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MEPC.1/Circ.901
24 June 2022

GUIDANCE ON METHODS, PROCEDURES AND VERIFICATION OF IN-SERVICE PERFORMANCE MEASUREMENTS

1 The Marine Environment Protection Committee, at its seventy-eighth session (6 to 10 June 2022), approved the *Guidance on methods, procedures and verification of in-service performance measurements* for the purpose of the EEXI calculation, as set out in the annex.

2 Member Governments are invited to bring the annexed Guidance to the attention of their Administrations, industry, relevant shipping organizations, shipping companies and other stakeholders concerned.

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ANNEX

GUIDANCE ON METHODS, PROCEDURES AND VERIFICATION OF IN-SERVICE PERFORMANCE MEASUREMENTS

CONTENTS

1 Introduction

In cases where the speed-power curve is not available or the sea trial report does not contain the EEDI or design load draught condition, the ship speed V_{ref} can be obtained from the in-service performance measurement method for the purpose of the EEXI calculation, in accordance with paragraph 2.2.3.5 of the EEXI Calculation Guidelines, as set out in resolution MEPC.350(78).

2 Overview

2.1 When carrying out the in-service performance measurements, common international standards[1] should be referred to, unless explicitly specified in this guidance.

2.2 An overview of preparations and procedures are outlined in the table below. The preparations and the processes should be discussed and agreed at the pre-meeting, see section "Preparations".

Table 1: In-service performance sea trial preparations and procedures

In-service performance measurement analysis	
Step 1: Preparing sensors	• Speed log / GPS • Echosounder • Heading control • Fuel flow meter • Shaft torsion meter • Draft measurement • Gyro compass
Step 2: Pre-trial parameters	• Displacement • Forward/Aft draughts • Water depth • Air/Sea temperature • Seawater density • Anemometer height • Fuel density • Fuel LCV
Step 3: In-service performance measurement	• Sea state • Wind • Water depth • Currents
Step 4: During trial parameters	• Reported data • System prints • Equipment control • Fuel analysis
Step 5: Documentation	• Shaft RPM/Power • Heading • Ship's speed • Distance • Wind speed/direction • Current speed/direction • Wave height/period/direction

[1] Such as ITTC quality procedures, ISO 15016:2002, ISO 15016:2015 and/or ISO 19030:2016.

2.3 When using the in-service performance measurement method, a meeting should be arranged between all stakeholders involved in the process: the owner, the possible consultant, the verifier and the authority before conducting the in-service performance measurements. An overview of the available information including but not limited to ship design, energy saving devices (ESD) and measurement sensors should be included. The plan for the period of the in-service performance measurements should be agreed upon and expectations regarding the delivery of the analysis and its format should be aligned.

3 Preparations

3.1 One of the most important aspects of a successful in-service performance measurement procedure is the preparation. Relevant instruments should be calibrated and their operational conditions prior to the commencement of the trials should be confirmed by the verifier.[2] The list below indicates the primary instruments to be used for collecting the data:

Table 2: Sensors for In-service performance trials

Sensor	Remarks
Shaft torque meter	The measurement system should be certified for power measurements with a bias error as small as practicable. Zero setting checked before and after test.
GPS	The GPS system should operate in the differential mode to ensure sufficient accuracy.
Anemometer	It should be clear of possible obstructions (superstructure, masts, funnel, etc.) and its height from sea level recorded.
Draft measurements	Draft measurement system (if available and calibrated): Otherwise, physical observation is required.
Speed log	The sensor should have been cleaned recently.
Echo sounder	Important for checking water depth for safety and ensuring there are no effects from shallow water on the ship performance.
Course recorder	Should be checked before the trial and be able to provide a course printout following each trial run.
Fuel flow meter	Either volume flow or mass flow meters to be fitted to ships. Both should be calibrated and cleaned/maintained as per manufacturer's recommendations.
Gyro compass	Record the ship's heading during the voyage and should be calibrated prior to the trials.

3.2 The ship should be equipped with a calibrated shaft torque meter, at least for the complete duration of the in-service performance measurement. For verification and cross checks, the detailed fuel properties information, the logged engine room conditions and the fuel oil consumption details will give an estimate of the power used at a certain fuel oil consumption value.

3.3 If an automated data acquisition system is installed on board, this should be checked for accuracy prior to the performance measurements, to ensure that the system has the required precision and measurement frequency, that can provide a trace of all the data required.

[2] The Verifier is the flag Administration, or a competent organization delegated by the flag Administration.

3.4 Before the start of each performance measurement run, the following should be noted in the data logging template form (example appendix C):

Table 3: In-service environment and conditions

Parameter	**Remarks**
Displacement	Speed trials should be performed at displacement and draught conditions, which are comparable to those of the delivery sea trials or model tests or assumed ballast conditions. The trim shall be maintained within very narrow limits. For the even keel condition, the trim shall be less than 0.1 % of the length between perpendiculars. For the trimmed trial condition, the fore draught shall be within ± 0.1 m of the ship's ideal condition.
Draught forward, mid and aft	
Water depth	No remarks
Air temperature	Air temperature and pressure should be measured using a calibrated thermometer and barometer.
Air pressure	
Sea water temperature	The local seawater temperature and density at the trial site should be recorded to enable the calculation of the ship's displacement and corrections with regards to viscosity. The water temperature should be taken at the waterline level.
Sea water density	
Anemometer height	Its height from sea level should be recorded.
Fuel density	The fuel's density and LCV to be obtained from a laboratory's analysis report.
Fuel LCV	

3.5 The in-service performance measurements should be performed at the EEXI draught condition, and if data exists for a reference condition, then a set of in-service performance measurements may also be performed at this condition in order to better calibrate the speed-power relation.

.1 The reference condition is the condition for which the ship documentation exists, e.g. a sea trial curve in ballast or a sea trial/model test curve in design conditions. The in-service performance measurement result may be calibrated towards the reference condition curve. The use of a reference condition, if available, should not lead to overestimation of the Vref but can be a useful tool to verify and calibrate the speed-power relation. If a reference condition is used, this calibration result may also be used for the EEXI draught condition.

.2 The EEXI draught condition is the draught condition as provided by paragraph 2.2.2 of the *2018 Guidelines on the method of calculation of the attained EEDI for new ships* (resolution MEPC.308(73), as amended, the "EEDI Calculation Guidelines" hereafter). The performance measurements results are used with the same calibration factor as at the reference condition if available.

3.6 In case the exact EEXI draught condition cannot be met, the Admiralty Coefficient formula may be accepted to adjust the speed-power relation, only for displacement variations of up to 2%, or to the satisfaction of the verifier.

3.7 The ship should perform at least one set of in-service performance measurements for the EEXI draught condition, and at power settings equivalent to the EEDI trial conditions (set out in MEPC.1/Circ.855/Rev.2, as amended). If that is not possible, then at each of the following power settings of 30%, 60%, 75% and 90% of MCR, with a margin of +/– 5%. If data for a reference condition is available, another set of in-service performance measurements should also be carried out at this condition for calibration purposes.

3.8 In case where an overridable Shaft/Engine Power Limitation is installed, the power settings of 30%, 60%, 83% and 90% of the limited power may be used, with a margin of +/– 5% for both sets of in-service performance measurements, to the satisfaction of the verifier.

3.9 If the in-service performance measurements are performed at consecutive power settings, sufficient time in between change of settings should be considered, to be sure that steady state conditions are obtained.

3.10 The duration of each run should be performed according to table 4.

3.11 Prior to the in-service performance measurements, the weather forecast should be studied to ensure that favourable weather conditions will prevail during the trials (close to calm conditions).

3.12 Crew members involved in the execution should be familiar with the performance measurements and be aware of their tasks and the importance of the measurements collected.

3.13 Safety of the ship is paramount, and the performance measurements should be suspended should any risks to the ship and/or crew be detected. All rules and regulations, as well as good seamanship, are to be followed at all times.

3.14 The conditions and plans specified in this section should be examined and confirmed by the verifier prior to the in-service performance measurements.

3.15 The ship may experience fouling of the hull and the propeller, which may influence the performance of the ship. If the ship is heavily fouled during the in-service performance measurements, the V_{ref} attained may be less than expected and this will lead to a penalty in the attained EEXI. It is recommended to carry out in-service performance measurements when the ship has a clean hull and propeller.

3.16 The ship may have installed ESDs post delivery. This will affect the performance and the in-service measurement may be used to reflect the effect of ESDs, as provided in paragraph 2.2.3.7 of the EEXI Calculation Guidelines.

4 During the in-service performance measurements

4.1 Once the in-service performance measurements have begun, variations should be minimized, as the accuracy of the ship performance measurements can be influenced greatly by fluctuations in the parameters. Thus, all control levers should remain unchanged.

4.2 An experienced helmsman or adaptive autopilot will be required to maintain heading during each run. Minimum rudder angles are to be used while maintaining a steady heading. The helm corrections should be limited to five (5) degrees or less.

4.3 The following conditions should be met, in order to reduce the influence of corrections and obtain the best possible accuracy of the results of the performance measurements:

Table 4: Environmental conditions for in-service performance measurements

Parameter	Remarks
Sea state	Conditions as specified in ISO 15016: 2015
Wind speed	Conditions as specified in ISO 15016: 2015
Water depth	Conditions as specified in ISO 15016: 2015
Currents	Avoid areas with known high current values and variations. During the trials, the following condition should be met: $V_{GPS} - V_{STW} < 0.3\ knots$, or conditions as specified in ISO 15016: 2015
Trials period	Trials should be conducted in daylight
Duration	The run duration should be the same for all speed runs with a minimum of 10 minutes, see figure 1 below

4.4 If any of above conditions are no longer met during in-service performance measurements, it should be necessary to abandon the run.

4.5 Each set of the in-service performance measurements in the respective load condition should be executed as at least one set of double runs. It is important that the ship is running on the same track and when the monitoring begins, the conditions are in steady state conditions. Each speed run should be commenced and completed at the same place.

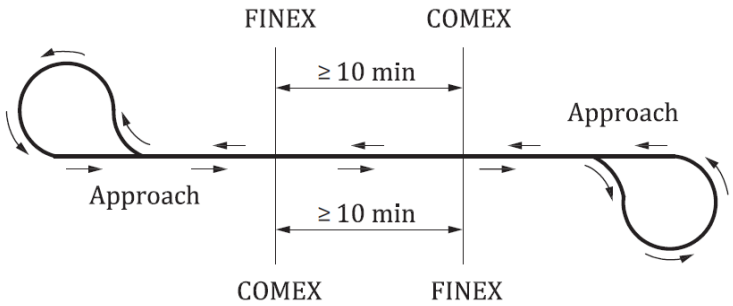


Figure 1: Sea trials with double runs

4.6 During the in-service performance measurements, accurate recordings of the required parameters are of great importance. Recording of parameters for each run should start when steady state ship conditions are met.

4.7 The following data should be collected at the beginning and end of each performance measurement run:

Main engine supply flowmeter reading	[ltr/h] or [kg/h]
Main engine supply flowmeter temperature	[deg]
Main engine return line flowmeter reading*	[ltr/h] or [kg/h]
Main engine return line flowmeter temperature*	[deg]

(*For ships fitted with flowmeter on return line)

4.8 The following data should be collected with a sampling rate of at least 1 Hz during the in-service performance measurement:

Table 5: Logged parameters during in-service performance measurements

Parameter	**Unit**
Date	dd-mm-yyyy
Time	hh:mm:ss
Revolution counter reading	[s^{-1}]
Shaft power	[kW]
Heading	[deg]
Ship's speed (GPS and Speed Log)	[knots]
Distance ("0" should be at the beginning of each run)	[nm]
Relative wind speed	[m/s]
Relative wind direction (coming from)	[deg]
Current speed	[knots]
Relative current direction (going to)	[deg]
Observed wave height	[m]
Observed wave period	[s]
Observed wave direction (going to)	[deg]

4.9 Apart from power, rpm and consumption, average prevailing values for the following main engine parameters should be provided for each run for the following:

Scavenge air temperature	[deg]
Scavenge air pressure	[kg/cm2]
Blower air inlet temperature	[deg]

4.10 These, as well as any other main engine data should be collected at local sensors' display and not their repeaters inside the ECR.

4.11 As far as practicable, the in-service performance measurement should be witnessed by the verifier. The verifier should be able to confirm that the in-service performance measurement was conducted in accordance with the agreed procedures.

5 After the in-service performance measurements

5.1 All information collected should be checked by the verifier and any errors/typos should be noted in supplementary documentation, including any corrected/replaced values clearly marked in the form. Data which is continually recorded should be provided "as is" and non-variable data should be noted at the beginning and the end of the in-service performance measurements in order to confirm that any changes are set to a minimum.

5.2 For each run the following should be submitted:

.1 one filled-in soft copy of the "In-service performance monitoring reporting form" (appendix C);

.2 printouts and/or soft copies from the performance monitoring system output;

.3 printouts and/or soft copies from the loading computer calculations representing the loading condition at which the run took place; and

.4 printouts and/or soft copies from the course recorder for the period covering the run.

5.3 Also, a copy of the fuel oil analysis for the fuel used during the in-service performance measurements should be submitted.

5.4 Any comments about the in-service performance measurements, including any large variations in environmental conditions, should be noted.

5.5 A summary of the required information to be submitted for verification can be found in appendix A, B, and C.

APPENDIX A

INFORMATION TO BE SUBMITTED PRIOR TO CONDUCTING THE IN-SERVICE PERFORMANCE MEASUREMENTS

The following information should be submitted prior to conducting the performance measurements.

Document	**Mandatory**	**Optional**
Hydrostatics	☐	☒
Shop tests of main engine	☒	☐
Sea trials (machinery and hull part)	☒	☐
Model tests	☐	☒
Propeller characteristics and structural drawings	☐	☒
GA drawing	☒	☐
Details of appendages and rudder	☐	☒
Fuel oil piping diagram	☐	☒

Ship's main particulars

IMO number:	
Date delivered:	
Ship's email address(s):	
Date ship was launched (when did ship enter the water):	
Ship's name:	
Owner:	
Managing company:	
Ship type:	
Ship capacity	
Yard:	
Length overall (m):	
Length between perpendiculars (m):	
Breadth moulded (m):	
Depth to upper deck (m):	
Design draft (m):	
Design displacement (mt):	
EEXI draft (m):	
Displacement at EEXI draft (mt)	
Lightship weight (mt)	

Design speed (knots):	

Dry-docking history (within the last five years):			
Date	Yard	Coating specs	Hull treatment
		Please attach	Please attach

Hull cleaning and propeller polishing history since last dry-dock:			
Date	Place	Brief description of works	Propeller polishing standard*

*only for propeller polishing events

Main engine(s)	
Maker:	
Type:	
Number:	
Type of fuel:	
MCR (kW):	
SMCR (kW) x RPM:	

Main engine modifications/upgrades		
	Yes	No
Derating	☐	☐
T/C cut offs	☐	☐
Part load tuning	☐	☐
Low load tuning	☐	☐
Retrofit	☐	☐
(please provide details)		
Other modifications	☐	☐
(please provide details)		

Propeller(s) including modifications/upgrades	
Type: (FP or CPP)	
Diameter (m)	
Pitch (m)	
Number	

	Yes	No
Trimmed	☐	☐
Other (please state)	☐	☐

Propulsion improvement devices		
	Yes	No
Ducts	☐	☐
Fins	☐	☐
Other (please provide details)	☐	☐

Power measurements		
	Yes	No
By torsion meter	☐	☐
(Details of torsion meter including last calibration)		
By load indicator diagrams	☐	☐
Other method (please provide details)		

Performance monitoring systems		
	Yes	No
PMS	☐	☐
please provide details of type and maker		

Fuel measurements		
	Yes	No
By volume flowmeter	☐	☐
(Details of flowmeter including last calibration)		
By mass flowmeter	☐	☐
(Details of flowmeter including last calibration)		
Soundings	☐	☐

Other instruments & gauges used for data collection	
	Dates of Calibration
Speed log	
DGPS	
Anemometer Provide height of anemometer in metres:	
Other (please provide details)	

Additional information		
	Yes	No
Reduction gear	☐	☐
(please provide details)		
Shaft motor	☐	☐
(please provide details)		
Shaft generator	☐	☐
(please provide details)		

Person to be contacted for further info:	

APPENDIX B

INFORMATION TO BE SUBMITTED FOR VERIFICATION AFTER THE IN-SERVICE PERFORMANCE MEASUREMENTS

The following information needs to be submitted after conducting the in-service performance measurements.

Document	Mandatory	Optional
Calibration certificate of torquemeter	☒	☐
Calibration certificate of flowmeters	☐	☒
Calibration certificate of anemometer	☐	☒
Calibration certificate of speed log	☐	☒
Calibration certificate of GPS	☐	☒
Calibration certificate of echosounder	☐	☒
Calibration certificate of gyro compass	☐	☒
Fuel oil analysis	☒	☐

Furthermore, for each run, the following needs to be submitted:

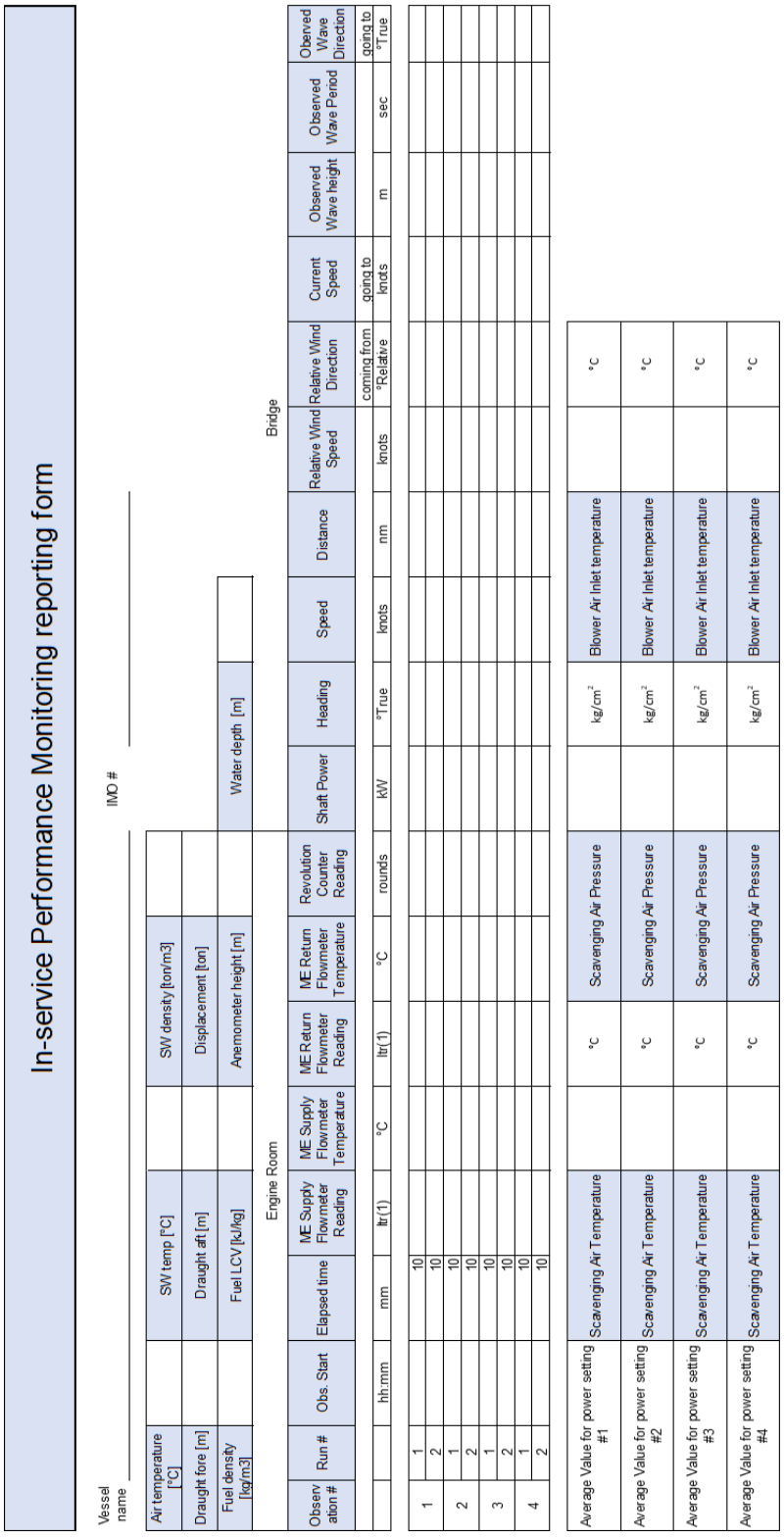
Document	Mandatory	Optional
Sea trial reporting form	☒	☐
A printout of course recorder	☒	☐
A printout of ME load indicator (depicting the loading condition of the ship during the trials)	☐	☒ *
A printout/soft copy of the anemometer output (if the anemometer is digital)	☐	☒ *

* Optional, but highly recommended outputs

APPENDIX C

EXAMPLE OF THE IN-SERVICE PERFORMANCE MEASUREMENTS REPORTING FORM

The form below includes all in service measurements at one loading condition.



In-service Performance Monitoring reporting form

Vessel name _____ IMO # _____

Air temperature [°C]		SW temp [°C]		SW density [ton/m3]			
Draught fore [m]		Draught aft [m]		Displacement [ton]			
Fuel density [kg/m3]		Fuel LCV [kJ/kg]		Anemometer height [m]		Water depth [m]	

				Engine Room								Bridge								
Observation #	Run #	Obs. Start	Elapsed time	ME Supply Flowmeter Reading	ME Supply Flowmeter Temperature	ME Return Flowmeter Reading	ME Return Flowmeter Temperature	Revolution Counter Reading	Shaft Power	Heading	Speed	Distance	Relative Wind Speed	Relative Wind Direction	Current Speed	Observed Wave height	Observed Wave Period	Obenved Wave Direction
		hh:mm	mm	ltr(1)	°C	ltr(1)	°C	rounds	kW	°True	knots	nm	knots	coming from °Relative	going to knots	m	sec	going to °True
1	1		10															
	2		10															
2	1		10															
	2		10															
3	1		10															
	2		10															
4	1		10															
	2		10															

Average Value for power setting #1	Scavenging Air Temperature	°C	Scavenging Air Pressure	kg/cm²	Blower Air Inlet temperature	°C
Average Value for power setting #2	Scavenging Air Temperature	°C	Scavenging Air Pressure	kg/cm²	Blower Air Inlet temperature	°C
Average Value for power setting #3	Scavenging Air Temperature	°C	Scavenging Air Pressure	kg/cm²	Blower Air Inlet temperature	°C
Average Value for power setting #4	Scavenging Air Temperature	°C	Scavenging Air Pressure	kg/cm²	Blower Air Inlet temperature	°C