131
12	-0.001	0.009	0.010	95.724
13	-0.001	0.006	0.006	96.047
14	0.002	0.004	0.004	57.899

Radius: 0.90
MEAN VALUE : -0.060

IHARM	A	B	C	PHASE
1	-0.020	-0.004	0.021	190.053
2	-0.048	0.005	0.048	174.579
3	-0.043	0.009	0.044	168.021
4	-0.025	0.010	0.027	157.720
5	-0.013	0.008	0.015	147.571
6	-0.006	0.005	0.008	143.602
7	-0.004	0.003	0.005	140.270
8	-0.002	0.002	0.002	135.920
9	-0.001	0.001	0.001	149.410
10	-0.001	0.003	0.003	115.722
11	0.001	0.003	0.003	80.321
12	0.001	0.003	0.003	70.801
13	0.001	0.001	0.001	42.202
14	-0.001	0.001	0.001	127.983

Wake Analysis 1.3 : 2021-05-26 Measurement date: 26-May-2021 14:11:41

E-10 3D WAKE TEST - DWL

E-10.13 HARMONIC ANALYSIS OF RADIAL WAKE (Page 3 of 3)

REFERENCE M3246

SOBC-1

HULL MODEL NO.: M3246A Model Scale: 32.000
Loading condition: DWL - Design waterline
Draught AP/FP: 11.000 / 11.000 [m]
Description: DWL-15 kn

Radius: 1.10
MEAN VALUE : -0.051

IHARM	A	B	C	PHASE
1	0.007	-0.003	0.008	335.963
2	-0.021	-0.002	0.021	185.323
3	-0.032	0.007	0.033	167.430
4	-0.023	0.010	0.026	156.239
5	-0.012	0.007	0.013	150.258
6	-0.004	0.003	0.005	144.882
7	-0.002	0.002	0.003	140.035
8	-0.002	0.000	0.002	162.853
9	0.000	0.001	0.001	126.302
10	0.000	0.000	0.001	219.179
11	-0.001	0.000	0.001	207.723
12	-0.001	0.000	0.001	165.357
13	0.000	0.001	0.001	71.508
14	0.001	0.001	0.002	37.183

Wake Analysis 1.3 : 2021-05-26 Measurement date: 26-May-2021 14:11:41

E-10 3D WAKE TEST - DWL

E-10.14 HARMONIC ANALYSIS OF TANGENTIAL WAKE (Page 1 of 3)

REFERENCE M3246

SOBC-1

HULL MODEL NO.: M3246A Model Scale: 32.000
Loading condition: DWL - Design waterline
Draught AP/FP: 11.000 / 11.000 [m]
Description: DWL-15 kn

Radius: 0.40
MEAN VALUE : 0.005

IHARM	A	B	C	PHASE
1	0.004	0.123	0.123	88.186
2	-0.004	0.047	0.047	95.338
3	0.013	0.019	0.024	55.733
4	-0.003	-0.006	0.007	238.533
5	-0.004	0.001	0.004	166.264
6	0.007	-0.002	0.007	341.523
7	0.002	-0.001	0.002	340.605
8	-0.005	-0.005	0.007	227.663
9	-0.008	0.001	0.008	175.704
10	0.002	-0.001	0.002	343.578
11	-0.002	-0.010	0.010	256.180
12	-0.001	-0.002	0.003	250.132
13	-0.005	-0.008	0.009	237.552
14	-0.002	0.004	0.004	123.836

Radius: 0.50
MEAN VALUE : -0.002

IHARM	A	B	C	PHASE
1	-0.009	0.018	0.020	117.364
2	0.004	0.026	0.026	81.853
3	0.013	0.030	0.033	65.960
4	0.002	0.000	0.002	355.141
5	-0.006	0.004	0.008	147.183
6	0.000	-0.016	0.016	271.755
7	-0.004	0.000	0.004	178.099
8	0.001	-0.005	0.005	277.668
9	0.004	-0.004	0.006	318.482
10	-0.002	0.000	0.002	174.167
11	-0.002	0.000	0.002	180.721
12	-0.003	0.002	0.003	152.803
13	-0.001	-0.002	0.003	244.279
14	-0.001	0.000	0.001	172.542

Wake Analysis 1.3 : 2021-05-26 Measurement date: 26-May-2021 14:11:41

E-10 3D WAKE TEST - DWL

E-10.15 HARMONIC ANALYSIS OF TANGENTIAL WAKE (Page 2 of 3)

REFERENCE M3246

SOBC-1

HULL MODEL NO.: M3246A Model Scale: 32.000
Loading condition: DWL - Design waterline
Draught AP/FP: 11.000 / 11.000 [m]
Description: DWL-15 kn

Radius: 0.70
MEAN VALUE : 0.004

IHARM	A	B	C	PHASE
1	-0.019	-0.094	0.096	258.291
2	-0.004	0.006	0.007	124.755
3	0.013	0.030	0.033	67.021
4	0.008	0.004	0.009	24.660
5	0.003	-0.005	0.005	299.922
6	-0.001	0.000	0.001	198.631
7	-0.008	-0.004	0.009	205.778
8	0.001	-0.006	0.006	283.618
9	0.005	-0.001	0.005	346.890
10	0.006	0.002	0.007	19.909
11	0.001	0.002	0.002	65.829
12	-0.003	0.002	0.004	141.332
13	-0.002	-0.001	0.003	216.443
14	-0.001	0.002	0.002	116.895

Radius: 0.90
MEAN VALUE : 0.000

IHARM	A	B	C	PHASE
1	-0.017	-0.140	0.141	262.895
2	-0.007	-0.042	0.042	259.994
3	0.003	0.005	0.006	54.810
4	0.004	0.013	0.013	71.355
5	0.002	0.003	0.003	62.948
6	-0.001	-0.001	0.001	215.923
7	-0.001	0.001	0.002	134.639
8	0.002	0.000	0.002	348.662
9	0.003	-0.002	0.004	327.274
10	0.002	-0.003	0.004	303.374
11	0.002	-0.001	0.002	340.314
12	0.002	0.000	0.002	6.662
13	0.003	0.002	0.003	27.391
14	0.003	0.001	0.003	22.808

Wake Analysis 1.3 : 2021-05-26 Measurement date: 26-May-2021 14:11:41

E-10 3D WAKE TEST - DWL

E-10.16 HARMONIC ANALYSIS OF TANGENTIAL WAKE (Page 3 of 3)

REFERENCE M3246

SOBC-1

HULL MODEL NO.: M3246A Model Scale: 32.000
Loading condition: DWL - Design waterline
Draught AP/FP: 11.000 / 11.000 [m]
Description: DWL-15 kn

Radius: 1.10
MEAN VALUE : 0.005

IHARM	A	B	C	PHASE
1	-0.010	-0.144	0.145	265.872
2	-0.009	-0.068	0.068	262.471
3	-0.002	-0.014	0.014	263.643
4	0.006	0.002	0.006	20.831
5	0.007	0.004	0.008	32.110
6	0.005	0.001	0.005	12.651
7	0.005	-0.001	0.005	344.992
8	0.004	-0.001	0.004	341.639
9	0.004	-0.001	0.005	348.549
10	0.003	0.000	0.003	2.933
11	0.004	0.000	0.004	3.535
12	0.003	0.000	0.003	6.720
13	0.004	0.000	0.004	357.886
14	0.004	0.000	0.004	0.545

Wake Analysis 1.3 : 2021-05-26 Measurement date: 26-May-2021 14:11:41

Appendices

A APPENDIX: RESISTANCE TESTS - SHIP RESISTANCE

The hull model is towed by the carriage at which the total resistance is measured at different speeds. The hull model is equipped with a rudder and a trip-wire at station 9 $^1/_2$ (19). The conversion from hull model (m) into ship (s) is made by using the form factor method. In this method it is assumed that the total resistance can be divided into two parts, represented by the viscous resistance and the residuary (due to vorticity, wave making and wave breaking) resistance (C_R). The viscous resistance is determined by multiplying the frictional resistance (C_F) with a constant form factor (k_0), which is identical for model and ship. Further, it is assumed that the residuary resistance (C_R) is identical for model and ship.

MODEL (m)

Total resistance coefficient: $C_{Tm} = \dfrac{R_{Tm}}{\frac{\rho_m}{2} V_m^2 S_m} = C_{Fm}(1+k_0) + C_{Rm} + C_{AAm} + C_{BDm} + C_{Appm}$

Frictional resistance coefficient: $C_{Fm} = \dfrac{0.075}{(log\ R_{nm} - 2)^2}$ (ITTC - 57 correlation line)

Residuary resistance coefficient: $C_{Rm} = C_{Tm} - (1+k_0)\, C_{Fm} - C_{AAm} - C_{BDm} - C_{Appm}$

SHIP (s)

Total resistance coefficient: $C_{Ts} = C_{Rm} + (C_{Fs} + \Delta C_F)(1+k_0) + C_A + C_{AAs} + C_{BDs} + C_{Apps}$

Frictional resistance coefficient: $C_{Fs} = \dfrac{0.075}{(log\ R_{ns} - 2)^2}$ (ITTC - 57 correlation line)

Total resistance: $R_{Ts} = C_{Ts} \dfrac{\rho_s}{2} V_s^2 S_s$

Effective power: $P_E = \dfrac{R_{Ts} V_s}{1000}$

Merit coefficient: $C_{ADX} = \dfrac{\nabla^{2/3} V_s^3}{P_E}$

Form factor: $k_0 = 0.6\,\phi + 75\,\phi^3$ where $\phi = \dfrac{C_B}{L_{WL}} \sqrt{(T_{AP} + T_{FP})}\, B$

Air resistance coefficient: $C_{AA} = \dfrac{\rho_{air} C_D A_V}{\rho S}$

Transom stern resistance coefficient: $C_{BD} = \dfrac{0.029\,(^{A_T}/_S)^{3/2}}{(C_F)^{1/2}}$

Roughness allowance: $\Delta C_F = [110.31\,(H\ V_s)^{0.21} - 403.33]\, C_{Fs}^2$

Where H = hull surface roughness in μ (10-3 mm) and V_s = ship speed in m/s.

Only ΔC_F values > 0 are used.

B APPENDIX: APPENDAGE RESISTANCE SCALING

In cases where resistance with and without appendages has not been measured, the total appendage resistance coefficient is calculated in model and full scale using the local Reynolds number of each appendage and estimated form factors and wake fraction of each appendage. The appendage resistance correction coefficient is calculated from the difference between the total appendage resistance coefficient in model and full scale.

Appendage resistance coefficient:

$$C_{App} = \frac{1}{{}^1/_2\ \rho\ V^2\ S} \sum_{i=1}^{n_{app}} R_{Appi} = \sum_{i=1}^{n_{app}} (C_{FAppi} + \Delta\ C_{FAppi})(1 + k_i)(1 - w_i)^2\ \frac{S_{Appi}}{S}$$

$$C_{FAppi} = \frac{0.075}{(log\ R_{ns} - 2)^2}\ \text{(ITTC - 57 correlation line)}$$

For full scale: $\Delta\ C_{FAppis} = [110.31\ (H\ V_s(1 - w_i))^{0.21} - 403.33]\ C^2_{FAppis}$

For model: $\Delta\ C_{FAppim} = 0$

The form factor k_i of each appendage is estimated based the shape of the appendage and on experience and published data. The wake fraction w_i of each appendage is estimated based on the location of the appendage on the hull and on experience and published data.

The total appendage resistance coefficient C_{App} is calculated for model and full scale.

where:

- S_{Appi} - wetted surface of appendage
- subscript i - appendage number i
- $R_{nAppi} = \dfrac{V\ (1 - w_i)\ \bar{l}_i}{\nu}$
- w_i - the assumed wake fraction experienced by appendage number i
- $\bar{l}_i$ - characteristic appendage length (mean length of all parts of the appendage number i, measured in the assumed flow direction)

C APPENDIX: PROPULSION TESTS

The hull model is supplied with a propelling machinery and a driving propeller. The rate of revolution is regulated until the model is free relatively to the attached towing carriage. In order to obtain turbulent flow around the model, a trip wire is placed at station $9\ ^1/_2$ (19). To compensate the difference between the frictional resistance of the model and the frictional resistance of the ship, converted to model scale, the model is unloaded with a towing force in the direction of motion.

Applied towing force: $F_D = C_s \frac{\rho_m}{2} V_m^2 S_m$

$C_s = [C_{Fm} - (C_{Fs} + \Delta C_F)] (1 + k_0) - C_A + (C_{BDm} - C_{BDs}) + (C_{Appm} - C_{Apps})$

During the tests, the following parameters are recorded:

- Propeller thrust T
- Propeller torque Q
- Rate of revolution n
- Model speed V
- Towing force F_{Dm}

In case of more than one propulsors, measured thrust, torque and propeller rate of revolutions are averaged before the analysis.

Thrust and torque measured during propulsion and open water tests are expressed non-dimensionally as:

$$K_T = \frac{T}{\rho\ n^2\ D^4} \text{ and } K_Q = \frac{Q}{\rho\ n^2\ D^5}$$

In the open water diagram K_T and K_Q are presented as functions of the advance coefficient (J). By entering the open water diagram with the thrust coefficient (K_T) measured during the propulsion test, corresponding J_0 and K_{Q0}-values are obtained which are used to estimate wake fraction, relative rotative efficiency, hull efficiency and quasi-propulsive coefficient.

Wake fraction: $w = 1 - \frac{J_0}{\frac{V}{n\ D}}$

Relative rotative efficiency: $\eta_R = \frac{K_{Q0}}{K_Q}$

Hull efficiency: $\eta_H = \frac{1-t}{1-w}$

Quasi-propulsive coefficient: $\eta_D = \eta_0\ \eta_H\ \eta_R$ (η_0 = propeller efficiency in open water)

Thrust deduction fraction: $t = 1 - \frac{R_T - F_{Dm}}{T}$

D APPENDIX: OPEN WATER TESTS

The propeller model is driven by a dynamometer at which thrust, torque and rate of revolution are recorded. The immersion of the propeller shaft is larger than one propeller diameter.

Test procedure:

The rate of revolution is kept constant and by varying the speed, we get the variation of the advance coefficient (J). At each advance coefficient exact rate of revolution, (n), propeller thrust, (T), and torque, (Q), are recorded. The results are presented dimensionless as:

$J = \frac{V_A}{n\ D}$, advance coefficient

$K_T = \frac{T}{\rho\ n^2\ D^4}$, thrust coefficient

$K_Q = \frac{Q}{\rho\ n^2\ D^5}$, torque coefficient

$\eta_0 = \frac{K_T\ J}{K_Q\ 2\pi}$, propeller efficiency in open water

E APPENDIX: PERFORMANCE PREDICTION, CONVENTIONAL SINGLE SCREW VESSELS

The performance prediction is based on the assumption that the thrust deduction fraction, t, and the relative rotative efficiency, η_R, are free from scale effects, while the wake fraction is scaled according to:

$$w_s = w_0 + (w_m - w_0)\,\frac{C_{Fs} + \Delta C_F}{C_{Fm}}$$

where

$$w_0 = 0.04 + t$$

From the total resistance of the ship, R_{Ts}, and the thrust deduction fraction, t, the following relation is established:

$$\frac{K_T}{J^2} = \frac{R_{Ts}}{\rho\,(1-t)\,D^2\,V_s^2\,(1-w_s)^2}$$

For each speed, the intersection point of the K_T-J^2 curve given above with the open water diagram is found. The advance coefficient J^* at this point gives the rate of revolution:

$$RPM = \frac{60\,(1-w_s)}{D}\,\frac{V_s}{J^*}$$

The corresponding torque coefficient K_Q, and the relative rotative efficiency, η_R, gives the delivered power:

$$P_D\,[kW] = \frac{2\pi}{1000}\,\rho\,D^5\,(\frac{RPM}{60})^3\,\frac{K_Q}{\eta_R}$$

The calculation is repeated for different speeds giving the speed/power curve for the actual pitch ratio. An extrapolation of the open water diagram gives speed/power curves for different pitch ratios. The final pitch ratio and speed/power curve is found by interpolation for the actual RPM and power.

Finally the brake power and merit coefficient are calculated:

$$P_B\,[kW] = \frac{P_D}{\eta_M}$$

$$C_{ADM} = \frac{\nabla^{2/3}\,V_s^3}{P_D}\;(V_s \text{ in } {}^{m}/_{s}.)$$

F APPENDIX: 3-D WAKE MEASUREMENTS

The hull model is towed by the carriage at the speed and draught of interest.

The 3-D wake measurements are performed with a five-hole spherical pitot tube that can be set in different radial positions and is revolvably attached to the propeller boss. The five-hole spherical pitot tube is set up to measure the differential pressure between the five holes located one at the top and the other four 20 deg. off the top of the sphere (see figure 1).

The non-dimensional expressions $\frac{S-P}{2C-S-P}$ and $\frac{T-B}{2C-T-B}$ are calculated from the measurements and β_H and β_V are found by interpolation in the calibration diagram for the specific pitot. The horizontal and vertical components of the total velocity vector is found from:

$V_H = \sqrt{(C-P)/C5}$ for $\beta_H > 0$ and $V_H = \sqrt{(C-S)/C6}$ for $\beta_H < 0$.

$V_V = \sqrt{(C-B)/C7}$ for $\beta_V > 0$ and $V_V = \sqrt{(C-T)/C8}$ for $\beta_V < 0$.

Where the coefficients $C5 - C8$ are found from the calibration curves as functions of β_H and β_V. When V and β have been determined, the wanted wake components are found from the following expressions:

Axial (Taylor) wake: $w_{ax} = 1 - {}^{V_A}/_{V}$ where V is the nominal (carriage) speed and V_A is axial velocity: $V_A = \frac{1}{2}\left(V_V\, cos\beta_V + V_H\, cos\beta_H\right)$

Tangential wake: $w_T = {}^{V_T}/_{V}$ where $V_T = V_H\, sin\beta_H$

Radial wake: $w_R = {}^{V_R}/_{V}$ where $V_R = V_V\, sin\beta_V$

Total velocity: $V_{tot} = \sqrt{V_A^2 + V_T^2 + V_R^2}$

w_{ax}, w_T and w_R are presented in the report as functions radius and angular position. 0 deg. is top vertical position, 90 deg. is to the SB side. The measuring plane is perpendicular to the propeller shaft and intersects with the generator line of the propeller blade at 0.7R (R = propeller radius).

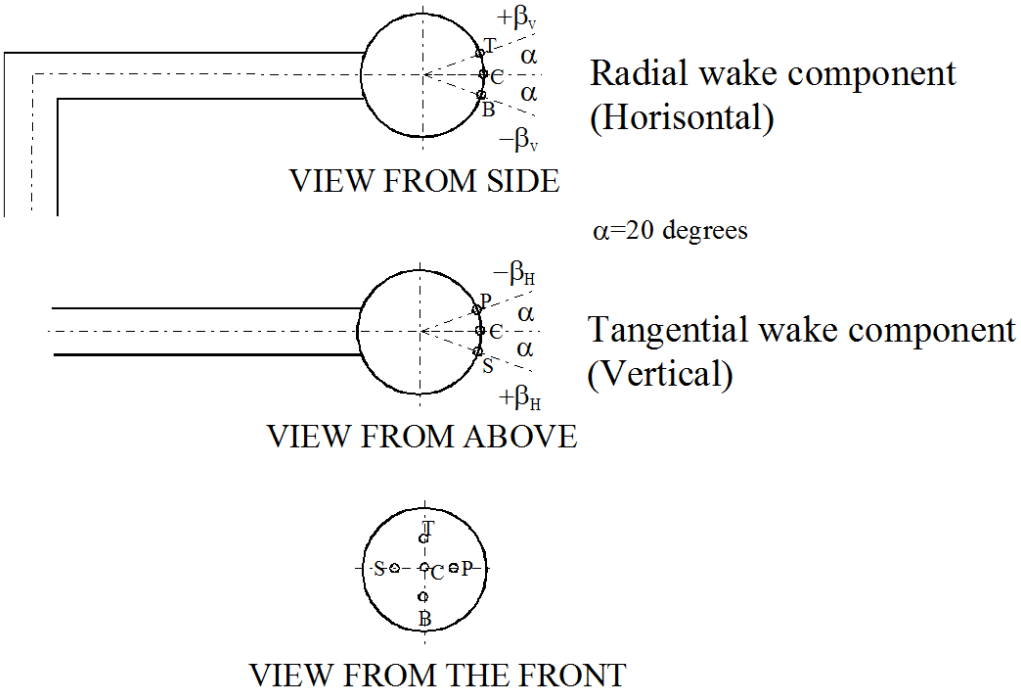


Figure 1: Five-hole spherical pitot tube

G APPENDIX: HARMONICS OF WAKE DISTRIBUTION

The circumferential variations of the wake fraction, $w(\phi)$, can for each of the measured radii be expressed as a Fourier-series:

$$w(\phi) = A(o) + \sum_{i=1}^{\infty}[A(i)\cos i\phi + B\sin i\phi] = \sum_{i=1}^{\infty} C(i)\ \cos[i\phi - \alpha(i)]$$

$$C = \sqrt{A^2 + B^2}$$

$$\alpha = \arctan(\frac{B}{A})$$

where

- $A(i)$, $B(i)$, $C(i)$ = amplitudes
- ϕ = angle of position within propeller area
- $\alpha(i)$ = phase angle of the i-th order

H APPENDIX: LIST OF SYMBOLS

Symbol	Title	Dimensions
a_i	Fraction of resistance carried by propulsor number i	-
A_E	Expanded blade area	L^2
A_O	Disc area	L^2
A_T	Transverse projected area of ship/model above the waterline	L^2
B	Breadth moulded	L
c	Chord length	L
C_A	Empirical correlation coefficient determined from trial analyses	-
C_{AA}	Air resistance coefficient	-
C_{ADM}	Merit coefficient	-
C_{ADX}	Admirality coefficient	-
C_{App}	Appendage (total) resistance coefficient	-
ΔC_{App}	Appendage resistance correction coefficient	-
C_B	Block coefficient	-
C_{BD}	Transom stern resistance coefficient	-
C_D	Drag coefficient	-
C_F	Frictional resistance coefficient	-
C_{FApp}	Frictional resistance coefficient of appendage	-
ΔC_F	Roughness allowance	-
C_M	Midship section coefficient	-
C_P	Prismatic coefficient	-
C_R	Residuary resistance coefficient	-
C_S	Towing force coefficient	-
C_T	Total resistance coefficient	-
C_{TH}	Thrust loading coefficient	-
C_{TApp}	Appendage resistance coefficient	-
C_V	Viscous resistance coefficient	-
d	Hub diameter	L
D	Propeller diameter	L
F_D	Towing force	LMT^{-2}
F_n	Froude number	-
g	Acceleration due to gravity	LT^{-2}
J	Advance coefficient	-
k	Form factor	-
k_0	Form factor computed according to standard empirical formula	-
K_Q	Torque coefficient	-
K_T	Thrust coefficient	-
K_{TD}	Duct thrust coefficient	-
K_{TP}	Propeller thrust coefficient	-
K_{TTot}	Total thrust coefficient	-
ΔK_{TB}	Correction factor for pod drag	-
L_{OA}	Length overall	L
L_{PP}	Length between perpendiculars	L
L_{WL}	Length of waterline	L

Symbol	Title	Dimensions
n	Rate of revolution	$\mathrm{REVS.T}^{-1}$
P	Propeller pitch	L
P_B	Brake power	$\mathrm{L}^2\mathrm{MT}^{-3}$
P_D	Delivered power at propeller	$\mathrm{L}^2\mathrm{MT}^{-3}$
P_E	Effective power	$\mathrm{L}^2\mathrm{MT}^{-3}$
P_S	Shaft power	$\mathrm{L}^2\mathrm{MT}^{-3}$
Q	Torque	$\mathrm{L}^2\mathrm{MT}^{-2}$
R	Propeller radius	L
R_n	Reynolds number	-
R_T	Total resistance	LMT^{-2}
S	Wetted surface	L^2
A_T	Area of transom stern below the waterline	L^2
t	Max. thickness of a propeller section	L
t	Thrust deduction fraction	-
T	Draught moulded	L
T	Thrust	LMT^{-2}
T_D	Duct thrust	LMT^{-2}
T_P	Propeller thrust	LMT^{-2}
T_{Tot}	Total thrust	LMT^{-2}
V	Speed of ship or model	LT^{-1}
V_A	Speed of advance of propeller	LT^{-1}
w	Wake fraction	-
Z	Number of blades of a propeller	-
α	Angle of attack	-
η_D	Propulsive efficiency or quasi-propulsive coefficient	-
η_H	Hull efficiency	-
η_M	Mechanical efficiency	-
η_0	Propeller efficiency in open water	-
η_R	Relative rotative efficiency	-
λ	Linear scale ratio	-
ν	Kinematic viscosity	$\mathrm{L}^2\mathrm{T}^{-1}$
ρ	Mass density of water	ML^{-3}
∇	Displacement volume	L^3
Δ	Displacement mass	M

Subscript m means model scale, while subscript s means full scale.

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