

Calculation Methods for Main Diesel Engine Output at Sea Trial

1. Scope

This Japanese Industrial Standard specifies the calculation methods for the output of main diesel engine at the sea trial.

Remark: In this standard units and numerical values in [] are in accordance with the conventional system of units, and given for reference only.

2. Classification

The methods of calculation of the output are classified as follows:

- (1) Calculation based on the graduation of fuel oil pump rack (or the indication of load indicator) and the rotational speed
- (2) Calculation based on the fuel oil consumption
- (3) Calculation based on the torque obtained by torsion meter
- (4) Calculation based on the indicated output obtained by pressure indicator

Remark: The word "output" mentioned in this standard means the shaft output for the case (3) and the brake output for the other cases.
Definition of the output shall be as shown in JIS F 0401.

3. Application

The calculation method to be applied to the output of main engine shall be that based on the graduation of fuel oil pump rack (or the indication of load indicator) and the rotational speed.

Remark: Calculation methods (2), (3) and (4) specified in 2. may be applied, where necessary.

4. Procedure, Preparation, Measuring Items, Calculation and Correction

(1) Calculation based on the graduation of fuel oil pump rack (or the indication of load indicator) and the rotational speed

(1.1) Procedure At the shop test of the main engine the output shall be measured accurately with the hydraulic dynamometer or other proper output meters and the graduation of fuel oil pump rack (or the indication of load indicator) and the rotational speed corresponding to the measured output shall be recorded simultaneously. On the basis of these data an estimated output curve shall be drawn up and the output at the sea trial can be obtained from this estimated output curve.

(1.2) Preparation

- (a) The estimated output curve shall be prepared. (Refer to **Reference Fig. 1.**)

Remark: The estimated output curve shall be prepared by the manufacturer of main engine on the basis of the shop test results.

- (b) The fuel oil properties (specific gravity, lower calorific value) shall be checked.
(c) The effective delivery stroke of fuel oil pump shall be checked.

(1.3) Measuring items

- (a) Graduation of fuel oil pump rack (or indication of load indicator)
(b) Rotational speed
(c) Fuel oil temperature at the inlet of main engine

The measurements of the graduations of the fuel oil pump rack (or the indication of the load indicator) shall be averaged except those of large deviations.

The rotational speed shall be measured by the revolution counter or the equivalent.

Reference Standard:

JIS F 0401 -- Terminology and Definition of Output of Propulsion Machinery Installed in Ships

- (1.4) **Calculation and correction** Determine the output on the basis of test results using the estimated output curve. However, if the fuel oil properties and the effective delivery stroke of the fuel oil pump at the sea trial differ from those at the shop test, correction shall be made in determining the output as follows:

$$BHP = BHP_1 \cdot \frac{S_a \cdot H_{ua} \cdot \gamma_a}{S \cdot H_u \cdot \gamma}$$

where

- BHP* : main engine output at sea trial (kW) [PS]
*BHP*₁ : output obtained from estimated output curve (kW) [PS]
S : effective delivery stroke of fuel oil pump at shop test (mm)
*S*_a : effective delivery stroke of fuel oil pump at sea trial (mm)
*H*_u : lower calorific value of fuel oil at shop test (kJ/kg) [kcal/kg]
*H*_{ua} : lower calorific value of fuel oil at sea trial (kJ/kg) [kcal/kg]
 γ : specific gravity of fuel oil at engine inlet at shop test
 γ_a : specific gravity of fuel oil at engine inlet at sea trial

(2) Calculation based on the fuel oil consumption

- (2.1) **Procedure** At the shop test of the main engine the output shall be measured accurately with hydraulic dynamometer or other proper output meter. On the basis of the output and the measurement of corresponding fuel oil consumption, an estimated output curve shall be obtained. The estimated output curve may be obtained by two methods as indicated below, according to whether the power factor test is carried out or not. The output at the sea trial shall be determined from these estimated output curves.

- (a) Estimated output curve without power factor test (Refer to **Reference Fig. 2.**)
 A curve showing the value of fuel oil consumption at each output.
 (b) Estimated output curve with power factor test (Refer to **Reference Fig. 3.**)

(2.2) Preparation

- (a) The estimated output curve shall be prepared.

Remark: The estimated output curve shall be prepared by the manufacturer of main engine on the basis of the shop test results.

- (b) The fuel oil properties (specific gravity, lower calorific value) shall be checked.

(2.3) Measuring items

- (a) Fuel oil consumption
 (b) Fuel oil temperature (temperature at the place where fuel oil consumption is measured)
 (c) Rotational speed
 (d) Graduation of fuel oil pump (or indication of load indicator)

Fuel oil consumption shall be measured by the integrating flowmeter with high accuracy or the equivalent.

The amount of leakage shall also be measured accurately. Measuring time shall be as long as practicable under the settled condition of main engine load.

Measurements for (c) and (d) shall be taken when the estimated output curve with power test is being used.

(2.4) Calculation and correction

- (a) **In the case without power test** Corrected fuel oil consumption shall be determined from the measured fuel oil consumption by applying the calorific value of the fuel oil used at the shop test. The output of main engine shall then be obtained from the estimated output curve. Formula for correcting the fuel oil consumption by the calorific value is as follows:

$$G_f = G_{fa} \cdot \frac{H_{ua}}{H_u}$$

where

- G_f : corrected fuel oil consumption at sea trial (kg/h)
 G_{fa} : measured fuel oil consumption at sea trial (kg/h)
 H_u : lower calorific value of fuel oil at shop test (kJ/kg) [kcal/kg]
 H_{ua} : lower calorific value of fuel oil at sea trial (kJ/kg) [kcal/kg]

- (b) **In the case with power test** Specific fuel oil consumption shall be determined from the estimated output curve on the basis of the measured rotational speed and the graduation of fuel oil pump rack (or the indication of load indicator).

On the other hand, corrected fuel oil consumption shall be calculated from the measured fuel oil consumption by applying the calorific value used for the curves of equal specific fuel oil consumption in the estimated output curve. Calculation method is similar to (a).

The output can be obtained from the following formula using the specific fuel oil consumption and the corrected fuel oil consumption.

$$BHP = \frac{1\,000\ G_f}{g_f}$$

where

- BHP : output at sea trial (kW) [PS]
 G_f : corrected fuel oil consumption (kg/h)
 g_f : specific fuel oil consumption (g/kW · h) [g/ps · h]

(3) Calculation based on the torque obtained by torsion meter

- (3.1) **Procedure** The shaft transmitting power from the main engine to the propeller is forced to cause torsional displacement due to turning force.

Torque can be determined from this torsional displacement (torsional angle) and the lateral modulus of elasticity (G) of the shaft.

The output may either be obtained from this torque measured by torque meter multiplied by rotational speed or be measured directly using output meter.

(3.2) Preparation

- (a) The lateral modulus of elasticity (G) shall be checked.
 For steel, $G : 82.1 \times 10^3 \text{ N/mm}^2$ ($8.37 \times 10^5 \text{ kgf/cm}^2$)
 (b) Torsion meter shall be mounted accurately to the shaft.
 (c) Zero adjustment of the torsion meter shall be carried out prior to main engine operation.

(3.3) Measuring items

- (a) Torque
 (b) Rotational speed

The measurements of the torque shall be averaged except those of large deviation.

The rotational speed shall be measured accurately using the revolution counter or the equivalent.

These measurements shall be taken simultaneously.

- (3.4) **Calculation and correction** The torsion meter is available in two types: torque meter and output meter. With torque meter, the output shall be calculated by the following formula.

Correction of the measurements shall be made when it is required after checking the zero adjustment before and after main engine operation with the torque meter mounted.

$$SHP = \frac{2\pi \cdot N \cdot Q}{1\,000 \times 60} \quad \left\{ \begin{array}{l} SHP_1 = \frac{2\pi \cdot N \cdot Q'}{75 \times 60} \end{array} \right\}$$

where

- SHP : shaft output (kW)
 SHP_1 : shaft output [PS]

(when the torque is calculated in kgf · m and the output is expressed in PS)