Notice of Compliance

Revised MARPOL Annex VI & NO_x Technical Code 2008

Engine Family D16-MG
AB Volvo Penta

This is to State

That above-mentioned engine family has been established under the requirements of Technical Code 2008 on Control of Emission of Nitrogen Oxides from Marine Diesel Engines showing that all engines covered by the engine family comply with the emission limits of Regulation 13.4 of Revised MARPOL Annex VI.

This is to Note

1. That every member engine of the above-mentioned engine family shall be subject to pre-certification in accordance with the procedure established to the parent engine to verify that the member engine, as designed, equipped and adjusted, complies with the applicable regulation 13.4 of Revised Annex VI of the Convention; and

2. That this Notice of Compliance does not replace the EIAPP Certificate to be issued for each individual engine.

Specification of the Engine Family

Engine manufacturer	:	AB Volvo Penta	
Engine type(s)	:	according to supplement	
GL approval no.	:	84818-09 HH	
Date of primary issue	:	2009-12-09	
No. of cylinders	:	6	
Power at speed	:	according to supplement	
Test cycle(s)	:	D2	E2
NO_x emission limit Tier II	:	7.8 g/kWh	7.8 g/kWh
Actual NO_x emission value	:	5.8 g/kWh	5.7 g/kWh

Specification of the Parent Engine

Parent engine type	:	D16C-A MG (450kW@1500rpm)
Parent engine no.	:	202161219

This is to Confirm

1. That the above-mentioned parent engine representing the above-mentioned engine family as specified in the document 'Technical File' has been approved in accordance with all requirements as applicable. The engine family will always represented by the parent engine, its approved Technical File and the family documentation; and

2. That the selection of the parent engine has been carried out on the basis of tests and engineering judgement in accordance with the applicable chapter of the NOx Technical Code 2008 providing that the parent engine incorporates those features and/or characteristics which most adversely affect the NOx emission level and result in the highest NOx emission level among all of the engines in the family; and

3. That adequate arrangements have been made by the engine manufacturer to ensure effective control of the conformity of production for all member engines within the family.

Germanischer Lloyd
Issued at Hamburg, 2010-10-05 / Rev. 2

Dr. Fabian Kock

Volker Pawils

Notice of Compliance

Revised MARPOL Annex VI & NO_x Technical Code 2008

Engine Family D16-MG
AB Volvo Penta

Supplement to the Notice of Compliance

Specification of the Engine Group / Family, continue

Engine	Rated Power [kW]	Rated Speed [rpm]	Cycle
D16C-A MG	450	1500	D2 / E2
	500	1800	
TAD1640GE	401	1500	D2
	445	1800	
TAD1641GE	441	1500	
	504	1800	
TAD1642GE	515	1500	
	551	1800	
TWD1643GE	553	1500	
	615	1800	

Germanischer Lloyd
Issued at Hamburg, 2010-10-05 / Rev. 2

Dr. Fabian Kock

Volker Pawils

VOLVO PENTA

Technical File

According to Revised MARPOL Annex VI and NOx Technical Code 2008

Manufacturer:	**AB Volvo Penta**
Engine Family:	**D16-MG**
GL family approval no.	**84818-09 HH**
Engine Type:	**D16C-A MG**
Engine Serial no.:	**202 16-1219**
Date of Manufacture:	**2005**
Rated Power:	**450 kW**
Rated Speed:	**1500 rpm**

Contents

GL EMISSION CERTIFICATION

Hamburg 2013-08-30 Approval No.: 84818-09 HH

VOLVO PENTA

1. Components, setting and operating values of the engine that influence NOx emissions

Common components for Engine Types D16C-A MG			
	ID-no. on component	**Volvo Penta part No.**	**Remarks**
Cylinder Head	20550757 20950117 21053833 21079398 21079397 21850215	20550757 20950117 21053833 21079398 21079397 21850215	
Camshaft	20733174 20950810 20894565	20733174 20950810 20894565	
Piston	3817512 and 80/12 21177489	3817512 21177489	
Turbo Charger	3885396 21420532	3885396 21420532	
Charge Air Cooler	3819675 21245572 21245200 21945663 21757126	3819675 21245572 21245200 21945663 21757126	
Charge Air Cooler (Radiator cooled)	3593989	3593989	
Unit Injector	3829087	3829087	
Injector nozzle	042	--	
Engine Electronic Control Unit	20814594 24425461 21695319	20814594 24425461 21695319	

Specific Settings			
Engine type	**D16C-A MG**	**D16C-A MG**	
Power kW	450	500	
Speed rpm	1500	1800	
Application(s)	E2, D2	E2, D2	
Dataset 1, part no.	3884159 20946775 21832450 22105721	3884159 20946775 21832450 22105721	

VOLVO PENTA

Common components for Engine Types TAD 1641 GE / TAD 1642 GE			
	ID-no. on component	Volvo Penta part No.	Remarks
Cylinder Head	21079397 21850215	21079397 21850215	
Camshaft	20894565	20894565	
Charge Air Cooler 1 (Radiator cooled)	3838129	3838129	
Charge Air Cooler 2 (Radiator cooled)	3587692	3587692	
Engine Electronic Control Unit	20814594 21695319	20814594 21695319	
Piston	21177493	21177493	
Turbo Charger	3837221	3837221	
Unit Injector	3829087	3829087	
Injector nozzle	042	--	

Specific Settings			
Engine type	TAD 1641 GE	TAD 1641 GE	
Power kW	441	504	
Speed rpm	1500	1800	
Application(s)	D2	D2	
Dataset 1, part no.	21081805 21639155 22100415	21081805 21639155 22100415	
Engine type	TAD 1642 GE	TAD 1642 GE	
Power kW	515	551	
Speed rpm	1500	1800	
Application(s)	D2	D2	
Dataset 1, part no.	21081806 21498768 21607634 22100418	21081806 21498768 21607634 22100418	

VOLVO PENTA

Common components for Engine Type TAD1640 GE			
	ID-no. on component	Volvo Penta part No.	Remarks
Cylinder Head	21079397 21850215	21079397 21850215	
Camshaft	20894565	20894565	
Charge Air Cooler 1 (Radiator cooled)	3838129	3838129	
Charge Air Cooler 2 (Radiator cooled)	3587692	3587692	
Engine Electronic Control Unit	20814594 21695319	20814594 21695319	
Piston	21177491 21177489	21177491 21177489	
Turbo Charger	3837220	3837220	
Unit Injector	889481	889481	
Injector nozzle	041	--	

Specific Settings			
Engine type	TAD 1640 GE	TAD 1640GE	
Power kW	401	445	
Speed rpm	1500	1800	
Application(s)	D2	D2	
Dataset 1, part no.	21222031 21639154 22100414	21222031 21639154 22100414	

Approval No. 84818-09 HH
Page 4 of 13

VOLVO PENTA

Common components for Engine Type TWD1643 GE			
	ID-no. on	**Volvo Penta part**	**Remarks**
Cylinder Head	21079397 21850215	21079397 21850215	
Piston	21177498	21177498	
Turbo Charger 1	3887606	3887606	2 stages with bypass controlled by software
Turbo Charger 2	3819093	3819093	2 stages with bypass controlled by software
Camshaft	3594958	3594958	
Charge Air Cooler 1	21245553 21709397 21945675 21712163	21245553 21709397 21945675 21712163	
Charge Air Cooler 2	21245200 21945663 21757126	21245200 21945663 21757126	
Unit Injector	3883426	3883426	
Injector nozzle	263	--	
Engine Electronic Control Unit	20814795 21695313	20814795 21695313	

Specific Settings			
Engine type	**TWD 1643 GE**	**TWD 1643 GE**	
Power kW	553	615	
Speed rpm	1500	1800	
Application(s)	D2	D2	
Dataset 1, part no.	21057877	21057877	

Maximum sea water temp., if applicable	38 ℃
Maximum charge air temp., if applicable	60 ℃
Maximum fresh water temp. from Keel Cooler, if applicable	45 ℃
Low / high temp. cooling system set points	86 / 98 ℃
Maximum inlet depression	- 3 kPa
Maximum exhaust back pressure	15 kPa
Maximum exhaust back pressure(TAD 164XGE, TWD1643GE)	10 kPa
Fuel oil specification	According to operator's manual
Fuel oil temp.	40 ℃
Lubricating oil specification	According to operator's manual
Please see section 3 "Test report of parent engine" for design details of engine family.	

2. On board verification procedure

Component	Procedure / location of ID-nos.	Remarks
Cylinder head	Check ID-no on machined surface (exhaust side). Inspection is recommended at overhaul when the engine is dismantled.	See Figure 1
Piston	Check ID-no on piston crown. Inspection is recommended at overhaul when cylinder head is removed.	See Figure 3
Turbocharger	Check ID-no on metal plate on compressor house.	
Unit injector	Check ID-no on injector body. Inspection is recommended at overhaul when the engine is dismantled and the injector unit is visible.	
Injector nozzle	N/A	See ID-no on Unit Injector.
Electronic control unit and data set	Check ID-no. on label. The data set can be checked by using a diagnostic tool at a service shop.	
Charge air cooler for engine types: D16C-A MG TWD 1643 GE	The ID-no is located at the backside of the charge air cooler. The ID-no is stamped on the housing. Inspection is recommended at overhaul when charge air cooler is dismounted.	
Charge air cooler for engine type: TAD1640-42 GE	Check ID no. on label. The ID-no is located on the upper side of the complete cooling system.	
Compression ratio	Determined by the correct piston and cylinder head combination. Inspection is recommended at overhaul when cylinder head is removed.	
Camshaft	The ID-no. is located at the rear end of the camshaft. Inspection is recommended at overhaul when valve cover is removed and the camshaft is visible.	See Figure 2

!	**Important!** The ID-nos that can not be controlled unless the engine is taken apart shall only be checked at regular overhaul when the engine is taken out of service and dismantled for maintenance. Check only if considerable doubt of the correctness of the ID-no exist.

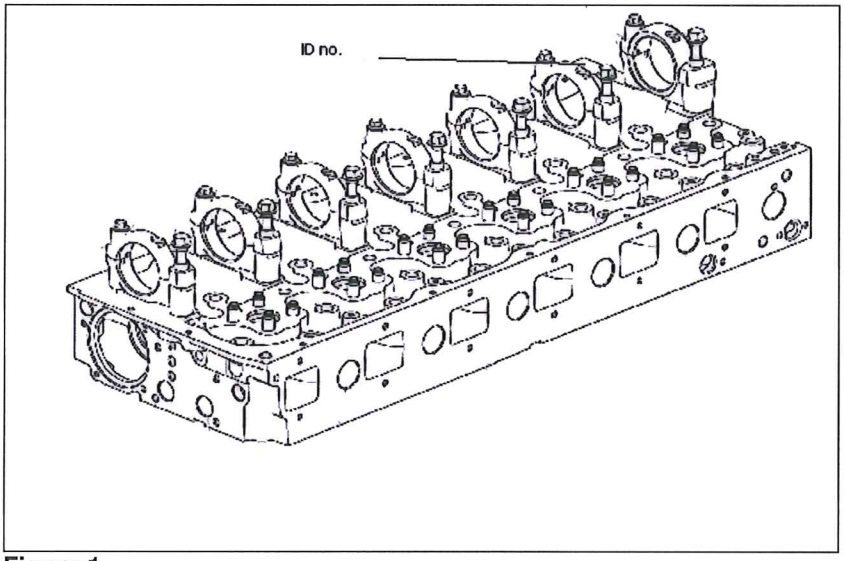

Figure 1

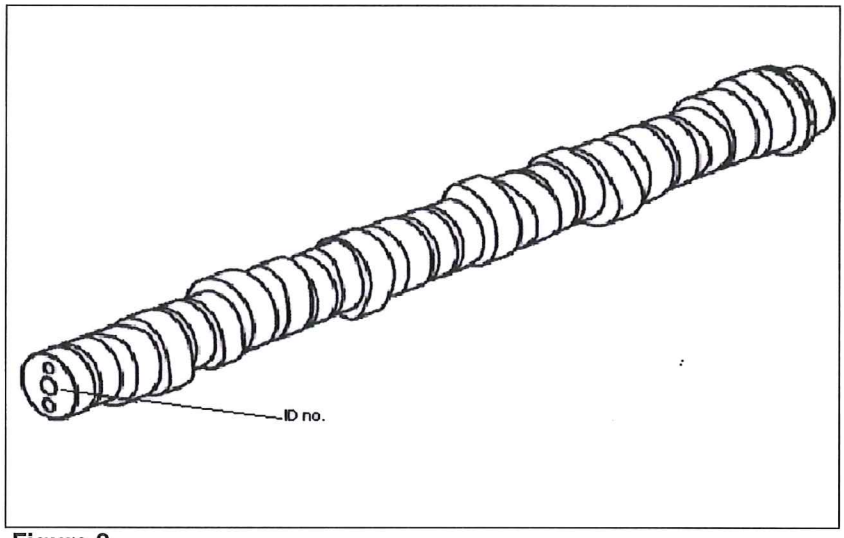

Figure 2

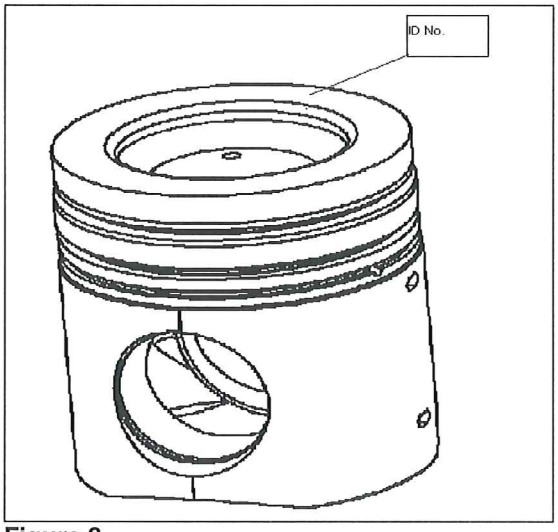

Figure 3

VOLVO PENTA

3. Test report of parent engine, D2/E2-cycle

D2/E2-cycle Emission test report

Engine information	
Manufacturer	AB Volvo Penta
Engine type	D16C-A MG
Family identification	D16-MG
Serial number	202 16-1219
Rated speed	1500 rpm
Rated power	450 kW
Intermediate speed	1500 rpm
Maximum torque at intermediate speed	2865 Nm
Static injection timing	N/A
Electronic injection control	no: yes: X
Variable injection timing	no: yes: X
Variable turbocharger geometry	no: X yes:
Bore	144 mm
Stroke	165 mm
Nominal compression ratio	17.5:1(16C-A MG,TAD 1640 GE) 16:5:1(TAD1641-42 GE, TWD 1643 GE)
Mean effective pressure, at rated power	2,23 MPa
Maximum cylinder pressure, at rated power	16,4 MPa
Cylinder number and configuration	Number: 6 V: In-line: X
Auxiliaries	None

Specified ambient conditions	
Maximum inlet cooling water temperature	38 °C
Maximum charge air temperature, if applicable	60 °C
Cooling system spec. intermediate cooler	no: yes: X
Cooling system spec. charge air stages	Single stage
Low/high temperature cooling system set points	86/98 °C
Maximum inlet depression	-3kPa
Maximum exhaust back pressure	15kPa
Fuel oil specification	RF-03-A-84
Fuel oil temperature	40 °C
Lubricating oil specification	Volvo VDS2 15W40

Emissions test results

Cycle			NOx (g/kWh)	PM	Test no.
D2			5,79		27002559
E2			5,69		27002559

Date/time	2005-12-21
Test site/bench	Volvo Penta Test cell 27
Surveyor	Sebastian Vocke, Germanischer Lloyd
Date and Place of report	2005-12-21, Volvo Penta Gothenburg
Signature	

VOLVO PENTA

Common Features Within the Engine Family

Family identification	D16-MG
Electronic injection control	Yes
Variable injection timing	Yes
Variable turbocharger geometry	No
Bore	144 mm
Stroke	165 mm
Nominal compression ratio	17,5:1
Cylinder configuration	6, in-line
Combustion cycle	4-stroke, compression ignition
Cooling medium	50/50 glycol/water
Method of aspiration	Pressure charged
Fuel type to be used on board	Distillate fuel
Combustion chamber	Open chamber
Valve and porting configuration	2 inlet valves Ø = 42 mm 2 exhaust valves Ø = 39,5 mm All valves are located in the cylinderhead
Fuel system type	Direct injection, electronic unit injectors
Auxiliaries	None

Miscellaneous features

Exhaust gas recirculation	No
Water injection / emulsion	No
Air injection	No
Charge air cooling system	Water to air (Marine engines) Air to air (GE-engines)
Exhaust aftertreatment	No
Exhaust aftertreatment type	N/A
Dual fuel	No

Engine Family Information (selection of parent engine for test bed test)

Family identification	D16-MG
Method of pressure charging	Turbo charger
Charge air cooling system	Water to air
Criteria of the Selection (specify)	Maximum NOx cycle emission (g/kWh)

Engine	**D16C-A MG**	**D16C-A MG**	**TAD 1640 GE**	**TAD 1640 GE**	**TAD 1641 GE**	**TAD 1641 GE**
Number of cylinder	6	6	6	6	6	6
Max. rated power per cyl.	75 kW	83,3 kW	66,3 kW	74,2 kW	73,5 kW	84 kW
Rated speed	1500	1800	1500	1800	1500	1800
Injection timing (range)	variable	variable	variable	variable	variable	variable
Max. fuel parent engine(mg/St)	339					
Selected parent engine	X					
Application	D2, E2	D2, E2	D2	D2	D2	D2
Engine	**TAD 1642 GE**	**TAD 1642 GE**	**TWD 1643 GE**	**TWD 1643 GE**		
Number of cylinder	6	6	6	6		
Max. rated power per cyl.	85,8 kW	91,8 kW	92,2 kW	102,5 kW		
Rated speed	1500	1800	1500	1800		
Injection timing (range)	variable	variable	variable	variable		
Max. fuel parent engine						
Selected parent engine						
Application	D2	D2	D2	D2		

Approval No. 84818-09 HH
Page **10** of **13**

VOLVO PENTA

D2/E2-cycle Emission test report

Exhaust pipe						
Diameter	150 mm					
Length	10 m					
Insulation			no: X		yes:	
Probe location	4,15 m					
Remark						

Measurement equipment					
	Manufacturer	Model	Measurement ranges	Calibration	
				Span gas conc.	Deviation
Analyser					
NOx Analyser	Horiba	CLA 755A	1000 ppm	988,2	< ±2% or 0.3% of full scale
CO Analyser	Horiba	AIA 721	300 ppm	283,6	< ±2% or 0.3% of full scale
CO_2 Analyser	Horiba	AIA 722	15 %	14,22 %	< ±2% or 0.3% of full scale
O_2 Analyser	Horiba	MPA 720	25 %	23,8 %	< ±2% or 0.3% of full scale
HC Analyser	Horiba	FIA 725A	100 ppm	96,12	< ±2% or 0.3% of full scale
Speed	Siemens	KH5431B	0-3020 rpm		<± 2% of reading or ± 1% of engines maximum value
Torque	Siemens	KH5431B	0-4500 Nm		< ± 2% of reading or ± 1% of engines maximum value
Power, if applicable	Calculated				
Fuel flow	AVL	734	1-350 kg/h		< ± 2%
Air flow	Flow	UGF20	8-3800 kg/h		< ± 2% of reading or ± 1% of engines maximum value
Exhaust flow	Calculated				
Temperatures					
Coolant	Heraeus	Type K	0-150 °C		< ± 2K absolute
Exhaust gas	Heraeus	Type K	0-800 °C		< ± 1 % absolute
Inlet air	Heraeus	Type K	0-150 °C		< ± 2 °C absolute
Intercooled air	Heraeus	Type K	0-150 °C		< ± 2K absolute
Fuel	Heraeus	Type K	0-150 °C		< ± 2K absolute
Pressures					
Exhaust gas	WIKA		-10 – 50 kPa		< ± 0,2 kPa Absolute
Inlet manifold	WIKA		-25 – 0 kPa		< 5%
Atmospheric	Druck		0 – 200 kPa		< ± 0,1 kPa Absolute
Vapour pressure					
Intake air	Calculated				
Humidity					
Intake air	Michell	Dewmet -02-TDH	0-100 %		< ±1% of point

Fuel characteristics						
Fuel type	RF-03-A-84 according to ISO-F-DMA					
Fuel properties				**Fuel elemental analysis**		
Density, at 15 °C		0,843	kg/l	Carbon	86,52	% mass
Viscosity, at 40 °C		2,66	mm^2/s	Hydrogen	13,4	% mass
Water		25	mg/kg	Nitrogen	0,0039	% mass
				Oxygen	< 0,1	% mass
				Sulphur	0,11	% mass
				LHV/Hu	42,81	MJ/kg

VOLVO PENTA
Emission test report of parent engine, D2/E2 cycle

D2/E2-cycle Emission test report

Mode		1	2	3	4	5
Power/Torque	%	100	75	50	25	10
Speed	%	100	100	100	100	100
Time at beginning of mode						
Ambient data						
Atmospheric pressure	kPa	102,1	102,1	102,1	102,1	102,1
Intake air temperature	°C	25	25	25	25	25
Intake air humidity	g/kg	4,4	4,4	4,5	4,5	4,5
Rel. Hum	%	27,15	27,32	27,7	28,4	27,57
Air temp at rel. h sensor	°C	22,01	21,95	21,97	21,59	22,04
Atmospheric factor (f_a)		0,984	0,984	0,985	0,986	0,986
Gaseous emission data						
NOx concentration dry/~~wet~~	ppm	767	706	628	425	293
CO concentration dry/~~wet~~	ppm	214	87	78	74	99
CO_2 concentration dry/~~wet~~	%	8,46	7,7	6,87	5,13	3,19
O_2 concentration dry/~~wet~~	%	9,16	10,2	11,29	13,65	16,32
HC concentration ~~dry~~/wet	ppm	19	20	29	53	81
NOx humidity correction factor		0,93	0,930	0,931	0,932	0,931
Dry/wet correction factor		0,93	0,93	0,94	0,95	0,97
NOx mass flow	g/h	2548	1919	1297	651	382
CO mass flow	g/h	465	156	105	74	84
CO_2 mass flow	g/h	289101	215322	145711	80654	42666
O_2 mass flow	g/h	227691	207274	174185	156032	158670
HC mass flow	g/h	22	19	21	28	35
NOx specific	g/kWh	5,66	5,68	5,77	5,79	8,51
CO specific	g/kWh	1,03	0,46	0,47	0,66	1,88
CO_2 specific	g/kWh	643	638	648	718	950
HC specific	g/kWh	0,049	0,056	0,091	0,245	0,78
Engine data						
Speed	rpm	1500	1500	1500	1500	1500
Auxiliary power	kW	0	0	0	0	0
Dynamometer setting	kW	450,1	337,6	224,9	112,4	44,9
Power	kW	450,1	337,6	224,9	112,4	44,9
Mean effective pressure	MPa	2,23	1,67	1,12	0,56	0,22
Fuel rack	mm	-	-	-	-	-
Uncorr. Spec. fuel cons.	g/kWh	203,2	200,8	204,6	224,7	296,7
Fuel flow	kg/h	91	68	46	25	13
Air flow	kg/h	2336	1904	1440	1058	893
Exhaust flow (gexhw)	kg/h	2430	1973	1487	1084	907
Exhaust temperature	°C	593	528	461	350	216
Exhaust back pressure	kPa	15,1	9,5	5,3	2,2	1,4
Charge air coolant in	°C	49	46	43	41	39
Charge air coolant out	°C	65	57	50	44	40
Charge air temp	°C	54	48	44	40	39
Charge air ref temp	°C	54	48	44	40	39
Inlet depression	kPa	-3,1	-1,9	-1	-0,4	-0,1
Charge air pressure	kPa	224	159	94	41	18
Fuel oil temp	°C	40	40	40	40	40

4. Specification of spare parts

Ship owners or persons responsible for ships required to undergo an engine parameter check method shall maintain on board a record book of engine parameters for recording of all the changes made relative to an engine's components and settings.

If any adjustments or modifications are made to any engine after its delivery from Volvo Penta, a full record of such adjustments or modifications shall be recorded in the engine's record book of engine parameters.

Any changes or modifications of the approved parameters and components of this engine that are not allowed by Volvo Penta may result in that the engine no longer complies with the approved specification. Volvo Penta has no responsibility for compliance if parts and components are used other than those authorized by Volvo Penta.