INTERNATIONAL MARITIME ORGANIZATION

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INTERSESSIONAL MEETING OF THE
GREENHOUSE GAS WORKING GROUP
2nd session
Agenda item 2

GHG-WG 2/2/4
4 February 2009
ENGLISH ONLY

# CONSIDERATION OF THE ENERGY EFFICIENCY DESIGN INDEX FOR NEW SHIPS

## Proposal for a verification procedure for Waste Heat Recovery Contribution

**Submitted by Denmark**

**SUMMARY**

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| ***Executive summary:*** | This document proposes a procedure for verification of the rated electrical power generation of waste heat recovery systems ($P_{WHR)}$ used in the Energy Efficiency Design Index (EEDI) calculation |
| ***Strategic direction:*** | 7.3 |
| ***High-level action:*** | 7.3.1 |
| ***Planned output:*** | 7.3.1.1 and 7.3.1.3 |
| ***Action to be taken:*** | Paragraph 10 |
| ***Related documents:*** | MEPC 58/4/9, MEPC 58/WP.8 and MEPC 58/23 |


## Introduction

1 This document is submitted in accordance with MSC-MEPC.1/Circ.2 Guidelines on the Organization and Method of Work.

2 At the fifty-eighth session of the Maritime Environment Protection Committee (MEPC 58), it was agreed that utilization of waste heat should be reflected as a reduction in the Energy Efficiency Design Index (EEDI). In the draft interim guidelines on the method of calculation of the energy efficiency design index for new ship, set out in MEPC 58/23, annex 11, the power generated by waste heat recovery ($P_{WHR}$) is defined as: "$P_{WHR}$ is the rated electrical power generation of waste heat recovery systems at $P_{ME(I)}$".

## Procedure for the verification of the rated electric power generated of waste heat recovery systems

3 The objective of this document is to propose a procedure for the verification of the rated electric power generated of waste heat recovery systems. A figure showing the principles of waste heat recovery systems is set out in annex 1.

4 The procedure should be in accordance with the verification procedure proposed in MEPC 58/4/9 with calculations of the energy efficiency design index at the early design stage and a verification of the calculations during a sea trial.

5 The contribution of electrical power from the waste heat recovery system should be measured at a sea trial with the main engine developing 75% of the rated installed engine power (MCR). As the contribution from the waste heat recovery system relates closely to the tuning of the main engine (and through this tuning to the fuel oil consumption), the power generation from waste heat should be measured simultaneously with the fuel consumption. During the measurements all steam from the exhaust boiler should be directed to the steam turbine generating electrical power.

6 The calculation of the rated electrical power generated by the waste heat recovery system should be based on the conditions for temperature of air and seawater, barometric pressure, and humidity specified in ISO 15550 Internal combustion engines – Determination and Method for the Measurement of Engine Power – General Requirements, Item 5, Standard Reference Conditions.

7 As the ISO condition for which the contribution was calculated will never be present at the sea trial, the data necessary to calculate a corrected contribution should be measured during the sea trial, and afterwards the measured power should be corrected to the mentioned ISO condition to allow comparison with the calculated contribution from the waste heat recovery system.

**Procedure**

8 The calculation of the power generated by the waste heat recovery system should be verified through the following three step process, where step 1 can be carried out in the early design stage when the engine type is decided, step 2 must be carried out during the shop test of the main engine and step 3 must be carried out during the sea trial:

1 calculation of the expected output of waste heat recovery system based on calculations of exhaust gas data for the main engine and exhaust gas boiler outlet;

2 verification of fuel consumption and exhaust gas data at the shop test of the main engine; and

3 verification of performance data during sea trial.

9 A more specific procedure for the verification process is set out in annex 2.

**Action requested of the Intersessional Meeting**

10 The Intersessional Meeting is invited to consider the proposal above and take action as appropriate.

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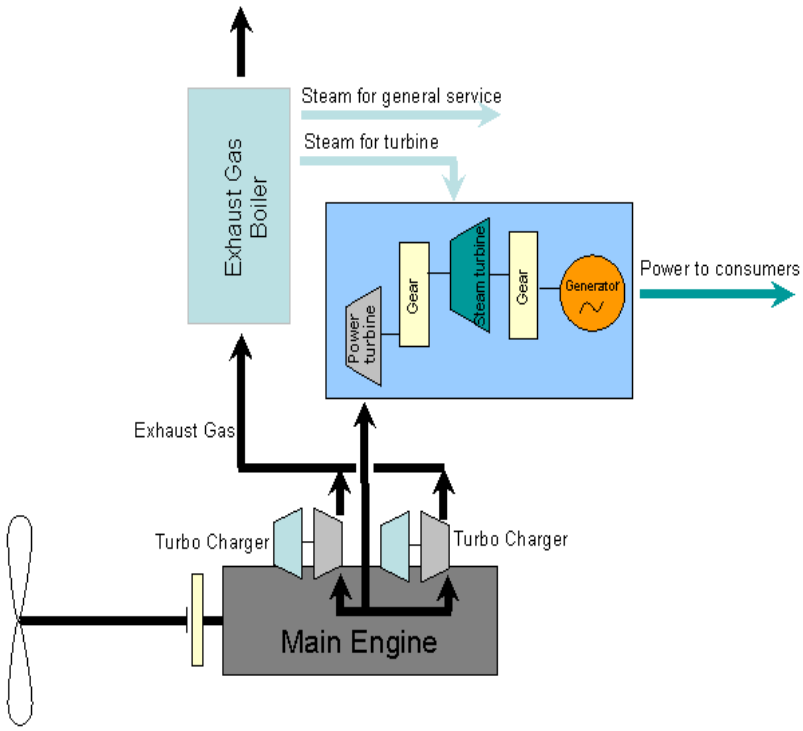
## ANNEX 1

The figure shows in principle a waste heat recovery system with a generator driven by both a steam turbine fed from an exhaust gas boiler and an exhaust gas power turbine. The waste heat recovery system may also be provided without the power turbine or without the steam turbine.

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# ANNEX 2

# VERIFICATION OF POWER GENERATION FROM WASTE HEAT RECOVERY SYSTEM

In order to calculate the power generated by the waste heat recovery system with the main engine developing 75% of the rated installed engine power (MCR), the following verification process consisting of three steps must be followed:

.1 calculation of the performance data for the waste heat recovery system;

.2 verification of fuel consumption and exhaust gas data at the main engine shop test; and

.3 verification of performance data during sea trial.

The calculation of the rated electrical power generated by the waste heat recovery system should be based on the conditions for temperature of air and seawater, barometric pressure, and humidity specified in ISO 15550 Internal combustion engines – Determination and method for the measurement of engine power – General requirements, Item 5, Standard reference conditions.

## 1 Calculations of performance data for the waste heat recovery system

### 1.1 Main engine data

During the design process of the engine, the engine builder calculates the exhaust gas data for the main engine at 75% MCR at different ambient air inlet temperatures, e.g., 5°C, 25°C (ISO) and 35°C. The results from these calculations are transferred to curves which are used when correcting the test results to the ISO conditions. The ambient air inlet temperature is the most dominant parameter influencing the waste heat output.

The exhaust gas data consist of:

- exhaust gas mass flow for turbo charger (kg/h);
- exhaust gas temperatures after turbo charger (C°);
- exhaust gas bypass mass flow available for power turbine, if any (kg/h);
- exhaust gas temperature for bypass flow (C°); and
- exhaust gas pressure for bypass flow (bar).

When calculating worst case scenarios (guaranteed performance values) it is important to consider that a low mass flow will result in higher temperatures and vice versa, thus the lowest possible mass flow is to be pared to the highest possible temperature within the given tolerances.

### 1.2 Exhaust boiler output data

Based on the exhaust gas data from the main engine, the expected output steam flows and steam temperatures for the exhaust boiler must be calculated at the different ambient temperatures 5°C, 25°C (ISO) and 35°C in order to be able to correct the test values to the ISO conditions.

### 1.3 Turbine unit output data

Based on the calculations of the exhaust gas boiler output, the expected steam turbine output can be calculated. Similarly, the output from a possible power turbine must be calculated from the exhaust flow. Based on these calculations the expected total power output of the waste heat recovery system is to be calculated. The calculation must be carried out at the different ambient temperatures 5°C, 25°C (ISO) and 35°C in order to be able to correct the test values to the ISO conditions.

## 2 Verification of fuel consumption and exhaust gas data at main engine shop test

### 2.1 Measurements

During the main engine shop test the fuel oil consumption, exhaust gas pressures and temperatures at 75% MCR must be measured at the actual ambient temperature. Based on these data the exhaust gas mass flow can be calculated.

The data measured and calculated must then be corrected for the actual ambient condition to establish reference values for the exhaust gas data (mentioned in 1.1) at ISO conditions.

## 3 Verification of performance data during sea trial

### 3.1 Measurements

During a sea trial a combined performance test of the complete waste heat recovery system and the main engine system must be carried out.

Measurements of main data (fuel consumption, power output of main engine, power output from steam turbine, etc.) as well as intermediate variables (temperatures, steam flow, etc.) must be performed with the main engine developing 75% MCR.

### 3.2 Condition

As the waste heat recovery performance can be improved by misadjusting the main engine it is important to combine the main engine performance test and the waste heat recovery test. The test should be carried out with the main engine optimized for the actual propeller curve.

During the test, the total amount of steam from the exhaust gas boiler must be directed to the steam turbine.

### 3.3 Calculations

After the sea trial the measured and calculated variables must be corrected to ISO conditions in order to calculate the corresponding rated electrical power ($P_{WHR}$) generated by the waste heat system.

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