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5. ITTC- 1978 PERFORMANCE PREDICTION METHOD (COMPUTER CODE)

COMMENTS OF PROPULSION COMMITTEE OF 22nd ITTC
In its original form the ITTC 1978 Performance Prediction Method offers a valuable and reasonably accurate prediction tool for reference purposes and conventional ships.
1978 ITTC Performance Prediction Method

1. PURPOSE OF PROCEDURE

The method predicts rate of revolution and delivered power of a ship from model results.

2. DESCRIPTION OF PROCEDURE

2.1.1 Introduction for the Original 1978 ITTC Performance Prediction Method for Single Screw Ships

The method predicts rate of revolution and delivered power of a ship from model results. The procedure used can be described as follows:

The viscous and the residuary resistance of the ship are calculated from the model resistance tests assuming the form factor to be independent of scale and speed.

The ITTC standard predictions of rate of revolutions and delivered power are obtained from the full scale propeller characteristics. These characteristics have been determined by correcting the model values for drag scale effects according to a simple formula. Individual corrections then give the final predictions.

2.1.2 Introduction for the 1978 ITTC Performance Prediction Method as Modified in 1984 and 1987

The 1978 ITTC Method developed to predict the rate of propeller revolutions and delivered power of a single screw ship from the model test results has been extended during the last two terms of the ITTC for a better and more convenient use of the program. These extensions are summarized as follows.

(1) Inclusion of prediction of propeller revolutions on the basis of power identity.

(2) Temporary measure for $w_{rs} > w_{rm}$

(3) Extension to twin screw ships

(4) Addition of speed trial data

(5) Extension for the case of a stock propeller in the self-propulsion test

(6) Adaptation to the input of the non-dimensional resistance coefficient and self-propulsion factors.

In recent years, many member organizations have been asked by their customers for a general description of the method, viz., model test and analysis of their results, calculation of full-scale power and rate of propeller revolutions, and the model-ship correlation factors used. Considering the above, it was decided to prepare a user's manual of the 1978 ITTC method which includes all of the extensions and modifications made.

2.2 Model Tests

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

In the resistance test the model is towed at speeds giving the same Froude numbers as for the full scale ship, and the total resistance of the model $R_{rs}$ is measured. The computer pro-
gram accepts either $R_{TM}$ in Newton, or in a non-dimensional form of residuary resistance coefficient $C_r$ assuming the form factor $1 + k$. In the latter case, the friction formula used can then be either of the ITTC 1957, Hughes, Prandtl-Schlichting or Schönherr's formulae.

The form factor $1 + k$ is usually determined from the resistance tests at low speed range or by Prohaska’s plot of $C_{ru}$ against $Fn^4$.

The ship model is not in general fitted with bilge keels. In this case the total wetted surface area of them is recorded and their frictional resistance is added in calculating the full-scale resistance of the ship.

In the self-propulsion test the model is towed at speeds giving the same Froude numbers as for the full-scale ship. Generally a towing force $F_D$ is applied to compensate for the difference between the model and the full-scale resistance coefficient.

During the test, propeller thrust ($T_o$), torque ($O_o$) and rate of propeller rotation ($n_o$) are measured.

In many cases, stock propellers are used which are selected in view of the similarity in diameter pitch and blade area to the full-scale propeller. Then the diameter and the open-water characteristics of the stock propeller have to be given as input data in the program. In the open-water test, thrust, torque and rate of revolutions are measured, keeping the rate of revolutions constant whilst the speed of advance is varied so that a loading range of the propeller is examined.

In the case when a stock propeller is used in the self-propulsion test, both the stock propeller and the model similar to the full-scale propeller should be tested in open water.

### 2.3 Analysis of the Model Test Results

Resistance $R_{ru}$ measured in the resistance tests is expressed in the non-dimensional form

$$ C_{TM} = \frac{R_{TM}}{\frac{1}{2} \rho SV^2} $$

This is reduced to residual resistance coefficient $C_r$ by use of form factor $k$,

$$ C_r = C_{ru} - C_{ru} (1 + k) $$

Thrust, $T$, and torque $Q$, measured in the self-propulsion tests are expressed in the non-dimensional forms

$$ K_{TM} = \frac{T}{\rho D^4 n^2} \quad \text{and} \quad K_{QM} = \frac{Q}{\rho D^5 n^2} $$

With $K_{ru}$ as input data, $J_{ru}$ and $K_{wru}$ are read off from the model propeller characteristics, and the wake fraction

$$ w_{TM} = 1 - \frac{J_{TM} D_M}{V} $$

and the relative rotative efficiency

$$ \eta_R = \frac{K_{QTM}}{K_{QM}} $$

are calculated. $V$ is model speed. The thrust deduction is obtained from

$$ t = \frac{T + F_D - R_C}{T} $$
with

\[ F_D = \frac{1}{2} \rho_M S_M V_M^2 \left[ C_{FM} - (C_{FS} + \Delta C_F) \right] \]

where \( R_C \) is the resistance corrected for differences in temperature between resistance and self-propulsion tests:

\[ R_C = \frac{(1 + k)C_{FMC} + C_R}{(1 + k)C_{FM} + C_R} R_{TM} \]

where \( C_{FMC} \) is the frictional resistance coefficient at the temperature of the self-propulsion test.

### 2.4 Full Scale Predictions

#### 2.4.1 Total Resistance of Ship

The total resistance coefficient of a ship without bilge keels is

\[ C_{TS} = (1 + k)C_{FS} + C_R + \Delta C_F + C_{AA} \]

Where

- \( k \) is the form factor determined from the resistance test
- \( C_{FS} \) is the frictional coefficient of the ship according to the ITTC-1957 ship-model correlation line
- \( C_R \) is the residual resistance calculated from the total and frictional coefficients of the model in the resistance tests:
  \[ C_R = C_{TM} - (1 + k)C_{FM} \]
- \( \Delta C_F \) is the roughness allowance

\[ \Delta C_F = \left[ 105 \left( \frac{k_S}{L_{WL}} \right)^3 - 0.64 \right] 10^{-3} \]

where the roughness \( k_S = 150 \cdot 10^{-6} \) m and

- \( C_{AA} \) is the air resistance

\[ C_{AA} = 0.001 \frac{A_T}{S} \]

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

\[ C_{TS} = \frac{S + S_{BK}}{S} \left[(1 + k)C_{FS} + \Delta C_F \right] + C_R + C_{AA} \]

#### 2.4.2 Scale Effect Corrections for Propeller Characteristics.

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

\[ K_{TS} = K_{TM} - \Delta K_T \]

\[ K_{QS} = K_{QM} - \Delta K_Q \]

where

\[ \Delta K_T = -\Delta C_D \cdot 0.3 \cdot \frac{P c Z}{D} \]

\[ \Delta K_Q = -\Delta C_D \cdot 0.25 \cdot \frac{c Z}{D} \]

The difference in drag coefficient \( \Delta C_D \) is

\[ \Delta C_D = C_{DM} - C_{DS} \]

where
\[ C_{DM} = 2 \left( 1 + 2 \frac{t}{c} \right) \left[ 0.04 \left( \frac{1}{R_{nco}} \right) + \frac{5}{(R_{nco})^2} \right] \]

and

\[ C_{DS} = 2 \left( 1 + 2 \frac{t}{c} \right) \left[ 1.89 + 1.62 \log \frac{c}{k_p} \right]^{-2.5} \]

In the formulae listed above, \( c \) is the chord length, \( t \) is the maximum thickness, \( P/D \) is the pitch ratio and \( R_{nco} \) is the local Reynolds number at \( x=0.75 \). The blade roughness \( k_p \) is put \( k_p=30.10^{-6} \text{ m} \). \( R_{nco} \) must not be lower than \( 2.10^5 \) at the open-water test.

### 2.4.3 Full Scale Wake and Operating Condition of Propeller

The full scale wake is calculated from the model wake, \( w_{TS} \), and the thrust deduction, \( t \):

\[ w_{TS} = (t + 0.04) + (w_{TM} - t - 0.04) \left( \frac{1+k}{1+k} \right) C_{PE} + \Delta C_F \left( \frac{(1+k)C_{FM}}{(1+k)C_{FM}} \right) \]

where 0.04 is to take account of rudder effect. The load of the full scale propeller is obtained from

\[ n_s = \frac{(1 - w_{TS}) V_s}{J_{TS} D} \quad (\text{r/s}) \]

- the delivered power:

\[ P_{DS} = 2\pi D^5 n_s^3 \frac{K_{OTS}}{\eta_R} 10^{-3} \quad (\text{kW}) \]

- the thrust of the propeller:

\[ T_s = \frac{K_T}{J^2} J_{TS}^2 \rho D^4 n_s^2 \quad (\text{N}) \]

- the torque of the propeller:

\[ Q_s = \frac{K_{OTS}}{\eta_R} \rho D^5 n_s^2 \quad (\text{Nm}) \]

- the effective power:

\[ P_E = C_{TS} 1/2 \rho V_s^3 S \cdot 10^{-3} \quad (\text{kW}) \]

- the total efficiency:

\[ \eta_D = \frac{P_{DS}}{P_E} \]

- the hull efficiency:

\[ \eta_H = \frac{1-t}{1-w_{TS}} \]

### 2.4.4 Model-Ship Correlation Factors

Trial prediction of rate of revolutions and delivered power with \( C_p - C_n \) corrections

if \( \text{CHOICE}=0 \) the final trial predictions will be calculated from

\[ n_r = C_n n_s \quad (\text{r/s}) \]

for the rate of revolutions and

\[ P_{DS} = C_r P_{DS} \quad (\text{kW}) \]
for the delivered power.

Trial prediction with $\Delta C_{FC} - \Delta w_C$ corrections

If CHOICE=1 the final trial predictions are calculated as follows:

$$K_T = \frac{S}{J^2} \cdot \frac{C_{TS} + \Delta C_{FC}}{2D^3 \left(1 - \frac{1}{J} \right) \left(1 - w_{TS} + \Delta w_C \right)^2}$$

With this $K_T/J^2$ as input value, $J_S$ and $K_{QTS}$ are read off from the full scale propeller characteristics and

$$n_T = \frac{\left(1 - w_{TS} + \Delta w_C \right) V_s}{J_{TS} \cdot D} \quad \text{(r/s)}$$

$$P_{DT} = 2\pi \cdot \rho \cdot D^5 \cdot n_T^3 \cdot \frac{K_{QTS}}{\eta_{RM}} \cdot 10^{-3} \quad \text{(kW)}$$

Trial prediction with $C_{NP}$ correction

If CHOICE = 2 the shaft rate of rotation is predicted on the basis of power identity as follows.

$$\left(\frac{K_Q}{J^3}\right)_T = \frac{1000 \cdot C_P \cdot P_{DS}}{2\pi \cdot \rho \cdot D^3 V_s^3 \left(1 - w_{TS}\right)^3}$$

$$\frac{K_{Q_s}}{J^3} = \left(\frac{K_Q}{J}\right)_T \cdot \eta_{RM}$$

$$n_s = V_s \left(1 - w_{TS}\right) / J_{TS} \cdot D$$

$$n_T = C_{NP} n_s$$

2.5 Analysis of Speed Trial Results

The analysis of trials data is performed in a way consistent with performance prediction but starting $P_s$ and $n$ backwards, i.e. from

$$K_Q = \frac{P_D}{2\pi \cdot \rho \cdot D^5 \cdot n^3 \cdot \eta_{RM}} \cdot 10^3$$

$J_r$ is obtained from the full-scale open-water characteristics $K_Q \approx J_r$ then

$$w_T = 1 - J_s \cdot n \cdot D / V$$

Further from $K_r \approx J_r$ characteristics

$$T = K_r \cdot \rho \cdot n^2 \cdot D^4$$

$$C_T = \frac{T \left(1 - \frac{1}{T}\right)}{1 - \rho \cdot V^2 \cdot S}$$

Then we obtain

$$\Delta C_{FC} = C_T - C_{TS}$$

$$\Delta w_C = w_{TS} - w_T$$

2.6 Input Data

- Input data sheets are given in ENCL.1

2.7 Output Data

- Output data I gives ITTC Standard Prediction with $C_r = C_T = 1.0$, together with model and full scale propulsive coefficients (ENCL. 4).
- Output data II gives the final ship prediction (ENCL. 5).
- Output data III gives the analysis of the speed trial results (ENCL. 6).

2.8 Test Example

To illustrate the program a prediction was made for a hypothetical ship with the following particulars:
length between perpendicul"ors Lpp = 251.5m
breath B = 41.5m
draft T = 16.5m

propeller diameter D = 8.2m

Calculations were carried out with the ITTC Trial Prediction Test Program with:

C_p = 1.01
C_N = 1.02

The input data were taken as shown in ENCL. 1 and the printout of the input data and results are given in ENCL. 4 - 6.
# Performance, Propulsion

## 1978 ITTC Performance Prediction Method

### Effective Date
- 1999

### Revision
- 00

---

**TABLE 1**

**Scale Factors**

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<tr>
<th>Project</th>
<th>Self Model</th>
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**Input Data**


**Stock Profile Characteristics**

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<th>Characteristics</th>
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**Propeller**

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<th>Pitch Ratio</th>
<th>Thrust</th>
<th>Torque</th>
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**Performance Data**

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<th>propulsive (kW)</th>
<th>propulsion (kW)</th>
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**Model Data**

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<td>Height</td>
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**Propeller Details**

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<th>Propeller</th>
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<th>Pitch (m)</th>
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**Conclusion**

The 1978 ITTC Performance Prediction Method provides a comprehensive approach to predicting the performance of single screw ships, considering various factors such as scale factors, input data, and model specifications. This method has been updated and modified since its initial release in 1984 and 1987, ensuring its relevance and accuracy in modern maritime engineering.
# 1978 ITTC Performance Prediction Method

**METHOD FOR SINGLE SCREW SHIPS (REVISED IN 1983)**

## Trial Analysis

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<td>Ship Model:</td>
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<td>Propeller Model</td>
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<td>Scale Factor:</td>
<td>37.00</td>
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<tr>
<td>Propeller:</td>
<td></td>
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</table>

- **Number of Propellers:** 1
- **Number of Blades:** 5
- **Diameter:** 8.200 (m) calculated according to ITTC-57
- **Pitch Ratio 0.75R:** 0.7600
- **Form Factor:** 0.250 (based on ITTC-57)
- **Friction Coefficient CF:**

## Trial Analysis According to ITTC 1979 Method

<table>
<thead>
<tr>
<th>Prop. RPM - Trial</th>
<th>15.00</th>
<th>17.00</th>
<th>19.00</th>
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<tr>
<td>Deliv. Power - Trial</td>
<td>11444.</td>
<td>26766.</td>
<td>44613.</td>
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</table>

| Prop. RPM - CN=1 | 81.00 | 93.39 | 109.37 |
| Deliv. Power - CP = 1 | 17271. | 26502. | 44174. |
| Prop. RPM - CNP=1 | 81.70 | 93.78 | 109.71 |

| CP | 1.010 | 1.010 | 1.010 |
| CN | 1.020 | 1.020 | 1.020 |
| CNP | 1.016 | 1.016 | 1.017 |

| DCFC + 1000 CP=CN=1 | -0.052 | -0.054 | -0.071 |
| DCFC + 1000 CP=CN=1 | 0.048 | 0.050 | 0.054 |

| DCF + 1000 ITTC-57 | 0.200 | 0.200 | 0.200 |
| DW = WM - WTRIAL | 0.096 | 0.087 | 0.103 |

| CR = 1000 | 0.042 | 0.207 | 0.644 |
| THOM | 0.211 | 0.230 | 0.209 |
| WTM | 0.352 | 0.347 | 0.353 |
| WTS CP=CN=1 | 0.304 | 0.311 | 0.304 |
| WTS Trial | 0.256 | 0.260 | 0.250 |
| ETARM | 0.950 | 1.004 | 0.999 |
### ITTC – Recommended Procedures

#### Performance, Propulsion

1978 ITTC Performance Prediction Method

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<th>Effective Date</th>
<th>Revision</th>
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<td>SCALE FACTOR</td>
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**PROPELLER:**

- NUMBER OF PROPELLERS: 1
- NUMBER OF BLADES: 5
- DIAMETER: 8.200 m
- PITCH RATIO: 0.75
- FORM FACTOR: 0.7600
- DISTANCE: 0 (M=2)
- DISPLACEMENT: 142000 m³

**1978 ITTC PERFORMANCE PREDICTION METHOD FOR SINGLE SCREW SHIPS**

Encl: 4

**OUTPUT DATA:**

**1978 ITTC STANDARD PREDICTION CP=CN=1.0:**

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<th>DELIV</th>
<th>POWER</th>
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**SPEED TOTAL EFFECTIVE, PROPELLER EFFECTIVE, HULL EFFECTIVE, SHIP WAKE OPEN WATER CHARACTERISTIC FULL SCALE:**

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<th>KNOTS</th>
<th>ETAD</th>
<th>ETAH</th>
<th>ETAH</th>
<th>WTS</th>
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<tr>
<td>20.0</td>
<td>0.616</td>
<td>0.546</td>
<td>1.122</td>
<td>0.321</td>
<td>0.500</td>
<td>1.566</td>
<td>2.055</td>
<td>0</td>
</tr>
</tbody>
</table>
### 1978 ITTC PERFORMANCE PREDICTION METHOD FOR SINGLE SCREW SHIPS

**IDENTIFICATION:**

**SHIP:**

- **PROJECT:** 123
- **SHIP MODEL:** M-4567
- **PROPeller MODEL:** P-89
- **SCALE FACTOR:** 37.00
- **LENGTH PP:** 251.50 (M)
- **LENGTH WL:** 260.00 (M)
- **DRAFT AFT:** 16.50 (M)
- **DRAFT AHEAD:** 16.50 (M)
- **BREADTH:** 41.50 (M)
- **WETTED SURFACE:** 16400. (M**2**)
- **DISPLACEMENT:** 14200G. (M**3**)

**NUMBER OF PROPellers:** 1
**NUMBER OF BLADES:** 5

**DIAmeter:** 8.200 (M)
**PITCH RATIO 0.75R:** 0.7600
**FRICTION COEFFICIENT OF FORM FACTOR:** 0.250 (BASED ON ITTC-57)

**SHIP TRIALS PREDICTION**

<table>
<thead>
<tr>
<th>SPEED (KNOTS)</th>
<th>DELIVERED POWER (KW)</th>
<th>DELIVERED POWER (HP)</th>
<th>RATE OF REV. (RPS)</th>
<th>RPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.0</td>
<td>10241</td>
<td>13927</td>
<td>1.281</td>
<td>76.88</td>
</tr>
<tr>
<td>15.0</td>
<td>12826</td>
<td>17444</td>
<td>1.377</td>
<td>82.62</td>
</tr>
<tr>
<td>16.0</td>
<td>15865</td>
<td>21576</td>
<td>1.477</td>
<td>88.65</td>
</tr>
<tr>
<td>17.0</td>
<td>19881</td>
<td>26766</td>
<td>1.568</td>
<td>95.26</td>
</tr>
<tr>
<td>18.0</td>
<td>2495A</td>
<td>33937</td>
<td>1.714</td>
<td>102.87</td>
</tr>
<tr>
<td>19.0</td>
<td>3280A</td>
<td>44613</td>
<td>1.859</td>
<td>111.55</td>
</tr>
<tr>
<td>20.0</td>
<td>4297B</td>
<td>59201</td>
<td>2.026</td>
<td>121.54</td>
</tr>
</tbody>
</table>
3. PARAMETERS

3.1 Parameters to be Taken into Account

Froude scaling law
ship-model correlation line, friction line
kinematic viscosity
mass density
blockage
form factor
propeller loading
hull roughness

see also 3.3 Input Data

3.2 Recommendations of ITTC for Parameters

see 4.9-03-03-01.1 Propulsion Test

1987 p.263 In using the 1978 ITTC Method it is recommended that the rudder(s) be fitted in hull resistance experiments for barge type forms where inflow velocity is relatively large.

3.3 Input Data

All data are either non-dimensional or given in SI-units.

Every data card defines several parameters which are required by the program; each of these parameters must be input according to a specific format.

"I" format means that the value is to be input without a decimal point and packed to the right of the specified field.

"F" format requires the data to be input with a decimal point; the number can appear anywhere in the field indicated.

"A" format indicates that alphanumeric characters must be entered in the appropriate card columns.

The card order of the data deck must follow the order in which they are described below.

Card No. 1 Identifications

<table>
<thead>
<tr>
<th>Card column</th>
<th>Format</th>
<th>CC Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-8</td>
<td>A</td>
<td></td>
<td>Project No.</td>
</tr>
<tr>
<td>9-16</td>
<td>A</td>
<td></td>
<td>Ship model No</td>
</tr>
<tr>
<td>17-24</td>
<td>A</td>
<td></td>
<td>Propeller model No.</td>
</tr>
<tr>
<td>25-32</td>
<td>F</td>
<td>SCALE</td>
<td>Scale ratio</td>
</tr>
</tbody>
</table>

Card No. 2 Ship particulars

<table>
<thead>
<tr>
<th>Card column</th>
<th>Format</th>
<th>CC Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-16</td>
<td>F</td>
<td>LWL</td>
<td>Length of waterline</td>
</tr>
<tr>
<td>17-24</td>
<td>F</td>
<td>TF</td>
<td>Draft, forward</td>
</tr>
<tr>
<td>25-32</td>
<td>F</td>
<td>TA</td>
<td>Draft, aft</td>
</tr>
<tr>
<td>33-40</td>
<td>F</td>
<td>B</td>
<td>Breadth</td>
</tr>
<tr>
<td>41-48</td>
<td>F</td>
<td>S</td>
<td>Wetted surface, without bilge keels</td>
</tr>
<tr>
<td>49-56</td>
<td>F</td>
<td>DISW</td>
<td>Displacement</td>
</tr>
<tr>
<td>157-64</td>
<td>F</td>
<td>SBK</td>
<td>Wetted surface of bilge keels</td>
</tr>
<tr>
<td>65-72</td>
<td>F</td>
<td>AT</td>
<td>Transverse projected area of ship above waterline</td>
</tr>
<tr>
<td>72-80</td>
<td>F</td>
<td>C3</td>
<td>Form factor determined at resistance tests</td>
</tr>
</tbody>
</table>
Card No. 3 Particulars of full scale

<table>
<thead>
<tr>
<th>Card column</th>
<th>Format</th>
<th>CC Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-8</td>
<td>I</td>
<td>NOPROP</td>
<td>Number of propellers should be 1 since method is valid only for single screw ships</td>
</tr>
<tr>
<td>15-16</td>
<td>I</td>
<td>NPB</td>
<td>Number of propeller blades</td>
</tr>
<tr>
<td>17-24</td>
<td>F</td>
<td>DP</td>
<td>Diameter of propeller</td>
</tr>
<tr>
<td>25-32</td>
<td>F</td>
<td>PD075</td>
<td>Pitch ratio at x=0.75</td>
</tr>
<tr>
<td>33-40</td>
<td>F</td>
<td>CH075</td>
<td>Chord length of Propeller blade at x=0.75</td>
</tr>
<tr>
<td>41-48</td>
<td>F</td>
<td>TMO75</td>
<td>Maximum blade thickness of propeller at x=0.75</td>
</tr>
<tr>
<td>49-56</td>
<td>F</td>
<td>RNCHM</td>
<td>Reynolds number at open-water test based on chord length and local velocity $v_{x0.75}$ at x=0.75.</td>
</tr>
</tbody>
</table>

Card No. 4 General

<table>
<thead>
<tr>
<th>Card column</th>
<th>Format</th>
<th>CC Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.-4</td>
<td>I</td>
<td>NOJ</td>
<td>Number of J-values in the open-water characteristics (J ≤ NOJ ≤ 10)</td>
</tr>
<tr>
<td>7-8</td>
<td>I</td>
<td>NOSP</td>
<td>Number of speeds in the self-propulsion tests (NOSPmax=10)</td>
</tr>
<tr>
<td>9-16</td>
<td>F</td>
<td>RHOM</td>
<td>Density of tank water</td>
</tr>
<tr>
<td>17-24</td>
<td>F</td>
<td>RHOS</td>
<td>Density of sea water</td>
</tr>
<tr>
<td>25-30</td>
<td>F</td>
<td>TEMM</td>
<td>Temperature of resistance test</td>
</tr>
<tr>
<td>31-36</td>
<td>F</td>
<td>TEMP</td>
<td>Temperature at self-propulsion test -</td>
</tr>
<tr>
<td>36-41</td>
<td>F</td>
<td>TEMS</td>
<td>Temperature of sea water</td>
</tr>
<tr>
<td>48-48</td>
<td>I</td>
<td>CHOICE</td>
<td>CHOICE=0 $C_p - C_{Np}$ trial corr. CHOICE=1: $\Delta C_{FC} - \Delta w_{FC}$ trial corr.</td>
</tr>
<tr>
<td>49-56</td>
<td>F</td>
<td>CP</td>
<td>Trial correction for shaft power.</td>
</tr>
<tr>
<td>57-64</td>
<td>F</td>
<td>CN</td>
<td>Trial correction for rpm</td>
</tr>
<tr>
<td>65-72</td>
<td>F</td>
<td>DELT CFC</td>
<td>Trial correction for $\Delta C_F$</td>
</tr>
<tr>
<td>72-80</td>
<td>F</td>
<td>DELTWC</td>
<td>Trial correction for $\Delta w$</td>
</tr>
</tbody>
</table>

Mean values of the trial correction figures, $C_p$ and $C_N$, can be obtained from the trial test material of the individual institutions by running the ITTC Trial Prediction Test Program. If an institution wishes to give predictions with a certain margin the input $C_p-C_N$-values must be somewhat higher than these mean values.

Cards Nos. 5-14 Result of resistance and self-propulsion tests and model propeller characteristics.

<table>
<thead>
<tr>
<th>Card column</th>
<th>Format</th>
<th>CC Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-8</td>
<td>F</td>
<td>VS</td>
<td>Ship speed in knots</td>
</tr>
<tr>
<td>9-16</td>
<td>F</td>
<td>RTM</td>
<td>Resistance of ship model</td>
</tr>
<tr>
<td>17-24</td>
<td>F</td>
<td>THM</td>
<td>Thrust of propeller</td>
</tr>
<tr>
<td>25-32</td>
<td>F</td>
<td>QM</td>
<td>Torque of propeller $Q_{M1.0}$</td>
</tr>
<tr>
<td>33-40</td>
<td>F</td>
<td>NM</td>
<td>Rate of revolution</td>
</tr>
<tr>
<td>41-48</td>
<td>F</td>
<td>FD</td>
<td>Skin friction correction force</td>
</tr>
<tr>
<td>49-56</td>
<td>F</td>
<td>ADVC</td>
<td>Advance coefficient, open water</td>
</tr>
<tr>
<td>57-64</td>
<td>F</td>
<td>KT</td>
<td>Thrust coefficient, open water</td>
</tr>
<tr>
<td>65-72</td>
<td>F</td>
<td>KQ</td>
<td>Torque coefficient, open water</td>
</tr>
</tbody>
</table>

The J-margin in the open-water characteristics must be large enough to cover the model and full scale J-values with some margin.

Input data sheets are given in ENCL. 1.
4. VALIDATION

4.1 Uncertainty Analysis
not yet available

4.2 Comparison With Full Scale Results

The data that led to the ITTC-78 method can be found in the following ITTC proceedings:

1) Proposed Performance Prediction Factors for Single Screw Ocean Going Ships
   (13th 1972 pp.155-180) Empirical Power Prediction Factor (1+X)

2) Propeller Dynamics Comparative Tests
   (13th 1972 pp.445-446)

3) Comparative Calculations with the ITTC Trial Prediction Test Programme
   (14th 1975 Vol.3 pp.548-553)

4) Factors Affecting Model Ship Correlation
   (17th 1984 Vol. 1, pp274-291)
5. ITTC-1978 PERFORMANCE PREDICTION METHOD (COMPUTER CODE)

C
C *****************************************************************************************************************************************
C  *  1978 ITTC PERFORMANCE PREDICTION METHOD FOR SINGLE SCREW SHIPS*
C  * (REVISED 1983 TO INCLUDE TRIAL ANALYSIS AND TWIN SCREW SHIPS) *
C  ********************************************************************************
C
C DECLARATIONS
C
COMMON /A/ FILE(2), MODELS(2), MODELPI(2), LPP, LWL, TF, TA, B, S,
*     SCALE, RNCHM, DISW, NOPROP, NP, DP, PD075, CH075,
*     TM075, C3, SB, AT, CP, CN, DELCF, DELWC, KSI, KPI,
*     RHOM, RHOS, TEM, TEMS, VS(10), RTM(10), THM(10),
*     QM(10), NM(10), ADV(10), KT(10), KQ(10), THD(10),
*     FD(10), IC, NOJ, NOSP, PI
C
COMMON /B/ ETM(10), ETA0(10), ETAH(10), ETAD(10), AWTM(10),
*     AWT(10), ACFM(10), ACTM(10), AVS(10), AVM(10),
*     ATO(10), AQS(10), APDS(10), APE(10), APDT(10),
*     ANS(10), ANT(10), BPT(10), BNT(10), KT(10), KT(10),
*     KQ(10), KT(10), ACTS(10)
DIMENSION FILE1(2), MODELS1(2), MODELPI1(2)
C
REAL     LPP, LWL, KS1, KS, KP1, KP, NM1, NM, KT, KQ, KTM, KQ0, JTM,
*     KT(10), JTS, NS, KQS, KTS, KQ, KTM
DATA     TRIAL /'TRIA'/
500 FORMAT(6A4,F8.0)
501 FORMAT(10F8.0)
502 FORMAT(2I4,9F8.0)
503 FORMAT(2I4,2F8.0,3F6.0,16,4F8.0)
504 FORMAT(9F8.0)
600 FORMAT(5X, 'NUMBER OF ADV, KT AND KQ POINTS =',15/
*     5X, 'NUMBER OF SPEEDS =',15/
*     5X, 'NUMBER OF SPEEDS OR ADV POINTS =',15/)
C CONSTANTS
G=9.81
PI=3.14159
KP1=30.0
KS1=150.0
KS=1.5E-4
KP=0.3E-4
C READ INPUT DATA
C
1000 CONTINUE
READ(5,500,END=999) FILE,MODELS,MODEL,P,SCALE
READ(5,501) LPP,LWL,TF,TA,B,S,DISW,SBK,AT,C3
READ(5,502) NOPROP,NPB,DP,PD075,CH075,TM075,RNCHM
READ(5,503) NOJ,NOSP,RHOM,RHOS,TEMM,TEMP,TEMS
  * IC,CP,CN,DELCF,DELWC
NMAX=MAX0(NOJ,NOSP)
IF(FILE(1).EQ.TRIAL) GOTO 100
READ(5,504)(VS(I),RTM(I),THM(I),QM(I),NM(I),FD(I),
  * ADVC(I),KT(I),KQ(I);I=1,NMAX)
C WRITE INPUT DATA
C CALL OUTPUT(1)
C CHECK
C
IF(NOJ.LE.10.AND.NOSP.LE.10) GOTO 2
WRITE(6,600) NOJ,NOSP
GOTO 1000
2 CONTINUE
C  RECALCULATION OF INPUT DATA
C
DO 3 I=1,NOJ
KT(I)=KT(I)*0.1
KQ(I)=KQ(I)*0.01
....3 CONTINUE
DELCF=DELCF*0.001
RNCHM=RNCHM*100000.
VISCP=((0.585E-3*(TEMP-12.0)-0.03361)*(TEMP-12.0)+
* 1.2350)*1.0E-6
VISCM=((0.585E-3*(TEMM-12.0)-0.0361)*(TEMM-12.0)+
* 1.2350)*1.0E-6
VISCS=((0.659E-3*(TEMS-1.0)-0.05076)*(TEMS-1.0)+
* 1.7688)*1.0E-6
C  CORRECTION OF PROPELLER CHARACTERISTICS
C
CDM=2.0*(1.0+2.0*TM075/CH075)*(0.044/RNCHM**0.16667-
* 5.0/RNCHM**0.66667)
CDS=2.0*(1.0+2.0*TM075/CH075)/(1.89+1.62*A ALOG10(CH075
* /KP))**2.5
DCD=CDM-CDS
DKT=-0.3*DCD*PD075*CH075*NPB/DP
DKQ=0.25*DCD*CH075*NPB/DP
DO 4 I=1,NOJ
KTS(I)=KT(I)-DKT
KQS(I)=KQ(I)-DKQ
KTSJ2(I)=KTS(I)/ADVC(I)**2
4 CONTINUE
DO 5 I=1,NOSP
VS1=VS(I)*0.15444
VM1=VS1/SQRT(SCALE)
NM1=NM(I)
C CALCULATE ROUGHNESS ALLOWANCE AND SHIP TOTAL RESISTANCE
C
RNLP=LWL*VM1/(VISCP*SCALE)
RNLM=LWL*VM1/(VISCM*SCALE)
RNLS=LWL*VS1/VISCS
CFMC=0.075/(ALOG10(RNLP)-2)**2
CFM=0.075/(ALOG10(RNLM)-2)**2
CFS=0.075/(ALOG10(RNLS)-2)**2
CTM=RTM(I)*SCALE**3/(0.5*RHOM*VS1**2*S)
CR=CTM-(1.0+C3)*CFM
RTMC=RTM(I)*(1.0+C3)*CFMC+CR)/((1.0+C3)*CFM+CR)
THD(I)=(THM(I)+FD(I)-RTMC)/THM(I)
DELCF=(105.0*(KS/LWL)**0.33333-0.64)*0.001
CAA=0.001*AT/S
CTS=((1.0+C3)*CFS*DELCF)*(S+SBK)/S+CR+CAA
C MODEL PROPULSIVE COEFFICIENTS
C
FNOP=NPROP
KTM=(THM(I)/FNOP)/(RHOM*(DP/SCALE)**4*NM1*NM1)
KQM=(QM(I)*0.01/FNOP)/(RHOM*(DP/SCALE)**5*NM1*NM1)
JTM=APOL(0,KT,ADVC,NOJ,KTM,IX)
KQ0=APOL(0,ADVC,KQ,NOJ,JTM,IX)
WTM=1.0-JTM*DP*NM1/(VM1*SCALE)
C FULL SCALE WAKE
C
IF(JRUDER) 6,5,6
5 WTS=(THD(I)+0.04)+(WTM-THD(I)-0.04)*((1.0+C3)*CFS+DELCF)/
* ((1.0+C3)*CFM)
GOTO 7
6 WTS=(THD(I) )+(WTM-THD(I) )*((1.0+C3)*CFS+DELCF)/
* ((1.0+C3)*CFM)
GOTO 7
7 IF(WTS.GT.WTM) WTS=WTM
ETARM(I)=KQ0/KQM
C SAVE AREAS
C
ACTM(I)=CTM
ACFM(I)=CFM
AWTM(I)=WTM
AWTS(I)=WTS
ACTS(I)=CTS
AVS(I)=VS1
AVM(I)=VM1
8 CONTINUE
C ITTC STANDARD PREDICTION
CALL IP

RETURN FOR NEW INPUT

DO 20 I=1,2
FILE1(I)=FILE(I)
MODLS1(I)=MODELS(I)

20 MODELP1(I)=MODELP(I)
SCALE1=SCALE
GOTO 1000

100 CONTINUE
DO 110 I=1,2
FILE(I)=FILE1(I)
MODELS(I)=MODLS1(I)

110 MODELP(I)=MODLP1(I)
SCALE=SCALE1

CALL ANLSYS

RETURN FOR NEW INPUT

GOTO 1000

999 STOP

END
**OUTPUT IS USED FOR PRINTING INPUT DATA AND RESULTS**

IOUT = 1  INPUT DATA IS PRINTED
IOUT = 2  RESULT PAGE 1
IOUT = 3  RESULT PAGE 2

**SUBROUTINE OUTPUT(IOUT)**

```fortran
COMMON /A/ FILE(2),MODELS(2),MODELp(2),LPP,LWL,TF,TA,B,S
* SCALE,RNCHM,DISW,NOPROP,NPB,DP,PD075,CH075,
* TM075,C3,SBK,AT,CP,CN,DELCFc,DELWC,KSI,KPI,
* RHOM,RHOS,TEMM,TEMP,TEMS,VS(10),RTM(10);THM(10),
* QM(10),NM(10),ADVc(10),KT(10),KQ(10),THD(10),
* FD(10),IC,NOJ,NOSP,PI

COMMON /B/ ETARM(10),ETA0(10),ETAH(10),ETAD(10),AWTM(10),
* AWTS(10),ACFM(10),ACTM(10),AVS(10),AVM(10),
* ATS(10),AQS(10),APDS(10),APE(10),APDT(10),
* ANS(10),ANT(10),BPDT(10),BNT(10),KTSJ2(10),
* KQS(10),KTS(10),ACTS(10)

REAL LPP,LWL,KS1,KS,KP1,KP,NM1,NM,KT,KQ,KTM,KQ0,JTM,
KTSJ2,JTS,NS,KQTS,KTS,KQS
DIMENSION TEXT (16)
DATA TEXT /'INPU','T DA','TA  ','     ',
* 'OUTP','UT D','ATA  ','1    ',
* 'OUTP','UT D','ATA..','2    ';`TRIA`,`L AN`,ÀLYS`,ÌS    `/600 FORMAT('1',19X,'1978 ITTC PERFORMANCE PREDICTION',10X,
* 'ENCL:'/
C?? * 20X,'METHOD     ','8X,
* 'REPORT:'//20X,4A4/)
### 1978 ITTC Performance Prediction Method

**Effective Date**
- 1999

**Revision**
- 00

#### FORMAT (5X, 'IDENTIFICATION :', '18X, 'SHIP :' /
- 5X, 'PROJECT :', '2A4,
- 10X, 'LENGTH PP :', 'F8.2, (M) /
- 5X, 'SHIP MODEL :', '2A4,
- 10X, 'LENGTH WL :', 'F8.2, (M) /
- 5X, 'PROPELLER MODEL :', '2A4,
- 10X, 'DRAFT FWD :', 'F8.2, (M) /
- 5X, 'SCALE FACTOR :', 'F8.2,
- 10X, 'DRAFT AFT :', 'F8.2, (M) /
- 43X, 'BREADTH :', 'F8.2, (M) /
- 5X, 'PROPELLER :',
- 28X, 'WETTED SURFACE :', 'F8.0, (M**2) /
- 43X, 'DISPLACEMENT :', 'F8.0, (M**3) /')

#### FORMAT (5X, 'NUMBER OF PROPELLERS :', 'I8 /
- 5X, 'NUMBER OF BLADES :', 'I8,
- 6X, 'FRICTION COEFFICIENT CF /
- 5X, 'DIAMETER :', 'F8.3, (M),
- 2X, 'CALCULATED ACCORDING TO ITTC-57 /
- 5X, 'PITCH RATIO 0.75R :', 'F8.4,
- 6X, 'FORM FACTOR :', 'F6.3, (BASED ON ITTC-57) /')

#### FORMAT (5X, 'HULL ROUGHN.*10**6 :', 'F6.1, (M),
- 2X, 'BILGE KEEL AREA :', 'F6.1, (M**2),
- 5X, 'PROPELLER BLADE ROUGHN.*10**6 :', 'F6.1, (M),
- 2X, 'PROJ.AREA ABOVE WL. :', 'F6.1, (M**2) /')

#### FORMAT (5X, 'CHORD LENGTH OF PROP.BLADE AT X=0.75 :',
- 'F7.4, (M) /
- 5X, 'THICKNESS OF PROP.BLADE AT X=0.75 :', 'F7.4, (M) /')

#### FORMAT (5X, 'DENSITY OF WATER (TANK ) :', 'F7.1,
- ' (KG/M**3)/
- 'DENSITY OF WATER (SEA ) :', 'F7.1,
- ' (KG/M**3)/
- 5X, 'TEMP. OF WATER (RESISTANCE TEST) :', 'F7.2,
- ' (CENTIGRADES)/
- 5X, 'TEMP. OF WATER (SELF PROP. TEST) :', 'F7.2,
- ' (CENTIGRADES)/
- 5X, 'TEMP. OF WATER (SEA ) :', 'F7.2,
- ' (CENTIGRADES))/
- 5X, 'MODEL TEST RESULTS :',
- 30X, 'OPEN WATER CHARACT. :',
- 54X, 'RNC :', 'F5.2,**10**5 /')
606 FORMAT(5X,'SHIP RESISTANCE, FRICTION, THRUST, TORQUE, RATE OF',
      2X,'ADVANCE, THRUST, TORQUE', 'REVOLUTIONS', 'RATIO', 'COEFFICIENT'.
      2X,'KNOTS', 'N', 'N', 'N', 'NM', 'RPS',
      7X,'J', '10*KT', '100*KQ')

607 FORMAT(1X)

608 FORMAT('+',3X,'F5.1,1X,F7.1,1X,F7.2,2X,2F7.1,F9.2)

609 FORMAT('+',49X,'F10.3,F7.3,F8.3)

610 FORMAT(5X,'SHIP MODEL:',
      8X,'SPEED', 'RESISTANCE COEFFICIENT', 'FRICTION COEFFICIENT', 'THRUST DEDUCTION',
      2X,'MEAN RELATIVE ROTATION',
      6X,'VS', 'VM', 'TOTAL', 'WAKE', 'EFFECTIVENESS',
      5X,'KNOTS', 'M/S', 'CTM*1000', 'CFM*1000', 'TM',
      7X,'WTM', 'ETARM')

611 FORMAT(4X,F5.1,F7.3,F8.3,6X,F7.3,7X,F7.3,3X,F7.3,8X,F7.3)

612 FORMAT(5X,'ITTC STANDARD PREDICTION CP=CN=1.0:',
      5X,'SPEED', 'EFFICIENCY', 'POWER DELIVERY POWER', 'RATE OF REVOLUTIONS',
      2X,'THRUST', 'TORQUE',
      6X,'VS', 'PE', 'PD', 'TPS', 'RPS', 'TM',
      7X,'WTM', 'ETARM')

613 FORMAT(4X,F5.1,F10.0,3X,F9.0,4X,F9.3,3X,F9.0,F8.0)

614 FORMAT(5X,'OPEN WATER CHAR. FULL SCALE:
      3X,'KNOTS', 'ETAD', 'ETA0', 'ETAH', 'WTS',
      9X,'J', '10*KT', '100*KQ')

615 FORMAT(4X,F5.1,2X,2F8.0,3X,F7.3,8X,F7.3)

616 FORMAT(5X,'SHIP DELIVERED POWER RATE OF REVOLUTIONS',
      5X,'SPEED', 'KW', 'HP', 'RPS', 'RPM')

617 FORMAT(5X,'SHIP TRIALS PREDICTION CP=CN=',
      F7.3,'DELFCF*1000=',
      F6.3,'DELCW=',F6.3)

ITEX=ICUT*4-4
WRITE(6,600) TEXT(ITEX+1),I=1,4
WRITE(6,601) FILE,LPP,MODELS,LWL,MODELP,TF,SCALE,TA,B,S,DISW
WRITE(6,602) NOPROP,NPB,DP,PD075,C3

C
GOTO(10,20,30,40),IOUT
C
INPUT DATA IS LISTED

10 CONTINUE
WRITE(6,603) KS1,SBK(KP1,AT
WRITE(6,604) CH075,TM075
WRITE(6,605) RHOM,RHOS,TEMM,TEMP,TEMS,RNCHM
WRITE(6,606)
NMAX=MAX0(NOJ,NOSP)
DO 1 I=1,NMAX
WRITE(6,607)
IF(I. LE. NOSP) WRITE(6,608) VS(I);RTM(I);FD(I),THM(I),
QM(I),NM(I)
IF(I. LE.NOJ) WRITE(6,609) ADVC(I),KT(I),KQ(I)
1 CONTINUE
RETURN

C
RESULTS PAGE 1

20 CONTINUE
WRITE(6,610)
DO 21 I=1,NOSP
CFM=ACFM(I)*1000.0
CTM=ACTM(I)*1000.0
WRITE(6,611) VS(I),AVM(I),CTM,CFM,THD(I),AWTM(I),ETARM(I)
21 CONTINUE
WRITE(6,612)
DO 22 i=1,NOSP
WRITE(6,613) VS(I),APE(I),APDS(I),ANS(I),ATS(I),AQS(I)
22 CONTINUE
WRITE(6,614)
DO 23 i=1,NMAX
WRITE(6,607)
IF(I.LE.NOSP) WRITE(6,615) VS(I),ETAD(I),ETA0(I),ETAH(I);
AWTS(I)
XKTS=KTS(I)*10.0
XKQS=KQS(I)*100.0
IF(I.LE.NOSP) WRITE(6,616) ADVC(I),XKTS,XKQS
23 CONTINUE
RETURN
C RESULTS PAGE 3

30 CONTINUE
   DCFC=DELCFC*1000.0
   IF(IC.EQ.1) WRITE(6,620)DCFC,DELWC
   IF(IC.NE.1) WRITE (6,619)CP,CN
   WRITE(6,617)
   DO 31 I=1,NOSP
   WRITE(6,618)VS(I),APDT(I),BPDT(I),ANT(I),BNT(I)
31 CONTINUE
....40 RETURN
END

C
C*****************************************************************************************************
*** C IRAT=  0 INTERPOLATION WITH A 2:ND DEGREE POLYNOMIAL
*** C      = 1 INTERPOLATION WITH A RATIONAL FUNCTION OF 2:ND DEGREE
*** C X        =  ARGUMENT ARRAY
*** C Y        =  VALUE ARRAY
*** C N        =  NUMBER OF ARGUMENTS
*** C EX      =  ARGUMENT
*** C IFEL  =  ERROR RETURN CODE
***
C
REAL FUNCTION APOL(IRAT,X,Y,N,EX,IFEL)
DIMENSION X(1),Y(1)

C CHECK NUMBER OF POINTS > 2

IFEL=0
   IF(X(1).GT.X(N)) GOTO 2
   IF(X(1).GT.EX.OR.X(N).LT.EX) GOTO 7
   DO 1 I=1,N
       L=1
       IF(EX-X(I)) 4,4,1
   1 CONTINUE
   GOTO 4
   2 CONTINUE
   IF(X(1).LT.EX.OR.X(N).GT.EX) GOTO 7
   DO 3 I=1,N
       L=I
       IF(EX-X(I)) 3,4,4
3 CONTINUE
4 CONTINUE
   M=2
   IF(L.EQ.1)  M=1
   IF(L.EQ.3)  M=3
   LM=L-M
   X1=X(LM+1)
   X2=X(LM+2)
   X3=X(LM+3)
   Y1=Y(LM+1)
   Y2=Y(LM+2)
   Y3=Y(LM+3)

   C   INTERPOL. 2:ND DEGREE POLYNOMIAL
   C
   X21=X2-X1
   X31=X3-X1
   X32=X3-X2
   IF(IRAT.EQ.1)  GOTO 6
   C1=Y1
   C2=(Y2-C1)/X21
   C3=(Y3-C1-C2*X31)/(X31*X32)
   APOL=C1+(EX-X1)*(C2+C3*(EX-X2))
   RETURN

6 CONTINUE

   C   INTERPOL. RAT. FUNCTION
   C
   Y21=Y2*X2*X2-Y1*X1*X1
   Y32=Y3*X3*X3-Y2*X2*X2
   A0=(Y32-X32*Y21/X21)/(X32*X31)
   B0=(Y21/X21-A0*(X1+X2)
   C0=((Y1-A0)*X1-B0)*X1
   APOL=(C0/EX+B0)/EX+A0
   RETURN

7 CONTINUE

   WRITE(6,8)
8 FORMAT(5X,'INCREASE THE J-RANGE')
STOP
END
SUBROUTINE IP

COMMON /A/ FILE(2),MODELS(2),MODELp(2),LPP,LWL,TF,TA,B,S,
* SCALE,RNCHM,DISW,NOPROP,NPB,DP,PD075,CH075,
* TM075,C3,SBK,AT,CP,CN,DELCF,C,DELWC,KSI,KPI,
* RHOM,RHOS,TEMM,TEMP,TEMS,VS(10),RTM(10),THM(10),
* QM(10),NM(10),ADVCC(10),KT(10),KQ(10),THD(10),
* FD(10),IC,NOJ,NOSP,PI

COMMON /B/ ETARM(10),ETA0(10),ETAR(10),ETAD(10),AWTM(10),
* AWTS(10),ACFM(10),ACTM(10),AVS(10),AVM(10),
* ATS(10),AQS(10),APDS(10),APE(10),APDT(10),
* ANS(10),ANT(10),BPDT(10),BNT(10),KTSJ2(10),
* KQS(10),KTS(10),ACTS(10)

REAL LPP,LWL,KS1,KS,KPI,KP,NM1,NM,KT,KQ,KT,KT,JTM,
* KTSJ2,JTS,NS,KQTS,KTSJ2,KQOS,KQS,KTS

DO 3 I=1,NOSP
VS1=AVS(I)
CTS=ACTS(I)

CALCULATE THE FULL SCALE LOAD ADVANCE COEFF. AND
TORQUE COEFF.

FNOP=NOPROP
KTJT2=S*CTS*0.5/((DP*(1.0-WTS))**2*(1.0-THD(I))) /FNOP
JTS=APOL(1,KTSJ2,ADVCC,NOJ,KT,KTJT2,IX)
KQOS=APOL(0,ADVCC,KQS,NOJ,JTS,IX)

THE RATE OF REV. AND THE DELIVERED POWER

NS=(1.0-WTS)*VS1/(JTS*DP)
APDS(I)=2.0*PI*RHOS*DP**5*NS**3*KQOS/ETARM(I)*0.001
ANS(I)=NS
THE THRUST AND TORQUE OF THE PROPELLER

\[ \text{ATS}(I) = K_{JT} T^2 J T S^2 R H O S^* D P^* 4 N S^* N S^* 0.001 \]
\[ \text{AQS}(I) = K_{Q} O S^* R H O S^* D P^* 5 N S^* N S^* / E T A R M(I)^* 0.001 \]

THE EFFECTIVE POWER, TOTAL AND HULL EFFICIENCY

\[ \text{APE}(I) = C T S^* 0.5^* R H O S^* V S^1^* 3^* S^* 0.001 \]
\[ \text{ETAD}(I) = \text{APE}(I) / \text{APDS}(I) \]
\[ \text{ETAH}(I) = (1.0 - \text{THD}(I)) / (1.0 - WTS) \]

IF(IC,EQ,1) GOTO 1

IC1 = IC - 1
IF(IC1)10,11,12

TRIAL PREDICTION WITH CP-CN CORRECTIONS (ITTC1978 ORIGINAL)

10 \[ \text{ANT}(I) = C N^* N S \]
\[ \text{BNT}(I) = \text{ANT}(I)^* 60.0 \]
\[ \text{APDT}(I) = C P^* \text{APDS}(I) \]
\[ \text{BPDT}(I) = 1.36^* \text{APDT}(I) \]
GOTO 100

TRIAL PREDICTION WITH CP-CN CORRECTIONS
CN BASED ON POWER IDENTITY

12 \[ \text{APDT}(I) = C P^* \text{APDS}(I) \]
\[ \text{BPDT}(I) = 1.36^* \text{APDT}(I) \]
\[ K_{QJ3T} = 1000.0^* \text{APDT}(I)/(2.0^* P I^* R H O S^* D P^* 2) / F N O P \]
\[ K_{QJ3T} = K_{QJ3T}/(V S^1^* 3^* (1.0 - W T S)^* 3) \]
\[ K_{Q0J3} = K_{QJ3T}^* E T A R M(I) \]
\[ J T S = A P O L(1, K Q S J 3, A D V C, N O J, K Q 0 J 3, I X) \]
\[ N S = (1.0 - W T S)^* V S^1^/ (J T S^* D P) \]
\[ \text{ANT}(I) = C N^* N S \]
\[ \text{BNT}(I) = \text{ANT}(I)^* 60.0 \]
GOTO 100

11 CONTINUE
TRIAL PREDICTION WITH DELCF-DELWC CORRECTIONS

\[
KTJT2 = S \left( CTS + \text{DELFCF} \right) / (2.0 \times (1.0 - \text{THD(I)}) \times (DP* (1.0 - (WTS - \text{DELWC}))))^{**2}
\]

\[
JTS = \text{APOL}(1, KTSJ2, \text{ADVC, NOJ, KTJT2, IX})
\]

\[
KQOS = \text{APOL}(0, \text{ADVC, KQS, NOJ, JTS, IX})
\]

\[
\text{ANT}(I) = (1.0 - WTS + \text{DELWC}) \times \text{VS}1 / (JTS \times DP)
\]

\[
\text{BNT}(I) = \text{ANT}(I) \times 60.0
\]

\[
\text{APDT}(I) = 2.0 \times \pi \times \rho_{OS} \times DP^{**5} \times \text{ANT}(I)^{**3} \times KQOS / \text{ETARM}(I) \times 0.001
\]

\[
\text{BPDT}(I) = 1.36 \times \text{APDT}(I)
\]

2 CONTINUE

\[
\text{ETAD}(I) = KTJT2 \times JTS^{**3} / (2.0 \times \pi \times KQOS)
\]

3 CONTINUE

WRITE OUTPUT

CALL OUTPUT(2)
CALL OUTPUT(3)
RETURN

SUBROUTINE ANLSYS

**************************************************************************
****
* ANALYSIS ACCORDING TO 1978 ITTC PREDICTION METHOD *
****
**************************************************************************

DIMENSION VST(10),XNT(10),XPD(10),
* THDT(10),WTMT(10),WTST(10),ETART(10),CRWT(10),
* YNT(10),YPD(10),CPT(10),CNT(10),CNPT(10),ZNT(10)
* DCFT(10),WTSS(10),DWT(10),DCF(10),DWM(10),
* KQJ3(10)

COMMON /A/ FILE(2), MODELS(2), MODEL(2), LPP, LWL, TF, TA, B, S,
* SCALE, RNCHM, DISW, NOPROP, NPB, DP, PD075, CH075,
* TM075, C3, SBK, AT, CP, CN, DELCFC, DELWC, KS1, KP1,
* RHOM, RHOS, TEMM, TEMP, TEMS, VS(10), RTM(10), THM(10),
* QM(10), NM(10), ADVC(10), KT(10), KQ(10), THD(10),
* RA(10), IC, NOJ, NOSP, PI
COMMON /B/ ETARM(10), ETA0(10), ETAH(10), ETAD(10), AWTM(10),
   * AWTX(10), ACFM(10), ACTM(10), AVS(10), AVM(10),
   * ATS(10), AQS(10), APDS(10), APE(10), APDT(10),
   * ANS(10), ANT(10), BPDT(10), BNT(10), KTSJ2(10),
   * KQS(10), KTS(10), ACTS(10)

REAL LPP, LWL, KS1, KS, KP1, KP, NM1, NM, KT, KQ, KTM, KQ0, JTM,
   * KTSJ2, JTS, NS, KQTS, KTSJ2, KQOS, KTS, KQS, KQM,
   * KQJ3, KQJ3T

   DO 5 I = 1, NOJ
5 KQJ3(I) = KQS(I)/ADVC(I)**3

NOST = 10

READ(5,510) (VST(I), I=1,NOST)
READ(5,510) (XNT(I), I=1,NOST)
READ(5,510) (XPD(I), I=1,NOST)

510 FORMAT (10F8.0)

COUNT NO. OF TRIAL RUNS
NOST = 0
DO 8 I = 1, 10
   IF (VST(I),GT.0.) NOST=NOST+1
8 CONTINUE

IF(XNT(1),GT.20.) GOTO 20
DO 10 I=1, NOST
   XNT(I) = XNT(I)*60.0
10 XPD(I) = XPD(I)*1.36
20 CONTINUE

VST1 = VST(I)*1852.0/3600.0

CTST = APOL(0, AVS, ACTS, NOSP, VST1, IX)
THDT(I) = APOL(0, AVS, THD, NOSP, VST1, IX)
WTMT(I) = APOL(0, AVS, AWTM, NOSP, VST1, IX)
WTST(I) = APOL(0, AVS, AWTS, NOSP, VST1, IX)
ETART(I) = APOL(0, AVS, ETARM, NOSP, VST1, IX)
CF = APOL(0, AVS, ACFM, NOSP, VST1, IX)
CT = APOL(0, AVS, ACTM, NOSP, VST1, X)
CRWT(I) = CT - (1.0+C3)*CF
FNOP = NOPROP
KTJT2 = S*(CTST/FNOP)*0.5 / (((1.0-WTST(I))**2*(1.0-THDT(I)))
JTS = APOL(1, KTSJ2, ADVC, NOJ, KTJT2, IX)
KQOS = APOL(0, ADVC, KQS, NOJ, JTS, IX)
NS = (1.0-WTST(I))*VST1/(JTS*DP)
PDS = 2.0*PI*RHOS*DP**5*NS**3*KQ0S/ETART(I)*0.001*FNOP
YN(T) = NS*60.0
YPD(I) = PDS*1.36
CPT(I) = XPD(I)/YPD(I)
CNT(I) = XNT(I)/YN(T)
PDT1 = XPD(I)/1.36
XNT1 = XNT(I)/60.0
FKQ = PDT1*START(I)*1000.0 / (2.0*PI*RHOS*DP**5*XNT1**3)/FNOP
FJT = APOL(0,KQS,ADVC,NOJ,FKQ,IX)
FKT = APOL(0,ADVC, KTS,NOJ,FJT,IX)
KQJ3T = FKQ * (DP*XNT1)**2 / (((1.0-WTST(I))*VST1)**3
FJQ = APOL(1,KQJ3,ADVC,NOJ,KQJ3T,IX)
ZNT(I) = (1.0 - WTST(I))*VST1 / (FJQ*DP) * 60.0
CNPT(I) = XNT(I) / ZNT(I)
THS = FKT * RHOS * DP**4*XNT1**2
CTS = THS*(1.0 - THDT(I)) / (0.5*RHOS*VST1**2*S) / FNOP
DCFT(I) = CTS - CTST)**1000.0
WTSS(I) = 1.0 - FJT*DP*XNT1/VST1
DWT(I) = WTST(I) - WTSS(I)
DWM(I) = WTMT(I) - WTSS(I)

**CALCULATION OF FRICTIONAL RESISTANCE ~COEFF. OF SHIP**

T = TEMS
FNU = (0.659E-3*(T-1.0)-0.05076)*(T-1)+1.7688)*1.0E-6
RNLS = ALOG10(LWL*VST1/FNU)
CFS = 0.075 / (RNLS-2.0)**2

DCFM(I) = CTS - (1.0+C3)*CFS - ( CRWT(I)+0.001*AT / S )*S / (S+SBK)
DCFM(I) = DCFM(I) * 1000.0
CRWT(I) = CRWT(I) * 1000.0

50 CONTINUE

CALL OUTPUT(4)
WRITE(6,600)
600 FORMAT(’ ’, ’19X,’TRIAL ANALYSIS ACCORDING TO ITTC 1978 METHOD’, ///)
610 WRITE(6,610) ( VST(I), I=1, NOST)
620 FORMAT(5X, ’SHIP SPEED - TRTAL’, 7(F10.2, 2X))
630 WRITE(6,630) ( XPD(I), I=1, NOST)
640 FORMAT(5X, ’PROP, RPM –TRTAL ’, 7(F10.2, 2X))
650 WRITE(6,650) ( YPD(I), I=1, NOST)
660 FORMAT(5X, ’DELIV. POWER-TRIAL ’, 7(F11.0,1X))
670 WRITE(6,670) ( CPT(I), I=1, NOST)
680 FORMAT(5X, ’CN’)
690 FORMAT(5X, ’CNP’)
700 FORMAAT(5X, ’DCFC*1000 -CP=CN=1’, 7(F10.3,2X))
710 WRITE(6,610) ( VST(I), I=1, NOST)
720 FORMAT(5X, ’THDM’)
730 WRITE(6,610) ( VST(I), I=1, NOST)
740 FORMAT(5X, ’WTM’)
750 WRITE(6,610) ( VST(I), I=1, NOST)
760 FORMAT(5X, ’WTS TRIAL ’)
770 FORMAT(5X, ’ETARM ‘)