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SS ESSO SUEZ

STANDARDIZATION TRIAL ANALYSIS

AND

COMPARISON WITH MODEL TEST RESULTS

By

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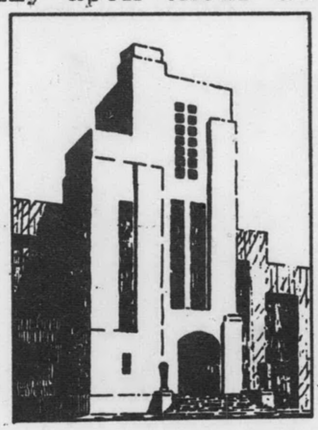

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January 1951 Report No. 750

SS ESSO SUEZ STANDARDIZATION TRIAL
ANALYSIS AND COMPARISON WITH MODEL TEST RESULTS

INTRODUCTION

As a part of the David Taylor Model Basin efforts to obta as much reliable full-scale trial data as practicable for the purpose of improving the accuracy of model test predictions th Newport News Shipbuilding and Dry Dock Company was requested (to permit Taylor Model Basin to observe the trials of the SS ESSO SUEZ. The ESSO SUEZ was the first ship of a 26,000 Ton D single-screw tanker class built by Newport News Shipbuilding a Dry Dock Company for the Standard Oil Company of New Jersey. trials were conducted by the Newport News Shipbuilding and Dry Dock Company on 29 March 1949.

A model of the ESSO SUEZ, 25.5 feet in length, TMB Model No. 4075, was tested self-propelled in the deep water basin of Taylor Model Basin at drafts corresponding as nearly as practi to the trial conditions.

The ship trial data have been analyzed and reduced to sta model basin conditions for comparison with the performance pre- dicted for the ship from the self-propulsion Test No. 6 of Mod 4075 which was corrected to simulate the actual ship particula and trial conditions.

APPARATUS AND METHODS FOR OBSERVING TRIAL DATA

In accordance with the present practices of conducting standardization trials, measurements were made of revolutions per minute, shaft horsepower and speed while traversing a meas mile.

The interval required by the vessel to traverse the measu mile on each run was timed by two observers each equipped with contact maker which electrically operated a stop watch at a co trol panel in the chart house. The average of the two stop wa times was used in calculating the speed of the vessel. The re tions per mile of the propeller shaft were indicated by a Veed Root counter electrically connected to the ships counter syste The revolutions per mile were divided by the elapsed time of t No. 1 observer, who operated this counter, to obtain the revol tions per minute (RPM). The torque in the propeller shaft was measured by a Ford type DTMB Modification III torsionmeter, Fo McNab torsionmeter and a General Electric strain-gage torsionm For the trial data given herein the shaft horsepower (SHP) was

* Numbers in parenthesis indicate reference on page 11.

computed from the average RPM and shaft torque as measured by the David Taylor Model Basin torsionmeter. Relative wind data were recorded for the individual runs with a standard 3-cup anemometer connected to an electrical counter on the control pa The counter was started and stopped by the No. 1 observer. The apparent wind direction was read from a wind direction indicatc mounted at the top of the main mast and read from the bridge de below.

SHIP TRIAL AND MODEL TEST CONDITIONS

The ship was steered by hand over the standardization course. In general rudder angles varied up to about 6 degrees except during the first three (low-speed) runs where they momen ly went as high as 15 degrees.

The principal dimensions and characteristics of the shir and model are given in Table 1. Table 1 also gives information on the conditions prevailing during the standardization trial. Figure 1 is a photograph of the stern of the model as fitted wi the propeller for these tests.

TABLE 1

SHIP AND MODEL CHARACTERISTICS AND TEST CONDITIONS

	SS ESSO SUEZ	MODEL 407'
Length on Waterline (LWL)	612 ft.	25.5 ft.
Max. beam at LWL	82.5 ft.	3.44 ft.
Linear ratio		24.0
Appendages	Rudder, Bilge Keels (Length 167.3 ft)	
No. of Props.	1	1
Model Prop. No.		2999
Prop. Plans *	Newport News SB & DD Co. Plan No. 630-296	C-2999
Des. Prop. Dia.	20 ft.	10 in.
Des. Prop. Pitch at 0.7 Radius	16.83 ft.	8 in. (16 ft. 0 i
Dev. blade area	173 sq. ft.	43.20 sq.
No. of blades	4	4
Direction of Rotation	Right hand	Right hand
P/D	0.8415	0.80
MWR	0.268	0.268
B.T.F.	0.052	0.052
Prop. Area/Disk Area	0.484	0.484

* Ship and model propeller designs have identical characteristics except for the pitch which was greater on the ship.

	SS ESSO SUEZ		SHIP CONDITI FOR MODEL 4075
Trial Course	Delaware Breakwater		--------
Length of Trial Course	6132 ft.		--------
Displacement	34,278 Tons		34,100 Ton
Date of Test	29 Mar 1949		27 May 194
Mean Draft	31 ft. 7-3/8 in.		31.5 ft.
Trim	zero		zero
Wetted Surface	73,730 sq. ft.		73,500 sq.
Days out of Dock	8 days		--------
Depth of Water	135 ft.		528 ft. (Basin depth
Temp. of Water	46° F	**	62° (Basin
Specific Gravity of water	1.026	***	1.00 (Basi
Wind (Beaufort Scale)	Force 0 to 2		zero
Bottom Paint	Red Hand Copper Paint		Enamel on

** Model test predictions have been corrected to a standard temperature of 59° F.

*** Model test predictions have been corrected to standard sea wa specific gravity of 1.028.

SHIP TRIAL ANALYSIS AND COMPARISON WITH PREDICTIONS FROM MODEL TESTS

Three runs were made over the measured mile at each of the approximate RPM's of 70, 90, 102 and 112. Two runs were made over the measured mile at 116 RPM. Elapsed time over the mile, propeller shaft RPM, propeller shaft torque and relative wind direction and velocity were recorded by Newport News Shipbuilding and Dry Dock Company personnel. These data are given in Appendix 1. Appendix 2 contains the information for calculating SHP from torque and RPM.

The data from the full-scale trial have been reduced to standard model basin conditions of zero wind and current by using Eggert's power method as described by Pitrie (3). This method is outlined in some detail in Appendix 3. Appendix 4 contains the corrected data which were used in plotting the ship trial curves.

The resistance test data were converted into EHP values by the use of the Schoenherr coefficients as described in (6). The self-propulsion test data was worked up by the methods outlined in (7). Turbulence was stimulated artificially by a 1/8 inch strut 6 inches ahead of the model to insure that laminar flow conditions did not exist during tests.

Curves of SHP, RPM, true slip, apparent slip and wake fracti for model and ship are presented in Figure 2. The model test, from which the data in Figure 2 was derived, was run at conditions closely corresponding to those of the full-scale trial as shown in Table 1. It should be noted that the model propeller used in this test had a pitch corresponding to a full-scale pitch of 16 ft 0 inches while the ship's propeller had a pitch of 16 ft. 10 inche The predictions from this model test have therefore been corrected by the use of the propeller charts developed by Schöenherr (4), to those which would have been obtained with a propeller of 16 ft. 10 inch pitch. Figure 3 shows the propeller characteristics as obtained from an open-water test for the model propeller as corrected for the change in pitch. In view of the comparatively low propeller RPM and SHP no cavitation tests were made of the model propeller.

It may be noted from Figure 2 that the SHP and RPM results for the ship are consistently lower than those for the model excep for the low speed spot. This discrepancy at low speed was noticed during the trials and all of the elapsed times over the mile were checked and also compared with the times recorded by unofficial observers without finding an error. It is believed that the rather large rudder angles (maximum of 15 degrees) recorded during the runs at this RPM may be partially responsible for the apparent discrepancy in SHP and RPM.

At a speed of 17 knots the SHP for the ship is approximately 9 percent less and the RPM 3 percent less than the corresponding values predicted from the model test. The true slip for the ship is less than the true slip for the model by approximately 1.5 percent. The difference in wake fraction for ship and model is small and is considered to be within the combined accuracies of ship trial and model test predictions.

It is necessary to consider some of the assumptions made in computing the ship data from the model test results when seekin an explanation for the discrepancy between the ship trial results and the model predictions. It is the practice at the Model Basin to use Schoenherr's frictional resistance coefficients for both model and ship with a roughness allowance coefficient added to the ship friction value. The roughness allowance coefficient now used is 0.0004 which is the figure adopted by the American Towing Tank Conference in 1947 pending the availability of further reliable full-scale trial data. On the assumption that the ship propulsive coefficient (PC) is the same as that predicted from the model test the roughness allowance coefficient for the ESSO SUEZ would be 0.00015. Since the ship PC is probably somewhat greater than that obtained from the model test because the RPM and therefore the tru slip is less and the propeller efficiency greater for the ship, th ship EHP is thus relatively greater. On this basis the roughness allowance coefficient obtained from EHP comparisons would be somewhat greater than 0.00015, probably about 0.00020. These results indicate a hull surface on the ESSO SUEZ which is smoother and les resistful than the average found on naval vessels with underwater surfaces painted with hot plastic paint.

Although the roughness allowance indicates a smooth paint surface it should be noted that the roughness allowance is composed of what might be called "built-in-roughness" as well as the paint roughness. The built-in-roughness is a function of the structural design of the hull, the material condition of the shell plating and the shipbuilding procedures. Specifically it is due to the mill scale on the hull plates, the butt and seam rivets, laps or welds, condenser scoops, overboard discharges and other hull excrescences. On the ESSO SUEZ most of the mill scale should have been removed as the plates were pickled before fabrication. Regarding ship construction methods it appears that the underwater surface of the ESSO SUEZ is smoother than that of most naval vessels since there are fewer sea chests and some of the sea chest on this vessel are fitted with doubler plates on the inside of the shell plating which is contrary to the average naval practice. The top and bottom edges of the bilge strakes were lapped and riveted, all other seams and butts being flush welded.

SUMMARY

The trials of the ESSO SUEZ were carefully conducted and the results appear to be consistent except at the lowest speed. It is believed that the SHP and RPM are in error at the lowest speed and that this discrepancy may be explained partially by the large rudder angles required to keep the ship on course during the runs at this speed.

At a speed of 17 knots the SHP for the ship is approximately 9 percent less and the RPM approximately 3 percent less than the corresponding values predicted from the model test.

It appears that the roughness allowance coefficient of 0.0004 adopted for ships by the American Towing Tank Conference (ATTC) in 1947 may be excessive for vessels painted with commercial-type paints, which evidently produce an underwater surface about as smooth as that of Navy type 15 RC paint. Full-scale trials of naval vessels painted with 15 RC indicated that ship values of thrust and SHP were generally less than predicted from model tests based on the 0.0004 roughness allowance coefficient. While some progress has been made in securing paint roughness data from carefully run trials of naval vessels, similar information for commercial-type vessels with commercial paints is very meager.

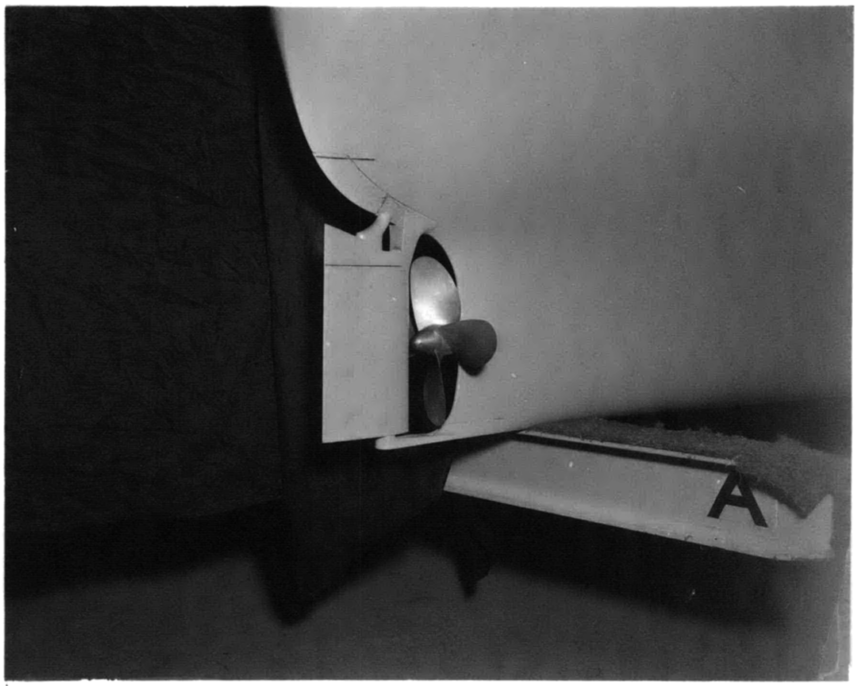

Figure 1 - Stern View of Model 4075
Representing SS ESSO SUEZ

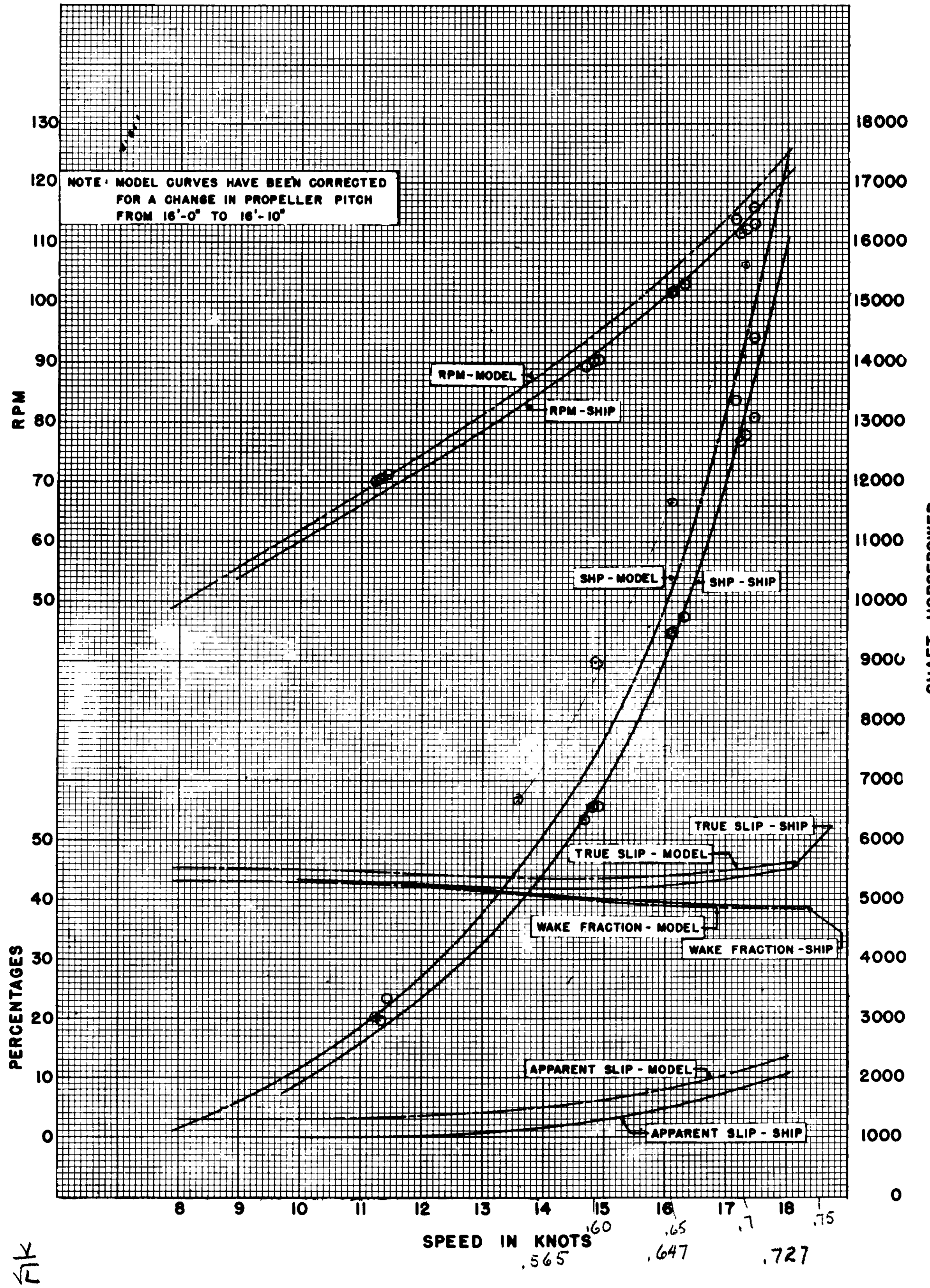

Figure 2 - Trial Results for SS ESSO SUEZ on 29 March 1949 at a Displacement of 34278 Tons, Compared with Self-Propulsion Model Test No. 6

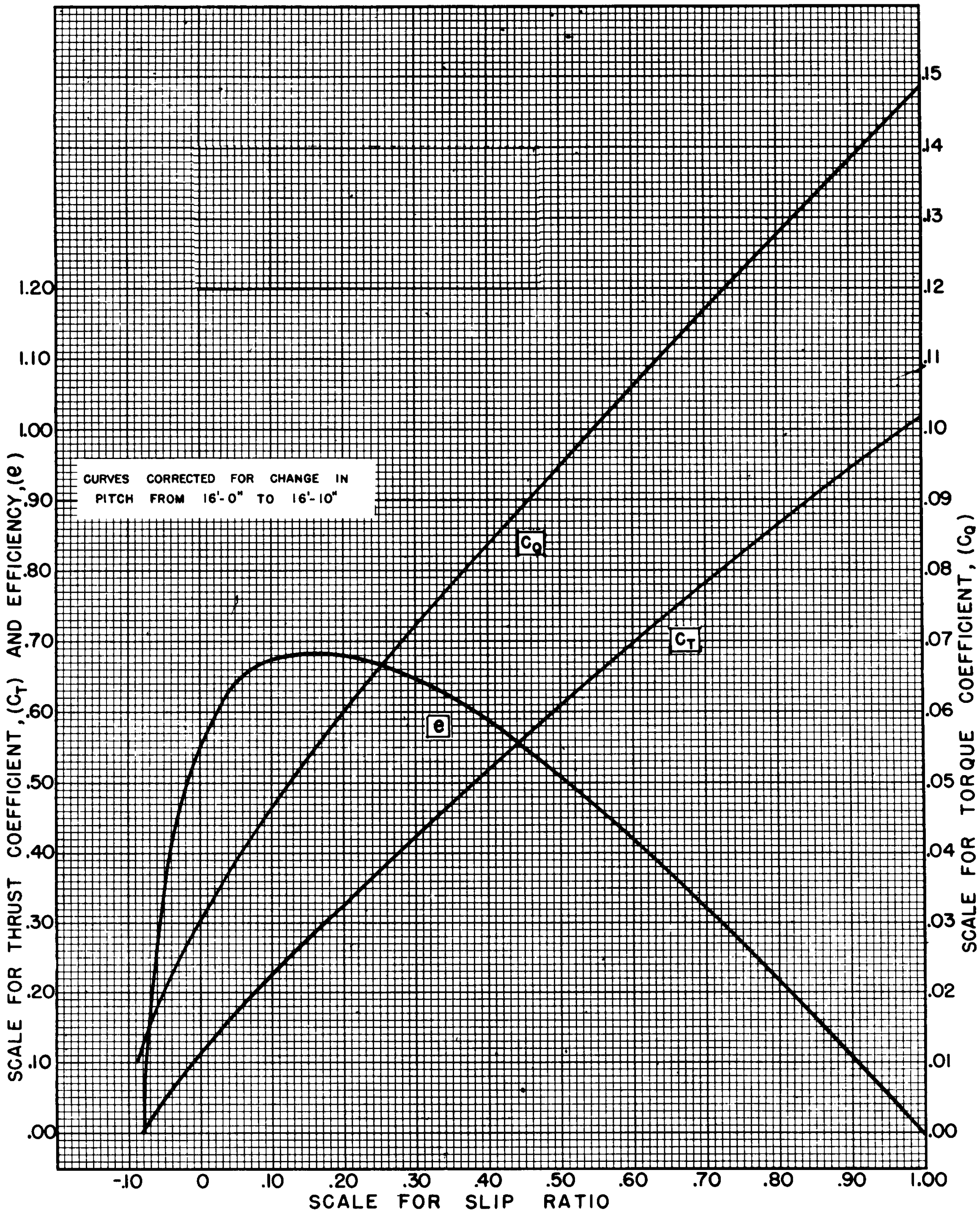

Figure 3 - Propeller Characteristic Curves Derived from Tests with Model Propeller No. 2999

REFERENCES

(1) Telephone conversation of 4 March 1949 between Mr. M. Ireland, Newport News, and Mr. R. B. Couch, DTMB.

(2) DTMB ltr S8/SS ESSO SUEZ of 18 March 1949.

(3) "Trial Analysis Methods," by A. S. Pitrie, Trans. Soc. Naval Arch. Marine Engrs., Vol. 40, 1932.

(4) "Principles of Naval Architecture", by Rossell and Chapman, Vol. II, pp. 160, 161.

(5) "Power Characteristics For The Newport News Shipbuilding and Dry Dock Company's 26,000-Deadweight-Ton Single-Screw Tanker as Predicted From Tests With Model 4075" by Commander P. G. Schultz, USN, DTMB Report No. 653, of June 1948.

(6) "The Prediction of the Effective Horsepower of Ships by Methods in Use at the David Taylor Model Basin" by M. Gertler, DTMB Report No. 576, of December 1947.

(7) "The Prediction of Speed and Power of Ships by Methods in Use at the United States Experimental Model Basin, Washington", by H. E. Saunders, C. and R. Bulletin No. 7, 1932.

Appendix 1

TABLE I

Standardization Data From Trials SS ESSO SUEZ on 29 March 1949

Run Number and Direction	Time at Start of Run LST	Observed Speed V_o Knots	Relative Wind Velocity W_a Knots	Relative Wind Direction	RPM	DTMB Torsionmeter Reading
1S	06-29	9.93	0.8	070	70.59	52.9 *
2N	06-50	12.68	18.7	010	71.25	58.5
3S	07-20	9.74	2.9	355	70.05	53.9
		11.26			70.78	
4N	07-44	16.19	22.2	000	89.34	85.8
5S	08-06	13.35	7.5	000	90.13	86.6
6N	08-28	15.85	20.4	0005	90.65	87.6
		14.69			90.06	
7S	08-51	15.00	9.7	350	101.66	111.1
8N	09-12	16.94	20.4	005	103.02	112.6
9S	09-33	15.60	9.8	355	101.86	111.1
		16.12			102.39	
10N	09-56	17.54	20.3	000	112.17	134.8
11S	10-18	17.35	13.1	010	111.57	134.4
12N	10-42	16.73	19.8	355	113.09	136.6
		17.24			112.10	
13S	11-04	18.51	15.0	005	115.96	146.4
14N	11-37	15.85	27.8	000	113.92	138.6
		17.18			114.94	

* All torsionmeter readings were in the white sector of the torsionmeter

Appendix 2

REDUCTION OF SHAFT TORQUE DATA TO SHAFT HORSEPOWER

The shaft torque data were obtained by three different type torsionmeters; a Ford type DTMB Modification III (Alternating Current) torsionmeter (indicator Number 2045) supplied by DTMB, a Ford McNab D. C. torsionmeter supplied by Newport News Shipbuilding and Dry Dock Company and a General Electric strain-gage type torsionmeter supplied by General Electric Company. The DTMB torsionmeter data were used throughout this report. The section modulus of the shaft was obtained by calibration of a similar shaf from a sister ship, SS ESSO LIMA, at Newport News Shipbuilding and Dry Dock Company. The torsionmeter and shaft constants are given in Table 3.

The torsionmeter zeros were obtained by the so called "drag shaft" method. The shafts were dragged ahead. The average of the drag readings are considered to be the zero readings, see Table 3.

The shaft torque data from the DTMB torsionmeter were converted to SHP by the following method:

$$SHP = \frac{M\,N}{K}$$

where N is the revolutions per minute of the propeller,
M is the average net torsionmeter reading, in drum divisions, taken during the measured mile run,
K is the torsionmeter constant computed at installatio where

$$K = \frac{33{,}000 \times 12 \times 32 \times L \times R}{2\pi^2 D^4 \times E_s \times 0.00025 \times TR}$$

where L is the distance in inches between the clamping rings of the torsionmeter husk,
R is the radius in inches of the husk transformer magnetic pole,
E_s is the modulus of rigidity in pounds per square inch of the propeller shaft,
D is the propeller shaft diameter in inches,
TR is the torsionmeter transformer ratio defined as average husk transformer displacement over average indicator transformer displacement,
0.00025 is the linear movement in inches of the indicator transformer armature for one drum division.

Table 3 gives the values of $\frac{1}{K}$ for the DTMB torsionmeters.

TABLE 3

TORSIONMETER DATA

		DTMB Torsionmeter
Calibration Data:		
	Section Modulus	11,946,000 lbs/in^2
	Shaft Material	Plain carbon steel
	Shaft Diameter	19.752 inches
	Torsionmeter Constant $\frac{1}{K}$	0.88027
Drag Data:		
	Afternoon Drag 28 Mar 49	5.0 White
	Evening Drag 28 Mar 49	5.2 White
	Morning Drag 29 Mar 49	5.4 White
	Average	5.2 White

APPENDIX 3

METHODS OF TRIAL ANALYSIS TO REDUCE DATA TO STANDARD CONDITIONS

1. The trial data were reduced by Eggert's power method as described by Pitrie in (3).

2. The analysis attempts to evaluate the effects of wind and current in order to reduce the data to standard model-basin conditions of zero current and zero air resistance. A description of the analysis as regards speed may be summarized as follows:

a. The wind direction coefficient, k, for the observed apparent wind direction is found from the wind resistance test of a 5-foot model of the SS PENNSYLVANIA. (Since the PENNSYLVANIA is very similar to the ESSO SUEZ the wind correction data can be used with minor error.)

b. The horsepower expended in overcoming the wind resistance is calculated from the formula

$$\Delta EHP = \frac{(R_W \, A \, W_a^2) V_o \, k}{325.7}$$

where R_W is the specific resistance coefficient from a model test (0.00261 from SS PENNSYLVANIA wind tunnel model test),
A is the above-water cross-sectional area of the ship (4230 sq. ft.),
W_a is the relative wind velocity,
V_o is the speed through the water (second mean of the observed speeds for a three-run group),
k is the wind direction coefficient representing the ratio of increase in axial resistance for any angle of attack, based on the axial resistance for zero angle of attack, and $\frac{1}{325.7}$ is a factor to reduce resistance (pounds) multiplied by speed (knots) to EHP.

c. A curve of slope of EHP against speed is plotted. The increase in EHP per knot change in speed, $\frac{\Delta EHP}{\Delta V}$, is read from this curve at the group average speeds.

d. The ΔEHP from Step b is divided by the EHP per knot from Step c, which gives the increment of speed ΔV due to the wind effect.

e. These increments of speed are added (subtracted if k is negative) to the observed speeds V_G over the ground with no air resistance.

f. The speeds V_G, Step e, corrected for wind effect, are sti influenced by the current existing over the trial course during th runs. It has been shown in more detailed papers on trial analysis that if the current varies uniformly, the second mean (weighted average) of the observed speeds in a three-run group at constant RPM is a close approximation to the true speed through the water. Since the RPM varies somewhat over a three-run group, the average RPM for the group is divided by the weighted average V_G to find th average RPM per knot.

g. The RPM for each run is in turn divided by the RPM per knot, Step f, to find the corrected speed through the water V_W.

h. The actual speed through the water, V_{AW}, is the corrected speed through the water, V_W, minus the speed correction ΔV due to the wind.

3. Values of torque coefficient, true slip, apparent slip and wake fraction are determined in the following manner:

a. The observed torque coefficient, C_{Qo}, is calculated from the formula

$$C_{Qo} = \frac{33000 \times 3600 \ SHP_o}{2\pi P^3 D^2 \ N_o^3 \ \partial}$$

where 33000 is a factor to convert SHP to pound feet per second
3600 is a factor to convert RPM to RPS,
∂ is the ratio of density of the water in which the ship trials were conducted to the density of the water in which the model propeller open-water test was run.
P is the pitch of the propeller, in feet,
D is the diameter of the propeller, in feet,
N_o is the RPM of the propeller.

b. Enter the open-water characteristic curves for the model propeller and determine the true slip ratio s_o for the values of C_{Qo}, Step a.

c. The speed of advance for the propeller, V_a, is expressed by the formula

$$V_a = \frac{(1-S_o)\ PN_o}{101.33}$$

where S_o is the observed true slip from Step b.
P and N are as defined in Step a
101.33 is a constant to convert feet per minute to knots

d. The wake fraction w is determined from the formula

$$w = \frac{V_o - V_a}{V_o}$$

where V_o is the weighted average of the observed speeds,
V_a is the weighted average of the speeds of advance.

e. The apparent slip $s_a = 1 - \frac{101.33\ V_w}{P\ N_o}$

where V_w is the corrected speed through water,
P, N_o, 101.33 are the same as in Step 3c, above.

Appendix 4

TABLE 4

Corrected Standardization Data from Trials SS ESSO SUEZ on 29 March 1949

Run Number and Direction	Corrected Speed Through Water (V_W) Knots	Observed RPM (N_o)	SHP DTMB Torsionmeter	Observed True Slip (s_t)	Wake Fraction w	Apparent Slip (s_a)
1S	11.32	70.59	3162			
2N	11.43	71.25	3342			
3S	11.23	70.05	3003			
	11.35	70.78	3162	.422	.436	.042
4N	14.68	89.34	6340			
5S	14.81	90.13	6458			
6N	14.90	90.65	6576			
	14.80	90.06	6458	.419	.423	.017
7S	16.08	101.66	9477			
8N	16.30	103.02	9741			
9S	16.12	101.86	9496			
	16.20	102.39	9614	.426	.336	.052
10N	17.32	112.17	12797			
11S	17.23	111.57	12690			
12N	17.46	113.09	13081			
	17.31	112.10	12815	.438	.335	.074
13S	17.45	115.96	14413			
14N	17.15	113.92	13378			
	17.30	114.94	13896	.442	.321	.100