IMO NOx TECHNICAL FILE

Hull No.	HMDS003
Engine Type	6S50MC-C
Engine No.	A A 3 3 8 2

HYUNDAI
HEAVY INDUSTRIES CO.,LTD.

DET NORSKE VERITAS

Certificate no.:
EIAPP-953-3-A
Date of issue:
2009-09-15

ENGINE INTERNATIONAL AIR POLLUTION PREVENTION CERTIFICATE

This Certificate shall be supplemented by
a Record of Construction, a Technical File and Means of Verification

Issued under the provisions of the Protocol of 1997 to amend the International Convention for the Prevention of Pollution from Ships, 1973, as modified of the Protocol of 1978 related thereto (hereinafter referred to as "the Convention") under the authority of the Government of

THE REPUBLIC OF LIBERIA

by **Det Norske Veritas**

Particulars of engine

Engine manufacturer:	**Hyundai Heavy Industries Co., Ltd.**
Model number:	**HYUNDAI-MAN B&W 6S50MC-C7**
Serial number:	**AA3382**
Test cycles(s):	**E3**
Rated power [kW] and speed [rpm]:	**8820 kW @ 119 rpm**
Engine approval number:	**EIAPP-G-0953-0003**

THIS IS TO CERTIFY:

1. That the above mentioned marine diesel engine has been surveyed for pre-certification in accordance with requirements of the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines made mandatory by Annex VI of the Convention; and

2. That the pre-certification survey shows that the engine, its components, adjustable features, and technical file, prior to the engine's installation and/or service onboard a ship, fully comply with the applicable regulation 13 of Annex VI of the Convention.

Remarks/Recommendations:

This Certificate is valid for the life of the engine, subject to surveys in accordance with Regulation 5 of the ANNEX VI of the Convention, installed in ships under the authority of this Government.

Issued at **Oslo** on **2009-09-15** (date)

for **Det Norske Veritas AS**

Tomas Heber Tronstad
Head of Section

DET NORSKE VERITAS * 1864 *

RJS iN516

DET NORSKE VERITAS

Record no.:
EIAPP-953-3-A
Date of issue:
2009-09-15

SUPPLEMENT TO ENGINE INTERNATIONAL AIR POLLUTION PREVENTION CERTIFICATE

(EIAPP CERTIFICATE)

RECORD OF CONSTRUCTION, TECHNICAL FILE AND MEANS OF VERIFICATION

In respect of the provisions of Annex VI of the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocols of 1978 and 1997 relating thereto (hereinafter referred to as "the Convention") and of the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines (hereinafter referred to as the "NO_x Technical Code").

Notes:

1 This Record and its attachments shall be permanently attached to the EIAPP Certificate. The EIAPP Certificate shall accompany the engine throughout its life and shall be available on board the ship at all times.

2 If the language of the original Record is neither English nor French, the text shall include a translation into one of these languages.

3 Unless otherwise stated, regulations mentioned in this Record refer to regulations of Annex VI of the Convention and the requirements for an engine's technical file and means of verifications refer to mandatory requirements from the NO_x Technical Code.

1. Particulars of the engine

.1	Name and address of manufacturer.....	**Hyundai Heavy Industries Co., Ltd. 1, Cheonha-Dong, Dong-Gu, ulsan, Korea**
.2	Place of engine build	**As above**
.3	Date of engine build	**June 2009**
.4	Place of pre-certification survey.....	**As above**
.5	Date of pre-certification survey	**2009-06-18**
.6	Engine type and model number	**HYUNDAI-MAN B&W 6S50MC-C7**
.7	Engine serial number	**AA3382**
.8	If applicable, the engine is a parent engine [-] or a member engine [X] of the following engine family [-] or engine group [X]	**HYUNDAI-MAN B&W 6S50MC-C-2008-15**
.9	Test cycle(s) (see chapter 3 of the NO_x Technical Code)	**E3**
.10	Rated power [kW] and speed [rpm]	**8820 kW @ 119 rpm**
.11	Engine approval number	**EIAPP-G-0953-0003**
.12	Specifications of the test fuel	**ISO 8217-F-DMC Grade**
.13	NO_x-reducing device designated approval number (if installed)	**Not Applicable**
.14	Applicable NO_x emission limit [g/kWh] (regulation 13 of Annex VI)	**17.0**
.15	Engine's actual NO_x emission value, cycle **E3**, [g/kWh].....	**15.4**

2 Particulars of the technical file

.1	Technical file identification/approval number	**EIAPP-G-0953-0003**
.2	Technical file approval date	**2009-09-15**
.3	The technical file, as required by Ch. 2 of the NO_x Technical Code, is an essential part of the EIAPP Certificate and must always accompany an engine throughout its life and always be available on board a ship.	

3. Specification for the On-board NO_x verification procedure for the engine parameter survey

.1	On-board NO_x verification procedures identification/approval number	**EIAPP-G-0953-0003**
.2	On-board NO_x verification procedures approval date	**2009-09-15**
.3	The specifications for the on-board NO_x verification procedures, as required by Ch. 6 of the NO_x Technical Code, are an essential part of the EIAPP Certificate and must always accompany an engine throughout its life and always be available on board a ship.	

THIS IS TO CERTIFY that this Record is correct in all respects:

Issued at **Oslo** on **2009-09-15** (date)

for **Det Norske Veritas AS**

Tomas Heber Tronstad
Head of Section

DET NORSKE VERITAS * 1864 *

HYUNDAI
HEAVY INDUSTRIES CO., LTD.

Technical File

Issued under the provisions of the Protocol of 1997 to the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 related thereto (MARPOL 73/78)

for

HYUNDAI-MAN B&W 6S50MC-C7

Certified as a 'Member' engine

Prepared by, ***HYUNDAI HEAVY INDUSTRIES CO., LTD., ENGINE & MACHINERY DIVISION, ENGINE DEVELOPMENT & TEST DEPARTMENT***

Identification/approval number ***HYUNDAI-MAN B&W 6S50MC-C-2008-15-AA3382/***

Issued at ***HYUNDAI HEAVY INDUSTRIES CO., LTD., ULSAN, KOREA***

Date of issue

Signature of duly authorized official issuing the certificate

(Seal or Stamp of the authority, as appropriate)

DET NORSKE VERITAS 1864
2009. 09. 15
SIGN :
DET NORSKE VERITAS AS

EIAPP-G-0953-0003

DET NORSKE VERITAS 1864

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A. General

The Technical file is issued under the provisions of Annex VI of the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocols of 1978 and 1997 relating thereto (hereinafter referred to as "the Convention") and of the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines (hereinafter referred to as "the IMO NOx Technical Code")

for

HYUNDAI-MAN B&W 6S50MC-C7

1. Certified as an a ☐ Individual / ☐ Parent / ■ Member Engine of Engine Group

Engine Manufacturer	: Hyundai Heavy Industries Co., Ltd.
Engine Type	: HYUNDAI-MAN B&W 6S50MC-C7
Engine Number	: AA3382
Number of Engine	: One(1) set as a Member Engine
Test Cycle	: E3
Rated Power	: 8820 kW
Rated Speed	: 119 RPM
M.E.P.	: 18.9 bar

2. Prepared & Issued by Hyundai Heavy Industries Co., Ltd., Engine & Machinery Division

This is to certify that this Technical File including procedures for demonstrating compliance with NOx emission limits on board a ship, Engine Parameter Check Method, for the above mentioned marine diesel engine, prior to the engine's installation and/or service on load a ship, fully comply with the requirements of the IMO NOx Technical Code made mandatory by Annex VI of the Convention.

Identification/approval number : *HYUNDAI-MAN B&W 6S50MC-C-2008-15-AA3382/*

.....

Date of issue

(Signature of duly authorized official issuing the certificate)

(Seal or Stamp of the authority, as appropriate)

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B. Summary

IMO NOx emission test on one(1) main propulsion engine for Hyundai Vinashin Shipyard Co., Ltd. Hull No. S001 was carried out as parent engine of the HYUNDAI-MAN B&W 6S50MC-C-2008-15-AA3182 at test bed in order to fully meet the IMO NOx Technical code.

However, if this group has member engines, additional IMO NOx compliance test for them is not to be performed because it can be considered as identical engines having the same NOx relevant components, rated power, rated RPM, nearly similar setting values and also identical IMO ID numbers compared with the Parent Engine.

1. *Calibrations of Zero & Span for gas analyzers were successfully carried out under the presence of the surveyor (s).*

2. *Analyzers and calibration gases have been confirmed in compliance with the IMO NOx Technical Code by the surveyor(s).*

3. *Calculations of the emission value and exhaust, gases emission have been done according to the IMO NOx Technical Code as follows :*

   (1) *Humidity correction factors for NOx for diesel engines (Khdies) have been calculated according to formula(14) of 5.12.3.6 on the IMO NOx Technical Code.*

   (2) *Humidity of intake air(Ha) according to formula(10) of 5.12.2.1 on the IMO NOx Technical Code.*

   (3) *Dry to wet correction factor (Kw,r) for the raw exhaust gas according to formula(11) of 5.12.2.2 on the IMO NOx Technical Code.*

   (4) *The exhaust gas mass flows were calculated according to Method 2, Universal, Carbon/Oxygen-balance, 3 of Appendix 6 on the IMO NOx Technical Code.*

   (5) *The NOx emission value was corrected to reference conditions as shown in Chapter I.8 which includes a scavenge air cooler fresh water coolant inlet temperature of 36 ℃ when operating under reference conditions-25 ℃ sea water temperature for central fresh water cooling system, whereas a scavenge air cooler sea water coolant inlet temperature of 25 ℃ for conventional sea water cooling system. Basically, charge air cooling system for this group is shown in the Chapter F, "List of NOx Relevant Components and Setting" and the Chapter N, "Engine Group Information".*

4. *The certificates for analytical instruments and calibration gases were not included in this Technical File because they had been checked and confirmed by surveyor during NOx emissions test. However, summarized information on the analytical instruments can be seen on Chapter O, Test Cell Information in this Technical File.*

Finally, the test result (NOx : 15.40 g/kWh) for parent engine which is corrected to ISO NOx values based on reference Pmax and scavenge air temperature as mentioned in Chapter I.8, HYUNDAI-MAN B&W 6S50MC-C-2008-15-AA3182 is showed far less than IMO NOx limit (17.0 g/kWh).

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C. Particulars of the Engine

Two-stroke, single acting, direct reversible, cross head, constant pressure turbocharging diesel engine, and using heavy fuel oil.

1. Name and address of manufacturer : Hyundai Heavy Industries Co., Ltd.
   1, Cheonha-Dong, Dong-Gu, Ulsan, Korea
2. Place of engine build : Same as the above
3. Date of engine build : June 2009
4. Place of pre-certification survey : Hyundai Heavy Industries Co., Ltd.
   1, Cheonha-Dong, Dong-Gu, Ulsan, Korea
5. Date of pre-certification survey : June 17, 2009
6. Engine type : HYUNDAI-MAN B&W 6S50MC-C7
7. Engine number : AA3382
8. If applicable, the Engine is ☐ an Individual Engine, ☐ Parent / ■ Member Engine of Engine Group of the following ☐ Engine Family, or ■ Engine Group,

   Engine Group Name : HYUNDAI-MAN B&W 6S50MC-C-2008-15

9. Test cycle(s)(acc. to Chapter 3 of the IMO NOx Technical Code) : E3
10. Rated Power & Speed : 8820 kW at 119 RPM
11. Mean effective pressure : 18.9 bar
12. Max. combustion pressure : 150 bar
13. Engine approval number :
14. Specification of test fuel
    (and/or Certification number of fuel sample analysis) : Bunker-A (ISO 8217, DMC)
    (Parent engine of engine group)
15. NOx reducing device designated approval number (if installed) : Not applicable
16. Applicable NOx emission limit (Regulation 13 of Annex VI) : 17.0 g/kWh
17. Engine's actual NOx emission value : 15.40 g/kWh (AA3182)
    (Parent engine of engine group)

D. Particulars of the Technical File

The Technical File, as required by Chapter 2 of the IMO NOx Technical Code, is an essential part of the EIAPP Certificate and must always accompany an engine throughout its lift and always be available on-board a ship.

1. Technical File identification/approval number : .....

.....

2. Technical File approval date : .....

.....

E. Specifications of the On-board NOx Verification Procedures for the Engine Parameter Survey

The Specifications for the on-board NOx verification procedures, as required by Chapter 6 of the IMO NOx Technical Code, is a essential part of the EIAPP Certificate and must always accompany and engine throughout its life and always be available on-board a ship.

1. On-board NOx verification procedures identification/approval number :

.....

2. On-board NOx verification procedures approval date :

.....

F. List of NOx Relevant Components and Settings

1. Components (Standard Engine set-up plus listing of allowed inter-changeable components)

Description	Value	Identification Number	Range/ Alternative	Notes
Engine Specification				
Number of cylinders	6	-	-	1)
Cylinder liner (bore, Ø mm)	500	A19-266039-5, A19-212323-4, 3170262-7	-	1), 2)
Stroke (mm)	2000	-	-	1)
Combustion chamber (compression ratio : see settings)				
Cylinder cover	-	A10-212926-7, 5025583-3	-	2)
Piston crown	-	A10-255133-2, 5012873-6	-	2)
Fuel injection equipment (per cylinder unit)				
Barrel of fuel pump	-	1170729-8	-	2)
Plunger of fuel pump (dia., Φmm)	52	1171182-5	-	1), 2)
Fuel injection valve (number of fuel valve(s))	2	-	-	1)
Atomizer of fuel valve (number, Φmm) (opening/closing : see settings)	-	3062332-6x115	-	2)
Fuel cam	-	A19-124775-1, 1173321-5	-	2)
Exhaust cam	-	A19-124779-9, 1173320-3	-	2)
Auxiliary blower	2	Serial No. : 08B0276-01-05, 08B0276-01-06	-	1), 2)
Turbocharger maker/type : Hyundai-ABB TPL77B12				
Number & S/No. of turbocharger(s)	1	Serial No. : XH002480	-	1), 2)
Compressor wheel	-	CV12 CT65	-	2)
Diffuser	-	CT65 CA17	-	2)
Turbine rotor	-	TT40 TF15	-	2)
Nozzle ring	-	TT40 TA22	-	2)
Charging air cooling system : Central fresh water cooling system				
Charge air cooler	1	Serial No. : 76667	A19-274025-8	1), 2)
Charge air cooling water inlet temp.(℃)	36	-	-	1), 3)

2. Settings (Engine matching at test bed)

Description	Value	Drawing/ Ident. No.	Range/ Alternative	Notes
Engine Layout				
Rated power (MCR, kW)	8820	-	-	1)
Rated speed (RPM)	119	-	-	1)
Mean effective pressure at rated power (M.E.P., bar)	18.9	-	-	1)
Maximum combustion pressure (bar)	150	-	150 ± 3	1)
Performance set-up				
Compression ratio (mm) (Compression shim thickness)	8	-	Piston rod effective length 2635 mm	1), 4)
Fuel valve opening pressure (bar)	350	-	350 ± 30	1)
Fuel cam lead angle (deg. CA)	Refer to Chapter I and S.		-	4)
Fuel cam lift (mm)	Refer to Chapter I and S.		Tolerance + 1	4)
Number of fuel pump shim (EA)/ Thickness of fuel pump shim (mm)	Refer to Chapter I and S.		Tolerance ± 1	4)
Fuel pump orifice (φmm, if applicable)	Refer to Chapter I.		-	-
Exhaust cam lead angle (deg. CA)	Refer to Chapter I and S.		Tolerance ± 1	4)

Certified range for maximum combustion pressrue(measured) - without VIT

Parameters	Actual adjustment on test bed	Certified range for adjustment	Checking of adjustment
Combustion pressure at 50% power	105.2 bar	111 bar or below	Pressure measurement
Combustion pressure at 75% power	132.2 bar	136 bar or below	Pressure measurement
Combustion pressure at 100% power	149.8 bar	153 bar or below	See chapter I and S.

Notes)

1) Parameters, operating values and settings can be verified through an engine performance check.

2) The Identification numbers for cylinder liner, cylinder cover, piston crown, exhaust cam and fuel cam are marked with one(1) or over two(2) kinds of numbers (i.e., HHI's number : XXX-XXXXXX-X, licensor's number as alternative : XXXXXXX-X). And even if only one of the above and/or both kinds of numbers can be marked on the above components, they are identical components each other. In addition, identification or serial numbers for fuel injection barrel, plunger, atomizer, turbo-charger(s), charge air cooler(s) and auxiliary blowers are marked with sub-manufacturer's number.

   Some NOx relevant components may have over two(2) IMO identification numbers as an alternative. Therefore, one of mentioned IMO Identification numbers in this technical file can be available on this engine.

   The revision number of IMO identification number for each NOx relevant components does not have an effect on NOx emission value because this revision number is only for HHI's drawing management system. (for instance, XXX-XXXXXX-X.X)

   ↘ (revision number)

3) For central fresh water cooling system, the temperature(36℃) is for cooling water inlet under reference conditions - 25℃ sea water temperature.

   For conventional sea water cooling system, the inlet temperature(25℃) is for cooling water inlet reference conditions and the Tsc. tolerance are given to the stated reference value in Chapter I-8 for each load, i.e., if the sea water temperature is 10℃ higher than the reference sea water temperature, the nominal Tsc. at 100% load would be 54℃ and actual max. allowable Tsc. Would be 60℃.

   For sea water cooling system, there is no intermediate cooler between sea water and the scavenge air coolant the maximum temperature under reference condition is 25℃.

4) Compression shim thickness, fuel cam lead angle, fuel pump top lift, fuel pump shim thickness/numbers and exhaust cam lead angle can be adjusted and changed in order to keep maximum combustion pressure within the approved ranges as given in Chapter F.2

   Note : Any adjustment(s) and change(s) should be recorded in the 'Record Book' of engine parameters.

G. Guideline for Components Replacements

1. General

If any of the components listed under "List of NOx Relevant Components and Settings" on Chapter F has to be changed during operation, the replacing component should be identical to the old one.

The guarantee to receive the correct component can only be achieved by ordering the new components through the engine manufacturer.

2. Proceeding for the replacement

1. Order the component indicating the ID numbers specified in this Technical File through the engine manufacturer.
2. Substitute the old component by the new one.
3 Record the substitution including component specification, date of replacement and component supplier in the "Engine's Record Book of engine parameters" which has to keep on board of the ship.

H. Measurements for IMO Compliance Test at Test Bed

The table 1 shows a list of the measured 'standard' performance parameters at test bed.
And the allowable ranges for some of the parameters are given in Chapter F.2.

Table 1. Measured Performance Parameters at Test Bed

*	- Engine rated power (kW)
*	- Engine rated speed (RPM)
	- Mean effective pressure (bar)
	- Cylinder maximum pressure (bar)
	- Compression pressure (bar)
	- Fuel injection timing (deg. CA bTDC)
*	- Fuel consumption (kg/h)
	- Turbocharger speed (RPM)
	- Exhaust gas temperature after cylinder outlet (℃)
* *	- Exhaust gas flow (kg/h)
* *	- Air consumption (kg/h)
*	- Exhaust gas emissions
*	- Exhaust gas pressure (at sampling position, mmWC)
*	- Exhaust gas temperature (at sampling position, ℃)
*	- Air inlet temperature (at turbocharger compressor side, ℃)
*	- Atmospheric pressure (kPa)
*	- Intake air humidity (%)
*	- Ambient temperature (℃)
*	- Charge air pressure (kg/cm2)
*	- Charge air temperature (℃)
*	- Charge air cooling water inlet/outlet temperature (℃)
*	- Lubricating oil cooler (i.e., oil side) inlet/outlet (℃)
*	- Fuel oil inlet temperature (℃)

Remarks)

1. The measurements marked ' * ' shall be carried out with gauges and analyzers calibrated according to the Appendix 4 of the IMO NOx Technical Code.
2. The measurements marked ' * * ' shall be carried out through the carbon balance method according to the IMO NOx Technical Code 5.5.3.
3. Concerning the engine dynamometer specified in the IMO NOx Technical Code Chapter 5, in case that an engine is supplied with alternator attached, it is not practical to apply a dynamometer to measure the engine power measurements.
   Therefore, by using of alternator power meter with alternator efficiency, the calculation of the power output from the engine based on reading taken from the alternator output shall be applied.

I. On Board Verification Procedure

1. General

The following described procedure shows an easy and reliable verification of the engine in order to confirm its compliance with Annex VI to MARPOL 73/78.
The procedure should be applied to initial, periodical and intermediate surveys after installation of the engine in the ship. The procedure can be performed during the stop in the harbor without running the engine except for some setting parameters. All ID-numbers, settings and dimensions mentioned in the following verification procedure are defined in the "List of NOx Relevant Components and Settings" on Chapter F.

2. The procedure for on board verification

The procedure of an engine for on-board verification shall be carried out as follows ;

Firstly,

The Technical File, Record Book and Technical documentation shall be checked by surveyor.

Secondly,

The engine components and parameter setting values shall be reviewed by surveyor.

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2009. 09. 15
SIGN : HAH
DET NORSKE
EIAPP - G-0953-0003

DET NORSKE VERITAS 1864

3. Check for engine components and parameters

The following summarize the easy and reliable verification of the engine in order to confirm its components compliance with Annex VI to MARPOL 73/78 for engine test shop and on-board verification.

Engine Specification

1. Rated power & RPM : Check the name plate on engine body.

Combustion chamber

1. Cylinder liner : Check the IMO ID-number.
2. Cylinder cover : Check the IMO ID-number.
3. Piston crown : Check the IMO ID-number.

Fuel injection equipment

1. Barrel of fuel pump : Check the IMO ID-number.
2. Plunger of fuel pump : Check the IMO ID-number and diameter.
3. Number of fuel valve(s) : Check the number of the fuel valve(s) per cylinder.
4. Atomizer of fuel valve : Check the IMO ID-number.
5. Fuel cam : Check the IMO ID-number.
6. Exhaust cam : Check the IMO ID-number.

Turbocharger

1. Maker : Check the name plate.
2. Number of T/C(s) : Check the number of the turbocharger(s).
3. Serial No./Model : Check the serial number/model on name plate.
4. Compressor wheel : Check the IMO ID-number.
5. Diffuser : Check the IMO ID-number.
6. Turbine rotor : Check the IMO ID-number.
7. Nozzle ring : Check the IMO ID-number.

Charge air cooling system

1. Maker : Check the name plate.
2. Number of air cooler(s) : Check the number of the air cooler(s).
3. Serial No./IMO ID : Check the name plate.
4. Cooling system : Check cooling system corresponds to Chapter F/M/N.

Governor

1. Maker : Check the name plate.
2. Model : Check the model name.

Aux. Blower

1. Maker : Check the name plate.
2. Serial No. : Check the name plate.

Performance set-up

1. Compression ratio : Check the thickness of compression shim.
2. Exhaust cam lead angel : Check the lead angle.
3. Fuel cam lead angel & top lift : Check the lift of fuel pump.
4. Fuel pump lead angle : Check the lead angle (only for reference)
5. Fuel pump shim(s) : Check the number and thickness of fuel pump shim(s). (only for without VIT system)
6. Fuel pump orifice : Check the size of orifice of fuel pump (if applicable)

4. Procedures for an engine parameter check method

No.	Inspection		Remarks
1	**Inspection of documents**		
1.1	Inspection of Technical File		
1.2	Inspection of Record Book of engine parameters		
1.3	Inspection of Technical Documentation of engine components modification		
2	**Inspection of engine components**		
2.1	Piston crown	Ident. No. : A10-255133-2, 5012873-6	
2.2	Cylinder cover	Ident. No. : A10-212926-7, 5025583-3	
2.3	Cylinder liner	Ident. No. : A19-266039-5, A19-212323-4, 3170262-7	
2.4	Barrel of fuel pump	Ident. No. : 1170729-8	
2.5	Plunger of fuel pump	Ident. No. : 1171182-5	Dia. : 52 mm
2.6	Fuel injection valve (number of fuel valve(s))	Number : 2/cylinder	
2.7	Atomizer of fuel valve	Ident. No. : 3062332-6x115	
2.8	Fuel cam	Ident. No. : A19-124775-1, 1173321-5	
2.9	Exhaust cam	Ident. No. : A19-124779-9, 1173320-3	
2.10	Governor	Maker : Kongsberg Maritime Korea Model : AC C20 DGS	Serial No. : Name plate
2.11	Turbocharger	Maker : Hyundai-ABB Model : TPL77B12 Serial No. : XH002480	Serial No. : Name plate
2.12	Scavenge air cooler	Maker : Vestas Aircoil Ident. No. : A19-274025-8 Serial No. : 76667	Serial No. : Name plate
2.13	Auxiliary blower	Maker : Tae Il Blower Mfg. Co., Ltd. Serial No. : 08B0276-01-05, 08B0276-01-06	Serial No. : Name plate
3	**Inspection of setting values**		
3.1	Rated power	8820 kW : See N.P. & T.F.	
3.2	Rated speed	119 RPM : See N.P. & T.F.	
3.3	Max. combustion pressure	150.0 bar at rated power	
3.4	Compression ratio (shim thickness)	8 mm (beneath piston rod)	
3.5	Exhaust cam	Lead angle : See next page.	
3.6	Fuel cam / Fuel pump	Lead angle and top lift : See next page.	
3.7	Fuel pump shim / thickness	Number and thickness : See next page.	
3.8	Fuel pump orifice	Diameter : See next page.	
4	**Review of operating values with fuel oil analysis as well as shop test report, if available**		for reference
4.1	Scav. air temperature	See I.8	
4.2	Max. cylinder pressure	See I.8	

Notes)
(1) T.F. : Technical File.
(2) N.P. : Name Plate of engine
(3) The most important : Atomizer of fuel valve
(4) The surveyor shall have the option of checking one or all the identified components, settings or operating values to ensure that the engine with number, or minor, adjustment or modifications complies with the applicable emission limits and that only components of the current specification are being used. Especially, if it is necessary to survey a combustion pressure, the combustion pressure at 50% and 75% load can be measured and evaluated according to the maximum combustion pressure table on page 9.

5. Inspection of turbocharger components

No.	Components	Identification No.	Remarks
1	Compressor wheel	CV12 CT65	-
2	Diffuser	CT65 CA17	-
3	Turbine rotor	TT40 TF15	-
4	Nozzle ring	TT40 TA22	-

6. Exhaust cam lead (advance angle)

*** for parent engine ***

Cylinder No.	1	2	3	4	5	6	7	8	9	10	11	12	Average
Measured angle (before TDC) at shop test bed	-3.40	-3.35	-3.45	-3.40	-3.35	-3.40	-	-	-	-	-	-	-3.39

(Design Value: Angle A : 112.9°, Lift = 10 mm / Angle B : 254.1°, Lift = 10 mm)

*** for member engine ***

Cylinder No.	1	2	3	4	5	6	7	8	9	10	11	12	Average
Measured angle (before TDC) at shop test bed	-3.40	-3.20	-3.35	-3.20	-3.35	-3.35	-	-	-	-	-	-	-3.31

(Design Value: Angle A: 112.9°, Lift = 10.0 mm / Angle B : 254.1°, Lift = 10.0 mm)

7. Fuel cam (lead angle) / Fuel pump(top lift)

*** for parent engine ***

Cylinder No.	1	2	3	4	5	6	7	8	9	10	11	12	Average
Measured angle (before TDC) at shop test bed	9.40	9.80	9.70	10.30	9.70	9.80	-	-	-	-	-	-	9.78
Number of fuel pump shim (EA)	8	8	8	8	8	8	-	-	-	-	-	-	8
Thickness of fuel pump shim (mm)	0.5	0.5	0.5	0.5	0.5	0.5	-	-	-	-	-	-	0.5
Top lift(mm) at shop test bed	10.64	11.36	11.09	11.93	11.07	11.28	-	-	-	-	-	-	11.23
Fuel pump orifice (φmm, if applicable)	-	-	-	-	-	-	-	-	-	-	-	-	-

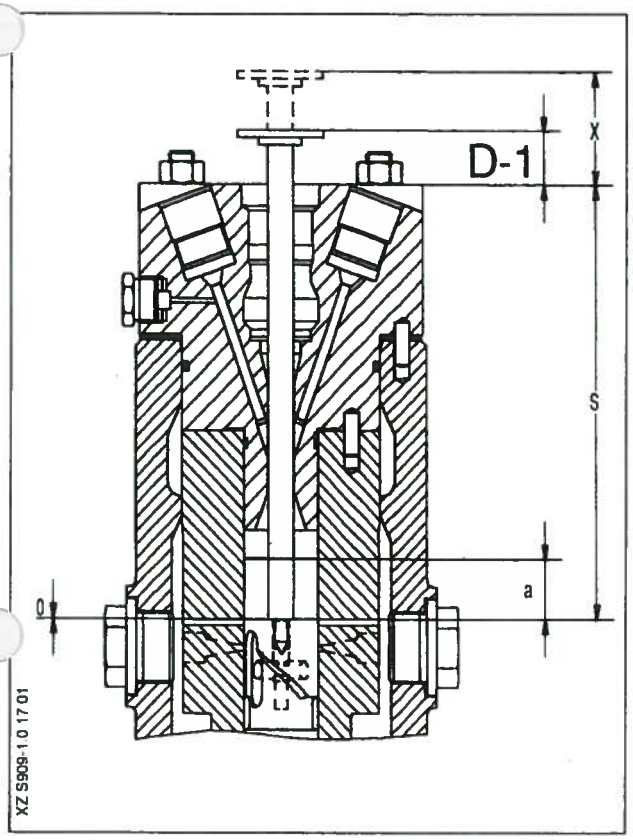
*** for member engine ***

Cylinder No.	1	2	3	4	5	6	7	8	9	10	11	12	Average
Measured angle (before TDC) at shop test bed	10.30	10.50	10.50	10.20	10.20	9.80	-	-	-	-	-	-	10.25
Number of fuel pump shim (EA)	8	8	8	8	8	8	-	-	-	-	-	-	8
Thickness of fuel pump shim (mm)	0.5	0.5	0.5	0.5	0.5	0.5	-	-	-	-	-	-	0.5
Top lift(mm) at shop test bed	11.97	11.98	12.18	11.67	11.76	11.25	-	-	-	-	-	-	11.80
Fuel pump orifice (φmm, if applicable)	-	-	-	-	-	-	-	-	-	-	-	-	-

Remarks)

Compression shim thickness, fuel cam lead angle, fuel pump top lift, fuel pump shim thickness/numbers and exhaust cam lead angle can be adjusted and changed in order to keep maximum combustion pressure within the approved ranges as given in Chapter F.2

Note : Any adjustment(s) and change(s) should be recorded in the 'Record Book' of engine parameters.



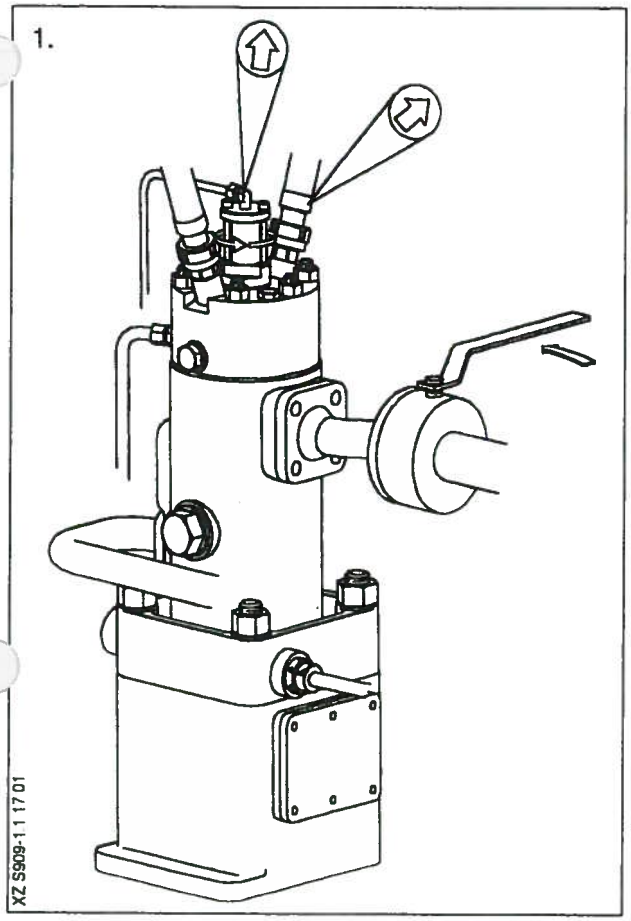
The fuel pump lead **a** (= the effective lead) is defined as the distance the top of the fuel pump plunger is lifted above the upper edge of the upper cut-off holes in the fuel pump barrel, when the piston of the cylinder concerned is in TDC.

Barrel + Top cover = **s**

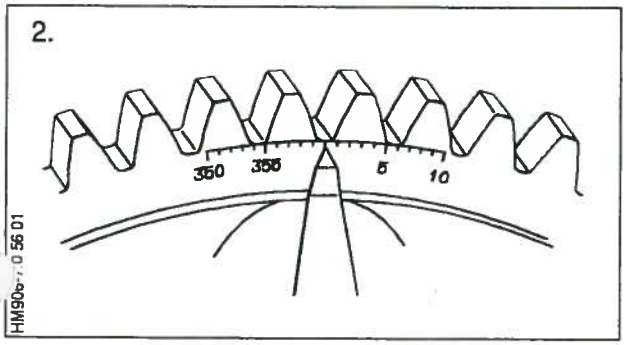
Tool length = **s + "D-1"**

Fuel pump lead **a = x - "D-1"**

1.



2.



1. To be able to measure the fuel pump lead, it is necessary to dismantle one of the high-pressure pipes and the combined puncture/suction valve from the top cover.

Note!
Before dismantling any part of the fuel pump, make sure the pump has been relieved of pressure and that all oil has been drained off.

Shut off the fuel oil inlet.

Open the fuel pump drain cock, and drain off the oil

Dismount one of the high-pressure pipes.

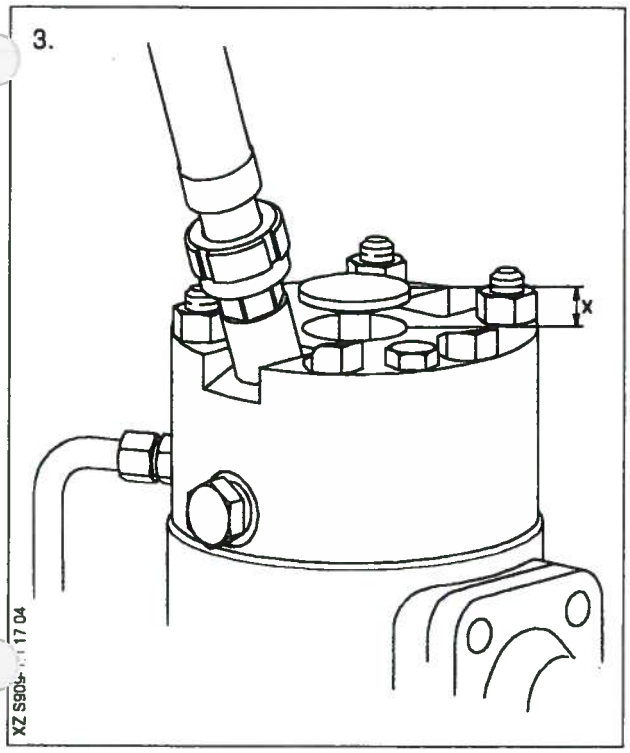
Dismount the air pipe on the puncture valve.

Dismount the puncture valve.

2.

Note!
The correct distance **x** can only be measured when the fuel pump plunger is in its delivery stroke.

Turn the engine in AHEAD direction until the main piston of the cylinder concerned is exactly at TDC.
See Procedure 906-3.1.



3. Mount the measuring tool on top of the fuel pump plunger, through the hole in the fuel pump top cover.

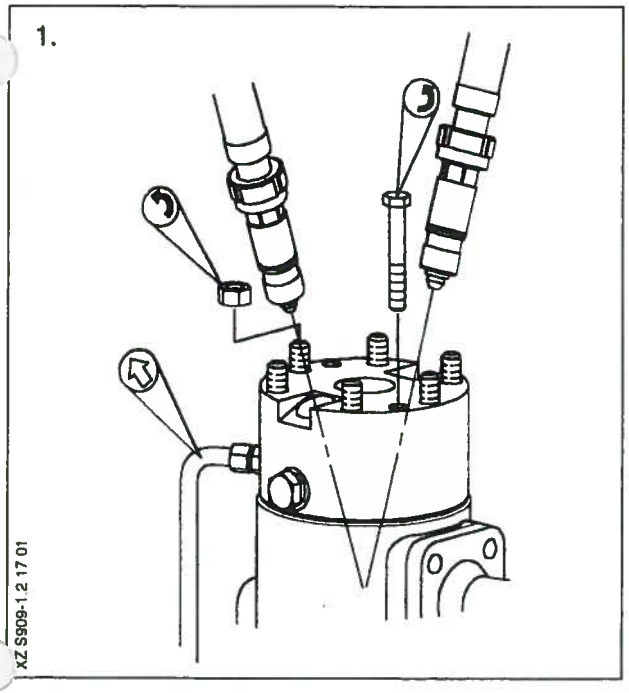
   Measure the distance **x** from the top of the measuring tool to the top of the fuel pump top cover.

   The fuel pump lead is then calculated as:
   a = x - "D-1"

   Note down the result for future reference.

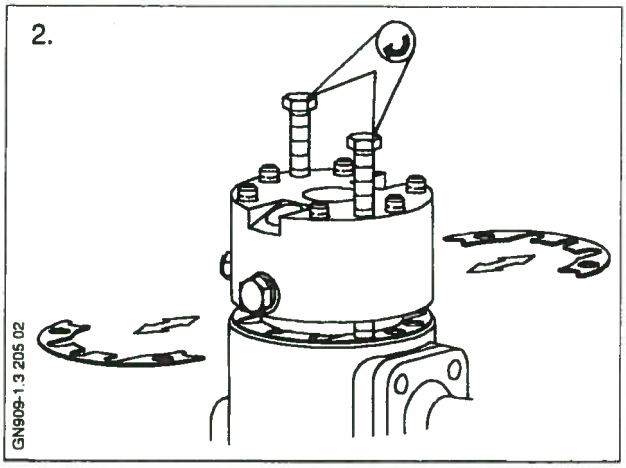
   For adjustment of fuel pump lead.
   See Procedure 909-1.3.

1.



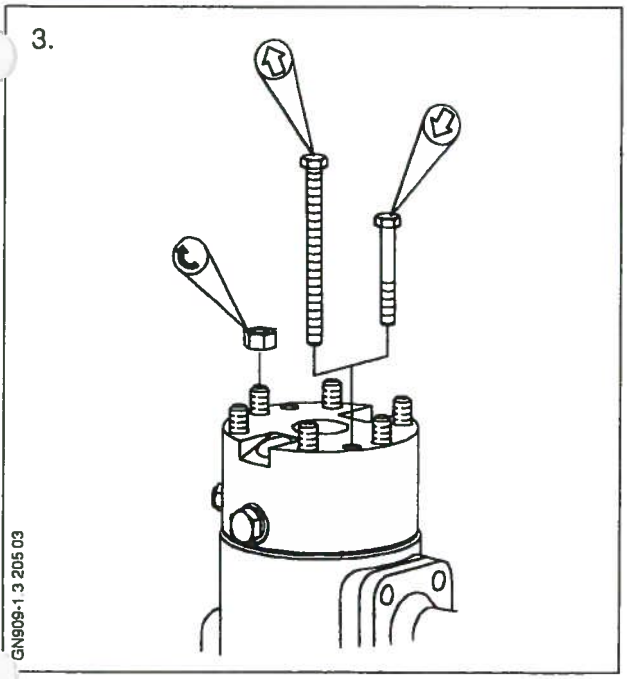
XZ S909-1 2 17 01

2.



GN909-1 3 205 02

3.



GN909-1 3 205 03

To insert or remove shims from the fuel pump, use the following procedure:

Note!
If the required adjustment of the fuel pump lead cannot be attained by inserting or removing *shims (see Data D-2)*, the adjustment must be carried out on the fuel cam disc. *See Procedure 909-3.3.*

1. Dismount the high-pressure pipes.

   Dismount the drain oil pipe on the top cover.

   Dismount the top cover fixing nuts. Remove the two screws in the threaded holes of the top cover.

2. Screw the two dismantling screws (from the tool panel) into the threaded holes of the top cover, thus lifting the top cover to provide space for inserting or removing shims.

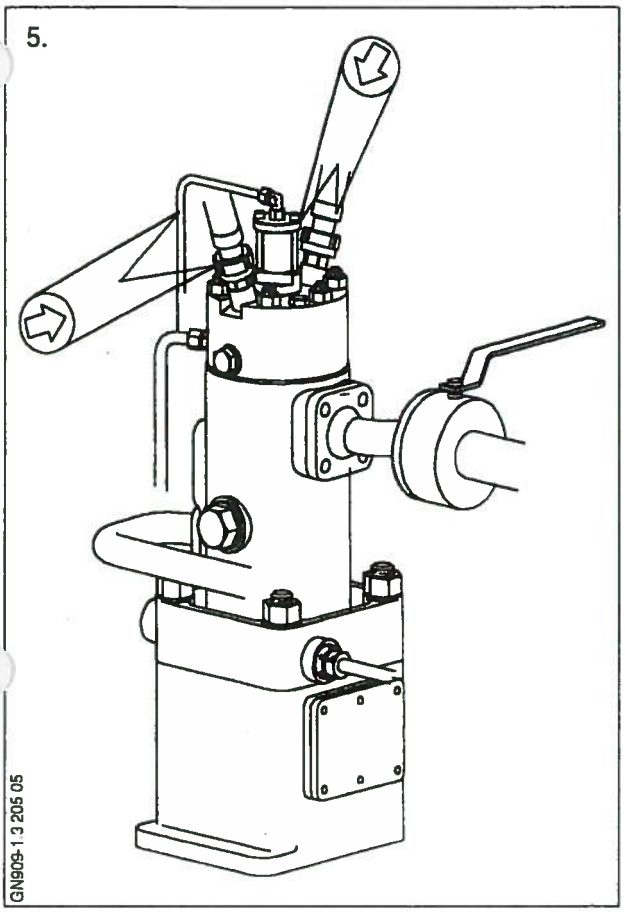
   The number of shims can now be adjusted.
   See Data D-2.

   Note down the new shim thickness.

3. Replace the dismantling screws with the two original screws, and press down the top cover.

   Mount the nuts for fastening the top cover, and tighten them diagonally, *see Data D-4.*

   If any of the top cover studs have come loose, tighten them, *see Data D-5.*



4. Measure the fuel pump lead again and note down the result for future reference.
   See Procedure 909-1.1

5. Close the drain cock in the pump housing.

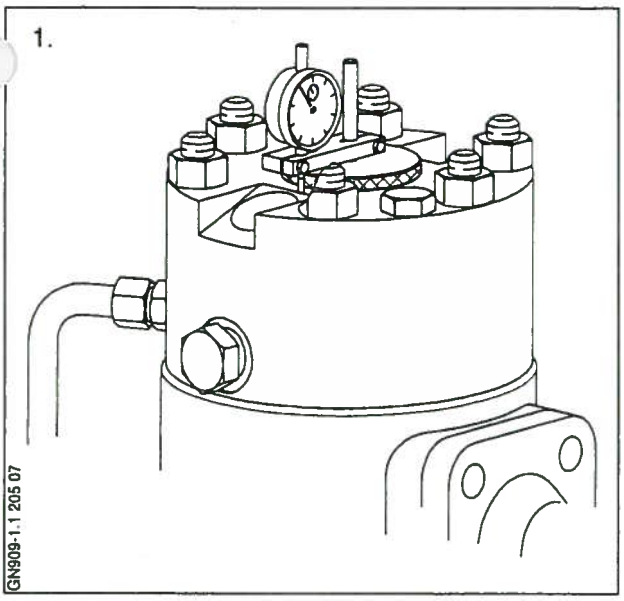
   Mount the combined puncture/suction valve in the top cover, *see Data D-3.*

   Connect the drain oil pipe to the top cover and the pipe connection to the puncture valve.

   Mount the two high-pressure pipes on the top cover/fuel valves, *see Data D-6.*

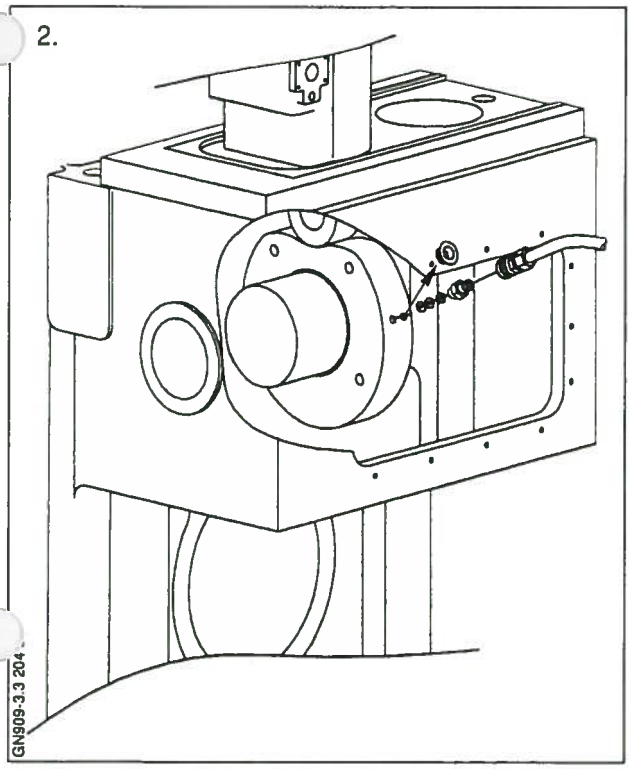
6. Open the fuel oil inlet.

1.



GN909-1.1 205 07

2.



GN909-3.3 204

If the required adjustment of the fuel pump lead cannot be accomplished by inserting or removing shims, the fuel pump lead must be altered by adjusting the fuel cam disc as described below. *See Procedure 909-1.3.*

1 Turn AHEAD until the piston of the cylinder concerned is in TDC. (If the engine is of the reversible type, ensure that the roller guide is in AHEAD position).

Mount the measuring tool and adjust the dial gauge to zero.

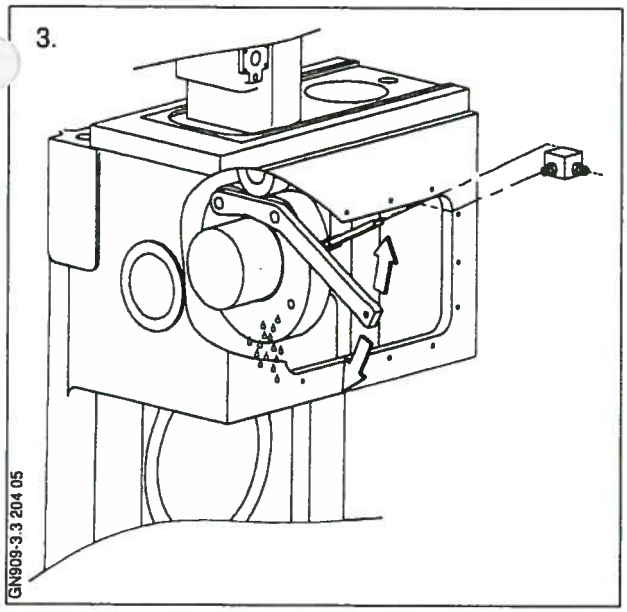
2 Remove the inspection cover from the camshaft housing.

Remove the plugs from the oil ducts on the fuel cam.

Insert three copper gaskets in each oil duct.

Mount quick couplings in the ducts, but do not tighten them.

Fit hydraulic hoses between the snap-on couplings, the distributor block and the high pressure pump.

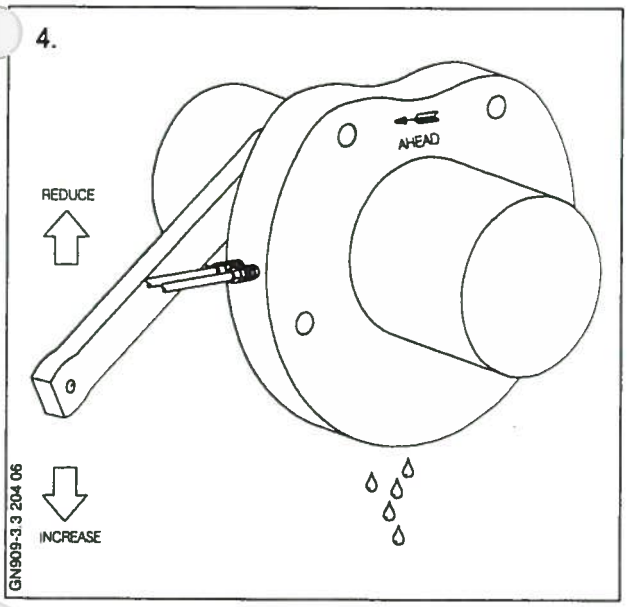


3. Mount the special spanner on the fuel cam disc and keep it close against the cam during the adjustment.

   Apply light pressure to the hydraulic system and, after venting the system, tighten the quick couplings.

   Raise the hydraulic pressure until oil seeps out between the camshaft and the cam disc.

   Turn the cam disc, using the fitted spanner, until the desired change of lead is read directly on the measuring tool.
   (The necessary turning of the cam disc is calculated as described in Procedure 909-1.1).



4. To increase the lead and P_{max}:

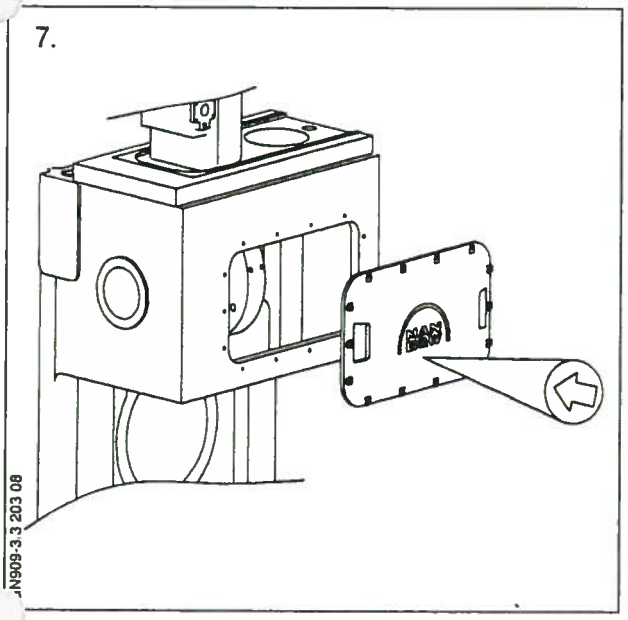
   ·turn the cam disc AHEAD.

   To reduce the lead and P_{max}:

   ·turn the cam disc ASTERN.

5. After completing the desired turning of the cam disc, relieve the hydraulic system of pressure and dismount the spanner and the hydraulic equipment.

   Wait at least 15 minutes - the cam must be allowed time to "settle" - before mounting the plugs again in the oil ducts of the cam disc.



6. Again measure the lead of the fuel pump. *See Procedure 909-1.1.*

7. Mount the inspection cover on the camshaft housing.

8. Evaluation of the performance influence on the ISO corrected NOx values

(Parent Engine of Engine Group)

A method to check NOx compliance for varying maximum combustion pressure and scavenge air temperature is shown in the following example neglecting the influence of turbine back pressure. The back pressure has been found out to have only a minor influence on NOx values.

Reference table for Ha , Khdies and Ta

Load(%)	Hsc	Ha	Khdies(*)	Ta	Khdies(**)
100	12.72	1.80	0.9158	22.0	0.9300
75	11.40	1.47	0.9057	18.0	0.9125
50	14.38	1.18	0.8917	15.0	0.8982
25	12.13	0.95	0.9200	13.0	0.9269

Remarks ;

Khdies(*) : Based on Tscref.
Khdies(**) : Based on max. allowable Tsc.

Table 8.1 Estimation of maximum combustion pressure and scavenge air temperature at 100%, 75%, 50% and 25% load and derive the equivalent change in NOx emission (g/kWh).

Load (%)	Max. combustion pressure(bar)		Absolute change in NOx (g/kWh)	Scavenge air temperature (ΔT)		Absolute change in NOx (g/kWh)
	Ref. value	ΔP		Tscref	ΔT	
100	150.0	increase 1 bar	0.1816	48.0	increase 1 ℃	Khdies
75	133.0	increase 1 bar	0.1760	43.0	increase 1 ℃	Khdies
50	108.0	increase 1 bar	0.1760	39.0	increase 1 ℃	Khdies
25	83.0	increase 1 bar	0.1760	44.0	increase 1 ℃	Khdies

Table 8.2 Maximum allowed tolerances of max. combustion pressure and scavenge air temperature at ISO ambient conditions and the relative change in NOx.

Load (%)	NOx (g/kWh) (Not corrected-Pmax.)		Max. combustion pressure(bar)			Change in NOx (g/kWh)	Scavenge air temp. (℃)		Scavenge Air temp. actual (℃)
	Corr. Tscref	Not corr.-Tscref	Actual value	Ref. value	Max. allowable Pmax		Tsc ref	Max. allowable Tsc	
100	13.78	15.05	150.0	150.0	153.0	0.5448	48.0	54.0	40.0
75	15.13	16.71	131.7	133.0	136.0	0.7568	43.0	46.0	34.0
50	17.60	19.74	105.8	108.0	111.0	0.9152	39.0	42.0	32.0
25	18.72	20.35	80.3	83.0	86.0	1.0032	44.0	47.0	22.0

Note : Tscref. - 48℃, 43℃, 39℃, 44℃ at load 100%, 75%, 50%, and 25% respectively.
Tscref. values are based on operation with a fresh water temperature of 36℃.

Corrected ISO NOx values(Based on reference Pmax. and scavenge air temperature)

IMO NOx = 0.2909 x 13.78 + 0.0000) +
0.5455 x 15.13 + 0.2288) +
0.1091 x 17.60 + 0.3872) +
0.0545 x 18.72 + 0.4752)
= **15.40 g/kWh**

Example ' Calculation of expected NOx at the given combustion pressure and scavenge air temperature.

1) Measure the maximum combustion pressure and scavenge air temperature at 100%, 75%, 50% and 25% load as following table.

Power (%)	Max. combustion pressure(bar)		Absolute change in NOx (g/kWh)	Scavenge air temperature (ΔT)		Absolute change in NOx (g/kWh)
	Actual value	ΔP		Actual value	ΔT	
100	149.0	-1 bar	-0.1816	54	14 ℃	-1.0535
75	129.7	-2 bar	-0.3520	46	12 ℃	-1.4625
50	103.8	-2 bar	-0.3520	42	10 ℃	-2.0101
25	78.3	-2 bar	-0.3520	47	25 ℃	-1.4876

Note : ΔP = Actual value - test bed value(parent eng.), ΔT = Actual value - test bed value(parent eng.)

2) Calculate the expected NOx emission at each load condition as a summation of the ISO NOx corrected value and the absolute changes (as given in the table). The ISO NOx corrected values for the E3-cycle load conditions are given in Chapter I-8.

100%

NOx value at shop test (Not corrected- Pmax & Tscref) = 15.05 g/kWh
Absolute change as a consequence of different max. pressure = -0.1816 g/kWh
Absolute change as a consequence of different scav. temp. = -1.0535 g/kWh
Expected NOx emission
15.05 + (-0.1816) + (-1.0535) = 13.81 g/kWh

75%

NOx value at shop test (Not corrected- Pmax & Tscref) = 16.71 g/kWh
Absolute change as a consequence of different max. pressure = -0.3520 g/kWh
Absolute change as a consequence of different scav. temp. = -1.4625 g/kWh
Expected NOx emission
16.71 + (-0.3520) + (-1.4625) = 14.89 g/kWh

50%

NOx value at shop test (Not corrected- Pmax & Tscref) = 19.74 g/kWh
Absolute change as a consequence of different max. pressure = -0.3520 g/kWh
Absolute change as a consequence of different scav. temp. = -2.0101 g/kWh
Expected NOx emission
19.74 + (-0.3520) + (-2.0101) = 17.38 g/kWh

25%

NOx value at shop test (Not corrected- Pmax & Tscref) = 20.35 g/kWh
Absolute change as a consequence of different max. pressure = -0.3520 g/kWh
Absolute change as a consequence of different scav. temp. = -1.4876 g/kWh
Expected NOx emission
20.35 + (-0.3520) + (-1.4876) = 18.51 g/kWh

3) Finally, calculate the ISO corrected IMO NOx value at the given maximum combustion pressure and scavenge air temperature using the following formula.

IMO NOx = 0.2909 x NOx(100%) + 0.5455 x NOx(75%) + 0.1091 x NOx(50%) + 0.0545 x NOx(25%)
IMO NOx = 0.2909 x 13.81 + 0.5455 x 14.89 + 0.1091 x 17.38 + 0.0545 x 18.51
= **15.05 g/kWh**
Since the IMO limit is 17.0 g/kWh, the engine still fulfills the requirements.

Example 2 : Calculation of expected NOx at max. allowable combustion pressure and scavenge air temperature.

IMO NOx = 0.2909 x 15.05 x 0.9300 + 0.5448) + 0.5455 x (16.71 x 0.9125 + 0.7568)
+ 0.1091 x 19.74 x 0.8982 + 0.9152) + 0.0545 x (20.35 x 0.9269 + 1.0032)
= **16.08 g/kWh**

J. Concept of Parent, Member Engine and Engine Group

Conditions for the application of this group concept are a set of identical engines having the identical components, same maximum power per cylinder and same rated speed.

The engine manufacturer should show a "Conformity of Production" in the production process. This includes ISO 9001 certificates or other quality insuring systems which should guarantee that member engines of engine group are identical.

Idea of this group concept is to have a need for emission measurements only for an engine, the so called "Parent Engine" and not need for emission measurements only for an engine, the so called "Member Engine". All the following identical engines can be adjusted and certified according to the procedures described in this page and according to the "List of NOx Relevant Components and Settings" on Chapter F.

Conditions for an Engine to be a member of the Engine Group

1. Identical Components :
If this is not the case the engine manufacturer has to show that the modified or exchanged components behave in the same way.

2. Same settings :
All settings and measured values according to the "List of NOx Relevant Components and Settings" on Chapter F should be within the limits approved for the Engine group.

K. Marking of Identification Number of the NOx Relevant Components

1. Application range

This is valid for components and engines which are built at Hyundai Heavy Industries Co., Ltd., Engine & Machinery Division works (HHI-EMD), in accordance with the requirements of the International Maritime Organization (IMO) document MP/CONF.3/35 - Resolution 2, Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines.

2. Purpose

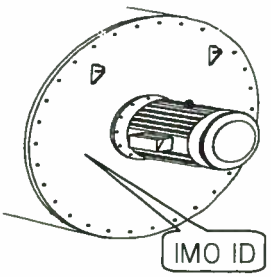
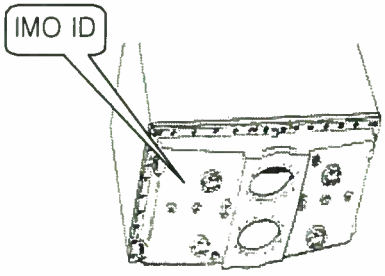
This controls
· that NOx relevant components are specified.
· that is ensured that only these components are installed and
· that they are marked with the provided identification numbers.

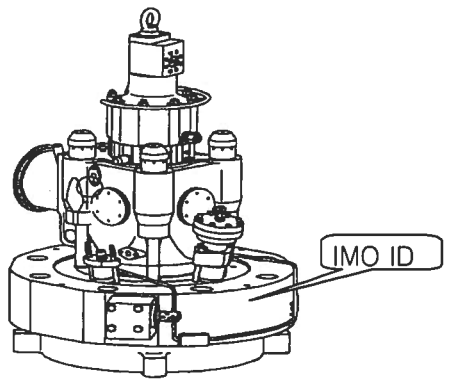
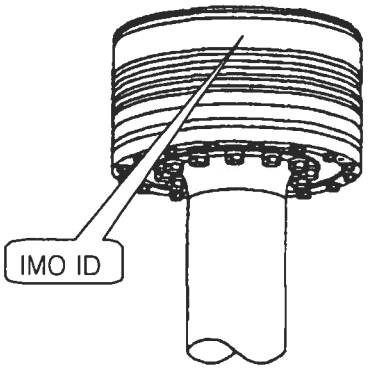
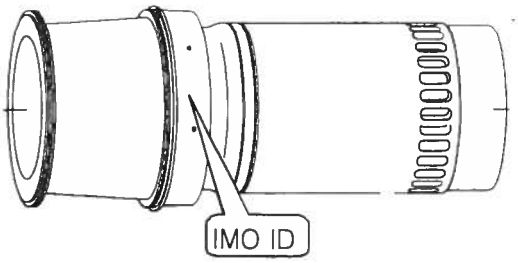
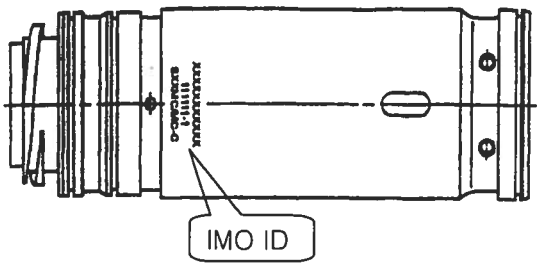
Checking

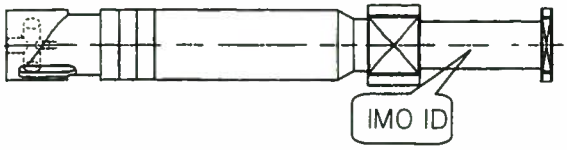
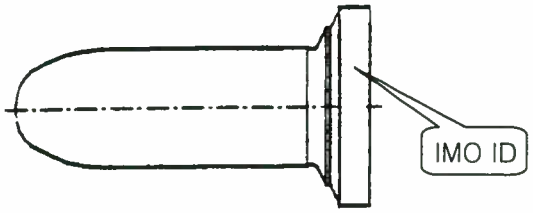
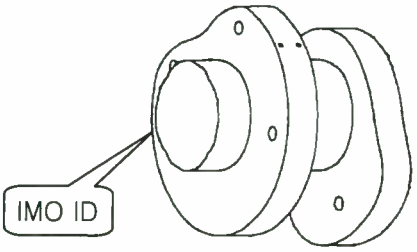
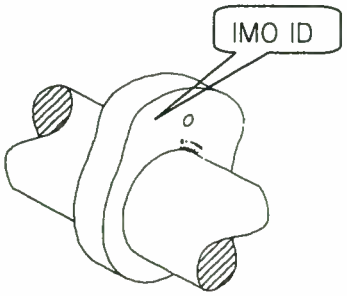
The ID number of NOx relevant components were checked during assembly of final inspection by duly authorized surveyor.

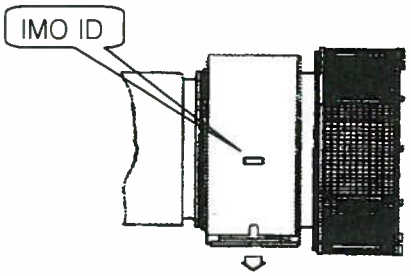
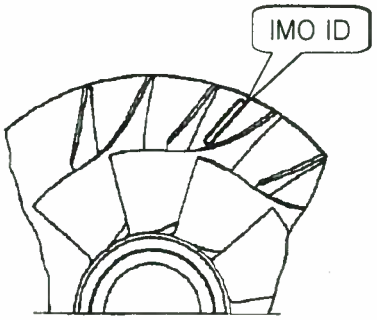
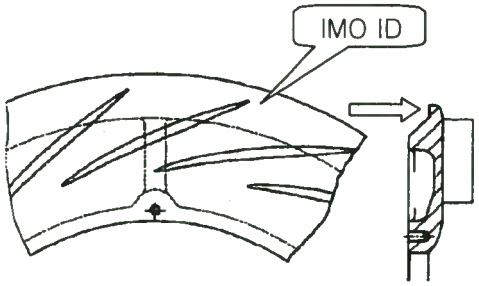
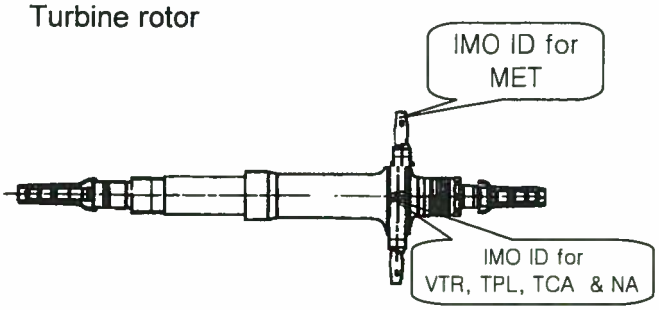
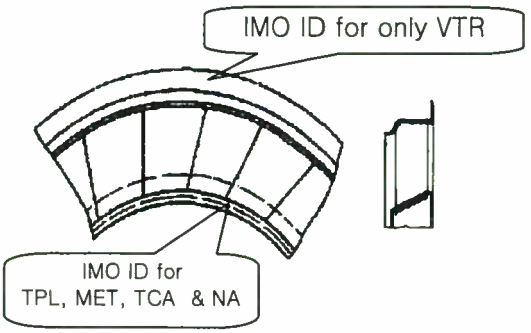
4. ID numbers of NOx relevant components

The ID number of NOx relevant components mentioned in the "List of the NOx Relevant Component and Settings" on Chapter F are marked as shown on the following sheets.

No.	Location of the IMO ID	IMO ID	Drawing No.
1	Auxiliary blower 	Serial No. 08B0276-01-05 08B0276-01-06	A14-321343-6
2	Air cooler 	A19-274025-8 Serial No. 76667	A14-332495-8

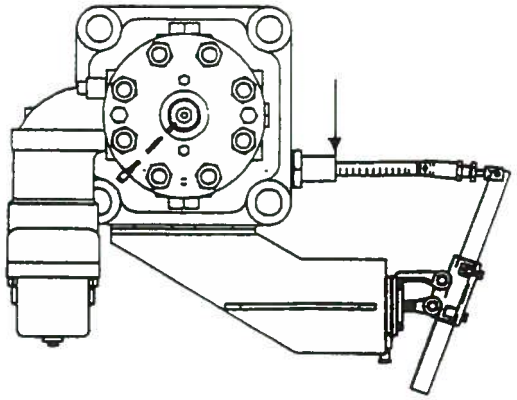
No.	Location of the IMO ID	IMO ID	Drawing No.
3	Cylinder cover 	A10-212926-7 5025583-3	A10-212926-7
4	Piston crown 	A10-255133-2 5012873-6	A10-255133-2
5	Cylinder liner 	A19-266039-5 A19-212323-4 3170262-7	A10-214402-3
6	Barrel of fuel pump 	1170729-8	A10-188640-2

No.	Location of the IMO ID	IMO ID	Drawing No.
7	Plunger of fuel pump 	1171182-5	A11-188641-4
8	Atomizer of fuel valve 	3062332-6x115	A12-224009-0
9	Fuel cam 	A19-124775-1 1173321-5	A10-169928-8 A10-169929-0 (for template dwg.)
10	Exhaust cam 	A19-124779-9 1173320-3	A10-169931-0 A10-169932-2 (for template dwg.)

No.	Location of the IMO ID	IMO ID
11	Turbocharger 	Type : TPL77B12 Serial No. : XH002480
11-1	Compressor wheel 	CV12 CT65
11-2	Diffuser 	CT65 CA17
11-3	Turbine rotor 	TT40 TF15
11-4	Nozzle ring 	TT40 TA22

5. Read the actual VIT-index

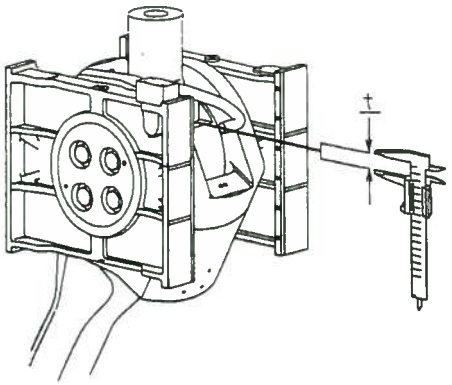
Read the actual VIT-index on the scale of the fuel pump timing racks.



6. Checking the shims

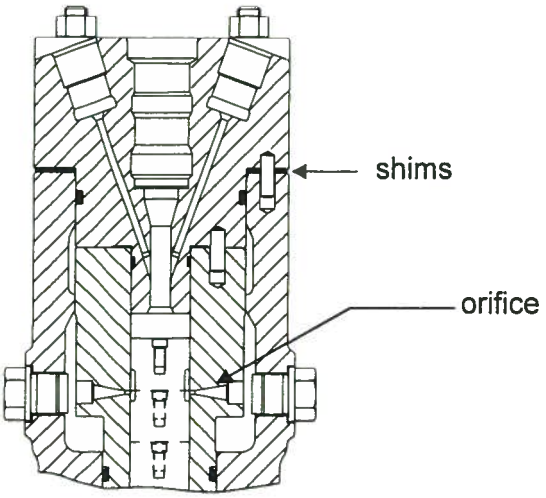
A. Checking the compression shims thickness (t), (compression volume)

Turning the crankthrow towards the exhaust side, to provide access for measuring the thickness of the shim which is inserted between piston rod and crosshead pin.



B. Number of shims in the fuel pump, (injection timing)

For engines without VIT, visually check the number of shims between the fuel pump top cover and the pump housing.



L. Test Report and Certificates

After the IMO NOx pre-certification test at test bed,

1. The test report is included in the Technical File.

After issuing of the EIAPP certificate (or 'the Statement of Compliance'),

2. The EIAPP Certificate(or the Statement of Compliance) shall be attached to the Technical File.

Number of Certificate : .....

Issued Date : .....

After issuing of the IAPP certificate (or 'the Statement of Compliance'),

3. The IAPP Certificate(or the Statement of Compliance) shall be attached to the Technical File.

Number of Certificate : .....

Issued Date : .....

M. Engine General Information

Project	**HMDS003 MAIN ENGINE**
Engine Type	**HYUNDAI-MAN B&W 6S50MC-C7**
Engine No.	**AA3382 (Member engine of engine group)**

Engine	
Manufacturer	Hyundai Heavy Industries Co., Ltd., Engine & Machinery Division
Rated speed	119 RPM
Rated power	8820 kW
Family / Group Identification	HYUNDAI-MAN B&W 6S50MC-C-2008-15
Serial number	AA3382
Intermediate speed	N/A
Maximum torque at intermediate speed	N/A
Static injection timing	-
Electronic injection control	Yes (-) , No (●)
Variable turbocharger geometry	Yes (-) , No (●)
Bore	500 mm
Stroke	2000 mm
Compression shim	8 mm
Mean effective pressure at rated power	18.9 bar
Maximum cylinder pressure at rated power	150 bar
Cylinder number, configuration	Number : 6 , In-line(●) , V (-)
Auxiliaries	N/A
Specified ambient conditions	
Maximum cooling water temperature	36 ℃ *
Maximum charge air temperature	54 ℃ *
Cooling system spec. intermediate cooler	Yes (●) , No (-)
Cooling system spec. charge air stages	One (1) stage
Low temp. cooling system set point	40 ℃
High temp. cooling system set point	90 ℃
Maximum inlet depression	150 mmWC
Maximum exhaust back pressure	450 mmWC
Fuel oil temp. (100% load at shop test, measured at the inlet to the fuel injection	See Chapter S.
Lubricating oil specification	MELINA 30S
Application / Intended for	
Customer	E.R.SCHIFFAHRT
Final application / installation, Ship	Hyundai Vinashin Shipyard Co., Ltd. Hull No. S003
Final application / installation, Engine	Main (●) , Aux (-)
Emission test results (Parent engine of engine group)	
Cycle	E3
NOx	15.40 g/kWh
Date	November 18, 2008
Test site / shop	HHI-EMD test shop
Surveyor	Mr. D. I. Park of DNV
Signature	Mr. J. W. Lee of HHI-EMD
Date and Place of report	July 22, 2009 , HHI-EMD

'*' : mark : Based on the engine design condition.

N. Engine Group Information

Project	**HMDS003 MAIN ENGINE**
Engine Type	**HYUNDAI-MAN B&W 6S50MC-C7**
Engine No.	**AA3382 (Member engine of engine group)**

Engine Group Information (common specifications)		
Combustion cycle	■ : 2-stroke cycle	□ : 4-stroke cycle
Cooling medium (Air cooler)	□ : Air	■ : Water
Cylinder configuration	6 cylinders, In-Line	
Method of aspiration	■ : Constant pressure	□ : Natural aspired
Fuel type to be used on board	■ : Heavy fuel ■ : Distillate	□ : Dual
Combustion chamber	■ : Open chamber	□ : Divided chamber
Valve port configuration	■ : Cylinder head	□ : Cylinder wall
Valve port size and number	Fuel valve : 2/cylinder	Exh. valve : 1/cylinder
Fuel system type	One fuel pump per cylinder	
Miscellaneous Features		
Exhaust gas recirculation	□ : Yes	■ : No
Water injection / emulsion	□ : Yes	■ : No
Air injection	□ : Yes	■ : No
Charge cooling system	■ : Yes	□ : No
Exhaust after - treatment	□ : Yes	■ : No
Exhaust after - treatment type	N/A	
Dual fuel	□ : Yes	■ : No
Engine Group Information (selection of parent engine for test bed)		
Group identification	HYUNDAI-MAN B&W 6S50MC-C-2008-15	
Method of pressure charging	Constant pressure	
Charge air cooling system	Central fresh water cooling system	
Number of cylinder	6	
Max. rated power per cylinder	1470 kW	
Rated speed	119 RPM	
Selected parent engine	AA3182	
Application	Hyundai Vinashin Shipyard Co., Ltd. Hull No. S001	

O. Test Cell Information (For Information)

Project	**HMDS001 MAIN ENGINE**
Engine Type	**HYUNDAI-MAN B&W 6S50MC-C7**
Engine No.	**AA3182 (Parent engine of engine group)**

Measurement Equipment

		Manufacturer	Model or Serial No.	Measurement range	Calibration	
					Span gas conc.	Deviation
Analyzers (HORIBA MEXA-9100F) 4039070001						
NOx Analyzer		HORIBA	CLA-155	2000 ppm	1886	± 0.1 %
CO Analyzer		HORIBA	AIA-120	500 ppm	473	0.5 %
CO2 Analyzer		HORIBA	AIA-120	10 %	9.23	0.5 %
O2 Analyzer		HORIBA	FMA-126D	25 %	23.2	0.3 %
HC Analyzer		HORIBA	FMA-126D	500 ppmC	454	± 0.1 %
Speed (engine tachometer)		YOKOGAWA	62GE0178	0.1~30000 rpm	-	0.0 %
Torque		-	-	-	-	-
Power meter (water brake)		PROUDE	97033	36000 bhp	-	0.17 %
Weighing machine (SFOC)		CAS	)806LS00303003	5000 kg	-	0.02 %
Air flow		-				
Exhaust flow		Calculated-IMO Universal, Carbon/Oxygen balance method				
Temperatures						
Scavenge air cooler	in	RUEGER	3TH-9	0~120 ℃	-	- 2 ℃
	out	RUEGER	K48-043	0~120 ℃	-	- 1 ℃
		-	-	-	-	-
Exh. Gas at T/C outlet		RUEGER	81878021	0~650 ℃	-	- 3 ℃
		-	-	-	-	-
Intake air at T/C		RUEGER	K48-032	0~120 ℃	-	0.0 ℃
		RUEGER	K48-035	0~120 ℃	-	0.0 ℃
		-	-	-	-	-
		-	-	-	-	-
		-	-	-	-	-
		-	-	-	-	-
		-	-	-	-	-
		-	-	-	-	-
Scavenge air receiver		RUEGER	3-TH1	0~160 ℃	-	- 1 ℃
		-	-	-	-	-
Ambient air		VAISALA	X3620034	-20~60 ℃	-	0.2 ℃
Fuel inlet		WIKA	1TH-23	0~120 ℃	-	- 0.5 ℃
Pressures						
Exh. Gas (manometer)		DIGITRON	441281463	0~700 kPa	-	- 0.14 %
Scavenge air		DIGITRON	441281463	0~700 kPa	-	- 0.14 %
Atmospheric		SATO	81023	970~1040 hPa	-	0.2 %
Humidity						
Intake air		VAISALA	X3620034	0~100 %RH	-	1.3 %RH
Exhaust pipe						
Diameter		1000 mm				
Insulation		■ : No		□ : Yes		
Probe location		6.0 m after turbocharger (30 m from exhaust gas exit)				
Remarks		Sampling gas temperature : min. 190℃ at all loads				

P. Ambient and Gaseous Emission Data (For Information)

Project	**HMDS001 MAIN ENGINE**
Engine Type	**HYUNDAI-MAN B&W 6S50MC-C7**
Engine No.	**AA3182 (Parent engine of engine group)**
Test Date	**November 18, 2008**

Mode	-	-	-	-	-
Test number	-	01	02	03	04
Running time	-	12:10-13:10	11:10-11:40	10:40-11:10	10:10-10:40
Recorded time	-	12:25-12:38	11:23-11:37	10:51-11:05	10:21-10:36
Engine power	%	100	75	50	25
	kW	8820.0	6615.0	4410.0	2205.0
Engine speed	%	100	91	79	63
	rpm	119.0	108.1	94.5	75.0
Max. combustion pressure	bar	150.0	131.7	105.8	80.3
Max. compression pressure	bar	133.8	106.5	75.0	49.5
Mean effective pressure	bar	18.9	15.6	11.9	7.5
Exhaust gas temp. at T/C outlet	℃	230	208	221	212
Turbocharger speed	rpm	15119	13352	10618	6413
Ambient Data					
Charge air pressure	kg/㎠	2.78	2.01	1.13	0.38
Barometric pressure	kPa	101.7	101.8	101.8	101.8
Intake air humidity	%	11.1	11.6	11.3	10.4
	g/kg	1.80	1.47	1.18	0.95
Intake air temperature	℃	22.0	18.0	15.0	13.0
Scavenge air temperature	℃	40.0	34.0	32.0	22.0
Intercooled air reference temperature	℃	48.0	43.0	39.0	44.0
Governor					
Pump index	mm	71.2	58.0	45.2	31.0
Load indicator governor	-	73.5	60.1	48.0	34.6
Fuel					
Uncorrected fuel consumption	kg/h	1588.2	1170.5	790.0	403.5
Charge Air					
Air flow	kg/h	77134	63057	47072	26113
Exhaust Gas					
Gas flow	kg/h	78722	64228	47862	26516
Gaseous Emission Data					
CO concentration (Dry)	ppm	41.5	37.0	26.5	20.5
CO2 concentration (Dry)	%	4.41	3.98	3.59	3.30
HC concentration (Wet)	ppmC	64.0	59.5	57.0	54.0
O2 concentration (Dry)	%	15.15	15.75	16.25	16.63
NOx concentration (Dry)	ppm	1110.0	1128.0	1188.0	1102.0
NOx humidity/temp. correction factor	-	0.916	0.906	0.892	0.920
Dry / Wet correction factor	-	0.963	0.967	0.970	0.973
NOx mass flow	kg/h	121.56	100.10	77.63	41.28
NOx specific	g/kWh	13.78	15.13	17.60	18.72
Test Cycle (E3)	**g/kWh**	**15.20**			

* The IMO NOx value is based on reference scavenge air temperature, but not corrected reference Pmax.

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Q. Results of NOx Emission (for Information)

Project	**HMDS001 MAIN ENGINE**
Engine Type	**HYUNDAI-MAN B&W 6S50MC-C7**
Engine No.	**AA3182 (Parent engine of engine group)**
Emission Test No.	**01 to 04**
Kind of fuel	**Bunker-A (ISO 8217, DMC)**

Engine output	kW	8,820
Output per cylinder	kW	1,470
Engine speed	RPM	119

Load	%	100	75	50	25
Oxides of Nitrogen (NOx)	g/kWh	13.78	15.13	17.60	18.72
IMO NOx-Cycle E3	g/kWh	15.20			
IMO NOx-Cycle E2	g/kWh				
IMO NOx-Cycle D2	g/kWh				

Maximum Allowable NOx	**g/kWh**	**17.0**

E3 : Test cycle for "Propeller law operated main & propeller law operated aux. engine" application
E2 : Test cycle for "Constant speed main propulsion engine" application including diesel electric drive and variable pitch propeller installation
D2 : Test cycle for "Constant speed auxiliary engine" application

* The IMO NOx value is based on reference scavenge air temperature, but not corrected reference Pmax.

R. Fuel Analysis (For Information)

Project	**HMDS001 MAIN ENGINE**
Engine Type	**HYUNDAI-MAN B&W 6S50MC-C7**
Engine No.	**AA3182 (Parent engine of engine group)**
Test Date	**November 18, 2008**
Kind of Fuel	**Marine Diesel Oil, Bunker-A** **ISO 8217, DMC**

Fuel elemental analysis & properties

Description	Unit	Result	Test Method
C (Carbon)	%, mass	87.48	Elementary Analysis
H (Hydrogen)	%, mass	11.63	Elementary Analysis
N (Nitrogen)	%, mass	0.1	Elementary Analysis
O (Oxygen)	%, mass	0.56	Elementary Analysis
S (Sulphur)	%, mass	0.21	ISO-8754
Density at 15℃	kg/ℓ	0.9107	ISO-3675
Viscosity at 40℃	mm2/s	6.80	ISO-3104
Carbon residue (Micro method)	%, mass	1.10	ISO-10370
Water	%, V/V	0.01	ISO-3733
Cetane Index	-	N/A	ISO-4264

* N/A : Not available due to mixed-bunker.

S. Engine Performance Data

Refer to the enclosed ten (10) sheets.

HYUNDAI HEAVY INDUSTRIES CO., LTD.

		Doc. No.: K630-IR09A-3383
SHOP TEST RESULT FOR MAIN ENGINE	Engine No.	AA3382
	Engine type	6S50MC-C7
	Hull No.	HMDS003
	Owner	E.R.SCHIFFAHRT
	Class	DNV
	Ship yard	HMD

HYUNDAI - MAN B&W

QUALITY MANAGEMENT DEPARTMENT
HHI-EMD

Rev.	Prepared	Checked	Approved	Description
2				
1				
0	J. W. Lee 2009-07-06	S. J. KIM 2009.07.06	S. D. PARK 2009.7.6	First issue

HYUNDAI
HEAVY INDUSTRIES CO., LTD.

Official shop test result for Main Engine	Hull No.	HMDS003	Owner	E.R.SCHIFFAHRT
	Engine No.	AA3382	Class	DNV
	Engine Type	6S50MC-C7	Test Date	June.17, 2009
Specification of Main Engine	Output(MCR)	8820 kW	Engineer	J.S.LIM
	Speed(MCR)	119 rpm	Operator	H.Y.KIM

PARTICULARS OF ENGINE

NUMBER OF CYLINDERS	6		
DIAMETER OF CYLINDER	500 mm		
STROKE	2000 mm		
FIRING ORDER	AH→	1 - 5 - 3 - 4 - 2 - 6 - 1	←AS
CYLINDER CONSTANT	0.6545		

PARTICULARS OF TURBOCHARGER

TYPE	1 × TPL77B12
SPECIFICATION	CT65CA17 TF15TA22
nMax / nBMax	17040 rpm / 550℃
tMax / tBMax	16200 rpm / 520℃
SERIAL No.	XH002480
MANUFACTURER	HYUNDAI HEAVY INDUSTRIES CO., LTD.

PARTICULARS OF DYNAMOMETER

MAKER / TYPE	FUCHINO CFSR-20
CONSTANT (kW)	1 / 1.35962
MAXIMUM CAPACITY	26500 kW x 200 rpm

SPECIFICATION OF OIL USED AT SHOP TEST

		F.O	System Oil	Cam Oil	Cyl. Oil	T/C Oil
KIND OF OIL		BUNKER-A	VERITAS 800 M 30	VERITAS 800 M 30	ALEXIA LS	VERITAS 800 M 30
SPEC. GRAVITY	(15 ℃)	0.9171	0.8809	0.8809	0.9144	0.8809
FLASH POINT	℃	78	258	258	260	258
VISCOSITY	cSt	(50℃) 5.72	(40℃) 103.1	(40℃) 103.1	(40℃) 198.7	(40℃) 103.1
WATER	vol%	0.05				
SULFUR	wt%	0.248				
CALORIFIC VALUE (LOWER)	kcal / kg	9993				

HYUNDAI
HEAVY INDUSTRIES CO., LTD.

Official shop test result for Main Engine	Hull No.	HMDS003	Owner	E.R.SCHIFFAHRT
	Engine No.	AA3382	Class	DNV
	Engine Type	6S50MC-C7	Test Date	June.17, 2009
Specifiction of Accessory	Output(MCR)	8820 kW	Engineer	J.S.LIM
	Speed(MCR)	119 rpm	Operator	H.Y.KIM

GOVERNOR

TYPE	AC C20 DGS
SERIAL No.	B0082B781140091
MANUFACTURER	KONGSBERG MARITIME KOREA

FUEL VALVE (ATOMIZER)

TYPE		3062332-6 x 115				
OPENING PRESSURE		350 ±30 bar				
SPEC.	HOLE No.	1	2	3	4	
	DIA. OF HOLE(Φ)	1.15	1.15	1.15	1.15	
	VERTI. ANGLE(α°)	27	17	13	12	
	HORIZ. ANGLE(β°)	-2	12	30	48	

AUXILIARY BLOWER

TYPE / CAPACITY		TBCS-060C-4526 / 1.92 / 3.90 m³/sec
SPEED / PRESSURE		3560 rpm / 571/327 mmAq
SERIAL No. 1 / 2		08B02760105 / 08B02760106
MANUFACTURER		TAE-IL BLOWER MFG. Co.,LTD.
ELECT. MOTOR	TYPE / VOLTAGE	HK-SD/F / 440 V
	FREQUENCY / POWER / Amp	60 Hz / 45 kW / 72.1 A
	SERIAL No. 1 / 2	8F696F11-001 / 8F696F11-002
	MANUFACTURER	HYUNDAI HEAVY INDUSTRIES Co., LTD.

AIR COOLER

TYPE	LKMY-C1-1420-EK-080822
SERIAL No.	76667
MANUFACTURER	VESTAS AIRCOIL

CYLINDER LUBRICATOR

TYPE	ELECTRIC CONTROLLED LUBRICATOR(ALPHA)
MANUFACTURER	HANMI HYDRAURIC MACHINERY CO.,LTD.

HYUNDAI HEAVY INDUSTRIES CO., LTD.

Official shop test result for Main Engine

Data sheet of 25% Load test

Hull No.	HMDS003	Weather	FINE
Engine No.	AA3382	Measuring Time	8:40
Eng. Type	6S50MC-C7	Test Date	June.17, 2009
Owner	E.R.SCHIFFAHRT	Engineer	J.S.LIM
Class	DNV	Operator	H.Y.KIM

* Room Temperature : 22.3 ℃ * Atmospheric Pressure : 1015.0 mbar

Engine Speed	Water Brake	Brake Power	Indicated Power	Mech.Efficiency	NOTCH
75.0 rpm	40.0 kNm	2205 kW	2504 kW	88.07 %	4.40

System		Main L.O	P.C.O	Cam L.O	Fuel Oil	Cooling F.W
In	Press.(kg/cm^2)	2.13			8.20	4.03
	Temp.(℃)	43.0			30.0	70.5

Cyl. No.		Avg.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Pmax.	bar	79.8	80	80	80	80	79	80								
Pcomp.	bar	48.8	49	49	49	48	49	49								
Pi	bar	8.50	8.47	8.49	8.52	8.56	8.40	8.57								
F.O Pump	Pθ	30.3	30.0	30.0	31.0	31.0	30.0	30.0								
	VIT	-	-	-	-	-	-	-								
Exh.Gas Out.	℃	253.7	260	252	250	260	260	240								
C.F.W Out.	℃	73.9	73.0	73.5	74.0	75.0	74.0	74.0								
Cam L.O Out.	℃	41.0	41.0													
P.C.O Out	℃	48.8	49.0	49.0	49.0	49.0	48.0	49.0								

Air Cooler

No.			1	2	3	4	Avg.
Bef. Cooler Press		mmHg	200				200.0
Press. Drop		mmAq	50				50.0
Air In.		℃	44	BLANK			44.0
Air Out.		℃	20.0				20.0
Cooling Water	In	℃	19.0				19.0
	Out	℃	21.0				21.0

Scavenging Air

Pressure		Temperature	
0.34	kg/㎠	28	℃
Air receiver pressure		250	mmHg
Exhaust Manifold Pressure		0.26	kg/㎠

Specific Fuel Oil Consumption

Meas.(kg/h)	Meas.(g/kWh)	Correct(g/kWh)
408.000	185.034	181.877

Turbocharger

Turbocharger	Speed	Blower Inlet			Before Turbine		After Turbine		L.O.(℃, kg/㎠)			F.W Temp
	rpm	℃		mmAq	℃	mmHg	℃	mmAq	In	Out	Press.	℃
No. 1	6350	22.0	28.0	5	262	190	215	16	43	44	1.58	-
No. 2		BLANK										
No. 3												
No. 4												
Avg.	6350	25.00		5	262	190.0	215	16	43	44	1.58	-

* Pressure vit : - kg/㎠ *Governor Position : 36.0 * Thrust Pad : 43.0 ℃

Note : The Fuel Oil Consumption is corrected to Lower Calorific Value 10200 kcal/kg & I.S.O condition

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HYUNDAI HEAVY INDUSTRIES CO., LTD.

Official shop test result for Main Engine

Data sheet of 50% Load test

Hull No.	HMDS003	Weather	FINE
Engine No.	AA3382	Measuring Time	9:55
Eng. Type	6S50MC-C7	Test Date	June.17, 2009
Owner	E.R.SCHIFFAHRT	Engineer	J.S.LIM
Class	DNV	Operator	H.Y.KIM

* Room Temperature : 22.7 ℃ * Atmospheric Pressure : 1016.0 mbar

Engine Speed	Water Brake	Brake Power	Indicated Power	Mech.Efficiency	NOTCH
94.5 rpm	63.45 kNm	4410 kW	4802 kW	91.83 %	6.40

System		Main L.O	P.C.O	Cam L.O	Fuel Oil	Cooling F.W
In	Press.(kg/cm^2)	2.10			7.80	4.00
	Temp.(℃)	43.0			32.0	72.0

Cyl. No.		Avg.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Pmax.	bar	105.2	105	105	106	105	105	105								
Pcomp.	bar	74.5	74	75	74	74	75	75								
Pi	bar	12.94	12.93	12.92	12.89	12.89	13.00	13.00								
F.O Pump	Pθ	44.0	44.0	44.0	44.0	44.0	44.0	44.0								
	VIT	-	-	-	-	-	-	-								
Exh.Gas Out.	℃	291.5	295	290	291	292	294	287								
C.F.W Out.	℃	75.7	75.0	75.0	75.0	77.0	76.0	76.0								
Cam L.O Out.	℃	44.0	44.0													
P.C.O Out	℃	50.6	50.5	51.0	51.0	50.5	50.0	50.5								

Air Cooler

No.			1	2	3	4	Avg.
Bef. Cooler Press		mmHg	780				780.0
Press. Drop		mmAq	94				94.0
Air In.		℃	88	BLANK			88.0
Air Out.		℃	30.0				30.0
Cooling Water	In	℃	19.5				19.5
	Out	℃	51.0				51.0

Scavenging Air

Pressure		Temperature	
1.08	kg/㎠	31	℃
Air receiver pressure		760	mmHg
Exhaust Manifold Pressure		0.90	kg/㎠

Specific Fuel Oil Consumption

Meas.(kg/h)	Meas.(g/kWh)	Correct(g/kWh)
793.000	179.819	175.729

Turbocharger

Turbocharger	Speed	Blower Inlet			Before Turbine		After Turbine		L.O.(℃, kg/㎠)			F.W Temp
	rpm	℃		mmAq	℃	mmHg	℃	mmAq	In	Out	Press.	℃
No. 1	11700	22.0	32.0	17	322	630	232	42	43	52	1.50	-
No. 2												
No. 3		BLANK										
No. 4												
Avg.	11700	27.00		17	322	630.0	232	42	43.0	52	1.50	-

* Pressure vit : - kg/㎠ *Governor Position : 50.0 * Thrust Pad : 45.0 ℃

Note : The Fuel Oil Consumption is corrected to Lower Calorific Value 10200 kcal/kg & I.S.O condition

DET NORSKE VERITAS 1864

HYUNDAI HEAVY INDUSTRIES CO., LTD.

Official shop test result for Main Engine

Data sheet of 75% Load test

Hull No.	HMDS003	Weather	FINE
Engine No.	AA3382	Measuring Time	10:25
Eng. Type	6S50MC-C7	Test Date	June.17, 2009
Owner	E.R.SCHIFFAHRT	Engineer	J.S.LIM
Class	DNV	Operator	H.Y.KIM

* Room Temperature : 23.8 ℃ * Atmospheric Pressure : 1015.0 mbar

Engine Speed	Water Brake	Brake Power	Indicated Power	Mech.Efficiency	NOTCH
108.1 rpm	83.20 kNm	6615 kW	7051 kW	93.82 %	7.60

System		Main L.O	P.C.O	Cam L.O	Fuel Oil	Cooling F.W
In	Press.(kg/cm²)	2.20			7.60	4.00
	Temp.(℃)	43.0			32.0	70.0

Cyl. No.		Avg.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Pmax.	bar	132.2	132	133	132	132	132	132								
Pcomp.	bar	105.3	105	106	106	105	105	105								
Pi	bar	16.61	16.63	16.70	16.66	16.52	16.57	16.58								
F.O Pump	Pθ	56.0	56.0	56.0	56.0	56.0	56.0	56.0								
	VIT	-	-	-	-	-	-	-								
Exh.Gas Out.	℃	300.0	300	295	300	305	305	295								
C.F.W Out.	℃	77.7	77.0	78.0	77.0	78.0	78.0	78.0								
Cam L.O Out.	℃	46.0	46.0													
P.C.O Out	℃	52.0	52.0	52.0	52.0	52.0	52.0	52.0								

Air Cooler

No.		1	2	3	4	Avg.
Bef. Cooler Press	mmHg	1440				1440.0
Press. Drop	mmAq	120				120.0
Air In.	℃	145	BLANK			145.0
Air Out.	℃	35.0				35.0
Cooling Water In	℃	22.0				22.0
Cooling Water Out	℃	55.0				55.0

Scavenging Air

Pressure		Temperature	
1.98	kg/㎠	34	℃
Air receiver pressure		1420	mmHg
Exhaust Manifold Pressure		1.71	kg/㎠

Specific Fuel Oil Consumption

Meas.(kg/h)	Meas.(g/kWh)	Correct(g/kWh)
1175.000	177.627	173.605

Turbocharger

Turbocharger	Speed	Blower Inlet			Before Turbine		After Turbine		L.O.(℃, kg/㎠)			F.W Temp
	rpm	℃		mmAq	℃	mmHg	℃	mmAq	In	Out	Press.	℃
No. 1	13500	23.0	36.0	40	350	1240	220	100	43	66	1.50	-
No. 2		BLANK										
No. 3												
No. 4												
Avg.	13500	29.50		40	350	1240.0	220	100	43	66	1.50	-

* Pressure vit : - kg/㎠ *Governor Position : 63.3 * Thrust Pad : 46.0 ℃

Note : The Fuel Oil Consumption is corrected to Lower Calorific Value 10200 kcal/kg & I.S.O condition

DET NORSKE VERITAS * 1864 *

HYUNDAI HEAVY INDUSTRIES CO., LTD.

Official shop test result for Main Engine

Data sheet of 90% Load test

Hull No.	HMDS003	Weather	FINE
Engine No.	AA3382	Measuring Time	11:10
Eng. Type	6S50MC-C7	Test Date	June.17, 2009
Owner	E.R.SCHIFFAHRT	Engineer	J.S.LIM
Class	DNV	Operator	H.Y.KIM

* Room Temperature : 23.7 ℃ * Atmospheric Pressure : 1015.0 mbar

Engine Speed	Water Brake	Brake Power	Indicated Power	Mech.Efficiency	NOTCH
114.9 rpm	93.93 kNm	7938 kW	8401 kW	94.49 %	8.30

System		Main L.O	P.C.O	Cam L.O	Fuel Oil	Cooling F.W
In	Press.(kg/cm^2)	2.20			7.50	4.00
	Temp.(℃)	43.0			32.0	70.0

Cyl. No.		Avg.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Pmax.	bar	144.8	145	144	145	145	145	145								
Pcomp.	bar	121.5	121	121	121	122	122	122								
Pi	bar	18.62	18.60	18.58	18.59	18.63	18.68	18.64								
F.O Pump	Pθ	64.2	64.0	64.0	64.0	64.0	65.0	64.0								
	VIT	-	-	-	-	-	-	-								
Exh.Gas Out.	℃	314.2	320	310	315	315	320	305								
C.F.W Out.	℃	79.2	79.0	79.0	79.0	79.0	80.0	79.0								
Cam L.O Out.	℃	48.0	48.0													
P.C.O Out	℃	53.7	54.0	54.0	54.0	53.0	53.0	54.0								

Air Cooler

No.			1	2	3	4	Avg.
Bef. Cooler Press		mmHg	1790				1790.0
Press. Drop		mmAq	130				130.0
Air In.		℃	167	BLANK			167.0
Air Out.		℃	35.0				35.0
Cooling Water	In	℃	23.0				23.0
	Out	℃	50.0				50.0

Scavenging Air

Pressure		Temperature	
2.45	kg/㎠	36	℃
Air receiver pressure		1770	mmHg
Exhaust Manifold Pressure		2.15	kg/㎠

Specific Fuel Oil Consumption

Meas.(kg/h)	Meas.(g/kWh)	Correct(g/kWh)
1420.500	178.949	174.976

Turbocharger

Turbocharger	Speed	Blower Inlet			Before Turbine		After Turbine		L.O.(℃, kg/㎠)			F.W Temp
	rpm	℃		mmAq	℃	mmHg	℃	mmAq	In	Out	Press.	℃
No. 1	14550	23.5	37.0	50	380	1560	222	160	43	71	1.60	-
No. 2												
No. 3		BLANK										
No. 4												
Avg.	14550	30.25		50	380	1560.0	222	160	43	71	1.60	-

* Pressure vit : - kg/㎠ *Governor Position : 71.3 * Thrust Pad : 46.0 ℃

Note : The Fuel Oil Consumption is corrected to Lower Calorific Value 10200 kcal/kg & I.S.O condition

DET NORSKE VERITAS * 1864 *

HYUNDAI HEAVY INDUSTRIES CO., LTD.

Official shop test result for Main Engine

Data sheet of 100% % Load test

Hull No.	HMDS003	Weather	FINE
Engine No.	AA3382	Measuring Time	11:40
Eng. Type	6S50MC-C7	Test Date	June.17, 2009
Owner	E.R.SCHIFFAHRT	Engineer	J.S.LIM
Class	DNV	Operator	H.Y.KIM

* Room Temperature : 24.0 ℃ * Atmospheric Pressure : 1015.0 mbar

Engine Speed	Water Brake	Brake Power	Indicated Power	Mech.Efficiency	NOTCH
119.0 rpm	100.77 kNm	8820 kW	9296 kW	94.88 %	8.60

System		Main L.O	P.C.O	Cam L.O	Fuel Oil	Cooling F.W
In	Press.(kg/cm^2)	2.20			7.50	4.00
	Temp.(℃)	43.0			34.0	70.0

Cyl. No.		Avg.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Pmax.	bar	149.8	150	150	149	150	150	150								
Pcomp.	bar	131.7	131	131	132	132	132	132								
Pi	bar	19.89	19.82	19.85	19.86	19.94	19.98	19.90								
F.O Pump	Pθ	69.8	70.0	70.0	69.0	70.0	70.0	70.0								
	VIT	-	-	-	-	-	-	-								
Exh.Gas Out.	℃	337.5	345	335	335	340	340	330								
C.F.W Out.	℃	80.0	80.0	80.0	80.0	80.0	80.0	80.0								
Cam L.O Out.	℃	48.0	48.0													
P.C.O Out	℃	54.3	54.0	55.0	55.0	54.0	54.0	54.0								

Air Cooler

No.			1	2	3	4	Avg.
Bef. Cooler Press		mmHg	2010				2010.0
Press. Drop		mmAq	135				135.0
Air In.		℃	180	BLANK			180.0
Air Out.		℃	38.0				38.0
Cooling Water	In	℃	24.0				24.0
	Out	℃	55.0				55.0

Scavenging Air

Pressure		Temperature	
2.77	kg/㎠	38	℃
Air receiver pressure		2000	mmHg
Exhaust Manifold Pressure		2.45	kg/㎠

Specific Fuel Oil Consumption

Meas.(kg/h)	Meas.(g/kWh)	Correct(g/kWh)
1594.200	180.748	176.814

Turbocharger

Turbocharger	Speed	Blower Inlet			Before Turbine		After Turbine		L.O.(℃, kg/㎠)			F.W Temp
	rpm	℃		mmAq	℃	mmHg	℃	mmAq	In	Out	Press.	℃
No. 1	15209	23.0	39.0	60	410	1780	235	200	43	73	1.50	-
No. 2												
No. 3		BLANK										
No. 4												
Avg.	15209	31.00		60	410	1780.0	235	200	43	73	1.50	-

* Pressure vit : - kg/㎠ *Governor Position : 77.9 * Thrust Pad : 47.0 ℃

Note : The Fuel Oil Consumption is corrected to Lower Calorific Value 10200 kcal/kg & I.S.O condition

DET NORSKE VERITAS * 1864 *

HYUNDAI
HEAVY INDUSTRIES CO., LTD.

Official shop test result for Main Engine

Engine performance

Hull No.	HMDS003	Owner	E.R.SCHIFFAHRT
Engine No.	AA3382	Class	DNV
Engine Type	6S50MC-C7	Test Date	June.17, 2009
Output(MCR)	8820 kW	Engineer	J.S.LIM
Speed(MCR)	119 rpm	Operator	H.Y.KIM

Project No.
HMDS003

Engine No.
AA3382

Engine Type
6S50MC-C7

T/C Type
1 × TPL77B12

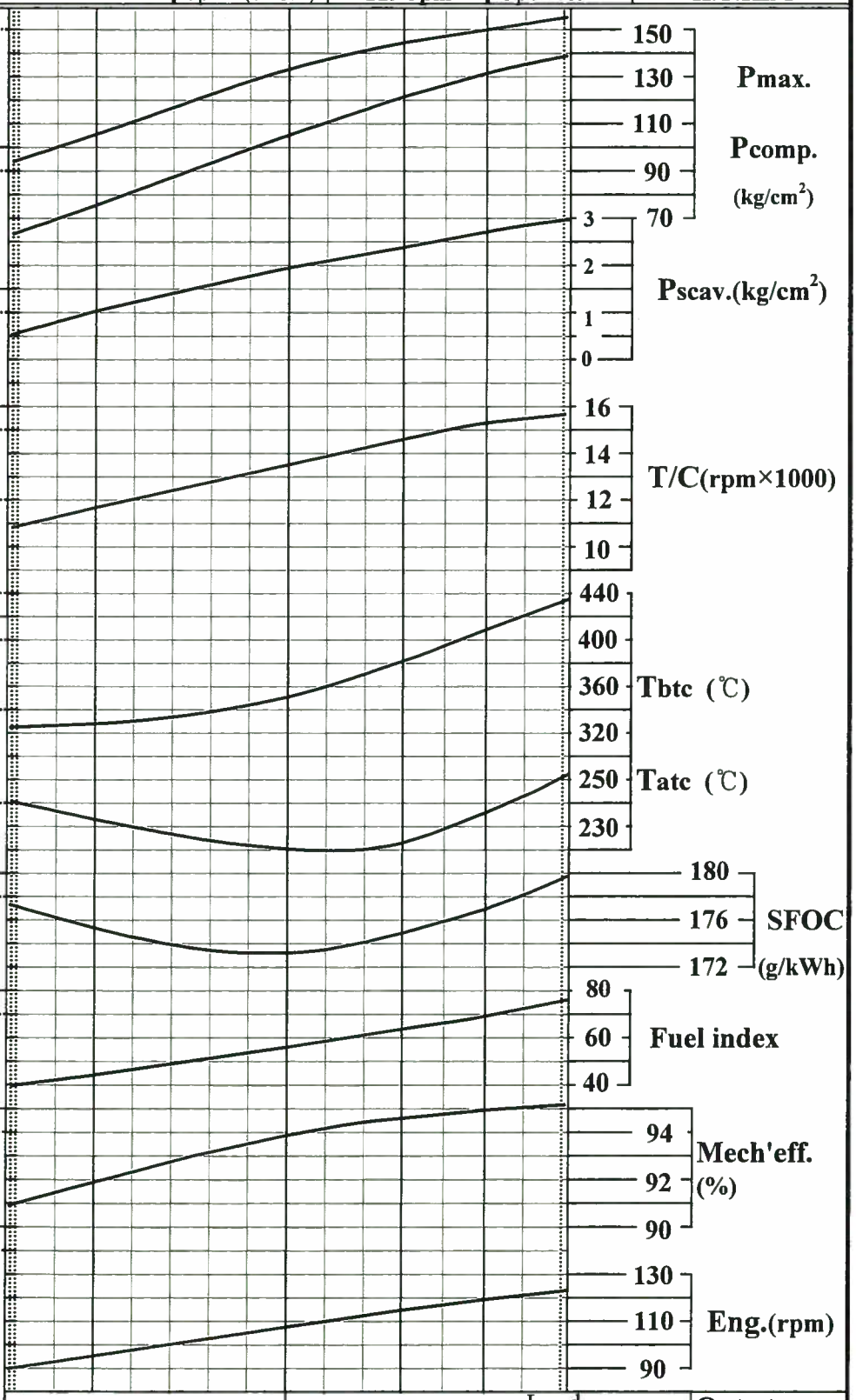
PTU/Bypass

Fuel Cam

Exh. Cam

Comp.Shim
8 mm

Remark
OFFICIAL SHOP TEST



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DET NORSKE VERITAS * 1864 *

HYUNDAI
HEAVY INDUSTRIES CO., LTD.

Official shop test result for Main Engine	Hull No.	HMDS003	Owner	E.R.SCHIFFAHRT
	Engine No.	AA3382	Class	DNV
	Engine Type	6S50MC-C7	Test Date	June.17, 2009
Inspection Report	Output(MCR)	8820 kW	Engineer	J.S.LIM
	Speed(MCR)	119 rpm	Operator	H.Y.KIM

Kind of Inspection.	Place of Inspection	Work Condition	Judgement
Timing Data	**Ass'y Shop**	**After Shop Test**	**Reference**

1. Exhaust Cam Lead (Advance Angle)

Cylinder No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Measured Timing(Ahead)	-3.40	-3.20	-3.35	-3.20	-3.35	-3.35	BLANK							

* Angle A : **112.9°** * Lift : **10.0** mm

* Angle B : **254.1°** * Lift : **10.0** mm

2. Fuel Pump

Cylinder No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Number of Shim(EA)/ Thickness of Shim(mm)	8/0.5	8/0.5	8/0.5	8/0.5	8/0.5	8/0.5	BLANK							
Top Lift (mm)	11.97	11.98	12.18	11.67	11.76	11.25	BLANK							
Lead Angle(Before T.D.C)	10.30	10.50	10.50	10.20	10.20	9.80	BLANK							

3. Compression Shim

Cylinder No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Thickness (mm)	8	8	8	8	8	8	BLANK							

4. Starting Air Distributor Lead (Advance Angle)

Cylinder No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Open Aft T.D.C (Ahead)	Equal of CYL No.1 T.D.C Scratch mark													
Open Aft T.D.C (Astern)														

DET NORSKE VERITAS

Certificate no.:
EIAPP-953-3-A
Date of issue:
2009-09-15

ENGINE INTERNATIONAL AIR POLLUTION PREVENTION CERTIFICATE

This Certificate shall be supplemented by
a Record of Construction, a Technical File and Means of Verification

Issued under the provisions of the Protocol of 1997 to amend the International Convention for the Prevention of Pollution from Ships, 1973, as modified of the Protocol of 1978 related thereto (hereinafter referred to as "the Convention") under the authority of the Government of

THE REPUBLIC OF LIBERIA

by **Det Norske Veritas**

Particulars of engine

Engine manufacturer:	**Hyundai Heavy Industries Co., Ltd.**
Model number:	**HYUNDAI-MAN B&W 6S50MC-C7**
Serial number:	**AA3382**
Test cycles(s):	**E3**
Rated power [kW] and speed [rpm]:	**8820 kW @ 119 rpm**
Engine approval number:	**EIAPP-G-0953-0003**

THIS IS TO CERTIFY:

1. That the above mentioned marine diesel engine has been surveyed for pre-certification in accordance with requirements of the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines made mandatory by Annex VI of the Convention, and
2. That the pre-certification survey shows that the engine, its components, adjustable features, and technical file, prior to the engine's installation and/or service onboard a ship, fully comply with the applicable regulation 13 of Annex VI of the Convention.

Remarks/Recommendations:

This Certificate is valid for the life of the engine, subject to surveys in accordance with Regulation 5 of the ANNEX VI of the Convention, installed in ships under the authority of this Government.

Issued at **Oslo** on **2009-09-15** (date)

for **Det Norske Veritas AS**

Tomas Heber Tronstad
Head of Section

DET NORSKE VERITAS * 1864 *

RJS iN516

Record no.:
EIAPP-953-3-A
Date of issue:
2009-09-15

DET NORSKE VERITAS

SUPPLEMENT TO ENGINE INTERNATIONAL AIR POLLUTION PREVENTION CERTIFICATE

(EIAPP CERTIFICATE)

RECORD OF CONSTRUCTION, TECHNICAL FILE AND MEANS OF VERIFICATION

In respect of the provisions of Annex VI of the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocols of 1978 and 1997 relating thereto (hereinafter referred to as "the Convention") and of the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines (hereinafter referred to as the "NO_x Technical Code").

Notes:

1 This Record and its attachments shall be permanently attached to the EIAPP Certificate. The EIAPP Certificate shall accompany the engine throughout its life and shall be available on board the ship at all times.

2 If the language of the original Record is neither English nor French, the text shall include a translation into one of these languages.

3 Unless otherwise stated, regulations mentioned in this Record refer to regulations of Annex VI of the Convention and the requirements for an engine's technical file and means of verifications refer to mandatory requirements from the NO_x Technical Code.

1. Particulars of the engine

.1	Name and address of manufacturer.....	**Hyundai Heavy Industries Co., Ltd.** **1, Cheonha-Dong, Dong-Gu, ulsan, Korea**
.2	Place of engine build	**As above**
.3	Date of engine build	**June 2009**
.4	Place of pre-certification survey.....	**As above**
.5	Date of pre-certification survey	**2009-06-18**
.6	Engine type and model number	**HYUNDAI-MAN B&W 6S50MC-C7**
.7	Engine serial number	**AA3382**
.8	If applicable, the engine is a parent engine [-] or a member engine [X] of the following engine family [-] or engine group [X]	**HYUNDAI-MAN B&W 6S50MC-C-2008-15**
.9	Test cycle(s) (see chapter 3 of the NO_x Technical Code)	**E3**
.10	Rated power [kW] and speed [rpm]	**8820 kW @ 119 rpm**
.11	Engine approval number	**EIAPP-G-0953-0003**
.12	Specifications of the test fuel	**ISO 8217-F-DMC Grade**
.13	NO_x-reducing device designated approval number (if installed)	**Not Applicable**
.14	Applicable NO_x emission limit [g/kWh] (regulation 13 of Annex VI)	**17.0**
.15	Engine's actual NO_x emission value, cycle **E3**, [g/kWh].....	**15.4**

2 Particulars of the technical file

.1	Technical file identification/approval number	**EIAPP-G-0953-0003**
.2	Technical file approval date	**2009-09-15**
.3	The technical file, as required by Ch. 2 of the NO_x Technical Code, is an essential part of the EIAPP Certificate and must always accompany an engine throughout its life and always be available on board a ship.	

3. Specification for the On-board NO_x verification procedure for the engine parameter survey

.1	On-board NO_x verification procedures identification/approval number	**EIAPP-G-0953-0003**
.2	On-board NO_x verification procedures approval date	**2009-09-15**
.3	The specifications for the on-board NO_x verification procedures, as required by Ch. 6 of the NO_x Technical Code, are an essential part of the EIAPP Certificate and must always accompany an engine throughout its life and always be available on board a ship.	

THIS IS TO CERTIFY that this Record is correct in all respects:

Issued at **Oslo** on **2009-09-15** (date)

for **Det Norske Veritas AS**

Tomas Heber Tronstad
Head of Section

RJS WS/6

HYUNDAI
HEAVY INDUSTRIES CO., LTD.

Technical File

Issued under the provisions of the Protocol of 1997 to the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 related thereto (MARPOL 73/78)

for

HYUNDAI-MAN B&W 6S50MC-C7

Certified as a 'Member' engine

Prepared by, ***HYUNDAI HEAVY INDUSTRIES CO., LTD., ENGINE & MACHINERY DIVISION, ENGINE DEVELOPMENT & TEST DEPARTMENT***

Identification/approval number ***HYUNDAI-MAN B&W 6S50MC-C-2008-15-AA3382/***

Issued at ***HYUNDAI HEAVY INDUSTRIES CO., LTD., ULSAN, KOREA***

Date of issue

Signature of duly authorized official issuing the certificate

(Seal or Stamp of the authority, as appropriate)

DET NORSKE VERITAS 1864

Examined for compliance with ... of Nitrogen Oxides

2009 09 15

SIGN HAH

DET NORSKE VERITAS AS

EIAPP - G-0953-0003

DET NORSKE VERITAS 1864

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A. General

The Technical file is issued under the provisions of Annex VI of the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocols of 1978 and 1997 relating thereto (hereinafter referred to as "the Convention") and of the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines (hereinafter referred to as "the IMO NOx Technical Code")

for

HYUNDAI-MAN B&W 6S50MC-C7

1. Certified as an a ☐ Individual / ☐ Parent / ■ Member Engine of Engine Group

Engine Manufacturer	: Hyundai Heavy Industries Co., Ltd.
Engine Type	: HYUNDAI-MAN B&W 6S50MC-C7
Engine Number	: AA3382
Number of Engine	: One(1) set as a Member Engine
Test Cycle	: E3
Rated Power	: 8820 kW
Rated Speed	: 119 RPM
M.E.P.	: 18.9 bar

2. Prepared & Issued by Hyundai Heavy Industries Co., Ltd., Engine & Machinery Division

This is to certify that this Technical File including procedures for demonstrating compliance with NOx emission limits on board a ship, Engine Parameter Check Method, for the above mentioned marine diesel engine, prior to the engine's installation and/or service on load a ship, fully comply with the requirements of the IMO NOx Technical Code made mandatory by Annex VI of the Convention.

Identification/approval number : *HYUNDAI-MAN B&W 6S50MC-C-2008-15-AA3382/*

.....

Date of issue

(Signature of duly authorized official issuing the certificate)

(Seal or Stamp of the authority, as appropriate)

DET NORSKE VERITAS * 1864 *

B. Summary

IMO NOx emission test on one(1) main propulsion engine for Hyundai Vinashin Shipyard Co., Ltd. Hull No. S001 was carried out as parent engine of the HYUNDAI-MAN B&W 6S50MC-C-2008-15-AA3182 at test bed in order to fully meet the IMO NOx Technical code.

However, if this group has member engines, additional IMO NOx compliance test for them is not to be performed because it can be considered as identical engines having the same NOx relevant components, rated power, rated RPM, nearly similar setting values and also identical IMO ID numbers compared with the Parent Engine.

1. *Calibrations of Zero & Span for gas analyzers were successfully carried out under the presence of the surveyor (s).*

2. *Analyzers and calibration gases have been confirmed in compliance with the IMO NOx Technical Code by the surveyor(s).*

3. *Calculations of the emission value and exhaust, gases emission have been done according to the IMO NOx Technical Code as follows :*

   (1) Humidity correction factors for NOx for diesel engines (Khdies) have been calculated according to formula(14) of 5.12.3.6 on the IMO NOx Technical Code.

   (2) Humidity of intake air(Ha) according to formula(10) of 5.12.2.1 on the IMO NOx Technical Code.

   (3) Dry to wet correction factor (Kw,r) for the raw exhaust gas according to formula(11) of 5.12.2.2 on the IMO NOx Technical Code.

   (4) The exhaust gas mass flows were calculated according to Method 2, Universal, Carbon/Oxygen-balance, 3 of Appendix 6 on the IMO NOx Technical Code.

   (5) The NOx emission value was corrected to reference conditions as shown in Chapter I.8 which includes a scavenge air cooler fresh water coolant inlet temperature of 36 ℃ when operating under reference conditions-25 ℃ sea water temperature for central fresh water cooling system, whereas a scavenge air cooler sea water coolant inlet temperature of 25 ℃ for conventional sea water cooling system. Basically, charge air cooling system for this group is shown in the Chapter F, "List of NOx Relevant Components and Setting" and the Chapter N, "Engine Group Information".

4. *The certificates for analytical instruments and calibration gases were not included in this Technical File because they had been checked and confirmed by surveyor during NOx emissions test. However, summarized information on the analytical instruments can be seen on Chapter O, Test Cell Information in this Technical File.*

Finally, the test result (NOx : 15.40 g/kWh) for parent engine which is corrected to ISO NOx values based on reference Pmax and scavenge air temperature as mentioned in Chapter I.8, HYUNDAI-MAN B&W 6S50MC-C-2008-15-AA3182 is showed far less than IMO NOx limit (17.0 g/kWh).

DET NORSKE VERITAS * 1864 *

C. Particulars of the Engine

Two-stroke, single acting, direct reversible, cross head, constant pressure turbocharging diesel engine, and using heavy fuel oil.

1. Name and address of manufacturer : Hyundai Heavy Industries Co., Ltd.
   1, Cheonha-Dong, Dong-Gu, Ulsan, Korea
2. Place of engine build : Same as the above
3. Date of engine build : June 2009
4. Place of pre-certification survey : Hyundai Heavy Industries Co., Ltd.
   1, Cheonha-Dong, Dong-Gu, Ulsan, Korea
5. Date of pre-certification survey : June 17, 2009
6. Engine type : HYUNDAI-MAN B&W 6S50MC-C7
7. Engine number : AA3382
8. If applicable, the Engine is ☐ an Individual Engine, ☐ Parent / ■ Member Engine of Engine Group of the following ☐ Engine Family, or ■ Engine Group,

   Engine Group Name : HYUNDAI-MAN B&W 6S50MC-C-2008-15

9. Test cycle(s)(acc. to Chapter 3 of the IMO NOx Technical Code) : E3
10. Rated Power & Speed : 8820 kW at 119 RPM
11. Mean effective pressure : 18.9 bar
12. Max. combustion pressure : 150 bar
13. Engine approval number :
14. Specification of test fuel
    (and/or Certification number of fuel sample analysis) : Bunker-A (ISO 8217, DMC)
    (Parent engine of engine group)
15. NOx reducing device designated approval number (if installed) : Not applicable
16. Applicable NOx emission limit (Regulation 13 of Annex VI) : 17.0 g/kWh
17. Engine's actual NOx emission value : 15.40 g/kWh (AA3182)
    (Parent engine of engine group)

D. Particulars of the Technical File

The Technical File, as required by Chapter 2 of the IMO NOx Technical Code, is an essential part of the EIAPP Certificate and must always accompany an engine throughout its lift and always be available on-board a ship.

1. Technical File identification/approval number : .....

.....

2. Technical File approval date : .....

.....

E. Specifications of the On-board NOx Verification Procedures for the Engine Parameter Survey

The Specifications for the on-board NOx verification procedures, as required by Chapter 6 of the IMO NOx Technical Code, is a essential part of the EIAPP Certificate and must always accompany and engine throughout its life and always be available on-board a ship.

1. On-board NOx verification procedures identification/approval number :

.....

2. On-board NOx verification procedures approval date :

.....

F. List of NOx Relevant Components and Settings

1. Components (Standard Engine set-up plus listing of allowed inter-changeable components)

Description	Value	Identification Number	Range/ Alternative	Notes
Engine Specification				
Number of cylinders	6	-	-	1)
Cylinder liner (bore, Ø mm)	500	A19-266039-5, A19-212323-4, 3170262-7	-	1), 2)
Stroke (mm)	2000	-	-	1)
Combustion chamber (compression ratio : see settings)				
Cylinder cover	-	A10-212926-7, 5025583-3	-	2)
Piston crown	-	A10-255133-2, 5012873-6	-	2)
Fuel injection equipment (per cylinder unit)				
Barrel of fuel pump	-	1170729-8	-	2)
Plunger of fuel pump (dia., Φmm)	52	1171182-5	-	1), 2)
Fuel injection valve (number of fuel valve(s))	2	-	-	1)
Atomizer of fuel valve (number, Φmm) (opening/closing : see settings)	-	3062332-6x115	-	2)
Fuel cam	-	A19-124775-1, 1173321-5	-	2)
Exhaust cam	-	A19-124779-9, 1173320-3	-	2)
Auxiliary blower	2	Serial No. : 08B0276-01-05, 08B0276-01-06	-	1), 2)
Turbocharger maker/type : Hyundai-ABB TPL77B12				
Number & S/No. of turbocharger(s)	1	Serial No. : XH002480	-	1), 2)
Compressor wheel	-	CV12 CT65	-	2)
Diffuser	-	CT65 CA17	-	2)
Turbine rotor	-	TT40 TF15	-	2)
Nozzle ring	-	TT40 TA22	-	2)
Charging air cooling system : Central fresh water cooling system				
Charge air cooler	1	Serial No. : 76667	A19-274025-8	1), 2)
Charge air cooling water inlet temp.(℃)	36	-	-	1), 3)

2. Settings (Engine matching at test bed)

Description	Value	Drawing/ Ident. No.	Range/ Alternative	Notes
Engine Layout				
Rated power (MCR, kW)	8820	-	-	1)
Rated speed (RPM)	119	-	-	1)
Mean effective pressure at rated power (M.E.P., bar)	18.9	-	-	1)
Maximum combustion pressure (bar)	150	-	150 ± 3	1)
Performance set-up				
Compression ratio (mm) (Compression shim thickness)	8	-	Piston rod effective length 2635 mm	1), 4)
Fuel valve opening pressure (bar)	350	-	350 ± 30	1)
Fuel cam lead angle (deg. CA)	Refer to Chapter I and S.		-	4)
Fuel cam lift (mm)	Refer to Chapter I and S.		Tolerance + 1	4)
Number of fuel pump shim (EA)/ Thickness of fuel pump shim (mm)	Refer to Chapter I and S.		Tolerance ± 1	4)
Fuel pump orifice (φmm, if applicable)	Refer to Chapter I.		-	-
Exhaust cam lead angle (deg. CA)	Refer to Chapter I and S.		Tolerance ± 1	4)

Certified range for maximum combustion pressrue(measured) - without VIT			
Parameters	Actual adjustment on test bed	Certified range for adjustment	Checking of adjustment
Combustion pressure at 50% power	105.2 bar	111 bar or below	Pressure measurement
Combustion pressure at 75% power	132.2 bar	136 bar or below	Pressure measurement
Combustion pressure at 100% power	149.8 bar	153 bar or below	See chapter I and S.

Notes)

1) Parameters, operating values and settings can be verified through an engine performance check.

2) The Identification numbers for cylinder liner, cylinder cover, piston crown, exhaust cam and fuel cam are marked with one(1) or over two(2) kinds of numbers (i.e., HHI's number : XXX-XXXXXX-X, licensor's number as alternative : XXXXXXX-X). And even if only one of the above and/or both kinds of numbers can be marked on the above components, they are identical components each other. In addition, identification or serial numbers for fuel injection barrel, plunger, atomizer, turbo-charger(s), charge air cooler(s) and auxiliary blowers are marked with sub-manufacturer's number.

   Some NOx relevant components may have over two(2) IMO identification numbers as an alternative. Therefore, one of mentioned IMO Identification numbers in this technical file can be available on this engine.

   The revision number of IMO identification number for each NOx relevant components does not have an effect on NOx emission value because this revision number is only for HHI's drawing management system. (for instance, XXX-XXXXXX-X.X)

   ↘ (revision number)

3) For central fresh water cooling system, the temperature(36℃) is for cooling water inlet under reference conditions - 25℃ sea water temperature.

   For conventional sea water cooling system, the inlet temperature(25℃) is for cooling water inlet reference conditions and the Tsc. tolerance are given to the stated reference value in Chapter I-8 for each load, i.e., if the sea water temperature is 10℃ higher than the reference sea water temperature, the nominal Tsc. at 100% load would be 54℃ and actual max. allowable Tsc. Would be 60℃.

   For sea water cooling system, there is no intermediate cooler between sea water and the scavenge air coolant the maximum temperature under reference condition is 25℃.

4) Compression shim thickness, fuel cam lead angle, fuel pump top lift, fuel pump shim thickness/numbers and exhaust cam lead angle can be adjusted and changed in order to keep maximum combustion pressure within the approved ranges as given in Chapter F.2

   Note : Any adjustment(s) and change(s) should be recorded in the 'Record Book' of engine parameters.

G. Guideline for Components Replacements

1. General

If any of the components listed under "List of NOx Relevant Components and Settings" on Chapter F has to be changed during operation, the replacing component should be identical to the old one.

The guarantee to receive the correct component can only be achieved by ordering the new components through the engine manufacturer.

2. Proceeding for the replacement

1. Order the component indicating the ID numbers specified in this Technical File through the engine manufacturer.
2. Substitute the old component by the new one.
3 Record the substitution including component specification, date of replacement and component supplier in the "Engine's Record Book of engine parameters" which has to keep on board of the ship.

H. Measurements for IMO Compliance Test at Test Bed

The table 1 shows a list of the measured 'standard' performance parameters at test bed.
And the allowable ranges for some of the parameters are given in Chapter F.2.

Table 1. Measured Performance Parameters at Test Bed

* - Engine rated power (kW)
* - Engine rated speed (RPM)
- Mean effective pressure (bar)
- Cylinder maximum pressure (bar)
- Compression pressure (bar)
- Fuel injection timing (deg. CA bTDC)
* - Fuel consumption (kg/h)

- Turbocharger speed (RPM)
- Exhaust gas temperature after cylinder outlet (℃)
* * - Exhaust gas flow (kg/h)
* * - Air consumption (kg/h)

* - Exhaust gas emissions
* - Exhaust gas pressure (at sampling position, mmWC)
* - Exhaust gas temperature (at sampling position, ℃)

* - Air inlet temperature (at turbocharger compressor side, ℃)
* - Atmospheric pressure (kPa)
* - Intake air humidity (%)
* - Ambient temperature (℃)

* - Charge air pressure (kg/cm2)
* - Charge air temperature (℃)
* - Charge air cooling water inlet/outlet temperature (℃)
* - Lubricating oil cooler (i.e., oil side) inlet/outlet (℃)
* - Fuel oil inlet temperature (℃)

Remarks)
1. The measurements marked ' * ' shall be carried out with gauges and analyzers calibrated according to the Appendix 4 of the IMO NOx Technical Code.
2. The measurements marked ' * * ' shall be carried out through the carbon balance method according to the IMO NOx Technical Code 5.5.3.
3. Concerning the engine dynamometer specified in the IMO NOx Technical Code Chapter 5, in case that an engine is supplied with alternator attached, it is not practical to apply a dynamometer to measure the engine power measurements.
   Therefore, by using of alternator power meter with alternator efficiency, the calculation of the power output from the engine based on reading taken from the alternator output shall be applied.

I. On Board Verification Procedure

1. General

The following described procedure shows an easy and reliable verification of the engine in order to confirm its compliance with Annex VI to MARPOL 73/78.
The procedure should be applied to initial, periodical and intermediate surveys after installation of the engine in the ship. The procedure can be performed during the stop in the harbor without running the engine except for some setting parameters. All ID-numbers, settings and dimensions mentioned in the following verification procedure are defined in the "List of NOx Relevant Components and Settings" on Chapter F.

2. The procedure for on board verification

The procedure of an engine for on-board verification shall be carried out as follows ;

Firstly,

The Technical File, Record Book and Technical documentation shall be checked by surveyor.

Secondly,

The engine components and parameter setting values shall be reviewed by surveyor.

DET NORSKE VERITAS 1864

Examined for compliance with requirement of MARPOL 73/78, Annex VI and the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines

2009. 09. 15

SIGN :

DET NORSKE VERITAS A/S

EIAPP - G-0953 -0003

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3. Check for engine components and parameters

The following summarize the easy and reliable verification of the engine in order to confirm its components compliance with Annex VI to MARPOL 73/78 for engine test shop and on-board verification.

Engine Specification

1. Rated power & RPM : Check the name plate on engine body.

Combustion chamber

1. Cylinder liner : Check the IMO ID-number.
2. Cylinder cover : Check the IMO ID-number.
3. Piston crown : Check the IMO ID-number.

Fuel injection equipment

1. Barrel of fuel pump : Check the IMO ID-number.
2. Plunger of fuel pump : Check the IMO ID-number and diameter.
3. Number of fuel valve(s) : Check the number of the fuel valve(s) per cylinder.
4. Atomizer of fuel valve : Check the IMO ID-number.
5. Fuel cam : Check the IMO ID-number.
6. Exhaust cam : Check the IMO ID-number.

Turbocharger

1. Maker : Check the name plate.
2. Number of T/C(s) : Check the number of the turbocharger(s).
3. Serial No./Model : Check the serial number/model on name plate.
4. Compressor wheel : Check the IMO ID-number.
5. Diffuser : Check the IMO ID-number.
6. Turbine rotor : Check the IMO ID-number.
7. Nozzle ring : Check the IMO ID-number.

Charge air cooling system

1. Maker : Check the name plate.
2. Number of air cooler(s) : Check the number of the air cooler(s).
3. Serial No./IMO ID : Check the name plate.
4. Cooling system : Check cooling system corresponds to Chapter F/M/N.

Governor

1. Maker : Check the name plate.
2. Model : Check the model name.

Aux. Blower

1. Maker : Check the name plate.
2. Serial No. : Check the name plate.

Performance set-up

1. Compression ratio : Check the thickness of compression shim.
2. Exhaust cam lead angel : Check the lead angle.
3. Fuel cam lead angel & top lift : Check the lift of fuel pump.
4. Fuel pump lead angle : Check the lead angle (only for reference)
5. Fuel pump shim(s) : Check the number and thickness of fuel pump shim(s). (only for without VIT system)
6. Fuel pump orifice : Check the size of orifice of fuel pump (if applicable)

4. Procedures for an engine parameter check method

No.	Inspection		Remarks
1	**Inspection of documents**		
1.1	Inspection of Technical File		
1.2	Inspection of Record Book of engine parameters		
1.3	Inspection of Technical Documentation of engine components modification		
2	**Inspection of engine components**		
2.1	Piston crown	Ident. No. : A10-255133-2, 5012873-6	
2.2	Cylinder cover	Ident. No. : A10-212926-7, 5025583-3	
2.3	Cylinder liner	Ident. No. : A19-266039-5, A19-212323-4, 3170262-7	
2.4	Barrel of fuel pump	Ident. No. : 1170729-8	
2.5	Plunger of fuel pump	Ident. No. : 1171182-5	Dia. : 52 mm
2.6	Fuel injection valve (number of fuel valve(s))	Number : 2/cylinder	
2.7	Atomizer of fuel valve	Ident. No. : 3062332-6x115	
2.8	Fuel cam	Ident. No. : A19-124775-1, 1173321-5	
2.9	Exhaust cam	Ident. No. : A19-124779-9, 1173320-3	
2.10	Governor	Maker : Kongsberg Maritime Korea Model : AC C20 DGS	Serial No. : Name plate
2.11	Turbocharger	Maker : Hyundai-ABB Model : TPL77B12 Serial No. : XH002480	Serial No. : Name plate
2.12	Scavenge air cooler	Maker : Vestas Aircoil Ident. No. : A19-274025-8 Serial No. : 76667	Serial No. : Name plate
2.13	Auxiliary blower	Maker : Tae Il Blower Mfg. Co., Ltd. Serial No. : 08B0276-01-05, 08B0276-01-06	Serial No. : Name plate
3	**Inspection of setting values**		
3.1	Rated power	8820 kW : See N.P. & T.F.	
3.2	Rated speed	119 RPM : See N.P. & T.F.	
3.3	Max. combustion pressure	150.0 bar at rated power	
3.4	Compression ratio (shim thickness)	8 mm (beneath piston rod)	
3.5	Exhaust cam	Lead angle : See next page.	
3.6	Fuel cam / Fuel pump	Lead angle and top lift : See next page.	
3.7	Fuel pump shim / thickness	Number and thickness : See next page.	
3.8	Fuel pump orifice	Diameter : See next page.	
4	**Review of operating values with fuel oil analysis as well as shop test report, if available**		for reference
4.1	Scav. air temperature	See I.8	
4.2	Max. cylinder pressure	See I.8	

Notes)
(1) T.F. : Technical File.
(2) N.P. : Name Plate of engine
(3) The most important : Atomizer of fuel valve
(4) The surveyor shall have the option of checking one or all the identified components, settings or operating values to ensure that the engine with number, or minor, adjustment or modifications complies with the applicable emission limits and that only components of the current specification are being used. Especially, if it is necessary to survey a combustion pressure, the combustion pressure at 50% and 75% load can be measured and evaluated according to the maximum combustion pressure table on page 9.

5. Inspection of turbocharger components

No.	Components	Identification No.	Remarks
1	Compressor wheel	CV12 CT65	-
2	Diffuser	CT65 CA17	-
3	Turbine rotor	TT40 TF15	-
4	Nozzle ring	TT40 TA22	-

6. Exhaust cam lead (advance angle)

*** for parent engine ***

Cylinder No.	1	2	3	4	5	6	7	8	9	10	11	12	Average
Measured angle (before TDC) at shop test bed	-3.40	-3.35	-3.45	-3.40	-3.35	-3.40	-	-	-	-	-	-	-3.39

(Design Value: Angle A : 112.9°, Lift = 10 mm / Angle B : 254.1°, Lift = 10 mm)

*** for member engine ***

Cylinder No.	1	2	3	4	5	6	7	8	9	10	11	12	Average
Measured angle (before TDC) at shop test bed	-3.40	-3.20	-3.35	-3.20	-3.35	-3.35	-	-	-	-	-	-	-3.31

(Design Value: Angle A: 112.9°, Lift = 10.0 mm / Angle B : 254.1°, Lift = 10.0 mm)

7. Fuel cam (lead angle) / Fuel pump(top lift)

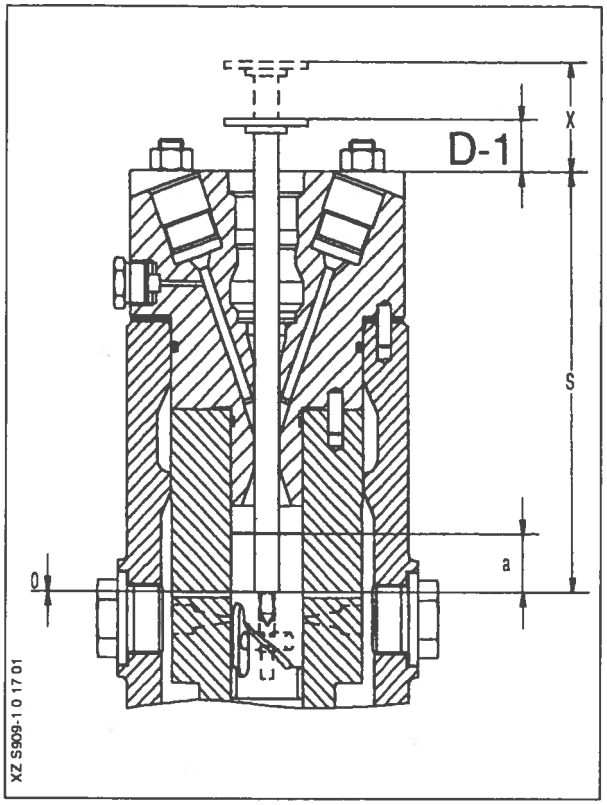
*** for parent engine ***

Cylinder No.	1	2	3	4	5	6	7	8	9	10	11	12	Average
Measured angle (before TDC) at shop test bed	9.40	9.80	9.70	10.30	9.70	9.80	-	-	-	-	-	-	9.78
Number of fuel pump shim (EA)	8	8	8	8	8	8	-	-	-	-	-	-	8
Thickness of fuel pump shim (mm)	0.5	0.5	0.5	0.5	0.5	0.5	-	-	-	-	-	-	0.5
Top lift(mm) at shop test bed	10.64	11.36	11.09	11.93	11.07	11.28	-	-	-	-	-	-	11.23
Fuel pump orifice (φmm, if applicable)	-	-	-	-	-	-	-	-	-	-	-	-	-

*** for member engine ***

Cylinder No.	1	2	3	4	5	6	7	8	9	10	11	12	Average
Measured angle (before TDC) at shop test bed	10.30	10.50	10.50	10.20	10.20	9.80	-	-	-	-	-	-	10.25
Number of fuel pump shim (EA)	8	8	8	8	8	8	-	-	-	-	-	-	8
Thickness of fuel pump shim (mm)	0.5	0.5	0.5	0.5	0.5	0.5	-	-	-	-	-	-	0.5
Top lift(mm) at shop test bed	11.97	11.98	12.18	11.67	11.76	11.25	-	-	-	-	-	-	11.80
Fuel pump orifice (φmm, if applicable)	-	-	-	-	-	-	-	-	-	-	-	-	-

Remarks)
Compression shim thickness, fuel cam lead angle, fuel pump top lift, fuel pump shim thickness/numbers and exhaust cam lead angle can be adjusted and changed in order to keep maximum combustion pressure within the approved ranges as given in Chapter F.2
Note : Any adjustment(s) and change(s) should be recorded in the 'Record Book' of engine parameters.



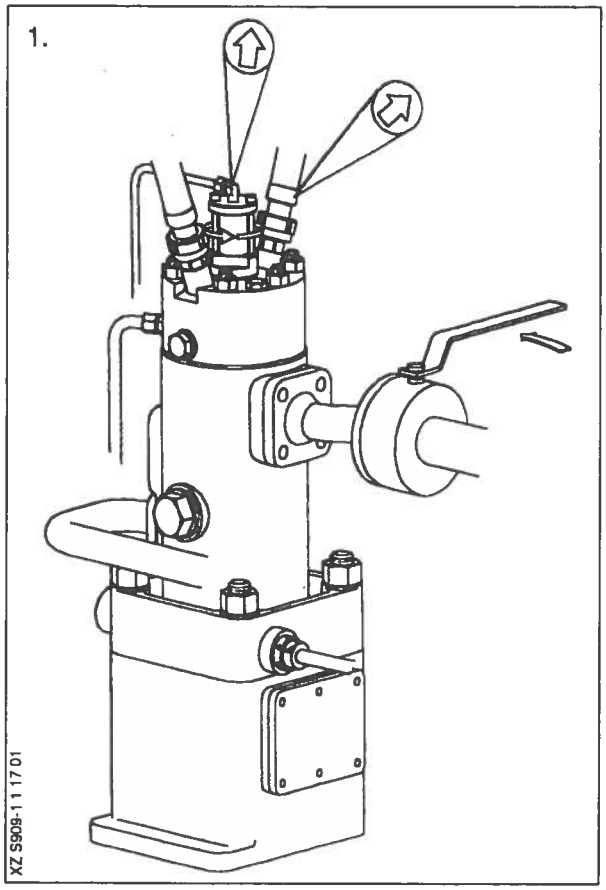
The fuel pump lead **a** (= the effective lead) is defined as the distance the top of the fuel pump plunger is lifted above the upper edge of the upper cut-off holes in the fuel pump barrel, when the piston of the cylinder concerned is in TDC.

Barrel + Top cover = **s**

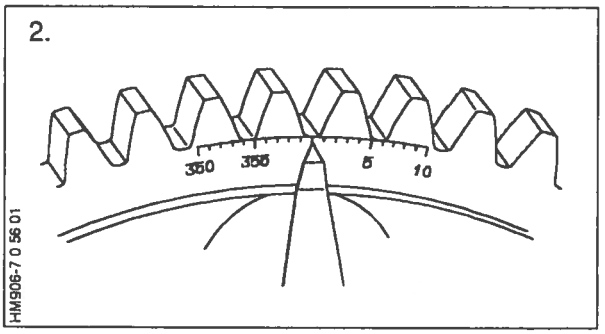
Tool length = **s + "D-1"**

Fuel pump lead **a = x - "D-1"**

1.



2.



1. To be able to measure the fuel pump lead, it is necessary to dismantle one of the high-pressure pipes and the combined puncture/suction valve from the top cover.

Note!
Before dismantling any part of the fuel pump, make sure the pump has been relieved of pressure and that all oil has been drained off.

Shut off the fuel oil inlet.

Open the fuel pump drain cock, and drain off the oil

Dismount one of the high-pressure pipes.

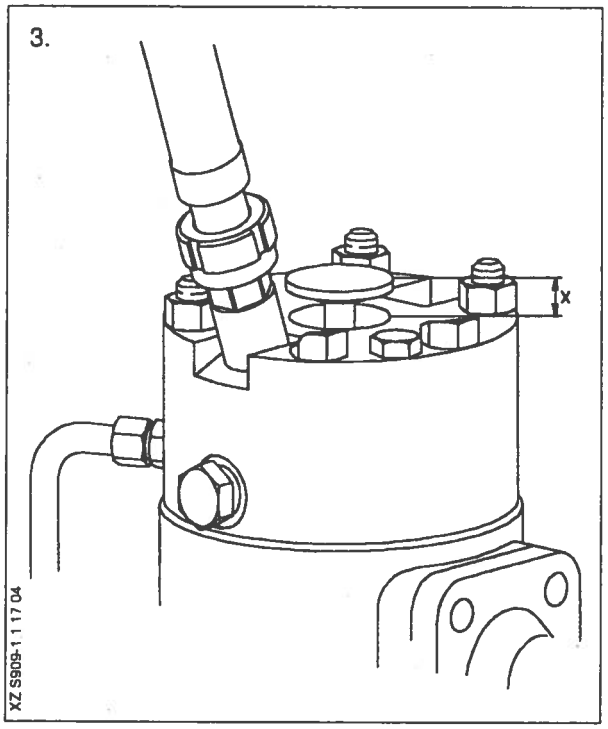
Dismount the air pipe on the puncture valve.

Dismount the puncture valve.

2.

Note!
The correct distance **x** can only be measured when the fuel pump plunger is in its delivery stroke.

Turn the engine in AHEAD direction until the main piston of the cylinder concerned is exactly at TDC.
See Procedure 906-3.1.



3. Mount the measuring tool on top of the fuel pump plunger, through the hole in the fuel pump top cover.

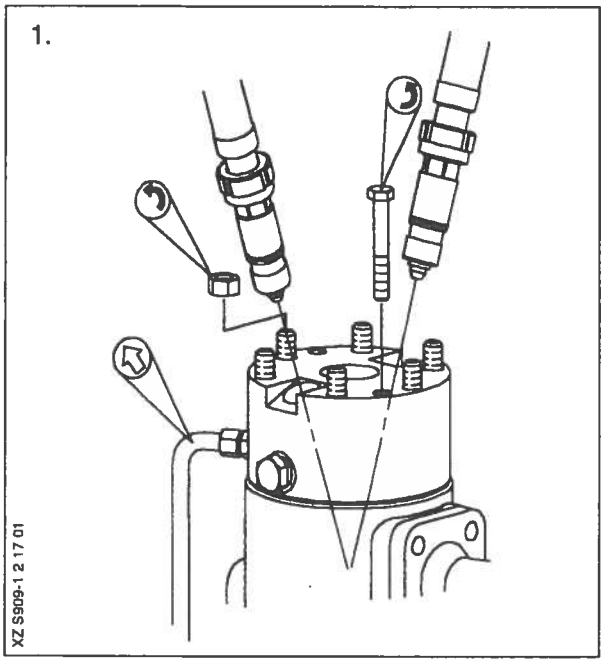
   Measure the distance **x** from the top of the measuring tool to the top of the fuel pump top cover.

   The fuel pump lead is then calculated as:
   a = x - "D-1"

   Note down the result for future reference.

   For adjustment of fuel pump lead.
   See Procedure 909-1.3.

1.



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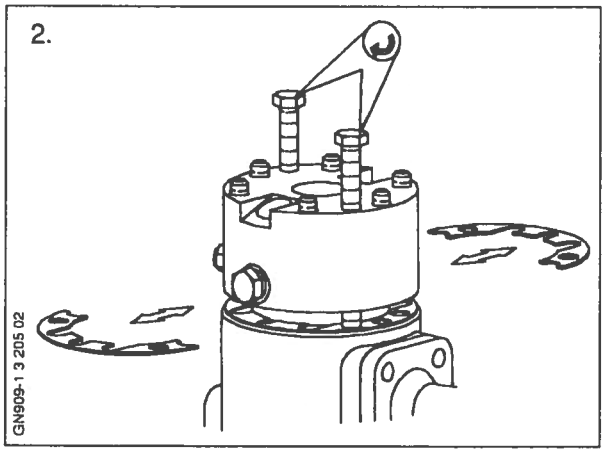
2.



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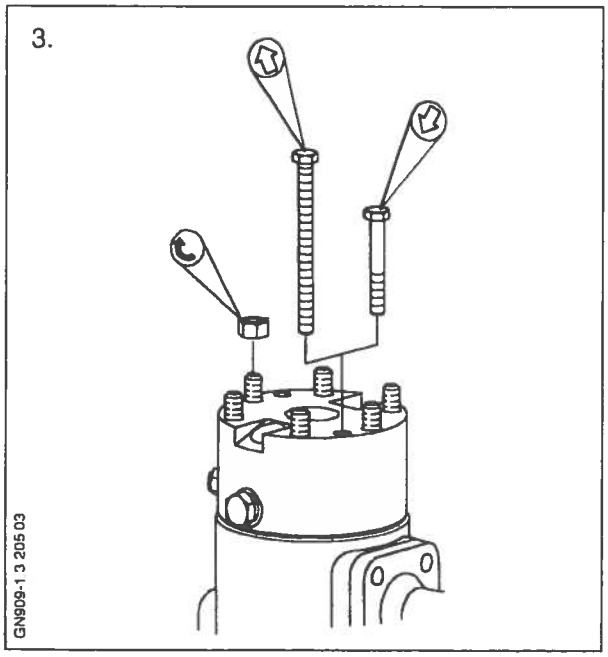
3.



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To insert or remove shims from the fuel pump, use the following procedure:

Note!
If the required adjustment of the fuel pump lead cannot be attained by inserting or removing *shims (see Data D-2)*, the adjustment must be carried out on the fuel cam disc. *See Procedure 909-3.3.*

1. Dismount the high-pressure pipes.

   Dismount the drain oil pipe on the top cover.

   Dismount the top cover fixing nuts. Remove the two screws in the threaded holes of the top cover.

2. Screw the two dismantling screws (from the tool panel) into the threaded holes of the top cover, thus lifting the top cover to provide space for inserting or removing shims.

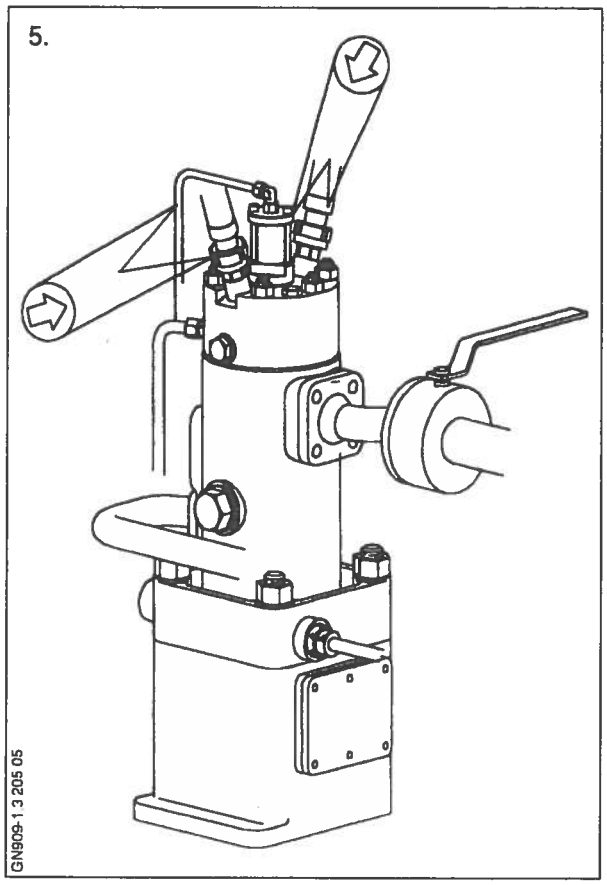
   The number of shims can now be adjusted.
   See Data D-2.

   Note down the new shim thickness.

3. Replace the dismantling screws with the two original screws, and press down the top cover.

   Mount the nuts for fastening the top cover, and tighten them diagonally, *see Data D-4.*

   If any of the top cover studs have come loose, tighten them, *see Data D-5.*



4. Measure the fuel pump lead again and note down the result for future reference.
   See Procedure 909-1.1

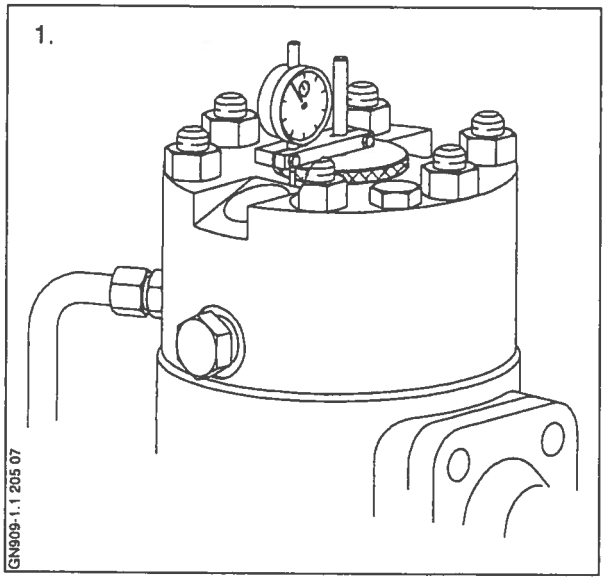
5. Close the drain cock in the pump housing.

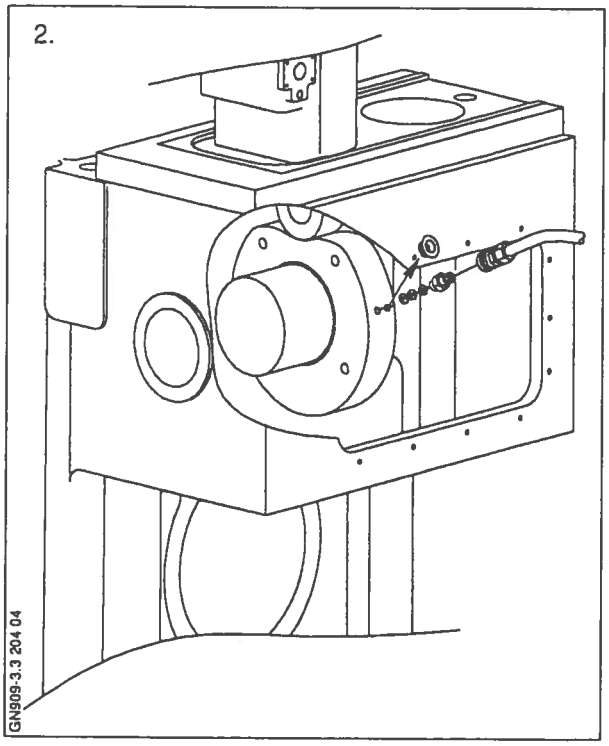
   Mount the combined puncture/suction valve in the top cover, *see Data D-3.*

   Connect the drain oil pipe to the top cover and the pipe connection to the puncture valve.

   Mount the two high-pressure pipes on the top cover/fuel valves, *see Data D-6.*

6. Open the fuel oil inlet.





If the required adjustment of the fuel pump lead cannot be accomplished by inserting or removing shims, the fuel pump lead must be altered by adjusting the fuel cam disc as described below. *See Procedure 909-1.3.*

1 Turn AHEAD until the piston of the cylinder concerned is in TDC. (If the engine is of the reversible type, ensure that the roller guide is in AHEAD position).

Mount the measuring tool and adjust the dial gauge to zero.

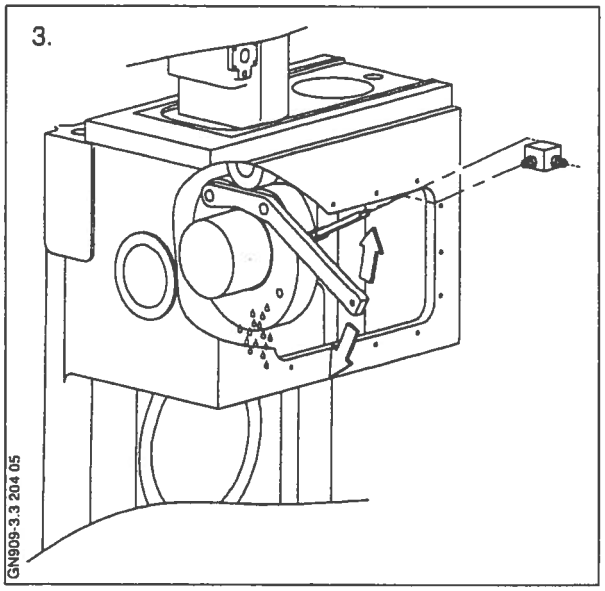
2 Remove the inspection cover from the camshaft housing.

Remove the plugs from the oil ducts on the fuel cam.

Insert three copper gaskets in each oil duct.

Mount quick couplings in the ducts, but do not tighten them.

Fit hydraulic hoses between the snap-on couplings, the distributor block and the high pressure pump.

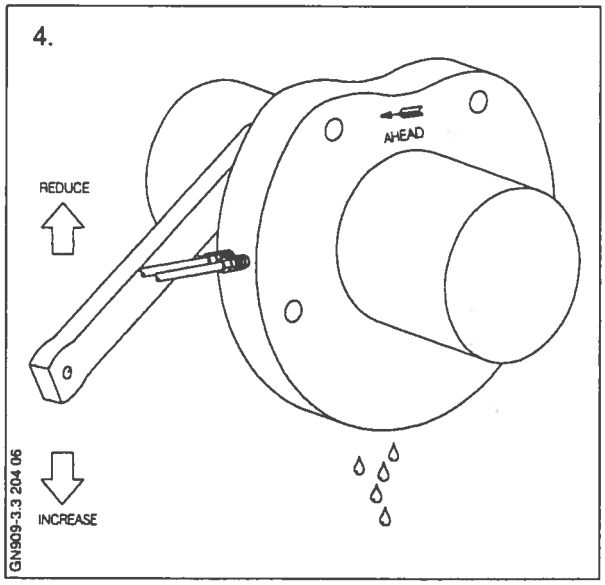


3. Mount the special spanner on the fuel cam disc and keep it close against the cam during the adjustment.

   Apply light pressure to the hydraulic system and, after venting the system, tighten the quick coupings.

   Raise the hydraulic pressure until oil seeps out between the camshaft and the cam disc.

   Turn the cam disc, using the fitted spanner, until the desired change of lead is read directly on the measuring tool.
   (The necessary turning of the cam disc is calculated as described in Procedure 909-1.1).



4. To increase the lead and P_{max}:

   ·turn the cam disc AHEAD.

   To reduce the lead and P_{max}:

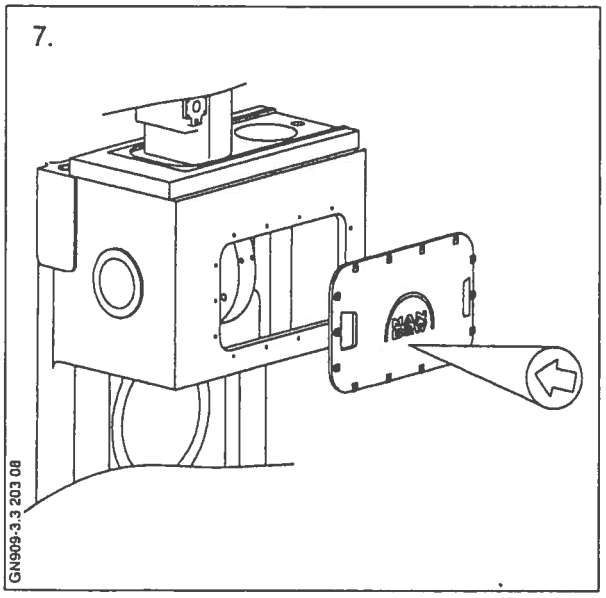
   ·turn the cam disc ASTERN.

5. After completing the desired turning of the cam disc, relieve the hydraulic system of pressure and dismount the spanner and the hydraulic equipment.

   Wait at least 15 minutes - the cam must be allowed time to "settle" - before mounting the plugs again in the oil ducts of the cam disc.

6. Again measure the lead of the fuel pump. *See Procedure 909-1.1.*

7. Mount the inspection cover on the camshaft housing.



8. Evaluation of the performance influence on the ISO corrected NOx values

(Parent Engine of Engine Group)

A method to check NOx compliance for varying maximum combustion pressure and scavenge air temperature is shown in the following example neglecting the influence of turbine back pressure. The back pressure has been found out to have only a minor influence on NOx values.

Reference table for Ha , Khdies and Ta

Load(%)	Hsc	Ha	Khdies(*)	Ta	Khdies(**)
100	12.72	1.80	0.9158	22.0	0.9300
75	11.40	1.47	0.9057	18.0	0.9125
50	14.38	1.18	0.8917	15.0	0.8982
25	12.13	0.95	0.9200	13.0	0.9269

Remarks ;

Khdies(*) : Based on Tscref.
Khdies(**) : Based on max. allowable Tsc.

Table 8.1 Estimation of maximum combustion pressure and scavenge air temperature at 100%, 75%, 50% and 25% load and derive the equivalent change in NOx emission (g/kWh).

Load (%)	Max. combustion pressure(bar)		Absolute change in NOx (g/kWh)	Scavenge air temperature (ΔT)		Absolute change in NOx (g/kWh)
	Ref. value	ΔP		Tscref	ΔT	
100	150.0	increase 1 bar	0.1816	48.0	increase 1 ℃	Khdies
75	133.0	increase 1 bar	0.1760	43.0	increase 1 ℃	Khdies
50	108.0	increase 1 bar	0.1760	39.0	increase 1 ℃	Khdies
25	83.0	increase 1 bar	0.1760	44.0	increase 1 ℃	Khdies

Table 8.2 Maximum allowed tolerances of max. combustion pressure and scavenge air temperature at ISO ambient conditions and the relative change in NOx.

Load (%)	NOx (g/kWh) (Not corrected-Pmax.)		Max. combustion pressure(bar)			Change in NOx (g/kWh)	Scavenge air temp. (℃)		Scavenge Air temp. actual (℃)
	Corr. Tscref	Not corr.-Tscref	Actual value	Ref. value	Max. allowable Pmax		Tsc ref	Max. allowable Tsc	
100	13.78	15.05	150.0	150.0	153.0	0.5448	48.0	54.0	40.0
75	15.13	16.71	131.7	133.0	136.0	0.7568	43.0	46.0	34.0
50	17.60	19.74	105.8	108.0	111.0	0.9152	39.0	42.0	32.0
25	18.72	20.35	80.3	83.0	86.0	1.0032	44.0	47.0	22.0

Note : Tscref. - 48℃, 43℃, 39℃, 44℃ at load 100%, 75%, 50%, and 25% respectively.
Tscref. values are based on operation with a fresh water temperature of 36℃.

Corrected ISO NOx values(Based on reference Pmax. and scavenge air temperature)

IMO NOx = 0.2909 x 13.78 + 0.0000) +
0.5455 x 15.13 + 0.2288) +
0.1091 x 17.60 + 0.3872) +
0.0545 x 18.72 + 0.4752)
= **15.40 g/kWh**

Example ' Calculation of expected NOx at the given combustion pressure and scavenge air temperature.

1) Measure the maximum combustion pressure and scavenge air temperature at 100%, 75%, 50% and 25% load as following table.

Power (%)	Max. combustion pressure(bar)		Absolute change in NOx (g/kWh)	Scavenge air temperature (ΔT)		Absolute change in NOx (g/kWh)
	Actual value	ΔP		Actual value	ΔT	
100	149.0	-1 bar	-0.1816	54	14 ℃	-1.0535
75	129.7	-2 bar	-0.3520	46	12 ℃	-1.4625
50	103.8	-2 bar	-0.3520	42	10 ℃	-2.0101
25	78.3	-2 bar	-0.3520	47	25 ℃	-1.4876

Note : ΔP = Actual value - test bed value(parent eng.), ΔT = Actual value - test bed value(parent eng.)

2) Calculate the expected NOx emission at each load condition as a summation of the ISO NOx corrected value and the absolute changes (as given in the table). The ISO NOx corrected values for the E3-cycle load conditions are given in Chapter I-8.

100%

NOx value at shop test (Not corrected- Pmax & Tscref) = 15.05 g/kWh
Absolute change as a consequence of different max. pressure = -0.1816 g/kWh
Absolute change as a consequence of different scav. temp. = -1.0535 g/kWh
Expected NOx emission
15.05 + (-0.1816) + (-1.0535) = 13.81 g/kWh

75%

NOx value at shop test (Not corrected- Pmax & Tscref) = 16.71 g/kWh
Absolute change as a consequence of different max. pressure = -0.3520 g/kWh
Absolute change as a consequence of different scav. temp. = -1.4625 g/kWh
Expected NOx emission
16.71 + (-0.3520) + (-1.4625) = 14.89 g/kWh

50%

NOx value at shop test (Not corrected- Pmax & Tscref) = 19.74 g/kWh
Absolute change as a consequence of different max. pressure = -0.3520 g/kWh
Absolute change as a consequence of different scav. temp. = -2.0101 g/kWh
Expected NOx emission
19.74 + (-0.3520) + (-2.0101) = 17.38 g/kWh

25%

NOx value at shop test (Not corrected- Pmax & Tscref) = 20.35 g/kWh
Absolute change as a consequence of different max. pressure = -0.3520 g/kWh
Absolute change as a consequence of different scav. temp. = -1.4876 g/kWh
Expected NOx emission
20.35 + (-0.3520) + (-1.4876) = 18.51 g/kWh

3) Finally, calculate the ISO corrected IMO NOx value at the given maximum combustion pressure and scavenge air temperature using the following formula.

IMO NOx = 0.2909 x NOx(100%) + 0.5455 x NOx(75%) + 0.1091 x NOx(50%) + 0.0545 x NOx(25%)
IMO NOx = 0.2909 x 13.81 + 0.5455 x 14.89 + 0.1091 x 17.38 + 0.0545 x 18.51
= **15.05 g/kWh**

Since the IMO limit is 17.0 g/kWh, the engine still fulfills the requirements.

Example 2 : Calculation of expected NOx at max. allowable combustion pressure and scavenge air temperature.

IMO NOx = 0.2909 x 15.05 x 0.9300 + 0.5448) + 0.5455 x (16.71 x 0.9125 + 0.7568)
+ 0.1091 x 19.74 x 0.8982 + 0.9152) + 0.0545 x (20.35 x 0.9269 + 1.0032)
= **16.08 g/kWh**

J. Concept of Parent, Member Engine and Engine Group

Conditions for the application of this group concept are a set of identical engines having the identical components, same maximum power per cylinder and same rated speed.

The engine manufacturer should show a "Conformity of Production" in the production process. This includes ISO 9001 certificates or other quality insuring systems which should guarantee that member engines of engine group are identical.

Idea of this group concept is to have a need for emission measurements only for an engine, the so called "Parent Engine" and not need for emission measurements only for an engine, the so called "Member Engine". All the following identical engines can be adjusted and certified according to the procedures described in this page and according to the "List of NOx Relevant Components and Settings" on Chapter F.

Conditions for an Engine to be a member of the Engine Group

1. Identical Components :
If this is not the case the engine manufacturer has to show that the modified or exchanged components behave in the same way.

2. Same settings :
All settings and measured values according to the "List of NOx Relevant Components and Settings" on Chapter F should be within the limits approved for the Engine group.

K. Marking of Identification Number of the NOx Relevant Components

1. Application range

This is valid for components and engines which are built at Hyundai Heavy Industries Co., Ltd., Engine & Machinery Division works (HHI-EMD), in accordance with the requirements of the International Maritime Organization (IMO) document MP/CONF.3/35 - Resolution 2, Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines.

2. Purpose

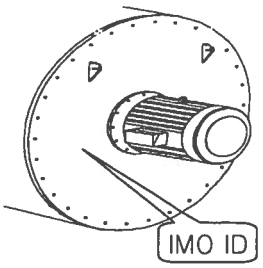
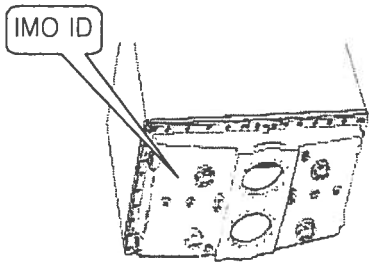
This controls
· that NOx relevant components are specified.
· that is ensured that only these components are installed and
· that they are marked with the provided identification numbers.

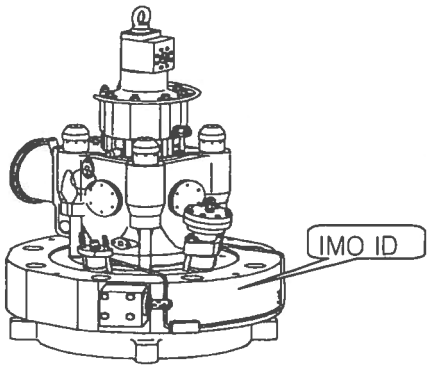
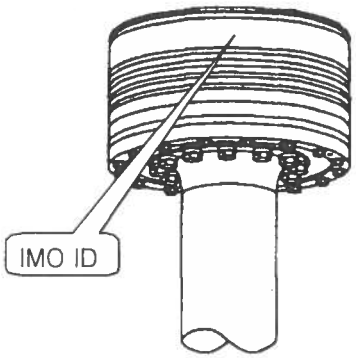
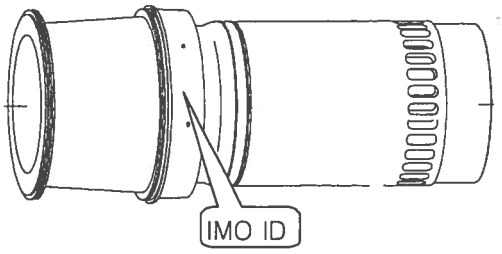
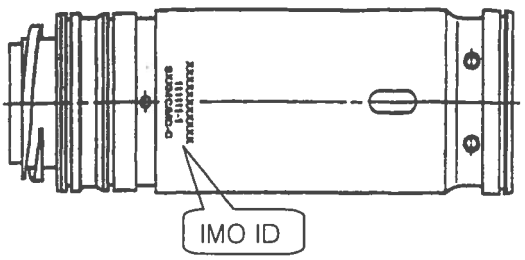
3. Checking

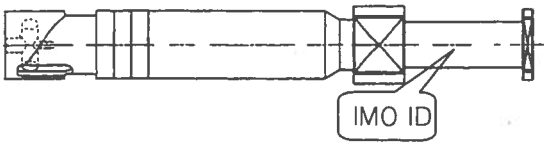
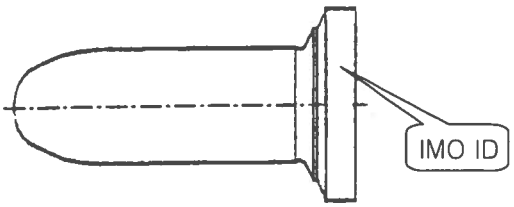
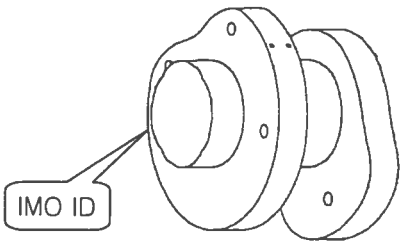
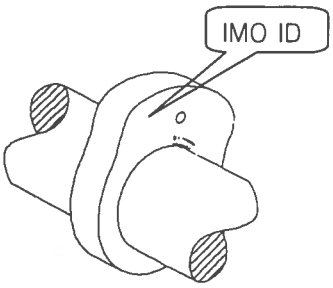
The ID number of NOx relevant components were checked during assembly of final inspection by duly authorized surveyor.

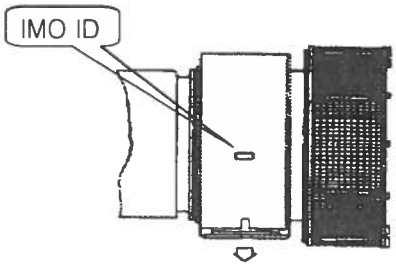
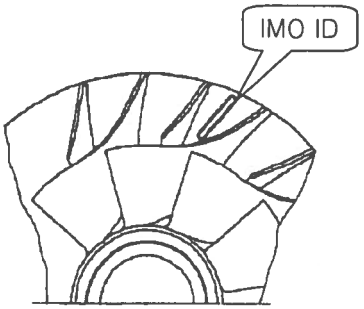
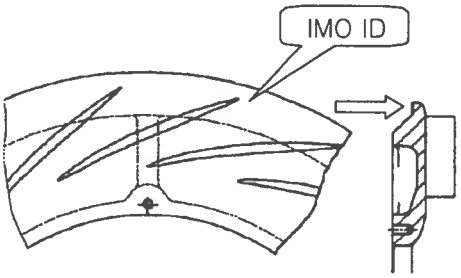
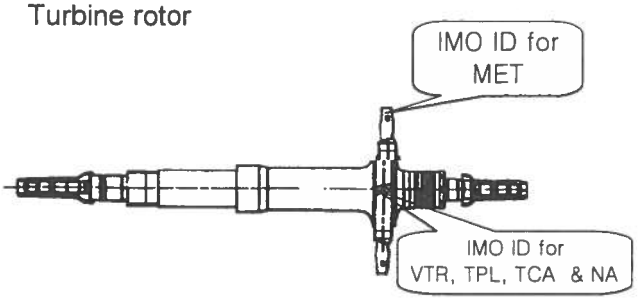
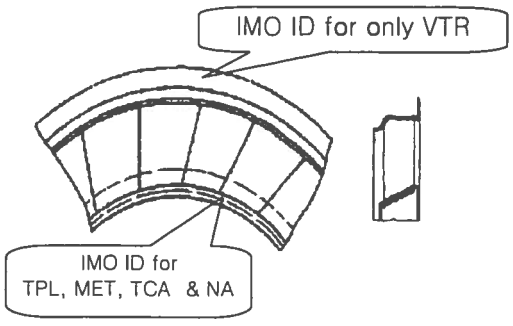
4. ID numbers of NOx relevant components

The ID number of NOx relevant components mentioned in the "List of the NOx Relevant Component and Settings" on Chapter F are marked as shown on the following sheets.

No.	Location of the IMO ID	IMO ID	Drawing No.
1	Auxiliary blower 	Serial No. 08B0276-01-05 08B0276-01-06	A14-321343-6
2	Air cooler 	A19-274025-8 Serial No. 76667	A14-332495-8

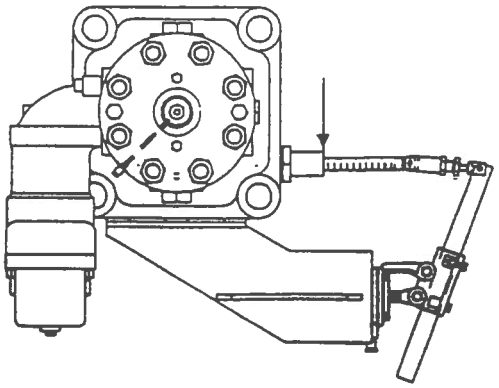
No.	Location of the IMO ID	IMO ID	Drawing No.
3	Cylinder cover 	A10-212926-7 5025583-3	A10-212926-7
4	Piston crown 	A10-255133-2 5012873-6	A10-255133-2
5	Cylinder liner 	A19-266039-5 A19-212323-4 3170262-7	A10-214402-3
6	Barrel of fuel pump 	1170729-8	A10-188640-2

No.	Location of the IMO ID	IMO ID	Drawing No.
7	Plunger of fuel pump 	1171182-5	A11-188641-4
8	Atomizer of fuel valve 	3062332-6x115	A12-224009-0
9	Fuel cam 	A19-124775-1 1173321-5	A10-169928-8 A10-169929-0 (for template dwg.)
10	Exhaust cam 	A19-124779-9 1173320-3	A10-169931-0 A10-169932-2 (for template dwg.)

No.	Location of the IMO ID	IMO ID
11	Turbocharger 	Type : TPL77B12 Serial No. : XH002480
11-1	Compressor wheel 	CV12 CT65
11-2	Diffuser 	CT65 CA17
11-3	Turbine rotor 	TT40 TF15
11-4	Nozzle ring 	TT40 TA22

5. Read the actual VIT-index

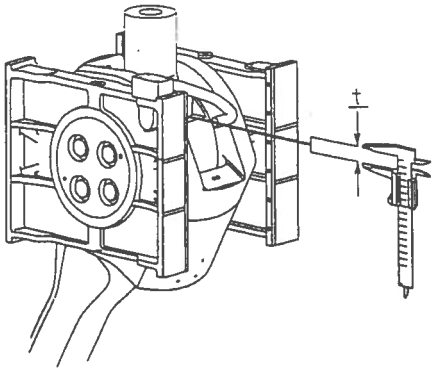
Read the actual VIT-index on the scale of the fuel pump timing racks.



6. Checking the shims

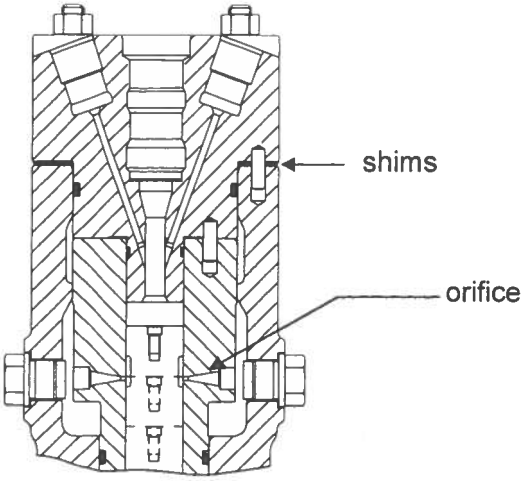
A. Checking the compression shims thickness (t), (compression volume)

Turning the crankthrow towards the exhaust side, to provide access for measuring the thickness of the shim which is inserted between piston rod and crosshead pin.



B. Number of shims in the fuel pump, (injection timing)

For engines without VIT, visually check the number of shims between the fuel pump top cover and the pump housing.



L. Test Report and Certificates

After the IMO NOx pre-certification test at test bed,

1. The test report is included in the Technical File.

After issuing of the EIAPP certificate (or 'the Statement of Compliance'),

2. The EIAPP Certificate(or the Statement of Compliance) shall be attached to the Technical File.

Number of Certificate : .....

Issued Date : .....

After issuing of the IAPP certificate (or 'the Statement of Compliance'),

3. The IAPP Certificate(or the Statement of Compliance) shall be attached to the Technical File.

Number of Certificate : .....

Issued Date : .....

M. Engine General Information

Project	**HMDS003 MAIN ENGINE**
Engine Type	**HYUNDAI-MAN B&W 6S50MC-C7**
Engine No.	**AA3382 (Member engine of engine group)**

Engine	
Manufacturer	Hyundai Heavy Industries Co., Ltd., Engine & Machinery Division
Rated speed	119 RPM
Rated power	8820 kW
Family / Group Identification	HYUNDAI-MAN B&W 6S50MC-C-2008-15
Serial number	AA3382
Intermediate speed	N/A
Maximum torque at intermediate speed	N/A
Static injection timing	-
Electronic injection control	Yes (-) , No (•)
Variable turbocharger geometry	Yes (-) , No (●)
Bore	500 mm
Stroke	2000 mm
Compression shim	8 mm
Mean effective pressure at rated power	18.9 bar
Maximum cylinder pressure at rated power	150 bar
Cylinder number, configuration	Number : 6 , In-line(●) , V (-)
Auxiliaries	N/A
Specified ambient conditions	
Maximum cooling water temperature	36 ℃ *
Maximum charge air temperature	54 ℃ *
Cooling system spec. intermediate cooler	Yes (●) , No (-)
Cooling system spec. charge air stages	One (1) stage
Low temp. cooling system set point	40 ℃
High temp. cooling system set point	90 ℃
Maximum inlet depression	150 mmWC
Maximum exhaust back pressure	450 mmWC
Fuel oil temp. (100% load at shop test, measured at the inlet to the fuel injection	See Chapter S.
Lubricating oil specification	MELINA 30S
Application / Intended for	
Customer	E.R.SCHIFFAHRT
Final application / installation, Ship	Hyundai Vinashin Shipyard Co., Ltd. Hull No. S003
Final application / installation, Engine	Main (●) , Aux (-)
Emission test results (Parent engine of engine group)	
Cycle	E3
NOx	15.40 g/kWh
Date	November 18, 2008
Test site / shop	HHI-EMD test shop
Surveyor	Mr. D. I. Park of DNV
Signature	Mr. J. W. Lee of HHI-EMD
Date and Place of report	July 22, 2009 , HHI-EMD

'*' : mark : Based on the engine design condition.

N. Engine Group Information

Project	**HMDS003 MAIN ENGINE**
Engine Type	**HYUNDAI-MAN B&W 6S50MC-C7**
Engine No.	**AA3382 (Member engine of engine group)**

Engine Group Information (common specifications)		
Combustion cycle	■ : 2-stroke cycle	□ : 4-stroke cycle
Cooling medium (Air cooler)	□ : Air	■ : Water
Cylinder configuration	6 cylinders, In-Line	
Method of aspiration	■ : Constant pressure	□ : Natural aspired
Fuel type to be used on board	■ : Heavy fuel ■ : Distillate	□ : Dual
Combustion chamber	■ : Open chamber	□ : Divided chamber
Valve port configuration	■ : Cylinder head	□ : Cylinder wall
Valve port size and number	Fuel valve : 2/cylinder	Exh. valve : 1/cylinder
Fuel system type	One fuel pump per cylinder	
Miscellaneous Features		
Exhaust gas recirculation	□ : Yes	■ : No
Water injection / emulsion	□ : Yes	■ : No
Air injection	□ : Yes	■ : No
Charge cooling system	■ : Yes	□ : No
Exhaust after - treatment	□ : Yes	■ : No
Exhaust after - treatment type	N/A	
Dual fuel	□ : Yes	■ : No

Engine Group Information (selection of parent engine for test bed)	
Group identification	HYUNDAI-MAN B&W 6S50MC-C-2008-15
Method of pressure charging	Constant pressure
Charge air cooling system	Central fresh water cooling system
Number of cylinder	6
Max. rated power per cylinder	1470 kW
Rated speed	119 RPM
Selected parent engine	AA3182
Application	Hyundai Vinashin Shipyard Co., Ltd. Hull No. S001

O. Test Cell Information (For Information)

Project	**HMDS001 MAIN ENGINE**
Engine Type	**HYUNDAI-MAN B&W 6S50MC-C7**
Engine No.	**AA3182 (Parent engine of engine group)**

Measurement Equipment					Calibration	
		Manufacturer	Model or Serial No.	Measurement range	Span gas conc.	Deviation
Analyzers (HORIBA MEXA-9100F) 4039070001						
NOx Analyzer		HORIBA	CLA-155	2000 ppm	1886	± 0.1 %
CO Analyzer		HORIBA	AIA-120	500 ppm	473	0.5 %
CO2 Analyzer		HORIBA	AIA-120	10 %	9.23	0.5 %
O2 Analyzer		HORIBA	FMA-126D	25 %	23.2	0.3 %
HC Analyzer		HORIBA	FMA-126D	500 ppmC	454	± 0.1 %
Speed (engine tachometer)		YOKOGAWA	62GE0178	0.1~30000 rpm	-	0.0 %
Torque		-	-	-	-	-
Power meter (water brake)		PROUDE	97033	36000 bhp	-	0.17 %
Weighing machine (SFOC)		CAS	0806LS0030300	5000 kg	-	0.02 %
Air flow		-				
Exhaust flow		Calculated-IMO Universal, Carbon/Oxygen balance method				
Temperatures						
Scavenge air cooler	in	RUEGER	3TH-9	0~120 ℃	-	- 2 ℃
	out	RUEGER	K48-043	0~120 ℃	-	- 1 ℃
		-	-	-	-	-
Exh. Gas at T/C outlet		RUEGER	81878021	0~650 ℃	-	- 3 ℃
		-	-	-	-	-
Intake air at T/C		RUEGER	K48-032	0~120 ℃	-	0.0 ℃
		RUEGER	K48-035	0~120 ℃	-	0.0 ℃
		-	-	-	-	-
		-	-	-	-	-
		-	-	-	-	-
		-	-	-	-	-
		-	-	-	-	-
		-	-	-	-	-
Scavenge air receiver		RUEGER	3-TH1	0~160 ℃	-	- 1 ℃
		-	-	-	-	-
Ambient air		VAISALA	X3620034	-20~60 ℃	-	0.2 ℃
Fuel inlet		WIKA	1TH-23	0~120 ℃	-	- 0.5 ℃
Pressures						
Exh. Gas (manometer)		DIGITRON	441281463	0~700 kPa	-	- 0.14 %
Scavenge air		DIGITRON	441281463	0~700 kPa	-	- 0.14 %
Atmospheric		SATO	81023	970~1040 hPa	-	0.2 %
Humidity						
Intake air		VAISALA	X3620034	0~100 %RH	-	1.3 %RH
Exhaust pipe						
Diameter		1000 mm				
Insulation		■ : No		□ : Yes		
Probe location		6.0 m after turbocharger (30 m from exhaust gas exit)				
Remarks		Sampling gas temperature : min. 190℃ at all loads				

DET NORSKE VERITAS

P. Ambient and Gaseous Emission Data (For Information)

Project	**HMDS001 MAIN ENGINE**
Engine Type	**HYUNDAI-MAN B&W 6S50MC-C7**
Engine No.	**AA3182 (Parent engine of engine group)**
Test Date	**November 18, 2008**

Mode	-	-	-	-	-
Test number	-	01	02	03	04
Running time	-	12:10-13:10	11:10-11:40	10:40-11:10	10:10-10:40
Recorded time	-	12:25-12:38	11:23-11:37	10:51-11:05	10:21-10:36
Engine power	%	100	75	50	25
	kW	8820.0	6615.0	4410.0	2205.0
Engine speed	%	100	91	79	63
	rpm	119.0	108.1	94.5	75.0
Max. combustion pressure	bar	150.0	131.7	105.8	80.3
Max. compression pressure	bar	133.8	106.5	75.0	49.5
Mean effective pressure	bar	18.9	15.6	11.9	7.5
Exhaust gas temp. at T/C outlet	℃	230	208	221	212
Turbocharger speed	rpm	15119	13352	10618	6413
Ambient Data					
Charge air pressure	kg/㎠	2.78	2.01	1.13	0.38
Barometric pressure	kPa	101.7	101.8	101.8	101.8
Intake air humidity	%	11.1	11.6	11.3	10.4
	g/kg	1.80	1.47	1.18	0.95
Intake air temperature	℃	22.0	18.0	15.0	13.0
Scavenge air temperature	℃	40.0	34.0	32.0	22.0
Intercooled air reference temperature	℃	48.0	43.0	39.0	44.0
Governor					
Pump index	mm	71.2	58.0	45.2	31.0
Load indicator governor	-	73.5	60.1	48.0	34.6
Fuel					
Uncorrected fuel consumption	kg/h	1588.2	1170.5	790.0	403.5
Charge Air					
Air flow	kg/h	77134	63057	47072	26113
Exhaust Gas					
Gas flow	kg/h	78722	64228	47862	26516
Gaseous Emission Data					
CO concentration (Dry)	ppm	41.5	37.0	26.5	20.5
CO2 concentration (Dry)	%	4.41	3.98	3.59	3.30
HC concentration (Wet)	ppmC	64.0	59.5	57.0	54.0
O2 concentration (Dry)	%	15.15	15.75	16.25	16.63
NOx concentration (Dry)	ppm	1110.0	1128.0	1188.0	1102.0
NOx humidity/temp. correction factor	-	0.916	0.906	0.892	0.920
Dry / Wet correction factor	-	0.963	0.967	0.970	0.973
NOx mass flow	kg/h	121.56	100.10	77.63	41.28
NOx specific	g/kWh	13.78	15.13	17.60	18.72
Test Cycle (E3)	**g/kWh**	**15.20**			

* The IMO NOx value is based on reference scavenge air temperature, but not corrected reference Pmax.

Q. Results of NOx Emission (for Information)

Project	**HMDS001 MAIN ENGINE**
Engine Type	**HYUNDAI-MAN B&W 6S50MC-C7**
Engine No.	**AA3182 (Parent engine of engine group)**
Emission Test No.	**01 to 04**
Kind of fuel	**Bunker-A (ISO 8217, DMC)**

Engine output	kW	8,820
Output per cylinder	kW	1,470
Engine speed	RPM	119

Load	%	100	75	50	25
Oxides of Nitrogen (NOx)	g/kWh	13.78	15.13	17.60	18.72
IMO NOx-Cycle E3	g/kWh	15.20			
IMO NOx-Cycle E2	g/kWh				
IMO NOx-Cycle D2	g/kWh				

Maximum Allowable NOx	**g/kWh**	**17.0**

E3 : Test cycle for "Propeller law operated main & propeller law operated aux. engine" application
E2 : Test cycle for "Constant speed main propulsion engine" application including diesel electric drive and variable pitch propeller installation
D2 : Test cycle for "Constant speed auxiliary engine" application

* The IMO NOx value is based on reference scavenge air temperature, but not corrected reference Pmax.

R. Fuel Analysis (For Information)

Project	**HMDS001 MAIN ENGINE**
Engine Type	**HYUNDAI-MAN B&W 6S50MC-C7**
Engine No.	**AA3182 (Parent engine of engine group)**
Test Date	**November 18, 2008**
Kind of Fuel	**Marine Diesel Oil, Bunker-A** **ISO 8217, DMC**

Fuel elemental analysis & properties

Description	Unit	Result	Test Method
C (Carbon)	%, mass	87.48	Elementary Analysis
H (Hydrogen)	%, mass	11.63	Elementary Analysis
N (Nitrogen)	%, mass	0.1	Elementary Analysis
O (Oxygen)	%, mass	0.56	Elementary Analysis
S (Sulphur)	%, mass	0.21	ISO-8754
Density at 15℃	kg/ℓ	0.9107	ISO-3675
Viscosity at 40℃	mm2/s	6.80	ISO-3104
Carbon residue (Micro method)	%, mass	1.10	ISO-10370
Water	%, V/V	0.01	ISO-3733
Cetane Index	-	N/A	ISO-4264

* N/A : Not available due to mixed-bunker.

S. Engine Performance Data

Refer to the enclosed ten (10) sheets.

HYUNDAI HEAVY INDUSTRIES CO., LTD.

		Doc. No.: K630-IR09A-3383
SHOP TEST RESULT FOR MAIN ENGINE	Engine No.	AA3382
	Engine type	6S50MC-C7
	Hull No.	HMDS003
	Owner	E.R.SCHIFFAHRT
	Class	DNV
	Ship yard	HMD

HYUNDAI - MAN B&W

QUALITY MANAGEMENT DEPARTMENT
HHI-EMD

Rev.	Prepared	Checked	Approved	Description
2				
1				
0	J. W. Lee 2009-07-06	S. J. KIM 2009.07.06	S. D. PARK 2009.7.6	First issue

HYUNDAI
HEAVY INDUSTRIES CO., LTD.

Official shop test result for Main Engine	Hull No.	HMDS003	Owner	E.R.SCHIFFAHRT
	Engine No.	AA3382	Class	DNV
	Engine Type	6S50MC-C7	Test Date	June.17, 2009
Specification of Main Engine	Output(MCR)	8820 kW	Engineer	J.S.LIM
	Speed(MCR)	119 rpm	Operator	H.Y.KIM

PARTICULARS OF ENGINE

NUMBER OF CYLINDERS	6		
DIAMETER OF CYLINDER	500 mm		
STROKE	2000 mm		
FIRING ORDER	AH→	1 - 5 - 3 - 4 - 2 - 6 - 1	←AS
CYLINDER CONSTANT	0.6545		

PARTICULARS OF TURBOCHARGER

TYPE	1 × TPL77B12
SPECIFICATION	CT65CA17 TF15TA22
nMax / nBMax	17040 rpm / 550℃
tMax / tBMax	16200 rpm / 520℃
SERIAL No.	XH002480
MANUFACTURER	HYUNDAI HEAVY INDUSTRIES CO., LTD.

PARTICULARS OF DYNAMOMETER

MAKER / TYPE	FUCHINO CFSR-20
CONSTANT (kW)	1 / 1.35962
MAXIMUM CAPACITY	26500 kW x 200 rpm

SPECIFICATION OF OIL USED AT SHOP TEST

		F.O	System Oil	Cam Oil	Cyl. Oil	T/C Oil
KIND OF OIL		BUNKER-A	VERITAS 800 M 30	VERITAS 800 M 30	ALEXIA LS	VERITAS 800 M 30
SPEC. GRAVITY	(15 ℃)	0.9171	0.8809	0.8809	0.9144	0.8809
FLASH POINT	℃	78	258	258	260	258
VISCOSITY	cSt	(50℃) 5.72	(40℃) 103.1	(40℃) 103.1	(40℃) 198.7	(40℃) 103.1
WATER	vol%	0.05				
SULFUR	wt%	0.248				
CALORIFIC VALUE (LOWER)	kcal / kg	9993				

DET NORSKE VERITAS * 1864 *

HYUNDAI
HEAVY INDUSTRIES CO., LTD.

Official shop test result for Main Engine	Hull No.	HMDS003	Owner	E.R.SCHIFFAHRT
	Engine No.	AA3382	Class	DNV
	Engine Type	6S50MC-C7	Test Date	June.17, 2009
Specifiction of Accessory	Output(MCR)	8820 kW	Engineer	J.S.LIM
	Speed(MCR)	119 rpm	Operator	H.Y.KIM

GOVERNOR

TYPE	AC C20 DGS
SERIAL No.	B0082B781140091
MANUFACTURER	KONGSBERG MARITIME KOREA

FUEL VALVE (ATOMIZER)

TYPE		3062332-6 x 115				
OPENING PRESSURE		350 ±30 bar				
SPEC.	HOLE No.	1	2	3	4	
	DIA. OF HOLE(Φ)	1.15	1.15	1.15	1.15	
	VERTI. ANGLE(α°)	27	17	13	12	
	HORIZ. ANGLE(β°)	-2	12	30	48	

AUXILIARY BLOWER

TYPE / CAPACITY	TBCS-060C-4526 / 1.92 / 3.90	m³/sec
SPEED / PRESSURE	3560 rpm / 571/327	mmAq
SERIAL No. 1 / 2	08B02760105 / 08B02760106	
MANUFACTURER	TAE-IL BLOWER MFG. Co.,LTD.	
ELECT. MOTOR TYPE / VOLTAGE	HK-SD/F / 440	V
FREQUENCY / POWER / Amp	60 Hz / 45 kW / 72.1	A
SERIAL No. 1 / 2	8F696F11-001 / 8F696F11-002	
MANUFACTURER	HYUNDAI HEAVY INDUSTRIES Co., LTD.	

AIR COOLER

TYPE	LKMY-C1-1420-EK-080822
SERIAL No.	76667
MANUFACTURER	VESTAS AIRCOIL

CYLINDER LUBRICATOR

TYPE	ELECTRIC CONTROLLED LUBRICATOR(ALPHA)
MANUFACTURER	HANMI HYDRAURIC MACHINERY CO.,LTD.

DET NORSKE VERITAS * 1864 *

HYUNDAI
HEAVY INDUSTRIES CO., LTD.

Official shop test result for Main Engine

Data sheet of 25% Load test

Hull No.	HMDS003	Weather	FINE
Engine No.	AA3382	Measuring Time	8:40
Eng. Type	6S50MC-C7	Test Date	June.17, 2009
Owner	E.R.SCHIFFAHRT	Engineer	J.S.LIM
Class	DNV	Operator	H.Y.KIM

* Room Temperature : 22.3 ℃ * Atmospheric Pressure : 1015.0 mbar

Engine Speed	Water Brake	Brake Power	Indicated Power	Mech.Efficiency	NOTCH
75.0 rpm	40.0 kNm	2205 kW	2504 kW	88.07 %	4.40

System		Main L.O	P.C.O	Cam L.O	Fuel Oil	Cooling F.W
In	Press.(kg/cm^2)	2.13			8.20	4.03
	Temp.(℃)	43.0			30.0	70.5

Cyl. No.		Avg.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Pmax.	bar	79.8	80	80	80	80	79	80								
Pcomp.	bar	48.8	49	49	49	48	49	49								
Pi	bar	8.50	8.47	8.49	8.52	8.56	8.40	8.57								
F.O Pump	Pθ	30.3	30.0	30.0	31.0	31.0	30.0	30.0								
	VIT	-	-	-	-	-	-	-								
Exh.Gas Out.	℃	253.7	260	252	250	260	260	240								
C.F.W Out.	℃	73.9	73.0	73.5	74.0	75.0	74.0	74.0								
Cam L.O Out.	℃	41.0	41.0													
P.C.O Out	℃	48.8	49.0	49.0	49.0	49.0	48.0	49.0								

Air Cooler

No.			1	2	3	4	Avg.
Bef. Cooler Press		mmHg	200				200.0
Press. Drop		mmAq	50				50.0
Air In.		℃	44	BLANK			44.0
Air Out.		℃	20.0				20.0
Cooling Water	In	℃	19.0				19.0
	Out	℃	21.0				21.0

Scavenging Air

Pressure		Temperature	
0.34	kg/㎠	28	℃
Air receiver pressure		250	mmHg
Exhaust Manifold Pressure		0.26	kg/㎠

Specific Fuel Oil Consumption

Meas.(kg/h)	Meas.(g/kWh)	Correct(g/kWh)
408.000	185.034	181.877

Turbocharger

Turbocharger	Speed	Blower Inlet			Before Turbine		After Turbine		L.O.(℃, kg/㎠)			F.W Temp
	rpm	℃		mmAq	℃	mmHg	℃	mmAq	In	Out	Press.	℃
No. 1	6350	22.0	28.0	5	262	190	215	16	43	44	1.58	-
No. 2												
No. 3		BLANK										
No. 4												
Avg.	6350	25.00		5	262	190.0	215	16	43	44	1.58	-

* Pressure vit : - kg/㎠ *Governor Position : 36.0 * Thrust Pad : 43.0 ℃

Note : The Fuel Oil Consumption is corrected to Lower Calorific Value 10200 kcal/kg & I.S.O condition

DET NORSKE VERITAS * 1864 *

HYUNDAI
HEAVY INDUSTRIES CO., LTD.

Official shop test result for Main Engine

Data sheet of 50% Load test

Hull No.	HMDS003	Weather	FINE
Engine No.	AA3382	Measuring Time	9:55
Eng. Type	6S50MC-C7	Test Date	June.17, 2009
Owner	E.R.SCHIFFAHRT	Engineer	J.S.LIM
Class	DNV	Operator	H.Y.KIM

* Room Temperature : 22.7 ℃ * Atmospheric Pressure : 1016.0 mbar

Engine Speed	Water Brake	Brake Power	Indicated Power	Mech.Efficiency	NOTCH
94.5 rpm	63.45 kNm	4410 kW	4802 kW	91.83 %	6.40

System		Main L.O	P.C.O	Cam L.O	Fuel Oil	Cooling F.W
In	Press.(kg/cm²)	2.10			7.80	4.00
	Temp.(℃)	43.0			32.0	72.0

Cyl. No.		Avg.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Pmax.	bar	105.2	105	105	106	105	105	105								
Pcomp.	bar	74.5	74	75	74	74	75	75								
Pi	bar	12.94	12.93	12.92	12.89	12.89	13.00	13.00								
F.O Pump	Pθ	44.0	44.0	44.0	44.0	44.0	44.0	44.0								
	VIT	-	-	-	-	-	-	-								
Exh.Gas Out.	℃	291.5	295	290	291	292	294	287								
C.F.W Out.	℃	75.7	75.0	75.0	75.0	77.0	76.0	76.0								
Cam L.O Out.	℃	44.0	44.0													
P.C.O Out	℃	50.6	50.5	51.0	51.0	50.5	50.0	50.5								

Air Cooler

No.			1	2	3	4	Avg.
Bef. Cooler Press		mmHg	780				780.0
Press. Drop		mmAq	94				94.0
Air In.		℃	88	BLANK			88.0
Air Out.		℃	30.0				30.0
Cooling Water	In	℃	19.5				19.5
	Out	℃	51.0				51.0

Scavenging Air

Pressure		Temperature	
1.08	kg/㎠	31	℃
Air receiver pressure		760	mmHg
Exhaust Manifold Pressure		0.90	kg/㎠

Specific Fuel Oil Consumption

Meas.(kg/h)	Meas.(g/kWh)	Correct(g/kWh)
793.000	179.819	175.729

Turbocharger

Turbocharger	Speed	Blower Inlet			Before Turbine		After Turbine		L.O.(℃, kg/㎠)			F.W Temp
	rpm	℃		mmAq	℃	mmHg	℃	mmAq	In	Out	Press.	℃
No. 1	11700	22.0	32.0	17	322	630	232	42	43	52	1.50	-
No. 2												
No. 3		BLANK										
No. 4												
Avg.	11700	27.00		17	322	630.0	232	42	43.0	52	1.50	-

* Pressure vit : - kg/㎠ *Governor Position : 50.0 * Thrust Pad : 45.0 ℃

Note : The Fuel Oil Consumption is corrected to Lower Calorific Value 10200 kcal/kg & I.S.O condition

DET NORSKE VERITAS * 1864 *

HYUNDAI
HEAVY INDUSTRIES CO., LTD.

Official shop test result for Main Engine

Data sheet of 75% Load test

Hull No.	HMDS003	Weather	FINE
Engine No.	AA3382	Measuring Time	10:25
Eng. Type	6S50MC-C7	Test Date	June.17, 2009
Owner	E.R.SCHIFFAHRT	Engineer	J.S.LIM
Class	DNV	Operator	H.Y.KIM

* Room Temperature : 23.8 ℃ * Atmospheric Pressure : 1015.0 mbar

Engine Speed	Water Brake	Brake Power	Indicated Power	Mech.Efficiency	NOTCH
108.1 rpm	83.20 kNm	6615 kW	7051 kW	93.82 %	7.60

System		Main L.O	P.C.O	Cam L.O	Fuel Oil	Cooling F.W
In	Press.(kg/cm²)	2.20			7.60	4.00
	Temp.(℃)	43.0			32.0	70.0

Cyl. No.		Avg.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Pmax.	bar	132.2	132	133	132	132	132	132								
Pcomp.	bar	105.3	105	106	106	105	105	105								
Pi	bar	16.61	16.63	16.70	16.66	16.52	16.57	16.58								
F.O Pump	Pθ	56.0	56.0	56.0	56.0	56.0	56.0	56.0								
	VIT	-	-	-	-	-	-	-								
Exh.Gas Out.	℃	300.0	300	295	300	305	305	295								
C.F.W Out.	℃	77.7	77.0	78.0	77.0	78.0	78.0	78.0								
Cam L.O Out.	℃	46.0	46.0													
P.C.O Out	℃	52.0	52.0	52.0	52.0	52.0	52.0	52.0								

Air Cooler

No.			1	2	3	4	Avg.
Bef. Cooler Press		mmHg	1440				1440.0
Press. Drop		mmAq	120				120.0
Air In.		℃	145	BLANK			145.0
Air Out.		℃	35.0				35.0
Cooling Water	In	℃	22.0				22.0
	Out	℃	55.0				55.0

Scavenging Air

Pressure		Temperature	
1.98	kg/㎠	34	℃
Air receiver pressure		1420	mmHg
Exhaust Manifold Pressure		1.71	kg/㎠

Specific Fuel Oil Consumption

Meas.(kg/h)	Meas.(g/kWh)	Correct(g/kWh)
1175.000	177.627	173.605

Turbocharger

Turbocharger	Speed	Blower Inlet			Before Turbine		After Turbine		L.O.(℃, kg/㎠)			F.W Temp
	rpm	℃		mmAq	℃	mmHg	℃	mmAq	In	Out	Press.	℃
No. 1	13500	23.0	36.0	40	350	1240	220	100	43	66	1.50	-
No. 2												
No. 3		BLANK										
No. 4												
Avg.	13500	29.50		40	350	1240.0	220	100	43	66	1.50	-

* Pressure vit : - kg/㎠ *Governor Position : 63.3 * Thrust Pad : 46.0 ℃

Note : The Fuel Oil Consumption is corrected to Lower Calorific Value 10200 kcal/kg & I.S.O condition

DET NORSKE VERITAS * 1864 *

HYUNDAI HEAVY INDUSTRIES CO., LTD.

Official shop test result for Main Engine

Data sheet of 90% Load test

Hull No.	HMDS003	Weather	FINE
Engine No.	AA3382	Measuring Time	11:10
Eng. Type	6S50MC-C7	Test Date	June.17, 2009
Owner	E.R.SCHIFFAHRT	Engineer	J.S.LIM
Class	DNV	Operator	H.Y.KIM

* Room Temperature : 23.7 ℃ * Atmospheric Pressure : 1015.0 mbar

Engine Speed	Water Brake	Brake Power	Indicated Power	Mech.Efficiency	NOTCH
114.9 rpm	93.93 kNm	7938 kW	8401 kW	94.49 %	8.30

System		Main L.O	P.C.O	Cam L.O	Fuel Oil	Cooling F.W
In	Press.(kg/cm^2)	2.20			7.50	4.00
	Temp.(℃)	43.0			32.0	70.0

Cyl. No.		Avg.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Pmax.	bar	144.8	145	144	145	145	145	145								
Pcomp.	bar	121.5	121	121	121	122	122	122								
Pi	bar	18.62	18.60	18.58	18.59	18.63	18.68	18.64								
F.O Pump	Pθ	64.2	64.0	64.0	64.0	64.0	65.0	64.0								
	VIT	-	-	-	-	-	-	-								
Exh.Gas Out.	℃	314.2	320	310	315	315	320	305								
C.F.W Out.	℃	79.2	79.0	79.0	79.0	79.0	80.0	79.0								
Cam L.O Out.	℃	48.0	48.0													
P.C.O Out	℃	53.7	54.0	54.0	54.0	53.0	53.0	54.0								

Air Cooler

No.			1	2	3	4	Avg.
Bef. Cooler Press		mmHg	1790				1790.0
Press. Drop		mmAq	130				130.0
Air In.		℃	167	BLANK			167.0
Air Out.		℃	35.0				35.0
Cooling Water	In	℃	23.0				23.0
	Out	℃	50.0				50.0

Scavenging Air

Pressure		Temperature	
2.45	kg/㎠	36	℃
Air receiver pressure		1770	mmHg
Exhaust Manifold Pressure		2.15	kg/㎠

Specific Fuel Oil Consumption

Meas.(kg/h)	Meas.(g/kWh)	Correct(g/kWh)
1420.500	178.949	174.976

Turbocharger

Turbocharger	Speed	Blower Inlet			Before Turbine		After Turbine		L.O.(℃, kg/㎠)			F.W Temp
	rpm	℃		mmAq	℃	mmHg	℃	mmAq	In	Out	Press.	℃
No. 1	14550	23.5	37.0	50	380	1560	222	160	43	71	1.60	-
No. 2												
No. 3		BLANK										
No. 4												
Avg.	14550	30.25		50	380	1560.0	222	160	43	71	1.60	-

* Pressure vit : - kg/㎠ *Governor Position : 71.3 * Thrust Pad : 46.0 ℃

Note : The Fuel Oil Consumption is corrected to Lower Calorific Value 10200 kcal/kg & I.S.O condition

DET NORSKE VERITAS * 1864 *

HYUNDAI
HEAVY INDUSTRIES CO., LTD.

Official shop test result for Main Engine

Data sheet of 100% % Load test

Hull No.	HMDS003	Weather	FINE
Engine No.	AA3382	Measuring Time	11:40
Eng. Type	6S50MC-C7	Test Date	June.17, 2009
Owner	E.R.SCHIFFAHRT	Engineer	J.S.LIM
Class	DNV	Operator	H.Y.KIM

* Room Temperature : **24.0** ℃ * Atmospheric Pressure : **1015.0 mbar**

Engine Speed	Water Brake	Brake Power	Indicated Power	Mech.Efficiency	NOTCH
119.0 rpm	**100.77 kNm**	**8820 kW**	**9296 kW**	**94.88 %**	**8.60**

System		Main L.O	P.C.O	Cam L.O	Fuel Oil	Cooling F.W
In	Press.(kg/cm^2)	**2.20**			**7.50**	**4.00**
	Temp.(℃)	**43.0**			**34.0**	**70.0**

Cyl. No.		Avg.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Pmax.	bar	**149.8**	**150**	**150**	**149**	**150**	**150**	**150**								
Pcomp.	bar	**131.7**	**131**	**131**	**132**	**132**	**132**	**132**								
Pi	bar	**19.89**	**19.82**	**19.85**	**19.86**	**19.94**	**19.98**	**19.90**								
F.O Pump	Pθ	**69.8**	**70.0**	**70.0**	**69.0**	**70.0**	**70.0**	**70.0**								
	VIT	-	-	-	-	-	-	-								
Exh.Gas Out.	℃	**337.5**	**345**	**335**	**335**	**340**	**340**	**330**								
C.F.W Out.	℃	**80.0**	**80.0**	**80.0**	**80.0**	**80.0**	**80.0**	**80.0**								
Cam L.O Out.	℃	**48.0**	**48.0**													
P.C.O Out	℃	**54.3**	**54.0**	**55.0**	**55.0**	**54.0**	**54.0**	**54.0**								

Air Cooler

No.			1	2	3	4	Avg.
Bef. Cooler Press		mmHg	**2010**				**2010.0**
Press. Drop		mmAq	**135**				**135.0**
Air In.		℃	**180**	BLANK			**180.0**
Air Out.		℃	**38.0**				**38.0**
Cooling Water	In	℃	**24.0**				**24.0**
	Out	℃	**55.0**				**55.0**

Scavenging Air

Pressure		Temperature	
2.77	kg/㎠	**38**	℃
Air receiver pressure		**2000**	mmHg
Exhaust Manifold Pressure		**2.45**	kg/㎠

Specific Fuel Oil Consumption

Meas.(kg/h)	Meas.(g/kWh)	Correct(g/kWh)
1594.200	**180.748**	**176.814**

Turbocharger

Turbocharger	Speed	Blower Inlet			Before Turbine		After Turbine		L.O.(℃, kg/㎠)			F.W Temp
	rpm	℃		mmAq	℃	mmHg	℃	mmAq	In	Out	Press.	℃
No. 1	**15209**	**23.0**	**39.0**	**60**	**410**	**1780**	**235**	**200**	**43**	**73**	**1.50**	-
No. 2												
No. 3		BLANK										
No. 4												
Avg.	**15209**	**31.00**		**60**	**410**	**1780.0**	**235**	**200**	**43**	**73**	**1.50**	-

* Pressure vit : - kg/㎠ *Governor Position : **77.9** * Thrust Pad : **47.0** ℃

Note : The Fuel Oil Consumption is corrected to Lower Calorific Value 10200 kcal/kg & I.S.O condition

DET NORSKE VERITAS * 1864 *

HYUNDAI
HEAVY INDUSTRIES CO., LTD.

Official shop test result for Main Engine

Engine performance

Hull No.	HMDS003	Owner	E.R.SCHIFFAHRT
Engine No.	AA3382	Class	DNV
Engine Type	6S50MC-C7	Test Date	June.17, 2009
Output(MCR)	8820 kW	Engineer	J.S.LIM
Speed(MCR)	119 rpm	Operator	H.Y.KIM

Project No.
HMDS003

Engine No.
AA3382

Engine Type
6S50MC-C7

T/C Type
1 × TPL77B12

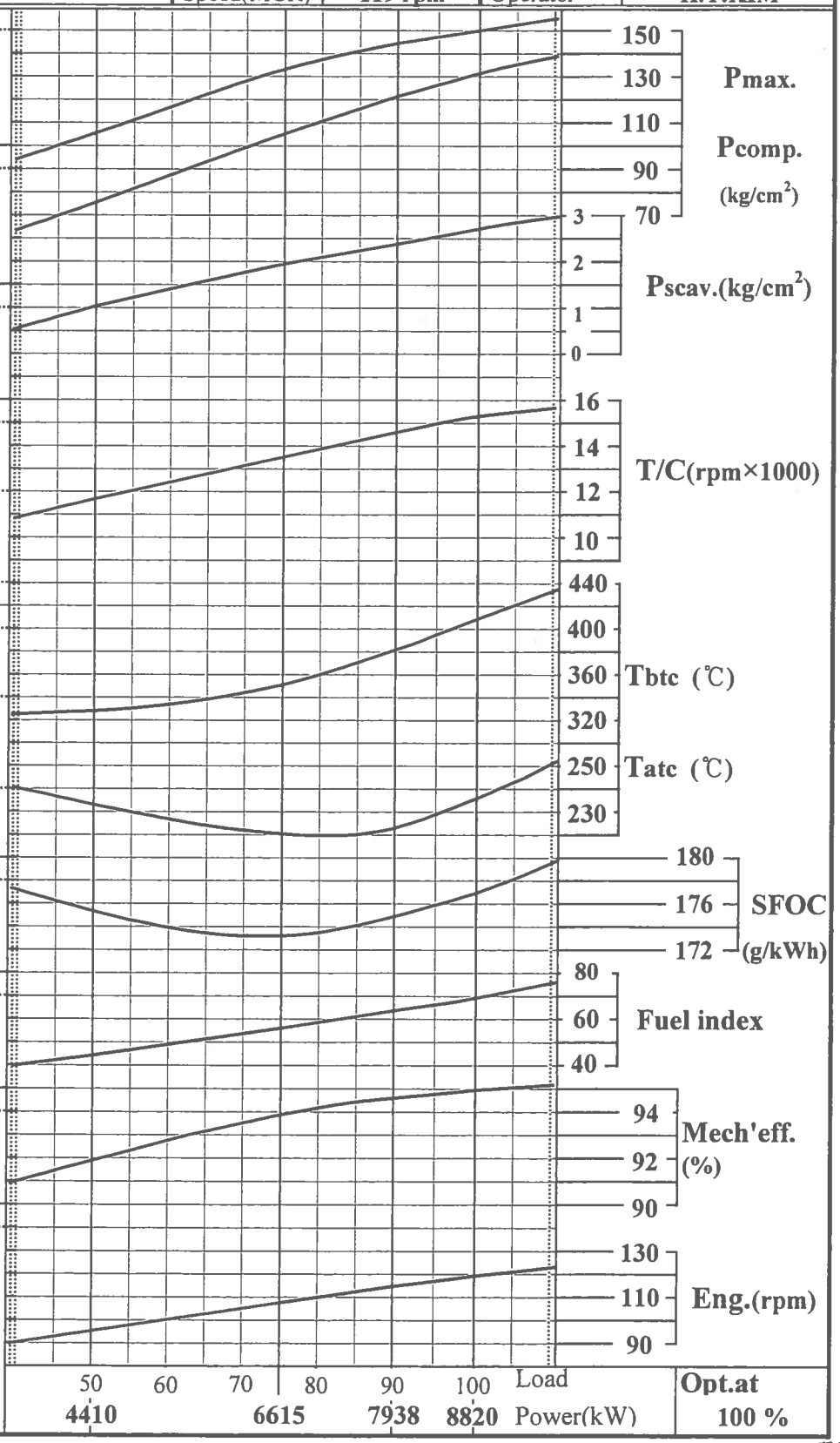
PTU/Bypass

Fuel Cam

Exh. Cam

Comp.Shim
8 mm

Remark
OFFICIAL
SHOP TEST



DET NORSKE VERITAS
1864

HYUNDAI
HEAVY INDUSTRIES CO., LTD.

Official shop test result for Main Engine	Hull No.	HMDS003	Owner	E.R.SCHIFFAHRT
	Engine No.	AA3382	Class	DNV
	Engine Type	6S50MC-C7	Test Date	June.17, 2009
Inspection Report	Output(MCR)	8820 kW	Engineer	J.S.LIM
	Speed(MCR)	119 rpm	Operator	H.Y.KIM

Kind of Inspection.	Place of Inspection	Work Condition	Judgement
Timing Data	**Ass'y Shop**	**After Shop Test**	**Reference**

1. Exhaust Cam Lead (Advance Angle)

Cylinder No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Measured Timing(Ahead)	-3.40	-3.20	-3.35	-3.20	-3.35	-3.35	BLANK							

* Angle A : **112.9°** * Lift : **10.0** mm

* Angle B : **254.1°** * Lift : **10.0** mm

2. Fuel Pump

Cylinder No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Number of Shim(EA)/ Thickness of Shim(mm)	8/0.5	8/0.5	8/0.5	8/0.5	8/0.5	8/0.5	BLANK							
Top Lift (mm)	11.97	11.98	12.18	11.67	11.76	11.25	BLANK							
Lead Angle(Before T.D.C)	10.30	10.50	10.50	10.20	10.20	9.80	BLANK							

3. Compression Shim

Cylinder No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Thickness (mm)	8	8	8	8	8	8	BLANK							

4. Starting Air Distributor Lead (Advance Angle)

Cylinder No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Open Aft T.D.C (Ahead)	Equal of CYL No.1 T.D.C Scratch mark													
Open Aft T.D.C (Astern)														

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