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THE DAVID W. TAYLOR MODEL BASIN

TENTATIVE ROUGHNESS ALLOWANCES FOR 1942

For Use with the Schoenherr Friction Formula

Sponsored by the American Towing Tank Conference

Naval Tank, University of Michigan, Ann Arbor
National Research Council, Ottawa, Canada
Seaplane Basin, NACA, Langley Field
Hydraulic Laboratory and Ship Model Basin, Newport News
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David W. Taylor Model Basin

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TENTATIVE ROUGHNESS ALLOWANCES FOR 1942 FOR USE WITH THE SCHOENHERR FRICTION FORMULA

The accompanying chart of roughness allowances represents the results to date of a systematic comparison between model tests and ship trial data which has been undertaken by the David W. Taylor Model Basin. It is planned to insert additional results as they become available, to modify or amplify the chart accordingly, and to reissue it periodically. Its initial issue at the present time, for the year 1942, has been deemed advisable because of the increasing use of the Schoenherr formula and because of the increasing necessity for comparing predictions from model tests made in different tanks.

The spots on the chart were obtained by taking the difference between the ship resistance deduced from trial data and the smooth-surface ship resistance derived from the model tests. To eliminate uncertainties as far as possible, only those ships were considered in the analysis for which thrust measurements or the results of full-size towing tests were available. Among them are several old ships, like H.M.S. GREYHOUND, which had hulls that were rougher and more irregular than the hulls of modern ships. The older vessels were included, however, to indicate the influence of the degree of roughness on ship resistance. The line marked "SUGGESTED FOR NEW SHIPS" was drawn arbitrarily through the spots derived from tests on new ships which incorporated the latest improvements in ship bottom construction.

The American Towing Tank Conference suggests that the chart be used as a guide in selecting roughness allowances for individual cases, whenever the Schoenherr friction formula is employed in expanding from model to ship.

The Conference has agreed that, in any case, the friction formula and roughness allowance used will be stated on all reports of test results.

The calculation of ship resistance from model tests takes the following form:

$$R = \frac{\rho}{2} S V^2 \left[\frac{r}{\frac{\rho}{2} s v^2} - (c_f - C_F - \Delta C_F) \right]$$

where

R is the resistance of ship in pounds

ρ is the mass density in pounds per cubic foot divided by g

1.94 for fresh water $\rho/2$ is 0.970

1.99 for salt water $\rho/2$ is 0.995

S is the wetted surface of ship in square feet

V is the speed of ship in feet per second (1 knot = 1.689 f/s)

r is the resistance of model in pounds

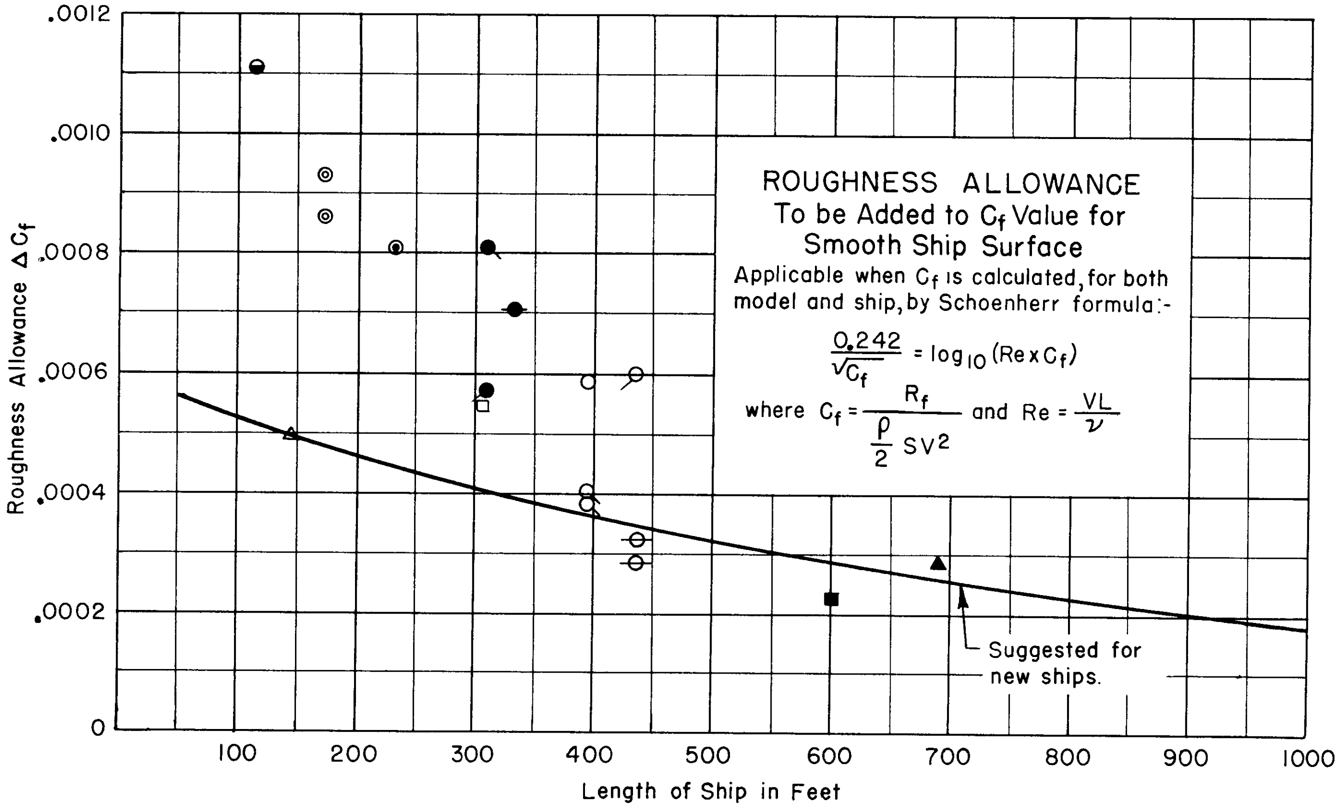
s is the wetted surface of model in square feet

v is the speed of model in feet per second

c_f is the friction coefficient of model, dimensionless, Table 1

C_F is the friction coefficient of ship, dimensionless, Table 1

ΔC_F is the roughness allowance, dimensionless, from the chart.



	Ship	Date of Building	Date of Trial		Ship	Date of Building	Date of Trial
○	S.S. CLAIRTON	1919	1931	●	U.S. DESTROYER HAMILTON	1919	1933
⚲	M.S. SAN FRANCISCO	1924	1934	-●-	U.S. DESTROYER	1934	1935
⚲	S.S. CAPE NEDDICK	1940	1941	■	U.S. CRUISER	1940	1940
-⊖-	S.S. RED JACKET	1939	1939	▲	U.S. AIRPLANE CARRIER	1939	1940
△	U.S. NET LAYER	1941	1941	◎	S.S. GREYHOUND (Towed)	1865	1873
□	U.S. GUN BOAT	1936	1937	⊙	S.S. YUDACHI (Towed)	1906	1928
●	U.S. DESTROYER PRUITT	1920	1920	◒	JAPANESE TUGBOAT (Towed)	-	1930

The double spots for three ships were derived from test data at two displacements.

Table of Schoenherr Friction Coefficients

Formula, $\frac{0.242}{\sqrt{C_f}} = \log_{10} (Re \cdot C_f)$

Values of $c_f \times 10^3$ and $C_F \times 10^3$ for

①	Re = ① x 10^5	Re = ① x 10^6	Re = ① x 10^7	Re = ① x 10^8	Re = ① x 10^9	①	Re = ① x 10^5	Re = ① x 10^6	Re = ① x 10^7	Re = ① x 10^8	Re = ① x 10^9
1.0	7.179	4.410	2.934	2.072	1.531	5.5	4.961	3.241	2.257	1.650	1.252
1.1	7.022	4.331	2.889	2.045	1.513	5.6	4.943	3.231	2.251	1.646	1.250
1.2	6.881	4.258	2.849	2.020	1.497	5.7	4.925	3.221	2.245	1.642	1.247
1.3	6.758	4.193	2.813	1.998	1.482	5.8	4.908	3.212	2.240	1.638	1.244
1.4	6.645	4.135	2.780	1.978	1.469	5.9	4.891	3.202	2.235	1.635	1.242
1.5	6.543	4.083	2.749	1.959	1.457	6.0	4.874	3.193	2.229	1.632	1.240
1.6	6.449	4.035	2.721	1.942	1.446	6.1	4.858	3.184	2.223	1.628	1.238
1.7	6.361	3.990	2.696	1.926	1.436	6.2	4.843	3.176	2.218	1.625	1.236
1.8	6.281	3.948	2.672	1.911	1.426	6.3	4.828	3.167	2.213	1.622	1.234
1.9	6.207	3.909	2.649	1.897	1.416	6.4	4.813	3.159	2.208	1.619	1.231
2.0	6.138	3.878	2.628	1.884	1.408	6.5	4.798	3.151	2.203	1.616	1.229
2.1	6.073	3.838	2.609	1.872	1.400	6.6	4.783	3.143	2.198	1.613	1.227
2.2	6.012	3.804	2.590	1.860	1.392	6.7	4.768	3.135	2.194	1.610	1.225
2.3	5.954	3.773	2.572	1.849	1.385	6.8	4.754	3.127	2.189	1.607	1.223
2.4	5.899	3.745	2.555	1.838	1.378	6.9	4.740	3.120	2.184	1.604	1.221
2.5	5.847	3.719	2.539	1.828	1.371	7.0	4.727	3.112	2.179	1.601	1.219
2.6	5.797	3.693	2.524	1.819	1.365	7.1	4.714	3.104	2.175	1.598	1.217
2.7	5.751	3.668	2.509	1.810	1.359	7.2	4.701	3.097	2.171	1.595	1.215
2.8	5.706	3.644	2.496	1.801	1.353	7.3	4.688	3.090	2.167	1.592	1.213
2.9	5.664	3.622	2.483	1.792	1.348	7.4	4.676	3.083	2.163	1.589	1.212
3.0	5.624	3.600	2.470	1.784	1.343	7.5	4.664	3.077	2.159	1.586	1.210
3.1	5.585	3.580	2.457	1.776	1.338	7.6	4.652	3.069	2.154	1.584	1.208
3.2	5.547	3.560	2.446	1.769	1.333	7.7	4.640	3.062	2.150	1.582	1.206
3.3	5.511	3.542	2.435	1.762	1.328	7.8	4.628	3.056	2.146	1.579	1.204
3.4	5.477	3.523	2.424	1.755	1.323	7.9	4.616	3.049	2.142	1.576	1.203
3.5	5.444	3.504	2.413	1.748	1.319	8.0	4.605	3.043	2.138	1.574	1.201
3.6	5.411	3.487	2.403	1.742	1.315	8.1	4.594	3.037	2.135	1.572	1.200
3.7	5.380	3.471	2.393	1.736	1.310	8.2	4.583	3.031	2.131	1.569	1.198
3.8	5.350	3.455	2.383	1.730	1.306	8.3	4.572	3.025	2.127	1.567	1.196
3.9	5.321	3.439	2.374	1.724	1.302	8.4	4.561	3.019	2.124	1.564	1.195
4.0	5.294	3.423	2.365	1.718	1.299	8.5	4.550	3.013	2.120	1.562	1.193
4.1	5.267	3.408	2.356	1.713	1.295	8.6	4.540	3.007	2.116	1.560	1.192
4.2	5.241	3.394	2.348	1.708	1.291	8.7	4.530	3.002	2.113	1.558	1.190
4.3	5.216	3.380	2.340	1.703	1.288	8.8	4.520	2.996	2.110	1.556	1.189
4.4	5.191	3.366	2.332	1.698	1.284	8.9	4.510	2.991	2.106	1.553	1.187
4.5	5.167	3.353	2.324	1.693	1.281	9.0	4.500	2.986	2.103	1.551	1.186
4.6	5.144	3.341	2.317	1.688	1.278	9.1	4.490	2.980	2.100	1.549	1.184
4.7	5.122	3.329	2.310	1.683	1.275	9.2	4.481	2.975	2.097	1.547	1.183
4.8	5.100	3.317	2.303	1.679	1.272	9.3	4.472	2.969	2.094	1.545	1.181
4.9	5.079	3.305	2.296	1.675	1.269	9.4	4.463	2.964	2.090	1.543	1.180
5.0	5.058	3.294	2.289	1.670	1.266	9.5	4.454	2.959	2.087	1.541	1.179
5.1	5.037	3.283	2.282	1.666	1.263	9.6	4.445	2.954	2.084	1.539	1.178
5.2	5.017	3.272	2.275	1.662	1.260	9.7	4.436	2.949	2.081	1.537	1.176
5.3	4.998	3.261	2.269	1.658	1.258	9.8	4.427	2.944	2.078	1.535	1.175
5.4	4.979	3.251	2.263	1.654	1.255	9.9	4.418	2.939	2.075	1.533	1.173
5.5	4.961	3.241	2.257	1.650	1.252	10.0	4.410	2.934	2.072	1.531	1.172

Reynolds number (usually abbreviated Re) is the length in feet, times the speed in feet per second, divided by the kinematic viscosity (at test temperature for the model, 50° F. for the ship). For table of kinematic viscosities of fresh water and sea water see Trans. Soc. Nav. Arch. and Mar. Engrs. 1939, Vol. 47, page 417.