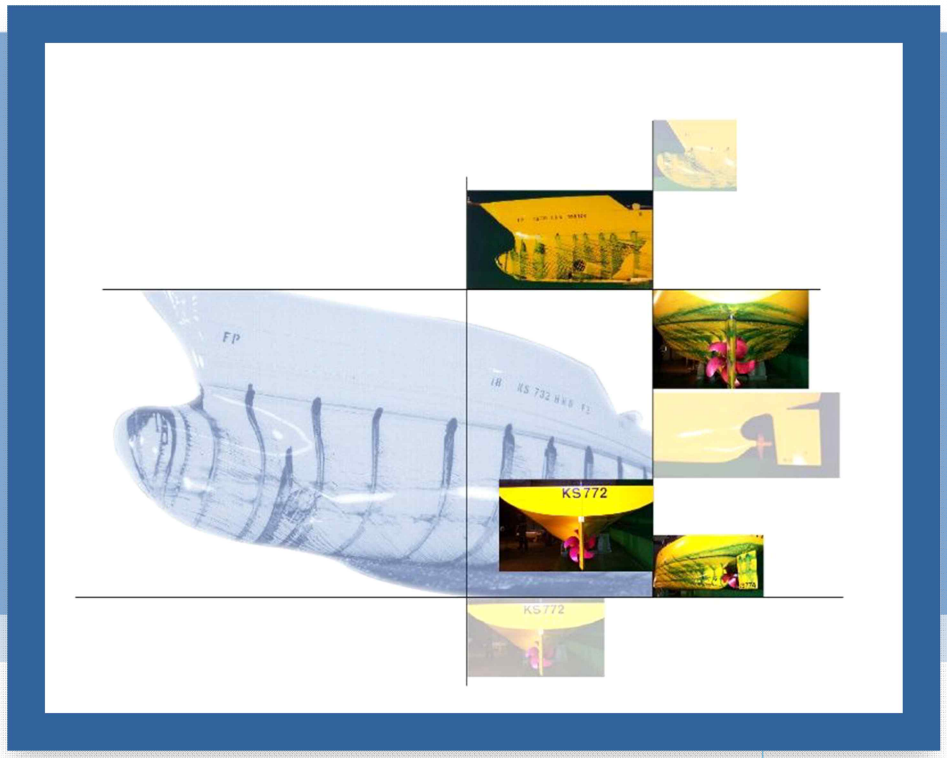
BUSINESS SENSITIVE



Apr. 2023

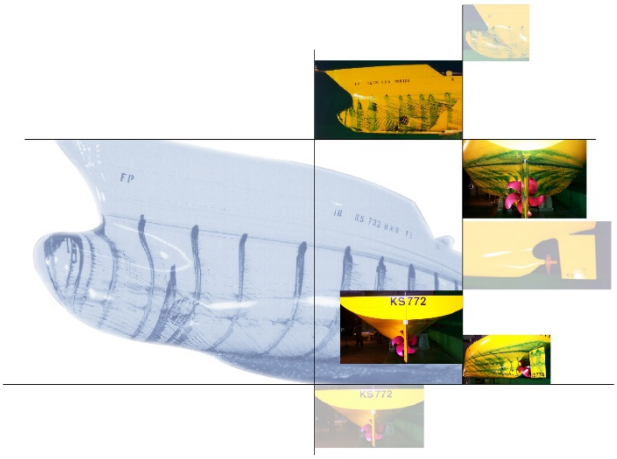
MODEL TEST REPORT

STD 13K Methanol PC Tanker

KRISO 선박해양플랜트연구소
KOREA RESEARCH INSTITUTE OF SHIPS & OCEAN ENGINEERING

REPORT

RESISTANCE AND PROPULSION TESTS



Korea Research Institute of Ships and Ocean Engineering

List of Tables

List of Figures

1 Introduction

This report was supported by the **government-funded project (P0020268)**. **Korea Research Institute of Ships and Ocean engineering (KRISO)** performed a study on the hull form of the **13K Methanol PC Tanker**. Series of model tests were conducted in the towing tank of **KRISO**.

Based on the drawings and information provided by **KRISO Eco-friendly Ship Design Engineering Unit**, the ship model with the scale ratio of 1/19.2 was manufactured. The stock propeller was used in the test.

To evaluate the performance of the subject ship, series of model tests listed below were carried out:

Hull Form (KS2048, Stock Propeller (KP2015))

Resistance Test	: 1 draft
Self-Propulsion Test	: 1 draft
Wake Survey	: 1 draft, 1 speed

Hull Form (KS2048 with Fin, Stock Propeller (KP2015))

Resistance Test	: 2 drafts
Self-Propulsion Test	: 2 drafts

This report describes the ship and the propeller models used in the towing tank tests, and presents data and analysis results for the powering performance, wake characteristics, and propeller open-water performance.

Brief descriptions on the analysis procedures for the test programs and nomenclature are presented in the Appendices A and B, respectively.

2 Test Descriptions

2.1 Test Conditions

Test items and conditions are as follows:

Item	Test No.	Load	Appendage	Remark
RES	S2048R01	Scantling	Rudder	-
SP	S2048S02	″	″	KP2015
RES	S2048R03	″	Fin & Rudder	-
SP	S2048S04	″	″	KP2015
RES	S2048R06	Ballast	″	-
SP	S2048S07	″	″	KP2015
Wake	S2048K05	Scantling	-	Vs= 13.0knots
POW	P2015O01	Propeller rps = 14.5		

2. 2 Model and Facilities

The ship model with the scale ratio of **1/19.2** was manufactured of wood in compliance with the lines drawing. The principal geometric characteristics of the hull form are listed in **Table 1**. The studs of 1.5mm diameter were nailed with 2.0mm height and 10.0mm interval at the station 19 and the middle of bow bulb to ensure the fully turbulent flow.

Propeller drawings are shown in **Figure 3**, and its principal geometric characteristics are given in **Table 2**.

The KRISO towing tank has the dimensions of 200m in length, 16m in width and 7m in water depth. An electronically controlled towing carriage with the maximum speed of 6.0 m/s is operating.

3 Test Results

3.1 Resistance and Propulsion Characteristics

The full-scale values are predicted from the model test, based on the Froude's assumption. The ITTC 1957 Model-Ship correlation line is used as an extrapolator and correlation allowances are chosen as follows:

C_A = -0.000 140 for Scantling condition
C_A = -0.000 180 for Ballast condition

The 1978 ITTC performance prediction method is utilized to consider the scale effect. The air resistance is included in the present analysis and the sea condition is assumed to be calm.

The measured data and the performance prediction results for resistance, propeller open-water, and propulsion characteristics are shown in tables and figures as follows:

(a) Propeller Open-Water Characteristics

Propeller	KP2015
Test Condition, Results	Table 3
Characteristic Curves	Figure 4

(b) Performances of Hull Form (KS2048) with stock propeller (KP2015)

Resistance & Propulsion	Draft Condition
	Scantling
Resistance Performance Model Test Results Performance Prediction	Table 4 Table 5 Tables 6,7
Curves of Resistance Coeff. Curves of Propulsive Coeff. Curves of Trial Prediction Curves of Service Prediction	Figure 5 Figure 6 Figure 7 Figure 8

(c) Performances of Hull Form (KS2048) with Fin and stock propeller (KP2015)

Resistance & Propulsion	Draft Condition	
	Scantling	Ballast
Resistance Performance Model Test Results Performance Prediction	Table 8 Table 9 Tables 10, 11	Table 12 Table 13 Tables 14, 15
Curves of Resistance Coeff. Curves of Propulsive Coeff. Curves of Trial Prediction Curves of Service Prediction	Figure 9 Figure 10 Figure 11 Figure 12	
Photographs of Running Model	Figures 18-23	Figures 24-29

3.2 Wake Characteristics

The wake survey results at the propeller plane of the model ship are presented in tables and figures as follows:

Wake Survey : KS2048, Scantling draft, 13.0 knots	
Measured Results & Mean Velocity Components	Tables 16,17
Harmonic Analysis of Velocity Components	Table 18
Circumferential Distribution of Velocity Component	Figure 13
Iso-Axial Velocity Contours	Figure 14
Transverse Velocity Vectors	Figure 15
Radial Distribution of Harmonic Amplitude	Figure 16
Radial Distribution of Circumferential Mean Velocity	Figure 17

4 Summary

Based on the test results and analysis listed in the present report for the 13K Methanol PC Tanker, the following conclusions are drawn.

Performance tests for the subject ship have been carried out at scantling and ballast drafts. According to the performance analysis for the hull form with the fin and the stock propeller, the ship speed and propeller revolution rate at trial condition (NCR) and the ship speed at service condition (NCR with 15% Sea Margin) are predicted as follows (Transmission efficiency 0.97 applied):

Scantling draft:	**14.13 knots × 120.5 RPM,**	**13.61 knots**
Ballast draft:	**14.38 knots × 118.9 RPM,**	**13.81 knots**

MCR	3,700.0 kW ×	130.0 RPM
NCR	2,970.0 kW ×	125.5 RPM
Sea Margin	15%	

TABLES

KRISO	13K Methanol PC Tanker	
Table 1	**Principal Dimensions of the Hull Form (KS2048)**	07-20-2023 S2048S04.lyy, S2048S07.lyy

Designation	File No.: SYMBOL(unit)	s2048s04 SHIP	s2048s04 MODEL	s2048s07 SHIP	s2048s07 MODEL
Scale ratio	SCALE	19.2		19.2	
Load condition		**Scantling**		**Ballast**	
Draft, moulded	TF(m)	8.550	0.4453	4.870	0.2536
	TA(m)	8.550	0.4453	5.730	0.2984
	TMEAN(m)	8.550	0.4453	5.300	0.2760
Length between per.	LPP(m)	122.000	6.3542	122.000	6.3542
Breadth, moulded	B(m)	21.000	1.0938	21.000	1.0938
Depth, moulded	D(m)	11.800	0.6146	11.800	0.6146
Number of propeller	NOPROP	1		1	
Length of waterline	LWL(m)	125.500	6.5365	122.258	6.3676
Wetted surface area	S(m2)	4028.1	10.9269	3040.1	8.2468
Fin area	S(m2)	2.7	0.0073	2.7	0.0073
Bilge keel area	SBK(m2)	40.8	0.1107	40.8	0.1107
Trans. area above WL	AT(m2)	342.0	0.9277	410.6	1.1138
Displacement volume	DISV(m3)	17134	2.4208	9982	1.4103
KB above moulded BL	KB(m)	4.504	0.2346	2.759	0.1437
LCB from midship, f+	LCB(m)	1.210	0.0630	1.850	0.0964
LCF from midship, f+	LCF(m)	-4.850	-0.2526	1.310	0.0682
Block coef.	CB	0.782		0.734	
Load waterline coef.	CW	0.894		0.818	
Midship section coef.	CM	0.995		0.992	
Prismatic coef.	CP	0.786		0.740	
LPP/B		5.8095		5.8095	
LPP/T		14.269		23.0189	
B/T		2.4561		3.9623	
LCB% (fwd.+)		0.9918		1.5164	

KRISO	13K Methanol PC Tanker	
Table 2	**Principal Dimensions of the Stock Propeller (KP2015)**	07-20-2023 S2048S04.lyy

Designation	FILE NO.: SYMBOL	s2048s04
Scale ratio	SCALE	19.2
Diameter of ship propeller (m)	DIA. S	4.800
Diameter of model propeller (m)	DIA. M	0.2500
Expanded blade area ratio	EAR	0.5000
Propeller pitch ratio, mean	PRMEAN	0.7500
at tip	PRTIP	0.7156
at 0.7R	PR70R	0.7756
at root	PRROOT	0.6388
Chord length-diameter ratio (0.7R)	CR70	0.2829
Max. blade thickn. -dia. ratio (0.7R)	TR70	0.0116
Hub-diameter ratio	HDR	0.1700
Rake angle (deg)	RDR	0.7610
Skew angle (deg)	SKEW	24.99
Number of blades	NPB	4
Turning direction		R.H.
Material		AL
Propeller section type		NACA66
Propeller stock number		KP2015

KRISO	13K Methanol PC Tanker	
Table 3	**Open-Water Characteristics of the Stock Propeller (KP2015)**	07-20-2023 S2048S04.lyy

Propeller **KP2015** **Scale Ratio:** **19.2**

Test	No.	Date	Temp. (deg)	Density (Kg/m3)
POW	P2015O01	10-Nov-22	20	998.21

KP2015	Propeller dimensions			
Diameter	ship(m)	4.8000	Chord length-dia.ratio (0.7R)	0.2829
	model(m)	0.2500	Max. blade thick.-dia.ratio(0.7R)	0.0116
			Hub-diameter ratio	0.1700
Expanded area ratio		0.5000	Rake angle (deg)	0.7600
Pitch ratio	mean	0.7500	Skew angle (deg)	25
	at tip	0.7156	Number of propeller blades	4
	at 0.7R	0.7756	Turning direction	R.H.
	at root	0.6388	Material	AL
Blade roughness KP(micron)		30.0	Propeller section type	NACA66

	Model scale			**Full Scale**		
	RPS	Temp.	Prop. Rn		Temp.	Prop. Rn
	14.5	20.0	5.734E+05		15	2.271E+07
J	KT	10KQ	ETAO	KT	10KQ	ETAO
0.000	0.3758	0.4045	0.000	0.3761	0.4017	0.000
0.050	0.3592	0.3908	0.073	0.3595	0.3880	0.074
0.100	0.3414	0.3759	0.145	0.3417	0.3732	0.146
0.150	0.3227	0.3601	0.214	0.3230	0.3574	0.216
0.200	0.3034	0.3437	0.281	0.3037	0.3410	0.283
0.250	0.2836	0.3268	0.345	0.2839	0.3241	0.349
0.300	0.2635	0.3094	0.407	0.2638	0.3067	0.411
0.350	0.2432	0.2917	0.464	0.2435	0.2890	0.469
0.400	0.2228	0.2737	0.518	0.2231	0.2710	0.524
0.450	0.2020	0.2551	0.567	0.2023	0.2524	0.574
0.500	0.1810	0.2358	0.611	0.1813	0.2331	0.619
0.550	0.1595	0.2156	0.648	0.1598	0.2129	0.657
0.600	0.1373	0.1943	0.675	0.1375	0.1916	0.685
0.650	0.1143	0.1714	0.690	0.1145	0.1687	0.702
0.700	0.0901	0.1465	0.685	0.0903	0.1438	0.700
0.750	0.0643	0.1192	0.644	0.0645	0.1166	0.661
0.800	0.0365	0.0888	0.523	0.0367	0.0862	0.543
0.850	0.0063	0.0548	0.156	0.0065	0.0522	0.170
0.860	0.0000	0.0476	0.000	0.0002	0.0450	0.007

KRISO	13K Methanol PC Tanker	
Table 4	**Resistance Performance (KS2048, Scantling draft)**	07-20-2023 S2048S02.lyy

Draft FP/AP: **8.55** **8.55** **Scale Ratio :** **19.2**

appendages: **Rudder** **Analysis Code :** **1111000**

Test	No.	Date	Temp. (deg.)	Density (Kg/m3)
RES	S2048R01	23-04-17	14.5	999.18
SEA			15.0	1026.02

Analysis method -- Based on 1978 ITTC performance prediction method -

* Model-ship correlation line : 1957 ITTC

* 2-dimensional method

* Correlation allowance (2-D) : CA = 0.000140

* w/ Bilge keel resistance

* w/ Air resistance : CAA = 0.0010*AT/S

KS2048	Ship dimension			
	Ship	Model		
LPP(m)	122.000	6.3542		
B(m)	21.000	1.0938		
D(m)	11.800	0.6146		
XP(m)	2.750	0.1432		
LWL(m)	125.500	6.5365	CB	0.7822
S(m2)	4028.1	10.9269	CW	0.8941
SBK(m2)	40.8	0.1107	CM	0.9953
AT(m2)	342.0	0.9277	CP	0.7859
DISV(m3)	17134.0	2.4208		
KB(m)	4.504	0.2346	LPP/B	5.81
LCB+f(m)	1.210	0.0630	B/TM	2.46
LCF+f(m)	-4.850	-0.2526	LCB%	0.99

VS (knot)	PE (kW)	CTS (e-3)	CR (e-3)	CFS (e-3)	CFM (e-3)	CTM (e-3)	RTM (N)	VM (m/s)	FN
11.00	997.9	2.665	0.789	1.633	3.170	3.958	36.04	1.2914	0.1613
12.00	1282.0	2.637	0.779	1.615	3.121	3.900	42.26	1.4089	0.1760
13.00	1625.4	2.630	0.788	1.599	3.077	3.865	49.15	1.5263	0.1906
13.50	1834.4	2.650	0.816	1.591	3.057	3.873	53.11	1.5850	0.1980
14.00	2085.0	2.701	0.874	1.584	3.037	3.912	57.69	1.6437	0.2053
15.00	2809.4	2.959	1.146	1.570	3.001	4.147	70.22	1.7611	0.2200

KRISO	13K Methanol PC Tanker	
Table 5	**Model Test Results (KS2048, Scantling draft, Stock propeller)**	07-20-2023 S2048S02.lyy

Draft FP/AP: **8.55** **8.55** **Scale Ratio :** **19.2**

appendages: **Rudder** **Condition :** **KP2015**

NOPROP : **1** Analysis Code : 1111000

Test	No.	Date	Temp. (deg.)	Density (Kg/m3)
RES	S2048R01	23-04-17	14.5	999.18
SP	S2048S00	23-04-17	14.5	999.18
POW	P2015O01	22-11-10	20.0	998.21

KP2015	Propeller dimension		
DIA.s	4.8	CR70(chord)	0.2829
DIA.m	0.25	TR70(thick)	0.0116
EAR	0.5	HDR(hub)	0.17
PRMEAN	0.75	RDR(rake)	0.761
TIP	0.7156	SKEW(deg)	24.99
0.70R	0.7756	Turn.	R.H.
ROOT	0.6388	Mater.	AL
Type	NACA66	Z :	4

KS2048	Ship dimension			
	Ship	Model		
LPP(m)	122.000	6.3542		
B(m)	21.000	1.0938		
D(m)	11.800	0.6146		
XP(m)	2.750	0.1432		
LWL(m)	125.500	6.5365	CB	0.7822
S(m2)	4028.1	10.9269	CW	0.8941
SBK(m2)	40.8	0.1107	CM	0.9953
AT(m2)	342.0	0.9277	CP	0.7859
DISV(m3)	17134.0	2.4208		
KB(m)	4.504	0.2346	LPP/B	5.81
LCB+f(m)	1.210	0.0630	B/TM	2.46
LCF+f(m)	-4.850	-0.2526	LCB%	0.99

VS (knot)	VM (m/s)	RTM (N)	FD (N)	TM (N)	QM (Nm)	NM (rps)	THDF	WFTM	ETAR	CR (e-3)
11.00	1.291	36.04	12.71	29.05	0.955	6.59	0.197	0.334	1.006	0.789
12.00	1.409	42.26	14.80	34.28	1.125	7.18	0.199	0.331	1.010	0.779
13.00	1.526	49.15	17.02	40.22	1.318	7.78	0.201	0.330	1.012	0.788
13.50	1.585	53.11	18.18	43.84	1.433	8.11	0.203	0.330	1.013	0.816
14.00	1.644	57.69	19.37	48.14	1.570	8.46	0.204	0.330	1.013	0.874
15.00	1.761	70.22	21.85	60.91	1.968	9.33	0.206	0.332	1.011	1.146

KRISO	13K Methanol PC Tanker	
Table 6	**Full Scale Prediction of Powering Performance (KS2048, Scantling draft, Stock propeller)**	07-20-2023 S2048S02.lyy

Draft FP/AP: **8.55** **8.55** **Scale Ratio :** **19.2**

appendages: **Rudder** **Condition :** **KP2015**

NOPROP : **1** Analysis Code : 1111000

Test	No.	Date	Temp. (deg.)	Density (Kg/m3)
RES	S2048R01	23-04-17	14.5	999.18
SP	S2048S00	23-04-17	14.5	999.18
POW	P2015O01	22-11-10	20.0	998.21

VS (knot)	PE (kW)	PD (kW)	N (rpm)	FN
11.00	998	1357	93.61	0.1613
12.00	1282	1739	101.91	0.1760
13.00	1625	2205	110.35	0.1906
13.50	1834	2495	114.89	0.1980
14.00	2085	2850	119.83	0.2053
15.00	2809	3920	131.92	0.2200

Analysis method -- Based on 1978 ITTC
performance prediction method -
* Model-ship correlation line : 1957 ITTC
* Propeller blade roughness KP= 30.e-6

* 2-dimensional method
* Correlation allowance (2-D) : CA = 0.000140
* w/ Bilge keel resistance
* w/ Air resistance : CAA = 0.0010*AT/S

KS2048	Ship dimension		
LWL(m)	125.500	Tm(m)	8.550
S(m2)	4028.1	AT(m2)	342.0
SBK(m2)	40.8	DIA(m)	4.800

VS (knot)	CTS (e-3)	CR (e-3)	ADVCA	THDF	WFTM	WFTS	ETAH	ETAR	ETAO	ETAD
11.00	2.665	0.789	0.536	0.197	0.334	0.291	1.133	1.006	0.645	0.735
12.00	2.637	0.779	0.537	0.199	0.331	0.291	1.129	1.010	0.646	0.737
13.00	2.630	0.788	0.537	0.201	0.330	0.291	1.127	1.012	0.646	0.737
13.50	2.650	0.816	0.535	0.203	0.330	0.292	1.126	1.013	0.644	0.735
14.00	2.701	0.874	0.531	0.204	0.330	0.293	1.126	1.013	0.642	0.732
15.00	2.959	1.146	0.515	0.206	0.332	0.295	1.126	1.011	0.629	0.717

KRISO	13K Methanol PC Tanker	
Table 7	**Trial Prediction of Powering Performance (KS2048, Scantling draft, Stock propeller)**	07-20-2023 S2048S02.lyy

Draft FP/AP: **8.55** **8.55** **Scale Ratio :** **19.2**
Appendages: **Rudder** **Condition :** **KP2015**

NOPROP : **1** Analysis Code : 1111000

Test	No.	Date	Temp. (deg.)	Density (Kg/m3)
RES	S2048R01	23-04-17	14.5	999.18
SP	S2048S00	23-04-17	14.5	999.18
POW	P2015O01	22-11-10	20.0	998.21

KS2048	Ship dimension		
LBP(m)	122.00	LWL(m)	125.50
B(m)	21.0	S(m2)	4028.1
DISV(m3)	17134.0	DIA(m)	4.8
AT(m)	342.0	SBK(m2)	40.8

Ship Speed		Brake Power		Speed of Shaft	
(knot)	(m/s)	(kW)	(PS)	(rpm)	(rps)
11.00	5.66	1,399	1,902	93.61	1.5602
12.00	6.17	1,793	2,438	101.91	1.6984
13.00	6.69	2,273	3,091	110.35	1.8392
13.50	6.94	2,572	3,498	114.89	1.9148
14.00	7.20	2,938	3,995	119.83	1.9972
15.00	7.72	4,041	5,495	131.92	2.1987

Condition	Ship Speed (knots)	Speed of Shaft (rpm)	Sea Margin (%)
Trial	14.04	120.3	-
Service	13.52	-	15.0
	Main Engine Power =		2,970.0 kW
	Transmission Efficiency =		0.970

[Notes]
- For the explanation of abbreviations, see the list of symbols.
- Analysis method : Based on 1978 ITTC performance prediction method
- Frictional resistance determined according to the ITTC-1957 formula.
- Reynolds and Froude number based on Lwl= 125.50
- A model-ship Correlation allowance (2-D) : CA = 0.000140
- w/o CP-CN correction
- A resistance of above water part through the air, Cair = 0.0000849
- The results are valid for unrestricted deep water of 15.0 deg C and a mass density of 1025.9 kg/m3, clean surfaces of hull and propeller blades and no effects of wind and waves.

KRISO	13K Methanol PC Tanker	
Table 8	**Resistance Performance (KS2048, Scantling draft with Fin)**	07-20-2023 S2048S04.lyy

Draft FP/AP: **8.55** **8.55** **Scale Ratio :** **19.2**

appendages: **Fin & Rudder** **Analysis Code :** **1111000**

Test	No.	Date	Temp. (deg.)	Density (Kg/m3)
RES	S2048R03	23-04-17	14.5	999.18
SEA			15.0	1026.02

Analysis method -- Based on 1978 ITTC performance prediction method -

* Model-ship correlation line : 1957 ITTC

* 2-dimensional method

* Correlation allowance (2-D) : CA = 0.000140

* w/ Bilge keel resistance

* w/ Air resistance : CAA = 0.0010*AT/S

KS2048	Ship dimension			
	Ship	Model		
LPP(m)	122.000	6.3542		
B(m)	21.000	1.0938		
D(m)	11.800	0.6146		
XP(m)	2.750	0.1432		
LWL(m)	125.500	6.5365	CB	0.7822
S(m2)	4030.8	10.9342	CW	0.8941
SBK(m2)	40.8	0.1107	CM	0.9953
AT(m2)	342.0	0.9277	CP	0.7859
DISV(m3)	17134.0	2.4208		
KB(m)	4.504	0.2346	LPP/B	5.81
LCB+f(m)	1.210	0.0630	B/TM	2.46
LCF+f(m)	-4.850	-0.2526	LCB%	0.99

VS (knot)	PE (kW)	CTS (e-3)	CR (e-3)	CFS (e-3)	CFM (e-3)	CTM (e-3)	RTM (N)	VM (m/s)	FN
11.00	964.2	2.573	0.697	1.633	3.170	3.867	35.23	1.2914	0.1613
12.00	1247.3	2.564	0.706	1.615	3.121	3.827	41.49	1.4089	0.1760
13.00	1579.4	2.553	0.712	1.599	3.077	3.789	48.22	1.5263	0.1906
13.50	1781.0	2.571	0.737	1.591	3.057	3.794	52.07	1.5850	0.1980
14.00	2025.1	2.621	0.795	1.584	3.037	3.833	56.56	1.6437	0.2053
15.00	2742.3	2.886	1.074	1.570	3.001	4.075	69.03	1.7611	0.2200

KRISO	13K Methanol PC Tanker	
Table 9	**Model Test Results (KS2048, Scantling draft with Fin, Stock propeller)**	07-20-2023 S2048S04.lyy

Draft FP/AP: **8.55** **8.55** **Scale Ratio :** **19.2**

appendages: **Fin & Rudder** **Condition :** **KP2015**

NOPROP : **1** Analysis Code : 1111000

Test	No.	Date	Temp. (deg.)	Density (Kg/m3)
RES	S2048R03	23-04-17	14.5	999.18
SP	S2048S04	23-04-17	14.5	999.18
POW	P2015O01	22-11-10	20.0	998.21

KP2015	Propeller dimension		
DIA.s	4.8	CR70(chord)	0.2829
DIA.m	0.25	TR70(thick)	0.0116
EAR	0.5	HDR(hub)	0.17
PRMEAN	0.75	RDR(rake)	0.761
TIP	0.7156	SKEW(deg)	24.99
0.70R	0.7756	Turn.	R.H.
ROOT	0.6388	Mater.	AL
Type	NACA66	Z :	4

KS2048	Ship dimension			
	Ship	Model		
LPP(m)	122.000	6.3542		
B(m)	21.000	1.0938		
D(m)	11.800	0.6146		
XP(m)	2.750	0.1432		
LWL(m)	125.500	6.5365	CB	0.7822
S(m2)	4030.8	10.9342	CW	0.8941
SBK(m2)	40.8	0.1107	CM	0.9953
AT(m2)	342.0	0.9277	CP	0.7859
DISV(m3)	17134.0	2.4208		
KB(m)	4.504	0.2346	LPP/B	5.81
LCB+f(m)	1.210	0.0630	B/TM	2.46
LCF+f(m)	-4.850	-0.2526	LCB%	0.99

VS (knot)	VM (m/s)	RTM (N)	FD (N)	TM (N)	QM (Nm)	NM (rps)	THDF	WFTM	ETAR	CR (e-3)
11.00	1.291	35.23	12.72	28.13	0.933	6.56	0.200	0.326	1.004	0.697
12.00	1.409	41.49	14.81	33.44	1.107	7.17	0.202	0.322	1.007	0.706
13.00	1.526	48.22	17.03	39.18	1.297	7.76	0.204	0.321	1.008	0.712
13.50	1.585	52.07	18.19	42.62	1.409	8.08	0.205	0.321	1.008	0.737
14.00	1.644	56.56	19.38	46.82	1.544	8.43	0.206	0.322	1.008	0.795
15.00	1.761	69.03	21.87	59.55	1.939	9.30	0.208	0.325	1.008	1.074

KRISO	13K Methanol PC Tanker	
Table 10	**Full Scale Prediction of Powering Performance (KS2048, Scantling draft with Fin, Stock propeller)**	07-20-2023 S2048S04.lyy

Draft FP/AP: **8.55** **8.55** **Scale Ratio :** **19.2**

appendages: **Fin & Rudder** **Condition :** **KP2015**

NOPROP : **1** Analysis Code : 1111000

Test	No.	Date	Temp. (deg.)	Density (Kg/m3)
RES	S2048R03	23-04-17	14.5	999.18
SP	S2048S04	23-04-17	14.5	999.18
POW	P2015O01	22-11-10	20.0	998.21

VS (knot)	PE (kW)	PD (kW)	N (rpm)	FN
11.00	964	1314	92.92	0.1613
12.00	1247	1700	101.40	0.1760
13.00	1579	2155	109.77	0.1906
13.50	1781	2436	114.23	0.1980
14.00	2025	2782	119.12	0.2053
15.00	2742	3842	131.29	0.2200

Analysis method -- Based on 1978 ITTC

performance prediction method -

* Model-ship correlation line : 1957 ITTC
* Propeller blade roughness KP= 30.e-6

* 2-dimensional method
* Correlation allowance (2-D) : CA = 0.000140
* w/ Bilge keel resistance
* w/ Air resistance : CAA = 0.0010*AT/S

KS2048	Ship dimension		
LWL(m)	125.500	Tm(m)	8.550
S(m2)	4030.8	AT(m2)	342.0
SBK(m2)	40.8	DIA(m)	4.800

VS (knot)	CTS (e-3)	CR (e-3)	ADVCA	THDF	WFTM	WFTS	ETAH	ETAR	ETAO	ETAD
11.00	2.573	0.697	0.542	0.200	0.326	0.288	1.124	1.004	0.650	0.734
12.00	2.564	0.706	0.543	0.202	0.322	0.287	1.119	1.007	0.651	0.733
13.00	2.553	0.712	0.543	0.204	0.321	0.288	1.117	1.008	0.651	0.733
13.50	2.571	0.737	0.541	0.205	0.321	0.288	1.117	1.008	0.650	0.731
14.00	2.621	0.795	0.537	0.206	0.322	0.289	1.117	1.008	0.646	0.728
15.00	2.886	1.074	0.520	0.208	0.325	0.292	1.118	1.008	0.633	0.714

KRISO	13K Methanol PC Tanker	
Table 11	**Trial Prediction of Powering Performance (KS2048, Scantling draft with Fin, Stock propeller)**	07-20-2023 S2048S04.lyy

Draft FP/AP: **8.55** **8.55** **Scale Ratio :** **19.2**
Appendages: **Fin & Rudder** **Condition :** **KP2015**

NOPROP : **1** Analysis Code : 1111000

Test	No.	Date	Temp. (deg.)	Density (Kg/m3)
RES	S2048R03	23-04-17	14.5	999.18
SP	S2048S04	23-04-17	14.5	999.18
POW	P2015O01	22-11-10	20.0	998.21

KS2048	Ship dimension		
LBP(m)	122.00	LWL(m)	125.50
B(m)	21.0	S(m2)	4030.8
DISV(m3)	17134.0	DIA(m)	4.8
AT(m)	342.0	SBK(m2)	40.8

Ship Speed		Brake Power		Speed of Shaft	
(knot)	(m/s)	(kW)	(PS)	(rpm)	(rps)
11.00	5.66	1,355	1,842	92.92	1.5487
12.00	6.17	1,753	2,384	101.40	1.6900
13.00	6.69	2,222	3,021	109.77	1.8295
13.50	6.94	2,511	3,415	114.23	1.9039
14.00	7.20	2,869	3,901	119.12	1.9854
15.00	7.72	3,961	5,387	131.29	2.1882

Condition	Ship Speed (knots)	Speed of Shaft (rpm)	Sea Margin (%)
Trial	14.13	120.5	-
Service	13.61	-	15.0
	Main Engine Power =		2,970.0 kW
	Transmission Efficiency =		0.970

[Notes]
- For the explanation of abbreviations, see the list of symbols.
- Analysis method : Based on 1978 ITTC performance prediction method
- Frictional resistance determined according to the ITTC-1957 formula.
- Reynolds and Froude number based on Lwl= 125.50
- A model-ship Correlation allowance (2-D) : CA = 0.000140
- w/o CP-CN correction
- A resistance of above water part through the air, Cair = 0.0000848
- The results are valid for unrestricted deep water of 15.0 deg C and a mass density of 1025.9 kg/m3, clean surfaces of hull and propeller blades and no effects of wind and waves.

KRISO	13K Methanol PC Tanker	
Table 12	**Resistance Performance (KS2048, Ballast draft with Fin)**	07-20-2023 S2048S07.lyy

Draft FP/AP: **4.87** **5.73** **Scale Ratio :** **19.2**

appendages: **Fin & Rudder** **Analysis Code :** **1111000**

Test	No.	Date	Temp. (deg.)	Density (Kg/m3)
RES	S2048R06	23-04-18	14.5	999.18
SEA			15.0	1026.02

Analysis method -- Based on 1978 ITTC performance prediction method -

* Model-ship correlation line : 1957 ITTC

* 2-dimensional method

* Correlation allowance (2-D) : CA = 0.000180

* w/ Bilge keel resistance

* w/ Air resistance : CAA = 0.0010*AT/S

KS2048	Ship dimension			
	Ship	Model		
LPP(m)	122.000	6.3542		
B(m)	21.000	1.0938		
D(m)	11.800	0.6146		
XP(m)	2.750	0.1432		
LWL(m)	122.258	6.3676	CB	0.7340
S(m2)	3042.8	8.2541	CW	0.8180
SBK(m2)	40.8	0.1107	CM	0.9920
AT(m2)	410.6	1.1138	CP	0.7399
DISV(m3)	9982.0	1.4103		
KB(m)	2.759	0.1437	LPP/B	5.81
LCB+f(m)	1.850	0.0964	B/TM	3.96
LCF+f(m)	1.310	0.0682	LCB%	1.52

VS (knot)	PE (kW)	CTS (e-3)	CR (e-3)	CFS (e-3)	CFM (e-3)	CTM (e-3)	RTM (N)	VM (m/s)	FN
11.00	850.3	3.006	1.028	1.639	3.185	4.212	28.97	1.2914	0.1634
12.00	1148.5	3.127	1.168	1.621	3.136	4.303	35.22	1.4089	0.1783
13.00	1518.2	3.252	1.308	1.604	3.091	4.400	42.27	1.5263	0.1931
14.00	1955.9	3.354	1.426	1.589	3.051	4.477	49.88	1.6437	0.2080
15.00	2472.4	3.447	1.533	1.576	3.015	4.548	58.16	1.7611	0.2229
16.00	3141.5	3.609	1.708	1.563	2.981	4.689	68.23	1.8785	0.2377

KRISO	13K Methanol PC Tanker	
Table 13	**Model Test Results (KS2048, Ballast draft with Fin, Stock propeller)**	07-20-2023 S2048S07.lyy

Draft FP/AP: **4.87** **5.73** **Scale Ratio :** **19.2**

appendages: **Fin & Rudder** **Condition :** **KP2015**

NOPROP : **1** Analysis Code : 1111000

Test	No.	Date	Temp. (deg.)	Density (Kg/m3)
RES	S2048R06	23-04-18	14.5	999.18
SP	S2048S07	23-04-18	14.5	999.18
POW	P2015O01	22-11-10	20.0	998.21

KP2015	Propeller dimension		
DIA.s	4.8	CR70(chord)	0.2829
DIA.m	0.25	TR70(thick)	0.0116
EAR	0.5	HDR(hub)	0.17
PRMEAN	0.75	RDR(rake)	0.761
TIP	0.7156	SKEW(deg)	24.99
0.70R	0.7756	Turn.	R.H.
ROOT	0.6388	Mater.	AL
Type	NACA66	Z :	4

KS2048	Ship dimension			
	Ship	Model		
LPP(m)	122.000	6.3542		
B(m)	21.000	1.0938		
D(m)	11.800	0.6146		
XP(m)	2.750	0.1432		
LWL(m)	122.258	6.3676	CB	0.7340
S(m2)	3042.8	8.2541	CW	0.8180
SBK(m2)	40.8	0.1107	CM	0.9920
AT(m2)	410.6	1.1138	CP	0.7399
DISV(m3)	9982.0	1.4103		
KB(m)	2.759	0.1437	LPP/B	5.81
LCB+f(m)	1.850	0.0964	B/TM	3.96
LCF+f(m)	1.310	0.0682	LCB%	1.52

VS (knot)	VM (m/s)	RTM (N)	FD (N)	TM (N)	QM (Nm)	NM (rps)	THDF	WFTM	ETAR	CR (e-3)
11.00	1.291	28.97	9.39	25.17	0.824	6.06	0.222	0.398	1.004	1.028
12.00	1.409	35.22	10.93	31.27	1.016	6.71	0.223	0.395	1.008	1.168
13.00	1.526	42.27	12.56	38.33	1.238	7.38	0.225	0.393	1.010	1.308
14.00	1.644	49.88	14.28	45.99	1.479	8.04	0.226	0.392	1.011	1.426
15.00	1.761	58.16	16.11	54.41	1.744	8.70	0.227	0.391	1.011	1.533
16.00	1.878	68.23	18.02	65.12	2.079	9.44	0.229	0.391	1.010	1.708

KRISO	13K Methanol PC Tanker	
Table 14	**Full Scale Prediction of Powering Performance (KS2048, Ballast draft with Fin, Stock propeller)**	07-20-2023 S2048S07.lyy

Draft FP/AP: **4.87** **5.73** **Scale Ratio :** **19.2**

appendages: **Fin & Rudder** **Condition :** **KP2015**

NOPROP : **1** Analysis Code : 1111000

Test	No.	Date	Temp. (deg.)	Density (Kg/m3)
RES	S2048R06	23-04-18	14.5	999.18
SP	S2048S07	23-04-18	14.5	999.18
POW	P2015O01	22-11-10	20.0	998.21

VS (knot)	PE (kW)	PD (kW)	N (rpm)	FN
11.00	850	1117	87.56	0.1634
12.00	1149	1519	96.76	0.1783
13.00	1518	2025	106.14	0.1931
14.00	1956	2624	115.41	0.2080
15.00	2472	3338	124.72	0.2229
16.00	3142	4287	134.91	0.2377

Analysis method -- Based on 1978 ITTC
performance prediction method -
* Model-ship correlation line : 1957 ITTC
* Propeller blade roughness KP= 30.e-6

* 2-dimensional method
* Correlation allowance (2-D) : CA = 0.000180
* w/ Bilge keel resistance
* w/ Air resistance : CAA = 0.0010*AT/S

KS2048	Ship dimension		
LWL(m)	122.258	Tm(m)	5.300
S(m2)	3042.8	AT(m2)	410.6
SBK(m2)	40.8	DIA(m)	4.800

VS (knot)	CTS (e-3)	CR (e-3)	ADVCA	THDF	WFTM	WFTS	ETAH	ETAR	ETAO	ETAD
11.00	3.006	1.028	0.533	0.222	0.398	0.340	1.178	1.004	0.643	0.761
12.00	3.127	1.168	0.527	0.223	0.395	0.339	1.175	1.008	0.639	0.756
13.00	3.252	1.308	0.521	0.225	0.393	0.339	1.172	1.010	0.633	0.750
14.00	3.354	1.426	0.516	0.226	0.392	0.339	1.171	1.011	0.630	0.745
15.00	3.447	1.533	0.511	0.227	0.391	0.339	1.170	1.011	0.626	0.741
16.00	3.609	1.708	0.503	0.229	0.391	0.340	1.169	1.010	0.621	0.733

KRISO	13K Methanol PC Tanker	
Table 15	**Trial Prediction of Powering Performance (KS2048, Ballast draft with Fin, Stock propeller)**	07-20-2023 S2048S07.lyy

Draft FP/AP: **4.87** **5.73** **Scale Ratio :** **19.2**

Appendages: **Fin & Rudder** **Condition :** **KP2015**

NOPROP : **1** Analysis Code : 1111000

Test	No.	Date	Temp. (deg.)	Density (Kg/m3)
RES	S2048R06	23-04-18	14.5	999.18
SP	S2048S07	23-04-18	14.5	999.18
POW	P2015O01	22-11-10	20.0	998.21

KS2048	Ship dimension		
LBP(m)	122.00	LWL(m)	122.26
B(m)	21.0	S(m2)	3042.8
DISV(m3)	9982.0	DIA(m)	4.8
AT(m)	410.6	SBK(m2)	40.8

Ship Speed		Brake Power		Speed of Shaft	
(knot)	(m/s)	(kW)	(PS)	(rpm)	(rps)
11.00	5.66	1,152	1,566	87.56	1.4594
12.00	6.17	1,565	2,129	96.76	1.6126
13.00	6.69	2,087	2,838	106.14	1.7690
14.00	7.20	2,705	3,679	115.41	1.9236
15.00	7.72	3,441	4,680	124.72	2.0787
16.00	8.23	4,420	6,011	134.91	2.2485

Condition	Ship Speed (knots)	Speed of Shaft (rpm)	Sea Margin (%)
Trial	14.38	118.9	-
Service	13.81	-	15.0
	Main Engine Power =		2,970.0 kW
	Transmission Efficiency =		0.970

[Notes]

- For the explanation of abbreviations, see the list of symbols.
- Analysis method : Based on 1978 ITTC performance prediction method
- Frictional resistance determined according to the ITTC-1957 formula.
- Reynolds and Froude number based on Lwl= 122.26
- A model-ship Correlation allowance (2-D) : CA = 0.000180
- w/o CP-CN correction
- A resistance of above water part through the air, Cair = 0.0001349
- The results are valid for unrestricted deep water of 15.0 deg C and a mass density of 1025.9 kg/m3, clean surfaces of hull and propeller blades and no effects of wind and waves.

KRISO	13K Methanol PC Tanker	
Table 16	**Measured Velocity Components and Circumferential Mean Velocities-I (KS2048, Scantling draft, 13.0 knots)**	07-20-2023 S2048K05.dat

Test Number	S2048K05	Load Condition	Scantling		Ship Speed(knots)	13.00	Water Temp.(deg)	14.5
Rake Number	M3-5	TF/TA(m)	8.55	8.55	Model Speed(m/s)	1.5261	Model Prop. Dia(m)	0.2500

	Angle	0	5	10	20	30	40	50	60	70	80	90
	(Deg.)	100	110	120	130	140	150	160	170	175	180	185
r/R		190	200	210	220	230	240	250	260	270	280	290
		0.419	0.443	0.438	0.445	0.444	0.436	0.417	0.409	0.395	0.387	0.376
	VX/V	0.353	0.330	0.289	0.237	0.203	0.197	0.197	0.235	0.227	0.243	0.227
		0.238	0.204	0.194	0.199	0.223	0.273	0.316	0.343	0.370	0.386	0.401
		-0.216	-0.214	-0.201	-0.169	-0.123	-0.075	-0.027	0.023	0.042	0.061	0.084
0.3000	VR/V	0.093	0.098	0.094	0.083	0.037	-0.028	-0.098	-0.131	-0.139	-0.136	-0.139
		-0.132	-0.098	-0.030	0.039	0.086	0.098	0.103	0.099	0.090	0.060	0.025
		-0.075	0.023	0.063	0.118	0.137	0.145	0.143	0.145	0.142	0.134	0.139
	VT/V	0.143	0.145	0.140	0.114	0.085	0.082	0.051	-0.011	0.013	-0.010	0.013
		-0.001	-0.040	-0.078	-0.081	-0.114	-0.139	-0.142	-0.138	-0.132	-0.126	-0.134
		0.449	0.459	0.472	0.451	0.375	0.313	0.298	0.289	0.316	0.339	0.355
	VX/V	0.378	0.401	0.405	0.436	0.446	0.463	0.469	0.448	0.412	0.407	0.407
		0.443	0.474	0.469	0.449	0.435	0.405	0.401	0.378	0.356	0.338	0.314
		-0.261	-0.249	-0.227	-0.149	-0.069	-0.024	0.008	0.019	0.022	0.024	-0.002
0.5000	VR/V	-0.016	-0.022	-0.043	-0.056	-0.063	-0.078	-0.101	-0.086	-0.061	-0.057	-0.062
		-0.086	-0.101	-0.078	-0.062	-0.056	-0.042	-0.019	-0.015	-0.004	0.024	0.023
		-0.001	0.046	0.049	0.062	0.052	0.023	-0.029	-0.070	-0.102	-0.122	-0.138
	VT/V	-0.130	-0.117	-0.087	-0.080	-0.061	-0.040	-0.033	0.008	0.017	0.005	-0.034
		-0.033	0.003	0.020	0.051	0.075	0.083	0.112	0.123	0.131	0.116	0.097
		0.450	0.454	0.490	0.424	0.335	0.335	0.399	0.477	0.562	0.643	0.712
	VX/V	0.756	0.782	0.811	0.827	0.840	0.843	0.851	0.819	0.800	0.770	0.804
		0.827	0.864	0.857	0.854	0.839	0.822	0.792	0.768	0.727	0.662	0.581
		-0.246	-0.229	-0.206	-0.106	-0.035	-0.022	-0.001	0.001	-0.034	-0.055	-0.073
0.7000	VR/V	-0.090	-0.097	-0.113	-0.120	-0.129	-0.135	-0.141	-0.145	-0.145	-0.145	-0.146
		-0.144	-0.141	-0.136	-0.131	-0.122	-0.114	-0.098	-0.091	-0.074	-0.057	-0.037
		-0.027	-0.096	-0.021	0.009	-0.046	-0.103	-0.161	-0.205	-0.229	-0.244	-0.231
	VT/V	-0.213	-0.194	-0.170	-0.143	-0.117	-0.098	-0.076	-0.049	-0.005	0.003	0.009
		0.017	0.048	0.077	0.102	0.137	0.170	0.197	0.217	0.235	0.246	0.230
		0.452	0.510	0.544	0.512	0.489	0.591	0.693	0.793	0.858	0.884	0.903
	VX/V	0.913	0.918	0.924	0.928	0.931	0.932	0.934	0.933	0.933	0.935	0.937
		0.938	0.939	0.936	0.934	0.928	0.922	0.915	0.910	0.901	0.883	0.859
		-0.181	-0.155	-0.120	-0.066	0.002	0.027	0.034	0.026	0.005	-0.034	-0.055
0.9000	VR/V	-0.070	-0.082	-0.090	-0.099	-0.105	-0.111	-0.116	-0.120	-0.121	-0.120	-0.122
		-0.121	-0.118	-0.113	-0.107	-0.101	-0.092	-0.083	-0.069	-0.052	-0.029	0.011
		0.023	-0.068	-0.085	-0.118	-0.172	-0.236	-0.273	-0.292	-0.282	-0.257	-0.230
	VT/V	-0.205	-0.179	-0.156	-0.134	-0.112	-0.091	-0.073	-0.054	-0.044	-0.001	0.006
		0.018	0.040	0.063	0.089	0.115	0.142	0.168	0.197	0.223	0.250	0.273
		0.445	0.510	0.562	0.622	0.683	0.754	0.813	0.852	0.874	0.896	0.906
	VX/V	0.914	0.922	0.926	0.929	0.931	0.932	0.934	0.931	0.932	0.933	0.934
		0.936	0.940	0.939	0.937	0.934	0.931	0.927	0.920	0.914	0.908	0.890
		-0.077	-0.063	-0.045	-0.001	0.030	0.042	0.031	0.005	-0.034	-0.059	-0.077
1.1000	VR/V	-0.090	-0.100	-0.109	-0.114	-0.120	-0.124	-0.127	-0.129	-0.130	-0.131	-0.131
		-0.130	-0.128	-0.126	-0.122	-0.117	-0.112	-0.105	-0.095	-0.083	-0.065	-0.041
		0.018	-0.079	-0.121	-0.196	-0.248	-0.271	-0.277	-0.267	-0.249	-0.225	-0.202
	VT/V	-0.180	-0.159	-0.138	-0.117	-0.099	-0.081	-0.062	-0.043	-0.002	0.003	0.010
		0.019	0.042	0.065	0.087	0.110	0.135	0.159	0.182	0.206	0.229	0.253

r/R	0.300	0.400	0.500	0.600	0.700	0.800	0.900	1.000
VX/V	0.339	0.356	0.393	0.496	0.645	0.743	0.799	0.827
VR/V	-0.024	-0.038	-0.056	-0.081	-0.094	-0.081	-0.062	-0.057
VT/V	0.001	-0.002	-0.004	-0.006	-0.007	-0.008	-0.007	-0.004

Volumetric	
Mean of VX/V =	0.629
Nominal Wake Fraction(WN) =	**0.371**

KRISO	13K Methanol PC Tanker	
Table 17	**Measured Velocity Components and Circumferential Mean Velocities-II (KS2048, Scantling draft, 13.0 knots)**	07-20-2023 S2048K05.dat

Test Number	S2048K05	Load Condition	Scantling	Ship Speed(knots) 13.00	Water Temp.(deg) 14.5
Rake Number	M3-5	TF/TA(m)	8.55 8.55	Model Speed(m/s) 1.5261	Model Prop. Dia(m) 0.2500

r/R	Angle (Deg.)	300	310	320	330	340	350	355	360
0.3000	VX/V	0.411	0.408	0.436	0.447	0.453	0.441	0.430	0.419
	VR/V	-0.007	-0.044	-0.075	-0.117	-0.167	-0.199	-0.212	-0.216
	VT/V	-0.137	-0.136	-0.138	-0.133	-0.107	-0.068	-0.070	-0.075
0.5000	VX/V	0.287	0.301	0.310	0.373	0.449	0.473	0.463	0.449
	VR/V	0.019	0.007	-0.023	-0.070	-0.147	-0.229	-0.254	-0.261
	VT/V	0.067	0.020	-0.032	-0.060	-0.074	-0.049	-0.014	-0.001
0.7000	VX/V	0.493	0.411	0.340	0.340	0.422	0.481	0.463	0.450
	VR/V	0.004	0.002	-0.022	-0.036	-0.106	-0.204	-0.231	-0.246
	VT/V	0.207	0.162	0.104	0.039	-0.014	-0.061	-0.065	-0.027
0.9000	VX/V	0.794	0.694	0.591	0.489	0.509	0.542	0.510	0.452
	VR/V	0.032	0.038	0.030	0.005	-0.065	-0.120	-0.155	-0.181
	VT/V	0.282	0.264	0.228	0.167	0.114	0.073	0.049	0.023
1.1000	VX/V	0.867	0.825	0.762	0.690	0.633	0.567	0.513	0.445
	VR/V	0.007	0.033	0.043	0.031	0.001	-0.048	-0.064	-0.077
	VT/V	0.272	0.284	0.279	0.255	0.200	0.123	0.077	0.018

r/R	0.300	0.400	0.500	0.600	0.700	0.800	0.900	1.000
VX/V	0.339	0.356	0.393	0.496	0.645	0.743	0.799	0.827
VR/V	-0.024	-0.038	-0.056	-0.081	-0.094	-0.081	-0.062	-0.057
VT/V	0.001	-0.002	-0.004	-0.006	-0.007	-0.008	-0.007	-0.004

Volumetric Mean of VX/V =	0.629
Nominal Wake Fraction(WN) =	**0.371**

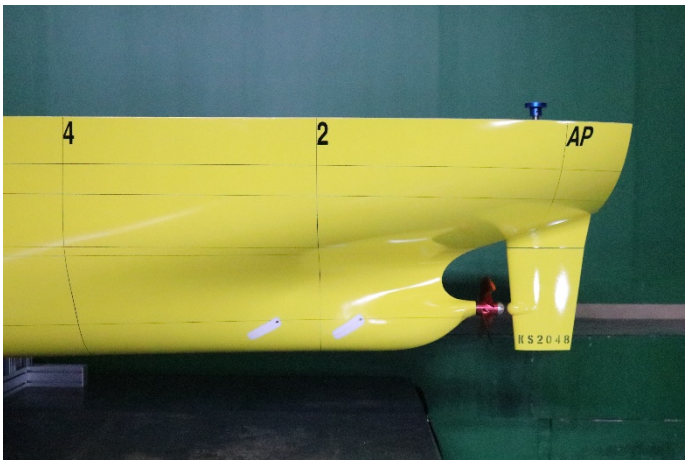
KRISO	13K Methanol PC Tanker	
Table 18	**Harmonic Analysis of Velocity Components (KS2048, Scantling draft, 13.0 knots)**	07-20-2023 S2048K05.dat

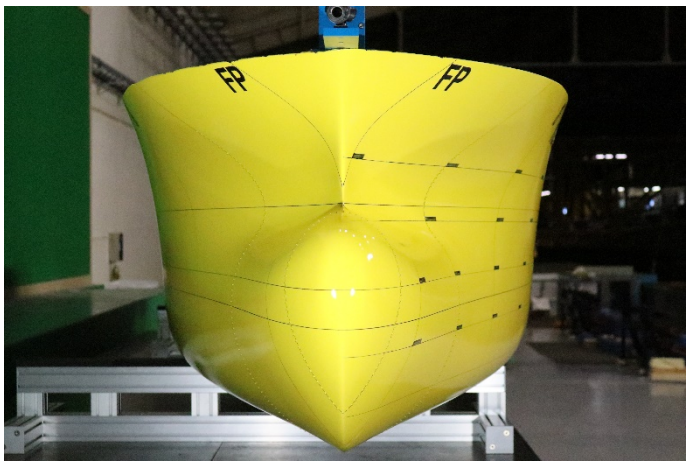
Test Number	S2048K05	Load Condition	Scantling	Ship Speed(knots) 13.00	Water Temp.(deg) 14.5
Rake Number	M3-5	TF/TA(m)	8.55 8.55	Model Speed(m/s) 1.5261	Model Prop. Dia(m) 0.2500

	k	0	1	2	3	4	5	6	7	8	9	10
r/R		Harmonic analysis of axial velocity component										
0.3000	a(k)	0.339	0.127	-0.020	-0.010	0.017	-0.016	0.002	-0.004	-0.003	0.000	0.001
	b(k)	0.000	0.003	-0.003	-0.001	0.002	-0.002	-0.001	-0.001	0.000	0.001	0.001
	c(k)	0.339	0.127	0.020	0.010	0.017	0.016	0.002	0.004	0.003	0.001	0.001
0.5000	a(k)	0.393	-0.037	0.055	0.048	0.016	0.014	-0.010	0.001	-0.011	-0.001	-0.007
	b(k)	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.001	-0.001	0.000	-0.001
	c(k)	0.393	0.037	0.055	0.048	0.016	0.014	0.010	0.001	0.011	0.001	0.007
0.7000	a(k)	0.645	-0.253	-0.037	0.058	0.039	0.033	0.002	0.006	-0.007	-0.003	-0.012
	b(k)	0.000	-0.008	0.001	0.000	0.003	0.000	0.000	0.000	0.001	0.000	0.000
	c(k)	0.645	0.253	0.037	0.058	0.039	0.033	0.002	0.006	0.007	0.003	0.012
0.9000	a(k)	0.799	-0.212	-0.101	-0.024	0.017	0.026	0.017	0.006	-0.001	-0.005	-0.006
	b(k)	0.000	0.000	0.000	-0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
	c(k)	0.799	0.212	0.101	0.024	0.017	0.026	0.017	0.006	0.001	0.005	0.006
1.1000	a(k)	0.842	-0.151	-0.088	-0.045	-0.022	-0.009	-0.006	-0.004	-0.005	-0.005	-0.006
	b(k)	0.000	-0.006	-0.002	-0.001	0.001	0.000	-0.001	-0.001	0.000	0.000	0.000
	c(k)	0.842	0.151	0.088	0.045	0.022	0.009	0.006	0.004	0.005	0.005	0.006
r/R		Harmonic analysis of radial velocity component										
0.3000	a(k)	-0.024	-0.054	-0.130	0.021	-0.026	0.002	-0.002	-0.004	0.004	-0.003	0.000
	b(k)	0.000	0.002	0.003	0.000	-0.004	-0.003	0.000	0.002	0.002	0.000	-0.001
	c(k)	0.024	0.054	0.130	0.021	0.027	0.003	0.002	0.004	0.004	0.003	0.001
0.5000	a(k)	-0.056	-0.017	-0.080	-0.049	-0.025	-0.017	-0.005	-0.010	0.000	-0.004	0.005
	b(k)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	c(k)	0.056	0.017	0.080	0.049	0.025	0.017	0.005	0.010	0.000	0.004	0.005
0.7000	a(k)	-0.094	0.029	-0.048	-0.048	-0.035	-0.020	-0.010	-0.006	-0.007	-0.006	-0.003
	b(k)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	c(k)	0.094	0.029	0.048	0.048	0.035	0.020	0.010	0.006	0.007	0.006	0.003
0.9000	a(k)	-0.062	0.046	-0.037	-0.045	-0.032	-0.015	-0.006	-0.005	-0.005	-0.003	0.000
	b(k)	0.000	-0.001	-0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	c(k)	0.062	0.046	0.037	0.045	0.032	0.015	0.006	0.005	0.005	0.003	0.000
1.1000	a(k)	-0.063	0.075	-0.003	-0.026	-0.026	-0.015	-0.006	-0.001	-0.001	-0.002	-0.002
	b(k)	0.000	0.002	-0.001	-0.001	0.000	0.001	0.001	0.000	0.000	0.000	0.000
	c(k)	0.063	0.075	0.003	0.026	0.026	0.015	0.006	0.001	0.001	0.002	0.002
r/R		Harmonic analysis of tangential velocity component										
0.3000	a(k)	0.001	-0.002	-0.004	-0.004	-0.003	-0.003	-0.004	-0.003	-0.003	-0.003	-0.003
	b(k)	0.000	0.158	0.021	0.021	0.020	0.002	0.004	0.002	0.004	-0.005	0.005
	c(k)	0.001	0.158	0.022	0.022	0.020	0.003	0.005	0.004	0.005	0.006	0.006
0.5000	a(k)	-0.004	0.004	-0.001	0.003	0.001	0.001	0.003	0.000	0.002	0.000	0.002
	b(k)	0.000	-0.085	0.033	0.054	0.017	0.011	0.000	0.006	-0.004	0.003	0.000
	c(k)	0.004	0.085	0.033	0.054	0.017	0.011	0.003	0.006	0.005	0.003	0.002
0.7000	a(k)	-0.007	-0.004	-0.013	-0.007	-0.007	-0.009	-0.004	-0.006	-0.003	-0.005	-0.002
	b(k)	0.000	-0.207	0.003	0.036	0.026	0.011	0.007	0.002	0.003	0.000	-0.002
	c(k)	0.007	0.207	0.013	0.037	0.027	0.014	0.008	0.007	0.004	0.005	0.003
0.9000	a(k)	-0.007	0.006	-0.003	0.001	0.001	-0.001	0.000	-0.001	0.000	0.000	0.001
	b(k)	0.000	-0.244	-0.068	-0.011	0.010	0.004	0.001	-0.005	-0.003	-0.004	-0.002
	c(k)	0.007	0.244	0.068	0.011	0.010	0.004	0.001	0.005	0.003	0.005	0.002
1.1000	a(k)	-0.001	0.005	-0.002	0.000	0.001	-0.001	0.001	-0.001	0.002	-0.001	0.002
	b(k)	0.000	-0.240	-0.090	-0.041	-0.014	-0.008	-0.003	-0.004	-0.002	-0.002	-0.002
	c(k)	0.001	0.240	0.090	0.041	0.014	0.008	0.003	0.004	0.002	0.002	0.002

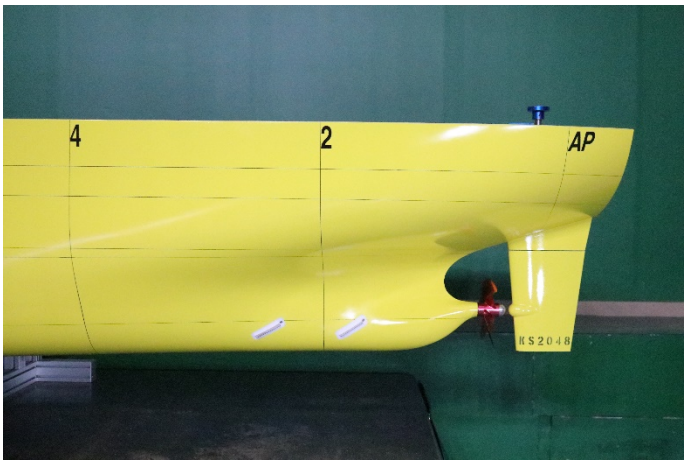
FIGURES

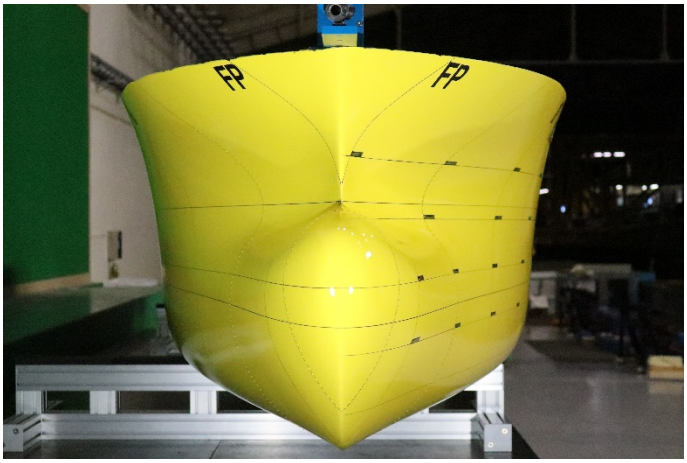
KRISO	13K Methanol PC Tanker	
Figure 1	**Photographs of the Model Ship (KS2048)**	07-20-2023 -



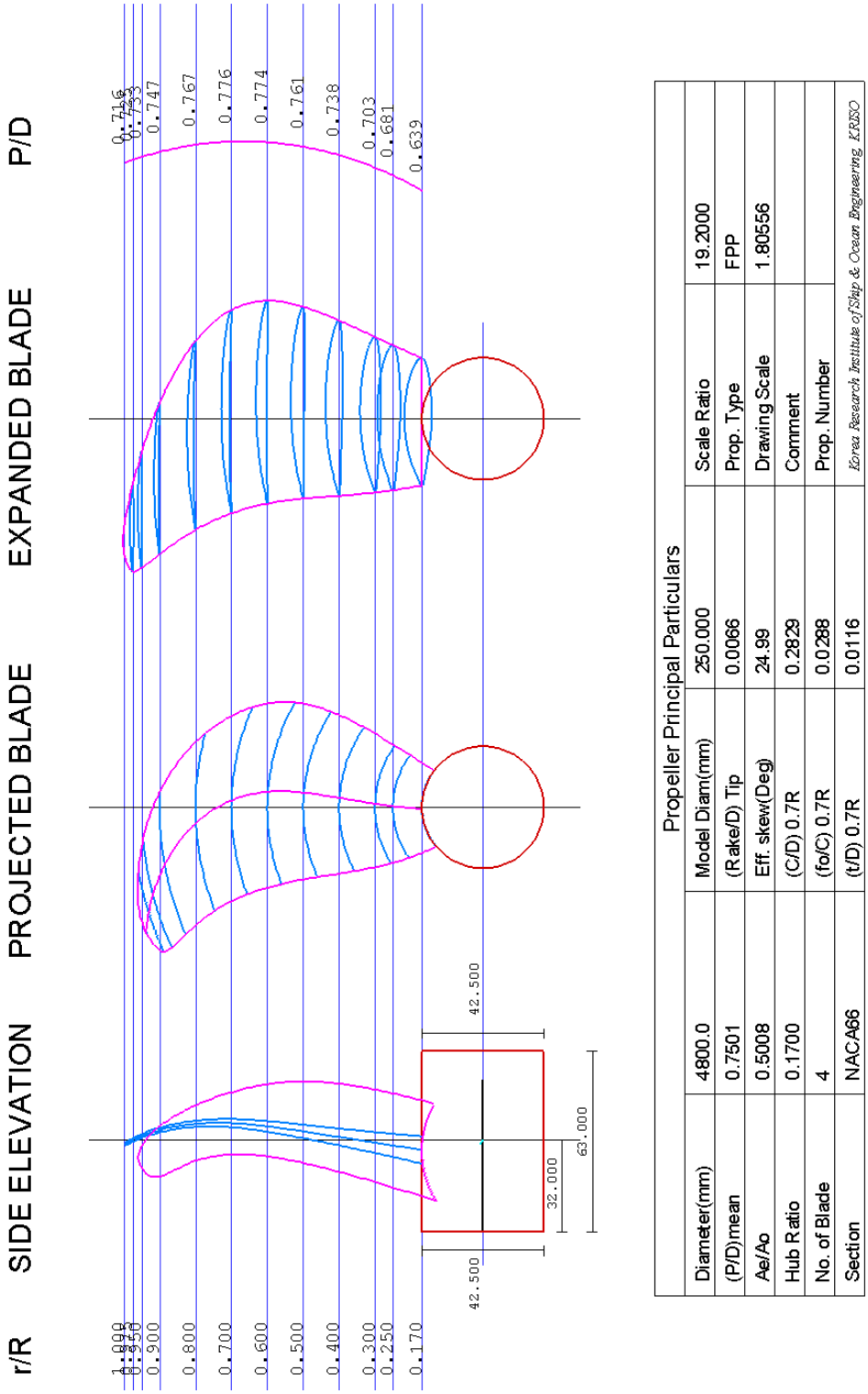


KRISO	13K Methanol PC Tanker	
Figure 2	**Photographs of the Model Ship (KS2048 with Fin)**	07-20-2023 -



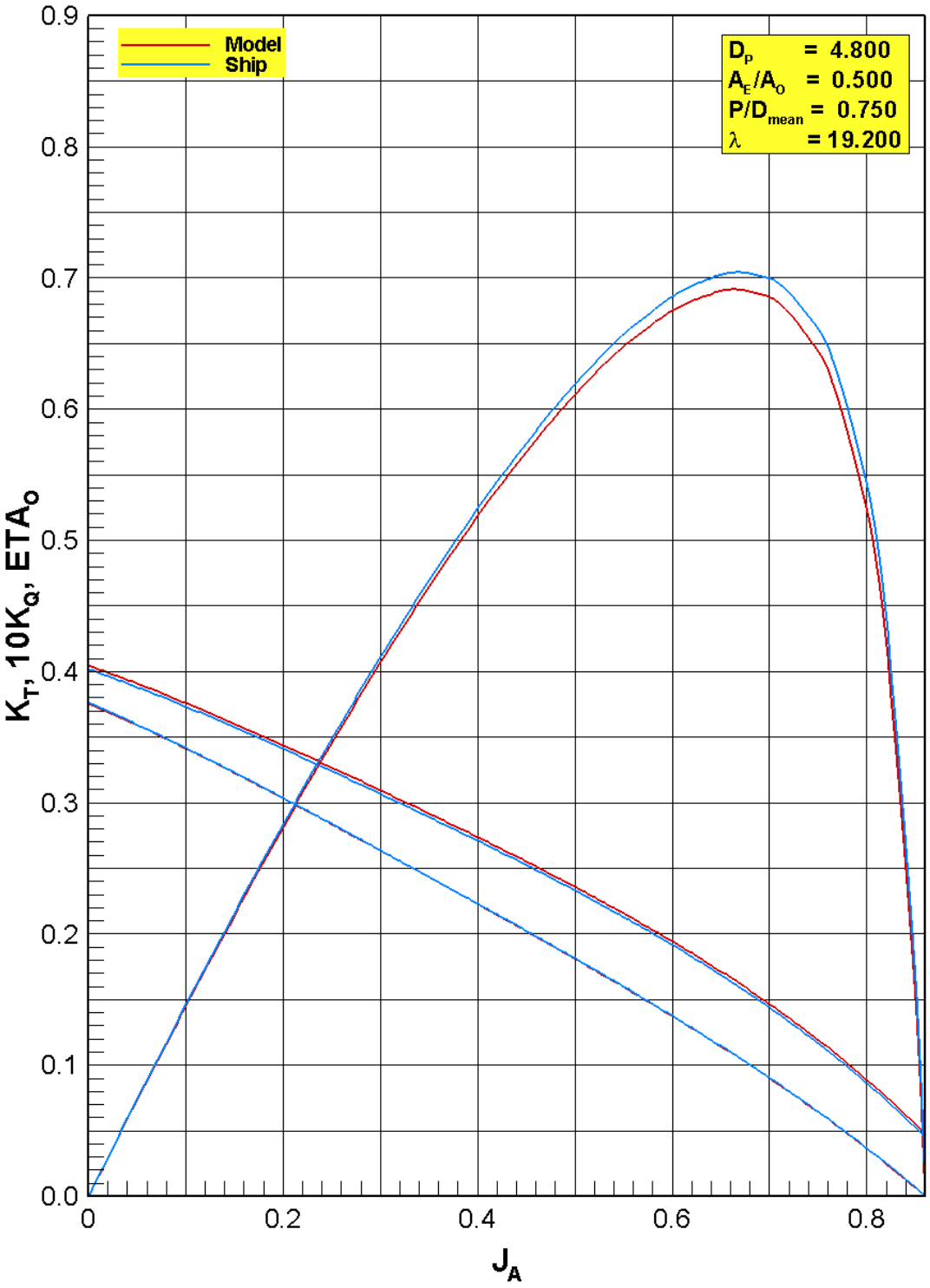


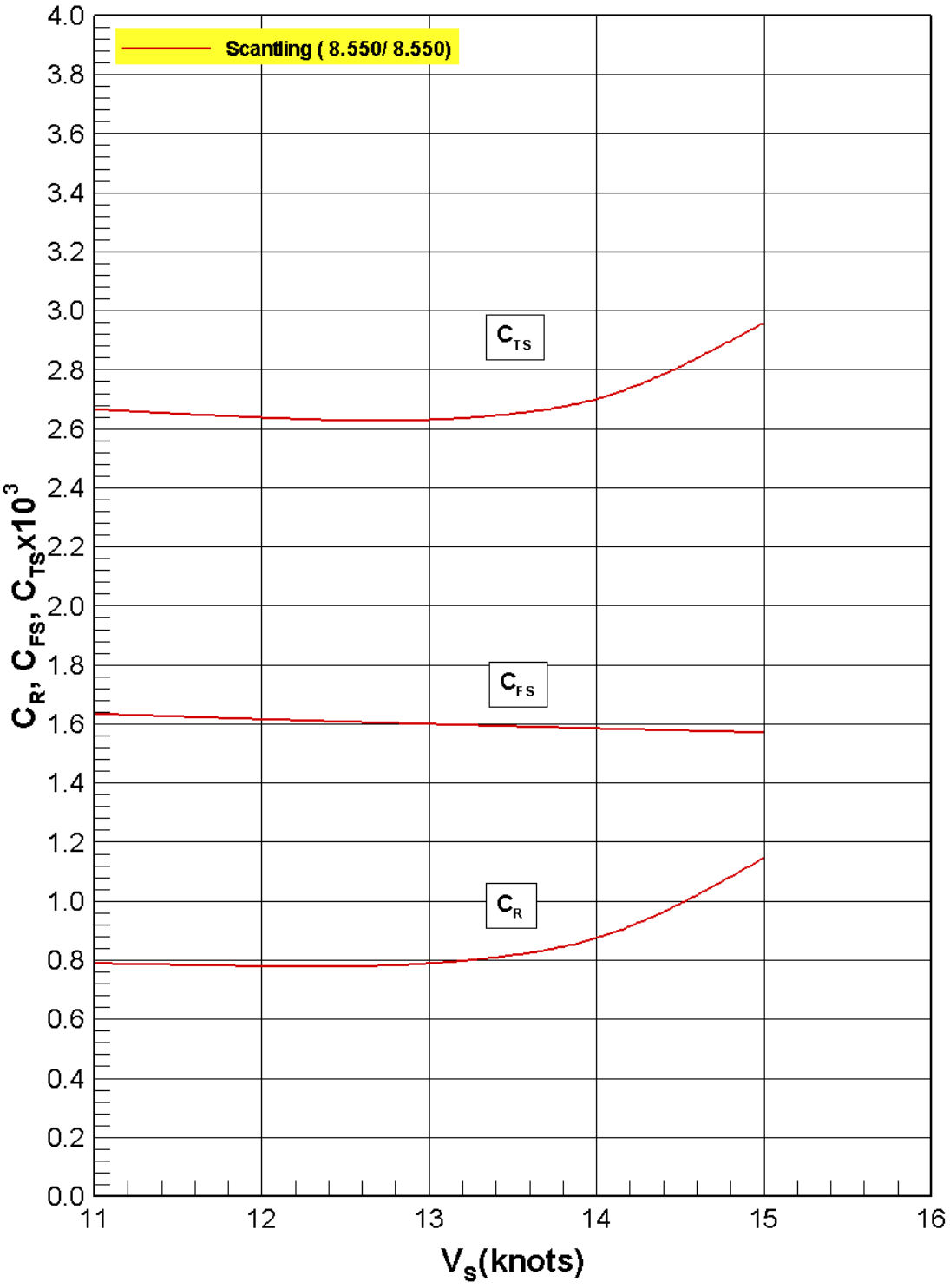
KRISO	13K Methanol PC Tanker	
Figure 3	**Drawing of the Stock Propeller (KP2015)**	07-20-2023 -



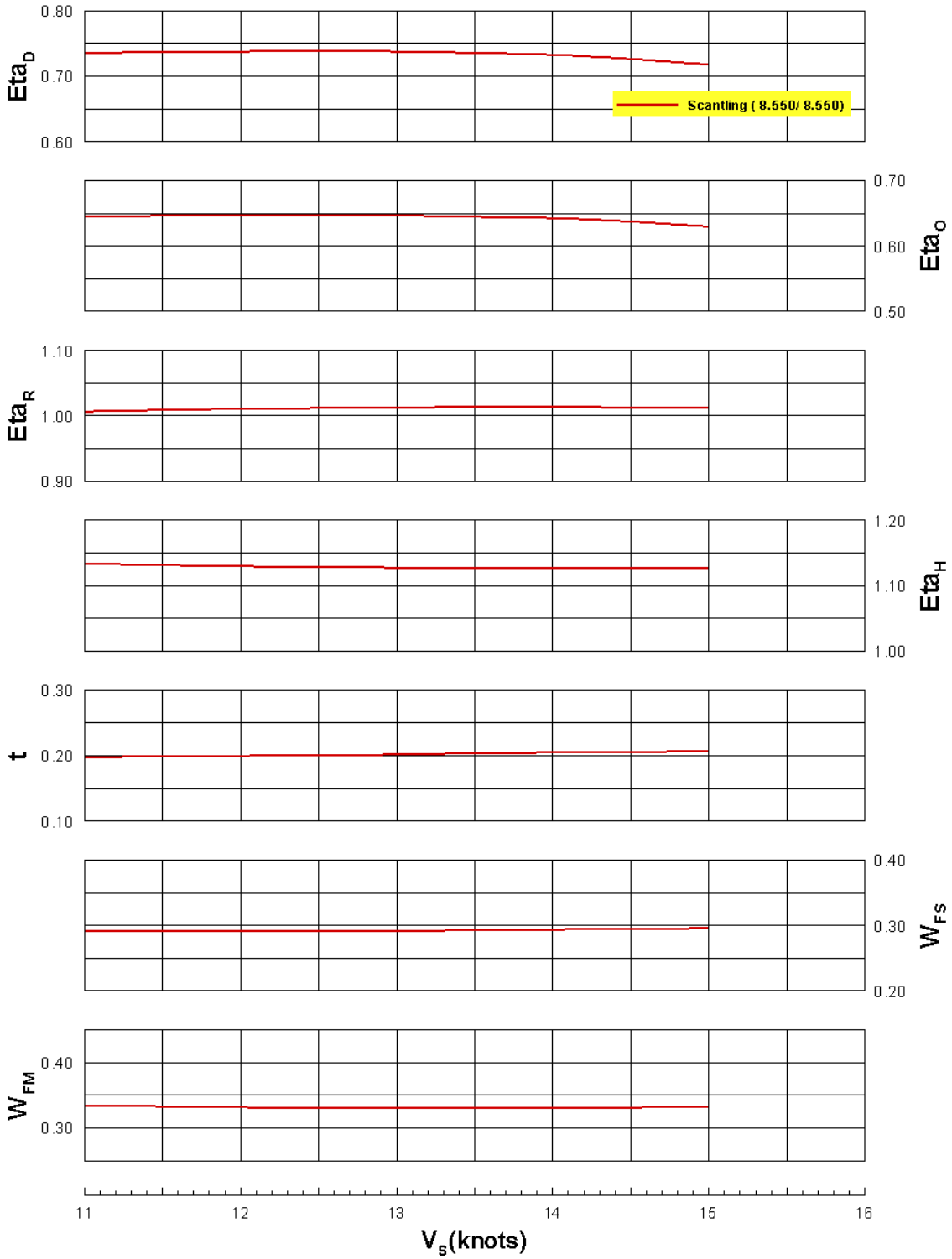
Propeller Principal Particulars

Diameter(mm)	4800.0	Model Diam(mm)	250.000	Scale Ratio	19.2000
(P/D)mean	0.7501	(Rake/D) Tip	0.0066	Prop. Type	FPP
Ae/Ao	0.5008	Eff. skew(Deg)	24.99	Drawing Scale	1.80556
Hub Ratio	0.1700	(C/D) 0.7R	0.2829	Comment	
No. of Blade	4	(fo/C) 0.7R	0.0288	Prop. Number	
Section	NACA66	(t/D) 0.7R	0.0116	*Korea Research Institute of Ship & Ocean Engineering KRISO*	

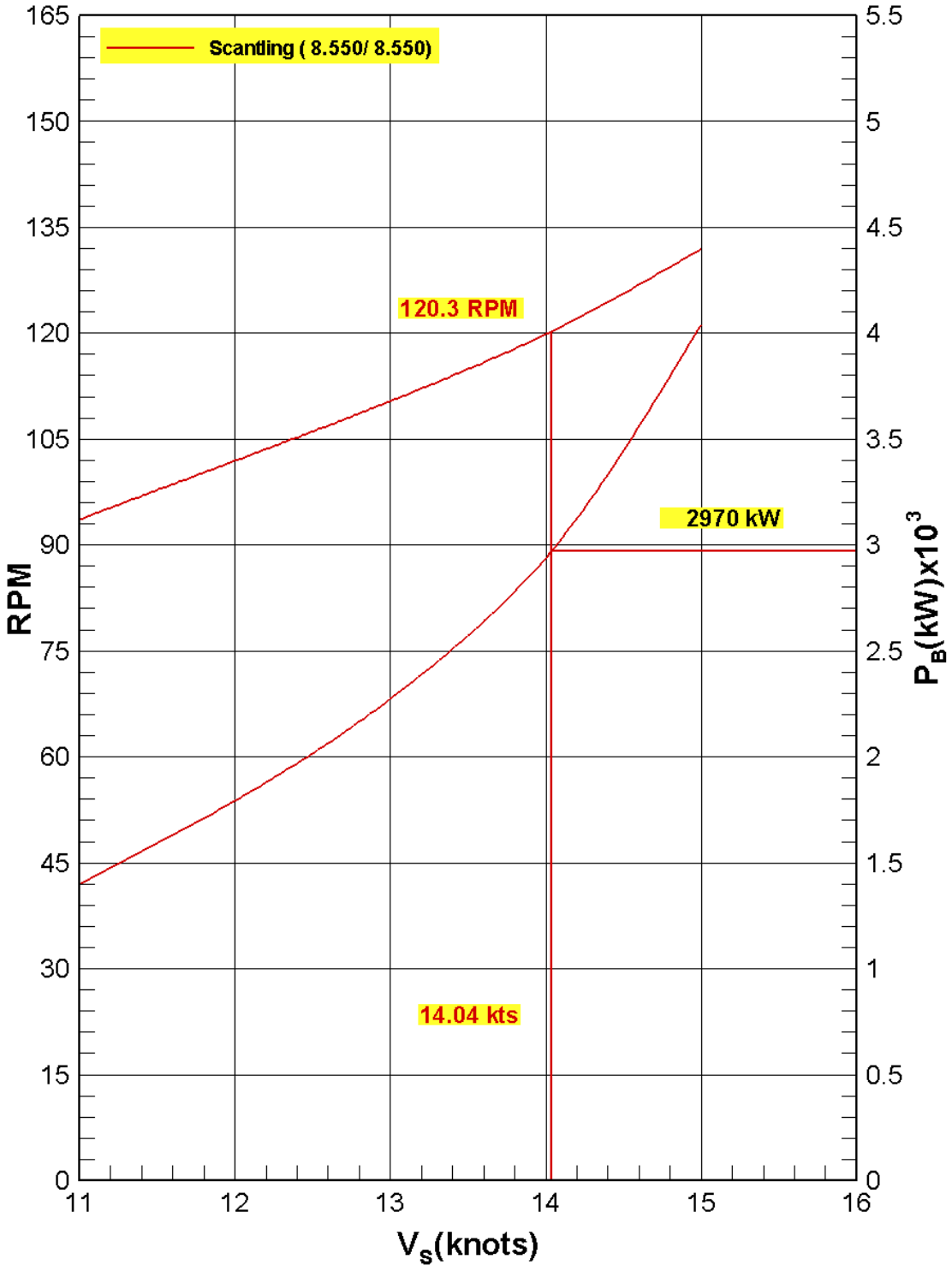

Model
Ship
D_P = 4.800
A_E/A_O = 0.500
P/D_{mean} = 0.750
λ = 19.200
$K_T, 10K_Q, ETA_o$
J_A
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0
0.2
0.4
0.6
0.8


Scantling (8.550/ 8.550)
C_{TS}
C_{FS}
C_R
C_R, C_{FS}, C_{TS}X10^3
V_S(knots)
4.0
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
11
12
13
14
15
16

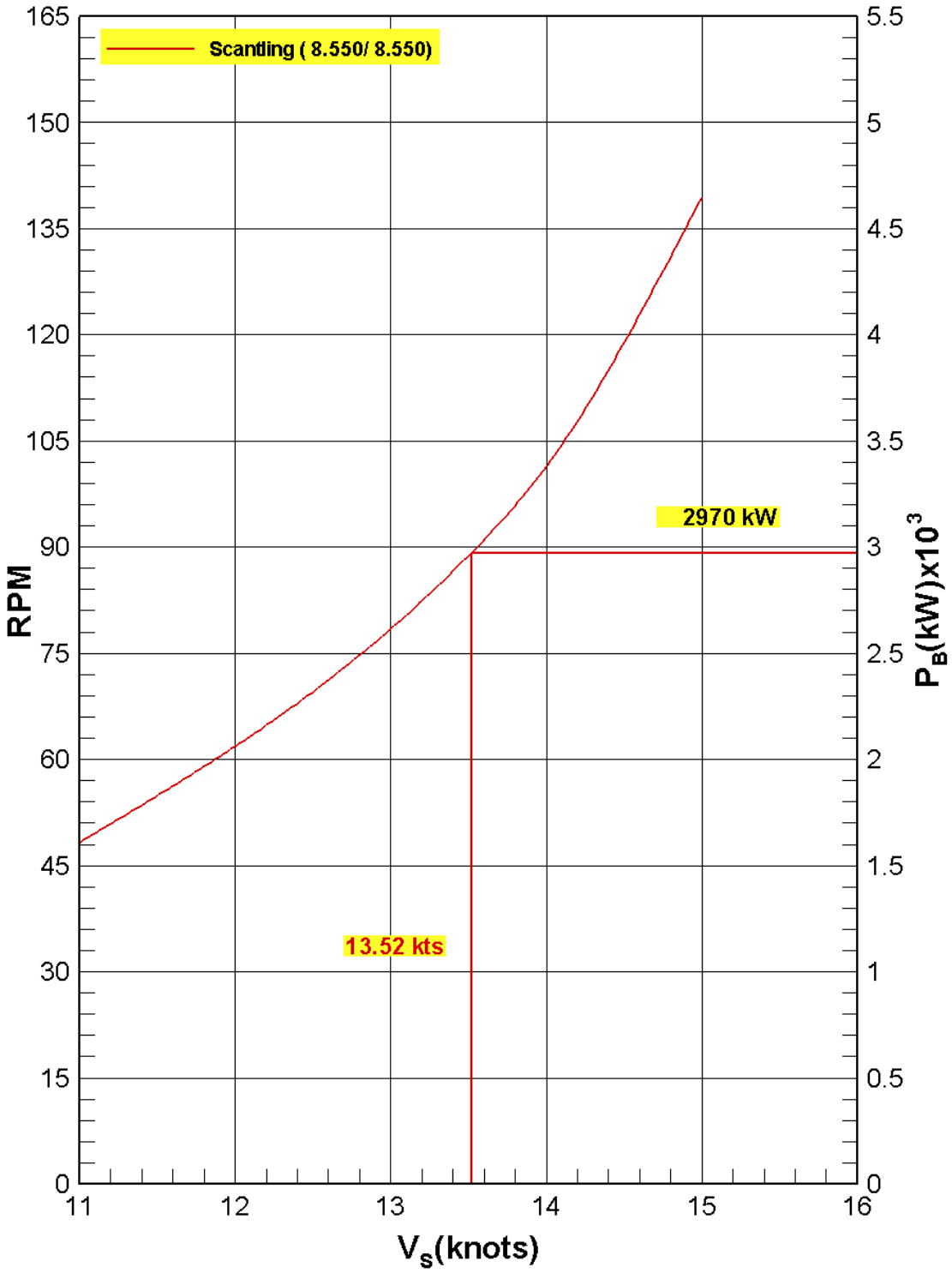
KRISO	13K Methanol PC Tanker	
Figure 6	**Propulsive Coefficients (KS2048, Scantling draft, Stock propeller)**	07-20-2023 S2048S02.lyy



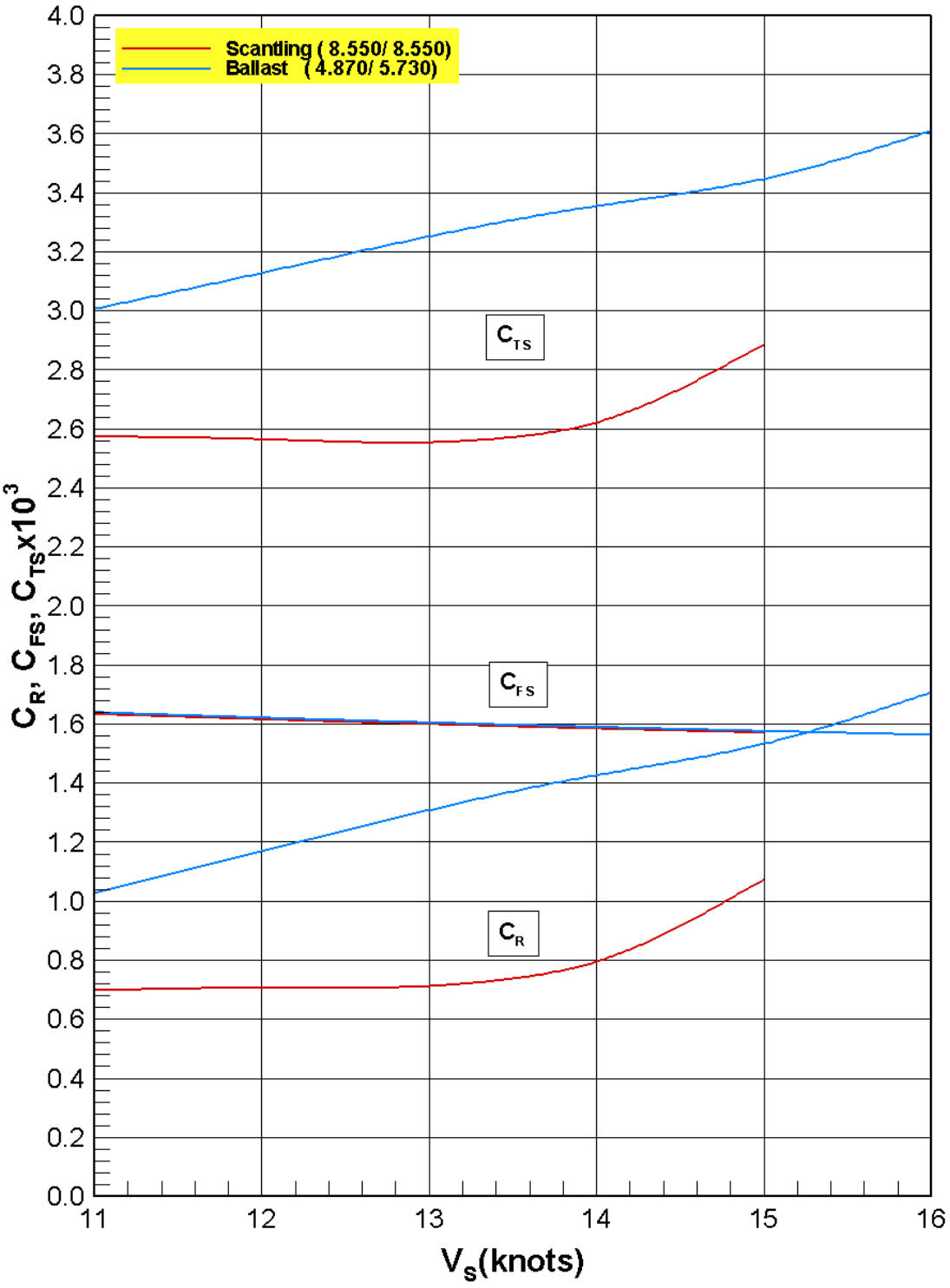
KRISO	13K Methanol PC Tanker	
Figure 7	**Prediction of Powering Performance (KS2048, Scantling draft, Stock propeller, at NCR)**	07-20-2023 S2048S02.lyy



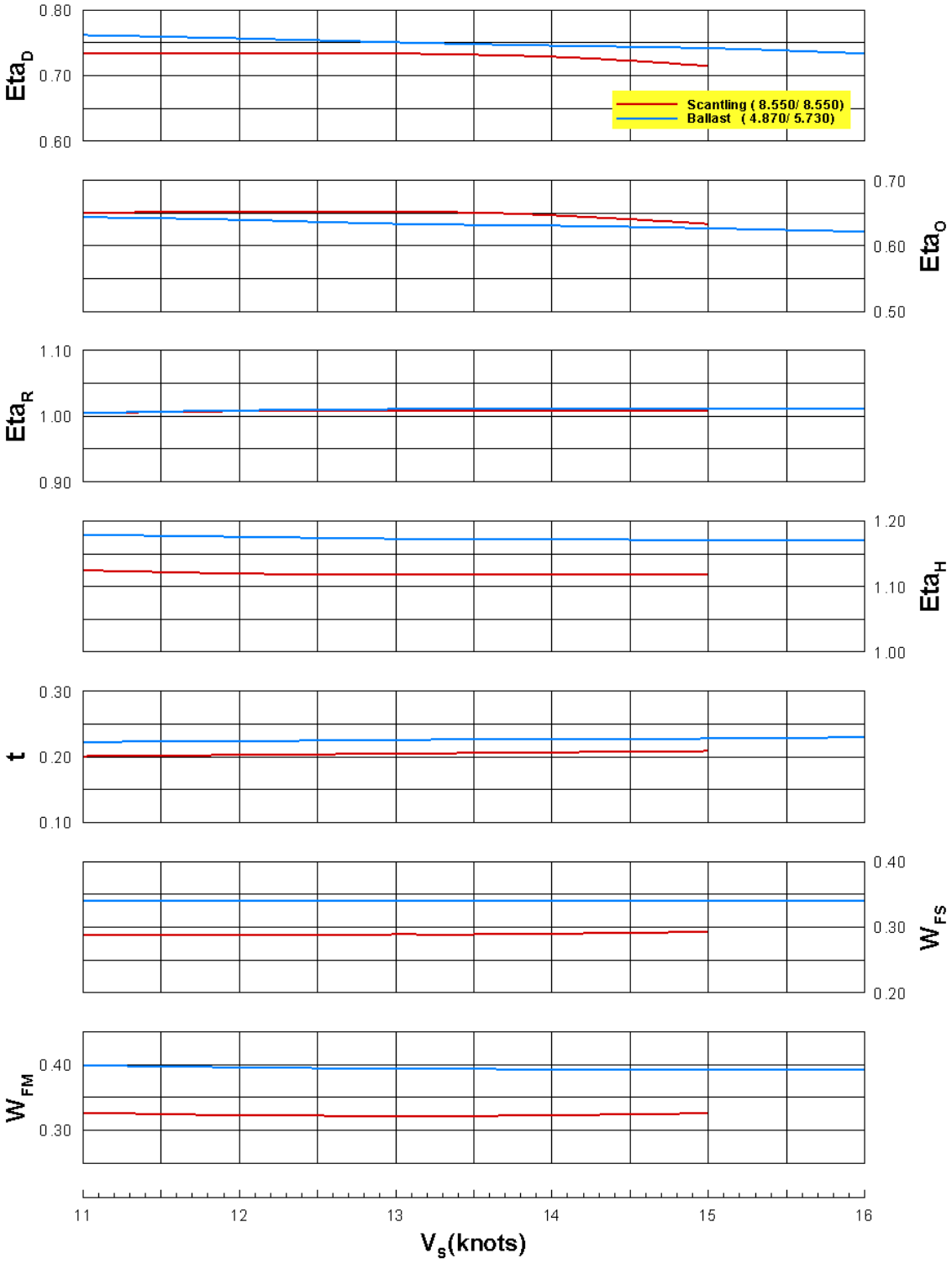
KRISO	13K Methanol PC Tanker	
Figure 8	**Prediction of Powering Performance (KS2048, Scantling draft, Stock propeller, at NCR with 15% Sea Margin)**	07-20-2023 S2048S02.lyy



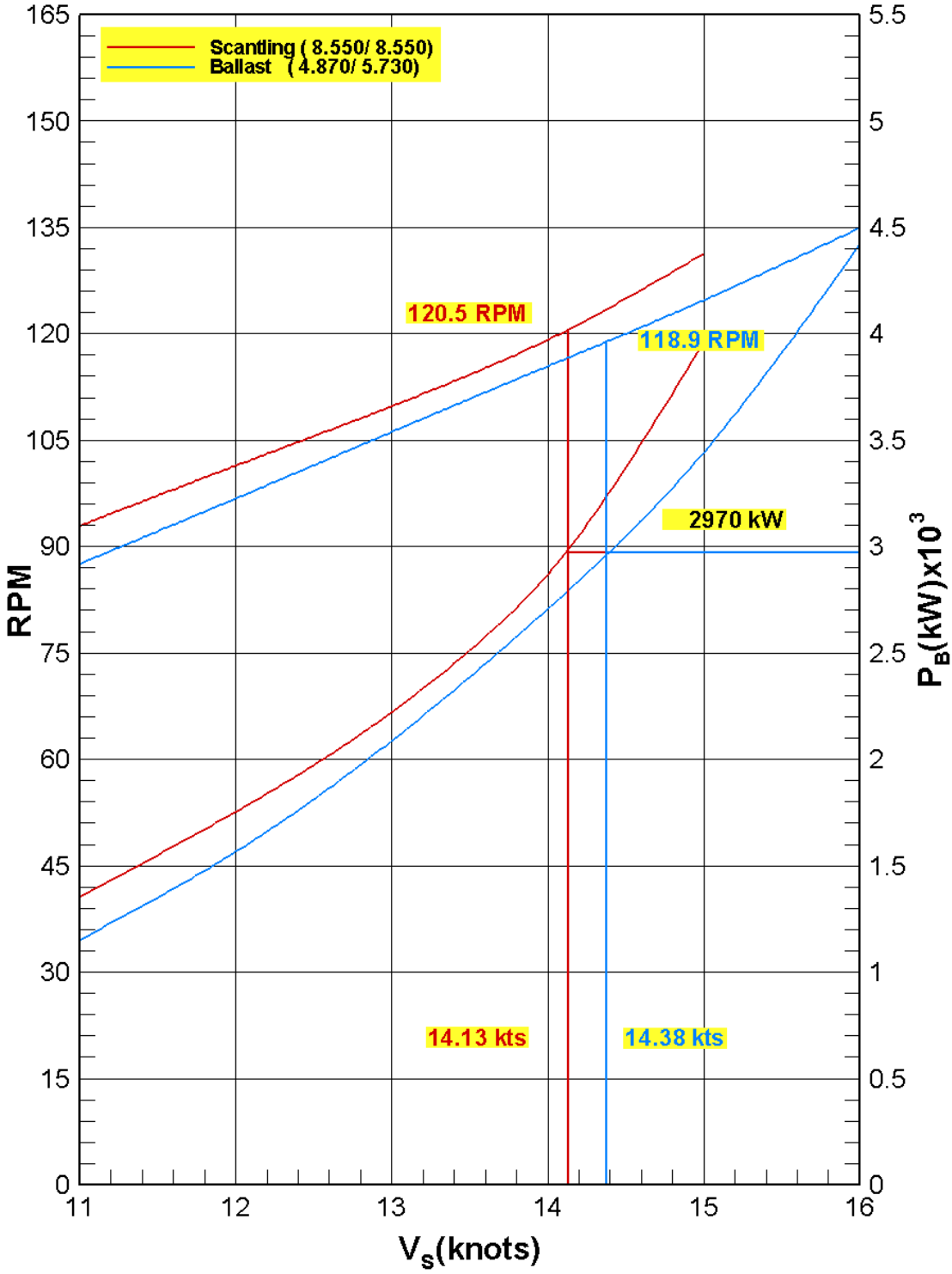
KRISO	13K Methanol PC Tanker	
Figure 9	**Resistance Coefficients (KS2048, Scantling and Ballast drafts with Fin)**	07-20-2023 S2048S04.lyy, S2048S07.lyy



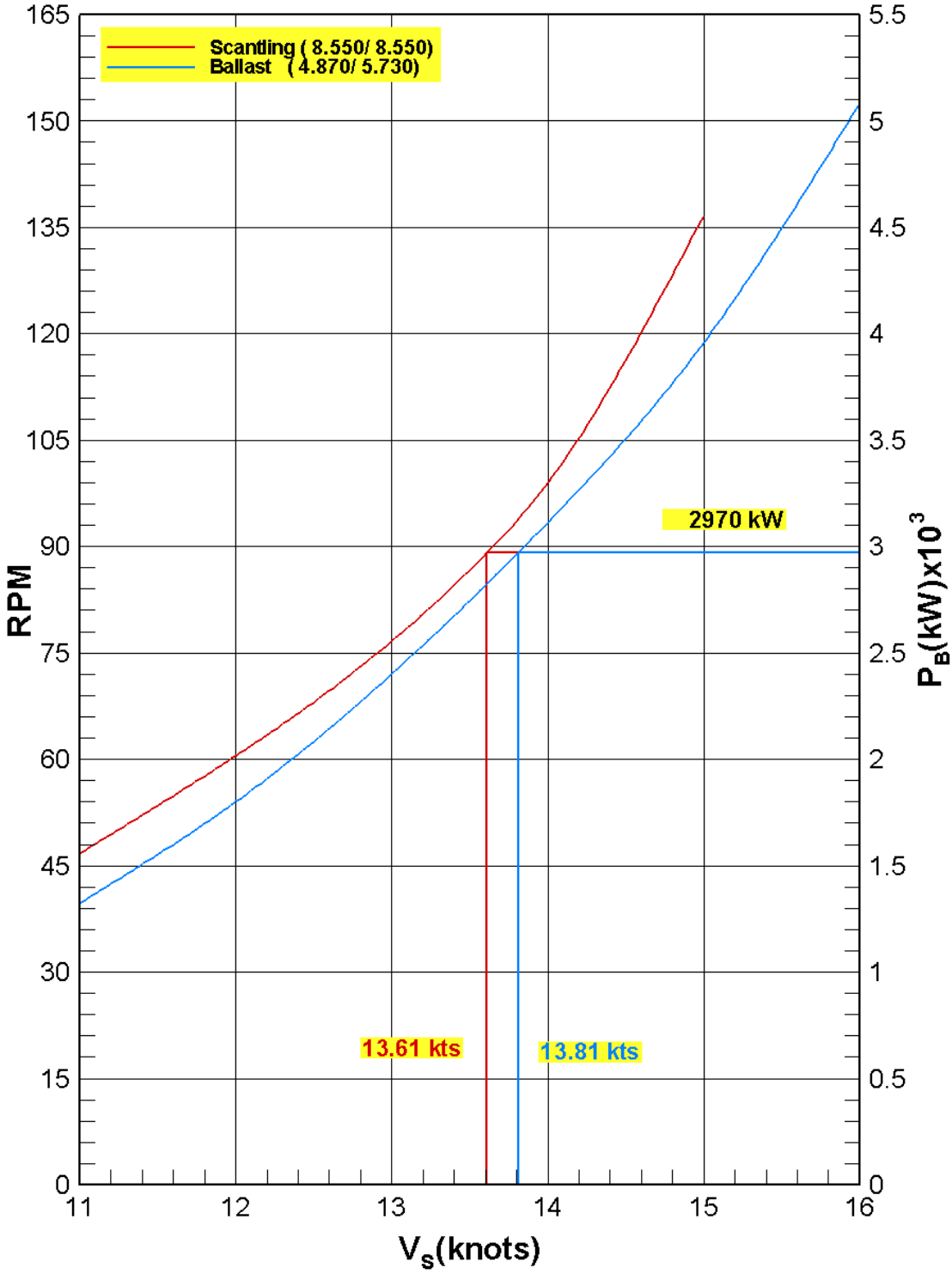
KRISO	13K Methanol PC Tanker	
Figure 10	**Propulsive Coefficients (KS2048, Scantling and Ballast drafts with Fin, Stock propeller)**	07-20-2023 S2048S04.lyy, S2048S07.lyy



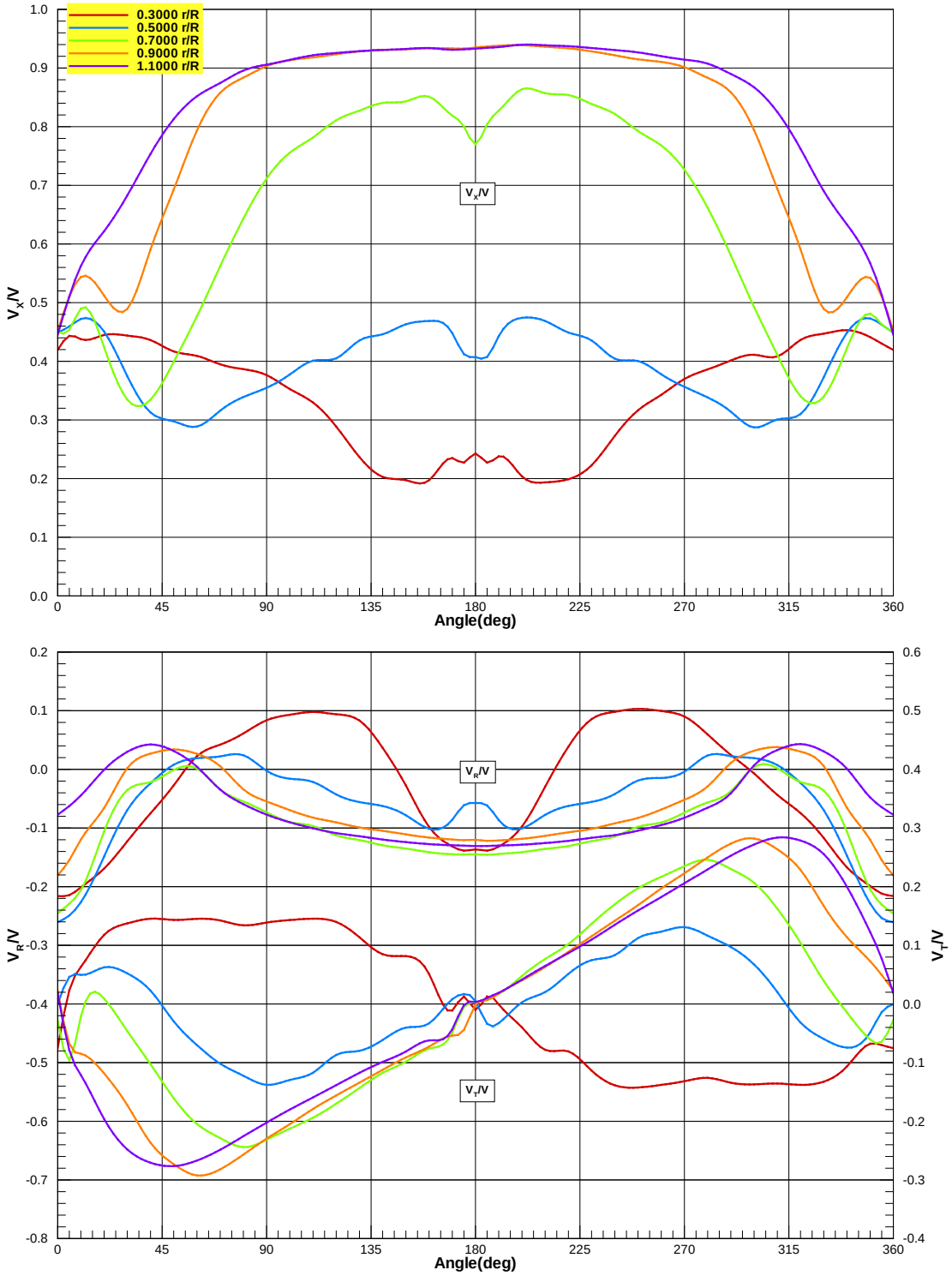
KRISO	13K Methanol PC Tanker	
Figure 11	**Prediction of Powering Performance (KS2048, Scantling and Ballast drafts with Fin, Stock propeller, at NCR)**	07-20-2023 S2048S04.lyy, S2048S07.lyy



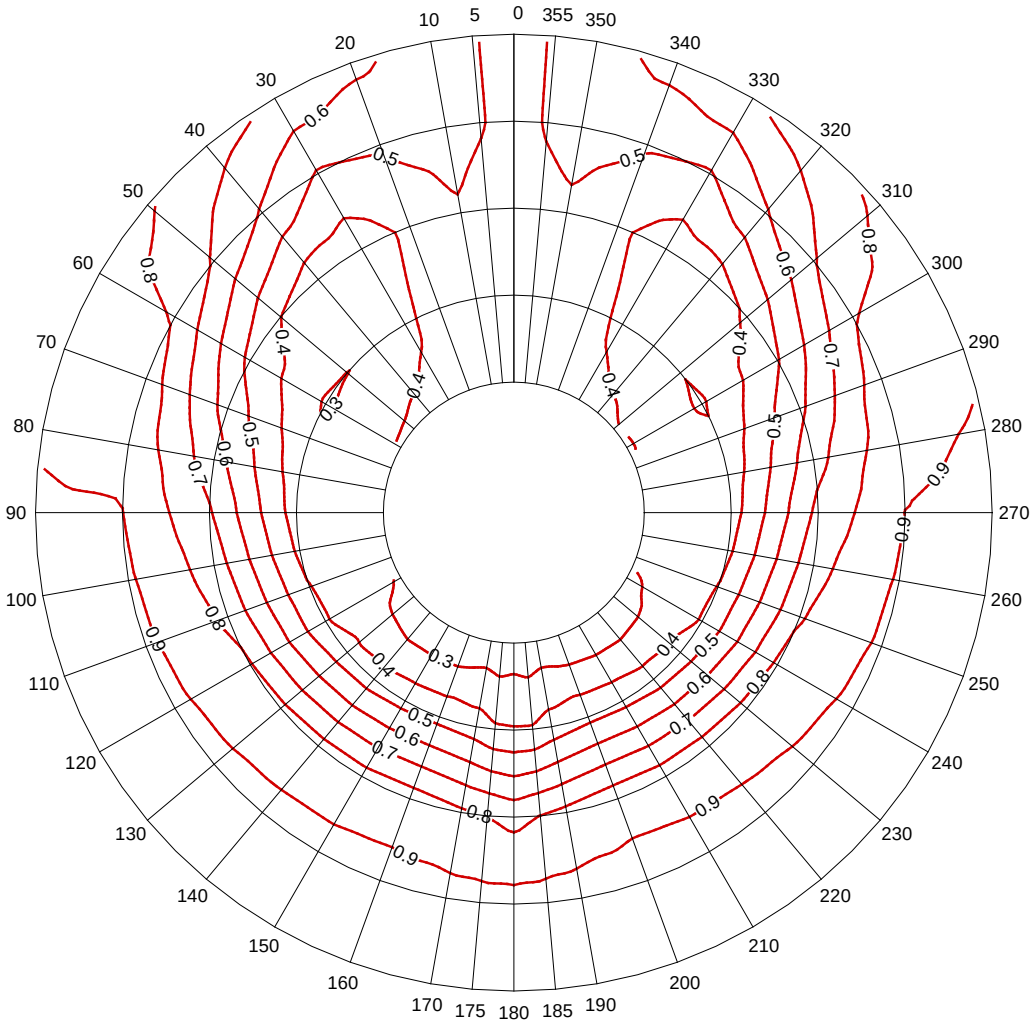
KRISO	13K Methanol PC Tanker	
Figure 12	**Prediction of Powering Performance (KS2048, Scantling and Ballast drafts with Fin, Stock propeller, at NCR with 15% Sea Margin)**	07-20-2023 S2048S04.lyy, S2048S07.lyy



KRISO	13K Methanol PC Tanker	
Figure 13	**Circumferential Distribution of Velocity Components (KS2048, Scantling draft, 13.0 knots)**	07-20-2023 S2048K07.dat

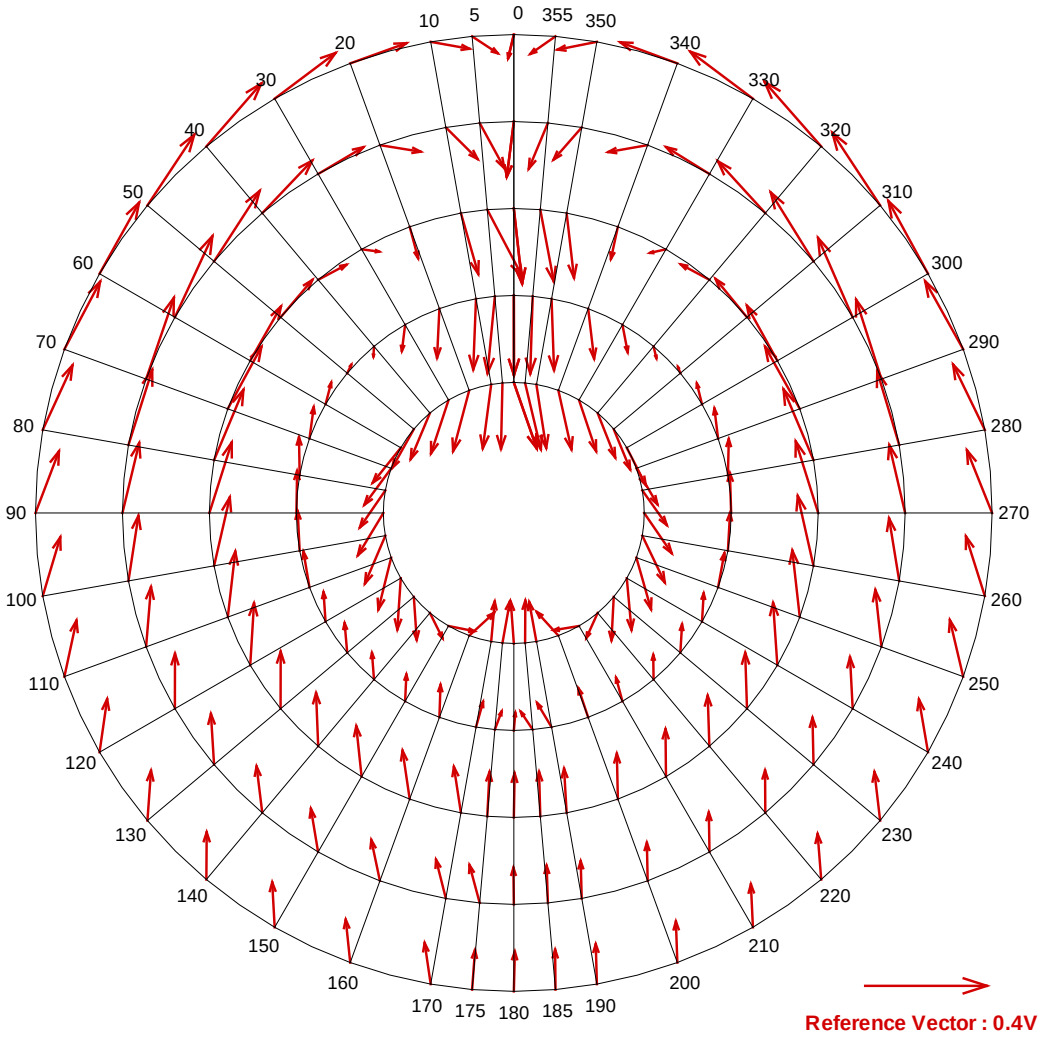


KRISO	13K Methanol PC Tanker	
Figure 14	**Iso-Axial Velocity Contours (KS2048, Scantling draft, 13.0 knots)**	07-20-2023 S2048K07.dat



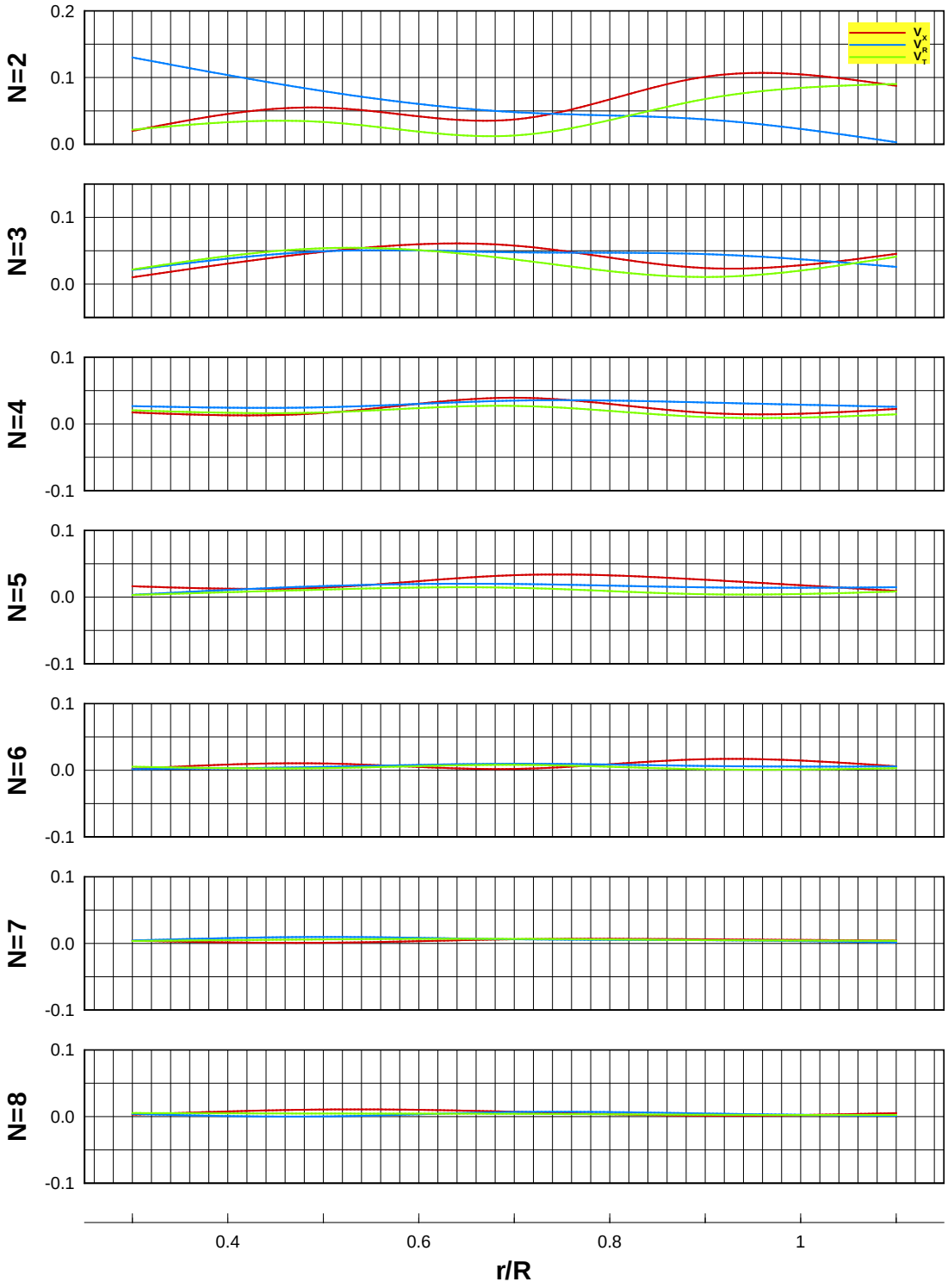
Radii : 0.3000 0.5000 0.7000 0.9000 1.1000

KRISO	13K Methanol PC Tanker	
Figure 15	**Transverse Velocity Vectors (KS2048, Scantling draft, 13.0 knots)**	07-20-2023 S2048K07.dat

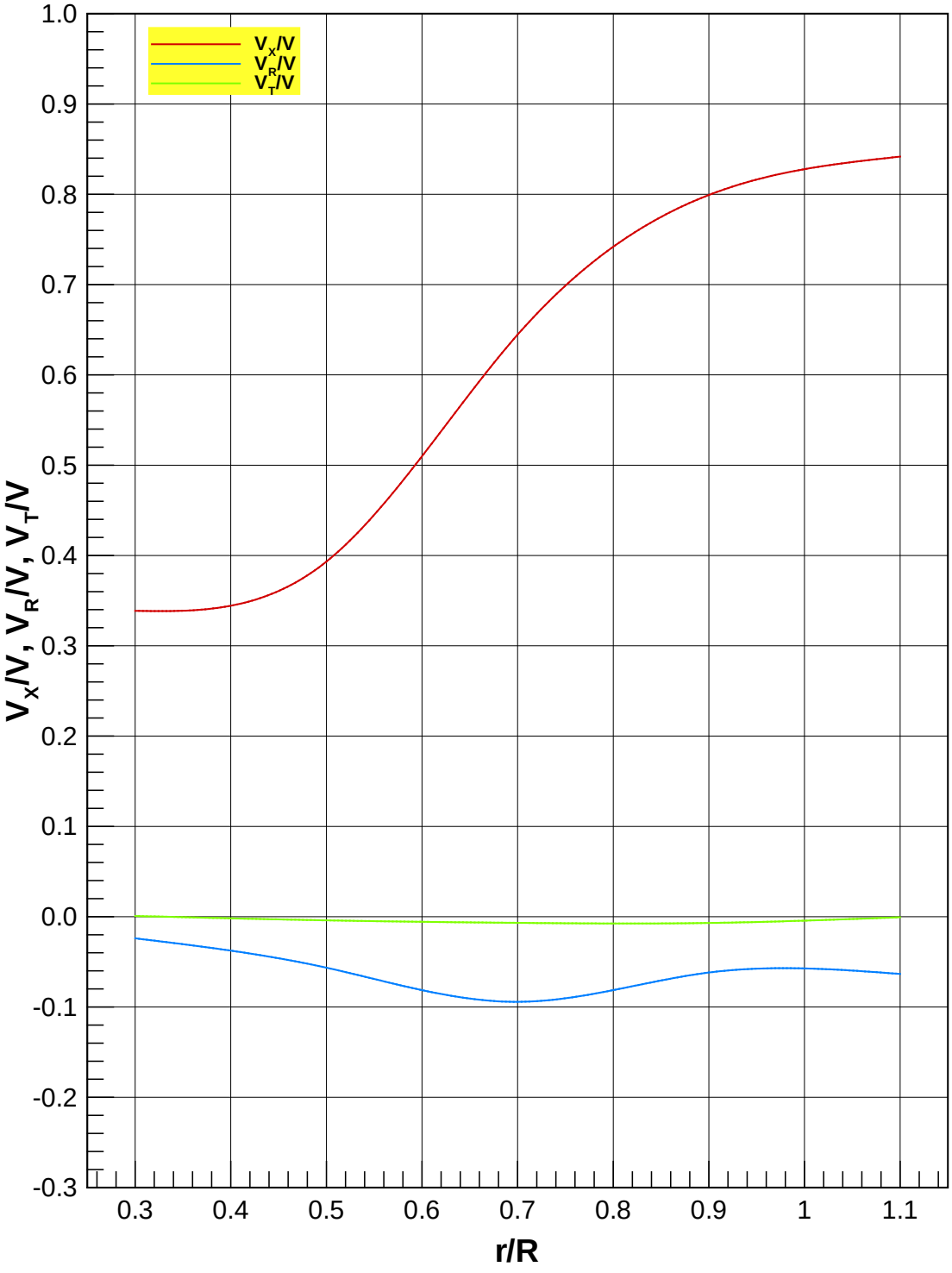


Radii : 0.3000 0.5000 0.7000 0.9000 1.1000

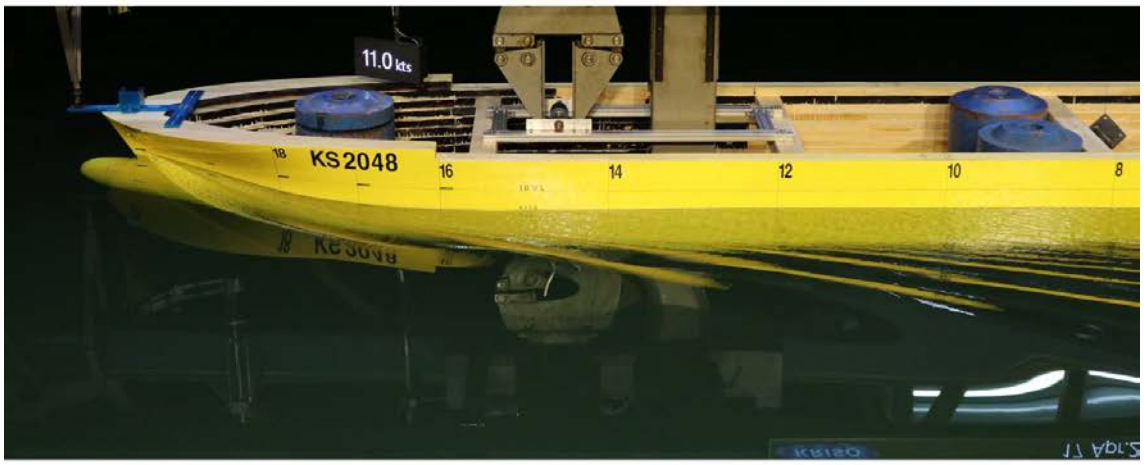
KRISO	13K Methanol PC Tanker	
Figure 16	**Radial Distribution of Harmonic Amplitudes of Velocities (KS2048, Scantling draft, 13.0 knots)**	07-20-2023 S2048K07.dat



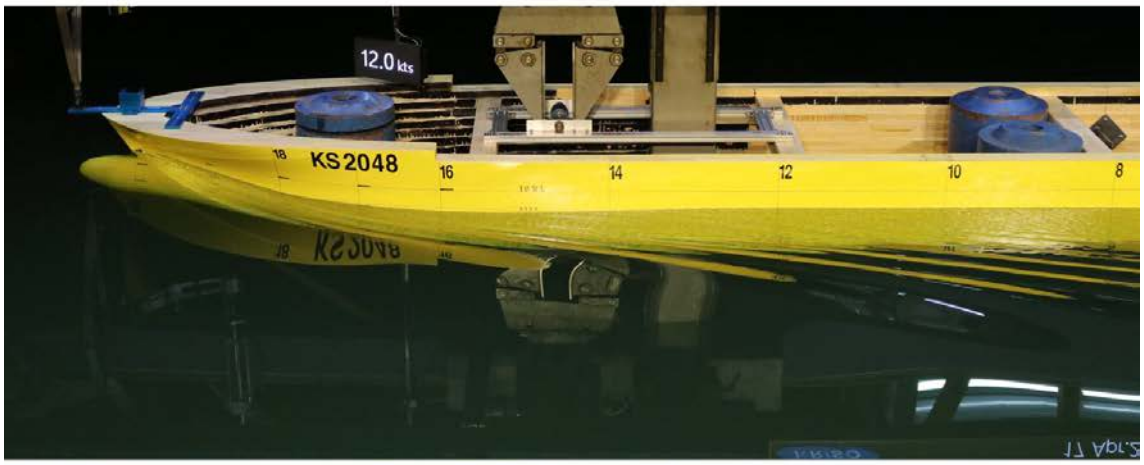
KRISO	13K Methanol PC Tanker	
Figure 17	**Radial Distribution of Circumferential Mean Velocity Components (KS2048, Scantling draft, 13.0 knots)**	07-20-2023 S2048K07.dat



KRISO	13K Methanol PC Tanker	
Figure 18	**Photographs of the Running Ship Model (KS2048, Scantling draft, 11.0 knots)**	07-20-2023 -

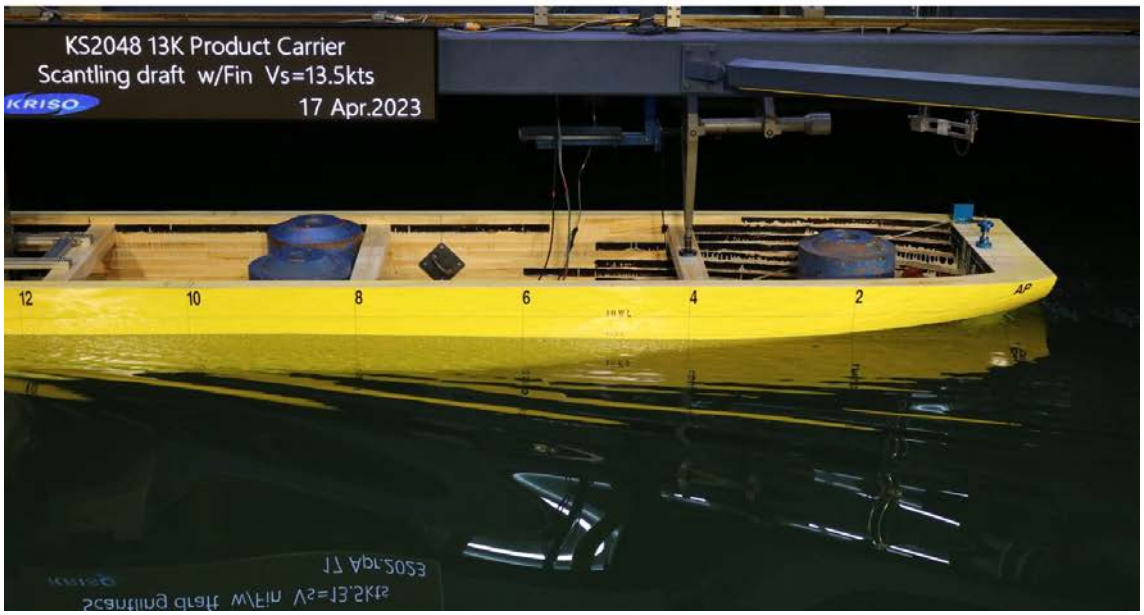


KRISO	13K Methanol PC Tanker	
Figure 19	**Photographs of the Running Ship Model (KS2048, Scantling draft, 12.0 knots)**	07-20-2023 -



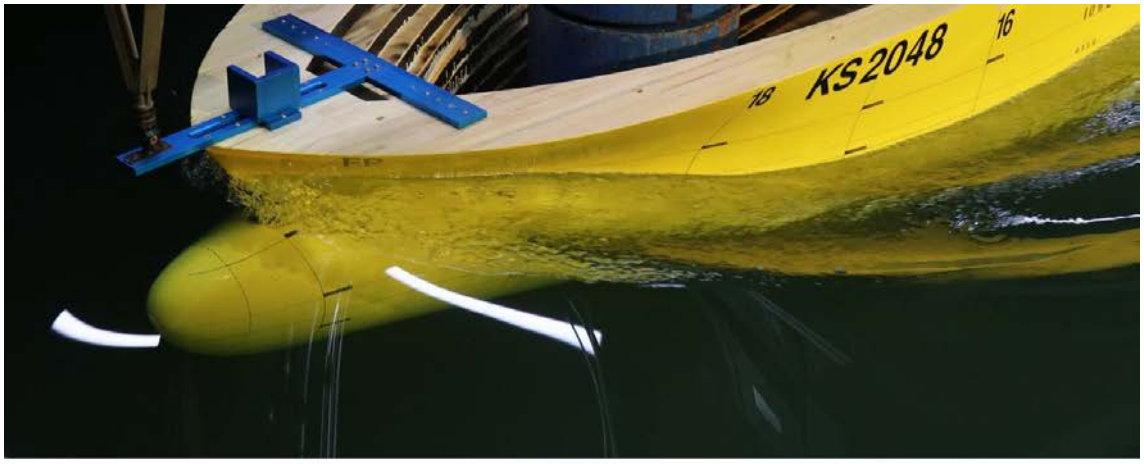
KRISO	13K Methanol PC Tanker	
Figure 20	**Photographs of the Running Ship Model (KS2048, Scantling draft, 13.0 knots)**	07-20-2023 -

KRISO	13K Methanol PC Tanker	
Figure 21	**Photographs of the Running Ship Model (KS2048, Scantling draft, 13.5 knots)**	07-20-2023 -

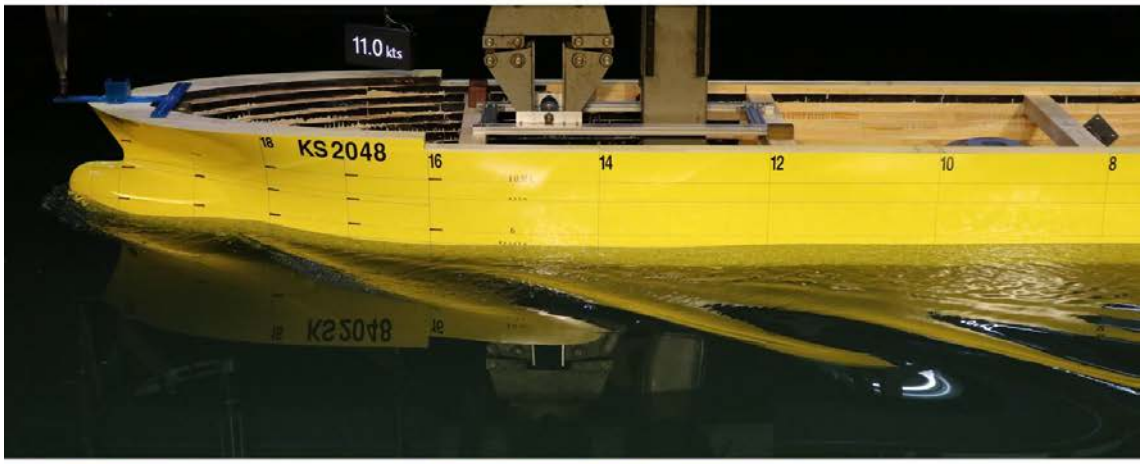


KRISO	13K Methanol PC Tanker	
Figure 22	**Photographs of the Running Ship Model (KS2048, Scantling draft, 14.0 knots)**	07-20-2023 -

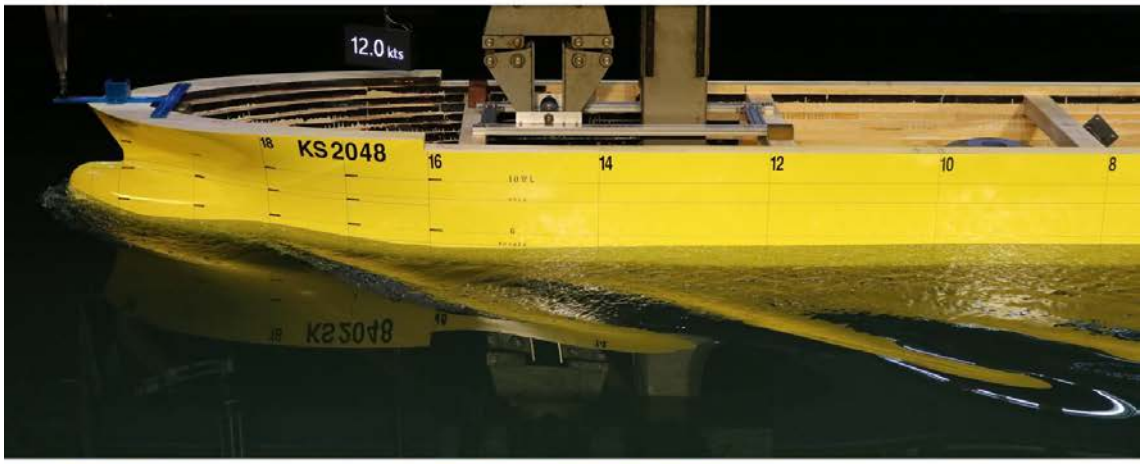
KRISO	13K Methanol PC Tanker	
Figure 23	**Photographs of the Running Ship Model (KS2048, Scantling draft, 15.0 knots)**	07-20-2023 -



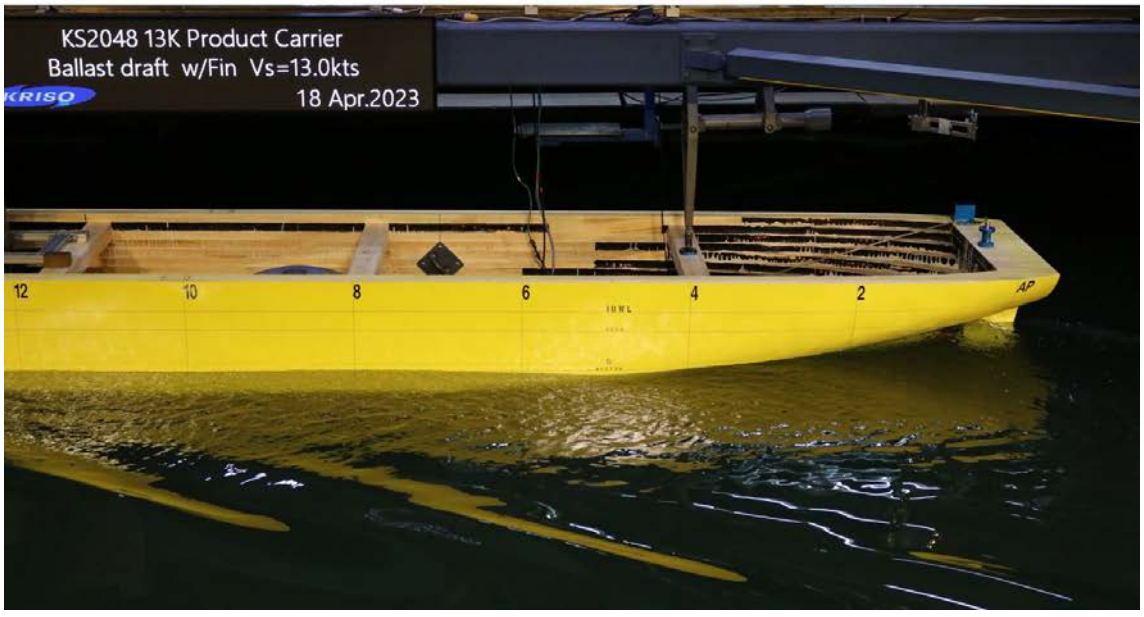
KRISO	13K Methanol PC Tanker	
Figure 24	**Photographs of the Running Ship Model (KS2048, Ballast draft, 11.0 knots)**	07-20-2023 -



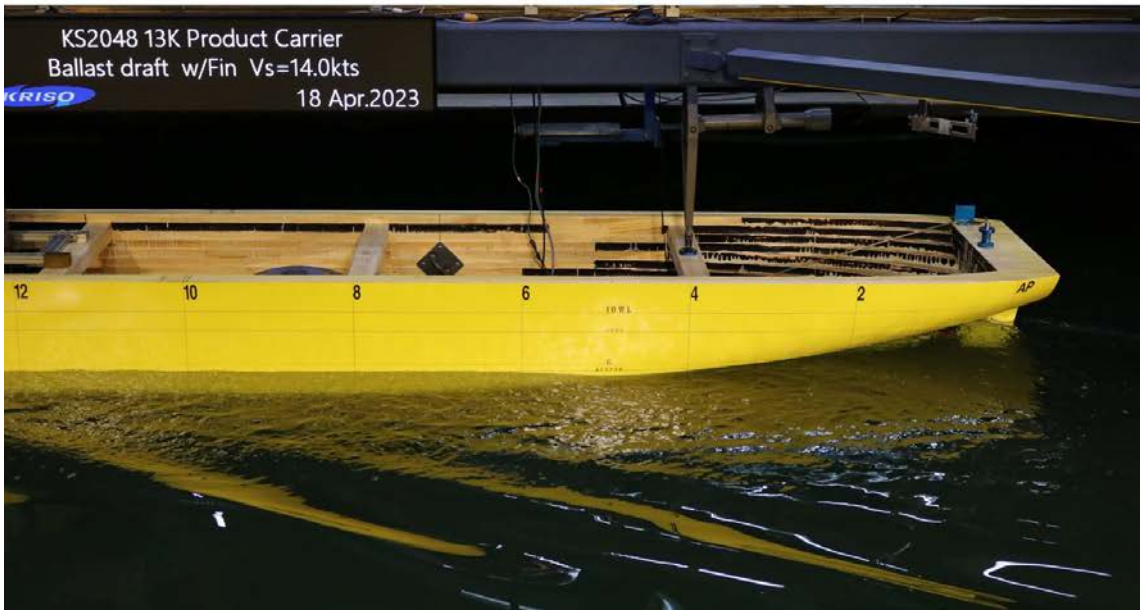
KRISO	13K Methanol PC Tanker	
Figure 25	**Photographs of the Running Ship Model (KS2048, Ballast draft, 12.0 knots)**	07-20-2023 -



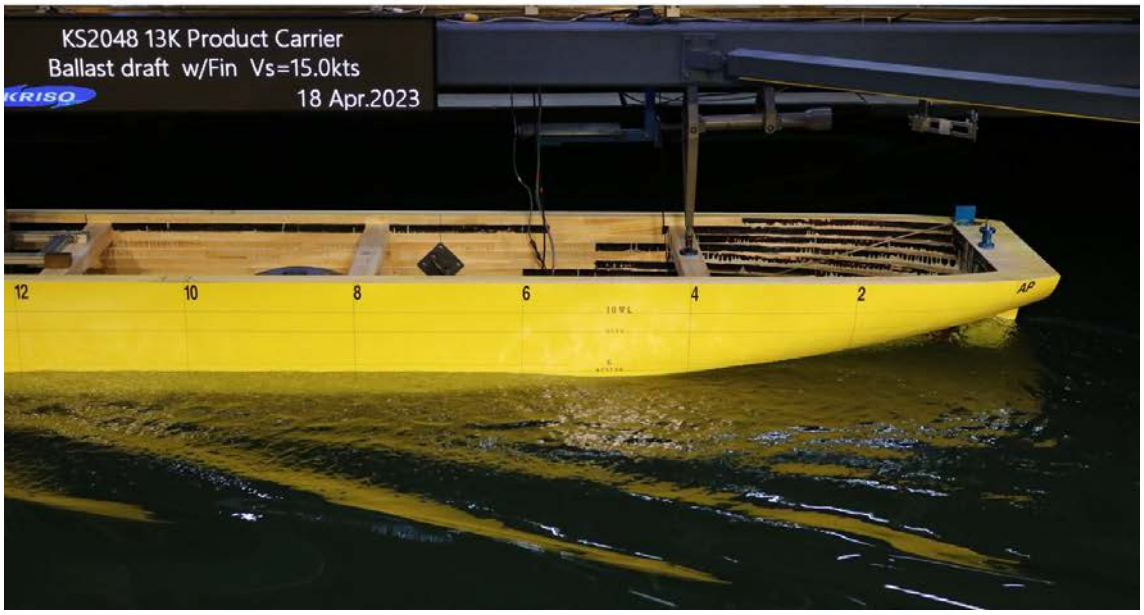
KRISO	13K Methanol PC Tanker	
Figure 26	**Photographs of the Running Ship Model (KS2048, Ballast draft, 13.0 knots)**	07-20-2023 -



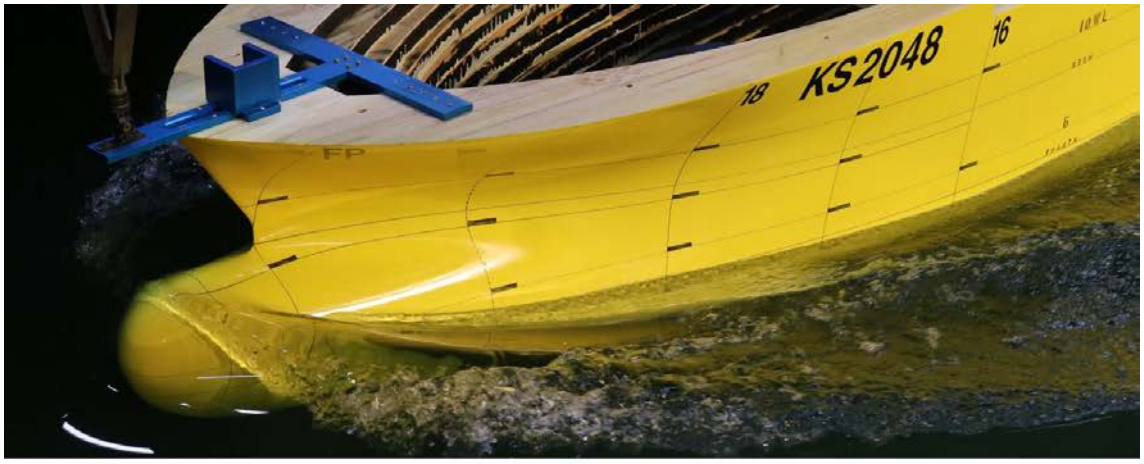
KRISO	13K Methanol PC Tanker	
Figure 27	**Photographs of the Running Ship Model (KS2048, Ballast draft, 14.0 knots)**	07-20-2023 -



KRISO	13K Methanol PC Tanker	
Figure 28	**Photographs of the Running Ship Model (KS2048, Ballast draft, 15.0 knots)**	07-20-2023 -



KRISO	13K Methanol PC Tanker	
Figure 29	**Photographs of the Running Ship Model (KS2048, Ballast draft, 16.0 knots)**	07-20-2023 -



APPENDICES

A. Test Descriptions

B. Nomenclature

A. Test Descriptions

A-1 Propulsion Tests

Model tests required for the full scale performance prediction comprise the resistance test, the self-propulsion test and the propeller open-water test.

In the resistance test the model is towed at the speeds giving the same Froude numbers for the model and ship, and the total resistance of the model $\left(R_{T_M}\right)$ is measured.

In the self-propulsion test, the model is propelled with its own propeller at the so-called ship propulsion point over the desired range of speeds. In order to compensate for the model's increased frictional resistance due to the difference in Reynolds numbers of the model and ship, the model is towed by the resistance dynamometer. This towing force is calculated as follows:

$$F_D = \frac{1}{2}\rho_M S_M V_M^2 \left[C_{VM} - \left(C_{F_S} + C_A \right) \right] \tag{1}$$

For each speed, propeller thrust $\left(T_M\right)$, torque $\left(Q_M\right)$ and propeller revolution $\left(N_M\right)$ are measured.

In these tests, a model is connected to the towing carriage by a resistance dynamometer at the center of buoyancy and restrained from yaw and sway.

To get the open-water characteristics of the propeller, the open-water test is performed and thrust, torque and rate of revolution are measured, keeping the rate of advance is varied so that a loading range of the propeller is examined.

A-1.1 Analysis of Model Test Results

Model Resistance $\left(R_{T_M}\right)$ measured in the resistance tests is expressed in the non-dimensional form

$$C_{T_M} = \frac{R_{T_M}}{\frac{1}{2}\rho S_M V_M^2} \tag{2}$$

This is reduced to the residual resistance coefficient $\left(C_R\right)$ by following relation.

$$C_R = C_{T_M} - C_{F_M} \tag{3}$$

Thrust (T_M), and torque (Q_M), measured at the self-propulsion tests are expressed in non-dimensional form as follows:

$$K_{T_M} = \frac{T_M}{\rho N_M^2 D_{P_M}^4} \tag{4}$$

$$K_{Q_M} = \frac{Q_M}{\rho N_M^2 D_{P_M}^5} \tag{5}$$

With K_{T_M} as input, J_{T_M} and $K_{Q_{T_M}}$ are read off from the model propeller characteristics. Then the wake fraction (w_{TM}) and the relative rotative efficiency (η_R) are calculated by the following relations.

$$w_{TM} = 1 - \frac{J_{TM} D_{P_M} N_M}{V_M} \tag{6}$$

$$\eta_R = \frac{K_{Q_{TM}}}{K_{Q_M}} \tag{7}$$

The thrust deduction is obtained from

$$t = \frac{\left(T_M - R_{T_{MC}} + F_D\right)}{T_M} \tag{8}$$

where $R_{T_{MC}}$ is the resistance corrected for the differences in temperature between resistance and self-propulsion tests:

$$R_{T_{MC}} = R_{T_M} \times \frac{C_{F_{MC}} + C_R}{C_{F_M} + C_R} \tag{9}$$

where $C_{F_{MC}}$ is the frictional resistance coefficient at the temperature of the self-propulsion test.

A-1.2 Total Resistance of Ship

The total resistance coefficient of a ship is defined as

$$C_{T_S} = C_{F_S} + C_A + C_R + C_{AA} \tag{10}$$

where C_{AA} is the air resistance coefficient:

$$C_{AA} = 0.001 \times \frac{A_T}{S_S} \times \frac{V_R^2}{V_S^2} \tag{11}$$

where V_R is the relative head wind speed.

If the ship is fitted with bilge keels, the total resistance coefficient is calculated as follows:

$$C_{T_S} = \frac{S_S + S_{BK_S}}{S_S} \times \left(C_{F_S} + C_A \right) + C_R + C_{AA} \tag{12}$$

A-1.3 Scale Effect Corrections for Propeller Characteristics

The characteristics of the full scale propeller are calculated from the model characteristics as follows:

$$K_{T_{OS}} = K_{T_{OM}} - \Delta K_{T_O} \tag{13}$$

$$K_{Q_{OS}} = K_{Q_{OM}} - \Delta K_{Q_O} \tag{14}$$

where

$$\Delta K_{T_O} = -\Delta C_D \times 0.3 \times \frac{P_{0.7R}}{D_P} \times \frac{c_{0.7R} Z}{D_P} \tag{15}$$

$$\Delta K_{Q_O} = \Delta C_D \times 0.25 \times \frac{c_{0.7R} Z}{D_P} \tag{16}$$

and ΔC_D is the difference in drag coefficient, such that

$$\Delta C_D = C_{D_M} - C_{D_S} \tag{17}$$

where

$$C_{D_M} = 2 \times \left(1 + 2 \frac{t_{0.7R_M}}{c_{0.7R}} \right) \times \left(\frac{0.044}{R_{n0.7R}^{1/6}} - \frac{5}{R_{n0.7R}^{2/3}} \right) \tag{18}$$

$$C_{D_S} = 2 \times \left(1 + 2 \frac{t_{0.7R_M}}{c_{0.7R}} \right) \times \left(1.89 + 1.62 \log \frac{C_{0.7R}}{k_P} \right)^{-2.5} \tag{19}$$

If ΔC_D is less than zero,

$$\Delta C_D = 0 \tag{20}$$

is used.

The blade roughness k_P is assumed as $3\times10^{-5} m$, and the local Reynolds number at $0.7R$ is calculated as follows:

$$R_{n0.7R} = c_{0.7R_M} N_M D_{P_M} \frac{\sqrt{J_{O_M}^2 + (0.7\pi)^2}}{\nu_M} \tag{21}$$

A-1.4 Full Scale Wake

The full scale wake is calculated from the model wake w_{TM}, and the thrust deduction t :

$$w_{TS} = (t + 0.04) + (w_{TM} - t - 0.04) \times \frac{C_{F_S} + C_A}{C_{F_{MC}}} \tag{22}$$

In the formula, the factor 0.04 is used to take account for rudder effect. If full scale wake w_{TS} is greater than model wake w_{TM}, following formula is used.

$$w_{TS} = w_{TM} \tag{23}$$

A-1.5 Standard Prediction

The load of the full scale propeller is obtained from the following relation.

$$\frac{K_T}{J^2} = \frac{S_S}{2D_{P_S}^2} \times \frac{C_{T_S}}{(1-t)(1-w_{TS})^2} \tag{24}$$

With this value of K_T / J^2 as input, J_{TS} and $K_{Q_{TS}}$ are read off from the full scale propeller characteristics and the following quantities are calculated.

* the effective power:

$$P_E = 1.36 \times \frac{\rho_S}{2} S_S V_S^3 C_{T_S} \times 10^{-3} : (PS) \tag{25}$$

* the rate of revolutions:

$$N_S = \frac{(1-w_{TS})V_S}{J_{TS} D_{P_S}} : (RPS) \tag{26}$$

* the delivered power:

$$P_D = 1.36 \times 2\pi \times \rho_S D_{P_S}^5 N_S^3 \frac{K_{Q_{TS}}}{\eta_R} \times 10^{-3} : (PS) \tag{27}$$

* the thrust of the propeller:

$$T_S = \frac{K_T}{J^2} J_{TS}^2 \rho_S D_{P_S}^4 N_S^2 : (N) \tag{28}$$

* the torque of the propeller:

$$Q_S = \frac{K_{Q_{TS}}}{\eta_R} \rho_S D_{P_S}^5 N_S^2 : (N-m) \tag{29}$$

* the total efficiency:

$$\eta_D = \frac{P_E}{P_D} \tag{30}$$

* the hull efficiency:

$$\eta_H = \frac{1-t}{1-w_{TS}} \tag{31}$$

A-2 Wake Survey Test

The wake survey test to determine the axial, radial and tangential velocity components in the propeller plane is executed by means of a rake assembly of 5 pitot tubes. The head of each pitot tube contains five holes joined by small diameter internal tubes: one on the center, one pair aligned with the radial plane, and the other pair in the tangential plane. Four static holes joined to a common internal tube is located at the middle part of each pitot tube.

A-2.1 Velocity Components

The pressure difference between center and static holes is measured by the differential type pressure transducer and the axial velocity component V_X can be obtained. From the results, iso-axial velocity contours are plotted to give the wake distribution at the propeller plane.

The tangential and radial velocity components V_t and V_r can be computed from the pressure differences between the pair of holes in the tangential and radial plane, respectively. Also the transverse component of velocity vector V_{tr} is computed as follows:

$$V_{tr} = \sqrt{V_t^2 + V_r^2} \tag{32}$$

The transverse flow direction at the propeller plane can be easily seen by plotting these velocity vectors.

A-2.2 Harmonic Series

The velocity components at the propeller plane are considered as a periodic function of period 2π for each radius and represented by the Fourier Series.

$$\begin{aligned} V_i &= a_o + \sum_{k=1}^{n} \left(a_k \cos(k\theta) + b_k \sin(k\theta) \right) \\ &= a_o + \sum_{k=1}^{n} \left(c_k \cos(k\theta - \varphi_k) \right) \end{aligned} \tag{33}$$

A-2.3 Mean Velocity Components

Circumferential mean velocity is the mean value of the measured velocity at the radius r and computed as follows:

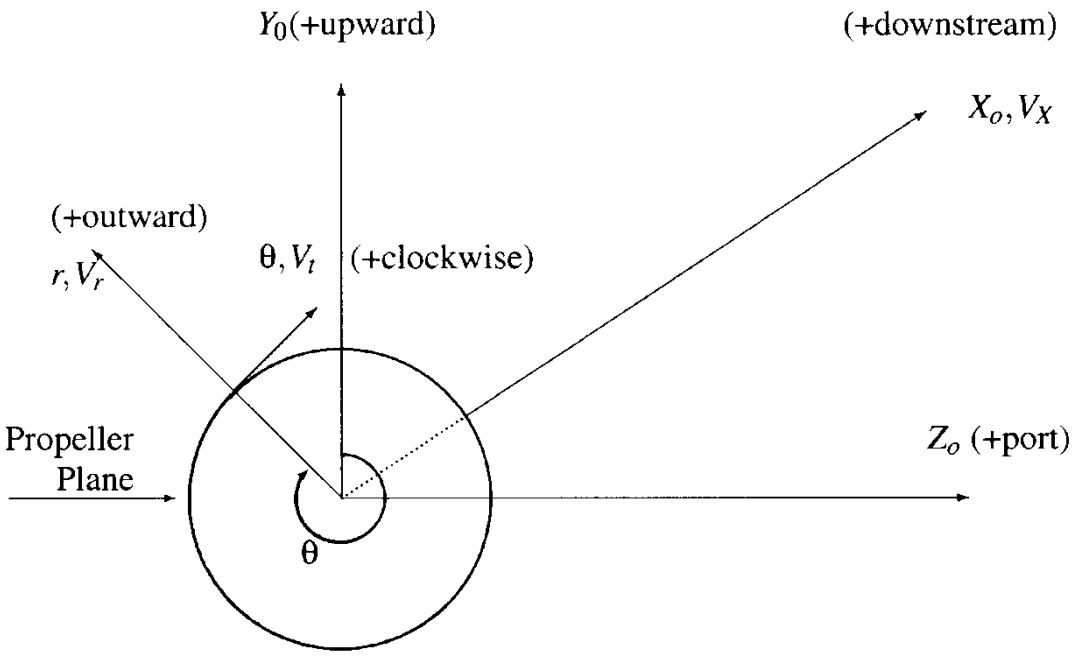
$$V_{Mi} = \frac{1}{2\pi} \int_0^{2\pi} V_i(\theta)\, d\theta \tag{34}$$

Total mean velocity is obtained from the value of circumferential mean velocity from propeller hub to propeller tip at the propeller plane and computed as follows:

$$V_{TMi} = \frac{2\pi \int_{r_h}^{r_p} V_{Mi} \cdot r \cdot dr}{\pi \left(r_p^2 - r_h^2 \right)} \tag{35}$$

Wake fraction represents the nominal wake fraction without propeller at the stern and is computed as follows:

$$w_N = 1 - \frac{V_A}{V} = 1 - V_{TMX} \tag{36}$$



B. Nomenclature

B-1 Geometry of Ship and Propeller

Symbol	C.Symbol	Title	Definition	Unit
A_E	AE	Expanded blade area	Outside of hub	m^2
A_M	AM	Midship section area	Midway between FP and AP	m^2
A_O	AO	Propeller disc area	$\pi D_P^2/4$	m^2
A_P	-	Projected area		m^2
A_T	AT	Transverse projected area of ship above waterline		m^2
A_W	AW	Waterplane area		m^2
$a_{x0.8}$	-	Longitudinal clearance from propeller to stern frame at a height of 0.8R above the propeller axis.		m
a_z		Vertical clearance to hull		m
B	B	Breadth, moulded of ship		m
BA	BA	Bulb section area in submerged part at FP		m
BAR	BAR	Bulb-midship section area ratio	BA/A_M	
BB	BB	Bulb breadth in submerged part		m
BBR	BBR	Bulb-midship breadth ratio	BB/B	
BH	BH	Bulb height of maximum length position		m
BHR	BHR	Bulb height-fwd draft ratio	BH/T_F	
BL	BL	Bulb length from maximum fore end to AP in submerged part		m
BLR	BLR	Bulb-ship length ratio	BL/L_{PP}	
c	C	Chord length of propeller blade section		
C_B	CB	Block coefficient	$\frac{\nabla}{L_{PP}BT}$	
C_M	CM	Midship section coefficient	$\frac{A_M}{BT}$	
C_P	CP	Prismatic coefficient, longitudinal	$\frac{\nabla}{A_M L_{PP}}$	
C_W	CW	Load waterline coefficient	$\frac{A_W}{L_{PP}B}$	

Symbol	C.Symbol	Title	Definition	Unit
$cR_{0.7R}$	CR070	Chord length-diameter ratio at 0.7R	$c_{0.7R}/D_P$	
$c_{0.7R}$	CH070	Chord length of blade at 0.7R		m
D	D	Depth, moulded of ship		m
D_P	DP	Diameter of a propeller		m
d	DH	Hub diameter		m
EAR	EAR	Expanded area ratio	A_E/A_O	
f_o	-	Maximum camber of propeller blade section		
G	-	Non-dimensional circulation	$\frac{\Gamma}{2\pi U_R}$	
h	-	Depth of submergence of the propeller axis		m
HDR	HDR	Hub-diameter ratio	d/D_P	
i_G	RAKG	Rake from the propeller plane to the tip generation line	Aft displacement is positive	m
KB	KB	Center of buoyancy above moulded baseline		m
LCB	LCB	Center of buoyancy from midship	Fwd. positive	m
LCF	LCF	Center of floatation from midship	Fwd. positive	m
L_{OS}	LOS	Length overall, submerged		m
L_{PP}	LPP	Length between perpendiculars		m
L_{WL}	LWL	Length of load waterline		m
N_P	NOPROP	Number of propellers		
P	P	Propeller pitch in general		
PR_{mean}	PRMEAN	Propeller pitch ratio, mean		
PR_{root}	PRROOT	Propeller pitch ratio at root		
PR_{tip}	PRTIP	Propeller pitch ratio at tip		
$PR_{0.7R}$	PR070	Propeller pitch ratio at 0.7R		
RDR	RDR	Propeller rake-diameter ratio	i_G/D_P	
S	S	Wetted surface area of a ship		m^2
S_{BK}	SBK	Wetted surface area of bilge keels		m^2
T	T	Draft, moulded of ship		m
T_A	TA	Draft at after perpendicular		m
T_F	TF	Draft at forward perpendicular		m
T_{mean}	TMEAN	Mean draft of AP and FP		m
t_o/c	-	Thickness-chord ratio		

Symb	C.Symbol	Title	Definition	Unit
$tR_{0.7R}$	TR070	Maximum blade thickness-diameter ratio at 0.7R	$\frac{t_{m0.7R}}{D_P}$	
$t_{m0.7R}$	TM070	Maximum blade thickness at 0.7R		m
U_R	-	Resultant velocity at 0.7 radius	$nD\sqrt{J_A^2+0.7^2\pi^2}$	
X_P	XP	Longitudinal propeller position	Distance between propeller plane and AP	m
Z	NPB	Number of propeller blades		
α	-	Angle of attack relative to zero-lift line		
δ	-	Taylor's diameter coefficient	$\frac{ND}{V_a}$	
θ_S	SKEW	Skew angle		deg.
λ	SCALE	Scale ratio		
Γ	-	Radial circulation distribution		
∇	DISV	Displacement volume		m^3

B-2 Resistance and Propulsion

Symbol	C.Symbol	Title	Definition	Unit
C_A	CA	Incremental resistance coefficient for model-ship corrlation	$\frac{R_A}{1/2\,\rho S V^2}$	
C_{AA}	CAA	Air resistance coefficient	$\frac{R_{AA}}{1/2\,\rho S V^2}$	
C_D	CD	Drag coefficient of propeller		
C_F	CF	Specific frictional resistance coefficient	$\frac{R_F}{1/2\,\rho S V^2}$	
C_N	CN	Trial correction for rpm		
C_P	CP	Trial correction for power		
C_R	CR	Specific residuary resistance coefficient	$\frac{R_R}{1/2\,\rho S V^2}$	
C_T	CT	Specific total resistance coefficient	$\frac{R_T}{1/2\,\rho S V^2}$	
C_V	CV	Specific total viscous resistance coefficient	$\frac{R_V}{1/2\,\rho S V^2}$	
C_W	CW	Specific wavemaking resistance coefficient	$\frac{R_w}{1/2\,\rho S V^2}$	
F_D	FD	Towing force in a self-propulsion test, measured		N
F_{D_O}	FDO	Towing force in a self-propulsion test, calculated	$\frac{C_{F_M} - C_{F_S} - C_A}{1/2\,\rho_M S_M V_M^2}$	
F_n	FN	Froude number		
J	ADVC	Advance coefficient of ship	$\frac{V}{ND_P}$	
J_A	ADVCA	Advance coefficient of propeller	$\frac{V_A}{ND_P}$	
K_Q	KQ	Torque coefficient	$\frac{Q}{\rho N^2 D_P^5}$	
K_T	KT	Thrust coefficient	$\frac{T}{\rho N^2 D_P^4}$	
k	C3	Three dimensional form factor	$\frac{C_V - C_F}{C_F}$	
k_P	KP	Blade roughness of a propeller		m
k_S	KS	Hull roughness of a ship		m

Symbol	C.Symbol	Title	Definition	Unit
N	N	Rate of revolution		$revs/\sec$
P_B	PB	Brake power		KW,PS
P_D	PD	Delivered power at propeller		KW,PS
P_E	PE	Effective power		KW,PS
Q	Q	Torque		$N-m$
R_A	RA	Model-ship correlation allowance		N
R_{AA}	RAA	Air resistance		N
R_F	RF	Frictional resistance	Due to fluid friction on surface	N
R_n	RN	Reynolds number		
R_R	RR	Residuary resistance	$R_T - R_F$	N
R_T	RT	Total resistance	Total towed resistance	N
R_V	RV	Total viscous resistance		N
R_W	RW	Wavemaking resistance	Due to formation of surface waves	N
T	T	Thrust		N
t	THDF	Thrust deduction fraction	$\frac{T-R_T}{T}$	
V	V	Speed of ship		$m/\sec$ $knot$
V_A	VA	Speed of advance of propeller	Speed in relation to water flow	
w	WFT	Taylor wake fraction	$\frac{V-V_A}{V}$	
ΔC_F	DCF	Roughness allowance		
ΔC_{FC}	DCFC	Trial correction for C_F		
η_D	ETAD	Propulsive efficiency or quasi-propulsive coefficient	$\frac{P_E}{P_D}$	
η_H	ETAH	Hull efficiency	$(1-t)/(1-w)$	
η_O	ETAO	Propeller open-water efficiency		
η_R	ETAR	Relative rotative efficiency		
ν	NU	Coefficient of kinematic viscosity		$m^2/\sec$
ρ	RHO	Mass density		kg/m^3

Subscript M : Value for model ship or propeller
Subscript S : Value for full scale ship or propeller
Subscript T : Value from thrust-identity
Subscript O : Value for propeller open-water characteristics

B-3 Wake Survey

Symbol	C.Symbol	Title	Definition	Unit
a_k	A	Fourier cosine coefficients		
a_0	A0	Fourier coefficient		
b_k	B	Fourier sine coefficients		
c_k	C	Harmonic amplitude		
r	R	Radial coordinate		
V	V	Velocity of undisturbed flow or speed of ship model		$m/\sec$
V_i	VI	Nondimensional velocity components		
V_M	VM	Mean velocity at the radius r		$m/\sec$
V_r	VR	Radial velocity component		$m/\sec$
V_{TM}	VTM	Mean velocity at the propeller plane		$m/\sec$
V_t	VT	Tangential velocity component		$m/\sec$
V_{tr}	VTR	Transverse component of velocity vector		$m/\sec$
V_x	VX	Axial velocity component		$m/\sec$
w_N	WN	Froude wake fraction	$\frac{V-V_A}{V_A}$	
θ	ANG	Position angle		deg.
ϕ	PHI	Phase angle		deg.

Subscript i : Axial, radial or tangential velocity components