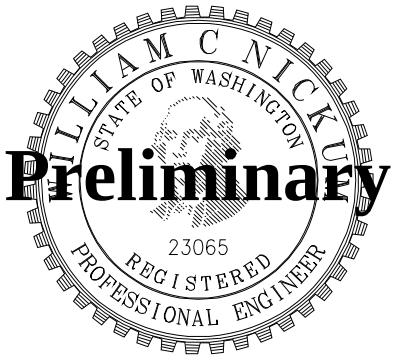

Preliminary

ALASKA CLASS FERRY
Speed and Power Estimate

Prepared for: Alaska Marine Highway System • Ketchikan, AK

Ref: 06137-006-050-1 Rev. 0 November 29, 2010

Elliott Bay Design Group
Architectural & Engineering Services for the Marine Industry

PREPARED BY

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REVISIONS

REV	DESCRIPTION	DATE	APPROVED
0	Preliminary issue	11/29/10	

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PURPOSE

The purpose of this report is to present the results of the speed and power estimate for the ALASKA CLASS FERRY. The subject vessel is a 350 ft long × 74 ft wide × 24 ft deep passenger vehicle ferry, and will be owned and operated by the Alaska Marine Highway System (AMHS). The vessel is intended for operation on inside-waters routes in the state of Alaska, and on international voyages to Canada.

PROCEDURE

EHP Calculation

NavCad 2009 software (Reference 1) is used to perform effective horsepower (EHP) calculations. Based on the vessel characteristics input into NavCad, the program is used to determine the best of dozens of widely accepted prediction methods to use for the prediction. NavCad then uses statistical regression to fit the vessel, based on its characteristics, into the matrix of existing performance data. The contribution of wind, wave and appendage data to resistance is included in the EHP calculation.

The "Holtrop 1984" method (References 2 and 3) is determined to be the most appropriate bare hull prediction method based on similarities in the hull data contained in that method to the subject vessel. Holtrop is a 3D method, meaning that it uses a form factor applied to the frictional resistance in addition to the normally used residuary coefficient and correlation allowance. This is a more modern method, and widely accepted to be more accurate than 2D methods which do not use a form factor.

No prediction method is perfect, and when sea trial data exists for similar vessels it is advantageous to compare actual results of sea trials to predictions so that accuracy can be verified or adjusted if necessary. The AMHS vessel M/V TAKU is the parent hull of the subject vessel, and as such, can be assumed to have a similar relation between predicted and actual resistance vs. powering curves. A "Holtrop 1984" prediction is performed for the TAKU, and the bare hull resistance prediction is compared to the sea trial data. Based on these results, the "Holtrop 1984" prediction method over predicts the resistance of the TAKU at speeds of greater than 14 knots. Therefore, no corrective margin is required for the prediction of the ALASKA CLASS FERRY, because the "Holtrop 1984" prediction will be conservative over the speed range being considered.

Powering

NavCad software is also used to size a propeller. The "B-Series" (References 5 and 6) regression is used because it is a widely used method for commercial vessel propellers.

A controllable pitch propeller (CPP) is used in this analysis. CPPs are used on many of the AMHS vessels because of the greater thrust control and reversibility they provide when maneuvering in port.

NavCad software has a routine that takes engine brake horsepower (BHP) curves and fuel consumption curves to simultaneously solve for optimal engine RPM and propeller pitch for a

given vessel speed. This method is used along with iteration of the propeller characteristics to find the highest vessel speed for each engine speed. Cavitation on the propellers is also considered. In accordance with commercial vessel recommendations of Reference 7, back cavitation is held below 5%.

The overall propulsive coefficient (OPC) is found once engine data and propeller characteristics are included in the propulsion analysis. An EMD engine model rated at 5000 BHP at 900 RPM is used in this analysis. Engine details are found in Appendix A.

The "combinator" solving routine is used to solve for the optimum propeller pitch and engine RPM which lies on the rated engine power curve. By solving for the optimum (most efficient) combination of RPM and pitch for given engine BHP values, the maximum vessel speed is calculated.

GIVEN AND ASSUMED PARAMETERS

Waves in southeast Alaska generally do not become fully developed. Because of this, standard sea state data does not accurately represent the actual conditions which will be encountered by the vessel. Therefore, wind and sea state numbers are selected based on the historical data reported in Reference 9. The 99^{th} percentile wave height correlates to Sea State 4, and the maximum 99^{th} percentile wind speed is 34 knots. Sea States 2 and 0 are selected with 20 and 10 knots, respectively, to demonstrate performance in expected normal operating conditions.

See "NavCad Output / Hull Data" in the Appendix for vessel parameters and sea state inputs.

Design Speed = 17 knots, maximum of 5% back cavitation allowed at design speed.

Gear Ratio = 4.42. This number was chosen to keep linear velocity to between 80 and 90 feet per second at 0.7R of the propeller blade.

CONCLUSIONS

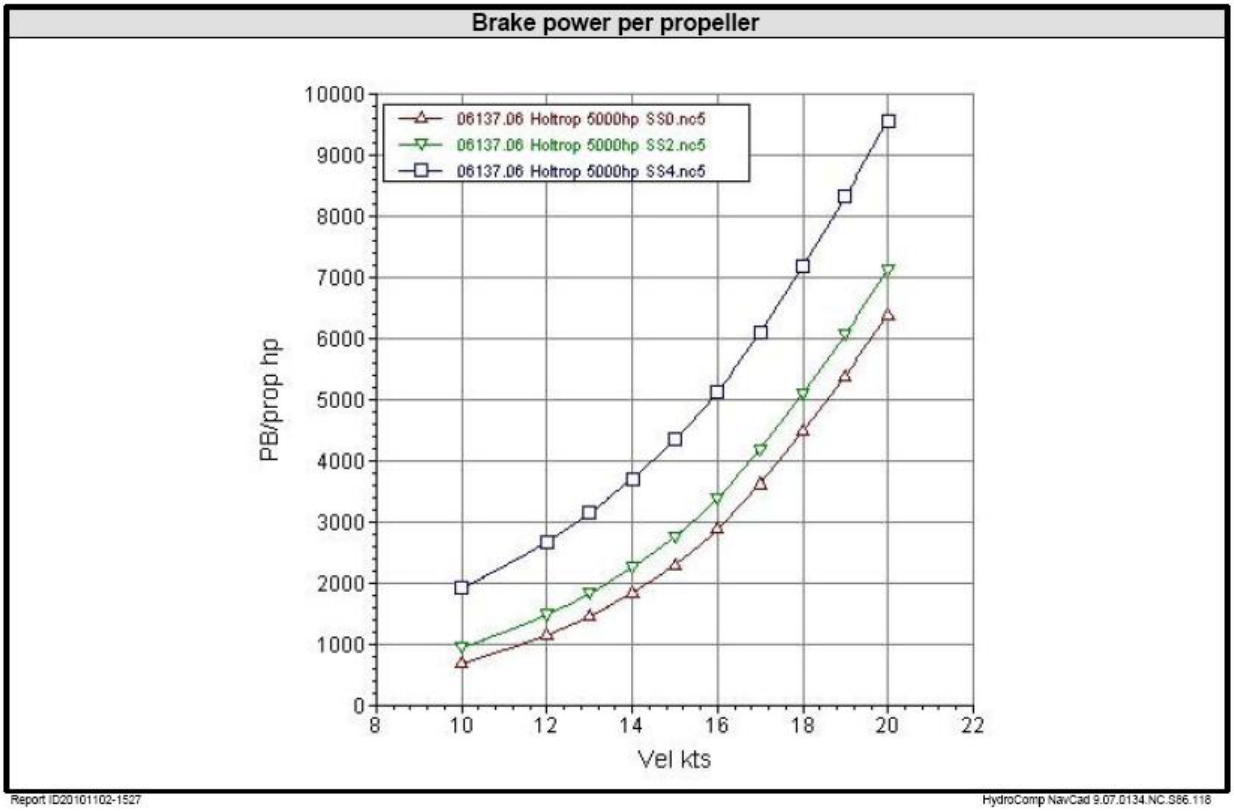
Resistance

Hull resistance is calculated before engine and propeller selections are made and include an allowance for appendages and bulbous bow. The resistance vs. speed curves for calm water with 10-knot head winds and for Sea States 2 and 4 are found in Appendix A.

Speed

Three conditions are analyzed to predict vessel speed for the specified engines at 80% and 100% (sprint) engine speeds. Shaft Horsepower (SHP) is given as well for comparison with the graphs included in Appendix A.

	5000 BHP (80% MCR)	5000 BHP (100% MCR)	Notes
Sea State 0	17.4 knots	18.6 knots	calm seas 10 knot head wind
Sea State 2	16.7 knots	17.9 knots	1.0 foot waves - head seas 20 knot head wind
Sea State 4	14.4 knots	15.8 knots	6.2 foot waves - head seas 34 knot head wind



Propeller and RPM

The following describes the preliminary propeller. The characteristics of this propeller are to be refined by the vendor at a later stage of design.

Type	Controllable Pitch Propeller	
Number of Blades	4	
Diameter	11 feet	15% tip clearance provided
Pitch	Varies	Pitch will be controlled at each running condition to optimize performance.
Expanded Area Ratio	0.640-0.670	Must be great enough to ensure less than 5% back cavitation.
RPM	224 maximum	Based on 90 fps rotational velocity at 0.7R.

REFERENCES

1. NavCad 2009, HydroComp 2009.
2. "A Statistical Re-Analysis of Resistance and Propulsion Data," Holtrop, J., International Shipbuilding Progress, Vol. 31, No. 363, November 1984.
3. "An Approximate Power Prediction Method," Holtrop, J. and Mennen, G.G.J., International Shipbuilding Progress, Vol. 29, No. 335, July 1982.
4. "Report of Still Water Resistance Tests of a 352-Foot Twin Screw Alaskan Ferry," Moss, J.L., University of Michigan Office of Research Administration, Project 04629, July 1961.
5. "Further Computer-Analyzed Data of The Wageningen B-Screw Series," Oosterveld, M.W.C. and Oossanen, P. van, International Shipbuilding Progress, Vol. 22, No. 251, July 1975.
6. Blount, D.L. and Hubble, E.N., "Sizing Segmental Section Commercially Available Propellers for Small Craft," SNAME Propeller Symposium, 1981.
7. Burrill Cavitation Diagram, PNA Vol. II, SNAME, 1988.
8. Vessel Rhino Model, 06137-006-800-1, Rev. P0, EBDG.
9. AMHS Vessel Suitability Study, Task 1 Report, File No. 99095, The Glosten Associates, Inc., March 23, 2000.

Appendix A

NavCad Output

EMD Engine Data

NAVCAD INPUT

Analysis parameters

Bare-hull drag	[Calc] Holtrop 1984	Appendage added drag	[Calc] Holtrop 1988
Friction line	Hughes	Wind added drag	[Calc] Taylor head wind
Technique	Prediction	Seas added drag	[Calc] NavSea small naval
Align to	[Off]	Channel added drag	[Off]
Align by	[Off]	Margin	[Off]
Correlation allowance	0.00034	Water type	Standard Salt
Roughness (mm)	[On] 0.7	Mass density	1.9905 slug/ft3
3D form factor	[On] 1.2398	Kinematic viscosity	1.2791e-05 ft2/s
Speed dependent corr	[Off]		

Hull data

[General]		**[Ct-based]**		
Length between PP	330.260 ft	Max section area	[Cx 0.734]	754.100 ft2
WL bow pt aft FP	0.000 ft	Waterplane area	[Cw 0.745]	15798.000 ft2
Length on WL	330.260 ft	Trim by stern		0.000 ft
Max beam on WL	64.180 ft	LCB aft of FP	[0.513 Lpp]	169.300 ft
Max model draft	16.000 ft	Bulb ext fwd FP		10.000 ft
Displacement bare	4364.40 LT	Bulb area at FP		75.000 ft2
Wetted surface	20093.400 ft2	Bulb ctr above BL		6.750 ft
Chine type	Round bilge	Transom area	[0.025 Ax]	19.000 ft2
[Principal parameters]		Transom beam	[0.288 B]	18.510 ft
Lwl/B	5.1458	Transom draft	[0.094 T]	1.500 ft
B/T	4.0113	Half ent angle		12.90 deg
Cb	0.4501	Bow shape	[Normal]	Average flow
Cws	2.8299	Stern shape	[Normal]	Average flow

Prediction method check

Parameters	Holtrop 1984	
Fn(Lwl)	0.16	0.1...0.609
Fn-high	0.33	0.1...0.609
Lwl/Bwl	5.15	3.9...14.9
Bwl/T	4.01	2.1...4 *
Cp(Lwl)	0.61	0.55...0.85
Lambda	0.73	0...0.85

* = Outside parameter limit

Appendages

	[Coef]	[Wetted value]		[Coef]	[Wetted value]
Rudders	1.35	413.000 ft2	Exposed shafts	2.00	242.000 ft2
Shaft brackets	4.00	124.000 ft2	Stablizer fins	2.80	384.000 ft2
Skeg	1.75	900.000 ft2	Dome	2.70	0.000 ft2
Strut bossing	3.50	0.000 ft2	Bilge keel	1.40	440.000 ft2
Hull bossing	2.00	0.000 ft2	Bow thruster diam	0.01	4.000 ft

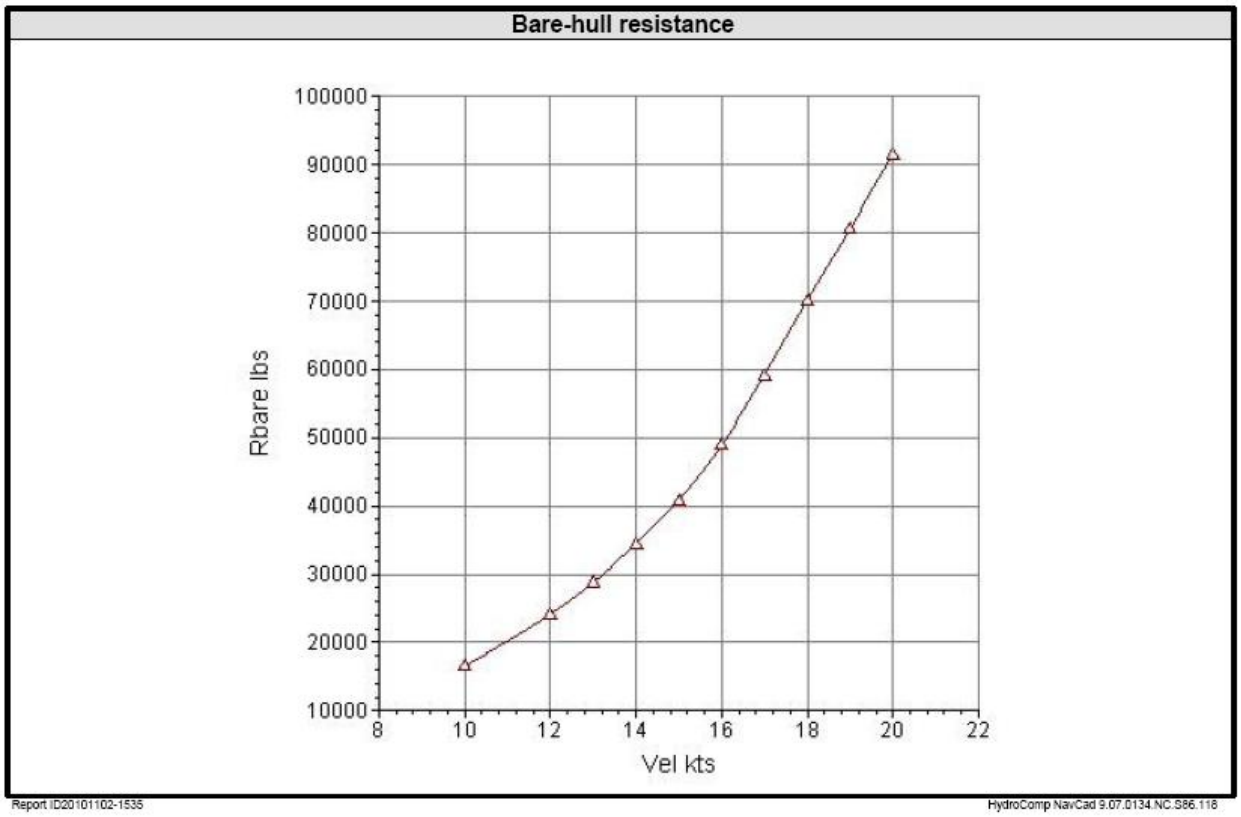
Report ID20101102-1539 HydroComp NavCad 9.07.0134.NC.S86.116

SYMBOLS AND VALUES

Symbols and values

Vel =	Ship speed
PEtotal =	Total effective power
WakeFr =	Taylor wake fraction coefficient
ThrDed =	Thrust deduction coefficient
RelRot =	Relative-rotative efficiency
EngRPM =	Engine RPM
PB/prop =	Break power per propeller
Pitch	CPP pitch
PropRPM =	Propeller RPM
PropEff =	Propeller open-water efficiency
HullEff =	Hull efficiency = (1-ThrDed) / (1-WakeFr)
OPC =	Overall propulsive coefficient
Thrust =	Total open-water thrust
Thr/prop =	Open-water thrust per propeller
DelThr =	Total delivered thrust
Torque =	Propeller open water torque
PD/prop =	Delivered power per propeller
PS/prop =	Shaft power per propeller
PBtotal =	Total brake power
Fuel/eng =	Fuel consumption per engine
J =	Advance coefficient
Kt =	Thrust coefficient (for horizontal thrust vector)
Kq =	Torque coefficient
Kt/J2 =	Propeller thrust-speed ratio
Kq/J3 =	Propeller torque-speed ratio
SigmaV =	Cavitation number based on advance velocity (Va)
SigmaN =	Cavitation number based on rotational velocity (nD)
Sigma7R =	Cavitation number based on helix velocity at 0.7 radius
%CavAvg =	Average percent back cavitation
%CavPeak =	Peak percent back cavitation (from shaft angle effects)
Press =	Average propeller blade pressure
MiniBAR =	Minimum recommended expanded blade area ratio
PropRn =	Propeller Reynolds number
Cth =	Propeller thrust loading coefficient
Cp =	Propeller power loading coefficient
MinP/D =	Minimum P/D ratio to avoid face cavitation
TipSpd =	Linear velocity of the propeller tips
* =	Propulsive coefficient prediction exceeds speed parameter
** =	Exceeds cavitation criteria
*** =	Cavitation breakdown is indicated

RESISTANCE VS. SPEED IN SEA STATE 0



Prediction results

Vel [kts]	Fn	Rn	Cf	[Cform]	[Cw]	Cr	Ct
10.00	0.164	4.36e+8	0.001511	0.000362	0.000384	0.000746	0.002914
12.00	0.196	5.23e+8	0.001475	0.000354	0.000457	0.000811	0.002943
13.00	0.213	5.67e+8	0.001460	0.000350	0.000531	0.000881	0.002998
14.00	0.229	6.10e+8	0.001446	0.000347	0.000633	0.000980	0.003083
15.00	0.246	6.54e+8	0.001433	0.000344	0.000759	0.001102	0.003193
16.00	0.262	6.97e+8	0.001422	0.000341	0.000940	0.001281	0.003359
17.00	0.278	7.41e+8	0.001411	0.000338	0.001183	0.001521	0.003589
18.00	0.295	7.84e+8	0.001401	0.000336	0.001405	0.001741	0.003798
19.00	0.311	8.28e+8	0.001391	0.000334	0.001542	0.001876	0.003924
20.00	0.327	8.72e+8	0.001382	0.000331	0.001640	0.001971	0.004010

Vel [kts]	Rw/W	Rr/W	Rbare/W	Rw [lbs]	Rr [lbs]	Rbare [lbs]	PEbare [hp]
10.00	0.00022	0.00043	0.00170	2185	4249	16598	509
12.00	0.00038	0.00068	0.00247	3751	6653	24144	889
13.00	0.00052	0.00087	0.00295	5115	8486	28867	1152
14.00	0.00072	0.00112	0.00352	7068	10941	34422	1479
15.00	0.00099	0.00145	0.00419	9724	14130	40923	1884
16.00	0.00140	0.00191	0.00501	13706	18678	48990	2405
17.00	0.00199	0.00256	0.00604	19474	25044	59085	3082
18.00	0.00265	0.00329	0.00717	25936	32135	70110	3873
19.00	0.00324	0.00395	0.00825	31717	38578	80693	4705
20.00	0.00382	0.00460	0.00935	37372	44925	91386	5609

Vel [kts]	Rapp [lbs]	Rwind [lbs]	Rseas [lbs]	Rchan [lbs]	Rmisc [lbs]	Rtotal [lbs]	PEtotal [hp]
10.00	2663	7089	0	0	0	26350	809
12.00	3765	8702	0	0	0	36612	1348
13.00	4384	9571	0	0	0	42822	1708
14.00	5048	10481	0	0	0	49951	2146
15.00	5755	11432	0	0	0	58110	2675
16.00	6507	12424	0	0	0	67922	3335
17.00	7303	13458	0	0	0	79846	4165
18.00	8143	14533	0	0	0	92786	5125
19.00	9026	15650	0	0	0	105368	6144
20.00	9952	16808	0	0	0	118145	7251

Report ID20101102-1529 HydroComp NavCad 9.07.0134.NC.S86.118

Environment data

[Wind]		**[Seas]**	
Wind Speed	**10.00 kts**	Sig wave height	**0.000 ft**
Angle off bow	**0.00 deg**	Modal wave period	**0 sec**
Transv hull area	**2265.700 ft2**		
VCE above WL	**32.040 ft**	**[Channel]**	
LCE fwd transom	**320.000 ft**	Channel width	**0.000 ft**
Transv superst area	**2494.500 ft2**	Channel depth	**0.000 ft**
VCE above WL	**64.950 ft**	Slope side	**0.00 deg**
LCE fwd transom	**275.000 ft**	Wetted hull girth	**0.000 ft**
Total longl area	**17088.000 ft2**	Channel depth	**0.000 ft**
VCE above WL	**43.450 ft**		
LCE fwd transom	**176.500 ft**		
Wind location	**Free stream**		
Hull type	**Passenger**		

Symbols and values

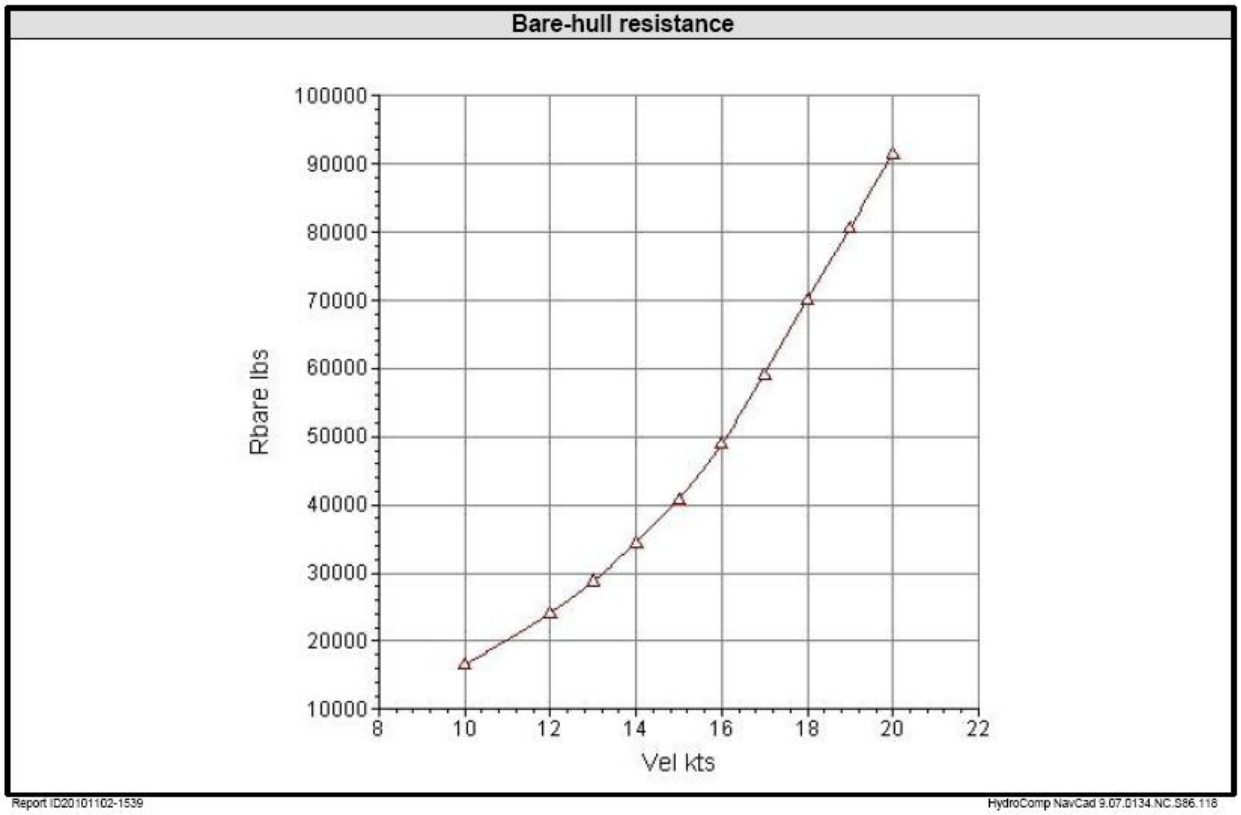
Fn = Length Froude number
Rn = Reynolds number
Cf = Frictional resistance coefficient
[Cform] = Viscous form resistance coefficient
[Cw] = Wave-making resistance coefficient
Cr = Residuary resistance coefficient
Ct = Total bare-hull resistance coefficient

Rw/W = Wave-making resistance-weight merit ratio
Rr/W = Residuary resistance-weight merit ratio
Rbare/W = Bare-hull resistance-weight merit ratio
Rw = Wave-making resistance component
Rr = Residuary resistance component
Rbare = Bare-hull resistance
PEbare = Bare-hull effectibe power

Rapp = Additional appendage resistance
Rwind = Additional wind resistance
Rseas = Additional sea-state resistance
Rchan = Additional channel resistance
Rmisc = Miscellaneous resistance
Rtotal = Total vessel resistance
PEtotal = Total effective power
Fnh = Depth based Froude number
Squat = Sinkage due to shallow water effects
SqTrim = Trim due to shallow water effects

* = Bare-hull drag prediction exceeds speed parameter
** = Exceeds parameter limit

RESISTANCE VS. SPEED IN SEA STATE 2



Prediction results

Vel [kts]	Fn	Rn	Cf	[Cform]	[Cw]	Cr	Ct
10.00	0.164	4.36e+8	0.001511	0.000362	0.000384	0.000746	0.002914
12.00	0.196	5.23e+8	0.001475	0.000354	0.000457	0.000811	0.002943
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17.00	0.278	7.41e+8	0.001411	0.000338	0.001183	0.001521	0.003589
18.00	0.295	7.84e+8	0.001401	0.000336	0.001405	0.001741	0.003798
19.00	0.311	8.28e+8	0.001391	0.000334	0.001542	0.001876	0.003924
20.00	0.327	8.72e+8	0.001382	0.000331	0.001640	0.001971	0.004010

Vel [kts]	Rw/W	Rr/W	Rbare/W	Rw [lbs]	Rr [lbs]	Rbare [lbs]	PEbare [hp]
10.00	0.00022	0.00043	0.00170	2185	4249	16598	509
12.00	0.00038	0.00068	0.00247	3751	6653	24144	889
13.00	0.00052	0.00087	0.00295	5115	8486	28867	1152
14.00	0.00072	0.00112	0.00352	7068	10941	34422	1479
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20.00	0.00382	0.00460	0.00935	37372	44925	91386	5609

Vel [kts]	Rapp [lbs]	Rwind [lbs]	Rseas [lbs]	Rchan [lbs]	Rmisc [lbs]	Rtotal [lbs]	PEtotal [hp]
10.00	2663	15115	245	0	0	34621	1062
12.00	3765	17433	236	0	0	45579	1678
13.00	4384	18654	232	0	0	52137	2080
14.00	5048	19916	228	0	0	59613	2561
15.00	5755	21219	223	0	0	68121	3136
16.00	6507	22564	219	0	0	78281	3844
17.00	7303	23950	215	0	0	90552	4724
18.00	8143	25377	211	0	0	103840	5736
19.00	9026	26846	207	0	0	116771	6808
20.00	9952	28356	204	0	0	129897	7972

Report ID20101102-1539 HydroComp NavCad 9.07.0134.NC.S86.116

Environment data

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* = Bare-hull drag prediction exceeds speed parameter
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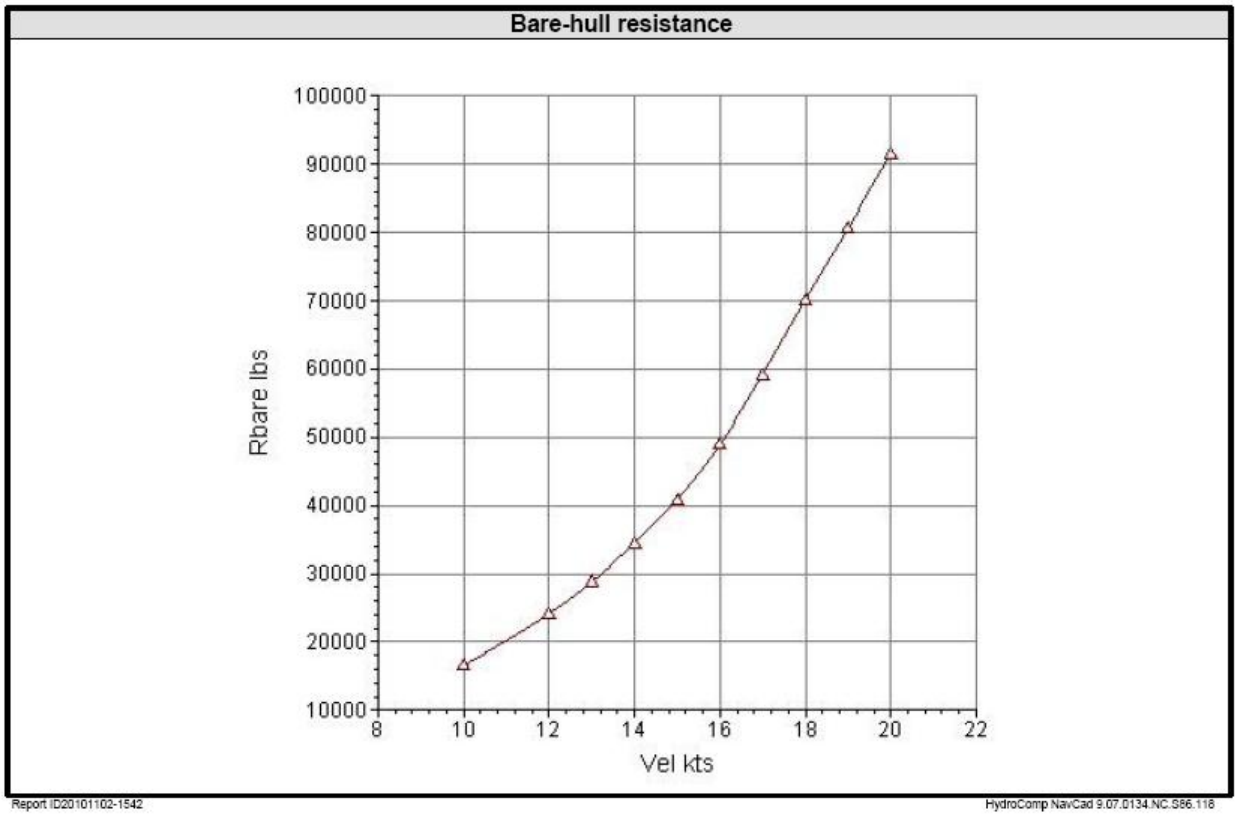
RESISTANCE VS. SPEED IN SEA STATE 4



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15.00	0.246	6.54e+8	0.001433	0.000344	0.000759	0.001102	0.003193
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19.00	0.311	8.28e+8	0.001391	0.000334	0.001542	0.001876	0.003924
20.00	0.327	8.72e+8	0.001382	0.000331	0.001640	0.001971	0.004010

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10.00	0.00022	0.00043	0.00170	2185	4249	16598	509
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13.00	0.00052	0.00087	0.00295	5115	8486	28867	1152
14.00	0.00072	0.00112	0.00352	7068	10941	34422	1479
15.00	0.00099	0.00145	0.00419	9724	14130	40923	1884
16.00	0.00140	0.00191	0.00501	13706	18678	48990	2405
17.00	0.00199	0.00256	0.00604	19474	25044	59085	3082
18.00	0.00265	0.00329	0.00717	25936	32135	70110	3873
19.00	0.00324	0.00395	0.00825	31717	38578	80693	4705
20.00	0.00382	0.00460	0.00935	37372	44925	91386	5609

Vel [kts]	Rapp [lbs]	Rwind [lbs]	Rseas [lbs]	Rchan [lbs]	Rmisc [lbs]	Rtotal [lbs]	PEtotal [hp]
10.00	2663	31397	11586	0	0	62244	1910
12.00	3765	34700	12477	0	0	75087	2765
13.00	4384	36414	12923	0	0	82588	3295
14.00	5048	38169	13368	0	0	91007	3910
15.00	5755	39966	13814	0	0	100458	4624
16.00	6507	41804	14259	0	0	111561	5478
17.00	7303	43683	14705	0	0	124775	6509
18.00	8143	45603	15150	0	0	139006	7678
19.00	9026	47565	15499	0	0	152782	8908
20.00	9952	49568	15827	0	0	166733	10233

Report ID20101102-1543 HydroComp NavCad 9.07.0134.NC.S86.116

Environment data

[Wind]		[Seas]	
Wind Speed	**34.00 kts**	Sig wave height	**6.200 ft**
Angle off bow	**0.00 deg**	Modal wave period	**8.8 sec**
Transv hull area	**2265.700 ft2**		
VCE above WL	**32.040 ft**	**[Channel]**	
LCE fwd transom	**320.000 ft**	Channel width	**0.000 ft**
Transv superst area	**2494.500 ft2**	Channel depth	**0.000 ft**
VCE above WL	**64.950 ft**	Slope side	**0.00 deg**
LCE fwd transom	**275.000 ft**	Wetted hull girth	**0.000 ft**
Total longl area	**17088.000 ft2**	Channel depth	**0.000 ft**
VCE above WL	**43.450 ft**		
LCE fwd transom	**176.500 ft**		
Wind location	**Free stream**		
Hull type	**Passenger**		

Symbols and values

Fn = Length Froude number
Rn = Reynolds number
Cf = Frictional resistance coefficient
[Cform] = Viscous form resistance coefficient
[Cw] = Wave-making resistance coefficient
Cr = Residuary resistance coefficient
Ct = Total bare-hull resistance coefficient

Rw/W = Wave-making resistance-weight merit ratio
Rr/W = Residuary resistance-weight merit ratio
Rbare/W = Bare-hull resistance-weight merit ratio
Rw = Wave-making resistance component
Rr = Residuary resistance component
Rbare = Bare-hull resistance
PEbare = Bare-hull effectibe power

Rapp = Additional appendage resistance
Rwind = Additional wind resistance
Rseas = Additional sea-state resistance
Rchan = Additional channel resistance
Rmisc = Miscellaneous resistance
Rtotal = Total vessel resistance
PEtotal = Total effective power
Fnh = Depth based Froude number
Squat = Sinkage due to shallow water effects
SqTrim = Trim due to shallow water effects

* = Bare-hull drag prediction exceeds speed parameter
** = Exceeds parameter limit

5000 BHP ENGINE – SEA STATE 0

Prediction results

Vel [kts]	PEtotal [hp]	WakeFr	ThrDed	RelRot	EngRPM	PB/prop [hp]	Pitch [ft]
10.00	809	0.0703	0.0816	0.9753	462.8	701	11.885
12.00	1348	0.0701	0.0816	0.9753	541.8	1164	12.151
13.00	1708	0.0700	0.0816	0.9753	583.2	1474	12.245
14.00	2146	0.0700	0.0816	0.9753	633.8	1853	12.120
15.00	2675	0.0699	0.0816	0.9753	695.4	2315	11.789
16.00	3335	0.0698	0.0816	0.9753	747.5	2897	11.765
17.00	4165	0.0698	0.0816	0.9753	809.2	3638	11.622
18.00	5125	0.0697	0.0816	0.9753	866.6	4499	11.579
19.00	6144	0.0697	0.0816	0.9753	927.2	5408	11.440
20.00	7251	0.0696	0.0816	0.9753	993.1	6397	11.219

Vel [kts]	PropRPM	PropEff	HullEff	OPC	Thrust [lbs]	Thr/prop [lbs]	DelThr [lbs]
10.00	104.7	0.6360	0.9879	0.6005	28691	14345	26350
12.00	122.6	0.6392	0.9877	0.6033	39864	19932	36612
13.00	131.9	0.6395	0.9876	0.6036	46626	23313	42822
14.00	143.4	0.6390	0.9875	0.6031	54388	27194	49951
15.00	157.3	0.6376	0.9874	0.6017	63272	31636	58110
16.00	169.1	0.6354	0.9874	0.5996	73956	36978	67922
17.00	183.1	0.6319	0.9873	0.5963	86938	43469	79846
18.00	196.1	0.6289	0.9872	0.5934	101028	50514	92786
19.00	209.8	0.6271	0.9872	0.5917	114728	57364	105368
20.00	224.7	0.6258	0.9871	0.5904	128640	64320	118145

Vel [kts]	Torque [ft-lb]	PD/prop [hp]	PS/prop [hp]	PBtotal [hp]	Fuel/eng [gph]
10.00	32275	660	673	1403	307.4
12.00	45750	1095	1117	2328	---
13.00	53835	1387	1415	2948	---
14.00	62286	1744	1779	3707	---
15.00	70919	2178	2223	4631	---
16.00	82537	2725	2781	5794	---
17.00	95765	3423	3493	7277	---
18.00	110575	4232	4319	8998	---
19.00	124235	5088	5192	10816	---
20.00	137197	6018	6141	12794	---

Report ID20101102-1546 HydroComp NavCad 9.07.0134.NC.S86.118

Propeller performance

Vel [kts]	J	Kt	Kq	Kt/J2	Kq/J3		
10.00	0.8174	0.1616	0.0331	0.2419	0.0605		
12.00	0.8380	0.1638	0.0342	0.2333	0.0581		
13.00	0.8435	0.1654	0.0347	0.2325	0.0579		
14.00	0.8360	0.1634	0.0340	0.2338	0.0582		
15.00	0.8164	0.1579	0.0322	0.2369	0.0591		
16.00	0.8101	0.1597	0.0324	0.2433	0.0609		
17.00	0.7952	0.1602	0.0321	0.2533	0.0638		
18.00	0.7863	0.1623	0.0323	0.2626	0.0665		
19.00	0.7758	0.1610	0.0317	0.2676	0.0679		
20.00	0.7624	0.1574	0.0305	0.2707	0.0689		
Vel [kts]	SigmaV	SigmaN	Sigma7R	%CavAvg	%CavPeak	Press [psi]	MinBAR
10.00	11.24	7.51	1.36	0.0	0.0	1.6	0.1532
12.00	7.80	5.48	0.99	0.0	0.0	2.3	0.1937
13.00	6.64	4.73	0.85	0.0	0.0	2.7	0.2187
14.00	5.73	4.00	0.72	0.0	0.0	3.1	0.2483
15.00	4.99	3.33	0.60	0.0	2.1	3.6	0.2830
16.00	4.38	2.88	0.52	0.0	2.7	4.2	0.3235
17.00	3.88	2.46	0.45	2.2	3.6	5.0	0.3732
18.00	3.46	2.14	0.39	3.0	5.0	5.8	0.4267
19.00	3.11	1.87	0.34	3.9	6.5	6.5	0.4788
20.00	2.80	1.63	0.30	4.9	8.2	7.3	0.5318
Vel [kts]	PropRn	Cth	Cp	MinP/D	TipSpd [fps]		
10.00	1.37e+7	0.6160	0.0018	0.928	60.3		
12.00	1.60e+7	0.5941	0.0017	0.948	70.6		
13.00	1.73e+7	0.5920	0.0017	0.954	76.0		
14.00	1.87e+7	0.5953	0.0017	0.946	82.6		
15.00	2.05e+7	0.6032	0.0018	0.925	90.6		
16.00	2.20e+7	0.6196	0.0018	0.921	97.4		
17.00	2.38e+7	0.6451	0.0019	0.908	105.4		
18.00	2.55e+7	0.6686	0.0020	0.901	112.9		
19.00	2.72e+7	0.6814	0.0020	0.891	120.8		
20.00	2.91e+7	0.6894	0.0021	0.877	129.4		

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Propulsive coefficients

Wake fraction	[Calc] Holtrop 1984	Wake fract scale correction	[Off]
Thrust deduction	[Calc] Holtrop 1984	Rudder loc	Free stream
Relative rotative efficiency	[Calc] Holtrop 1984	Wake fract duct correction	[Off]
Friction line	Hughes	Tunnel stern correction	[Off]
Correlation allowance	0.00034		
3D form factor	1.2398		

Hull data

[General]		[Ct-based]		
Length between PP	330.260 ft	Max section area	[Cx 0.734]	754.100 ft2
WL bow pt aft FP	0.000 ft	Waterplane area	[Cw 0.745]	15798.000 ft2
Length on WL	330.260 ft	Trim by stern		0.000 ft
Max beam on WL	64.180 ft	LCB aft of FP	[0.513 Lpp]	169.300 ft
Max model draft	16.000 ft	Bulb ext fwd FP		10.000 ft
Displacement bare	4364.40 LT	Bulb area at FP		75.000 ft2
Wetted surface	20093.400 ft2	Bulb ctr above BL		6.750 ft
Chine type	Round bilge	Transom area	[0.025 Ax]	19.000 ft2
[Principal parameters]		Transom beam	[0.288 B]	18.510 ft
Lwl/B	5.1458	Transom draft	[0.094 T]	1.500 ft
B/T	4.0113	Half ent angle		12.90 deg
Cb	0.4501	Bow shape	[Normal]	Average flow
Cws	2.8299	Stern shape	[Normal]	Average flow

Prediction method check

Wake fraction	Holtrop 1984	
Fn(Lwl)	0.16	0.1...0.8
Fn-high	0.33	0.1...0.8
Lwl/Bwl	5.15	3.9...14.9
Bwl/T	4.01	2.1...4 *
Cp(Lwl)	0.61	0.55...0.85
Lambda	0.73	0...0.85

* = Outside parameter limit

Thrust deduction	Holtrop 1984	
Fn(Lwl)	0.16	0.1...0.8
Fn-high	0.33	0.1...0.8
Lwl/Bwl	5.15	3.9...14.9
Bwl/T	4.01	2.1...4 *
Cp(Lwl)	0.61	0.55...0.85
Lambda	0.73	0...0.85

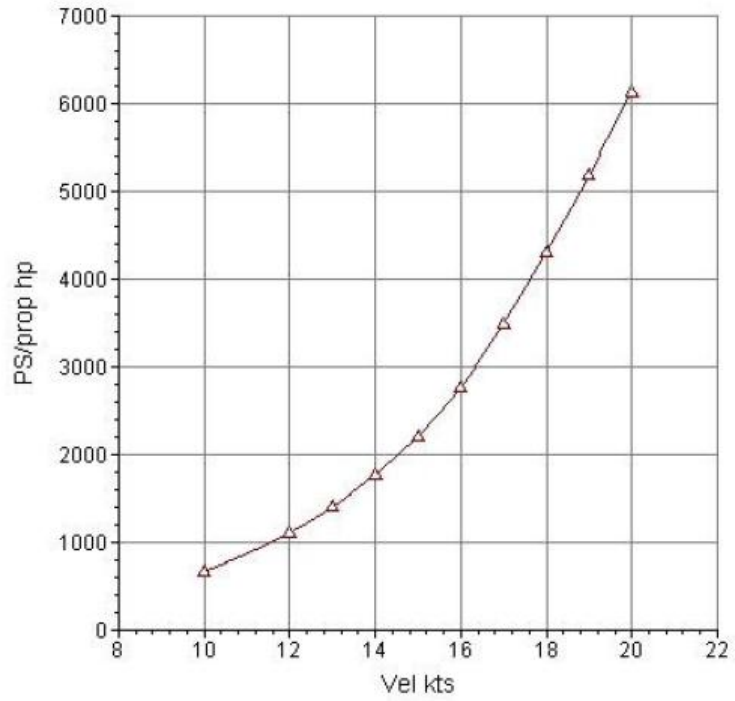
Rel-rot efficiency	Holtrop 1984	
Fn(Lwl)	0.16	0.1...0.8
Fn-high	0.33	0.1...0.8
Lwl/Bwl	5.15	3.9...14.9
Bwl/T	4.01	2.1...4 *
Cp(Lwl)	0.61	0.55...0.85
Lambda	0.73	0...0.85

Report ID20101102-1546 HydroComp NavCad 9.07.0134.NC.S86.118

System analysis			
Analysis type	**Free run**	Water type	**Standard Salt**
Cav criteria	**Keller eqn**	Mass density	**1.9905 slug/ft3**
CPP analysis method	**[On** Combinator	Viscosity	**1.2791e-05 ft2/s**
CPP Engine RPM	**900**		
Propulsor data			
Description		Blades	**4**
Propulsors	**2**	Exp area ratio	**0.640**
Propulsor type	**Series**	Diameter	**11.000 ft**
Propeller series	**B-series**	Pitch	**12.110 ft**
		Immersion	**10.500 ft**
Propeller options			
Scale corr	**Full ITTC-78**	Propeller cup	**0.0 mm**
Kt mult	**0.960**	Pitch type	**CPP**
Kq mult	**1.050**	Cav breakdown	**[On]**
Blade t/c	[Std] **0.000**	Shaft angle corr	**[On] 1.50 deg**
Roughness	[Std] **0.0 mm**	Added angle of run	**6.62 deg**
Engine data			
Engine file	**EMD 20-710G7C-T2[...].eng**	Gear ratio	**4.420**
Rated RPM	**900**	Gear efficiency	**0.960**
Rated power	**5000 hp**	Shaft efficiency	**0.980**

Report ID20101102-1546 HydroComp NavCad 9.07.0134.NC.S86.116

Shaft power per propeller



Report ID20101102-1549 HydroComp NavCad 9.07.0134.NC.S86.116

5000 BHP ENGINE – SEA STATE 2

Prediction results

Vel [kts]	PEtotal [hp]	WakeFr	ThrDed	RelRot	EngRPM	PB/prop [hp]	Pitch [ft]
10.00	**1062**	**0.0703**	**0.0816**	**0.9753**	**514.5**	**959**	11.272
12.00	**1678**	**0.0701**	**0.0816**	**0.9753**	**585.9**	**1495**	11.741
13.00	**2080**	**0.0700**	**0.0816**	**0.9753**	**632.6**	**1845**	11.693
14.00	**2561**	**0.0700**	**0.0816**	**0.9753**	**688.9**	**2267**	11.463
15.00	**3136**	**0.0699**	**0.0816**	**0.9753**	**736.9**	**2774**	11.473
16.00	**3844**	**0.0698**	**0.0816**	**0.9753**	**791.8**	**3405**	11.398
17.00	**4724**	**0.0698**	**0.0816**	**0.9753**	**846.7**	**4201**	11.391
18.00	**5736**	**0.0697**	**0.0816**	**0.9753**	**907.9**	**5118**	11.284
19.00	**6808**	**0.0697**	**0.0816**	**0.9753**	**972.3**	**6085**	11.098
20.00	**7972**	**0.0696**	**0.0816**	**0.9753**	**1042.3**	**7135**	10.842

Vel [kts]	PropRPM	PropEff	HullEff	OPC	Thrust [lbs]	Thr/prop [lbs]	DelThr [lbs]
10.00	**116.4**	**0.6111**	**0.9879**	**0.5770**	**37697**	**18848**	**34621**
12.00	**132.6**	**0.6196**	**0.9877**	**0.5849**	**49627**	**24814**	**45579**
13.00	**143.1**	**0.6221**	**0.9876**	**0.5872**	**56768**	**28384**	**52137**
14.00	**155.9**	**0.6234**	**0.9875**	**0.5884**	**64909**	**32454**	**59613**
15.00	**166.7**	**0.6239**	**0.9874**	**0.5888**	**74172**	**37086**	**68121**
16.00	**179.1**	**0.6229**	**0.9874**	**0.5879**	**85234**	**42617**	**78281**
17.00	**191.6**	**0.6207**	**0.9873**	**0.5857**	**98596**	**49298**	**90552**
18.00	**205.4**	**0.6186**	**0.9872**	**0.5837**	**113064**	**56532**	**103840**
19.00	**220.0**	**0.6176**	**0.9872**	**0.5827**	**127144**	**63572**	**116771**
20.00	**235.8**	**0.6168**	**0.9871**	**0.5820**	**141436**	**70718**	**129897**

Vel [kts]	Torque [ft-lb]	PD/prop [hp]	PS/prop [hp]	PBtotal [hp]	Fuel/eng [gph]
10.00	**39698**	**902**	**921**	**1918**	**---**
12.00	**54330**	**1406**	**1435**	**2989**	**---**
13.00	**62111**	**1736**	**1771**	**3690**	**---**
14.00	**70089**	**2133**	**2176**	**4534**	**---**
15.00	**80182**	**2610**	**2663**	**5548**	**---**
16.00	**91609**	**3204**	**3269**	**6811**	**---**
17.00	**105668**	**3952**	**4032**	**8401**	**---**
18.00	**120075**	**4815**	**4913**	**10236**	**---**
19.00	**133299**	**5725**	**5842**	**12170**	**---**
20.00	**145802**	**6713**	**6850**	**14270**	**---**

Report ID20101102-1551 HydroComp NavCad 9.07.0134.NC.S66.118

Propeller performance

Vel [kts]	J	Kt	Kq	Kt/J2	Kq/J3		
10.00	0.7352	0.1718	0.0329	0.3178	0.0828		
12.00	0.7749	0.1744	0.0347	0.2905	0.0746		
13.00	0.7776	0.1711	0.0340	0.2831	0.0724		
14.00	0.7691	0.1650	0.0324	0.2790	0.0712		
15.00	0.7705	0.1648	0.0324	0.2777	0.0708		
16.00	0.7649	0.1641	0.0321	0.2804	0.0716		
17.00	0.7600	0.1660	0.0323	0.2873	0.0737		
18.00	0.7505	0.1655	0.0320	0.2938	0.0756		
19.00	0.7397	0.1623	0.0309	0.2965	0.0764		
20.00	0.7264	0.1571	0.0294	0.2977	0.0768		
Vel [kts]	SigmaV	SigmaN	Sigma7R	%CavAvg	%CavPeak	Press [psi]	MinBAR
10.00	11.24	6.07	1.13	0.0	0.0	2.2	0.1924
12.00	7.80	4.68	0.86	0.0	0.0	2.8	0.2345
13.00	6.64	4.02	0.74	0.0	0.0	3.2	0.2612
14.00	5.73	3.39	0.62	0.0	2.1	3.7	0.2923
15.00	4.99	2.96	0.55	0.0	2.7	4.2	0.3269
16.00	4.38	2.56	0.47	2.2	3.4	4.9	0.3688
17.00	3.88	2.24	0.41	2.9	4.6	5.6	0.4193
18.00	3.46	1.95	0.36	3.8	6.1	6.5	0.4742
19.00	3.11	1.70	0.32	4.8	7.8	7.3	0.5277
20.00	2.80	1.48	0.28	6.0	9.7	8.1	0.5823
Vel [kts]	PropRn	Cth	Cp	MinP/D	TipSpd [fps]		
10.00	1.50e+7	0.8094	0.0025	0.862	67.0		
12.00	1.72e+7	0.7396	0.0022	0.898	76.4		
13.00	1.86e+7	0.7208	0.0022	0.899	82.4		
14.00	2.02e+7	0.7105	0.0021	0.887	89.8		
15.00	2.16e+7	0.7071	0.0021	0.889	96.0		
16.00	2.32e+7	0.7141	0.0021	0.883	103.2		
17.00	2.48e+7	0.7316	0.0022	0.880	110.3		
18.00	2.66e+7	0.7483	0.0023	0.871	118.3		
19.00	2.84e+7	0.7551	0.0023	0.860	126.7		
20.00	3.04e+7	0.7580	0.0023	0.845	135.8		

Report ID20101102-1551 HydroComp NavCad 9.07.0134.NC.S86.116

Propulsive coefficients

Wake fraction	**[Calc] Holtrop 1984**	Wake fract scale correction	**[Off]**
Thrust deduction	**[Calc] Holtrop 1984**	Rudder loc	**Free stream**
Relative rotative efficiency	**[Calc] Holtrop 1984**	Wake fract duct correction	**[Off]**
Friction line	**Hughes**	Tunnel stern correction	**[Off]**
Correlation allowance	**0.00034**		
3D form factor	**1.2398**		

Hull data

[General]		**[Ct-based]**		
Length between PP	**330.260 ft**	Max section area	[Cx 0.734]	**754.100 ft2**
WL bow pt aft FP	**0.000 ft**	Waterplane area	[Cw 0.745]	**15798.000 ft2**
Length on WL	**330.260 ft**	Trim by stern		**0.000 ft**
Max beam on WL	**64.180 ft**	LCB aft of FP	[0.513 Lpp]	**169.300 ft**
Max model draft	**16.000 ft**	Bulb ext fwd FP		**10.000 ft**
Displacement bare	**4364.40 LT**	Bulb area at FP		**75.000 ft2**
Wetted surface	**20093.400 ft2**	Bulb ctr above BL		**6.750 ft**
Chine type	**Round bilge**	Transom area	[0.025 Ax]	**19.000 ft2**
[Principal parameters]		Transom beam	[0.288 B]	**18.510 ft**
Lwl/B	**5.1458**	Transom draft	[0.094 T]	**1.500 ft**
B/T	**4.0113**	Half ent angle		**12.90 deg**
Cb	**0.4501**	Bow shape	[Normal]	**Average flow**
Cws	**2.8299**	Stern shape	[Normal]	**Average flow**

Prediction method check

Wake fraction	**Holtrop 1984**	
Fn(Lwl)	**0.16**	0.1...0.8
Fn-high	**0.33**	0.1...0.8
Lwl/Bwl	**5.15**	3.9...14.9
Bwl/T	**4.01**	2.1...4 *
Cp(Lwl)	**0.61**	0.55...0.85
Lambda	**0.73**	0...0.85
Thrust deduction	**Holtrop 1984**	
Fn(Lwl)	**0.16**	0.1...0.8
Fn-high	**0.33**	0.1...0.8
Lwl/Bwl	**5.15**	3.9...14.9
Bwl/T	**4.01**	2.1...4 *
Cp(Lwl)	**0.61**	0.55...0.85
Lambda	**0.73**	0...0.85
Rel-rot efficiency	**Holtrop 1984**	
Fn(Lwl)	**0.16**	0.1...0.8
Fn-high	**0.33**	0.1...0.8
Lwl/Bwl	**5.15**	3.9...14.9
Bwl/T	**4.01**	2.1...4 *
Cp(Lwl)	**0.61**	0.55...0.85
Lambda	**0.73**	0...0.85

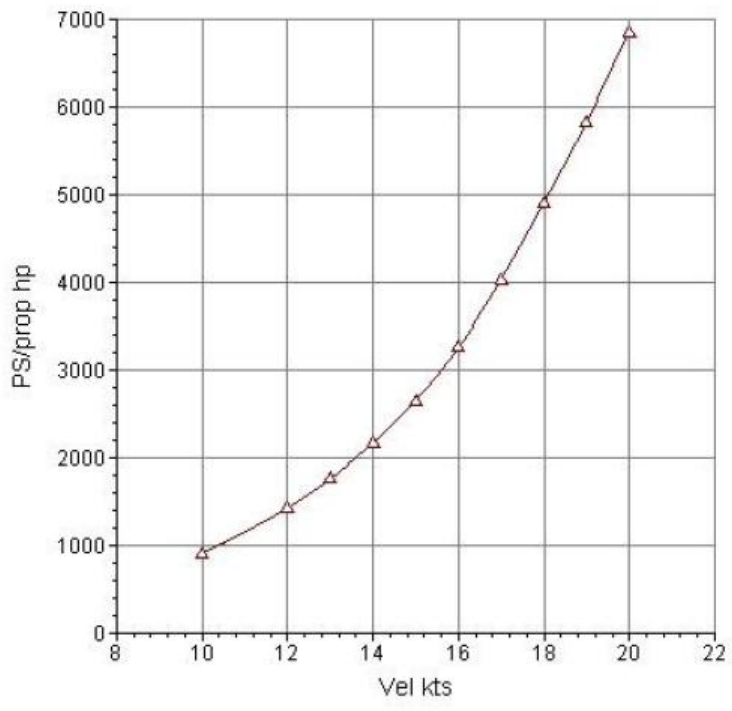
* = Outside parameter limit

Report ID20101102-1551 HydroComp NavCad 9.07.0134.NC.S86.116

System analysis			
Analysis type	**Free run**	Water type	**Standard Salt**
Cav criteria	**Keller eqn**	Mass density	**1.9905 slug/ft3**
CPP analysis method	**[On** Combinator	Viscosity	**1.2791e-05 ft2/s**
CPP Engine RPM	**900**		
Propulsor data			
Description		Blades	**4**
Propulsors	**2**	Exp area ratio	**0.640**
Propulsor type	**Series**	Diameter	**11.000 ft**
Propeller series	**B-series**	Pitch	**12.110 ft**
		Immersion	**10.500 ft**
Propeller options			
Scale corr	**Full ITTC-78**	Propeller cup	**0.0 mm**
Kt mult	**0.960**	Pitch type	**CPP**
Kq mult	**1.050**	Cav breakdown	**[On]**
Blade t/c	[Std] **0.000**	Shaft angle corr	**[On] 1.50 deg**
Roughness	[Std] **0.0 mm**	Added angle of run	**6.62 deg**
Engine data			
Engine file	**EMD 20-710G7C-T2[...].eng**	Gear ratio	**4.420**
Rated RPM	**900**	Gear efficiency	**0.960**
Rated power	**5000 hp**	Shaft efficiency	**0.980**

Report ID20101102-1551 HydroComp NavCad 9.07.0134.NC.S86.116

Shaft power per propeller



Report ID20101102-1553 HydroComp NavCad 9.07.0134.NC.S86.116

5000 BHP ENGINE – SEA STATE 4

Prediction results

Vel [kts]	PEtotal [hp]	WakeFr	ThrDed	RelRot	EngRPM	PB/prop [hp]	Pitch [ft]
10.00	**1910**	**0.0703**	**0.0816**	**0.9753**	**644.0**	**1930**	10.371
12.00	**2765**	**0.0701**	**0.0816**	**0.9753**	**729.4**	**2689**	10.446
13.00	**3295**	**0.0700**	**0.0816**	**0.9753**	**770.6**	**3162**	10.542
14.00	**3910**	**0.0700**	**0.0816**	**0.9753**	**814.4**	**3716**	10.608
15.00	**4624**	**0.0699**	**0.0816**	**0.9753**	**857.5**	**4363**	10.705
16.00	**5478**	**0.0698**	**0.0816**	**0.9753**	**909.6**	**5145**	10.688
17.00	**6509**	**0.0698**	**0.0816**	**0.9753**	**973.5**	**6103**	10.544
18.00	**7678**	**0.0697**	**0.0816**	**0.9753**	**1046.2**	**7193**	10.306
19.00	**8908**	**0.0697**	**0.0816**	**0.9753**	**1122.3**	**8335**	10.030
20.00	**10233**	**0.0696**	**0.0816**	**0.9753**	**1204.9**	**9574**	9.711

Vel [kts]	PropRPM	PropEff	HullEff	OPC	Thrust [lbs]	Thr/prop [lbs]	DelThr [lbs]
10.00	**145.7**	**0.5459**	**0.9879**	**0.5154**	**67773**	**33886**	**62244**
12.00	**165.0**	**0.5675**	**0.9877**	**0.5357**	**81757**	**40878**	**75087**
13.00	**174.4**	**0.5749**	**0.9876**	**0.5426**	**89924**	**44962**	**82588**
14.00	**184.3**	**0.5807**	**0.9875**	**0.5480**	**99091**	**49546**	**91007**
15.00	**194.0**	**0.5850**	**0.9874**	**0.5520**	**109382**	**54691**	**100458**
16.00	**205.8**	**0.5877**	**0.9874**	**0.5546**	**121471**	**60735**	**111561**
17.00	**220.3**	**0.5887**	**0.9873**	**0.5555**	**135859**	**67929**	**124775**
18.00	**236.7**	**0.5892**	**0.9872**	**0.5560**	**151354**	**75677**	**139006**
19.00	**253.9**	**0.5900**	**0.9872**	**0.5566**	**166354**	**83177**	**152782**
20.00	**272.6**	**0.5901**	**0.9871**	**0.5567**	**181544**	**90772**	**166733**

Vel [kts]	Torque [ft-lb]	PD/prop [hp]	PS/prop [hp]	PBtotal [hp]	Fuel/eng [gph]
10.00	**63837**	**1816**	**1853**	**3860**	**---**
12.00	**78505**	**2529**	**2581**	**5377**	**---**
13.00	**87404**	**2975**	**3036**	**6325**	**---**
14.00	**97184**	**3496**	**3567**	**7432**	**---**
15.00	**108365**	**4104**	**4188**	**8725**	**---**
16.00	**120463**	**4840**	**4939**	**10289**	**---**
17.00	**133526**	**5742**	**5859**	**12206**	**---**
18.00	**146447**	**6767**	**6906**	**14387**	**---**
19.00	**158183**	**7842**	**8002**	**16670**	**---**
20.00	**169238**	**9007**	**9191**	**19147**	**---**

Report ID20101102-1553 HydroComp NavCad 9.07.0134.NC.S86.116

Propeller performance

Vel [kts]	J	Kt	Kq	Kt/J2	Kq/J3		
10.00	0.5874	0.1972	0.0338	0.5714	0.1666		
12.00	0.6225	0.1854	0.0324	0.4785	0.1342		
13.00	0.6384	0.1827	0.0323	0.4484	0.1241		
14.00	0.6506	0.1803	0.0321	0.4259	0.1167		
15.00	0.6620	0.1795	0.0323	0.4095	0.1114		
16.00	0.6658	0.1771	0.0319	0.3996	0.1082		
17.00	0.6610	0.1730	0.0309	0.3959	0.1070		
18.00	0.6513	0.1669	0.0294	0.3934	0.1063		
19.00	0.6409	0.1594	0.0276	0.3880	0.1047		
20.00	0.6284	0.1509	0.0256	0.3821	0.1031		
Vel [kts]	SigmaV	SigmaN	Sigma7R	%CavAvg	%CavPeak	Press [psi]	MinBAR
10.00	11.24	3.88	0.75	0.0	2.3	3.9	0.3151
12.00	7.80	3.02	0.58	2.3	3.0	4.7	0.3653
13.00	6.64	2.71	0.52	2.6	3.6	5.1	0.3949
14.00	5.73	2.42	0.46	3.1	4.4	5.7	0.4284
15.00	4.99	2.19	0.41	3.7	5.4	6.2	0.4663
16.00	4.38	1.94	0.37	4.6	6.7	6.9	0.5114
17.00	3.88	1.70	0.32	5.7	8.4	7.8	0.5657
18.00	3.46	1.47	0.28	7.1	10.4	8.6 **	0.6245
19.00	3.11	1.28	0.24	8.7	12.7	9.5 **	0.6815 **
20.00	2.80	1.11	0.21	10.6 **	15.6	10.4 **	0.7393 **
Vel [kts]	PropRn	Cth	Cp	MinP/D	TipSpd [fps]		
10.00	1.85e+7	1.4551	0.0050	0.754	83.9		
12.00	2.10e+7	1.2185	0.0040	0.775	95.1		
13.00	2.23e+7	1.1418	0.0037	0.786	100.4		
14.00	2.36e+7	1.0847	0.0035	0.795	106.1		
15.00	2.48e+7	1.0428	0.0033	0.804	111.7		
16.00	2.64e+7	1.0177	0.0032	0.806	118.5		
17.00	2.82e+7	1.0081	0.0032	0.799	126.9		
18.00	3.03e+7	1.0017	0.0032	0.786	136.3		
19.00	3.24e+7	0.9880	0.0031	0.772	146.2		
20.00	3.48e+7	0.9730	0.0031	0.756	157.0		

Report ID20101102-1553 HydroComp NavCad 9.07.0134.NC.S86.116

Propulsive coefficients

Wake fraction	**[Calc] Holtrop 1984**	Wake fract scale correction	**[Off]**
Thrust deduction	**[Calc] Holtrop 1984**	Rudder loc	**Free stream**
Relative rotative efficiency	**[Calc] Holtrop 1984**	Wake fract duct correction	**[Off]**
Friction line	**Hughes**	Tunnel stern correction	**[Off]**
Correlation allowance	**0.00034**		
3D form factor	**1.2398**		

Hull data

[General]		**[Ct-based]**		
Length between PP	**330.260 ft**	Max section area	[Cx 0.734]	**754.100 ft2**
WL bow pt aft FP	**0.000 ft**	Waterplane area	[Cw 0.745]	**15798.000 ft2**
Length on WL	**330.260 ft**	Trim by stern		**0.000 ft**
Max beam on WL	**64.180 ft**	LCB aft of FP	[0.513 Lpp]	**169.300 ft**
Max model draft	**16.000 ft**	Bulb ext fwd FP		**10.000 ft**
Displacement bare	**4364.40 LT**	Bulb area at FP		**75.000 ft2**
Wetted surface	**20093.400 ft2**	Bulb ctr above BL		**6.750 ft**
Chine type	**Round bilge**	Transom area	[0.025 Ax]	**19.000 ft2**
[Principal parameters]		Transom beam	[0.288 B]	**18.510 ft**
Lwl/B	**5.1458**	Transom draft	[0.094 T]	**1.500 ft**
B/T	**4.0113**	Half ent angle		**12.90 deg**
Cb	**0.4501**	Bow shape	[Normal]	**Average flow**
Cws	**2.8299**	Stern shape	[Normal]	**Average flow**

Prediction method check

Wake fraction	**Holtrop 1984**	
Fn(Lwl)	**0.16**	0.1...0.8
Fn-high	**0.33**	0.1...0.8
Lwl/Bwl	**5.15**	3.9...14.9
Bwl/T	**4.01**	2.1...4 *
Cp(Lwl)	**0.61**	0.55...0.85
Lambda	**0.73**	0...0.85
Thrust deduction	**Holtrop 1984**	
Fn(Lwl)	**0.16**	0.1...0.8
Fn-high	**0.33**	0.1...0.8
Lwl/Bwl	**5.15**	3.9...14.9
Bwl/T	**4.01**	2.1...4 *
Cp(Lwl)	**0.61**	0.55...0.85
Lambda	**0.73**	0...0.85
Rel-rot efficiency	**Holtrop 1984**	
Fn(Lwl)	**0.16**	0.1...0.8
Fn-high	**0.33**	0.1...0.8
Lwl/Bwl	**5.15**	3.9...14.9
Bwl/T	**4.01**	2.1...4 *
Cp(Lwl)	**0.61**	0.55...0.85
Lambda	**0.73**	0...0.85

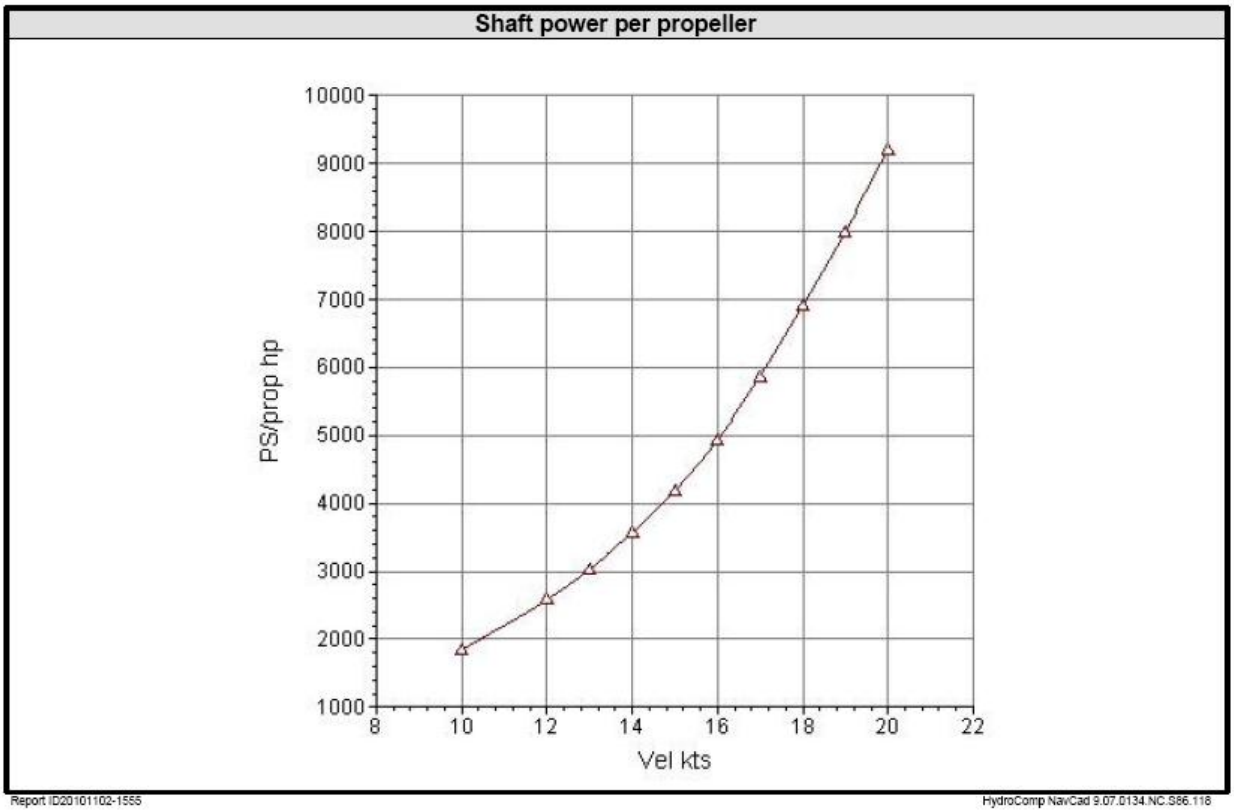
* = Outside parameter limit

Report ID20101102-1553 HydroComp NavCad 9.07.0134.NC.S66.116

System analysis			
Analysis type	**Free run**	Water type	**Standard Salt**
Cav criteria	**Keller eqn**	Mass density	**1.9905 slug/ft3**
CPP analysis method	**[On** Combinator	Viscosity	**1.2791e-05 ft2/s**
CPP Engine RPM	**900**		
Propulsor data			
Description		Blades	**4**
Propulsors	**2**	Exp area ratio	**0.640**
Propulsor type	**Series**	Diameter	**11.000 ft**
Propeller series	**B-series**	Pitch	**12.110 ft**
		Immersion	**10.500 ft**
Propeller options			
Scale corr	**Full ITTC-78**	Propeller cup	**0.0 mm**
Kt mult	**0.960**	Pitch type	**CPP**
Kq mult	**1.050**	Cav breakdown	**[On]**
Blade t/c	[Std] **0.000**	Shaft angle corr	**[On] 1.50 deg**
Roughness	[Std] **0.0 mm**	Added angle of run	**6.62 deg**
Engine data			
Engine file	**EMD 20-710G7C-T2[...].eng**	Gear ratio	**4.420**
Rated RPM	**900**	Gear efficiency	**0.960**
Rated power	**5000 hp**	Shaft efficiency	**0.980**

Report ID20101102-1553 HydroComp NavCad 9.07.0134.NC.S86.116

Shaft power per propeller



Report ID20101102-1555 HydroComp NavCad 9.07.0134.NC.S86.116

EMD ENGINE DATA

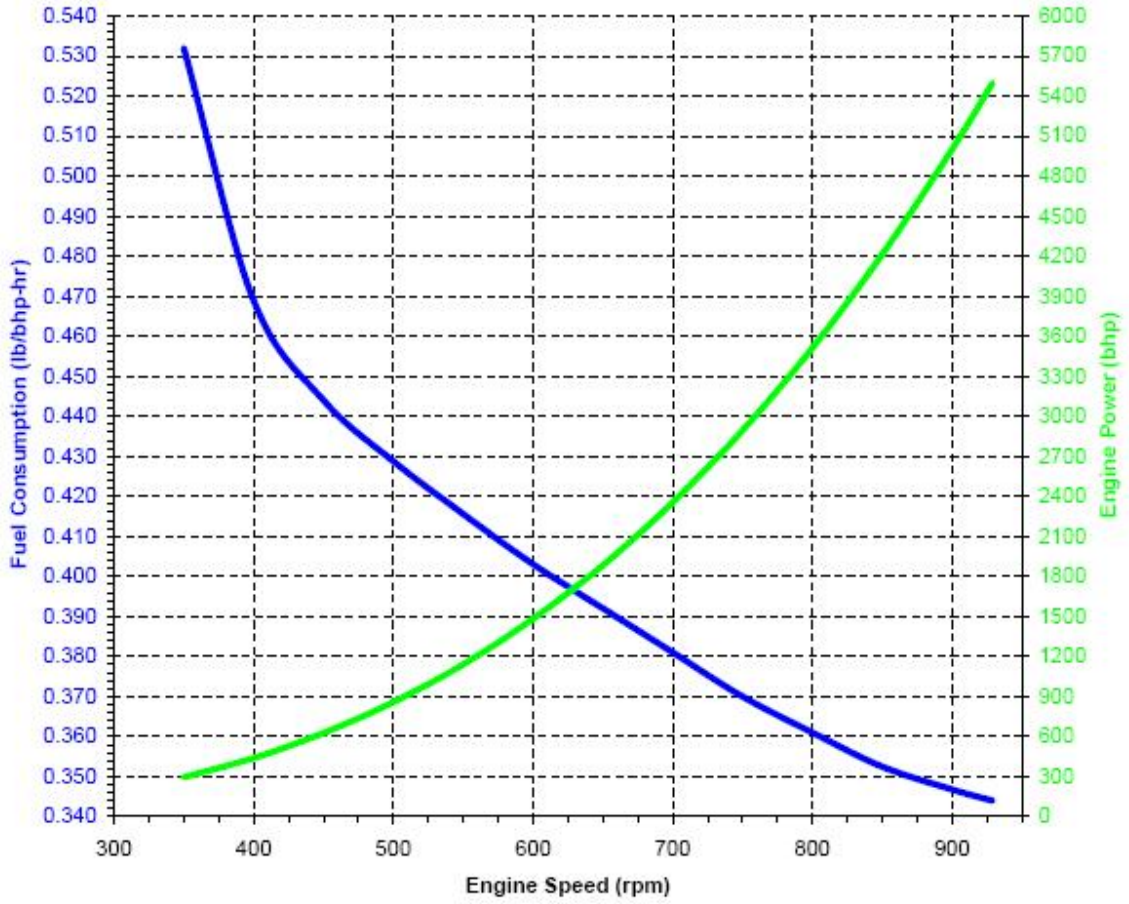
ELECTRO-MOTIVE

Fuel Consumption

Conditions: ISO 15550 & ISO 3046-1 Standard Reference
Air In Temp: 77°F (25°C)
Barometer: 29.61 in Hg (100 kpa)
Fuel S. G.: 0.855 (7.1 lbs/gal)
Fuel LHV: 18360 btu/lb (42700 kJ/kg)
Airbox Temp: 120°F (49°C) maximum
BSFC Tolerance: + 5% maximum

Application: Fixed Pitch Prop Propulsion

Model: 20-710G7C-T2
Operating Speed: Variable
Load: Variable
Rated Speed: 900 RPM
Idle Speed: 350 RPM
ISO Continuous Power: 5000 BHP
ISO Overload Power: 5500 BHP
Emissions: US EPA 40 CFR 94
Emissions Tier: 2
EPA Duty Cycle Table: B-1
ISO Cycle: E3



Comments:

Engine mounted pumps included.
Horsepower / fuel consumption will vary with deviation from stated conditions.
Data is provided in accordance with ISO 3046-1:2002E conditions and associated tolerances, and is intended only for purpose of comparison with competitive manufacturer engines.
Electro-Motive Diesel, Inc. maintains ISO9001:CURRENT REVISION registration for its engine manufacturing and test facilities. Factory engine test data is recorded at observed site conditions in accordance with ISO9001/QMS9000 procedures.

Appendix B

TAKU Model Test Report

THE UNIVERSITY OF MICHIGAN
ANN ARBOR
COLLEGE OF ENGINEERING

NAVAL ARCHITECTURE AND MARINE ENGINEERING

RICHARD B. COUCH, B.S., N.A. & M.E., AERO. ENG., PROFESSOR
HENRY C. ADAMS, A.B., M.S., PROFESSOR
HARRY BENFORD, B.S.E., PROFESSOR
GEORGE L. WEST, JR., B.S.E., ASSOCIATE PROFESSOR
FINN C. MICHELSEN, B.S.E., M.S.E., PH.D., ASSISTANT PROFESSOR
RAYMOND A. YAGLE, B.S.E., M.S.E., ASSISTANT PROFESSOR

LOUIS A. BAIER, B.MAR.E., N.A.
PROFESSOR EMERITUS

450 WEST ENGINEERING BUILDING

July 21, 1961

Mr. Philip F. Spaulding
P. F. Spaulding and Associates
65 Marion Street
Seattle 4, Washington

Dear Phil:

We have completed the tests on the model of the 350 foot Alaskan ferry, and a report of the work is enclosed herewith. As you will note, the bilge keel flow data are also enclosed. In the case of the rudders, average flow direction for the mid-height of the rudders was also measured. The speed for the flow measurements was 20 knots with a check at about 18 knots and at about 22 knots. There was little change over this speed range.

The rudder setting for zero angle of attack was almost exactly fore and aft with perhaps a slight toe-in of the trailing edge. The best way to check the rudders is, of course, in a propulsion test. In my experience with destroyer hulls which had the same type of stern, rudders, etc., the angle for minimum SHP is usually about $1\frac{1}{2}^{o}$ to 2^{o} toed in aft. I recommend that such a setting be used on the ferry.

The EHP curves are for bare hull - i.e., no appendages except centerline skeg - and for the hull with all appendages except bilge keels. The estimated increase in EHP due to bilge keels is about 2.5 percent. This assumes keels 30 percent of the length and 18 inches deep.

The model was actually tested with rudders and the estimated rudder resistance subtracted to get the bare hull data. The estimated resistance of shafts and struts was based upon the data for Model 707A, your previous design, and should be good for the present model.

The new hull is substantially better than the others. As you will note, the EHP is slightly less at 20 knots in spite of a considerably greater displacement. This comparison is somewhat affected by the fact that Cap Baier used a slightly

smaller roughness allowance whereas we used a straight 0.0004. The latter is almost the same as Baier's at the top speed. If exactly the same allowance was used in both cases, the new hull could look even better.

I have not had time to analyze the hull and its performance in detail. It appears, however, to be very good. The LCB could be shifted aft a small amount, but the effect would be quite small.

I have to be away a week; when I get back, I will look into this a little further.

We will hold the model until you have time to digest the data. Let us know when you want it. In the meantime, we are in the process of shifting over to the new towing carriage which will take about two weeks. We can go ahead with the other model construction whenever you are ready.

Yours truly,

R. B. Couch

RBC/ss
Encs.

UNIVERSITY OF MICHIGAN
SHIP MODEL TOWING TANK

REPORT OF STILL WATER RESISTANCE TESTS OF A 352-FOOT TWIN SCREW ALASKAN FERRY

for

Philip F. Spaulding and Associates

by

J. L. Moss

University of Michigan
Office of Research Administration

Project Number 04629
July, 1961

Approved:

R. B. Couch, Director

UNIVERSITY OF MICHIGAN
SHIP MODEL TOWING TANK

July 21, 1961

FOR: Philip F. Spaulding and Associates

SHIP: 352-Foot Twin Screw Alaskan Ferry

SHIP PARTICULARS:

LOA	352'-0"	
LWL	326'-0"	
LBP	314'-0"	
B_{LWL}	55 '-6"	
H	15 '-0"	
Δ	3454 L.T.	
Wetted Surface	18,850 Sq.Ft.	(including appendages except bilge keels)
C_B	0.458	
C_X	0.812	
C_P	0.563	
Trial Speed	20 Knots	

APPENDAGES: One Skeg and Two Rudders

MODEL SCALE: 3/8" = 1 Foot

MODEL NUMBER: U of M 934

FRICTION EXTRAPOLATER: 1947 A.T.T.C.

ROUGHNESS ALLOWANCE: $\Delta C_f = 0.0004$

TURBULENCE STIMULATION: 0.036 Inch Diameter Trip Wire
Approximately .05L Aft F.P.

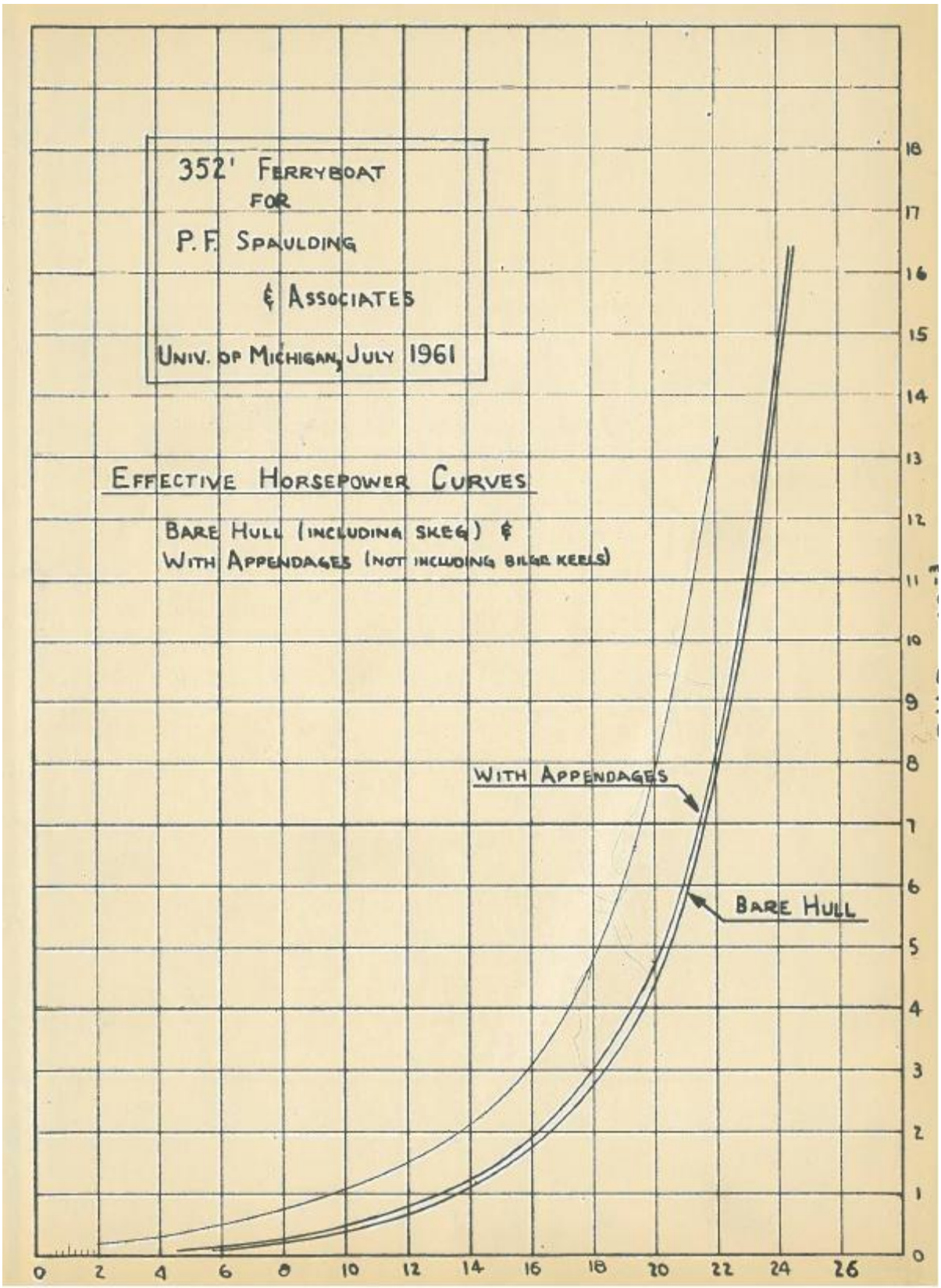
DATA:

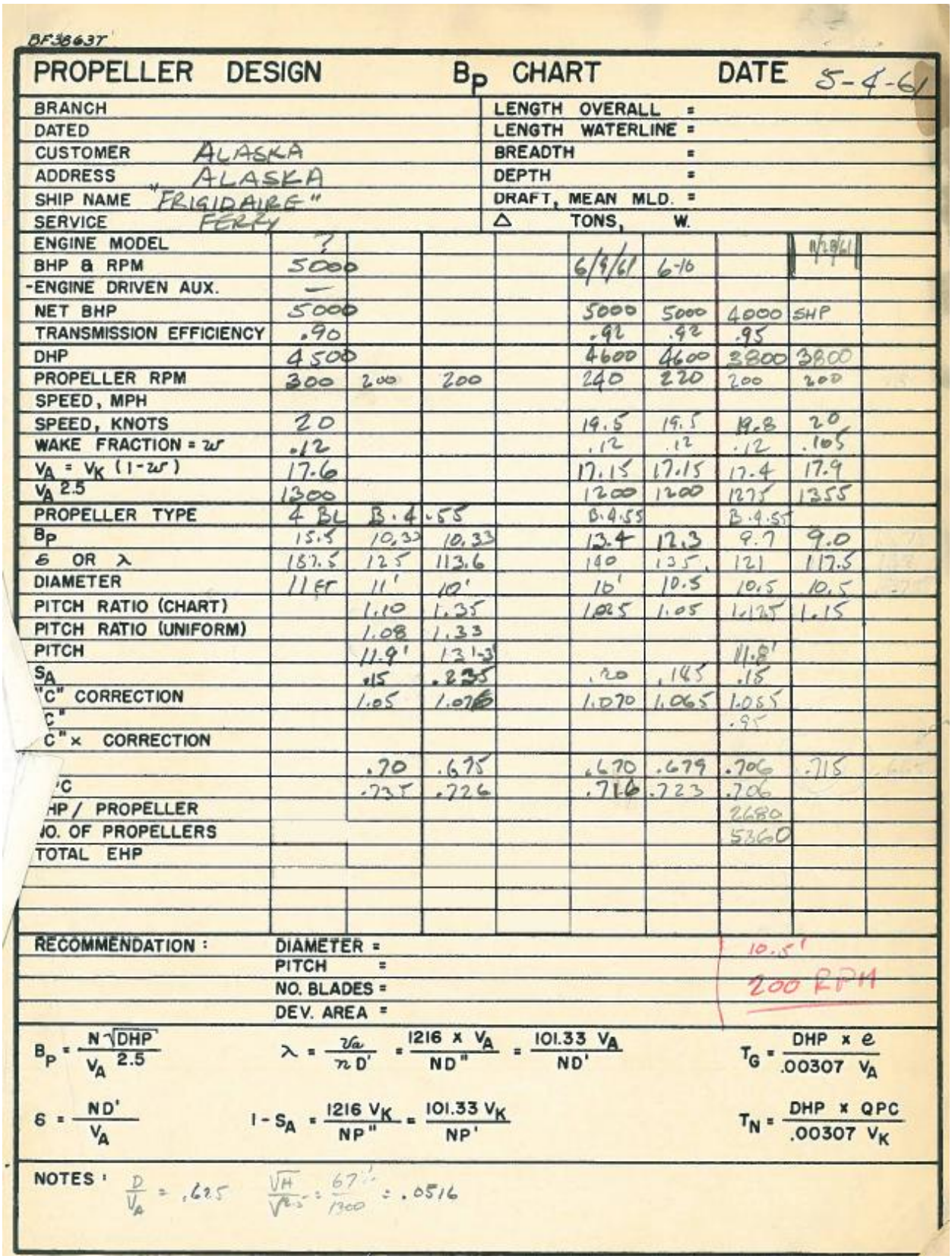
$v/\sqrt{gL}$	V_K KNOTS	EHP BARE (INCL. SKEG)	EHP WITH APPEN. (EXCEPT BILGE KEELS)	* % INCREASE IN EHP FOR BILGE KEELS	EST. SERV. EHP
.100	6	89	111	3.3	143
.132	8	210	252		322
.166	10	414	480		615
.181	11	547	629		806
.198	12	687	776		994
.214	13	874	979		1255
.231	14	1089	1209		1550
.247	15	1386	1525		1953
.264	16	1686	1838		2360
.280	17	2224	2424		3105
.297	18	2784	3007		3860
.313	19	3489	3733		4780
.330	20	4364	4669		5990
.346	21	5652	6048		7750
.363	22	7891	8364		10,730
.379	23	10154	10763		13,800
.396	24	14111	14817	1.3	19,000

* Based on Bilge Keels Approximately 100 Feet Long and 18 Inches Deep.

NOTE: SEA TRIALS OF MALISPINA & TAKU INDICATE "EST. SERV. EHP" IS MORE LIKE "TRIAL EHP" W/ $\bar{H}$ = 14'-11" & 14'-10" RESP. ON 1/10/63 & 3/24/63 Δ = 3525 & 3460 TONS

FULL PWR V. MALI. 19.4 TAKU


352' FERRYBOAT
FOR
P. F. SPAULDING
& ASSOCIATES
UNIV. OF MICHIGAN, JULY 1961
EFFECTIVE HORSEPOWER CURVES
BARE HULL (INCLUDING SKEG) &
WITH APPENDAGES (NOT INCLUDING BILGE KEELS)
WITH APPENDAGES
BARE HULL
0 2 4 6 8 10 12 14 16 18 20 22 24 26
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18



BF-38637

PROPELLER DESIGN — B_P CHART — DATE 5-4-61

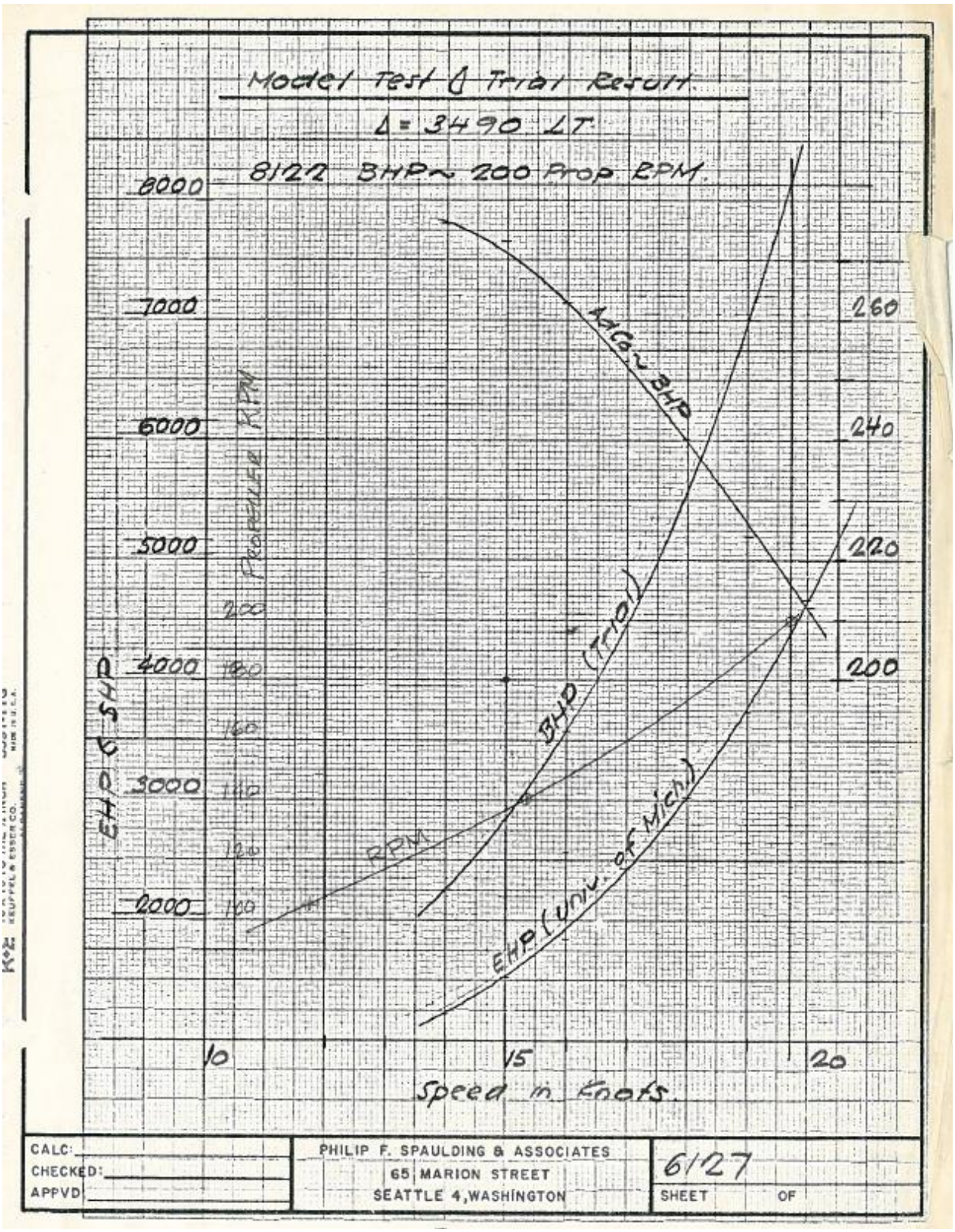
BRANCH					LENGTH OVERALL =				
DATED					LENGTH WATERLINE =				
CUSTOMER ALASKA					BREADTH =				
ADDRESS ALASKA					DEPTH =				
SHIP NAME "FRIGIDAIRE"					DRAFT, MEAN MLD. =				
SERVICE FERRY					△ TONS, W.				
ENGINE MODEL	?							11/29/61	
BHP & RPM	5000				6/9/61	6-16			
-ENGINE DRIVEN AUX.	—								
NET BHP	5000				5000	5000	4000	SHP	
TRANSMISSION EFFICIENCY	.90				.92	.92	.95		
DHP	4500				4600	4600	3800	3800	
PROPELLER RPM	300	200	200		240	220	200	200	
SPEED, MPH									
SPEED, KNOTS	20				19.5	19.5	19.8	20	
WAKE FRACTION = w	.12				.12	.12	.12	.105	
$V_A = V_K (1-w)$	17.6				17.15	17.15	17.4	17.9	
V_A 2.5	1300				1200	1200	1275	1355	
PROPELLER TYPE	4 BL	B.4.55			B.4.55		B.4.55		
B_P	15.5	10.33	10.33		12.4	12.3	9.7	9.0	
δ OR λ	187.5	125	113.6		140	135	121	117.5	
DIAMETER	11 FT	11'	10'		10'	10.5	10.5	10.5	
PITCH RATIO (CHART)		1.10	1.35		1.225	1.05	1.125	1.15	
PITCH RATIO (UNIFORM)		1.08	1.33						
PITCH		11.9'	13.3'				11.8'		
S_A		.15	.235		.20	.145	.18		
"C" CORRECTION		1.05	1.07		1.070	1.065	1.065		
"C"							.95		
"C" × CORRECTION									
		.70	.675		.670	.679	.706	.715	
'C		.735	.726		.716	.723	.706		
HP / PROPELLER							2680		
NO. OF PROPELLERS							5360		
TOTAL EHP									

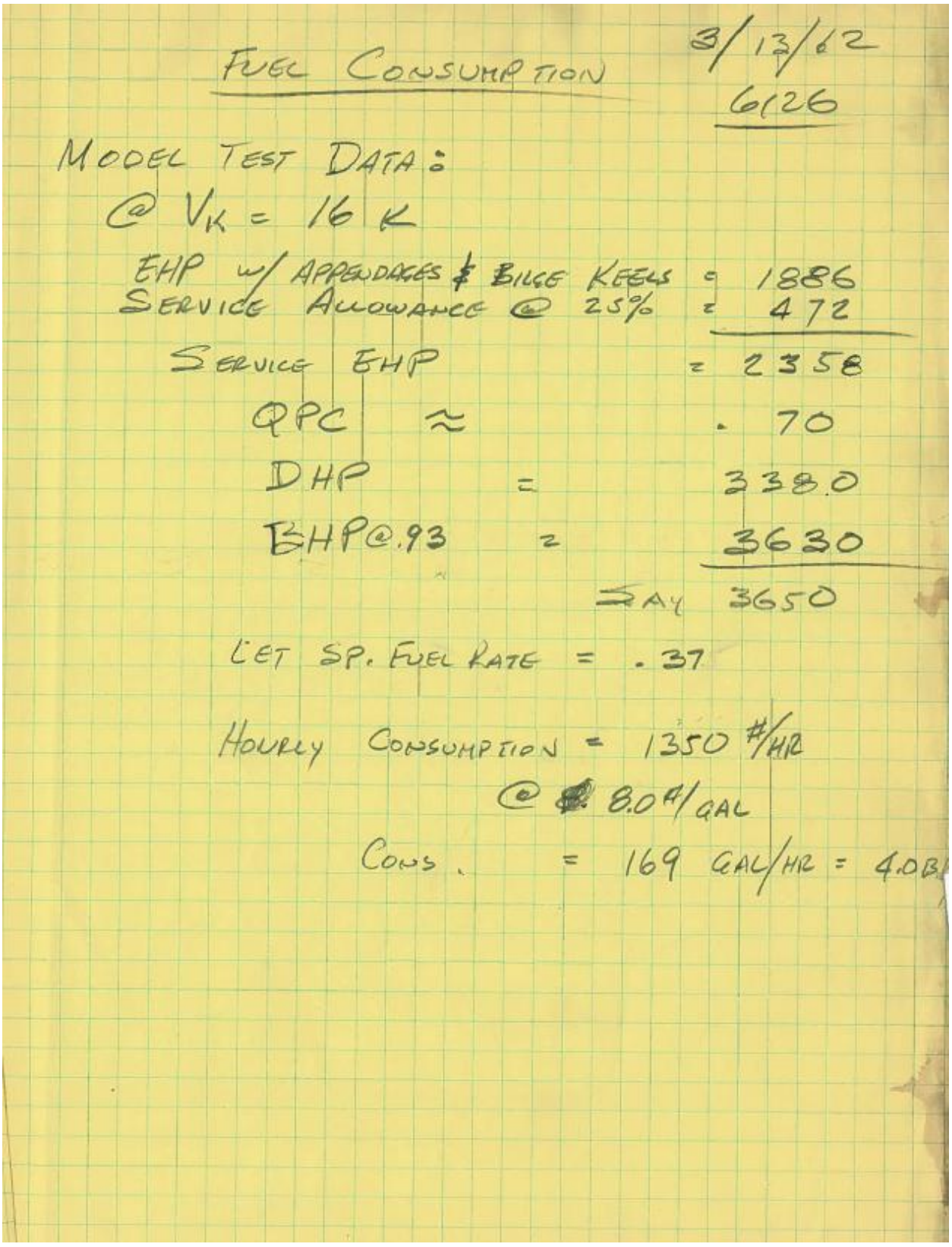
RECOMMENDATION : DIAMETER = 10.5'
PITCH =
NO. BLADES =
DEV. AREA =
200 RPM

$$B_P = \frac{N\sqrt{DHP}}{V_A^{2.5}} \qquad \lambda = \frac{V_a}{n D'} = \frac{1216 \times V_A}{ND''} = \frac{101.33\ V_A}{ND'} \qquad T_G = \frac{DHP \times e}{.00307\ V_A}$$

$$\delta = \frac{ND'}{V_A} \qquad 1 - S_A = \frac{1216\ V_K}{NP''} = \frac{101.33\ V_K}{NP'} \qquad T_N = \frac{DHP \times QPC}{.00307\ V_K}$$

NOTES : $\frac{D}{V_A} = .625$ $\frac{\sqrt{H}}{V_A^{2.5}} = \frac{67}{1300} = .0516$


Model Test & Trial Result
Δ = 3490 LT
8122 BHP ~ 200 Prop RPM
8000
7000
6000
5000
4000
3000
2000
EHP & SHP
Propeller RPM
200
180
160
140
120
100
260
240
220
200
KAG ~ BHP
BHP (Trial)
RPM
EHP (Univ. of Mich.)
10
15
20
Speed in Knots.
CALC:
CHECKED:
APPVD
PHILIP F. SPAULDING & ASSOCIATES
65 MARION STREET
SEATTLE 4, WASHINGTON
6127
SHEET OF



FUEL CONSUMPTION 3/13/62
6(26

MODEL TEST DATA:

@ V_K = 16 K

EHP w/ APPENDAGES & BILGE KEELS	= 1886
SERVICE ALLOWANCE @ 25%	= 472
SERVICE EHP	= 2358
QPC	≈ .70
DHP	= 3380
EHP@.93	= 3630
	SAY 3650

LET SP. FUEL RATE = .37

HOURLY CONSUMPTION = 1350 #/HR

@ 8.0 #/GAL

CONS. = 169 GAL/HR = 4.0B