

### 1. Engine design parameters (to be completed before measurement)

<b>1.1 Engine</b>	Production year:	<u>2010</u>
	Location:	x Testbed □ Ship
<b>1.2 Engine freshly manufactured</b>	X Yes      □ No	
	If no: Documentation of relevant maintenance provided	□ Yes      □ No
<b>1.3 Engine total running hours</b>	<u>new</u>	[h]
<b>1.4 Regular maintenance interval</b>	<u>          </u>	[h]
<b>1.5 Hours since last regular maintenance</b>	<u>          </u>	[h]
<b>1.6 Engine category</b>	X 4-stroke □ 2-stroke	
<b>1.7 Engine fuel type</b>	X Diesel      □ Gas      □ Dual fuel	
<b>1.8 Engine max. rated power</b>	<u>9100</u>	[kW]
<b>1.9 Mean effective pressure at rated power</b>	<u>27.3</u>	[bar]
<b>1.10 Engine speed</b>	□ Less than 130 rpm X 130 or more but less than 2,000 rpm □ 2,000 rpm or more	
<b>1.11 Method of air aspiration</b>	□ Naturally aspirated X Pressure-charged single stage □ Pressure-charged multi stage	
<b>1.12 Injection system</b>	□ Conventional X Common rail	
<b>1.13 Applicable emission limit</b>	□ IMO Tier I      X IMO Tier II      □ IMO Tier III □ Others: _____	
<b>1.14 Applicable test cycle</b>	□ C1      □ D2      □ E2      X E3 □ Others:	

<b>1.15.1 Specific lubrication oil consumption</b>		SLOC:		[g/kWh]
		Breaking-in period:		<input checked="" type="checkbox"/> Finished <input type="checkbox"/> Not finished <input type="checkbox"/> Not applicable
<b>1.15.2 Cylinder liner lubrication</b>				
<input checked="" type="checkbox"/> None <input type="checkbox"/> Yes, active at		<input type="checkbox"/> 100% <input type="checkbox"/> 75% <input type="checkbox"/> 50% <input type="checkbox"/> 25% <input type="checkbox"/> 10%	Feed rate: Feed rate: Feed rate: Feed rate: Feed rate:	_____ [g/h] _____ [g/h] _____ [g/h] _____ [g/h] _____ [g/h]
		Breaking-in period:		<input type="checkbox"/> Finished <input type="checkbox"/> Not finished <input type="checkbox"/> Not applicable

1.15.3 Inlet valve seat lubrication

X None

☐ Yes, active at

☐ 100%

Feed rate: [g/h]

☐ 75%

Feed rate: [g/h]

☐ 50%

Feed rate: [g/h]

☐ 25%

Feed rate: [g/h]

☐ 10%

Feed rate: [g/h]

1.16 Exhaust gas treatment device

X None

☐ Yes

☐ SCR
☐ Scrubber
☐ EGR
☐ Water injection
☐ Others:

2. Fuel

2.1 Fuel in use

X ULSD

☐ DMX

☐ DMA

☐ DMZ

☐ DMB

☐ RMA

☐ RMB

☐ RMD

☐ RME

☐ RMG

☐ RMK

☐ Other: acc. standard:

☐ Natural Gas

☐ Other gases acc. IGF:

☐ Liquid to gas fuel ratio as certified at mode point:

100%

75%

50%

25%

10%

## Fuel properties and composition (in use during testing)

### 2.2 Gas

Please fill in as far as possible  
most important marked with \*)

Property	Unit / Standard	Actual value	Remark
Methane number*)	[-] / DIN EN 16726		
Lower calorific value*)	[MJ/kg] / ISO 6976		
Higher calorific value	[MJ/kg] / ISO 6976		
Wobbe Indices Ws / Wi	[MJ/m <sup>3</sup> ] / ISO 6976		
Density*)	[kg/m <sup>3</sup> ] / ISO 6976		
Methane*)	wt.-% [kg/kg] / ISO 6974 or DIN 51894		
Ethane*)	wt.-% [kg/kg] / ISO 6974 or DIN 51894		
Propane*)	wt.-% [kg/kg] / DIN 51894		
Isobutane*)	wt.-% [kg/kg] / DIN 51894		
N-Butane*)	wt.-% [kg/kg] / DIN 51894		
Pentane	wt.-% [kg/kg] / DIN 51894		
Hexane	wt.-% [kg/kg] / DIN 51894		
Heptane	wt.-% [kg/kg] / DIN 51894		
Nitrogen	wt.-% [kg/kg] / ISO 6974		
Sulphur*)	wt.-% [kg/kg] / ISO 6326-5		
Hydrogen sulfide	wt.-% [kg/kg] / ISO 8819		
Carbon dioxide	wt.-% [kg/kg] / ISO 6974		
Hydrogen	wt.-% [kg/kg] / DIN 51894		
Others			

### 2.3 Liquid fuel

Please fill in as far as possible  
most important marked with \*)  
essential \*\*)

Property	Unit / Standard	Actual value	Remark
Type of fuel	Grade / ISO 8217	EN 590:2014-04	
Flash point*)	[°C] / ISO 2719	55	
Viscosity @ 40/50°C **)	[mm <sup>2</sup> /s] / ISO 3104	min 2 / max. 4,5	
Density @ 15°C *)	[kg/m <sup>3</sup> ] / ISO 3675 or 12185	min 820 / max 845	
Net calorific value (Hu) *)	[J/g] / DIN 51900		
Sulphur content*)	ppm [mg/kg] / ISO 8754 or 14596	max. 10	
Ash content*)	ppm [mg/kg] / ISO 6245	0.01	
Water content*)	ppm [mg/kg] / ISO 3733	200	

Carbon content*)	wt.-% [kg/kg] / ASTM D5291		
Hydrogen content*)	wt.-% [kg/kg] / ASTM D5291		
Nitrogen content*)	wt.-% [kg/kg] / DIN 51444		
Oxygen content*)	wt.-% [kg/kg] / DIN 51732		
Cetane index*)	ISO 4264	min 46	
CCAI*)			
FAME content*)	wt.-% [kg/kg] / EN 14078	max 7	
Mono aromatic compounds*)	wt.-% [kg/kg] / EN 12916		
Poly aromatic compounds*)	wt.-% [kg/kg] / EN 12916		
Di aromatic compounds	wt.-% [kg/kg] / EN 12916		
Tri aromatic compounds	wt.-% [kg/kg] / EN 12916		
Inorganic constituents (V)	ppm [mg/kg] / ISO 14597 or 8691		
Inorganic constituents (Ni)	ICP		
Carbon residues*)	wt.-% [kg/kg] / ASTM D4530		
Others			

### 3. Lube oil properties and composition (in use during testing; Producers specification can be used)

#### 3.1 Circulation lubrication oil Please fill in as far as possible

Property	Unit / Standard	Actual value	Remark
Lube oil	Brand / Type	Shell Sirius X30	
Grade	Multi / Mono	Mono	
BN	mg KOH/g / ISO 3771		
Ash content	wt.-% [kg/kg] / ISO 6245	1.85	
Viscosity	[mm <sup>2</sup> /s] / ASTM D7042	11	@100°C
Sulphur content	wt.-% [kg/kg] / ISO 20884		

#### 3.2 Cylinder oil Please fill in as far as possible Please fill in if applicable

Property	Unit / Standard	Actual value	Remark
Lube oil	Brand / Type		
Grade	Multi / Mono		
BN	mg KOH/g / ISO 3771		
Ash content	wt.-% [kg/kg] / ISO 6245		
Viscosity	[mm <sup>2</sup> /s] / ASTM D7042		
Sulphur content	wt.-% [kg/kg] / ISO 20884		

#### 3.3 Valve seat lubrication oil Please fill in as far as possible Please fill in if applicable

Property	Unit / Standard	Actual value	Remark
Lube oil	Brand / Type		
Grade	multi / mono		
BN	mg KOH/g / ISO 3771		
Ash content	wt.-% [kg/kg] / ISO 6245		
Viscosity	[mm <sup>2</sup> /s] / ASTM D7042		
Sulphur content	wt.-% [kg/kg] / ISO 20884		

#### 4. Measurement equipment information (to be completed before measurement) and parameters

##### Measurement instrument

##### 4.1 BC measurement instrument information

Make: AVL Model: AMA 415 S

##### 4.2 Measurement principle

☐ LII ☒ FSN ☐ PAS ☐ MAAP  
☐ Others: \_\_\_\_\_

##### 4.3 Values reported as

☐ EC (thermal) Protocol acc.: \_\_\_\_\_  
☐ rBC  
☐ eBC  
☒ FSN  
☐ Others: \_\_\_\_\_

##### 4.4 Values reported in unit

☐  $\text{mg}/\text{m}_n^3$  (wet basis; act.  $\text{O}_2$ -concentration)  $\text{H}_2\text{O}$ -conc.: \_\_\_\_\_ [Vol.-%] (wet)  
☐  $\text{mg}/\text{m}_n^3$  (dry basis; act.  $\text{O}_2$ -concentration)  
☐  $\text{mg}/\text{m}_n^3$  (dry basis; Ref.  $\text{O}_2$ -concentration)  $\text{O}_2$ -conc.: \_\_\_\_\_ [Vol.-%] (dry)  
☐  $\text{mg}/\text{kWh}$  refer to 5.  
☒ FSN  
☐  $\text{mg}/\text{kg}$  fuel refer to 5.  
☐ Others: \_\_\_\_\_

##### 4.5 Reference conditions

(only if 4.4 is referred to Norm-cubic meters [ $\text{m}_n^3$ ])

Norm temperature: \_\_\_\_\_ [°C]  
Norm pressure: \_\_\_\_\_ [mbar]

##### 4.6 Sampling time / -number

Sampling time of each measurement: automatic mod [s]  
If mean values are reported: Number of consecutive  
measurements at each mode point: 1 [-]  
Acc. manufacturer specification: ☒ Yes ☐ No

##### 4.7 BC instrument parameter

Temperature inside measuring cell: 65 [°C]  
Pressure inside measuring cell: 980 [mbar]  
Wavelength(s) used: \_\_\_\_\_ [nm]  
Mass absorption cross section(s) used: \_\_\_\_\_ [ $\text{m}^2/\text{g}$ ]  
Conversion equation(s) used: \_\_\_\_\_  
Repeatability of the instrument used: (+/-0,005 FSN +3% of value)  
Reproducibility of the instrument used: (+/-0,005 FSN +6% of value)  
Acc. manufacturer specification: ☒ Yes ☐ No

Other parameters which could influence the measured values:

Parameter / Correction	Unit

##### 4.8 BC Instrument Calibration

Date of last calibration: \_\_\_\_\_ (dd.mm.yyyy)

Calibration procedure according manufacturer specification:

☒ Yes ☐ No ☐ Others: \_\_\_\_\_

Calibration including zero point: ☐ Yes ☐ No

Used medium for zero point calibration: \_\_\_\_\_

Used calibration standard: ☐ Synthetic flame soot  
☐ Printex-U  
☐ Graphite spark aerosol generator GfG soot  
☐ Soot with inorganic coatings  
☐ Soot without inorganic coatings  
☒ Reflectance standards  
☐ Others: \_\_\_\_\_

Remark: \_\_\_\_\_

Leakage test performed before or after calibration: ☐ Yes ☐ No ☐ Not applicable

##### 4.9 Sample gas pre-treatment

Please fill in if applicable

Exhaust gas dilution: ☐ Yes ☒ No  
If yes, dilution ratio (1:x) \_\_\_\_\_ at mode point: \_\_\_\_\_ [%]

_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

Dilution medium: ☐ Ambient air ☒ Exhaust gas  
☐ Others: \_\_\_\_\_

Filtration of the dilution medium before dilution: ☐ Yes ☐ No

Temperature of the dilution medium: \_\_\_\_\_ [°C]  
Temperature of the diluted exhaust gas: \_\_\_\_\_ [°C]

Evaporation tube ☐ Yes ☒ No  
Temperature \_\_\_\_\_ [°C] acc. manufacturer spec. ☐ Yes ☐ No

Catalytic stripper ☐ Yes ☒ No  
Temperature \_\_\_\_\_ [°C] acc. manufacturer spec. ☐ Yes ☐ No

Thermo-denuder ☐ Yes ☒ No  
Temperature \_\_\_\_\_ [°C] acc. manufacturer spec. ☐ Yes ☐ No  
Others: \_\_\_\_\_

#### 4.10 Sample flow rate/volume

Acc. manufacturer specification: ☒ Yes ☐ No  
Sample flow rate of the raw exhaust gas: \_\_\_\_\_ up to 10 [l/min]  
Sample flow rate of the diluted exhaust gas: \_\_\_\_\_ [l/min]  
Sample volume of the raw exhaust gas: \_\_\_\_\_ [l]  
Sample volume of the diluted exhaust gas: \_\_\_\_\_ [l]  
☐ Subkinetic ☐ Isokinetic ☐ Superkinetic ☐ Not applicable

### Sample line and probe

#### 4.11 Sample/transfer line Please fill in if applicable

Use of a sample line: ☒ Yes ☐ No (in situ,...)

Acc. manufacturer specification: ☒ Yes ☐ No

Length of the sample line: \_\_\_\_\_ [m]

Heated sample line: ☒ Yes ☐ No  
Temperature: \_\_\_\_\_ 70 [°C]

Sample line material: Viton

Inner diameter of the sample line: \_\_\_\_\_ 4 [mm]

Isolated or heated connections between sample line, measurement instrument and probe: ☒ Yes ☐ No

Electrical conductive (sample line material): ☒ Yes ☐ No  
Grounded: ☒ Yes ☐ No  
Grounding method: connected with grounded exhaust pipe

Backflushing sample line between measurements: ☐ Yes ☐ No

#### 4.12 Sample probe Please fill in if applicable

Use of sample probe: ☒ Yes ☐ No (in situ,...)

Acc. manufacturer specification: ☒ Yes ☐ No

Material: ☒ Stainless steel ☐ Others: \_\_\_\_\_

Type/design:  
☐ Probe with single hole at the end (pipe)

X Probe with single hole at the end (45° beveled)

☐ Multi-hole

☐ L-shaped pipe with single hole, opening shielded with preclassifier (e.g. hat)

☐ Others: \_\_\_\_\_

Direction of the probe opening relative to the exhaust gas flow:

☐ With flow X Against flow

☐ Others: \_\_\_\_\_

Effective cross section of sample hole opening(s) \_\_\_\_\_ [mm<sup>2</sup>]

Backflushing sample probe between measurements: X Yes ☐ No

## Sampling point and probe location

4.13 Sample point and probe location X Engine Outlet

☐ Downstream heat exchanger

☐ Downstream exhaust gas treatment device

Treatment device active during measurement ☐ Yes ☐ No

☐ Others: \_\_\_\_\_

Distance between engine outlet and sampling point: \_\_\_\_\_ [m]

Diameter of the exhaust gas pipe: \_\_\_\_\_ [m]

Type of exhaust gas pipe where the sample probe is located:

☐ Straight part of the exhaust gas pipe

☐ Bent part of the exhaust gas pipe

Immersion depth of the sample probe: middle of pipe [m]

Orientation of the exhaust gas pipe where the sample probe is located:

☐ Horizontal ☐ Vertical ☐ Others: \_\_\_\_\_

Length of straight part of the exhaust gas pipe,

if sample probe is located at straight part of the exhaust gas pipe:

Upstream sample probe: \_\_\_\_\_ [m]

Downstream sample probe: \_\_\_\_\_ [m]

Exhaust gas pulsation at the sampling point during measurement:

X No ☐ Yes \_\_\_\_\_ [mbar]

## 5. Determination of engine load, exhaust gas flow, exhaust water content, fuel mass flow, O<sub>2</sub> and CO<sub>2</sub>

(if applicable)

5.1 Determination of values, instrument performance and calibration shall be in accordance with the requirements of NOx Technical Code 2008 (NTC 2008) and its applicable appendices

5.2.1 Method of load determination

5.2.2 Estimated accuracy of engine load determination +/- \_\_\_\_\_ [%] of reading

5.3.1 Method of exhaust gas flow determination

5.3.2 Estimated accuracy of exhaust gas flow determination C-balance  
+/- \_\_\_\_\_ [%] of reading

5.4.1 Method of exhaust water content determination

5.4.2 Estimated accuracy of exhaust water content determination ---  
+/- \_\_\_\_\_ [%] of reading

5.5.1 Method of fuel mass flow determination

5.5.2 Estimated accuracy of fuel mass flow determination flow meter  
+/- \_\_\_\_\_ [%] of reading

5.6.1 Method of O<sub>2</sub> and CO<sub>2</sub> determination

5.6.2 Estimated accuracy of O<sub>2</sub> and CO<sub>2</sub> determination PMD / IRD analyser  
+/- \_\_\_\_\_ [%] of reading

## 6. Measured values for BC determination (to be completed during measurement; measured values)

Date of measurement (dd.mm.yyyy) 15/10/2010

### Engine parameters

Measurement at mode points:

100	75	50	25	
↓	↓	↓	↓	↓

 [%]

#### 6.1 Stabilized mode point

Actual Speed

1151	1046	913	726	
------	------	-----	-----	--

 [rpm]  
Speed variation during measuring  
+/- [%]

Actual Load

9102	6826	4548	2274	
------	------	------	------	--

 [kW]  
Load variation during measuring  
+/- [%]

6.2 Charge air temperature

49	48.7	52.7	55.9	
----	------	------	------	--

 [°C]

6.3 Charge air pressure 

3980	3170	2710	2070	
------	------	------	------	--

 [mbar]

6.4 Exhaust gas temp. at engine outlet 

474.3	391.4	363.1	327.7	
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 [°C]

6.5 Exh. gas temp. at sampling point 

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 [°C]

(only if there is a significant difference to the exhaust gas temperature at the engine outlet)

6.6 Exhaust gas back pressure 

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 [mbar]

6.7 Exhaust gas mass flow 

50398	37239	27502	16379	
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 [kg/h]

#### Ambient conditions

6.8 Ambient temp. at engine inlet 

26.1	25.8	25.7	26	
------	------	------	----	--

 [°C]

6.9 Ambient pressure at engine inlet 

975	977	974	981	
-----	-----	-----	-----	--

 [mbar]

6.10 Absolute humidity of ambient air 

5.26	5.44	5.54	5.5	
------	------	------	-----	--

 [g/kg]

7. Black Carbon Reported as (see 4.3): 

FSN
-----

 Unit (see 4.4): 

FSN
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7.1 Estimated accuracy of measured value 

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 +/- [%]

7.2 Black Carbon emission 

0.37	0.39	0.37	0.2	
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Remark: 

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#### 8. Measurement repeatability Indicators

8.1 95% confidence interval 

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( +/- unit measured)

8.2 Variance 

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8.3 Sample size 

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(number of measurements taken)