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HYUNDAI

INSTRUCTION BOOK VOLUME I Engine type H35DFV Hyundai Global Service Co., Ltd. 6th Floor, Centum Science Park, 79, Centum jungang-ro, Haeundae-gu, Busan, Korea, 48058 http://www.hyundai-gs.com

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Pag 3
VOL. SECTIONDESCRIPTIONⅠHiMSEN INSTRUCTION BOOK VOLUME - IM.00GENERAL INSTRUCTIONM.01ENGINE DESIGN OUTLINE AND OPERATING DATAM.02NORMAL OPERATIONM.03SPECIAL OPERATIONM.04TROUBLE SHOOTINGM.05SYSTEM INSTRUCTION AND TREATMENTM.09ENGINE MAINTENANCE GENERALM.11COMMON BASE FRAME, ENGINE BLOCK, BEARINGS, CYLINDER LINER, WATERJACKET, FEED MODULE, COVERSM.21CYLINDER HEAD, VALVE TRAIN MECHANISM, CAMSHAFT WITH BEARINGM.31PISTON WITH CONNECTING ROD, CRANKSHAFT, GEARSM.40ENGINE AUTOMATION, STARTING SYSTEM, ECU PANELM.50FUEL OIL & GAS SYSTEMM.60LUBRICATING OIL SYSTEMM.70COOLING WATER SYSTEMM.80EXHAUST GAS AND CHARGE AIR SYSTEMⅡHiMSEN INSTRUCTION BOOK VOLUME - II1TURBOCHARGER2ELECTRIC GOVERNOR USER MANUAL for 20H35DFV3TURNING GEAR4AIR COOLER MANUAL 2(G-TECH)5PRE-LUBRICATING OIL PUMP6KNOCKING SENSOR MONITORING7CYLINDER PRESSURE SENSOR8CYLINDER PRESSURE SENSOR MONITORING9ENGINE CONTROL SYSTEM10LOCAL OPERATING SYSTEM PANEL11SOGAV12OIL MIST DETECTOR13TORSIONAL VIBRATION DAMPER

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EQUIPMENT - V1BOILER UNIT (BOOK 3, 4)XELECTRICAL & CONTROL EQUIPMENT - I1GENERATOR2TRANSFORMER3ELECTRICAL PANEL4BLACK START D/G SETXIELECTRICAL & CONTROL EQUIPMENT - II CENTRAL CONTROL SYSTEM AND CONTROL PANEL COMMUNICATION SYSTEM FIELD INSTRUMENT

This instruction manual describes mainly on the engine proper. As for the some special components mounted on the engine, please refer to the additional manual provided separately. This book includes instructions for engine operation, maintenance and assembly drawings, which can be identified by sheet number as follows. Sheet Number Each sheet of this manual has its own Sheet No. for identification, which consists of Section No., Page No. and Revision Number. It is recommended to use this Sheet No. whenever communicating with engine maker for quicker response. 1. Section No. A Sub Group or Part Number Group Number 00~09 : Group for Engine Complete 10~99 : Group for Engine Sub Section G : General Instruction for each section A : Assembly Drawing & Part List (for H21/32) C : Assembly Drawing & Part List (for H25/33) S : Assembly Drawing & Part List (for H17/28) L : Assembly Drawing & Part List (for H32/40) LDF : Assembly Drawing & Part List (for H35DF) LG : Assembly Drawing & Part List (for H35G) LDFV : Assembly Drawing & Part List (for H35DFV) LGV : Assembly Drawing & Part List (for H35GV) M : Maintenance Procedure 0 : Information for Engine Operation 2. Rev. No. Revision No. : A ~ Z Alternative or Design Application No. : 1 ~ 9

G00200

Symbol for ‘Safety’ It explains precautions for proper operation and easier works of the engine and s hould be followed this instruction carefully. It describes precautions that should be followed for the safe operation or maintenance works. Also should notify all safety guidance to other workers. Additionally, it must be followed general law for safety or precaution of the accident. Symbol for ‘Reference’

Mxxxxx Mxxxxx

Refer to the sheet or part corresponding section number for more information. Symbol for ‘Screw fastening’ : Manual tightening : Hydraulic tightening The value followed by the symbol means tightening torque or pressure. Symbol for ‘Bolt and nut dimension’ , The dimension shows the size of bolt head or nut for corresponding wrench or spanner.

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General Introduction Ordering Spare Parts

All type Section No.

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G00300

When ordering, the following data must be filled in ordering sheet. 1) Name of plant 5) Section number 2) Consignee 6) Item number 3) Engine type 7) Name of spare parts 4) Engine number 8) Quantity required The correct data descriptions are essential for the quicker supply of spare parts properly. When ordering spare parts of engine, if possible, please use a following form.

Information for ordering of spare parts found out from the “Assembly Drawing & Part List” Engine Type Page No. Revision No. Section No. Illustration Description Quantity Item No. A form of order sheet for spare parts

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N+1 N+2

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H35DFV Page 2/2

B - Bank B1 B2 B3 B4 B5 B6 B7 B8

A1 A2 A3 A4 A5 A6 A7 A8 A - Bank

Camshaft Gear Idle Gear A Crankshaft Gear (CW)

Camshaft Gear Idle Gear B Crankshaft Gear (CCW)

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Engine Design Outline & Operating Data Principal Data

H35DFV Section No. G01100

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Engine Design Outline &

Principal Data for H35DFV Gen-Set 4-stroke, vertical, direct injection single acting and trunk piston type with turbocharger and inter-cooler

Type of Engine

Cylinder Configuration V -Type Number of Cylinder 12 – 14 – 16 – 18 – 20 Rated Speed rpm 720 750 Power per Cylinder(kW) kW 480 480 Cylinder Bore(mm) mm 350 Piston Stroke(mm) mm 400 Swept Volume per Cylinder dm 3 38.5 Mean Piston Speed m/s 9.6 10.0 Mean Effective Pressure bar 20.8 20.0 Compression Ratio 13.5:1

Direction of Engine Rotation

Clockwise Viewed from Generator Side (Non-Reversible)

Cylinder Firing Order 12H35DFV 1 – 4 – 2 – 6 – 3 – 5 14H35DFV 1 – 2 – 4 – 6 – 7 – 5 – 3 16H35DFV 1 – 3 – 5 – 7 – 8 – 6 – 4 – 2 18H35DFV 1 – 3 – 5 – 7 – 9 – 8 – 6 – 4 – 2 20H35DFV 1 – 5 – 9 – 4 – 3 – 10 – 6 – 2 – 7 – 8 Note) The principal data stated above are based on nominal MCR, and the actual data depend on each project specification. Please refer to the technical specification on final drawing.

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H35DFV Section No. G01210 M.80 Air/Gas System M.20

Engine Design Outline & Operating Data Engine Cross Section

Engine Design Outline &

Combustion System M.40 Eng. Control System M.30 Power Driving System

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H35DFV Section No. G01220 M.50

Engine Design Outline & Operating Data Engine Longitudinal Section

Engine Design Outline &

M.20 Combustion System M.60

M.80 Air/Gas System M.70 C.W System

Fuel Injection System M.40 Eng. Control System M.10 Engine Structure

M.30

L.O System

Power Driving System

Engine Design Outline & Operating Data Engine Performance

All type Section No. G01300

Page 1/4 Rev. 1B

Engine Design Outline &

Recording Engine Performance Data Performance of the engine varies in accordance with the operating condition and the engine condition. Therefore, it is strongly recommended to record the data of engine performance as frequently as possible, at least weekly, which will provide a reliable guide for better service and maintenance. A continuous trend analysis of the recorded data with reference to the engine maker’s shop test result and c ommissioning data will contribute to diagnose the condition of the engine precisely and the precautions or prescriptions can be made easily. The forms of data sheets can be referred to the engine maker’s shop test report or the like. Performance Parameters and Evaluation As the engine produces power by burning fuel with continuous breathing air and exhaust gas, the performance data are influenced by the change of such combustion parameters as ambient condition or fouled components for fuel injection, air and gas flow system. If there is any deviation from normal operating condition, the exhaust gas temperature and fuel consumption appear to be i ncreased generally, which eventually influence on reliability of the engine and need more frequent maintenance. Therefore, engine power shall be restricted if exhaust gas temperature or turbocharger speed exceed normal operating range. Some of the sensitive parameters are as below. 1. Ambient Condition Engine room atmospheric temperature and pressure, cooing water temperature, etc. influence engine power, fuel consumption, exhaust gas temperature and so on. G01310 G01320

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2. Amount of air-flow Intake air contributes not only to the combustion but also to the cooling of surrounding components. The amount of air-flow tends to be reduced due to fouling of the system by operating hours. Any one or some fouled components regarding air and exhaust gas passage can increase air-flow resistance and consequently causes increased pressure drop and reduced amount of air flow. Increased pressure drop means reduction of charge air pressure, which results lower cylinder pressure and more fuel consumption consequently. Reduced amount of air-flow results higher temperature of exhaust gas and cylinder components as well as more fuel consumption. The components liable to be fouled are as follows. Air filter, compressor of turbocharger and charge air cooler can be fouled by dust in engine room. Fouled charge air cooler also reduces its cooling efficiency and causes increased temperature of charge air to cylinder, which results in further increase of temperature of exhaust gas and the components in addition to the influence by reduced air-flow. Therefore, charge air cooler needs careful attention to keep cleanness.

 The exhaust valves, gas passages, nozzle ring and turbine of turbocharger are apt to be fouled and attacked by the products of combustion, which depends on the fuel used

and operating condition.

In general, the engine performance is sensitive to the fouling of the nozzle ring of the turbocharger, which reduces effective nozzle area and cause increasing of turbocharger speed in the beginning stage and reducing of air-flow finally. Therefore, cleaning of turbocharger is important for engine performance. See manual for T/C Back pressure after turbocharger is apt to be increased due to fouling of total exhaust system of the plant, which also cause the reduction of air flow and increased temperature of the exhaust gas. Therefore, periodical checking of the influence of the back pressure provides useful information for the reliable operation of the plant. Normally the backpressure of exhaust system in total should not exceed 300 mmWC. The measuring position is approx. 1~2m after the turbocharger gas outlet casing not turbocharger gas outlet casing. 3. Quality of fuel injection. Fuel quality and Injection characteristics affect engine performance as well as maintenance interval. Bad fuel quality increases not only wear of the injection equipment but the fouling of combustion chamber and exhaust system, which will finally increase the exhaust gas temperature and fuel consumption. G05200

G05200

 Calorific heat value of fuel influences rack index of fuel injection pump. Therefore, when adjusting load limiter, this influence should be considered and r eadjusted if the heat value changed considerably. Otherwise, engine may be operated in overloaded condition or lack of power. Fuel quality and worn fuel system affects the maximum firing pressure which is one of the critical parameters not only for engine reliability but also for fuel consumption and NOx emission. In general, higher maximum firing pressure reduces fuel consumption but increases NOx emission, and vise versa. Whenever changing the fuel, maximum firing pressure should be measured and readjusted or reconditioned if out of normal operating

M51101

range.

M51101

All type Page 1/1

Rev. 2A

Correction for Ambient Condition Specific fuel oil consumption (SFOC) is referred to the ISO 3046/1 standard condition normally. However, for the condition other than ISO 3046/1 standard condition, the SFOC at MCR can be estimated according to the below mentioned formula. SFOCamb = SFOCISO * dSFOC dSFOC = [100 + (Tamb-25)*0.05 - (Pamb-1000)*0.007 + (TCW-25)*0.07]/100* (42700/LCV) SFOCamb : Specific fuel oil consumption at actual operating condition [g/kWh] SFOCISO : Specific fuel oil consumption at ISO 3046/1 standard condition [g/kWh] dSFOC : Deviation of the SFOC Tamb : Ambient air temperature at actual operating condition [℃] Pamb : Ambient air pressure at actual operating condition [mbar] TCW : Cooling water temperature before charge air cooler(CAC) at actual operating condition [℃] LCV : Lower Calorie Value of the fuel oil [kJ/kg] Example Ambient air temperature(Tamb) : 30 [℃] TaturbISO: 335 [℃] at 720 [rpm], MCR Cooling water temperature(TCW) : 30 [℃] Lower Calorie Value(LCV) : 42700 [kJ/kg] SFOCISO : 182 [g/kWh] at 720 [rpm], MCR Then, dSFOC = 1.006 and the SFOC at site condition will be increased to 184.1 [g/kWh]

All type Section No. G01311

Page 1/1 Rev. 1A

Engine Design Outline &

Correction for Ambient Condition (Gas mode) Heat rate of the gas engine is referred to the ISO 3046/1 standard condition normally. However, for the condition other than ISO 3046/1 standard condition, the Heat Rate at MCR can be estimated according to the below mentioned formula. First, there is a relationship between the Heat Rate and the Efficiency, Eff [%] = 3600 / Heat Rate [kJ/kWh] * 100 Effamb = EffISO * dEff dEff = [100 - (Tamb-25)*0.021 - (1000- Pamb)*0.0025 - (Tboost-45)*0.008] / 100 Effamb : Engine efficiency at actual operating condition [% or kJ/kWh] EffISO : Engine efficiency at ISO 3046/1 standard condition [[% or kJ/kWh] dEff : Deviation of the efficiency Tamb : Ambient air temperature at actual operating condition [℃] Pamb : Ambient air pressure at actual operating condition [mbar] Tboost : charged air temperature after charge air cooler(CAC) at actual operating condition [℃] Notice) 1. Maximum value of dEff is 1. 2. Between ISO and ambient condition, same operating parameters must be used. 3. If there is a change of main component, this correction should be updated.

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Section No. G01320

Rev. 1B

Correction of Exhaust Gas Temp. after Turbine Exhaust gas temperature after turbine is referred to ISO 3046/1 standard condition normally. However, for the condition other than ISO 3046/1 standard condition, the exhaust gas temperature after turbine could be estimated according to the below mentioned formula. Taturbexh = TaturbISO + dTaturb dTaturb = (Tamb-25)*1.5 + (TCW-25)*0.7 Taturbexh : Exhaust gas temperature after turbine at actual operating condition [℃] TaturbISO : Exhaust gas temperature after turbine at ISO 3046/1 standard condition [℃] dTaturb : Deviation of the exhaust gas temperature after turbine [℃] Tamb : Ambient air temperature at actual operating condition [℃] TCW : Cooling water temperature before charge air cooler(CAC) at actual operating condition [℃] Example Ambient air temperature(Tamb) : 35 [℃] Cooling water temperature(TCW) : 35 [℃] TaturbISO : 290 [℃] at 720 [rpm], MCR Then, dTaturb = 22 [℃] and the Taturbexh at actual operating condition will be increased to 312 [℃]

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All type Page 1/3

Rev. 1C

Specification of Fuel Oil Drain Rate The fuel oil drain from the diesel engine contains various impurities such as lube oil, cooling water during operation and maintenance, and normally some amount of fuel oil is drained from diesel engine using conventional fuel injection equipment. So the drain rate of fuel oil cannot be free from fuel oil quality. The specification of fuel oil drain rate for HiMSEN engines is shown below table, and it depends on the fuel oil type.

No. Drainage from Disposal Total drain rate (liter / cyl. hour)

a) H17/28: 0.20 x Cf 2) b) H21/32, H21C: 0.23 x Cf 2) c) H25/33: 0.30 x Cf 2) d) H32/40(V): 0.30 x Cf 2) e) H35DF: 0.30 x Cf 2)

High pressure block (Fuel injection valve and its connection) Recycling fuel oil a) H17/28: 0.20 x Cf b) H21/32, H21C: 0.2

Fuel injection pump Recycling or Waste 1)Engine block (F.O & L.O & C.W during overhaul)

)f f) H27DF: 0.30 x Cf 2)

F.O safety filter (F.O during overhaul) F.O safety filter (Periodical drained F.O from filter)

)f g) H35DFV: 0.30 x Cf 2) - Tolerance: 50% - Amount of clean fuel oil, which can be recycled, is accounted for 70 ~ 80 % of total drain rate except for MGO (50~60%).

Waste fuel oil

If the sealing condition is bad or the crack occurred on the surface, the fuel oil is spilt too much with higher flow rate due to high fuel oil injection pressure. If so, the fuel leakage alarm tank’s level will become higher then it will alarm. In that case, should be overhauled and inspected fuel injection valve, high pressure pipe(block), connection piece and fuel injection pump regarding sealing of each connection and crack of their components.

1) HFO operation (without sealing oil application): Recycling   MDO or MGO operation (with sealing oil application): Waste   2) Cf : HFO = 0.5, MDO = 1.0, MGO = 2.0

Rev. 1C

Measurement of Fuel Oil Drain Rate The fuel oil drain from each cylinder is gathered together and drained to waste oil drain line and recycling fuel oil line, and the drain rate of each line can be evaluated by total amount of fuel oil drain volume per hour divided by cylinder number. The ratio between waste oil and recycling fuel oil of total drain rate can be different by fuel oil type. The internal fuel oil system diagram is shown on below figure.

[Internal FO System Diagram (H17/28, HFO)]

[Internal FO System Diagram (H32/40V, MDO/MGO only)]

Drain line from fuel injection valve

fuel injection pump

Drain line from

Rev. 1C

[Internal FO System Diagram (H35DF, HFO)] Drain line from fuel injection pump [Internal FO System Diagram (H35DFV, HFO)] AI HEAVY INDUSTRIES CO., LTD. Engine & Machinery Division 2017.07/GHL

Rev. 1D

Normal operating data of the engine are generally listed as below table. However, some data may be subject to change and shall be informed separately for specific project. Therefore, engine operator should understand the difference and run the engine within the specified range.

Normal

NormalAlarm & Sensor Autostopof EngineOperation RangeDescriptionst R t d

at Rated power

Alarm & Sensor

Engine speedSE47720 rpm/SGTH47750 rpm SAH47

10% speeddev iation※)SSH47115% MCRRatedspeed※)113%

10% speeddev iation※)SSH47115% MCRRated

SpeedControlFuel OilSystemFuel Gassystem

Engine speed &TDC

SE48

720 rpm/ 750 rpm

TC speedSE42SAH42

(A)

Main FO pressure, filter differential For continuous HFO operation Main FO pressure, engine inletPT51 (Emergency MDO) 4.0~6.0 bar 7.0~9.0 bar

PDAH50-510.8 bar

PAL51PAL51

1 bar6 bar

PT51

For continuous MDO operation Main FO pressure, engine inlet

7.0~8.0 barPAL516 bar 30~45 ℃

Main FO temp, engine inletTE51 (MDO) (HFO)

110~140℃TAH51

150 ℃85 ℃0.8 bar3 bar

70 ℃

Nozzle cooling oil temp., engine outlet Pilot FO pressure, filter differential

TAH54PDAH55-56

TE54★)

PT564.0~6.0 bar Pilot FO pressure, engine inletPPTL56

PPTH568 bar

PT57800~1000bar500 bar Pilot fuel pressure, pump outletPPTL57

PPTH57 PDPTL57 Pilot FO temp, engine inletTE5630~45 ℃TAH56

1300 bar100 bar(ref)50 ℃

Main FO dirty leakage tank level FO clean leakage tank level Pilot FO dirty leakage tank level Gas pressure at engine inlet

LS541LS542LS59

LAH541LAH542LPTH59

depends on loadPT87PAH87

depends on load1.5 bar dev fromC.A pressPAH87

PDGTH87

C.A press0.5 bar f rom ref .PDAH870.3 bar f rom ref .PDGTH87

PT81PAH81 Gas pressure at GRU inlet1.0~6.0 bar7.0 bar

PAL81

0.8 dev fromC.A press0 5 df

Gas filter differential pressurePDAH80/81

C.A pressPGTL810.5 dev fromC.A press

C.A press0.5 bar

Gas temperature TE8215~25 ℃TGTL82 0 ℃TGTH8250 ℃

Gas temperature TE8215~25 ℃TGTL82

GRU control airPT835~10 bar

Inert gas pressure

PT906.5~8 bar

PGTL834 barPAL906 bar

Rev. 1D

DescriptionsNormalAlarm & SensorAutostopof EngineOperation Rangeat Rated power

DescriptionsNormalAlarm & SensorAutostopof EngineOperation Ranget R t d

LO pressure, filter differentialPDAH61-62 LO pressure, engine inletPT624.0~5.0 barPAL62 LO pressure, TC inletPT63(A)PAL63 LO temp, engine inletTE6160~70 ℃TAH61

1.5 bar3.5 barPSL6280 ℃(A)85 ℃1.7 bar1.4 bar

3 bar

Lub. OilSystemCoolingWaterSystemCombustionGas/AirSystemCompressedAir SystemCylinderMonitoringSystem

LO temp, TC outletTE65★)65~75 ℃TAH65 LO pressure, pilot fuel pump inletPT643.0~5.0 barPAL64PPTL64 LO sump level tankLS68LAH/LAL68

95 ℃High levelTSH69 Oil mist detectorLS92LAH92 Main bearing temp.TE69TLRH69LSH92100 ℃High level

Oil mist detectorLS92LAH92

LSH9295 ℃High levelTSH69

HT water pressure, jacket inletPT752.0~4.5 barPAL750.6+(B) barPLRL750.4+(B) bar

HT water temp, jacket inletTE7565~75 ℃TAL7550 ℃TSBL7540 ℃

HT water temp, jacket outlet LT water pressure, CAC inlet LT water temp, CAC inlet

TE7675~85 ℃TAH7692 ℃TSH7695 ℃PT712.0~4.5 bar PAL710.4+(B) barTE7135~40 ℃TAH7145 ℃

Exh. gas temp. of cylindersTE25350~530℃TGTH25590℃TAH25580 ℃TLRH25590 ℃TDGTH25mapped ±(C)TDLRH25 100 ℃±(C)

Exh. gas temp. inlet T/CTE26480-560℃TAH26580 ℃TSH26620 ℃TLRH26590 ℃ Exh. gas temp. outlet T/CTE27300-500℃TAH27550 ℃

Air temp, T/C inlet

TE20TAH2050 ℃

CA pressure, engine inletPT24depends on load (At gas mode) (At diesel mode) (At gas mode) (At diesel mode) CA temp, engine inletTE2443-50℃

PGTH244.5 barPAH245.5 barPDGTH240.5 barPDAH240.5 bar

PGTH244.5 barPAH245.5 bar

(At gas mode)TAH2455 ℃ (At gas mode)TGTH2460 ℃

(At diesel mode)TAH24 (At diesel mode)TLRH24

60 ℃65 ℃14 bar4 bar3.5 bar

Starting air pressure, engine inletPT41

30 barPSBL41

Instrument air pressurePT424.5~8.0 barPAL42

PT46 DVT control air pressurePGTL42PAL/PAH4

PT46

PAL/PAH46(D)

LT89PT90★)

LAH89LGTH89PAH90

(E) > 6°CA(F) >10°CA190 bar

Knock sensor cylinder

Cylinder pressure sensor (At gas mode) (At gas mode) (At diesel mode) (At diesel mode)

PGTH90200 barPAH90180 barPLRH90190 bar

Rev. 1D

Remark :

(A). Depending on cylinder No. and T/C maker (B). Depend on the height of expansion tank (C). Average exhaust temperature

Cyl. Maker Normal rangeAlarm 6(12) ABB 3~4.5 bar 2.7 bar7,8,9(14,16,18)ABB 2~3 bar 1.7 bar

(D). Depends on DVT on/off condition (E). Total retardation of ignition timing generated by knocking (F). When predefined times of last 10 cycle exceed this value ★). Can be applied as an option.

SGTH High speed gas trip PPTL High press pilot trip SAH High speed alarm PLRL Low press load reduction SSH High speed shut down PSL Low pressure shutdown LAH High level switch alarm PSBL Low press start block LGTH High level gas trip TAL Low temp alarm LLRH High level load reduction TAH High temp alarm LSH High level switch shutdown TSH High temp shut down PAL Low press alarm TGTL Low temp gas trip PAH High press alarm TGTH High temp gas trip PDAH High delta press alarm TDGTH High delta temp gas trip PGTL Low press gas trip TLRH High temp load reduction PGTH High press gas trip TSBL Low temp start block PDGTH High delta press gas trip TSBH High temp start block PPTH High press pilot trip

Operation Rangeat Rated powerDescriptionsNormalAlarm & SensorAutostopof Engine

Liner &Bearing

TLRH6995 ℃ Cylinder liner temperatureTLRH24130 ℃TE66★) Main & thrust bearing temp.TE69

TSH69100 ℃TSH26140 ℃

Oil mist detectorLS92

LSH92High levelLLRH92High level

(At gas mode) Crankcase pressurePT94

1 ~ 4 mbar

1 ~ 4 mbar (At gas mode) Crankcase pressurePT94PGTH9410b(Atd)PAH947 mbarMiscellaneoussystem

(At gas mode)

PGTH9410 mbar

(At diesel mode)

PAH9412 mbar

Usually fill out and file the engine operating data at below table, and make a claim with below filled table if a problem occurred at engine.

Engine Serial No.No. DateDD.MM.YY Total Operating HoursHours Ambient Press. / Temp.mbar/℃ Load Point % Engine Speedrpm Generator LoadkW Generator Efficiency% Engine LoadkWPressure Filter inlet / outletbarPressure T/C InletbarTemperature Engine Inlet℃LONozzle Cooling Oil Temp℃Pressure PFO Inletbar

PT75Pressure Engine InletbarTemp Engine inlet /Jacket Outlet℃Pressure Engine InletbarTemperature Engine Inlet/outlet℃

PT24Charge Air PressurebarA

Charge Air Temperature

TE24

PT41Starting Air Pressurebar

PT42Instrument Air Pressurebar

Wastegate PositionGovernor Indicator Position

ZT26ZT25

-Gas Injection Duration'CA-Gas Pressure Offsetbar

PT51Main F.O Pressure engine inletbar

Main F.O Temp Engine Inlet

TE51

PT50Main F.O Pressure Filter Inletbar

Nozzle Cooling Oil Temp

TE54

PT55/PT56Pilot F.O Press. Filter Inlet/Outletbar

PT57Pilot F.O Press. Pump Outletbar

Pilot F.O Temp. Engine inlet

TE56

PT81Gas Supply Pressurebar

bar

Gas Supply Pressure Regulator outletGas Temperature Engine Inlet

PT82TE82

PT87Gas Pressure Engine inletbar

PT83GRU Control Air PressurebarGen.Bearing Temp Coupling/End℃Gen.Winding Temperature℃

CylLinerTemp

Cyl.No.No.1No.2No.3No.4No.5No.6No.7No.8No.9No.10mean

mmbar℃℃℃mmmmbar℃℃℃

bar

ExhGasTemp

PumpIndex

MainBRGTempPmax

Cylinder Unit

SpeedrpmExhaust Gas Temp. Inlet℃Exhaust Gas Temp. Outlet℃

The engine is a complicated power-generating machine by means of burning fuel and the engine room normally has various other equipment, which require careful attention for the safety and reliable operation. Therefore, the below mentioned warnings should be always kept as basic rule for the persons who are involved in the engine operation and maintenance. Qualified Personnel Only The engine system should be operated and maintained only by qualified personnel who can understand engine and be familiar with specific plant including the engine. This book should be provided to the right persons in order to be familiar with this engine before entering into operation and maintenance works. Engine maker will provide training course for users, if requested. Unauthorized personnel should not be allowed to be near or touch the engine. It is dangerous especially during the engine is running, which is out of engine makers warranty. The engine operators should understand potential dangers of the engine and be authorized to manage the operation and maintenance works of the engine including further warnings as below mentioned. Maintenance staffs are always well aware of some components including sharp edge or spring or similar, which may escape and cause hurting person. Careful attention is required when handling heavy parts that need stable working condition and proper lifting tools. Flashlight, fire extinguisher, and other emergency tools, spare parts should be always kept ready at hand near the engine.

Fire Precaution Engine room, especially around the engine should be kept always clean and bright to avoid any possibility of fire and for easier checking of fuel leakage or any abnormalities. Cleanness of the engine and below floor plate around the engine should be checked frequently and ensured before the engine operating and after maintenance work. Engine room should be always free from any explosive gases or inflammable fluid especially during engine running or any repair works which cause spark such as welding work or similar. Hot ! Opening of covers or loosening of some screws is not allowed during operation of the engine or related other equipment or before ensuring the engine cooled and fluid circuits drained, which may cause escape of hot gas or fluid. Temperature sensing by hand touch is not allowed only except for authorized personnel. Non-contact infrared type thermometer is recommendable for checking surface temperature of the engine body Freezing When the engine is out of service and the temperature in the engine room is below the freezing point (0℃), the water in the engine, pumps, coolers, and pipe systems

should be drained to prevent freezing.

Genuine Part All the parts for replacements should be genuine parts from the engine maker. Otherwise the engine maker will be free from any responsibility for any damage or bodily injury induced from not using genuine parts. Do not use for any other purpose. All parts and articles of consumption should be only used in designated purpose. Otherwise the engine maker will be free from any responsibility for any damage or bodily injury induced from use of other usage. Language We recognize only English text in case of having trouble with something about this book. The Korean text is only supplied to understand contents of this book easily for Korean people. We do not guarantee any problem induced from the wrong translation or interpretation of English text.

O02200

General The commissioning of an engine after installation on site is something very critical for the whole life of the engine. Therefore, it is strongly recommended to carry out commissioning properly to provide the engine can be operated in normal condition for the expected performance and reliability of the engine later on. Note on Commissioning 1. Installation of an engine should be carried out in the presence of representative(s) from engine maker and processed properly according to the engine maker’s recommendations. Any particularities should be contacted to and cleared by the engine maker. 2. All data recorded during the commissioning should be pr eserved as reference guide to compare the condition of the engine service later on, as the operating condition may be different from that of engine maker’s shop test which represent contractually valid. 3. Engine operator should be familiarized with local operating condition of the engine and related machineries before running in the system.

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O02300

Be sure to make it a rule to check the readiness for every starting of the engine according to the following procedures. More careful checking of the readiness is required for the starting initially after installation or overhaul or a period of standstill. 1. Preparation of the Engine for Starting Check the last date when the Crank Case Cover opened for ensuring everything cleared after inspection or maintenance. Check the date when the last tightening of major fasteners. Check if there is any loosened part and correct them, if any. Check all covers are closed. Do not open the covers of the engine during running. Check cleanness around the engine. Make sure that the rotating parts of the engine are free from any obstacles. Take out tools and rags from the engine. Electric power ‘ON’ for the control system. Check functions of monitoring panel, local and remote control, etc. 2. Preparation of Cooling Water System Check cooling water tank level and fill, if needed. Operate cooling water supply system, if stopped. Check valves and set to operating position. Check and correct any leakages. Check air venting in the cooling water circuit. Check water pressure and temperature.

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Normal Operation Preparations for Engine Starting

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O02300

3. Preheating of the Engine Preheating of the engine is required for protecting the engine from thermal shock as well as proper circulation of fuel oil and lubricating oil. Operate cooling water heating system. Make sure to circulate heating water through the cylinders at least for 2 hours before starting. Temperature of the water shall be depending on the fuels for starting as below. Starting on HFO : over 60 ℃ Starting on MDO : over 40 ℃ 4. Preparation of Fuel System Diesel Fuel Drain fuel tanks for water and check filters. Check fuel tank level and fill, if needed. Check cooling system for diesel fuel oil. For starting on HFO, recheck preheating of the engine ready for HFO circulation. Emergency cold starting on HFO is not accepted. Cold engine may cause clogging of the fuel injection system by heavy fuel oil, which may cause serious damages on fuel injection system due to excessively high fuel injection pressure when starting. If engine stopped on HFO without heating continuously, the HFO inside fuel injection system should be removed and cleaned by MDO before re-starting. All fuel injection

pumps, valves and high pressure pipes should be dismantled and cleaned.

O02300

Operate fuel supply system, if stopped. Check valves and set to operating position. Check any leakages and correct them. Check air venting in the circuit. Check fuel oil temperature, viscosity and pressure. Gas Fuel Check the filter of Gas Regulating Unit (GRU) Check the operation of electric shut-off and venting valves of GRU in engine test mode. If there’s external gas compression or regulation system, activate it. Open the manual shut-off valve of GRU and check the inlet pressure Perform gas leakage test. Check the leakage of every shut-off valve, venting valve and connection pieces by monitoring gas pressure and soapy water. Gas leakage test is performed in engine test model. In engine test mode, all gas shut-off and venting valves can be activated individually. When gas is filled in pipe by operating shut-off valves, the pressure of gas must not be decreased if there’s no leakage. If there’s gas leakage in the circuit, the engine start should be aborted until the problem is solved. Vent the rest of gas after leakage test and check there’s no gas in engine and GRU. Check gas venting in the circuit.

O02300

5. Preparation of Lubricating Oil System Check the date when the last sampling for oil quality test. Check oil filters and replace them, if needed or after long term out of operation or overhaul. Check oil sump tank level and fill, if needed. Check valves and set them to operating position 6. Pre-lubrication of the Engine Check lubricating oil temperature which should be heated up to about 40℃ by circulating L.O through L.O purifier or enough jacket water preheating. If oil temperature is too low or oil viscosity is higher than 1500 cSt (10 ℃ SAE40),

electric motor for pre-lubricating pump may be overloaded. Operate pre-lubricating pump, if stopped. Check and c orrect any leakages of the system. Check oil pressure rise and pre-lubricating condition. Prelubricating should be con-tinued at least for 5 minutes before starting. If the engine has been stopped for a period of time or overhauled, make sure that oil comes out from bearings, rollers on cam and rocker arms on cylinder heads. Tapes attached during maintenance may block the oil passages. Engage turning gear and rotate crankshaft manually at least two turns to ensure engine moving parts are in order. Disengage from turning gear.

Normal Operation Preparations for Engine Starting

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O02300

7. Preparation of Starting Air System Drain air tank for water and check filters. Check air tank pressure and fill, if needed. (20 ~ 30bar)

Check control air pressure.

G01400

G01400

Check valves and make them operation position. Check any leakages and correct them. Rotate the engine by slow turn to ensure engine status Engine slow turning should be set 4 turns between 10~50 second.

by Controlling the LOP(Local Operating Panel). By switching on the “Slow Turning Valve” and switching the “Starting Valve, Slow Turning is performed. In case of Slow turning failure, operator should check the combustion chamber if there is left fluid like cooling water or fuel oil. After disassemble Cyl. Pressure Sensor, Operator can check released fluid by slow turning. If continuous inflow of fluid is monitored, Operator should inspect the engine assembly status. After checking fluid out, sensor bush should be clean by air gun. Fuel remained inside cylinder before starting may cause over pressure and heavy smoke during starting.

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8. Preparation of Diesel Control System. Check smooth movement of fuel regulating linkages from governor to every rack of the fuel injection pump. Check ‘Stop’ and ‘Max’ position for both Governor Load Index and Fuel Pump rack.

Check function of ‘Emergency Stop’ button and reset. Push the handle on fuel regulating shaft to ‘Max’ position and press ‘Emergency Stop’ button, then every rack of fuel injection pump should be ex truded to ‘Stop’ position. Check flexibility of each rack of fuel injection pump. Rack of fuel injection pump should be returned to original position when pushing or pulling it manually. Check mechanical fuel limiter for over load (Set to 110% load). If mechanical fuel limiter is not set correctly, the engine may be seriously damaged. Check mechanical fuel limiter for start (Set to about 30 ~ 50% load).

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9. Air Running Check air intake and exhaust gas passages are free. Check ‘Start Ready’ lamp ‘ON’.

Choose “Starting Valve” at test mode of LOP(Local Operating Panel) and press “Switch On” button. Check air running condition. Air running is recommended to ensure pre-lubrication and readiness for starting, if only possible.

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1. Starting the Engine Check ‘Ready to Start’ lamp ‘On’. Check ‘Diesel Mode’ lamp ‘On’. Press ‘Start’ button. This should be done by authorized personnel only. Except starting after short period of ‘Stop’ with normal engine condition, the engine should be started manually by ‘Local’ control system (‘Local’ mode) and the operator should be ready to stop the engine immediately, if needed during checking the condition of engine running. Be sure to check the surroundings of the engine in case of ‘Remote Start’ 2. Checking immediately after Starting Listen to the engine running sound carefully. If unusual noise detected or anything suspected, stop the engine immediately and proper investigation should be carried out. Check pre-lubricating pump stopped and oil pressure rising as soon as the engine runs. Check water pressure and air venting. Check fuel feed pressure. Check turbocharger speed. Check exhaust gas temperature of each cylinder whether firing occurs. Check any leakages around the engine and feed system. Check all shutdowns and alarms function correctly. Check the all DVT(Daul Valve Timing) working correctly.

The DVT can be monitored by DVT Feed-back sensor(switch) via LOP. Also Operator can check the spool valve at the DVT. When DVT is active, Spool valve is pushed out. In case of DVT deactivated, during engine start, Heavy smoke and misfiring can be occurred. Check Micro Pilot System working correctly.

Micro Pilot System is checked automatically when engine idle speed. At this time, Engine runs by pilot oil injection only. By checking each Cyl. Exh. Gas Temp., micro pilot injector can be checked. In case of rail pressure built failure and injection failure, Pilot trip will be released. Engine will run at Back-up mode under pilot trip condition. More than 30 min. running at back-up mode is not recommended, because Micro Pilot nozzle can be blocked by particle from main injection. If pilot trip occurred, should be checked after engine stop. 3. Rechecking after Initial Starting For the case of first starting after installation or a period of standstill or overhaul, it is strongly required to check the condition of engine rotating parts again before loading up the engine. Stop the engine after idle running for about 5 minutes. Open the covers on engine block to inspect the internal sliding parts for abnormal overheating due to friction.

 Inspect bearings (for main, big end, small end, camshaft, and alternator), gear

wheels, cams and rollers visually and check surface temperatures by means of hand touch or non- contact type (infrared ray type) temperature measuring devices. Start again and run the engine for about 30 minutes at idle speed, then stop the engine and repeat the inspection of internal sliding parts as same manner as above mentioned.

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All type Page 1/2

1. Load Up with Cold Engine It is required to warm up the engine by loading up gradually upto about 50% load for a few minutes with MDO only. The cylinder cooling water temperature should be minimum 60 ℃ to load-up to 100 % load. 2. Load Up with Warm Engine A warm engine or stand-by engine with cooling water temperature over 60 ℃ can be loaded up from starting to 100 % load immediately without any restriction. However, the sudden load-up will take time to achieve stable frequency. 3. Quick Load Up The quickest way to load-up from 0% to 100% load can be achieved by increasing the load continuously and gradually. 4. Step by Step Load Up Considering the time required for stabilizing the frequency deviation due to sudden load-up, it is recommended to load up from idle to full load by more than three steps(Diesel mode only) under approval of classification society. In case of Gas mode, it is possible to load up from idle to full load at least five steps. Excessive step load increasing can cause heavy knocking at gas mode. 5. Checking during Load Up □ Check pressure and temperatures for lubricating oil and cooling water. □ Check fuel pump rack index and governor index.

Pag 53
All type Page 2/2

Check the exhaust gas temperatures after cylinders and turbocharger inlet and outlet. Check maximum firing pressure of each cylinder. Check the Gas supply pressure at gas mode. Check the Rail pressure at Micro Pilot System. Operating data for each load step should be within the normal operating range and always compared with shop test record and previous operating records

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Pag 54
Normal Operation Engine Normal Operation

All type Section No.

Page 1/2 Rev.

O02600

Operating with constant load provides better service results continuously. Avoid abrupt load or speed change as possible. Regular checks and measures mentioned should be carried out during normal operation, which will contribute to earlier detection of any abnormality. The most important actions required during normal operation are as follows; 1. Checking during Normal Operation Check and r ecord engine performance according to the format of shop test report or the like. Any unusually high or low tempera-ture or pressure should be investigated. Check operating condition of fuel supply system. Check fuel oil temperature of engine inlet In case the engine is running on HFO, viscosity of HFO should be controlled by heating properly. High viscosity cause excessive fuel injection pressure and may result damage of fuel injection system. In case the engine is running on Diesel Fuel Oil, the oil should be cooled properly. Otherwise, the viscosity will be too low, which may cause sticking of fuel pump plunger. Watch the color of exhaust gas out of funnel. Sound the engine operating noise. Check condition of filter for turbocharger and pressure drop of filters for lubricating oil and fuel oil to avoid any interruption of continuous operation due to alarm or shutdown.

O02600

Check air venting of cooling water circuit and fuel oil circuit, which should be opened during operation. Not sufficient air venting may cause hammering and damage of the systems due to severe vibration. Check water drain pipes from engine block opened and drain quantity, which will contribute to clarify whether the water source from normal condensation or leakage of cooling water. Check drain hole of cylinder head for the detection of cooling water or combustion gas between cylinder head and liner. G21000 Check drain pipe for fuel oil and dirty oil, which will contribute to clarify whether the normal drain from fuel injection pump or any leakage around covered cylinders. Check oil level and the condition by sampling and analysis. Check the condition of cooling water by sampling to inspect whether the inhibitor is still active or it there is any rust included. Check drain pipe of cooling water pump. If leakage of oil or water detected, the pump should be overhauled and maintenanced.

G21000

The engine provides various stop mechanisms, which cut off fuel supply and stop firing fundamentally. 1. Normal Stop Procedure Change over heavy fuel to marine diesel oil, if necessary for maintenance or long-term standstill. For the case of normal operation on heavy fuel, it is recommended to stop on heavy fuel oil, if only heavy fuel oil can be circulated continuously until next start. Otherwise, the fuel should be changed over to marine diesel oil to avoid clogging of the fuel system due to cooled down of heavy fuel oil. Load down to idle gradually (by releasing generator load for generator application) and idle running within two minutes and stop the engine. Do not run the engine more than two minutes at low load before stopping to avoid contamination of exhaust gas system. Press ‘STOP’ button on remote or local control panel This activates governor lever to ‘STOP’ position and fuel rack to ‘STOP’ position consequently. (Diesel mode) The gas valves are closed, gas injection and the ignition system remains active until standstill for burning the rest gas after the gas valves. (Gas mode) The venting valves are open to purge the remained gas in the circuit. (Gas mode)

Check engine successfully stopped. Check pre-lubricating pump running. Keep running pre-lubricating pump and external cooling water pumps for a period of time to cool down heated parts of the engine gradually. Do not open crank case door or dismantle any parts just after engine stopped, which may cause escaping of hot fluids.

2. Emergency Stop If normal stop failed in urgent situation, the engine can be stopped by pressing ‘Emergency Stop’ button on remote or local control panel. The ‘Emergency Stop’ button activates every Fuel Injection Pump Rack to stop position by compressed air through stop solenoid valve. In this case, the engine will be stopped suddenly with loaded condition. Therefore, it is recommended to stop the engine manually instead of by ‘Emergency Stop’ button. 3. Manual Stop The engine provides mechanical manoeuvring handle, which is independent of engine control system. The engine can be stopped by turning the handle to stop position manually. The manual stop should be done as same procedure as normal stop. Keep the handle at ‘STOP’ position until the engine completely stopped. Otherwise, the engine may revive. Engine & Machinery Division 2017.07/HJO

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4. Auto-Stop (shut-down) If there is any abnormality which pre-determined for auto-stop, the engine will be stopped automatically by the engine control system. However, the alarm will normally precede the auto-stop by showing the abnormality. G01400

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1. Stand-by Engine In order to be ready for imminent normal

service, all the requirements of O02400

the preparations for starting should be fulfilled together with further requirements as follows; Keep fuel oil and cooling water circulating and pre-lubricating continuously. Keep the engine in warm condition similar to normal operating condition by circulating high temperature cooling water of the other engine or cooling water heating system. Otherwise, warming up of the engine should be required before entering into normal service. Slow turn the flywheel at least 3 revolution in every 24 hours. By selecting Stand-by mode at remote or local, automatically set the system to do cyclic slow turning, engine warming. At this time L.O/HT Preheater should be selected auto mode. 2. Engine under Maintenance Wait until the engine cooled down before starting maintenance work. Keep clean around engine and protect lubricating oil and fuel oil system from contamination. 3. Engine Stopping for a few hours Keep the pre-lubricating pump running continuously. Try to keep the engine in warm condition as possible. Otherwise warming up will be required for next operation. Engine & Machinery Division 2017.07/HJO

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4. Engine Standstill for days Select Standstill mode at local or remote. Shut off valves of engine external feed system for starting air, cooling water and fuel oil. If there is any risk of freezing, drain cooling water in the engine. 5. Engine Standstill for a longer period Further to above actions for the engine stand still for days, following actions are required; Shut off exhaust gas duct to

avoid any dust or humid entering into the engine.

 Run the pre-lubricating pump for about 30 minutes at least once a week. If humidity is high around the engine, daily pre-lubrication is recommended. Turn crankshaft by more than 2 revolutions during every pre-lubrication and stop at new crank position. It is recommended to circulate cooling water for about 30 minutes daily. It is recommended to run the engine once a week for checking the conditions for next starting. 6. Engine Preservation for long term disuse Relevant cleaning and Anti-corrosion treatment should be required for long term preservation. Please contact engine maker with information of the site condition and period of disuse. Engine & Machinery Division 2017.07/HJO

Special Operation Running-in after Renewal of Sliding Parts

All type Section No.

Page 1/2 Rev.

O03100

After renewal or repair of piston rings or cylinder liners or bearings, the new sliding parts need to fit to mating parts to avoid any abnormal wear. Therefore, the engine should have running in operation step by step as follows : Make sure that there is no abnormality by checking according to procedure of ‘Recheck-

ings after initial starting’.

O02400

Speed up to rated speed gradually by manual. See Instruction Manual for Governor If not sufficiently warmed up, run the engine until temperatures and pressures to be i n normal operating condition and adjust them, if needed. Prepare for putting load on the engine (Connect to switch board). Load up the engine according to following running-in procedures [See fig. 1]. I. Load up from idle to 25% load gradually for about 20 minutes. II. Run at 25% load continuously for about 30 minutes. III. Load up from 25% to 50% load gradually. IV. Run at 50% load continuously for about 50 minutes. V. Load up from 50% to 75% load gradually. VI. Run at 75% load continuously for about 50 minutes. VII. Load up from 75% to 100% load gradually. VIII. Run at 100% load continuously for about 40 minutes.

Special Operation Running-in after Renewal of Sliding Parts

All type Section No.

Page 2/2 Rev.

O03100

After running-in, the engine can be in normal service mode. The purpose of running-in is to fit the sliding surfaces for various load cases, therefore, do not run the engine with continuous load in initial stage. In case of piston overhaul, running-in is also necessary to refit new position of piston rings. Running-in can be done by using normal lubrication oil and fuel oil of either distillate or heavy fuel.

Pag 63
Special Operation Long Term Low Load Operation

All type Section No.

Page 1/1 Rev.

O03200

Operating the engine with the load of below 20% may cause incomplete combustion and result fouling of combustion chamber as well as air and exhaust gas flow passages. Therefore, long term low load operation should be avoided as possible. However, if it is inevitable to operate the engine at lower than 20% load for a l ong time continuously, following measures should be carried out to minimize contamination of the engine inside. Operating duration should be restricted as below. Idle running : 1min(max. 5 min) Running below 15% on MDO or below 20% on HFO : See below graph Flushing operating duration at not less than 70% of full load : See below graph More frequent cleaning of turbine is recommended.

 Minimum Duration of flushing operation : HFO 1.15 hours(Line B), MDO 0.75 hours(Line B’)

Time Limits for Low-load Operation Minimum Duration of Flushing Operation

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Pag 64
Special Operation Emergency Operation

O03300

In case of very unavoidable emergency situation such as the last solution, the engine may be operated with abnormal condition as follows with some restrictions to minimize hazard to engine 1. Overload Operation 1) Marine Genset The engine can be operated with maximum up to 110% load on condition that a duration for maximum one hour per 12 hours. However, even in this intermittent overload running case, following restrictions should be noted. (Diesel mode) Do not adjust mechanical load limiter or change all settings for normal operation.

 All the operating data should be within normal operating range. Operator should be always check overload running condition and ready to reduce the load immediately, if any abnormality detected. 2) Stationary Genset Over load > 100% may only be run for a short time to compensate for a frequency drop when a load is applied.(Blocking of the output for engine, driving generator, at 110% of the rated output) If gas mode, maximum load is 100%

Pag 65
Special Operation Emergency Operation

O03300

2. Emergency starting In case of an electric power failure in emergency situation, the engine control system can get electric power from UPS. The capacity of UPS is for 30 minute operation. Operator can start the engine via start button from LOP(Local Operating Panel) or Remote system.

Pag 66
Troubleshooting Starting Failure

O04100

Engine does not start 1. Engine is not under ‘START READY’ condition Check whether starting tried after ‘START READY’ lamp ‘ON’. Prepare for starting and reset.

O02300 O02300

Check function of control system and governor. No engine starting with the signal of turning gear engaged. Check the interlock valve and wiring for

LDFV42300

turning gear.

LDFV42300

2. Flywheel does not rotate (Slow turning failure). No starting air noise from air starter when pressing ‘START’ button. Check valves for starting air supply line opened. Check function of solenoid valves. Check the wiring connection. Check the fuse at control panels. Check the combustion chamber if liquid is in or not by using turning gear or slow

turning more than 3 turns. O2300 O2300

3. Flywheel rotate, but too slowly Check oil temperature. (Too high viscosity) Warm up the engine, if too low. Check starting air pressure and leakage. Charge air, if too low Repair, if leaked. Check engine under load. Release the load, if loaded.

O04100

4. No firing of cylinders. Check fuel oil circulating. Charge fuel tank, if

empty. Clean or replace fuel oil filter element, if clogged Check if first starting after maintenance. (Incomplete air venting of fuel injection pump) Check movement of fuel rack, control shaft and governor lever. Press ‘Reset’ button, if fuel rack blocked by stop signal. Lubricate linkages, if stiff.

Adjust the levers, if distorted.

LDFV41000 LDFV41000

Check if fuel oil drained too much. Tightening of fuel high pressure block, if

loosened. LDFV52300 LDFV52300

Check fuel injection valve by tester. (Opening pressure and Spray pattern) Adjust valve opening pressure, if

changed. LDFV52000 LDFV52000

Clean nozzle, if clogged by heavy fuel oil. Replace, if needle sticked.

 Check fuel injection pump. LDFV51000 LDFV51000

Replace, if sticked or worn excessively.

 Check the DVT operation. G24100 G24100

DVT should turn on at low load and turn off at high load. If it doesn’t, proper alarm or load reduction request is occurred. Check that an engine is preheated enough

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Engine does not stop 1. Normal stop by control system failed. □ Check function of control system and

governor. LDFV41000 LDFV41000

2. Emergency stop failed. □ Check if control air pressure is too low. □ Check function of emergency stop solenoid valve. 3. Manual stop failed. □ Check movement of fuel rack, control shaft and governor lever.

O04300

Gas trip □ When gas trip occur, Engine Control system detect the caution and release related alarm. Operator can recognize the alarm and fix the trouble by checking system. □ Gas trip by controller failure □ Controller power failure □ Check the power supply line □ Controller power failure □ Check the cable and wiring condition

Gas trip by speed measurement □ Speed deviation □ Check the engine load fluctuation. □ Speed sensor fault □ Check the wiring condition. □ Check the sensor mounting condition. (air gap) □ Check the sensor healthy and exchange the Gas trip by control air □ Pressure sensor fault □ Check the control air pressure which is in the normal range or not. □ Exchange the sensor in case of sensor fault Gas trip by exhaust gas □ Exhaust gas temp. fault □ Check the Fuse and Wiring □ Exchange the sensor in case of sensor fault

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O04300

 Exhaust gas temp. deviation Check the ignition system and gas supply system Check the Exh. Gas temp. sensor Check the Wastegate opening position which is well matched with command position. Gas trip by Intake air system Charge air pressure sensor failure Check the Fuse and wiring Exchange the sensor in case of sensor fault Charge air pressure deviation from set point Check the Wastegate opening position which is well matched with command position. Check the Pressure relief valve is opened or not. Charge air temperature sensor fault Check the Fuse and wiring Exchange the temperature sensor in case of sensor fault Charge air temperature high Check the air cooler Check the LT 3-way control valve working correctly. Gas trip by abnormal combustion Continuous or heavy knocking Abnormal combustion can be occurred by Excessive lube oil or hot spot at combustion chamber. In case of continuous or heavy knocking, operator need to check

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 Misfiring Misfiring can be occurred by Micro pilot injector fault. In this case, injector should be fixed or exchanged. Misfiring can be occurred by Gas admission valve. In this case, valve should be fixed or exchanged. Gas trip by Gas supply system Gas / Control pressure sensor fault Check the Fuse and wiring Exchange the sensor in case of sensor fault Gas supply system high Check the Gas supply system Fuel Gas temp. high/low Check the Gas supply system Control air for Gas Regulator Check the aux. system Gas Shut-off / Venting valve Check the valve operation Gas trip by Auxiliary system Load signal fault Check the wiring condition and Power Management System Fuel Gas leakage Check the Gas supply system Exhaust gas ventilation system fault Check the Ventilation system

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Pilot trip 1. Released during starting Auto-stop due to starvation of fuel. Check if fuel oil tank empty. Check if fuel oil filter clogged. Check if fuel oil feed pump out of operation. Pressure building failure in Rail. Check the motor rotation direction. Check the oil leakage at Double wall pipe connection (including Leakage alarm tank, High pressure sensor, safety valve) Check the wiring condition of Pressure control solenoid valve at High Pressure Pump stop due to low lube oil pressure. Check lubricating oil system.

2. Pilot test failure during idle speed Fail to maintain idle speed Check the speed sensor trip alarm and fix it. Check the pilot injection controller trip alarm and fix it. Test failure by exh.gas temp. deviation Check the open coil / over current alarm and fix it by making connector correct or replacing the injector. If nozzle seem to be bl ocked by dirty particle, exchange the nozzle or injector.

O04300

Engine stopped suddenly 1. Alarmed before stopped. Auto-stop due to starvation of fuel. Check if fuel oil tank empty. Check if fuel oil filter clogged. Check if fuel oil feed pump out of operation. Check if fuel contains water or air. Auto-stop due to over-speed. Check governor and linkage system. See Manual for Governor Auto-stop due to low lubricating oil pressure. Check lubricating oil system.

O04500 O04500

Auto-stop due to high cooling water temperature. Check cooling water system.

O04600 O04600

3. No alarm before stopped. Engine can be turned manually. Check governor and engine control system. Check electric power supply system to engine. Check fuel injection system and linkages. Check if engine overloaded. Check if fuel oil

contains water or air.

Engine cannot be turned manually. □ Check pistons, bearings and gear s of engine.
ine & Machinery Division 2017.07/HJO

Troubleshooting Insufficient Power Output

H35DFV Section No.

Page 1/1 Rev.

O04400

Engine power is reduced than usual 1. Misfiring of a cylinder(s). □ Check if alarmed due to high deviation of exhaust gas temperature. □ Check if fuel injection pump stuck. □ Check if fuel injection valve and nozzle clogged. □ Check if fuel rack stuck or disengaged.

□ Check if intake and exhaust valves stuck □ (Gas mode) Gas fuel mode tripped diesel mode. 2. Insufficient power of all cylinders. □ Mechanical fuel limiter is in limiting position. □ Check starting fuel limiter active. □ Check fuel quality and fuel rack index. □ Check fuel filters and clean them. □ Check engine loading condition. □ Mechanical fuel limiter is in free position. □ Check fuel high pressure block and pipe. □ Retighten, if loosened and leaked.

Check fuel injection pump and valve. □ Replace, if worn or stuck.

LDFV51000 LDFV51000 LDFV52000 LDFV52000

Check fuel control linkages. □ Retighten, if loosened. □ Lubricate, if malfunctions. Check if engine moving parts (piston and bearing) scorched. Check color of exhaust gas. □ Recondition, if abnormal.

O04700 O04700

H35DFV Page 1/2

1. Pre-lubricating pump failed. Check the oil temperature and viscosity. Check electric power supply and wiring.

2. Pressure of lube oil is too low or too high. Check pressure gauge if malfunctioned. Check the oil pressure control valve of engine. Adjust or replace, if needed. LDFV64000 Check oil cooler. Clean, if dirty.

LDFV62000 LDFV61000

LDFV64000

Check the oil pump , driving gears

LDFV61000 LDFV64000

and thermostatic valves of the engine.

 Repair or replace, if needed. Check oil filters and pressure drop. Replace filters, if needed. (Do not

reuse.) LDFV63000 LDFV63000

 Check the oil viscosity and property. Check oil sump level and suction strainer. 3. Temperature of lubricating oil is too high

Check lubricating oil cooler LDFV62000

and thermostatic valve.

 Check abnormal friction of bearings, gears, pistons and cylinder liners. 4. Lubricating oil consumption is too high Check oil property (Sample inspection by oil maker). Replace, if inferior.

Check piston ring and liner LDFV31100

bore.

LDFV15000

 Replace, if worn or damaged or blow-by. Check engine if overloaded or overheated. Adjust or repair, if needed. 5. Lubricating oil consumption is too low or oil level is increasing. Lubricating oil contains fuel oil. Check oil seal of fuel boost pump Replace, if defective. Check fuel Injection pump and sealing oil drain line. Clean, if clogged. Replace, if worn. LDFV51000 Lubricating oil contains water. Check oil cooler. Replace, if defective.

LDFV62000 LDFV62000

Check cylinder heads, engine block and feed module. Repair if cracked.

Troubleshooting Abnormal Cooling Water Condition

All type Section No.

Page 1/1 Rev.

O04600

1. Cooling water temperature is too high. Temperature of cooling water engine inlet is high. Check cooling water supply system. Adjust or repair cooling water feed system, if too high. Fill the water tank, if not sufficient. Temperature of cooling water cylinder outlet is high. Check air venting line if air infiltrated.

 Open valves for venting line, if closed. Repair supply system, if air suctioned. Check exhaust gas temperature and engine loading condition. Release the load, if overloaded. Check water pumps, driving gears and thermostatic valves of the engine. Repair or replace, if needed. Check cooling water passage inside the engine (Air cooler, Cylinder head, Cylinder liner, Water jacket, etc). Clean water passage, if clogged or defective. Repair or replace, if cracked. 2. Cooling water contaminated. Cooling water contains oil or blackened. Check cooling water supply pump. Check oil cooler. Check cylinder heads, if cracked. Check feed module, if cracked.

1. Exhaust gas temperature is too high. Intake air temperature is high. Check if ambient air temperature is high. Reduce load, if engine overheated. Check air temperature after charge air cooler. Check LT control valve condition. Clean or repair, if fouled. LDFV84000 Different temperatures of exhaust gas cylinder outlet. Check fuel pump rack index. Adjust for even distribution. LDFV41000 Check maximum firing pressure. Adjust injection timing. Check fuel valve by injection tester. Clean or replace, if clogged or

LDFV84000

LDFV52000

worn.

LDFV52000

 Adjust valve opening pressure. Check fuel injection pump. LDFV51000 Replace, if worn or stuck. Check intake and exhaust valves. Replace, if worn or stuck. Check fuel oil pressure at engine inlet. G01400 Check DVT (Dual Valve Timing). (Gas mode) Check Gas admission valve. (Gas mode) Check Micro pilot F.O

injector .

G24100

Temperatures of exhaust gas after turbine is high. Check turbocharger. Clean, if fouled. M80000

2. Exhaust gas color is unusual. White or blue smoke. Check if the engine is running at cold condition. Check if the engine is running at low load for long time. Check misfiring of some cylinders. Check max. firing pressure if too low. Check piston rings if broken or

damaged. LDFV31100 LDFV31100

Black or Brown smoke.

 Check fuel quality. G05100 G05100 Check exhaust gas temperature.

Check fuel valves by injection tester.

LDFV52000 LDFV52000

 Check intake and exhaust valves if clogged. Check turbocharger if fouled. 3. Fuel consumption is excessive. Check fuel quality. Check lubricating oil if viscosity is too high. Check color of exhaust gas. Check cylinder pressure if too low. Check fuel valves by injection tester.

  LDFV52000 LDFV52000

(Gas mode) Check flow meter condition.

Troubleshooting Abnormal Noise

H35DFV Section No.

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O04800

1. Unstable intermittent running noise.

 Check governor system. LDFV41000 LDFV41000

Check if fuel control linkages move smoothly.

 Check fuel feed pump and filter if clogged. Check if fuel injection pump and roller tappet hitching. Check if fuel leaks excessively. Check if exhaust gas temperature is too low than others. 2. Continuous unusual running noise Check if engine overloaded. Check engine driven pumps and gears. Check engine moving parts. Check if exhaust gas temperature is too low than others. 3. Turbocharger

surging noise. Check if engine stopped suddenly under load. Check if engine loaded abruptly. Check ambient air condition if abnormal. Check turbochager if fouled. Check charge air cooler if fouled. Check fuel injection nozzle if fouled. Check intake and ex haust valves if sealing failed.

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1. General The engine can be operated on Residual fuel oil (HFO/MDO) of viscosity up to 700cSt at 50℃, which corresponds to the grades of ISO8217(2010). It can be also operated on blended fuels of lower viscosity as well as distillate fuel oil (MDO/MGO). The quality requirements for MDO/MGO shall be in accordance with ISO-F-DMA, DMZ and DMB grade in ISO8217(2010). The fuel should be cleaned and preheated before entering the engine as follows. 2. Fuel Treatment 1) Purification Residual fuel oil should be purified by centrifuging because the fuel oils are always contaminated with solid particles, salt and water etc. Solid contaminants in the fuel oils can cause excessive wear to the piston rings and cylinder liners or seizure of fuel injection pump and fuel valve. Liquid contaminants in the fuel oils can cause fouling of exhaust systems and turbochargers as well as corrosion and cavitations of fuel injection pumps and fuel valves. Therefore qualified separation equipment should be included in the external fuel oil system not only for HFO but also for MDO/MGO which is easily contaminated on board. Fuel oil separation should be carried out accordance with separator maker's manual.

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2) Heating The viscosity of residual fuel oil(HFO) between RMB30 and RMK700 to the engine should be kept within the value of 12 ~ 18 cSt. (Viscosity range at engine inlet for distillate fuel oil and RMA10 fuel oil(MDO/MGO) :2~ 14 cSt) However, the viscosity varies depending on the properties and the temperature of the fuel oil. Maximum preheating temperature of HFO is limited up to 155℃ to avoid vapouring in fuel system. Therefore, the fuel should be heated according to the suppliers' recommendation. A typical fuel oil viscosity diagram regarding temperature is as follows.

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3) Viscosity Control In order to ensure correct injection viscosity of 12 ~ 18 cSt, the heater are to be controlled by an automatic viscosity controller before the fuel enters into the engine fuel system. Higher or lower viscosity

may cause serious damages on fuel injection system. 3. Standard Fuel Oil Characteristics The engine is designed to operate continuously on the fuels with the following specifications without reduction of the rated output,

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DMADMZDMBCharacteristicsUnitLimitCategory ISO-F-

CharacteristicsUnitLimitCategory ISO-F-

Kinematic viscosity at 40°Camm2/s

max.6,0006,00011,00min.2,0003,0002,000

Density at 15 °CCetane indexSulfurbFlash pointHydrogen sulfideAcid numberTotal sediment by hot filtrationOxidation stabilityCarbon residue: micro method on the 10% volumedistillation residueCarbon residue: micro methodCloud point

kg/m3max.890,0890,0900,0 -min.404035 mass %max.1,501,502,00 °Cmin.60,060,060,0 mg/kgmax.2,002,002,00 mg KOH/gmax.0,50,50,5 mass %max.--0,10d g/m3max.252525e mass %max.0,300,30- mass %max.--0,30 °Cmax.---

Pour point (upper)c

winter quality°Cmax.-6-6 summer quality°Cmax.00

--AppearanceClear and brighth

d,e,f

WaterAshLubricity, corrected wear scar diameter(wsd 1,4) at 60°Cha   1 mm2/s=1 cSt.

volume %max.--0,30d mass %max.0,0100,0100,010 µmmax.520520520g

b   Notw ithstanding the limits given, the purchaser shall define the maximum sulfur content in accordance w ith relevant   statutory limitations. See Annex C of ISO8217(2012). c   Purchasers should ensure that this pour point is suitable for the equipment on board, especially if the ship operates in   cold climates. d   If the sample is not clear and bright, the total sediment by hot filtration and w ater tests shall be required. (See 7.4   and 7.6 of ISO8217(2012). e   If the sample is not clear and bright, the test cannot be undertaken and hence the oxidation stability limit shall not apply. f   If the sample is not clear and bright, the test cannot be undertaken and hence the lubricity limit shall not apply. g   This requirement is applicable to fuels w ith a sulfur content below 500 mg/kg (0,050 mass %). h   If the sample is dyed and not transparent, then the

w ater limit and test method as given in 7.6 of ISO8217(2012) shall apply.

Note 1: The following kinds of fuel are not to be used: 1) Bunker fuel including cat-fines 2) Bunker fuel including land-used lubricating oil waste 3) Bunker fuel including acidic compounds (Acid Number ≥ 3 mg KOH/g)

CharacteristicsUnitLimit

RMA RMB RMDRME

Category ISO-F-RMGRMK

Kinematic viscosity at 50℃

10a30801801803805007003805007 00mm2/smax.10,00 30,00 80,00 180,0 180,0 380,0 500,0 700,0 380,0 500,0 700,0

kg/m3max.920,0 960,0 975,0 991,0Density at 15 ℃991,01010,0

kg/m3max.920,0 960,0 975,0 991,0Density at 15 ℃991,01010,0

—max.850860860860CCAI870870

mass %max.SulfurCStatutory requirements

℃min.60,060,060,060,0Flash point60,060,0

mg/kgmax.2,002,002,002,00Hydrogen sulfide2,002,00

mg KOH/gmax.2,52,52,52,5Acid numberd2,52,5

mass %max.0,100,100,100,10Total sediment aged0,100,10

mass %max.2,5010,00 14,00 15,00Carbon residue: micro method18,0020,00

Pour point(upper)e

winter quality℃max.003030summer quality℃max.663030

30303030

volume %max.0,300,500,500,50Water0,500,50

mass %max.0,040 0,070 0,070 0,070Ash0,1000,150

mg/kgmax.50150150150Vanadium350450

mg/kgmax.5010010050Sodium100100

mg/kgmax.25404050Aluminium plus silicon6060

mg/kg—Used lubricating oils (ULO)The fuel shall be free from ULO. A fuel shall be considered to contain ULOwhen either one of the following conditions is met: calcium and zinc; or calcium > 30 and zinc > 15; or calcium and phosphorus calcium > 30 and phosphorus > 15a This category is based on a previously defined distillate DMC category that w as described in ISO 8217:2005, Table 1. ISO 8217:2005 has been w ithdraw n.b 1 mm2/s=1 cSt.c The purchaser shall define the maximum sulfur content in accordance w ith relevant statutory limitations. See 0.3 and Annex C of ISO8217(2012).d See Annex H of ISO8217(2012).e Purchasers shall ensure that this pour point is suitable for the equipment on board, especially if the ship operates in cold climates.

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1. General Basically the engine is operated with natural gas, but the gas has to fulfill the following requirements for continuous operation without the reduction in the rated output.

Property Unit Value Lower calorific value (LCV), min MJ/Nm3 28 Methane Number (MN), min - 80 Particle (or solids) size, max μm 5 Particles (or solids) content, max mg/Nm3 50 Hydrogen sulphide content (H2S), max mg/Nm3 30 Gas inlet temperature ℃ 0~50

1) Lower calorific value (LCV) The lower calorific value is defined as the amount of heat released by the combustion of the fuel per unit volume at standard state(0℃, 1atm). It is the effective calorie without the latent heat of vapor produced. If the LCV is lower than the above value, the engine output can be reduced. 2) Methane number (MN) The methane number is the index which indicates the resistance of abnormal explosion, anti-knock rating of a fuel gas. Hydrogen(H2), which is highly liable to knocking, has the MN ‘0’, while pure methane has the MN ‘100’. If the components and contents-ratio of a fuel gas are known, the MN could be calculated.

Note : Not allowed the condensate water or liquids at engine inlet.

In case the MN of the fuel gas does not match with the above requirement, the engine output could be reduced because of the abnormal ignition and incomplete combustion. 3) Particles (or solids) Particles, of which the size is beyond 5μm, could cause the malfunction of the main gas admission valve(SOGAV). In case particles feed to the engine with the amount; 50mg/Nm3 and over, it could cause the vital damage to the engine. The filter of the gas regulating unit retain it is overhauled regularly 4) Hydrogen Sulfide (H2S) The high sulfur content in the fuel may increase the risk of low temperature corrosion in the combustion chamber and contribute to the formation of high temperature deposit.

G05200

1. Fuel Characteristics 1) Viscosity The viscosity of fuel oil to the engine should be kept within the value of 12 ~18 cSt (Heavy fuel oil) and 2~14 cSt (Diesel fuel oil) which could be achieved by proper heating recommended by fuel supplier as the viscosity varies depending on t he properties of the fuel oil. 2) Density If the density of the fuel oil is above the maximum density (991 kg/m3 at 15℃), the fuel cannot be used because of water and solid contaminants which are not removed by a centrifuging. The special centrifuging sys-tem should be installed to use the fuel oil with the maximum density (1010 kg/m3 at 15℃). 3) Sulfur It is important to keep proper sulfur contents in the fuel oil. The high sulfur content in the fuel may increase the risk of low temperature corrosion in the combustion chamber and c ontribute to the formation of high temperature deposit. It is also recommended to keep the proper alkalinity of the lubricating oil for neutralizing. 4) Ash The ash content comes from natural crude oil and al so from contamination during treatment of the fuel. The solid ingredients can be removed mostly by centrifuging of the fuel. However there are soluble compounds such as vanadium and sodium, which can be transformed as ash after combustion.

G05200

As the ash in any form promotes mechanical wear of engine parts and harmful deposits in the combustion chamber, the ash components should be carefully analyzed and removed in advance. 5) Vanadium and Sodium Vanadium is oil – soluble and comes from crude oil mostly. However sodium is water-soluble and comes from crude oil as well as contaminated fuel by salt water. As vanadium and sodium become corrosive ash after combustion, these should be removed as possible. Sodium compounds contribute to lower the melting point of vanadium ash, which is very corrosive and harmful to exhaust valves and turbocharger. Therefore, compounds should be less than 1/3 of vanadium contents in weight. 6) Conradson Carbon Including much conradson carbon may impair combustion properties of the fuel and cause deposit formation in combustion chamber and ex haust system particularly at low engine output. 7) Asphaltenes High asphaltenes content may contribute to deposit formation in combustion chamber as well as exhaust system at low loads and stick the fuel injection pump. It also causes excessive centrifuge sludge and deposits in the fuel system.

All type Section No.

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G05200

8) Water The water content can be measured by a standardized distillation test. The water causes corrosion and cavitations of the fuel injection pump and fouling of the exhaust system and turbochargers. The water content should be reduced to maximum 0.2% by centrifuging 9) Abrasive Particles Fuel oil can be contaminated by abrasive particles composed of aluminium and silicon. If the efficient fuel treatment is not applied, these fine catalysts can cause abnormal wear on injection system and c ylinder liners / piston rings. The aluminium plus silicon should be reduced to maximum 15 mg/kg before engine inlet. 2. Ignition Quality The ignition quality is related to the ignition delay that is the intervals between fuel injection and combustion. If the engine is operated at low load or in the condition of low temperature or pressure in the combustion chamber, the ignition delay is lengthened. During first operating, the engine can be damaged by the low ignition quality without sufficient preheating. The equation of CCAI (Calculated Carbon Aromaticity Index) developed by Shell can be used to get the ignition quality of the heavy fuel oil.

G05200

Calculated Carbon Aromaticity Index

If the value of CCAI is increased, the ignition quality has decreased value. The fuel oil with high CCAI value may be happened a combustion problem. The CCAI guidelines are specified in G05100 (Fuel oil specification).

CCAI = D – 81 – 141 log [log (Vk + 0.85)] D = density (kg/m3 at 15℃)
vk = viscosity (cSt at 50)

G05300

It is very important to follow the temperature/load requirement of the change-over procedure in order to prevent fuel injection pump and fuel injection valve sticking/scuffing, poor combustion and so on. 1. Change-over from DO to HFO Maintain the HFO level with 50~90% and HFO temperature with 60~90 ℃ in HFO service tank. Maintain the engine load with 30~70 %. Open the steam tracing and auto filter steam inlet valve in F.O system. Open the steam in/out valve in F.O heater. Rise F.O temperature gradually until 60 ℃ at a rate of about 2 ℃ per minute through opening steam control valve in viscosity controller. Maintain the F.O viscosity over 4 cSt because F.O viscosity is the first priority than temperature. And maintain the cylinder outlet cooling water temperature with 75~85 ℃. When the DO temperature at engine inlet reaches 50~60 ℃, change-over from DO to HFO using HFO/MDO change-over valve. When the HFO temperature at engine inlet reaches 70 ℃, viscosity controller is set with auto-mode. When the change between viscosity and temperature to be observed, viscosity is set 12~18 cSt on viscosity controller.

G05300

2. Change-over from HFO to DO Reduce the engine load below 50 %. Close the steam in/out valve slowly in F.O heater until 25 cSt viscosity in viscosity controller to protect the F.O injection equipment against rapid temperature changes. Close the steam tracing and auto filter steam inlet valve in F.O system. Change-over from HFO to DO using HFO/DO change-over valve. Confirm that DO viscosity is 4~5 cSt when the DO temperature is about 60 ℃. In case of MGO, confirm that MGO viscosity is about 2~3 cSt when the MGO temperature is about 40 ℃. Although DO viscosity range at engine F.O inlet is limited 2 ~ 14 cSt in Section No. G05100, DO viscosity should not drop 3 cSt for safety as this might cause fuel injection pump and fuel injection valve sticking/scuffing.

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1. Quality of Lubricating Oil Lubricating oil has significant roles for the engine system, which can be summarized as below; Lubrication of the sliding parts to reduce friction and wear. Cooling of the engine parts (piston, bearing, etc). Sealing of piston ring. Dispersion of detergent. Neutralization of combustion by products. Therefore, engine system oil should be selected to fulfill these functions depending on the fuel used and the operating condition. The recommendable brand names of the lubricants are listed separately and the basic requirements of new oil are as follows:

Oil grade API service grade CD (MIL-L/2104C and D) for heavy duty marine diesel engine. Viscosity SAE 40(120-180 cSt @ 40 ℃) Flash Point Over 220 ℃ Pour Point -15 ℃

BN (Base Number, Alkalinity) should be selected carefully because it is important that proper balance is maintained between the BN coming from the lube oil and the fuel sulfur level by choosing proper lube oil in order to avoid following problems. - High sulfur fuel + Low BN lube oil → Excessive corrosive wear - Low sulfur fuel + High BN lube oil → Excessive top land deposit formation → Lacquering formation on cylinder liner surface Do not mix the lubricating oil with different brands, which may cause serious problem on the engine.

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Generally, the sulfur level of natural gas is lower than its liquid fuel. Therefore, BN should be selected on the basis of what kind of fuel will be dominantly used. If the natural gas is used as a main fuel consistently, the lubricating oil with BN 3 ~ 7 is recommended. In continuous MGO or MDO operation and periodic changeover to gas operating mode, the lubricating oil with BN 10 ~ 15 can be acceptable. However, If HFO is used as a main fuel, the lubricating oil should be selected in right balance between the amount of HFO sulfur contents and BN.

 Typical recommended BN depending on the fuel sulfur contents and SLOC (g/kWh)

[Reference: CIMAC recommendation number 29/2008 ‘Guide lines for the lubrication of medium speed diesel engine’]

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2. Checking of Lubricating Oil Condition The quality of the lubricating oil will be changed slowly due to ageing and contamination via various sources. The typical contaminators are soot and particles from combustion chamber, penetrated or condensed water and salt, wear particles, and oxidation of oil itself, etc. Therefore, regular checking of lubricating oil condition by supplier or specialist, at least every three months interval, is strongly recommended. In this case, the checking should include at least the analysis of Viscosity, Flash point, BN, insoluble, and water content and the nature. During the intervals between laboratory checking, a simple test method proposed by oil supplier will be also informative on the quality of oil. Correct sampling of oil for checking is critical for correct evaluation of the analysis. The sample oil should be taken after the filter during engine running. The container for sample oil should be cleaned thoroughly before sampling. All checking results should be recorded and kept for trend evaluation, which contribute to reliable engine operation.

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3. Condition of Lubricating Oil The condition of lubricating oil inside the engine is recommended to be within the following range;

Ingredients Tolerable range Test method BN: max. 50 % of initial value. ISO 3771 Viscosity min. –20 % and max. 30 % of new oil. ISO 3104 Flash Point min. 180 ℃ ISO 2719 Water content below 0.3 %(volume) ISO 3733 n-Pentan insoluble max. 2.5 %(mass) ASTM D-893/B

The condition of the lubricating oil should be evaluated not by a single parameter but as a whole. Replacement or filling of the lubricating oil is recommended to consult the oil supplier based on the analysis results. As a sudden change of parameters may indicate abnormal operating condition or malfunction of the system, investigating the cause and remedying the fault should precede replacing the lubricating oil. NOTICE Lubricating oil should be replaced when BN value is below 50% of initial value and it is important to refill with (top-up) dissipated amounts of lubricating oil periodically. If any parameter reaches tolerable limit, some measures instead of entire replacement of the oil may be effective for recovering the oil to normal condition. In some cases, this can be achieved by proper treatment or by intensive purification or by partial filling (top-up) of the oil. If flash point is below 150 ℃, there may be a risk of crank case explosion.

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4. Purifying of Lubricating Oil In addition to engine filter, it is recommended to install a purifying device for the lubricating oil. A built on centrifugal filter is recommended for the engine running on marine diesel oil. A centrifugal type purifier is required for the engine running on heavy fuel oil. Continuous centrifuging with heated lubricating oil for lower viscosity is recommended for more effective purifying. It is recommended to follow the purifier maker’s recommendation for the flow rate and preheating temperature (normally 85-95 ℃). It is recommended to separate the oil on the engine while operating. In this way, the dirt can be removed immediately when it is supplied to the engine. At the same time energy is saved because it is necessary to warm up the oil only by a little. If only one separator is installed on several engines, it is only connected with one engine at a time. This is to ensure that there is no suction and discharging from one engine to another. It is recommended to split up the time so that there is separation on all engines, which are operating in turns. NOTICE In any case, cleaning the lubricating oil by water is not allowed to avoid contamination and decreasing of BN value. 5. Lubricating Oil for Other Machinery The engine system oil covers moving parts of the engine and turbocharger. However, hydraulic governor requires own specification and refer to the manual for the governor.

Oil brand

Engine system lubricating oil

Governor oil1) Same as Engine system L.O2) Refer to the governor manual for detailed L.O specification, volume of governor.3) Initial filling: Oil filled4) Electrical (Digital) Governor: Not applied

Oil companyBrand nameSAEBN*)

40404040404040 Mysella LA 405.2 Shell Gadinia S3 4012 Shell Argina S2 4020 Shell Argina S3 4030 Shell Argina S4 4040 Shell Argina S5 4050 Aurelia LNG5 Nateria X 4055.2 DISOLA M 401212 DISOLA M 401514 DISOLA M 402020 AURELIA XL 403030 AURELIA XL 4040 40 AURELIA XL 4055 55 AURELIA TI 403030 AURELIA TI 4040 40 AURELIA TI 4055 55 Geotex LA5.2 DELO SHP 4012 DELO 1000 Marine 40 12 TARO 20 DP 40(X)20 TARO 30 DP 40(X)30 TARO 40 XL 40(X)40 TARO 50 XL 40(X)50 Pegasus 7055.3 Pegasus 8056.2 Pegasus 9056.2 Pegasus 16.5 Mobilgard ADL 40, Mobil Delvac 164012 Mobilgard 41215 Mobilgard M43030 Mobilgard M44040 BP ENERGAS NGL4.5 BP ENERGOL DL-MP 409 BP ENERGOL DS3-15415 CASTROL Duratex L4.5 CASTROL MLC 4012 CASTROL MHP 15415 BP IC-HFX 20420 BP IC-HFX 30430 BP IC-HFX 40440 BP IC-HFX 50450 CASTROL TLX PLUS 20420 CASTROL TLX PLUS 30430 CASTROL TLX PLUS 40440 SUPERMAR 13TP 4013 SUPERMAR 24TP 4024 SUPERMAR 30TP 4030 SUPERMAR 40TP 4040 Navigo TPEO 12/4012 Navigo TPEO 15/4015 Navigo TPEO 20/4020 Navigo TPEO 30/4030 Navigo TPEO 40/4040 Navigo TPEO 50/40 50 Navigo TPEO 55/4055

Shell

40

TOTAL(Lubmarine)40 DISOLA M 4020 AURELIA XL 4030AURELIA XL 4040

Chevron(Taxaco, Caltex)40 DELO 1000 Marine 40 TARO 20 DP 40(X)TARO 30 DP 40(X)

ExxonMobilBP

40

40

SUPERMAR 24TP 40SUPERMAR 30TP 40SK Lubricants40

LUKOIL

40

This list is given as guidance only. *) Refer to Sheet No. G06100 when BN value selected *) Lubricating oil quantity (Initial filling: Oil empty, Without oil overflow system) : Please see the drawing for "L.O in baseframe" in Approval/Working/Final drawing

Oil brand

Engine system lubricating oil

Governor oil1) Same as Engine system L.O2) Refer to the governor manual for detailed L.O specification, volume of governor.3) Initial filling: Oil filled4) Electrical (Digital) Governor: Not applied

Oil companyBrand nameSAEBN*)

40Gulf Oil MarineENI S.p.A.40Petronas4040AEGEAN40SINOPEC TPEOHyundai Oilbank40 GulfSea Power MDO 4012, SeaLub Power MDO 401212 GulfSea Power MDO 4015, SeaLub Power MDO 401515 GulfSea Power MDO 4020, SeaLub Power MDO 402020 GulfSea Power 4030, SeaLub Power 403030 GulfSea Power 4040, SeaLub Power 404040 GulfSea Power 4055, SeaLub Power 405555 AGIP CLADIUM 12012 AGIP CLADIUM 30030 AGIP CLADIUM 40040 AGIP CLADIUM 500S50 PETRONAS Disrol 506 PETRONAS Disrol 12012 PETRONAS Disrol 30032 PETRONAS Disrol 40042 PETRONAS Disrol 50051 ALFAMAR 43030 ALFAMAR 44040 ALFAMAR 45050 ALFAMAR 45555 SINOPEC TPEO 401212 SINOPEC TPEO 401515 SINOPEC TPEO 402020 SINOPEC TPEO 403030 SINOPEC TPEO 404040 SINOPEC TPEO 405050 Hyundai XTeer HGSL 404.5 Hyundai XTeer TPEO 401212 Hyundai XTeer TPEO 401515 Hyundai XTeer TPEO 402020 Hyundai XTeer TPEO 403030 Hyundai XTeer TPEO 404040 Hyundai XTeer TPEO 405050Petro-Canada Sentinel 445404.7

Gulf Oil Marine

40

AGIP CLADIUM 300AGIP CLADIUM 400ENI S.p.A.40

PETRONAS Disrol 300Petronas40

AEGEAN

40

SINOPEC TPEO

40

Hyundai XTeer TPEO 4020Hyundai Oilbank40

Oil volume UG-25+: 2.1 Liter Europa : 1.5 Liter See the separate data for sump volume as per each engine type.

Rev. 1M

Quality of Cooling Water The cooling of the engine should be only distilled (demineralized) or fresh water, which should be checked and treated to satisfy following requirements below table before adding corrosion inhibitor. It is necessary for keeping effective cooling and preventing corrosion of the system. Though the distilled water matches best to the requirements for cooling water, it is necessary to add corrosion inhibitor before applying cooling water to engine cooling water system because untreated cooling water absorbs carbon dioxide from the air and then becomes corrosive.

pH 7 to 9 Total hardness as $CaCO_3$ max. 75 ppm(mg/l) Chlorides Cl^- max. 80 ppm(mg/l) Sulphates as SO_4^{2-} max. 100 ppm(mg/l) Silica as SiO_2 max. 60 ppm(mg/l) Residue after evaporation max. 400 ppm(mg/l)

Chloride and Sulphate are corrosive even in the presence of an inhibitor. Sea water or fresh water contaminated by sea water even in small amount is not allowed to be used as cooling water of the engine due to high risk of severe corrosion and deposits formation in the system. Rainwater is heavily contaminated and highly corrosive in general, which is also not recommended as cooling water. Tap water (drinking water) is not recommended as cooling water due to risk of chalk deposit formation inside the cooling system. However, if the distilled water, for example from fresh water generator, is not available, tap water may be used as cooling water after softening and some other treatments according to the ingredients.

Rev. 1M

Treatment of Cooling Water Cooling water should be treated properly and corrosion inhibitor should be added. The analysis and treatment of cooling water are recommended to be carried out by a famous and familiar specialist. Otherwise, keep the treatment procedures strictly according to the instructions from the supplier. Some recommended products are listed as follows:

Manufacturer Brand Name Constituent Delivery Form Min. Dosage HANYU CLEAN TECH Marine Chemical CWT-CIL Nitrite Liquid 6 liter / 1,000 liter Chevron (FAMM) Havoline XLi Carboxylates Liquid 50 liter / 1,000 liter

DEWT-NC

Powder 3.2 kg / 1,000 liter

Drew Ameroid Marine Boonton

Nitrite LIQUIDEWT Liquid 8 liter / 1,000 liter MAXIGARD Liquid 16 liter / 1,000 liter

Nitrite LIQUIDEWT Liquid 8 liter / 1,000 liter

VECOM CWT DIESEL QC2 Nitrite Liquid 12 liter / 1,000 liter DIESELGUARD NBNitrite, Borate Powder 2 kg / 1,000 liter

Rocor NB Nitrite, Borate Liquid 9 liter / 1,000 liter Cooltreat AL Carboxylates Liquid 50 liter / 1,000 liter 9-108 Nitrite, Borate Liquid 2.25 liter / 1,000 liter9-111 Nitrite, Silicate Liquid 8 liter / 1,000 liter Nalfleet2000 Nitrite, Borate Liquid 32 liter / 1000 liter NALCOOL2000 Nitrite, Borate Liquid 32 liter / 1,000 liter TRAC102 Nitrite, Borate Liquid 32 liter / 1,000 liter TRAC100 Molybdate, Silicate Liquid 3.5 liter / 1,000 liter TRAC109 Nitrite, Borate Liquid 4.0 liter / 1,000 liter

Wilhelmsen Chemicals (Unitor Chemicals & Nalfleet Marine Chemical) NALCO

GE Water & Process Technologies CorrShield NT4200 Nitrite Liquid 10 liter / 1,000 liter

Oily inhibitors adhere to cooling surface and influence cooling efficiency, which are not recommended for cooling water. Only nitrite-borate based inhibitors are recommended. Do not mix the inhibitors of different types or properties. Some inhibitors may be toxic and hazardous. Strict control is required when handling inhibitors.

Rev. 1M

Use of Antifreeze If the cooling water of the engine is exposed to the environment below a certain point of temperature, antifreeze should be added. Before adding antifreeze, the engine line must be cleaned. In accordance with cooling water usage, the corrosion inhibitor should be used with antifreeze and the reaction between two must be checked before use by each maker. The main ingredient of antifreeze is Ethylene Glycol which has different freezing points according to its content rates as follows:

Antifreeze (Volume %)20 25 30 35 40 45 50 55 Water (Volume %) 80 75 70 65 60 55 50

45 Freezing Points (℃) -10.5 -13.5 -16.5 -20.5 -26.5 -31.5 -37.5 -43.5

In case of using antifreeze, it makes it difficult for engine to cool down due to change in cooling water’s properties (specific heat decrease, pressure loss increase due to viscosity increase, heat exchanger efficiency decrease due to low heat conduction coefficient). Also, engine’s thermal load will increase because increased boiling point will restrain the cooling effect of nucleate boiling. For such a reason, antifreeze is not recommended to use unless it is absolutely necessary. When using antifreeze inevitably, it is not recommended to use antifreeze more than 55% of the total mixture since it does not affect further decrease of freezing point. Thus, it is recommended to use up to 50% maximum. Starting from 20% antifreeze, engine power is to be de-rated 0.22% per 1% antifreeze in the cooling water. (Ex. When using 40% antifreeze, maximum engine power is 95.6 %.) Corrosion inhibitor must be used regardless of antifreeze in the cooling water.

If there are impurities in antifreeze, it cannot decrease the freezing points accurately, so antifreeze must be managed by Cleanness Level (NAS1638 / IOS4406) with the specification level below NAS8 (ISO19/17/14). Some recommended products are listed as follows:

Manufacturer Brand Name Delivery Form OPS (Offshore Petrochemicals & Service) Tectyl EG(NAS8) Liquid

Checking Cooling Water and the System The property of the cooling water may be changed during service due to contamination or evaporation. Therefore, the cooling water itself and the system should be checked periodically during service, preferably once a week. These tests may be done by means of test kits from inhibitor maker with sample water from the circulating system. However, laboratory test of the sample water by specialist is also recommended regularly at least every three months. All checking results should be recorded and kept for trend evaluation, which contribute to reliable engine operation with right cooling water treatment. If test result shows that the contents of cooling water changes suddenly or gradually, the cooling water system should be checked to trace the cause. Some of the changes may indicate the cause as follows: Chloride content increasing: □ Check possibility of seawater penetrating into cooling water. □ Check the system which includes sea water, for example fresh water cooler cooled by sea water.

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pH value decreasing or sulphate content increasing: Check if cooling water is contaminated by exhaust gas. Check cylinder head by hydraulic pressure test. If the quality of the cooling water after checking exceeds control limit by water treatment, the cooling water should be replaced completely by newly treated water. Cleaning of Cooling Water System If any deposit or rust is abnormally detected in the cooling water system, the system should be cleaned thoroughly and then the cooling water also should be refilled up completely by newly treated water. The cleaning of the cooling system includes degreasing and descaling procedures which need special <HANYU CLEAN TECH RR-R/RR-RO>or equivalent chemicals. As the chemicals may be hazardous, the cleaning of the cooling water system is recommended to be carried out by reliable specialist firm. Otherwise it should be done strictly in accordance with instructions from the supplier of cleaning chemicals. Descaling process by acid is hazardous, which needs protective equipment for human body, for example, everybody near the system should put on protective glasses and gloves at least. Careful attention is required to avoid contamination of lubricating oil by acid during descaling process. Check the acid content of lubricating oil of the engine directly after descaling work of the cooling system by acid and check again next day.

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Filling-Up of Cooling Water Directly after cleaning process of the cooling system, flush the system thoroughly with water until pH value to be about 7, and then drain the water. Fill up the system with distilled water until the water level of the expansion tank to have margin for treatment. Prepare the solution of inhibitor according to the instruction from the maker and add the solution into the expansion tank. Add distilled water more to the normal level of the expansion tank. Run the engine for settlement according to the inhibitor maker’s recommendation or at least for 24 hours and then check the quality of the water for confirmation. If the amount of cooling water is reduced due to evaporation or leakage or drainage for maintenance, the water level of the tank should be maintained by adding water. Water for compensating evaporation should be distilled water, while the water for loss due to leakage or drainage should be same treated water. After adding the water, checking of the quality of the water should be carried out to confirm the correct concentration of the ingredients. Replace cooling water completely with newly treated water with interval of at least every two years. Waste cooling water should be treated in compliance with governing laws.

All type Section No. G08100 0.00

Air and Exhaust Gas System Water Condensation in   Charge Air Cooler

Air and Exhaust Gas System Water Condensation in   Charge Air Cooler

 1020304050607080Charge Air Temperature (C)

0.100.090.080.070.060.050.040.03

3-0.10-0.09-0.08-0.07-0.06-0.05-0.04-0.03-0.02-0.010.000.010.020.030.040.050.060.07
0.080.090.1035

0.010.016100%

0.010 016

0.020.021

0.021

0.020.030.040.050.060.070.08

0.010.00

0.09

0.100

0.1001015202530354045505560Ambient Air Temperature (C)

Condensation of water in the charge air is related with not only humidity and temperature of the ambient air but also pressure, temperature of the charge air. To calculate the amount of condensation in charge air cooler, above diagram can be used. Example If the ambient air temperature is 30 ℃ and relative air humidity is 80 %, the water content in the air can be read 0.021 (kg water/kg dry air) in the diagram. If the charge air pressure is 2.8 bar and charge air temperature is 45 ℃, maximum water content of charge air is 0.016 (kg water/kg charge air). Using these values, draw the line from point of the water content in the air to point of the water content in the charge air. Then, read the value in the intersection between the line and the middle Y-axis. In this case, the amount of condensation in charge air cooler is 0.005 (kg water/kg charge air).

0.005

90%80%70%60%

50%

Overhaul Interval (hours)

SectionNo.DescriptionMajor Fasteners - ConfirmationM11100LDFV11100Bolt for Base Frame and Resilient MountG11100-Nut for Resilient Mount and Foundation-LDFV13000Hyd. Nut for Engine Block and Base FrameM13250LDFV13000Hyd. Nut for Main Bearing CapM21100LDFV13000Hyd. Nut for Cylinder HeadM25000LDFV25000Bolt and Nut for CamshaftM31000LDFV32000Hyd. Nut for Con-Rod (Shaft)M31000LDFV32000Hyd. Nut for Con-Rod (Big-end)M33200LDFV33000Hyd. Nut for Counter WeightM35300LDFV35000Bolt and Nut for Timing Gear-LDFV83000Bolt and Nut for Turbocharger MountingMajor BearingM13250LDFV13250Main BearingM13250LDFV13250Thrust Washer : Axial ClearanceM25000/M25300LDFV25300Camshaft Bearing : Clearance M31000/M32120LDFV32000Con-Rod Bearing (Big-end)M32130LDFV32000Con-Rod Bearing (Small-end)M35300LDFV35000Bearing Bush for Idle Gear : ClearanceResilient MountM11100LDFV11100Resilient MountCylinder Unit and Con. RodM15100LDFV15000Cylinder LinerM15100LDFV15000Flame RingM21100LDFV15000LDFV21100Cylinder Head &Water Jacket Cooling Water SpaceM21120/M21130/M21200LDFV21100LDFV21200Intake/Exhaust v/v Spindle, Seat Ring and v/vGuide: Overhaul and ReconditioningM21210LDFV21200Intake/Exhaust v/v : ClearanceM21210LDFV21200Rocker Arm Shaft and BushM21220LDFV21200RotocapM21400LDFV21400Starting ValveM24100LDFV24100Duel Valve TimingM31100LDFV31100Piston RingsM31100LDFV31100Piston and Piston PinM31000/M31101LDFV32000Con-Rod Bore (Big-end)M31100/M32130LDFV31100LDFV32000Piston Pin & Con-Rod (Small-end) : ClearanceM31000LDFV32000Shim Plate for Con-RodM31000LDFV32000Stud for Con-Rod ShaftCrankshaft and GearsM33100LDFV33000Crankshaft : Deflection-LDFV33300LDFV42300Gear Teeth on Flyw heel & Turning Gear

Remark

-LDFV33400Torsional Vibration Damper : Fluid sampling(Only for Viscous Damper)◎(See Manual for T/V Damper)-LDFV33500Flexible Coupling▲(See Manual for Flex.Coupling)M35300LDFV35000Timing Gear and Pump Driving Gear: Clearance and Backlash◎▣ Expected life time✓ 1 Cylinder overhaul. If not good, check all cylinders.■ Overhaul inspection◆ Confirm tightening: Tighten w ith specified torque or hyd.pressure. Do not loosen!● Check & adjustment◎ Measuring or sampling w ithout dismantling○ Function test▲ Visual Inspection*) These are not parts of normal maintenance interval, but, the confirmation or visual inspection of the specified ones to be carried out after Overhaul/New.When doing maintenance and

overhaul work, seals (o-rings & gaskets, etc.) should be renewed.The overhaul intervals and expected life time stated above are only for guidance as these depend on the actual service condition, the quality of used fuel or lubricatingoil, the treatment of cooling water and so on.

Overhaul Interval (hours)

SectionNo.DescriptionValve Operating MechanismM23000LDFV23000Sw ing Arm Roller Shaft and BushM25000LDFV23000LDFV25000Contact Faces of Cam and Sw ing Arm RollerCamshaft BearingControl System

Remark

-LDFV41000Fuel Control Linkage : Movement Check○WeeklyG40001-Safety Device : Function Check○Monthly-LDFV41000Governor Oil Level(Only for Mechanical Hydraulic Governor)▲Daily(See Manual for Governor)-LDFV45000Engine RPM Pick-up Sensor : Clearance●LDFV45000Cylinder Pressure Sensor (if applied)▣-LDFV45000Knock Sensor : Tightening Torque Check◆M45200LDFV45000Temperature / Pressure Sensor○In case of necessityFuel SystemG05100/G05200-Analyze Fuel Oil Properties : Sampling◎Every BunkeringFuel Injection Pump - Deflector : Erossion◎▣

- Plunger Assembly - Delivery Valve Assembly (except case) - Delivery Valve Case - Roller Bush for Tappet

M51100LDFV51000

M52000/M52001M52002/M52003LDFV52000Fuel Injection Valve : Opening Pressure●●▣Atomizer life time

LDFV52002Micro Pilot Injector CompleteLDFV52002High Pressure Pump

Every 6,000hrs : Nozzle replacementIf necessary, reconditioningEvery 18,000hrs : Replacement

-LDFV52003Micro Pilot Oil Filter■If pressure drop reaches limit(See G01400)-LDFV53000O-rings for Feed Block▣M53010LDFV56000Fuel Oil Shock Absorber■M56000LDFV56000Fuel Oil Filter■If pressure drop reaches limit(See G01400)Fuel Gas Supply SystemG05201-Analyze Fuel Gas Properties : Sampling◎Weekly during the first 3 monthsoperation-LDFV53001Main Gas Feed Pipe■-LDFV53002Gas Admission Valve▣Lubricating Oil SystemG06100-Analyze Lub. Oil Properties : Sampling◎Every 3 monthM61000LDFV61000Lubricating Oil Pump■M62000LDFV62000Lubricating Oil Cooler■(See Manual for LO Cooler)M63000LDFV63000Lubricating Oil Filter (Cartridge Type)■▣If pressure drop reaches limit(See G01400)-LDFV63000Auto Backw ashing Filter (If Applied)■(See Manual for Auto Filter)-LDFV64000Thermostatic Valve : Clean & Check the

Elements■(See Manual for Thermo.v/v)M67000LDFV67000Lubricating Oil Centrifugal Filter■(See Manual for Centrifugal Filter)▣ Expected life time✓ 1 Cylinder overhaul. If not good, check all cylinders.■ Overhaul inspection◆ Confirm tightening: Tighten w ith specified torque or hyd.pressure. Do not loosen!● Check & adjustment◎ Measuring or sampling w ithout dismantling○ Function test▲ Visual Inspection*) These are not parts of normal maintenance interval, but, the confirmation or visual inspection of the specified ones to be carried out after Overhaul/New.When doing maintenance and overhaul work, seals (o-rings & gaskets, etc.) should be renewed.The overhaul intervals and expected life time stated above are only for guidance as these depend on the actual service condition, the quality of used fuel or lubricatingoil, the treatment of cooling water and so on.

Overhaul Interval (hours)

SectionNo.DescriptionCooling Water System

Remark

G07100-Analyze Cooling Water Properties : Sampling◎Weekly : Test KitEvery 3 month : Lab. TestM70000LDFV71000Cooling Water Pump■-LDFV74000Thermostatic Valve : Clean & Check the Elements■(See Manual for Thermo.V/v)Compressed Air SystemO02300-Air Running○MonthlyG40000-Check Starting & Stop System○Weekly(Over a Week Stand-still Condition)Supercharging SystemTurbocharger■(See Manual for Turbocharger)

- Clean Air Filter (Only for Filter Silencer type)■▣Every 500hrs running - Turbine : Water-w ashing●Every 200hrs running - Compressor : Water-w ashing●Every 24~50hrs running

M80000

M83200-Exhaust Gas Waste Gate○WeeklyM84000LDFV84000Charge Air Cooler■▣ Expected life time✓ 1 Cylinder overhaul. If not good, check all cylinders.■ Overhaul inspection◆ Confirm tightening: Tighten w ith specified torque or hyd.pressure. Do not loosen!● Check & adjustment◎ Measuring or sampling w ithout dismantling○ Function test▲ Visual Inspection*) These are not parts of normal maintenance interval, but, the confirmation or visual inspection of the specified ones to be carried out after Overhaul/New.When doing maintenance and overhaul work, seals (o-rings & gaskets, etc.) should be renewed.The overhaul intervals and expected life time stated above are only for guidance as these depend on the actual service condition, the quality of used fuel or lubricatingoil, the treatment of cooling water and so on.

SectionNo.Parts DescriptionQuantity for the operating hours/

0-200000-24000set/ea0-280000-320000-40000-80000-120000-16000

0-200000-24000

Covers for Engine BlockLDFV13000 Gaskets for gear case coverset-1122334LDFV19300 O-ring for crankcase coverea-1 x C1 x C2 x C2 x C3 x C3 x C4 x CLDFV19300 O-ring for camshaft coverea-1 x C1 x C2 x C2 x C3 x C3 x C4 x C BearingsLDFV13250 Main bearing (upper & lower)set-----0.5xC+10.5xC+10.5xC+1LDFV13250 Thrust washerea-------4LDFV25300 Camshaft bearingea-------1xC+4LDFV32000 Big-end bearing (upper & lower)set-----1 x C1 x C1 x CLDFV32000 Small-end bearingea-------1 x CLDFV35000 Bearing bush for idle gearea-------2 Cylinder Unit and Con-RodLDFV15000 Flame ringea---1 x C1 x C1 x C1 x C2 x CLDFV15000 O-rings & gasket for cylinder liner / cooling water jacketset-111xC+11xC+12xC+12xC+13xC+1LDFV21100 O-rings for cylinder head coverset0.5 x C1 x C1.5 x C2 x C2.5 x C3 x C3.5 x C4 x CLDFV21100 O-ring for cylinder headea-111xC+11xC+12xC+12xC+13xC+1LDFV21100 Bush & O-ring for fuel valveset---1 x C1 x C1 x C1 x C2 x CLDFV21100 Bush & O-ring for MP injectorset---1 x C1 x C1 x C1 x C2 x C

LDFV21100 O-rings for valve guide & exh. valve seat ringset---1 x C1 x C2 x C2 x C3 x CLDFV21100LDFV21200 Intake v/v spindle, seat ring and v/v guideset-----1 x C1 x C1 x CLDFV21100LDFV21200 Exhaust v/v spindle, seat ring and v/v guideset-----1 x C1 x C1 x CLDFV21400 O-rings for starting valveset---0.5 x C0.5 x C0.5 x C0.5 x C1 x CLDFV23000 Roller bush for swing armea-------1 x CLDFV24100 O-rings for DVTset-111xC+11xC+12xC+12xC+13xC+1LDFV31100 Piston ring-top ring / 2nd ring / scraper ringset---1 x C1 x C1 x C1 x C2 x CLDFV32000 Shim plate for con-rodea---1 x C1 x C1 x C1 x C2 x CLDFV32000 Stud for con-rod shaftea-------4 x C Control SystemLDFV45000 Cylinder pressure sensor (if applied)ea-1 x C1 x C2 x C2 x C3 x C3 x C4 x C Fuel SystemLDFV51000 Plunger assembly for fuel pumpea-----1 x C1 x C1 x CLDFV51000 O-rings & seal ring for plunger ass'yset-1 x C1 x C2 x C2 x C3 x C3 x C4 x CLDFV51000 Gaskets & seal ring for fuel pumpset-----1 x C1 x C1 x CLDFV51000 Deflector & gasket for fuel pumpset-1 x C1 x C2 x C2 x C3 x C3 x C4 x CLDFV51000 Delivery valve assembly (except case)set---1 x C1 x C1 x C1 x C2 x CLDFV51000 Delivery valve caseea-------1 x CLDFV51000 O-ring for fuel pumpset-1 x C1 x C2 x C2 x C3 x C3 x C4 x CLDFV51000 Roller bush for tappetea-------1 x CLDFV51000 O-ring for fuel pump driveea-------1 x CLDFV52000 Fuel injection nozzle with dowel pinset1 x C2 x C3 x C4 x C5 x C6 x C7 x C8 x CLDFV52000 O-rings & gasket for fuel injection valve set2 x C4 x C6 x C8 x C10 x C12 x C14 x C16 x C* The list of consumable parts stated above is only for guidance as this depends on the actual service condition, the quality of used fuel or lubricating oil, the treatment of cooling water and so on.

Quantity for the operating hours

SectionNo.Parts Description

0-120000-16000set/ea0-280000-320000-200000-240000-40000-8000

LDFV52002 Micro pilot injector compl. (incl. nozzle)set-1 x C1 x C1 x CLDFV52002 Micro pilot injector nozzleset1 x C1 x C2 x C2 x C2 x C2 x C3 x CLDFV52002 O-ring & gasket for micro pilot injector and pipeset1 x C1 x C2 x C2 x C3 x C3 x C4 x CLDFV52002 O-rings for high pressure pumpset-----1 x C1 x C1 x CLDFV52002 High pressure pump set-----1 x C1 x C1 x CLDFV52003 Spare parts for micro pilot oil filter (See manual formicro pilot oil filter)set--------LDFV52300 O-rings for fuel injection pipe block set2 x C4 x C6 x C8 x C10 x C12 x C14 x C16 x CLDFV53000 O-rings for fuel feed pipe connection set-1122334

LDFV56000 Spare parts for fuel oil filter (See manual for fuel oil filter filter)set--------LDFV56000 Wearing ring & sealing ring for F.O shock absorberset1 x U2 x U3 x U4 x U5 x U6 x U7 x U8 x U Fuel Gas Supply SystemLDFV53001 O-rings for gas feed pipe to each cylinder set-111xC+11xC+12xC+12xC+13xC+1LDFV53001 O-rings & gasket for main gas feed pipeset11112LDFV53002 Gas admission valveset---1 x C1 x C1 x C1 x C2 x CLDFV53002 O-rings for gas admission valveset---1 x C1 x C1 x C1 x C2 x C Lubricating Oil SystemLDFV61000 Bushes for lub. oil pumpset---1 x U1 x U1 x U1 x U2 x ULDFV61000 O-rings for lub. oil pumpset---1 x U1 x U1 x U1 x U2 x ULDFV62000 O-ring for lub. oil cooler connection (Installation on engine side)ea---44448LDFV63000 Lub. oil filter cartridge (Paper cartridge type)ea2 x U4 x U6 x U8 x U10 x U12 x U14 x U16 x ULDFV63000 O-rings for lub. oil filter assembly (Paper cartridge type)set1 x U2 x U3 x U4 x U5 x U6 x U7 x U8 x ULDFV63000 Spare parts for auto backwashing filter (See manual for auto backwashing filter)set--------LDFV63000 Packing for auto backwashing filterea---11112LDFV64000 O-ring for lub. oil thermostat valveea---1 x U1 x U1 x U1 x U2 x ULDFV64000 Gasket for thermostatic valve cover (No installation of auto backwashing filter)ea---11112LDFV67000 Spare parts for centrifugal filter (See manual for centrifugal filter)set--------

Cooling Water System

gyLDFV71000 Oil seal, mechanical seal & O-ring for HT and LT-pumpset---1 x U1 x U1 x U1 x U2 x U

gppLDFV74000 O-ring for C.W thermostat valve (Wax type installed on engine)ea---1 x U1 x U1 x U1 x U2 x U

(ypg)LDFV74000 Gasket for thermostatic valve cover (Wax type installed on engine)ea---1 x U1 x U1 x U1 x U2 x U

LDFV77000 O-ring for cooling water connection ea-2244668LDFV78000 O-ring for cyl.head cooling water connectionea-88(4xC)+6(4xC)+6(4xC)+14 (4xC)+14 (8xC)+12LDFV78000 O-ring for cyl.head outlet connectionea-11(1xC)+1(1xC)+1(1xC)+2(1xC)+2(2xC)+2* The list of consumable parts stated above is only for guidance as this depends on the actual service condition, the quality of used fuel or lubricating oil, the treatment of cooling water and so on.

Quantity for the operating hours

SectionNo.Parts Description Supercharging System

set/ea0-40000-80000-120000-160000-200000-24000

0-280000-32000

LDFV81000 Gaskets for compressor outset---11112LDFV82000 Gasket for connection flangeea-111xC+11xC+12xC+12xC+13xC+1LDFV83000 O-rings for T/C connectionset---11112 Charge Air CoolerLDFV84000 O-rings and gaskets for air coolerset---11112

Turbocharger Spare parts for turbocharger (See manual for turbocharger)set-------- Air filter mat (Engine room air suction)ea48121620242832* The list of consumable parts stated above is only for guidance as this depends on the actual service condition, the quality of used fuel or lubricating oil, the treatment of cooling water and so on.

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Before Maintenance Read and understand maintenance procedures mentioned in this manual thoroughly. Prepare required tools and commodities in advance. Wait until Engine stopped and cooled Check if the following points are satisfied, Start air - shut off Cooling water - shut off and drain Fuel oil – shut off and drain Lubricating oil circulation – stopped and drain Pressure (F.O, L.O, H.T, L.T, Air) – released Crankcase ventilation (after gas mode operation) – N2

purging gas valve open about 40 seconds After the N2 purging on the crankcase, it requires sufficient time to enter the crankcase. Data for Maintenance Planning Some components can be dismantled directly from the engine and the others should be dismantled and remounted step by step in sequence. As guidance, summarized information for planning of overhaul are listed as a table to the next page. Normal overhaul in this sheet includes dismounting, inspection, cleaning and remounting etc. Manhours are only for reference valve based on normal working conditions by qualified persons with suitable tools.

G09110

List of Overhaul Manhours for One Unit and Related Special Tools

Working Sequence Special Tools Maintenance Overhaul manhours for one unit : Dismantling Step Sheets

Working Sequence

Special Tools

Maintenance

Sheets

Sheets : Remounting Step Tool No. Description Persons Hours

91.400 Hydraulic jack (M48x3) 91.460 Support (M48x3) 91.290 Lifting device for main bearing cap 91.300 Fitting device for main bearing 91.420 Hydraulic jack (M33x2) 91.490 Support (M33x2) 91.511 Extension screw (M33x2) 91.200 Guide support for connection rod mounting 91.210 Turing bracket for connecting rod

● Main Bearing M13250 ● Big End Bearing M32120

4.0 2.5

● Camshaft Bearing M25300 91.860 Camshaft bush removal device 2 3.0 91.400 Hydraulic jack (M48x3) 2 1.0

● Cylinder Head M21100

91.480 Support (M48x3) 91.110 Lifting tool for cyl.head

3.0

● Intake/Exhaust Valve M21200 91.120 Fit/removal device for valve cone/spring 1 1.0

● Intake/Exhaust Valve M21200 91.120 Fit/removal device for valve cone/spring

91.650 Fitting device for exh.seat ring 1 2.0 91.660 Fitting device for inlet.seat ring 91.580 Removal device for exh.valve seat

● Valve Seat Ring M21120

● Valve Guide M21130 91.670 Fit/Removal device for valve guide 1 1.0 91.420 Hydraulic jack (M33x2) 91.490 Support (M33x2) 91.511 Extension screw (M33x2)

● Piston + Connecting Rod M31000

2.5

91.170 Piston lifting 91.160 Piston Guide 91.210 Turing bracket for connecting rod 91.220 Clamping support for connecting rod

● Piston, Piston Rings M31100 91.250 Plier for piston ring opener 1 0.5 ● Con Rod, Piston Pin M31100 91.240 Plier for piston pin lock ring (plier 125) 1 0.5 ● Small End Bearing M32130 91.910 Removal Device for Piston Pin Bush 1 1.0 91.140 Grinding tool

● Cylinder Liner M15100

1 2.0 91.150 Extract./suspension device 91.260 Cylinder bore gauge

● Water Jacket +Cylinder Liner M15100 - 1 2.0

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Working Sequence Tools Maintenance Overhaul manhours for one unit : Dismantling Step Sheets

Working Sequence

Tools

Maintenance

Sheets

: Remounting Step Tool No. Description Persons Hours

91.130 Removal device for fuel injection valve 91.340 Nozzle tester

● Fuel Injection Valve ● Fuel Injection Nozzle

M52000

2.5

91.370 Cleaning tool for fuel injection nozzles 91.350 Lapping device for injection valve bush

● Fuel Injection Pump M51000 - 1 1.5 ● Lubricating Oil Filter M63000 - 1 1.0 ● Lubricating Oil Pump M61000 - 2 2.0 ● Lubricating Oil Thermostat Valve - - 1 1.0 ● Lubricating Oil Cooler M62000 - 2 9.0 ● Cooling Water Pump M71000 - 1 2.0 ● Cooling Water Thermostat Valve - - 1 2.0 ● Air Cooler M84000 - 2 7.0

G09200

ection No. Part Schematic drawing Nominal Size Clearance Wear and Repair Limi

Inner diameter of cylinder liner Wall thickness of flame ring Cylinder liner Water jacket 1st ring 1st groove 2nd ring 2nd groove Oil scraper ring 3rd groove Piston pin and boss Piston pin and bush Big-end bearing

D=ϕ350

+0.057

ϕ350.4

M15000 M15100

Cylinder liner

Max=7.47 Min =7.42 7.2 A=11.5 B=99

A=8 -0.01 -0.035

a = 0.183~0.235 0.4 8.4 b = 0.153~0.205 0.4 7.37 c = 0.053~0.095 0.4 8.2 a = 0.06~0.112 150.18 b = 0.129~0.197 (For MiBA) 0.26 b = 0.175~0.248 (For DiBE) 0.33 a = 0.272~0.384 (For MiBA) 0.52 a = 0.340~0.452 (For DiBE) 0.62 b = 0.306~0.418 (For MiBA) 0.57 a = 0.340~0.452 (For DiBE) 0.62

A1=8 +0.2 +0.17

-0.035 B=7 -0.013

M31100 Piston ring and groove Piston pin M31000 M32130 Crankshaft M13250

B1=7 +0.17 +0.14

C=8 -0.013 -0.035

C1=8 +0.06 +0.04 A=150 A=340

Main bearing B=340

Thrust bearing C=152 c = 0.5~0.7 1.0

Section

Repair Limit

-0.035 7 0.013

G09200

ection No. Part Schematic drawing Nominal Size Clearance Wear and Repair Limit

a = 0.187~0.378 (For MiBA) 0.37 a = 0.200~0.298 (For DiBE) 0.39

Camshaft bearing

A=208

M25000 Camshaft M21210 Valve operating mechanism and tappet M23000 M21130

Camshaft thrust bearing B=93 b = 0.1~0.2 0.25

Intake/exhaust rocker arm shaft and bearing

A=56

a = 0.2~0.7 a’ = 0.2~0.7

Tappet and tappet guide B=70 b = 0.03~0.095 0.2

C=40 D=70 E=35 F=50 G=27

c = 0.08~0.135 d = 0.060~0.109 e = 0.15~0.40 f = 0.080~0.144 g= 0.14~0.9

Tappet roller shaft and bearing Intake valve (stem part) and guide Exhaust valve (stem part) and guide

A=22 a = 0.08~0.163 0.3 A=22 a = 0.08~0.163 0.3 B=28 b = 0.034~0.067 0.2 C=10 R1=30˚ R1= 0˚ ~ -0˚ 5’ 9 D=1.05 R2=30˚ R2= 0˚ ~ 0˚ 5’ D=0.3 E=10 R3=30˚ R3= 0˚ ~ -0˚ 5’ 9

M21210 Guide pin for yoke

Intake and exhaust valve

Intake valve (face part) Intake valve seat Exhaust valve (face part)

M21200

Exhaust valve seat F=1.1 R4=30˚ R4= 0˚ ~ 0˚ 5’ F=0.3

Section

G09200

ection No. Part Schematic drawing Nominal Size Clearance Wear and Repair Limit

Idle gear shaft and bushing

A=110 B=70

a = 0.156~0.232 b = 0.200~0.450

0.4 0.6

Timing gear

M35000 M21210

Backlash c = 0.15~0.4 0.5 Other gear Backlash c = 0.15~0.4 0.7

Intake Valve Clearance (a)

0.9 mm 1) Valve clearance is with engine cold.

2) (b) should be set at ‘0’ prior to the adjustment of (a) Exhaust valve Clearance (a) 0.9 mm

Section

Engine Maintenance General Assessment of Bearings

Section No.

Rev.

G09210

General Various sliding bearing are applied on moving parts of the medium speed 4 stroke engine. Generally the sliding bearings are classified 3 types like below Fig. 1 according to the composition of materials.

Overlay (Electroplating or Sputtering) Lining (Bearing alloy) Steel back Tri-metal bearing and bushing

Lining (Bearing alloy) Steel back

Solid bearing and bushing

Bi-metal bearing and bushing

Fig. 1 Bearing types

HiMSEN also adopts various bearings described above and major bearings are listed on blow Table 1.

Main bearingSteel-backed Aluminium-base bi-metal Big-end bearingSteel-backed Aluminium-base bi-metal Main bearing and Big-endbearing of several typeSteel-backed Aluminium-base grooved tri-metal (Rillenlager®) Camshaft bushSteel-backed Aluminium-base bi-metal Small-end bushSteel-backed Leaded bronze bi-metal Thrust washerSolid form Aluminium-base or Solid form Leaded bronze(depend on bearing maker) Table 1 HiMSEN Bearings

DescriptionBearing material

G09210

Bearing shells are to be checked or replaced regularly according to maintenance schedule Section G09100. However the opening frequently the bearing shell without a specific reason is not advisable Criteria for bi-metal bearing replacement Visual evaluation of the wear is impossible for bi-metal bearings, since they have no visual indication for wear on lead area, in contrast with tri-metal bearing. Actual wear can be determined by measuring wall thickness or via clearance measurements in comparison to the specification for bearing in new condition. (See G09200 for bearing clearance) A bearing should be replaced if the wear limit is reached or can be expected to be reached during the next period of operation before the planned overhaul. However the remaining lifetime of bi-metal bearing is very difficult to judge mostly since the wear of bearing is very minor and a change in the visual appearance of the lining material over the whole lifetime cannot be seen under normal operating condition. So the regular replacement of bi-metal bearing is recommended according to G09100 or G09101.

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 Normal running pattern – Reusable Without flash (Fig. 2) Slightly polished mark in the most loaded zone. Isolated and minor scoring has no influence on bearing performance. With flash (Fig. 3) Slightly polished mark in the most loaded zone. Isolated and minor scoring has no influence on bearing performance. Flash is partly removed. Leaded bronze bearing with flash (Fig. 4) The typical appearance of leaded bronze is revealed after partly removal of flash in the most loaded zone.

Fig. 2 Normal running pattern without flash Fig. 3 Normal running pattern with flash Fig. 4 Normal running pattern of small-end bush

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 Minor edge loading (Fig. 5) – Reusable Slightly polished stripes along the side face. Minor edge loading is allowed if it is not pronounced. Localized heavy smearing of lining material (Fig. 6) - Replace An evidence of a disturbance of oil film in bearing operation in the past (most probably in a single occurrence). Causes : Short time lack of oil/loss of oil pressure. A bulk of small foreign particles was floated into the bearing.

Fig. 5 Minor edge loading Fig. 6 Localized heavy smearing of lining material

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G09210

 Extensive area of damage with seizure (Fig. 7) - Replace An evidence of a heavy disturbance of oil film in bearing operation in the past. Causes : Lack of oil/loss of oil pressure for a certain time. A bulk of foreign particles was floated in. Localized separation of lining material on aluminum-base bi-metal bearing (Fig. 8) - Replace Due to overheating of the lining material (Thermal influences combined with excessive shear forces) Causes of overheating : Lack of oil/loss of oil pressure for a certain time A bulk of foreign particles was floated in. Engine overspeed

Fig. 7 Extensive area of damage with seizure Fig. 8 Localized separation of lining material

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 Shallow scoring and/or a few imprints in unloaded area due to foreign particles (Fig. 9) – Reusable Many scoring or multiple deep grooves and/or imprints in loaded area due to foreign particles (Fig. 10 & Fig. 11) – Replace

Fig. 9 Shallow scoring and a few imprints Fig. 10 Deep scoring and imprints
Lining material locally smeared.

Fig. 9 Shallow scoring and a few imprints Fig. 10 Deep scoring and imprints

Fig. 11 Many deep imprints

G09210

 Minor and shallow cavitation outside the most loaded zone (Fig. 12 & Fig. 13) - Reusable Deep puncture cavitation (Fig.14) - Replace In severe cases the cavitation extends to the steel back, spreads along the interface between steel back and lining material. Fig. 13 Minor cavitation off oil groove

Fig. 14 Deep puncture cavitation

Engine Maintenance General Assessment of Bearings

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Grooved tri-metal bearing replacement The running surface of new bearings consists of approx. 75% electroplated overlay and appr ox.25% bearing alloy ridges. Overlay (~75%) Bearing alloy (~25%)   Ni intermediate layer (max. 5 %)

Fig. 15 Composition of grooved tri-metal bearing

In case aluminum-base groove tri-metal bearing, overlay is recognizable as a d ark zone and bearing alloy ridge as light zone. The ratio of the bearing alloy ridge width to the groove width, as well as the size of the worn surface, is the important factor for evaluating the degree of wear in loaded area. So, a magnifying glass (minimum magnification 5x) is required for precise evaluation of the degree of wear of the running surface. For every assessment of the condition of the ridges, the benchmark should be the running surface in the least loaded area, where is almost new condition. This bearing can still function when the overlay in the grooves has partly worn away. Moreover, in actual practice, it has been proven that its function can be continued without any ill effects, even with partially empty grooves.

Engine Maintenance General Assessment of Bearings

 Normal running pattern – Reusable The geometry of the groove is as new (Fig. 16) The overlay inside the groove is fully intact. The dark spots embedded in overlay are mostly oil coke particles. The ratio between the bearing alloy ridges and the overlay is 25 % to 75 %. The overlay in the grooves has worn uniformly by about 0.005 mm. (Fig. 17) The bearing alloy ridges show no sign of wear. The dark spots are predominantly embedded oil coke particles. As a result of overlay wear, the bearing alloy ridges appear slightly wider.

Fig. 16 Normal running pattern Fig. 17 Wear of overlay in groove

Small foreign particles are spread over the entire running surface. (Fig. 18) No significant alteration of the bearing alloy ridges

The overlay has been locally displaced and smeared over the bearing alloy ridges. (Fig. 19) The bearing alloy ridges can no longer be seen in some places.

Fig. 18 Small foreign particle Fig. 19 Displacement of overlay

 Wear of bearing alloy and overlay – Replace depending on condition Wear (Fig. 20) In some places the bearing has been worn down to such an extent that the bearing alloy ridges and the overlay grooves have reached a ratio of 1:1. The width of the bearing alloy ridges has increased from 25 % (when new) to 50 %. The overlay still exists in the grooves. The bearing is to be replaced when the extent of wear reaches the limit described in Fig. 22. Wear and local leveling of the ridge (Fig. 21) The bearing alloy ridges are worn locally to be no groove. The bearing is to be

replaced when the extent of wear reaches the limit described in Fig. 22.

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Fig. 20 Wear ratio of 1:1 Fig. 21 Wear and local leveling of the ridge

Fig. 22 Criteria of wear

Strip-shaped wear

Strip-shaped

Wear of 1:1 Bearing alloy ridges worm

A: max. 30% of circumference B: max. 70% of width C: max. 50% of circumference D: max. 35% of width

E: max. 20% of width F: max. 5% of circumference G: max. 10% of width H: max. 35% of circumference I: max. 10% of width

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 Wear of bearing ally and overlay – Replace depending on condition Cracks in overlay (Fig. 23) Fatigue of the electroplated overlay due to local overload. The bearing is to be replaced when the extent of wear reaches the limit described in Fig. 25. Cracks in overlay and empty groove (Fig. 24) Empty grooves are visible due to a washing out of the broken overlay. Local wear of the bearing alloy ridges may be visible. The bearing is to be replaced when the extent of wear reaches the

limit described in Fig. 25. Cavitation outside loaded zone (Fig. 26) – Reusable A cavitation next to oil groove out of loaded zone, the bearing is functional. A portion of shallow cavitation spreading on the loaded zone (Fig. 27) – Replace depending on condition Shallow cavitation off the oil groove is mostly found at main bearings. This cavitation makes erosion similar to wear, cracks in overlay or empty groove, so the bearing is reusable according to the criteria described in Fig.22 and Fig.25 when the cavitation spreads on the loaded zone.

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Fig. 23 Cracks in overlay Fig. 24 Empty groove

Fig. 25 Criteria of cracks in overlay and empty groove

Empty grooves Cracks in overlay A: max. 25% of circumference B: max. 70% of width C: max. 50% of circumference D: max. 35% of width

Bearing alloy ridges worm E: max. 40% of width F: max. 10% of circumference G: max. 30% of width H: max. 40% of circumference I: max. 15% of width

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Fig. 26 Cavitation next to oil groove Fig. 27 Cavitation next to oil groove

If a condition as described criteria in Fig.22 and Fig.25 is anticipated within the next service interval, then the bearing should be replaced for safety reasons.
Free spread of bearing shell Bearing shell must have a positive spread to provide

that the bearings can be assembled into the housing without lateral play. All bearing shells are losing a certain amount of free spread during operation because of the thermal expansion differential between the back steel and lining materials when bearings are installed and run up to normal working temperature. If the free spread is bigger than housing bore and keeps in place during handling, the loss of free spread is acceptable.

Bearing diameter + spread

Fig. 28 Free spread of bearing

245

310.5

747 125

Cylinder head and rocker arms assembly (Weight : approx. 492 kg)

Cylinder liner (Weight : approx. 192.8 kg)

487

786.5

Water jacket (Weight : approx. 117.9 kg)

Connecting rod shaft (Weight : approx. 71.4 kg)

800

830

800 Air cooler cover (Weight : approx. 230.7 kg)

830

418.75 418.75

418.75 418.75

Piston (Weight : approx. 93.3 kg)

Air cooler (Weight : approx. 790 kg)

G09400

Method

Tightening

Item No.

Description Size

Nut for rocker arm adjusting M20x1.5 30 250 Nm LDFV21200 314 + Molykote Nut for valve yoke setting M16x1.5 24 170 Nm LDFV21200 439 + Molykote Nut for rocker arm support M20x2.5 32 380 Nm LDFV21200 353 + Molykote Nut for swing arm support M24x3.0 36 600 Nm LDFV23000 902 + Molykote Nut for camshaft joint M16x1.5 24 270 Nm LDFV25000 122 + Loctite 243

*) See M31100 Bolt for piston M27x1.5 40 80 Nm +135° LDFV31000 113 +Molykote Nut for flywheel M30x2.0 45 1500 Nm LDFV33300 333 +Molykote Bolt for flexible coupling M22x2.5 34 450 Nm LDFV33400 491 + Molykote Nut for flexible coupling M16x2.0 24 250 Nm LDFV33400 447 + Oil Nut for flexible coupling M30x3.5 46 1300 Nm LDFV33400 449 + Oil Bolt for crankshaft gear wheel M20x2.5 30 450 Nm LDFV35000 191 + Loctite 243 Bolt for idle gear wheel M16x2.0 24 230 Nm LDFV35000 291 + Loctite 243 Bolt for camshaft gear wheel M16x2.0 24 230 Nm LDFV35000 392 + Molykote Bolt for air start valve M16x2.0 24 220 Nm LDFV42000 408 + Molykote Socket head bolt for fuel inj. pump M12x1.75 10 100 Nm LDFV51000 112 + Molykote Socket head bolt for fuel inj. pump M14x2.0 12 100 Nm LDFV51000 113 + Molykote Deflector for fuel inj. Pump M30x1.5 30 250 Nm LDFV51000 122 Bolt for fuel injection pump M16x2.0 24 200 Nm LDFV51000 911 + Molykote Nut for nozzle - 41 250 Nm LDFV52000 103 + Molykote Nut for nozzle adjust M27x2.0 36 150 Nm LDFV52000 107 + Oil Nut for fuel injection valve M16x2.0 24 200 Nm LDFV52000 195 + Molykote

80 Nm Socket head bolt for high press. block M16x2.0 14 20 → 50 →

*) See M5230→ 50 →80 Nm LDFV52300 114 + Molykote

Molykote *) See M52300

Nut for high pressure block M16x1.5 24 20 → 50 → 80 Nm

*) See M5230→ 50 → 80 Nm LDFV52300 118 + Molykote

Molykote *) See M52300

Bolt for L.O pump driving gear M22 550 Nm LDFV61000 210 + Loctite 242 Bolt for L.O pump cover M16x2.0 24 140 Nm LDFV61000 211 + Loctite 242 Bolt for C.W pump driving gear M20x2.5 30 340 Nm LDFV71000 213 + Loctite 242 Bolt for C.W pump impeller M16x2.0 24 200 Nm LDFV71000 220 + Loctite 242

(Spanner/ Wrench)

gTorque (Nm)

Related Section

Remarks

G09400

Description Size

No lubricant Anti-seizure lubricant or loctite

M6x1.0 10 10 Nm 7 Nm M8x1.25 13 25 Nm 20 Nm M10x1.5 17 50 Nm 40 Nm M12x1.75 19 80 Nm 70 Nm M14x2.0 21 120 Nm 110 Nm M16x2.0 24 200 Nm 170 Nm M18x2.5 27 280 Nm 240 Nm M20x2.5 30 400 Nm 340 Nm M22x2.5 33 550 Nm 450N m M24x3.0 36 700 Nm 600 Nm M6x1.0 10 14 Nm 10 Nm M8x1.25 13 35 Nm 25 Nm M10x1.5 17 70 Nm 50 Nm M12x1.75 19 120 Nm 85 Nm M14x2.0 21 190 Nm 130 Nm M16x2.0 24 280 Nm 200 Nm M18x2.5 27 390 Nm 280 Nm M20x2.5 30 560 Nm 380 Nm M22x2.5 33 800 Nm 700 Nm M24x3.0 36 1000 Nm 900 Nm

General bolts and nuts (Strength grade 8.8) General bolts and nuts (Strength grade 10.9)

Notes)

)1. Thread of nuts/bolts are to be greased with specified anti-seizure agent by the + marked

ead outs/bo ts a e to be g easbefore tightening-up where stated.

ggp2. High temperature parts should be tightened with anti-seizure agent for the high temperature.

gtepe atu e pa ts s ou d be t g te edta t se u e age t o t egtepe atu e+ Molycote : lubricating paste up to 400℃ (Ex. GLEITMO 100) + MH   : high-temperature lubricating up to 1100 ~ 1150℃ (Ex. Molycote 1000 or COPASLIP)   (Coefficient of friction : 0.12)

()3. The bolts and nuts should be tightened in a diagonally alternating sequence.
4. General bolts and nuts are generally tightened without anti-seizure agent.

Method (Spanner/ Wrench)

Method

Tightening Torque (Nm)

Remarks

or loctite

G09500

General In principle, a screw can be tightened when nut is screwed in during tensioning by hydraulic force and then release the hydraulic force. This hydraulic tightening method provides easier working and more reliable result than manual tightening in general. Therefore, most of the important or big screws are tightened hydraulically. A hydraulic tightened screw always consists of a s et of stud and nut which are designed properly for a hy draulic tool set. The nut has pin holes for turning through the hole of support for jack as shown in fig 1.   PIN or WRENCH

The engine also has some important screws which should be tightened and loosened hydraulically by means of hydraulic tool sets. The hydraulic tool set consists of a hydraulic pump, hoses and a distributing piece, which are for common use regardless of screw size. Most of the hydraulic screws are tightened in pair(s), which need

distribut-ing piece for same tightening pressure. There are two kinds of distributing piece with different number of ports. Screws on cylinder head need four ports and the others need two ports as shown in fig 2 and 3.

G09500

Each screw needs own set of hydraulic jack and support for the corresponding screw size. Depending on the working condition, extension screw should be added for the jack as shown in fig 4.

G09500

Each screw also needs own tightening pressure which should be kept absolutely. The screws and data for hydraulic tightening are

G09510 Put on protecting glasses against injuries

listed in

due to failure of highly pressurized hoses and jack. Before pressurizing the hydraulic jack, make sure the pressure gage is calibrated and display the actual pressure. Applied oil pressure must be within a range of ±5 bar of given pressure for each stud type.

All type Section No.

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G09500

Tightening Procedure 1. Check pre tightening of the stud and tighten by wrench, if loosened. 2. Clean studs, nuts and around seats. 3. Screw the nut manually until the nut contacting the seat closely. 4. Check condition of the hydraulic tool set and make them ready to use. 5. Mount support (extension screw) and screw the jack by hand. 6. Connect hoses from the pump to the jacks via the distributing piece. 7. Close the release valve of the hydraulic pump. 8. Open air venting plug of the jack and check air venting by pumping. 9. Close the venting plug and pressurize up to the specified pressure for tightening the nut. 10. Turn the nut to be screwed firmly by a p in manually through the hole of the support. 11. Release the hydraulic pressure by opening the release valve of the hydraulic pump. 12. Repeat pressurizing and check the nut loosened. Retighten the nut, if loosened. If the stud or nut has been replaced by new ones, repeat the tightening three times for the first tightening. This repeat is necessary for the settlement of the threads. 13. Release the hydraulic pressure and dismount the tool set.

All type Section No.

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G09500

Loosening Procedure 1. Clean seat and threads. 2. Check condition of the hydraulic tool set and make them ready to use. 3. Mount support (extension screw) and jack. 4. Connect hoses from the pump to the jacks via the distributing piece. 5. Turn the piston of jack until contacting the nut and then unscrew the piston by about half turn. This is important to provide space for loosening the nut. 6. Open the release valve of the hydraulic pump. 7. Open air venting plug of the jack and check air venting by pumping.. 8. Close the venting plug and pressurize up to the specified pressure for loosening the nut. 9. Unscrew the nut by half turn manually by means of a pin through the hole of the support. 10. Be sure to check that loosened nut moves freely without contacting the piston of the jack. Otherwise, jack and the nut may be stuck each other after releasing hydraulic pressure. If stuck, increase hydraulic pressure slightly and turn the nut about 1/4 turn clockwise for loosening from the piston of the jack. 11. Release the hydraulic pressure and dismount the tool set.

ection no. Description

Size TighteninTightening Untightening (H mm) Tool no. Tool partstightening for Stud for Nut for Nut

Stud for main bearing cap Side bolt for main bearing cap Stud for cylinder head

91.400 91.460 91.410 91.470 91.400 91.500 91.480.

M48× 3.050 + loctite 2431200 1200 + 20 bar (max. 5%) M39× 3.050 + Molycote900 900 + 20 bar (max. 5%) M48× 3.050 + Loctite 243 1150 1150 + 20 bar (max. 5%) 1100 1100 + 20 bar (max. 5%) M33× 2.050 + Molycote

133+3-2 111 +2-1 113.5 +30 84.5 +2-1 84 +3-1 108+2 -1

M13250 M15000

M32000 Stud for connecting rod shaft M32120 Stud for connecting rod Bigend

91.421 91.420 91.511 91.490

M35000 Stud for Idle gear 1000 1000 + 20 bar (max. 5%)

Section

Required tool

Screw Size

Torque

Pre-

Stud length after

Tightening

tightening

ggfor Stud

(Nm)

Hydraulic Tightening

gfor Nut

(bar)

Untightening

Hydraulic

gfor Nut

(bar)

M33200 Stud for counter weight M13000 Coupling Stud for engine block

91.410 91.470 91.411 91.471

M39× 3.050 + Molycote1000 1000 + 20 bar (max. 5%)

122 +2-1 81+2-1

M36× 2.050 + Molycote1200

1200 +20bar (max. 5%)

Note : 1. Hydraulic oil pressure for untightening is normally +20 bar (max. 5%) above hydraulic oil pressure for tightening. For example : Tightening pressure : 1050 bar Untightening pressure : 1070 bar (1050+20) – Normal
1103 bar (1050*1.05) – Maximum + Molycote : lubricating paste up to 400℃ (Ex. GLEITMO 100) (Coefficient of friction : 0.12) 2. Stud length after tightening (H) If doubt, Please contact Hyundai Global Service Co., Ltd

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H35DFV Section No.

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G09600

a) List of Standard Tool No. Description Related Section Q'ty Weight Tool No.

Remarks (kg) 1 DVT(Dual Valve Timing) assembly tool M24100 1 2.9 91.063 2 Tool for press sensor tool 1 0.6 91.100 3 Torque wrench 22.5Nm 1 0.3 91.101 4 Torque wrench spanner head 8 1 0.2 91.102 5 Torque wrench spanner head 16 1 0.2 91.103 6 Lifting Tool for Cylinder Head M15000 M21200 1 6.5 91.110 7 Fit/Removal device for valve conical clamping piece M21200 1 6.2 91.120 8 Removal device for fuel injection valve M52000 1 4.2 91.130 9 Grinding tool for cylinder head/liner/block M15100 1 18.9 91.140 10 Extract/Suspension device for cylinder liner M15100 1 19.4 91.150 11 Lifting tool for water jacket with cylinder liner 1 17.4 91.151 12 Guide bush for piston M31000 1 11 91.160 13 Lifting tool for piston M31000 1 9.3 91.170 14 Con-rod support for crank pin bearing M32120 2 1.2 91.180 15 Supporting device for crank pin bearing 1 11.2 91.181 16 Screw-on plate for crank pin bearing 1 3 91.182 17 Big-end lower support for crank pin bearing 1 1.1 91.183 18 Big-end upper guide bar for con-rod 1 3.4 91.184 19 Extension pipe for crank pin bearing 2 1.6 91.185 20 Guide pipe for crank pin bearing 2 0.7 91.186 21 Big-end upper support for crank pin bearing 1 4.2 91.187 22 Con-rod shaft guide for piston 1 0.4 91.190 23 Guide support for con-rod M31000 1 19.2 91.200 24 Turning bracket for con-rod M31000 1 2.5 91.210

G09600

No. Description Related Section Q'ty Weight Tool No. Remarks (kg)

25 Clamping support for con-rod M31000 2 0.8 91.220 26 Plier 125 for piston pin locking ring M31100 1 0.2 91.240 27 Plier for Piston Ring Opener M31100 1 0.2 91.250 28 Cylinder bore gauge M15100 1 0.2 91.260 29 Removal Device for Flame Ring M31000 1 14.7 91.270 30 Feeler gauge for in/exh valve General 1 0.1 91.280 31 Lifting device(Eye bolt M12) for main bearing cap M13250 1 0.4 91.290 32 Fitting device for main bearing M13250 1 0.1 91.300 33 Deflection Gauge for Crankshaft M33100 1 1.5 91.310 34 Spanner for high pressure block 1 0.2 91.330 35 Test Tool for Fuel Valve Nozzle M52000 1 33 91.340 36 MP Injector test jig Part 1 6.3 91.341 37 Test tool for MP Driver 1 6.1 91.342 38 Lapping device for Injection Valve Bush M52000 1 7 91.350 39 Lapping device for in/exh valve seat M52000 1 5.9 91.360 40 Cleaning tool for fuel injection valve nozzle M52000 1 0.1 91.370 41 Removal Device for Cooling Water Connection M15000 1 3.5 91.380 42 Removal tool for atomizer nut M52000 1 4.9 91.390 Hydraulic Jack (M48x3) for Cylinder Head M15000

43 44

7.7 91.400

Main Bearing Cap M13250 Counter Weight Hydraulic Jack (M39x3) for 2 6.5 91.410 Side Stud M13250 Idle gear

(kg)

G09600

No. Description Related Section Q'ty Weight Tool No. Remarks (kg)

Hydraulic Jack (M33x2) for Con-Rod shaft M31000 Con-Rod Big end M31000 Base frame

45

91.420

46 Angle piece 2 0.6 91.421 47 Set of spare parts for hyd. jack M48 M15000 1 0.1 91.430 48 Set of spare parts for hyd. jack M39 M13250 1 0.1 91.440 49 Set of spare parts for hyd. jack M33 M31000 1 0.1 91.450 Support (hyd. Jack M48) for

50 51 52 53 54 55

2 2.4 91.460 Main bearing cap M13250 Counter weight Support (hyd. Jack M39) for 2 1.4 91.470 Side Stud (M39x3) M13250 Long Support (hyd. Jack M48) for

9.6 91.480 1.1 91.490

Cylinder head M15000 Support (hyd. Jack M33) for Con-Rod shaft M31000 Con-Rod Big end M31000 Base frame Extension screw (hyd. Jack M48) for

M15000 4 5.8 91.500 2 1.2 91.510

Cylinder Head (M48x3) Insert screw (hyd. Jack M33) for Con-Rod shaft Con-Rod Big end Base frame

(kg)

G09600

No. Description Related Section Q'ty Weight Tool No. Remarks (kg)

Extension screw (hyd. Jack M39) for Idle gear Long Support (hyd. Jack M39) for Idle gear

56 57

2 91.520 3.9 91.530

All Cases except 1 0.7 91.541 M15000

58 Distributing Piece (2-port)

59 Distributing Piece (4-port) M15000 1 1 91.542 60 High pressure hose (L=800) All Cases 4 2 91.551 61 High pressure hose (L=4000) All Cases 2 10 91.552 62 Removal device for exh valve seat All Cases 1 18.5 91.580 63 Adapter for Hydraulic pump 1 91.590 Only for marine 64 Turning pin (Φ10) All Cases 2 0.1 91.600 65 Turning Pin (ϕ6) All Cases 2 0.1 91.610 66 Air Gun M21000 1 91.620 67 Long Socket for Nozzle Nut M52000 1 91.630 68 Spare & Tool Box General 4 22.3 91.640 69 Removal device for fuel valve bush M21140 1 1.5 91.720 70 Fitting device for MPI bush 1 0.9 91.725 71 Removal device for MPI bush 1 0.2 91.726

Only for PPS, DFPP, EPP

72 Pneumatic hydraulic pump 1 16 91.850 73 Turbocharger cleaning hose valve 1/Eng 91.934 74 Plier for Locking Ring 1 91.940 75 Tool for air starting valve 1 0.6 91.950 76 Lapping device for starting valve 1 6.4 91.960 77 Turbocharer cleaning hose M80000 1 5.3 98.100

(kg)

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b) List of Optional Tools

No. Description Related Section Q’ty

Tool No. Remarks

1 Adapter for Hydraulic Pump All Cases 1 0.7 91.590 2 Fit/Removal Device for Valve Guide M21130 1 5.4 91.670 3 Touching Device for Inlet Valve M21120 1 91.680 4 Touching Device for Exhaust Valve M21120 1 91.690 5 Fitting Device for Injection Valve Bush M21120 1 91.700 6 Grinding Machine for Valve Seat Ring (complete) M21120 1 27 91.730 7 Grinding Machine for Valve Spindle (complete) M21120 1 91.740 8 Hydraulic Test Jig for Cylinder Head M21120 1 160 91.745 9 Honing machine for Cylinder Liner M15100 1 91.780 10 Lifting Device for Flywheel (incl. eye bolt) L33300 1 91.790 11 Grease Gun (Ball type) M41100 1 91.800 12 Torque Spanner (80-360Nm) All case 1 2.2 91.810 13 Torque Spanner (20-120Nm) All case 1 1.2 91.820 14 Torque Spanner (140-760Nm) All case 1 2.9 91.830 15 Torque Spanner (750-2000Nm) All case 1 11.1 91.840 16 Camshaft Bush Removal Device M35300 1 91.860 17 Lifting Jig for Engine General 1 91.870 18 Lifting Strap General 1 91.890 19 Removal Device for Piston Pin Bush M31100 1 91.910 20 Torque wrench for camshaft joint nut M25000 1 2.0 91.930 21 Interchangeable head (S24) for camshaft M25000 1 0.26 91.932

Weight

(kg)

G09610

Size Item Part

Hydraulic Jack M48x3 (Tool No.: 91.400) Part No. Description Q’ty 91.403 O-ring 1 91.404 Back-up Ring 1 91.405 O-ring 1 91.406 Back-up Ring 1 91.407 Quick Coupling 1 Hydraulic Jack M39x3 (Tool No.: 91.410) Part No. Description Q’ty 91.413 O-ring 1 91.414 Back-up Ring 1 91.415 O-ring 1 91.416 Back-up Ring 1 91.417 Quick Coupling 1 Hydraulic Jack M33x2 (Tool No.: 91.420) Part No. Description Q’ty 91.418 Back-up Ring 2 91.419 O-ring 2 91.428 Back-up Ring 3 91.429 O-ring 3

M48x3 M39x3 M33x2

405 406

407

403

404

417

413

414

415

416

418

429

428

419

429

428

429

Engine Maintenance General List of Hyd.Jack Spare Part

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Angle Piece

Angle piece for Hydraulic Jack M33x2 (Tool No. : 91.421) Part No. Description Q’ty
91.421 Angle piece 1

(for

(Hyd.jack M33x2)

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Base Frame Assembly Assembly Drawing & Part List

H35DFV Section No.

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LDFV11000

031

032 029 001

Part List Item No. Description Q’ty / Eng. Weight(kg) Remarks / See Note 001 Base frame 1 Approx.25.48 029 Rubber cord 1 031 O-ring 2 Approx.0.01 032 O-ring 1 Approx.0.03

Note 1. Mounting position and shape can be changed each project 2. Rib plates can be changed each project.

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H35DFV Section No. LDFV11100 Detail “A”

Holding Down Bolt Arrangement Assembly Drawing & Part List

Holding Down Bolt

Part List

Item no. Description Q’ty / Mount.

Weight (kg) Remarks / See Note

Weight

001 Elastic Mounting 12 Approx.38.00 002 Nut 24 Approx.0.03 003 Bolt 24 Approx.0.16 004 Bolt 48 Approx.0.09 007 Washer 24 Approx.0.01 008 Washer 72 Approx.0.01 Note 1. Mounting position and shape can be changed each project 2. Rib plates can be changed each project.

Pag 154
Engine Block General Instruction

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G13000

Description The engine block is made of cast iron and h as combustion air chamber and lubricating oil channel. Engine block needs no maintenance normally except cleaning inside air chamber and outside. Combustion air flows into the engine block from charge air cooler. Air channel of the engine block distributes the air to each cylinder. Lubricating oil flows into casting oil channel of the engine block from the feed module, and is distributed to every main bearing.

The main bearings are fixed by LDFV13250

the main bearing caps. Each main bearing cap is hung to the engine block by two studs, and the engine block is also reinforced by two side studs of the bearing cap.

The thrust bearings are on install- LDFV13250

ed both sides of the crank gear wheel to prevent axial movement of the crankshaft.
Lub.Oil Channel LDFV13000 Main Bearing Cap

Engine Block Assembly Assembly Drawing & Part List

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LDFV13000

212 211 926 221 B 923 231 222 966 232 924 922 902 913 903 A 291 Detail “B” Detail “A”

919 911

Engine Block Assembly Assembly Drawing & Part List

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LDFV13000

902 901

917 915

917 913 915 906

913 906

905 930 915 917

910 909 931

967

934 951 934

Detail “C” 914 932 951

Detail “C”

916 View “D”

918 933 951

Engine Block Assembly Assembly Drawing & Part List

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LDFV13000

Part List

Item No. Description

Q’ty / Eng. Weight

Q’ty / Eng. Weight (kg) Remarks / See Note 12Cyl 14 Cyl 16 Cyl 18 Cyl 20 Cyl

g(kg)

211 Main bearing cap 6 7 8 9 10 Approx.136.0 212 Thrust bearing cap 1 1 1 1 1 Approx.137.78 221 Main bearing stud 14 16 18 20 22 Approx.9.16 222 Nut 14 16 18 20 22 Approx.1.61 231 Side bolt 14 16 18 20 22 Approx.4.12 232 Nut 14 16 18 20 22 Approx.1.29 291 Parallel pin 7 8 9 10 11 Approx.0.03 311 Cylinder head stud 48 56 64 72 80 Approx.11.43 312 Nut 48 56 64 72 80 Approx.1.61 901 Cam gear cover(A-bank) 1 1 1 1 1 Approx.17.58 902 Gasket 2 2 2 2 2 903 Cam gear cover(B-bank) 1 1 1 1 1 Approx.16.5 905 Cover 1 1 1 1 1 Approx.19.43 906 Gasket 1 1 1 1 1 909 Air duct cover 1 1 1 1 1 Approx.6.0 910 Gasket 1 1 1 1 1 Approx.0.09 911 Parallel pin 2 2 2 2 2 Approx.0.09 913 Socket Head Bolt 52 52 52 52 52 Approx.0.04 914 Plug 6 7 8 9 10 Approx.1.05 915 Plug 3 3 3 3 3 Approx.0.13 916 Gasket 6 7 8 9 10 917 Gasket 3 3 3 3 3 918 Bolt 6 6 6 6 6 Approx.0.21 919 Bolt 28 32 36 40 44 Approx.0.38 922 Coupling bolt 26 30 34 38 42 Approx.1.3 923 Hydraulic nut 26 30 34 38 42 Approx.0.5 924 Protective cap. liner 12 16 18 20 22 Approx.0.06 925 Protecting cap 60 64 68 72 80 Approx.0.08 926 Protecting cap 26 30 34 38 42

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Engine Block Assembly Assembly Drawing & Part List

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Q’ty / Eng. Weight

Item No. Description

Q’ty / Eng. Weight (kg) Remarks / See Note 12Cyl 14 Cyl 16 Cyl 18 Cyl 20 Cyl

Weigh(kg)

930 Bolt 16 16 16 16 16 Approx.0.05 931 Bolt 6 6 6 6 6 Approx.0.09 932 Socket Head Bolt 16 16 16 16 16 Approx.0.19 933 Socket Head Bolt 10 10 10 10 10 Approx.0.24 934 Socket Head Bolt 23 23 23 23 23 Approx.0.34 950 Washer 16 16 16 16 16 951 Washer 8 8 8 8 8 Approx.0.01 964 Cylindrical pin 24 28 32 36 40 Approx.0.02 965 O-ring 60 64 68 72 80 966 O-ring 12 16 18 20 22 Approx.0.01 967 Parallel pin 1 1 1 1 1 Approx.0.06

Pag 159
Main/Thrust Bearings Assembly Drawing & Part List

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LDFV13250

LDFV25300

252 251

253 254 Section A-A Stopper (O.D 27mm)

Part List

Item No. Description

Q’ty / Eng. Weight

Q’ty / Eng. Weight (kg) Remarks / See Note 12 cyl. 14 cyl. 16 cyl. 18 cyl. 20 cyl.

g(kg)

251 Main bearing 7 8 9 10 11 Approx.7.1 for DiBE Approx.7.21 for MiBA

251 Main bearing 7 8 9 10 11 Approx.7.1 for DiBE A7 21fMiBA

252 Thrust washer 4 4 4 4 4 Approx.4.1 for DiBE Approx.1.72 for MiBA

252 Thrust washer 4 4 4 4 4 Approx.4.1 for DiBE A1 72fMiBA

253 Socket head bolt 254 Stopper (O.D 27mm)

458 ± 0.2

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M13250

Dismantling of Main Bearings 1. Install the hydraulic tool set on two nuts of side studs as shown in fig 1. 2. Loosen the two nuts hydraulically at the same time.

G09500

Loosening procedure :

G09500

Loosening pressure : 920 bar (max. 945 bar)

91.410

91.470

91.470 91.410 G09500

Hydraulic tool : :

3. Dismount the hydraulic tools and t ake out the studs and nuts from the engine.
4. Screw Eye bolts(M10) 4EA on main bearing cap and c onnect chain blocks to eye bolts. Install hydraulic tool set on two nuts of main bearing cap studs as shown in fig.2.

91.460 91.400

91.460 91.400 G09500

Hydraulic tool :

M13250

5. Loosen the two nuts hydraulically at the same time.

G09500

Loosening procedure :

G09500

Loosening pressure : 1220 bar (max. 1260 bar) 6. Dismount the hydraulic tools. 7. Lower the main bearing cap slowly on oil sump after unscrewing the nuts. 8. Take out lower bearing from the cap carefully. 9. Turn the crankshaft and mount the fitting plug on the oil hole of the journal as shown in fig 3.

91.300

91.300 91.300

Fitting plug : Exhaust side Cam side

10. Dismantle upper bearing by turning the crankshaft clockwise slowly and take out the bearing. Be careful not to drop or damage the bearing during taking out from the engine.

M13250

Inspection of Main Bearings and Journal 1. Inspect the journal carefully by turning the crankshaft. 2. Put tapes on the oil hole of journal to keep clean against dirt. Be sure to put off the tape before reassembling. 3. Inspect the engine block around journal and bearing cap. 4. Inspect the bearings and measure the thickness of bearings by means of a ball anvil micrometer and check the wear limit.

G09200 G09200

5. Keep the record of the measurements and inspection results. If there is any sign of abnormality on the journal or bearings, it should be investigated and repaired by experienced specialists. Poor repair works deteriorate the condition and may cause serious damage on crankshaft. Assembling of Main Bearings 1. Check the studs for main bearing cap loosened and retighten, if loosened. Pre tightening

torque : 50 Nm (with loctite 243) 2. Clean the bearings by cleaner and coat clean lubricating oil. 3. Clean the journal, bearing cap and i nside the engine around the journal carefully by clean lubricating oil. 4. Put off the covering tapes on the oil holes of journal.

M13250

5. Turn the crankshaft and mount the fitting plug on the oil hole of the journal as same as dismantling.

Fitting plug : 91.300 91.300

6. Mount upper bearing by turning the crankshaft counter clockwise slowly. 7. Mount lower bearing on the main bearing cap. Do not mix the bearings with other counter part. The bearings should be matched with correct pairs. 8. Mount the main baring cap by lifting and screwing the nuts. 9. Mount side studs firmly by hand. 10. Mount hydraulic tool sets for side studs and main bearing studs. 11. Tighten the nuts for side studs of exhaust side only (preliminary tightening). Preliminary tightening pressure : 200 bar 12. Tighten the two nuts for main bearing studs simultaneously. Tightening pressure : 1200 bar (repeat 3 times). 13. Tighten the two nuts for side studs simultaneously. Tightening pressure: 900 bar (repeat 3 times). 14. Dismount the hydraulic tool sets.

M13250

Checking Axial Clearance of Thrust Bearings 1. Open two crankcase covers for both sides of flywheel end. 2. Move crankshaft fully in axial direction by a lever. 3. Measure the clearance between the thrust bearing and crankshaft by means of a

filler gauge in three points of bearing (both ends and middle). 4. Move crankshaft fully in axially opposite direction by a lever. 5. Measure the clearance between the thrust bearing and crankshaft of the other side by means of the filler gauge. Be careful not to damage the thrust bearings when measuring by filler gauge. Maintenance of the Thrust Bearings The clearance between thrust bearing and crankshaft should be within the tolerance.

G09200

Tolerance :

G09200

If the clearance is out of the tolerance, then the thrust bearings need maintenance as below. 1. Dismount main bearing cap for thrust bearings.

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2. Dismantle the thrust bearings by unscrewing the fixing bolts. 3. Inspect the surfaces of thrust bearings and repair them. If the measured clearance is smaller than the tolerance, then reduce the thickness of the bearing by polishing the running surface evenly. If the measured clearance is bigger than the tolerance, then replace them by the new ones. 4. Coat loctite 243 on fixing bolts and assemble the thrust bearings on the main bearing cap. 5. Mount the main bearing cap on the engine. Page 3/5

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Cylinder Liner & Water Jacket Assembly Drawing & Part List

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LDFV15000

941 902

Detail "A"

192

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Cylinder Liner & Water Jacket Assembly Drawing & Part List

LDFV15000

Part List Item No. Description Q’ty / Cyl. Weight(kg) Remarks / See Note 111 Cylinder liner 1 Approx.193 120 Flame ring 1 Approx.3 191 Metal gasket 1 Approx.0.47 192 O-ring 1 Approx.0.12 193 O-ring 2 Approx.0.08 194 O-ring 1 Approx.0.07 195 Compensation ring 1 Approx.0.17 210 Water jacket 1 Approx.118 901 O-ring 1 902 O-ring 1 921 Piece 1 Approx.0.47 922 O-ring 1 923 O-ring 1 924 Cylindrical pin 1 Approx.0.02 931 Socket head bolt 1 Approx.0.01 941 Socket head bolt 4 Approx.0.12

Cylinder Liner & Water Jacket General Instruction

G15100

Cylinder Liner and Water Jacket Cylinder liner is made of special alloy cast iron for high wear resistance, which is cooled by fresh water only on upper part surrounded by water jacket. Flame ring is mounted on the upper part of the cylinder liner and scrapes carbon deposit as well as excessive lubricating oil on piston crown, which contributes to reduce lubricating oil consumption. Water jacket is made of ductile cast iron and mounted on t he engine block. The water jacket provides not only cooling water flow channel between cylinders but also combustion air passage from engine block to cylinder head as shown in fig. 1. Combustion Air

Whenever cylinder liner and water jacket dismantled from the engine, inspect carefully if there is any damage or abnormal wear or deposits. Clean them thoroughly before remounting on the engine.

Lifting Cylinder Liner For maintenance, the cylinder liner can be liftedby water

jacket (a) or lifting tool (b) as shown In fig 1. When lifting the cylinder liner with the water jacket, the water jacket should be dismantled in advance. The cooling water in the water jacket should be drained through drain cock prior to dismantlement. While lifting the cylinder liner, taking care that the O-rings don’t tear. 91.150

Mounting Cylinder Liner on Water Jacket Before mounting, the cylinder liner and water jacket should be maintained and cleaned in advance. 1. Install lifting tool for cylinder liner as shown on (b) of fig 1. 2. Coat clean grease on O-ring of the cylinder liner.

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3. During lowering the cylinder liner into water jacket, match the positioning bolt and groove as shown in fig 2.

4. After mounting, check the height of cylinder liner

from top of the water jacket. G09200 G09200 Measurement of Cylinder Liner Bore

from top of the water jacket. G09200 G09200

Measure the diameter of the cylinder liner bore at regular interval and keep the records. Check th

e bore is within the wear limit. G09200G09200

The measurements for both diameters of trans-verse and longitudinal direction should be taken at three points of the cylinder liner as shown in fig 3. When measuring, the temperatures of

bore gauge and the cylinder liner sho91.260

uld be same. If the diameters of the cylinder liner bore are not within the wear limit during measuring, be sure to horn the bore of cylinder liner. Please contact Hyundai Global Service Co., Ltd for more information

Groove

Bolt

91.260

91.260

Grinding of Sealing Faces Whenever cylinder head and liner is dismantled, check the sealing faces carefully and, if necessary, grinds the surfaces as shown in fig 4. Sealing faces for grinding; 1. Cylinder liner (a) 2. Engine Block (b) 3. Cylinder head bottom (c)

Grinding tool : 91.140 91.140

When grinding the engine block, turn over the tool. When grinding the cylinder liner, take out sealing ring.

91.140

Honing the Cylinder Liner Re-honing will restore the original state of roughness of the cylinder liner running surface. This roughness is needed to ensure a sufficiently thick and properly adhering lubricating film. While the original micro geometry can be restored, the wear profile, the macro geometry of the cylinder liner, cannot be altered. Prior to honing, deposits of coke and possible wear edges at the top of the liner must be removed by scraping.

Honing Machine :(optional) 91.782 91.782

A used flame ring must be used during the honing process. The used flame ring must be cleaned in water. Subsequently, the flame ring is remounted in the cylinder liner before carrying out the honing process. Upon completion of the honing process the used flame ring is discarded. A new flame ring is always mounted in the cylinder liner when replacing the piston rings. Chris-marin HONS or Hunger PHM machine is recommended for cylinder liner rehoning.

Removal device for flame ring: 91.270 91.270

Rehoning must be continued until the cylinder wall is covered by honing grooves and the surface has a slightly matt appearance without any signs of glaze. During the honing it is important to lubricate freely with honing oil or cutting oil. After the honing, the liner is carefully cleaned with gas oil. Make sure that all abrasive particles are removed.

91.270

91.270

Pag 173
Inspection and Honing Measurement of Cylinder Liner

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M15101

99 99

99

Cam□□Exh.Side Fwd.□□Aft. Side

Pag 174
Feed Block Assembly General Instruction

H35DFV Section No.

Page 1/2 Rev.

G17000

Description The engine needs continuous feeding of combustion air, cooling water and lubricating oil for normal operation. The engine has modularized feed system which called Feed Module. Feed Module consists of feed block and components for each fluid system. The feed block is a s tructure made of cast iron and installed at free end side of the engine. The feed block provides cast-in passages and spaces for mounting the equipments for each fluid system. Hence, the engine internal circuits for water, oil and air can be completed without pipe connections, which provide easier maintenance. This section describes the feed block proper and attached parts. The details regarding each fluid system are described in later sections.

Exh. Gas Outlet

Oil Mist Vent Connection

HT Water Inlet Connection

LT Water Inlet Connection

HT Water Outlet Connection

LT Water Outlet Connection

G17000

LDFV84000 Charger Air Cooler LDFV71000 C.W Pump

100

919920924925

919920911912

101 917 918 902 526 527

913914

902520 521

Detail “A”

917 918 919920960

911912960

915269261916901Detail “B”

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912 911

954912911View “C”

912 911

918

912

912

950 904 905 600

Part List Item No. Description Q’ty / Eng.Weight(kg) Remarks / See Note 100 Front end block-lower 1 Approx.1,724.0 101 Front end block-upper 1 Approx.2,543.93 261 Cover 1 Approx.7.70 269 O-ring 1 Approx.0.03 520 Cover 1 Approx.12.76 521 Gasket 1 Approx.0.19 526 Cover 1 Approx.17.84 527 Gasket 1 Approx.0.16

917

911

911

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Pag 180
Arr. Of flywheel cover Assembly Drawing & Part List

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151 22 1 Detail "A"

131 211 216 212 221 218 215 217 214

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Arr. Of flywheel cover Assembly Drawing & Part List

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LDFV19100

Part List

Item No. Description Q’ty / Cyl. Weight (kg) Remarks / See Note 110 Oil sealing cover assembly 1 Approx.178 Include item no.211~221 211 Sealing ring upper 1 Approx.52.8 212 Sealing ring(lower) 1 Approx.32.4 213 Sealing cover 1 Approx.88.6 214 Drain pipe 1 215 Oval packing 2 216 Parallel pin 2 Approx.0.02 217 Bolt 4 Approx.0.13 218 Bolt 8 Approx.0.05 219 Bolt 8 Approx.0.07 220 Nut 8 Approx.0.02 221 Parallel pin 2 Approx.0.02 131 Bolt 28 Approx.0.11 150 Splash ring 1 Approx.21.85 151 Parallel pin 1 Approx.0.01

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500

200

226

230

6225 View "C" 227

222 224 224 232 228 223Detail "A"

227221

228View "B"

Arr. Of Cam/Crankcase Cover Assembly Drawing & Part List

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LDFV19300

323 611 612

323 611

363 364 360 611 612 390 340

380

322 321 614 621 622 380 613 320 324 614 613 362 361

324 322 614 613

322

362 361

A-bank

340 390 611 612

611 612

910 380 318 380 319 614 614 613 621 622 613

910 380 318 380 319 614 614 613 621 622

B-bank

Arr. Of Cam/Crankcase Cover Assembly Drawing & Part List

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511 513 517 512

515 516 View “A”

514

Part List

Q’ty / Eng. Weight

Item No. Description

Remarks / See Note

Remarks / See

12 Cyl 14 Cyl 16 Cyl 18 Cyl 20 Cyl

Weigh(kg)

318 Crankcase cover 5 6 7 8 9 Approx.15.17 380 Sealing ring 5 6 7 8 9 Approx.0.05 319 Crankcase cover 1 1 1 1 1 Approx.14.98 380 Sealing ring 1 1 1 1 1 Approx.0.05 320 Crankcase cover 5 6 7 8 9 Approx.16.91 360 Relief valve 5 6 7 8 9 Approx.16.1 361 Bolt 30 36 42 48 54 362 Washer 30 36 42 48 54 Approx.0.41 363 O-ring 5 6 7 8 9 364 caution plate 5 6 7 8 9 Approx.0.01 380 Sealing ring 5 6 7 8 9 Approx.0.05 321 Crankcase cover 1 1 1 1 1 Approx.16.71 322 Relief valve 1 1 1 1 1 Approx.16.1 323 O-ring 1 1 1 1 1 324 caution plate 1 1 1 1 1 Approx.0.01 380 Sealing ring 1 1 1 1 1 Approx.0.05

Arr. Of Cam/Crankcase Cover Assembly Drawing & Part List

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Item No. Description

Q’ty / Eng. Weight

g(kg)

Remarks / See Note

Remarks / See

12 Cyl 14 Cyl 16 Cyl 18 Cyl 20 Cyl

340 Cover 12 14 16 18 20 Approx.8.62 390 Sealing ring 12 14 16 18 20 Approx.0.11 511 Air chamber relief valve 1 1 1 1 1 512 Support 1 1 1 1 1 Approx.21.18 513 Gasket 1 1 1 1 1 Approx.0.1 514 Bolt 8 8 8 8 8 Approx.0.36 515 Washer 8 8 8 8 8 Approx.0.01 516 Bolt 8 8 8 8 8 Approx.0.08 517 Gasket 1 1 1 1 1 Approx.0.11 611 Bolt 48 56 64 72 80 Approx.0.1 612 Nut 48 56 64 72 80 Approx.0.06 613 Bolt 24 28 32 36 40 Approx.0.11 614 Washer 24 28 32 36 40 Approx.0.01 621 Bolt 72 84 96 108 120 Approx.0.04 622 Nut 72 84 96 108 120 Approx.0.03 910 Plate(check tightening) 2 2 2 2 2 Approx.0.01 Remark) Refer to position of cover with relief valve ass’y(POS.318, 319)

NO. of Cylinder

Engine type

Engine

10

12H35DFV 14H35DFV 16H35DFV 18H35DFV 20H35DFV

Cylinder head assembly includes cylinder head, rocker arms and valves for intake air and exhaust gas. Fuel injection valve, MP (Micro Pilot) injection valve,

engine starting valve and cylinder pressure sensor are mounted on the cylinder head. Cylinder head is mounted on the cylinder liner and fixed by four hydraulic studs on the engine block. Cylinder head is made of ductile cast iron and has cast-in passages for cooling water, intake air and exhaust gas. Fig 1 shows the cooling water flow in

cylinder head. (See for lubricating M23000

oil flow in cylinder head) Two intake valves and two exhaust valves are mounted on the cylinder head. Each valve has a spring and a valve rotator, which is operated by yoke and rocker arm.

Seats for intake and exhaust valves are fitted on the bottom of cylinder head and replaceable when worn or damaged. Seats for exhaust valves are cooled by cooling water. Fuel injection valve and MP injection valve are mounted on the bush which is assembled in the cylinder head. Cylinder head is a part of combustion chamber, which should be overhauled and maintained at regular interval for reliable operation with high performance. Cylinder head has a check hole against leakage of contact faces between cylinder head and liner as shown in fig. 2. Watch the check hole always. If there is any leakage of combustion gas or water, stop the engine immediately and overhaul the cylinder.

Cylinder Head Assembly Assembly Drawing & Part List

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LDFV21100

605 606 600 903 902

101

807

116 134

811 802 812

903 View "A" 902

903

Part List Item No. Description Q’ty / Cyl. Weight(kg) Remarks / See Note 101 Cylinder head 1 Approx. 374 114 Bush 1 Approx.1.88 119 O-Ring for fuel valve bush 2 500 MP injector bush 1 Approx.0.96

LDFV21100

Item No. Description Q’ty / Cyl. Weight(kg) Remarks / See Note 504 O-Ring for MPI bush 2 115 Closing cover 4 Approx.0.05 116 Plug 1 Approx.0.1 117 Plug 1 Approx.0.01 131 Plug 1 Approx.0.06 132 Gasket 1 134 Gasket 1 140 Gasket 1 141 Plug 1 Approx.0.41 142 Gasket 1 902 Plug 2 Approx.0.19 903 Gasket 2 111 Intake valve seat ring 2 Approx.0.86 112 Exhaust valve seat ring 2 Approx.1.29 113 Valve guide 2 Approx.1.21 114 Valve guide 2 Approx.1.19 118 O-Ring 2 121 Retaining ring 1 Approx.0.02 291 O-Ring 2 292 Valve stem seal 2 Approx.0.01 505 Retaining ring 1 Approx.0.01 600 Pressure sensor bush 1 Approx.0.8 605 Bolt 2 Approx.0.02 606 Nord-lock washer 2 701 Parallel pin 2 901 O-Ring 1 800 Cylinder head cover complete 1 Approx.12.95 Include Pos.801~810 801 Cylinder head top cover - Upper 1 Approx.6.4 802 Cylinder head top cover - Lower 1 Approx.5.1 803 Spring pin 1 Approx.0.01 804 Grip 1 Approx.0.47

LDFV21100

Item No. Description Q’ty / Cyl. Weight(kg) Remarks / See Note 805 O-Ring 1 806 O-Ring 1 807 O-Ring 1 808 Washer 1 Approx.0.01 809 Washer 1 Approx.0.01 810 Nut 1 Approx.0.05 811 Bolt 4 Approx.0.2 812 Plan Washer 4 Approx.0.02

M21100

Dismounting a Cylinder Head from the Engine 1. Check prerequisites to dismount a cylinder head. Cooling water, lubricating oil and fuel oil should be drained from the engine. (See “Preparations

for Maintenance” in

G09110

2. Dismount insulations on exhaust duct of cylinder head. 3. Disconnect cooling water pipes by moving axially toward driving end. 4. Dismount upper/lower cover on the cylinder head and cover for fuel pump room. 5. Dismount high pressure block from the cylinder head and the fuel injection pump. Put on clean rag around fuel high pressure block and wrap the block against fuel oil dropping. After dismounting fuel high pressure block, put a covering tape on the outlet of fuel injection pump to avoid contamination of fuel injection pump inside. 6. Dismount cables for cylinder pressure sensor, knocking sensor, SOGAV (Solenoid Gas Admission Valve), exhaust gas temp. sensor. Reassemble for cylinder pressure sensor knocking sensor and then tightened correctly with tightening torque. Knocking sensor : 20 Nm, Cylinder sensor : 15 Nm 7. Dismount all sorts of pipes (LO, Air) from the cylinder head. 8. Loosen and dismount four nuts for cylinder head studs hydraulically at the same time.

Loosening procedure : G09500 G09500

Loosening pressure : max. 1170 bar

Hydraulic tool : 91.400 91.480 91.500 91.400 91.480 91.500

M21100

9. Install lifting tool on the studs for fuel injection valve and hook up onto a crane.

Lifting Tool : 91.110 91.110

Lifting Tool : 91.110 91.110

(After remounting a stud for top cover support and Install the lifting jig.) 10. Lift up the cylinder head slowly and carefully. (Fig. 2-b) Be careful not to be damaged by touching adjacent parts. 11. Move and put the cylinder head o n a s table working stand (Optional). (Fig. 2-a) 91.858

M21100

Mounting a Cylinder Head on the Cylinder Liner and Water Jacket 1. Make sure that covering tapes or the likes are removed. 2. Install lifting tool on the studs for fuel injection valve and h ook up ont o a c rane. 3. Lift up the cylinder head from the working stand and c lean the bottom of cylinder head. 4. Check and c lean the contact areas before mounting Water jacket, cylinder liner and frame ring Exhaust gas duct. 5. All O-rings should be checked and replaced by new ones, which also should be c leaned and greased before mounting.

 rings on the bottom of cylinder head ring on the cylinder liner 6. Clean the sealing ring on top of the cylinder liner, after coat sealing paste (COPASLIP) for heat resistance. 7. Move and lower the cylinder head slowly down through the bore of the water jacket, while positioning the connection pieces for lubricating oil and cooling water correctly. Be careful not to be damaged by touching adjacent parts. 8. After landing the cylinder head on t he water jacket, check the assembled condition. 9. Continue the processes for mounting of the cylinder head.

Replacement of the Valve Seat Rings If a valve seat ring is so worn or damaged that cannot be reconditioned any more, then the valve seat ring should be replaced by new one. The valve seat ring can be replaced by a special tool or scrapped valve as following procedures. Extracting the Old Valve Seat Ring by welding 1. Prepare a scrapped valve spindle and machine the valve diameter to be smaller for easier welding of the valve and the seat ring. 2. Mount the scrapped valve spindle on the head. 3. Weld the valve spindle to the seat ring diagonally by means of electric beam welding. Protect the machined surface around valve seat of the cylinder head by shielding noninflammable material against welding. 4. Press or knock the valve spindle by means of soft hammer to extract the seat ring. Be careful not to damage the valve guide bush and cylinder head. Extracting the Old Valve Seat Ring by Tool

1. Mount the extracting tool (optional)

on the valve seat as shown in fig 1. 2. Clamp valve seat ring tightly by turning nut (A). 3. Extract the valve seat ring by turning nut (B).

91.580

91.580

91.580

Fitting a New Intake Valve Seat Ring into the Cylinder Head 1. Measure the diameters for pressure fitting. Interference in diameter between cylinder head and seat ring should be 0.067-0.117 mm. 2. Clean the new seat ring and cylinder head thoroughly. Scratched mark or burr inside bore of the cylinder head should be removed. 3. Fit the seat ring into the cylinder head by cooling or by pressing as shown in fig 2. When cooling : the seat ring to be –190 ℃ by means of liquid nitrogen.

When pressing : use tool 91.65091.650

(Optional) 91.660

4. The contact of both seating surfaces of valve and seating should be checked. 1) Coat blue compound to be thin layer on the seating surface of the valve. 2) Mount valve into the valve guide of cylinder head. 3) Rotate valve about 1/3 turn several times with pressing lightly. 4) Check whether the contact mark starts from outer diameter radially and counties circumferentially more than 2~3mm width. 5. Grind the seat ring by valve grinding tool, if necessary. (See “Grinding of the seating surface”

in) M21200

M21200

M21200

Fitting a New Exhaust Valve Seat Ring into the Cylinder Head 1. Measure the diameters for pressure fitting. Interference in diameter between the bore of cylinder head and seat ring should be 0.067-0.117 mm. 2. Clean the new seat ring and cylinder head thoroughly. Scratched mark or burr inside bore of the cylinder should be removed. 3. Never cool down the seat ring by means of liquid nitrogen or dry ice. If cooled down, the O-ring may be damaged. 4. Coat oil on O-ring and loctite 640 on sealing surface of the seat ring. 5. Fit the seat ring by pressing or hammering on the tool as shown in fig 2.

Tool for intake valve seat ring (Optional)

91.660

91.650

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6. Grind the seat ring by valve grinding tool. (See “Grinding of the seating surface”

in) M21200

7. Check water leakage around the new valve seat by hydraulic pressure test.

Use tool (Optional) 91.745

Test pressure : 7 - 10 bar * Repair by using oversize valve seat rings If the interference between a valve seat ring and a cylinder head exceeds the following minimum limit, a special action should be taken, i.e. using a specially oversized seat ring and re-machining cylinder head. (For detail, please contact Hyundai Global Service Co., Ltd) * Nominal interference : 0.067~0.117, in diameter * Minimum limit : 0.030, in diameter

M21200

M21200

M21130

Replacement of the Valve Guide If a valve guide exceeds the wear limit or damaged

G09200

(see), then the valve seat ring should G09200 be replaced by a new one. When extracting and fit-ting the valve guide, same tool can be used as shown in fig 3. 1. Mount the tool as shown in fig 3.

Fit/Removal device : , (Optional) 91.670

Pag 200
Valve Spindle Guide Maintenance Procedure

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M21130

4. Cool down the valve guide to –70 ℃ by liquid nitrogen.

5. Fit valve guide by means of the tool

with hammering softy on the tool as shown in fig 4. Be careful not to damage the valve guide during hammering. 6. Insert a new O-ring inside bore of valve guide by means of the tool or valve spindle or rounded rod. Do not use sharp edged rod such as screwdrivers which can scratch the bore of valve guide.

Pag 201
Fuel Valve Bush Maintenance Procedure

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M21140

Dismounting of the Fuel Valve Bush 1. Mount the tool as shown in fig 1.

, Removal device : 91.940 91.940

Removal device :

2. Hook the tip of the tool on the hole of locking

ring and extract the locking ring as shown in

ring and extract the locking ring as shown in 91.940 91.940 fig 2

fig 2.

Fig. 2 Dismounting of Locking Ring

3. Mount the tool as shown in fig 3.

Removal device : 91.720 91.720 91.730

Removal device : 91.720 91.730 91.730

Removal device : 91.720

4. Press or knock the tool by means of soft hammer to extract the valve bush. 5. Assemble the fuel valve bush in the reverse order of dismounting. To be press fitted with Loctite 620 or equivalent. 91.730

Fuel injection valve bush MP injection valve bush

Valve and Rocker Arm Mounting Assembly Assembly Drawing & Part List

H35DFV Section No. LDFV21200

Page 1/3 Rev. 1A

Valve and Rocker Arm

328 325 442 206

324 328 321 322

204 36 201

Part List Item No. Description Q’ty / Cyl. Weight(kg) Remarks / See Note 200 Intake & exhaust valve assembly 1 Include Pos.201,202,204,206,207 201 Valve spindle - inlet 2 Approx.2.86 202 Exhaust valve spindle 2 Approx.3.17 204 Roto cap 4

Approx.0.6 206 Conical clamping piece 4 Approx.0.07 207 Valve spring 4 Approx.1.9

Valve and Rocker Arm

Item No. Description Q’ty / Cyl. Weight(kg) Remarks / See Note 300 Rocker arm and yoke assembly 1 Include Pos.310,320,330,341, 343,430,440,436 310 Rocker arm assembly - intake 1 Include Pos.311~318 311 Rocker arm - intake 1 312 Adjusting screw 1 Approx.0.26 313 Thrust piece 1 Approx.0.17 314 Nut 1 Approx.0.07 315 Ball seat 1 Approx.0.2 316 Clip ring 1 317 Bush 1 Approx.0.71 318 Fine threaded plugs 2 320 Rocker arm assembly - Exhaust 1 Include Pos.321, 440 321 Rocker arm - Exhaust 1 322 Adjusting screw 1 Approx.0.26 323 Thrust piece 1 Approx.0.17 324 Nut 1 Approx.0.07 325 Ball seat 1 Approx.0.2 326 Clip ring 1 327 Bush 1 Approx.0.71 328 Fine threaded plugs 2 330 Shaft 1 Include Pos.331 331 Fine threaded plugs 1 Approx.0.01 341 Rocker arm support 1 Approx.8.28 343 Parallel pin 4 430 Yoke assembly - intake 1 Include Pos.431,432,435,439 431 Yoke - intake 1 Approx.1.86 432 Thrust piece 1 Approx.0.12 435 Adjusting screw 1 Approx.0.2 439 Nut 1 Approx.0.03 436 Shaft pin 2 Approx.0.8 440 Yoke assembly - Exhaust 1 Include Pos.441,442,445,449

Valve and Rocker Arm

Item No. Description Q’ty / Cyl. Weight(kg) Remarks / See Note 441 Yoke - Exhaust 1 Approx.1.85 442 Thrust piece 1 Approx.0.12 445 Adjusting screw 1 Approx.0.2 449 Nut 1 Approx.0.03 351 Stud 2 Approx.0.64 352 Spacer 2 Approx.0.19 353 Nut 2 Approx.0.1

M21200

Dismantling of Intake and Exhaust Valves The intake and exhaust valves should be overhauled and checked at regular interval as frequently as possible. Before dismantling the valves, cylinder head should be dismantled from the engine and rocker arms, yokes and f uel injection valve also should be dismantled from the cylinder head. Whenever dismantling, it is recommended to overhaul the four valves at the same time. Hence, the tool for dismantling valves is adequate for this purpose. 1. Mount tool for dismantle as shown in fig 1.

91.120

Fit/Removal device :

91.120

2. Press and lower the spring by turning the nut of the tool as shown in fig 2.

M21200

Assembling of Intake and Exhaust Valves on the Cylinder Head The valves, springs and rotocaps should be maintained and cleaned before remounting. Before remounting, each valve and seat rings should be free from any crack. Make sure that crack test, for example, dye penetration test has been carried out for them. 1. Clean the valve guides and seat rings thoroughly. 2. Coat clean lubricating oil inside valve guide.

3. Replace O-rings on the valve guide. L21100

The O-rings should be replaced by new one at every overhaul of valve spindle. If there is any blow-by through the valve seats, the O-ring may be overheated and also should be replaced by a new one. 4. Coat clean lubricating oil on the valve stem. 5. Check location mark which has been done before dismantling. The valve should be fitted at the original position. 6. Insert valve spindle into valve guide carefully and then check its smooth movement. 7. Assemble the springs and rotocaps on t he cylinder head in the reverse order of dismantling. Overhaul of the Intake and Exhaust Valves and Seat Rings 1. Check the deposits on the valves and around seat rings. If unusual deposits are found, contact the engine manufacturer. 2. Remove carbon deposits on the valves and seat rings and clean them thoroughly.

M21200

3. Measure the dimensions for wearing.

G09200 G09200

If the measurements exceed the wear limit, the valve or seat ring should be scrapped and not reused. 4. Inspect all around valve spindles and seat rings carefully. 5. Check crack on a ll around valve spindles and seat rings by means of, for example, dye penetration test. Any crack is not allowed. Reconditioning of the Seating Surface In order to judge the condition of the seating surface, coat small amount of a f ine lapping compound on both seating surfaces and rub the surfaces by rotating valve manually several times. Then clean the surfaces and check the conditions. Depending on the condition of the seating surface, the countermeasures are as follows. 1) Criteria for major overhaul (Refer to G09100 for overhaul interval) If the surface has continuous contact area, the valve and seat can be used more. Black Spot or Minor Dent In case of black spots or minor dents on contact surface, it can be reused after lapping until the surface is clean. It is not essential to remove all marks in noncontact area. Minor marks after lapping can be acceptable.

Dent It can be reused after reconditioning until the surface is clean by grinding. Minor mark left after reconditioning can be acceptable. If the surface has several small shallow pits, lapping is recommended instead of grinding.

Lapping device for inlet/exhaust valve :

(optional) If the surface has pits all around or grooves, grinding by machine is required. Gas passage If there is a gas passage more than 1/3 length on contact surface, valves or seats are to be replaced.

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2) Criteria for aperiodic inspection If the surface has continuous contact area without gas passage, the valves and seats can be used more. If the engine operating data(G01400) are within normal range, the valves and seats which found black spots or dents on contact area can be used until next major overhaul without replacement or maintenance. Grinding of the Seating Surface The grinding works should be carried out by a qualified personnel according to the procedures specified by the machine maker. Before grinding, check the dimensions if there is any margin for grinding. The grinding dimensions are as follows. Grinding angle Valve spindle : 30 ˚-0˚5' / 0 Valve seat ring : 30 ˚+0˚10' / +0˚15' Grinding limit Valve spindle : 9 mm (G09200 : C, E) Valve seat ring : 0.3 mm Be careful that material loss by the grinding should be minimized. The grinding should be proceeded only until to get clean surface all around. After grinding, crack test on seating surface, for example, dye penetration test should be carried out. The seating surface should be free from any crack.

M21200

Checking of the Seating Surfaces after Reconditioning After grinding, the contact of both seating surfaces of valve and seat ring should be checked. 1. Coat blue compound to be thin layer on the seating surface of the valve. 2. Mount valve into the valve guide of cylinder head. 3. Rotate valve about 1/3 turn several times with pressing lightly. 4. Pull the valve and check the contact mark on the seat ring. The contact mark should be started from outer diameter toward inward radially and the contact area should be more than 2~3mm.

Pag 211
Rocker Arm Assembly Maintenance Procedure

M21210

The rocker arm assembly has wearing parts and adjusting parts as well, which should be overhauled at regular interval and whenever cylinder head dismounted. The wearing parts especially bearing and shaft for rocker arm should be overhauled and replaced by

new one if they exceed the wear limits.

G09200

The clearances of the rocker arms and yokes are critical for reliable operation of the engine with good performance, which should be c hecked periodically as frequent as possible. In addition, be sure to carry out the adjustment whenever cylinder head remounted and check again after about 50 running hours firstly at least. The adjustment procedures are same for both intake and exhaust valve systems. Adjustment for balancing Yoke As two intake or exhaust valves are pressed by one yoke simultaneously, the yoke should be well balanced by precise adjustment as follows. Maladjustment of yoke clearance causes unbalance force on the yoke which results abnormal

wear or damage on the yoke and guide pin. L21100 If the guide pin or the

yoke is damaged or broken, repeated unbalanced motion of the valve spindles may lead to failure of the valve spindle and serious damage on the engine.

M21210

1. Rotate crankshaft so that the valves are in fully closed position. The corresponding cylinder needs to be at around firing TDC. 2. Check both push rods are free from spring forces and have clearances. 3. Loosen the lock nuts (1, 3) and adjusting screws (2, 4). 4. Press the non-adjusting side of yoke in order to contact with top of valve stem (A) firmly as shown on fig 1.

5. While contacting (A) by pressing, rotate the adjusting screw (2) until contacting with top of the valve stem (B). 6. Tighten the lock nut (1). 7. In order to check the simultaneous contact of both valve stems, coat blue compound after dismantling yoke and check the contact after remounting yoke. 8. If the both valve stems were not contacted simultaneously, check the contact after readjusting the lock nut (2). (Yoke has to be replaced to new one when simultaneous contact is not fulfilled.)

M21210

9. Repeat the adjustment until the both clearances are same value, and then tighten the lock nut (1) while holding the adjusting screw (2) not to be

turned. G09400 G09400

Tightening torque : 170 Nm (with molycote) This repeat is necessary because the

yoke can be tilted when pressing one side due to clearance between yoke and guide pin. 10. After locking, measure the both clearances again for confirmation. Adjustment of Valve Clearance After adjustment of the yoke balancing, continue to adjust valve clearance as follows; 1. Check the wearing parts of rocker arm assembly maintained correctly. 2. Check the nut (5) for fixing rocker arm tightened correctly or tighten them again. Tightening torque: 400 Nm (with molycote) 3. Loosen the lock nut (3) and adjusting screw (4) of rocker arm. 4. Put a dial gauge on the yoke and insert a feeler gage between rocker arm and yoke (D). Thickness of feeler gauge : 0.9 mm 5. Rotate the adjusting screw (4) until bottom of the adjusting screw contacting with push rod. 6. Tighten the lock nut (3) while holding the adjusting screw (4) not to be turned. Tightening torque:250 Nm (with molycote) 7. After locking, measure the clearances again for confirmation while pressing the push rod side of rocker arm firmly. If necessary, readjust. Adjust method of Intake and exhaust valve clearance is same.

Roto Cap Maintenance Procedure

All type Section No.

Page 1/3 Rev.

M21220

The roto cap is installed on the intake and ex haust valves in the cylinder head and the function of roto cap is making proper rotation of valve spindles. Incorrect rotation of the roto cap may cause carbon bite-in on the valve seating surface and shorten the service lifetime of the valve spindles and valve seats. Therefore the function test and overhaul inspection of the roto cap should be done regularly according to the maintenance schedule.

Maintenance Interval: G09100 G09100 Motion Mechanism of Roto Cap

Maintenance Interval: G09100 G09100

Valve Spindle

Valve Spring

Fig. 1 Valve Spindle Assembly and Roto cap

When the valve spindle is opened by rocker arm and yoke, the disk spring located in the roto cap is flattened out by the increasing force of the valve spring [Fig.1].

Body Disc Spring Retainer Stop Ring Coil Spring Steel Ball

In the process, it applies a load to the steel balls inserted in the pockets of the body, forcing them to roll on their sloping ways, and rolls on the balls itself. On the other hand, disk spring, retainer, and valve spring are engaged frictionally, so that they cannot rotate relative to on another. The relative rotation between the disk spring, retainer and body is transmitted via the body of roto cap to the valve spindle, so the body and valve spindle rotate. When the valve closes, the load on the disk spring is relieved, and thus the steel balls are then pushed back into their initial position by the coil springs, without rolling. Function Test of Roto Cap 1. Dismantle the cylinder head cover from cylinder head. 2. Put the marking between roto cap and yoke with same direction. [Fig.2] 3. Mount the cylinder head cover, start the engine and run with idle condition for 1~2 minutes. 4. Stop the engine, and open the cover to check the moved marking position. [Fig.3] 5. If the marking position is same with initial one, operate the test running 2 or 3 times more to check the marking position. 6. The roto cap should be overhauled and checked abnormality if there is no change of marking position at re-checking. 7. The procedure of overhaul inspection is following ‘maintenance procedure of intake & exhaust valve ass’y’.

Maintenance Procedure: M21200 M21200

8. When you remove the roto cap without dismantling cylinder head, set the piston to TDC (Top Dead Center) to make sure that the intake /exhaust valves do not fall down to combustion chamber

Fig. 2 Marking on the roto cap and yoke Fig. 3 Changed marking position

Overhaul Inspection of Roto Cap 1. Remove the stop ring. 2. Remove the retainer and disc spring. 3. Remove the steel balls and coil springs from body. 4. Clean each individual part. 5. Check the mating parts for groove wear, deformation, breakage and corrosion, etc. Replace them if necessary. 6. Insert steel balls and c oil springs in the ball-pocket slopping ways located in the body. 7. Insert the disk spring, put on the retainer, and install the stop ring. 8. Immerse the roto cap in clean lub. oil and remove it again shortly before installing. Make sure that the coil springs, steel balls and disc springs should be installed in the correct direction. Never pack the roto cap with grease.

Starting Valve Assembly Assembly Drawing & Part List

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LDFV21400

B-bank A-bank 408 420 417 416 415 414 411

424

431

408 501 417 416

407 418 401 405 403 406 404

415 414 413 412 411 402

A-bank B-bank

Starting Valve Assembly Assembly Drawing & Part List

H35DFV Section No.

Page 2/2 Rev.

LDFV21400

Part List

Q’ty / Eng. Weight

Item No. Description

Remarks / See Note

Remarks / See

12 Cyl 14 Cyl 16 Cyl 18 Cyl 20 Cyl

Weigh(kg)

400 Starting valve complete 6 7 8 9 10 Approx.3.9 Include item no.401~418 401 Valve 6 7 8 9 10 Approx.0.31 402 Casing 6 7 8 9 10 Approx.2.95 403 Piston 6 7 8 9 10 Approx.0.47 404 Spring 6 7 8 9 10 Approx.0.17 405 O-ring energized seal 6 7 8 9 10 406 O-ring energized seal 6 7 8 9 10 407 Castle locking nut 6 7 8 9 10 Approx.0.01 411 O-ring 12 14 16 18 20 412 O-ring 6 7 8 9 10 413 O-ring 6 7 8 9 10 418 Split pin 6 7 8 9 10 501 Pusher complete 6 7 8 9 10 Include item no.414~418 414 O-ring 12 14 16 18 20 415 O-ring 12 14 16 18 20 416 O-ring 12 14 16 18 20 417 O-ring 12 14 16 18 20 418 Split pin 6 7 8 9 10 408 Bolt 24 28 32 36 40 Approx.0.09 420 Starting valve blank 6 7 8 9 10 Approx.11.7 Include item no.411~417 424 Plug 6 7 8 9 10 Approx.0.04 425 Gasket 6 7 8 9 10 431 Plug 6 7 8 9 10 Approx.0.31 432 Gasket 6 7 8 9 10

M21400

Dismantling and assembling of starting valve

[Fig. 1]

▲ Caution: When dismantling the starting valve make sure that no dirt can enter the inner pipe system with blocking the entrance. 1. Drain the HT cooling water. [Fig.1] 2. Drain HFO. [Fig.1] 3. Dismantle the high pressure block and connection piece.[Fig. 1-3] 4. Dismantle the rocker arm and rocker arm support [Fig. 1-4]

Connection piece

<Section drawing>

[Fig. 2]

pusher

[Fig. 3] starting valve

M21400

5. To dismantle the stating valve, dismantle the pusher on the starting valve with lifting eye bolt after removing two M16 bolts (POS.502). 6. The starting valve can be subtracted with lifting tool at the M12 stud. 7. Remounting procedures are reverse order of dismantling.

LDFV21800

B-BANK B 913 900 812 903 902 800 149 835 914 Detail "A"

903

902 151 152 156 150 915

LDFV21800

925 900 901

901 900

823 903 902

814 900 923 903 902 800 149 834 914

151 152 156 150 915 Detail "B"

900 901

923 900 925

900 925

900 913 813 903 902 922

811 903 902

922 914 914 Detail "C" Detail "D"

LDFV21800

831 : 12H, 16H, 18H

832 : 14H, 20H 831 : 12H, 16H, 18H 832 : 16H 831 : 14H, 18H, 20H

825 821 890 912 893 892 905 902 891 822 904 908 902 924 833 913 900 909 Detail "E"

LDFV21800

Part List

Item No. Description

Q’ty / Eng. Weight(kg) Remarks / See Note 12 Cyl 14 Cyl 16 Cyl 18 Cyl 20 Cyl

811 Side cover (A-bank,front) 1 1 1 1 1 Approx.11.68 149 Air cylinder 1 1 1 1 1 150 Cap nut 1 1 1 1 1 Approx.0.06 151 Bolt 4 4 4 4 4 Approx.0.01 152 Nut 4 4 4 4 4 156 Washer 4 4 4 4 4 Approx.0.11 800 Name plate 1 1 1 1 1 812 Side cover(A-bank, flywheel) 1 1 1 1 1 Approx.14.38 813 Side cover(B-bank,front) 1 1 1 1 1 Approx.13.44 149 Air cylinder 1 1 1 1 1 150 Cap nut 1 1 1 1 1 Approx.0.06 151 Bolt 4 4 4 4 4 Approx.0.01 152 Nut 4 4 4 4 4 156 Washer 4 4 4 4 4 Approx.0.11 800 Name plate 1 1 1 1 2 814 Side cover(B-bank, flywheel) 1 1 1 1 1 Approx.14.29 834 Flywheel side cover(B-bank) 1 1 1 1 1 Approx.0.40 835 Flywheel side cover(A-bank) 1 1 1 1 1 Approx.0.41 821 Front cover 12 14 16 18 20 Approx.0.38 825 Handle 20 24 28 32 40 Approx.0.19 822 Pump cover F.O pump cover-lower 12 14 16 18 20 Approx.1.74 890 Bracket 12 14 16 18 20 Approx.2.15 891 Anti splash cover 12 14 16 18 20 Approx.0.31 892 Bolt 20 24 28 32 40 Approx.0.01 893 Washer 20 24 28 32 40 Approx.0.21 905 Bolt 48 56 64 72 80 Approx.0.01 924 Nut 48 56 64 72 80 Approx.0.01 823 Anti splash cover 12 14 16 18 20 Approx.3.51 831 Arrangement pump room duct 3cyl 2 2 4 6 4 Approx.13.98 832 Arrangement pump room duct 2cyl - 4 2 - 4 Approx.9.32

Fuel Pump Side Cover Assembly Drawing & Part List

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LDFV21800

Q’ty / Eng. Weight(kg) Remarks / See Note 12 Cyl 14 Cyl 16 Cyl 18 Cyl 20 Cyl

Item No. Description

Q’ty / Eng.

833 Support 12 14 16 18 20 Approx.2.89 900 Washer 116 134 152 170 188 Approx.0.41 901 Bolt 68 80 92 104 116 Approx.0.02 902 Washer 54 60 66 72 78 Approx.0.01 903 Bolt 18 18 18 18 18 Approx.0.04 904 Bolt 24 28 32 36 40 Approx.0.11 908 Bolt 24 28 32 36 40 Approx.0.07 909 Bolt 12 14 16 18 20 Approx.0.04 912 Washer 24 28 32 36 40 Approx.0.01 913 Bolt 42 48 54 60 66 Approx.0.02 914 Bolt 12 12 12 12 12 Approx.0.01 915 Nut 8 8 8 8 8 Approx.0.01 922 Washer 4 4 4 4 4 Approx.0.21 923 Bolt 6 6 6 6 6 Approx.0.03 925 Nut 6 6 6 6 6 Approx.0.01

Valve Train Assembly Assembly Drawing & Part List

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LDFV23000

901

902 903

213 216 214

208 218

Part List

Item No. Description Q’ty / Cyl. Weight (kg) Remarks / See Note 100 Push rod assembly 1 Include item no.101-102 101 Push rod sleeve 1 Approx.5.1 102 Ball seat 2 Approx.0.52 200 Swing arm and shaft assembly 1 Approx.29 Include item no.201~202, 207~209 201 Swing arm shaft 1 Approx.7.3 219 Fine threaded plug 2 202 Swing arm assembly 2 Approx.9.8 211 Swing arm body 2 Approx.8.86 217 Fine threaded plug 6 212 Roller 2 Approx.0.84

Valve Train Assembly Assembly Drawing & Part List

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LDFV23000

Item No. Description Q’ty / Cyl. Weight (kg) Remarks / See Note

Item No. Description Q’ty / Cyl. Weight (kg)

213 Roller pin 2 Approx.0.61 218 Fine threaded plug 2 214 Roller bush 2 Approx.0.18 215 Swing arm piece bolt 2 Approx.0.17 216 Set screw 2 Approx.0.01 207 Spacer 1 Approx.0.98 208 Disc 2 Approx.0.22 209 Retaining ring 2 Approx.0.02 901 Stud 2 Approx.0.44 902 Nut 2 Approx.0.13 903 Washer 2

M23000

Overhaul of Valve Train Valve Train actuate intake and exhaust valves according to the cam profile, which consists of swing arm, push rod and rocker arms on cylinder head. The swing arm assembly has two rollers and bearings for intake and exhaust valves, which should be overhauled periodically and replaced by new ones if damaged or worn.

(See “Wear limits” of

The swing arms are hung on engine block by a shaft which is fixed 2 bolts. When the bolts unscrewed and both rollers positioned in lowest position on the cams, swing arm can be dismantled through the camshaft cover side as shown in fig 1.

M23000

Fig. 2 shows the lubricating oil flow in valve trains and cylinder head. The lubricating oil supplied from oil channel of the engine block flows into fuel injection pump, tappet rollers and valve trains such as rocker arm, yoke and valve. Then the lubricating oil returns to oil sump after circulating.

Fig. 2 The lubricating oil flow in valve train and cylinder head

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Fig. 3 shows the installation of pipe covers for push rods. When the cylinder head to be mounted, inner half of clamp(1) is place on the flange(2). The pipe covers for push rod(3) are inserted into the flange, then cylinder head is mounted. The pipe covers for push rod is shifted up by hand and outer half of the clamp is slight tightened through its bolt(4). If the pipe covers for push rod is slightly rotatable, then the bolts(5) for clamp to be tightend

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Description H35DF(V) engine is applied Miller timing (early intake valve closing) to satisfy high fuel efficiency and low NOx emission. When intake valve close timing is more advanced, the volumetric efficiency is decreased. As a result, undesirable heavy smoke will be emitted especially in low load operation. Therefore dual valve timing system is required to provide optimal combustion condition for low load operation. DVT system is developed with simple hydraulic principle based on hydraulic non-return valve mechanism. The aimed timing retard is achieved by oil passages in the housing and movements of plungers.

Fig. 1 Dual Valve Timing (DVT)

The system is controlled by charge air pressure and managed with lubricating oil connection and simple air control system powered by 7 bar air from supply line. DVT is actuated only low load operation and the system will be back to the standard valve timing (Miller Timing) at high load operation. DVT is positioned between the engine block and cylinder head where is the space for pushrod covers. • DVT activation at low load (Below predefined engine load) Intake valve close timing retard: crank angle 35°

At the engine is below predefined load, shut-off valve “A” is always in closed position without any external force. When the oil passage to upper side is blocked by the shut-off valve, the downward movement of the upper pushrod is delayed until the passage is opened by the groove of lower plunger “B”. As a result, intake valve is closed later than original timing.

Fig. 2 Delayed timing for smoke reduction at low load

Due to late intake valve closing, air filling in the combustion chamber is better than original. And more air is available for a complete fuel combustion process. • DVT deactivation at high load (Over predefined engine load) At the engine load is higher than predefined load, shut-off valve “A” is always in opened position by cut off control air. Since the return passage to upper side is opened, the oil can flow from lower chamber to upper side without time delay. In this case, early intake close timing (Miller timing) is occurred as designed cam profile.

Fig. 3 Standard Miller timing for high load optimization

• DVT Control System DVT is activated by 3/2 way solenoid valve and pressure switch depending on charge air pressure. The system is switched as follow: ► Engine load < Predefined load : DVT ON (Charge air pressure switch Close, Solenoid valve ON, Control air Cut-off, Shut-off valve Open) ► Engine load > Predefined load : DVT OFF (Charge air pressure switch Open, Solenoid valve OFF, Control air 7 bar, Shut-off valve Close) DVT activation status can be checked on ECU(Engine Control Unit) by PS43(Pressure Switch 43)

Dual Valve Timing Assembly Assembly Drawing & Part List

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820 810 820 320 310 150 160 170 200

140 141 130 120 910 920 112

610 Part List Item No. Description Q’ty / Cyl. Remarks / See Note 100 Dual valve timing assembly 1 Include item no. 110~192 110 Housing for H32 DVT 1 111 O-ring 1 112 Retaining ring 1 113 Plug 3 115 Parallel pin 1 120 Ball seat thrust 1

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Dual Valve Timing Assembly Assembly Drawing & Part List

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Item No. Description Q’ty / Cyl. Remarks / See Note 130 Plunger lower for DVT 1 140 Spring for H32 DVT 1 141 Shim plate for spring seat 2 150 Plunger upper for DVT 1 160 Plunger for check valve 1 170 Spring check valve 1 180 Pusher body 1 181 O-ring 1 182 Pusher tip for DVT 1 190 Cover for spool pusher body 1 191 O-ring 1 192 Bolt 2 200 Guide for plunger 1 300 Housing upper for DVT 1 Include item no.310~340 310 Ball seat thrust upper 1 320 Thrust piece for DVT 1 330 Socket head bolt 4 340 O-ring 1 410 Cover push rod 2 420 O-ring 4 510 Cover flange H35DF DVT 2 520 Flange push rod cover 1 530 Stud bolt 1 540 Nut 1 600 Housing lower for H35DF DVT 1 610 O-ring 3 611 O-ring 1 620 Socket head bolt 2 630 Nut 2 650 Socket head bolt 2 660 Nut 2

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Dual Valve Timing Assembly Assembly Drawing & Part List

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LDFV24100

Item No. Description Q’ty / Cyl. Remarks / See Note 700 Push rod sleeve 1 710 O-ring 2 800 Push rod Ass'y for DVT 1 810 Push rod sleeve for DVT 1 820 Ball seat for DVT 2 900 Push rod Ass'y lower for DVT 1 910 Thrust piece for DVT 1 920 Push rod sleeve for lower 1

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Dual Valve Timing Assembly Maintenance Procedure

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M24100

Overhaul of Dual Valve Timing assembly Dual Valve Timing System(DVT) retard intake

valve closing timing than original, which consists of upper pushrod, cover pushrod, flange holder, cover flange, DVT sub assembly, fixing bolt, exh. pushrod cover, lower housing & lower pushrod. The Dual Valve Timing sub assemblu has one pusher tip for de-activating NRV(Non Return Valve), which should be overhauled periodically and replaced by new ones if damaged or worn.

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Dual Valve Timing Assembly Maintenance Procedure

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M24100

• Dismantling sequence Step 1. Take out pushrod after dismantling rocker arm
Step 2. Take out flange holder for dismount cover flange.

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Dual Valve Timing Assembly Maintenance Procedure

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M24100

Step 3. Lower flange cover with by using general tool. (Mounting flange cover may use special tool.) 91.063 DVT assembly tool

Step 4. Dismount exhaust pushrod cover.

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Dual Valve Timing Assembly Maintenance Procedure

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M24100

Step 5. Dismount two cover pushrod. (Caution for O-ring damage) Step 6. Loosen two fixing bolts.

M24100

Step 7. Take out DVT sub assembly from Engine block. Step 8. Separate lower pushrod from swingarm assembly. Mounting procedures are reverse order of dismantling procedures.

M24100

• Overhaul & Replace pusher tip Separate cover from DVT by loosening two bolts. Check push tip after taking out pusher body. If damaged or worn, replace it with new one.

(See “Wear limits” of) G09200

A-BANK

335

334 331

B-BANK

Section "A - A"

335

334 331

115 117 115 117

117 115 115117

115117

16CYL

12 CYL18 CYL

14 CYL20 CYL

Section "C - C"

116 118 11611814 CYL12 CYL

11811616 CYL

116 118 18 CYL

11811620 CYL

Section "B - B"

120

120119

120

120

119 119

12 CYL 14 CYL16 CYL

120 119

11918 CYL 20 CYL

Section "D - D" Part List Item No. Description Q’ty / Eng. Weight(kg) Remarks / See Note12 Cyl14 Cyl16 Cyl18 Cyl20 Cyl 115 Fitted stud bolt 24 28 32 36 40 Approx.0.23 116 Fitted stud bolt 4 4 4 4 4 Approx.0.2 117 Stud bolt 48 70 96 126 160 Approx.0.23 118 Stud bolt 8 10 12 14 16 Approx.0.2 119 Fitted bolt 20 24 28 32 36 120 Bolt 40 60 84 112 144 122 Nut 228 308 400 504 620 Approx.0.03 123 Fitted bolt 4 4 4 4 4 124 Bolt 8 10 12 14 16 125 Nut 12 14 16 18 20 Approx.0.03

126

Approx.33.6

127 - 1 - - - Approx.33.6

Shaft(A-bank) 128 - - 1 - - Approx.33.6129 - - - 1 - Approx.33.6130 - - - - 1 Approx.33.6

120

120 119 120 119

120

11911912 CYL14 CYL16 CYL12011918 CYL 20 CYL

136

Approx.34.3

137 - 1 - - - Approx.34.3

Shaft(B-bank) 138 - - 1 - - Approx.34.3139 - - - 1 - Approx.34.3140 - - - - 1 Approx.34.3

146

12 - - - - Approx.35.1

147 - 14 - - - Approx.35.1

Bearing disc 148 - - 16 - - Approx.35.1149 - - - 18 - Approx.35.1150 - - - - 20 Approx.35.1

316

Approx.33.4

317 - 2 - - - Approx.33.4

Bearing shaft rear 318 - - 2 - - Approx.33.4 319 - - - 2 - Approx.33.4 320 - - - - 2 Approx.33.4 330 Thrust case assembly 2 2 2 2 2 Approx.38.3Incl.item 331~332331 Thrust case 2 2 2 2 2 Approx.37.5 332 Thrust bush 4 4 4 4 4 Approx.0.4 334 Camshaft thrust housing 2 2 2 2 2 Approx.1.06 335 Camshaft cover 2 2 2 2 2 Approx.0.88

511

12 - - - - Approx.51.16

611 - 14 - - - Approx.51.16

Camshaft part piece 711 - - 16 - - Approx.51.16811 - - - 18 - Approx.51.16911 - - - - 20 Approx.51.16912 O-ring 2 2 2 2 2 913 O-ring 2 2 2 2 2 914 Bolt 16 16 16 16 16 Approx.0.09916 Socket head bolt 8 8 8 8 8 Approx.0.02917 Socket head bolt 12 12 12 12 12 Approx.0.01

Camshaft Assembly Maintenance Procedure

M25000

Camshaft is of a s plit type for each cylinder and jointed by screws each other. Each piece of camshaft has a fuel cam, an intake cam and an exhaust cam. Inspection of Joint Screws Joint screws should be checked as frequently as possible. Check tightening condition of every nut periodically. If a nut is found to be loosened, take out the stud and check carefully. If the nut or stud is transformed or damaged, replace it with new one. The both nuts of a stud should be secured by loctite 243 before retightening them. Tightening torque : 270 Nm

Torque spanner: , (Optional) 91.930

Interchangeable head : , ,(Optional) 91.932 Inspection of Cams and Bearings Running surfaces of cams and be arings of each camshaft should be inspected at regular interval. The surfaces of cams can be c hecked easily by turning the flywheel. However, the surface of bearing cannot be checked directly without moving or dismantling camshafts. Therefore, inspect carefully around the bearings if there is any bearing particles dropped or abnormal color on the side of bearing. When suspicious, dismantle the camshaft thrust and then move the camshaft axially for inspection of bearing surfaces. If the surfaces has any damage or abnormal condition, be sure to contact engine manufacturer and consulted.

Camshaft Assembly Maintenance Procedure

M25000

Dismantling of Camshaft If a camshaft itself or a bearing shell for camshaft needs to be replaced, the piece of camshaft should be dismantled. The camshaft can be dismantled one by one through the cam side door as shown in fig 1. 1. Loosen all fuel injection pumps, rocker arms and then dismantle all push rods and swing arms. 2. Unscrew the joint nuts of camshaft. 3. Mark the location of assembling position. 4. Dismantle the camshaft thrust bearing ass’y. If necessary, dismantle the camshaft timing gear.

(See

This is necessary to move camshaft axially when the camshaft is dismantled. 5. Take out camshaft through the cam side door

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Camshaft Assembly Maintenance Procedure

M25000

Remounting of Camshaft Remounting procedures are reverse order of dismantling. However, be sure to carry out following notices; Check markings of cylinder number on camshaft and mount corresponding cylinder. Check positioning markings on the flanges of camshaft and accord the markings with mating camshafts. And remount after according TDC markings on both camshafts as shown in fig 2. Coat loctite 243 on the thread of all nuts for joint studs before tightening. Tightening torque : 270 Nm.

Torque spanner : (Optional) 91.930

Interchangeable head :

91.932

,(Optional) When dismantling and remounting camshaft, be careful not to damage the bearing surfaces. Camshaft

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LDFV25300

102

POS 101 POS 102 101

Part List

Q’ty / Eng. Weight

Item No. Description

Q’ty / Eng. Weight (kg) Remarks / See Note 12cyl. 14cyl. 16cyl. 18cyl. 20cyl.

Weigh(kg)

101 Camshaft bearing 12 14 16 18 20 Approx.2.26 MiBA 102 Camshaft bearing 4 4 4 4 4 Approx.1.79 MiBA

Pag 253
Camshaft Bearing Maintenance Procedure

H35DF(V) Section No.

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M25300

Replacement of Camshaft Bearing After dismantling the camshaft, bearing shell can be dismantled by the tool (optional) as shown fig 2.

91.860 Engine block

Bearing

When mounting a b earing shell on t he frame, be sure to carry out following notices; Cool down the bearing shell to –90 ℃ lower than frame temperature by dry Ice or the likes. Insert bearing shell, and accord the oil hole of bearing shell and frame by means of a pin with diameter 9.5mm as shown in Fig 3. The refitting works should be done as quickly as possible. Otherwise, bearing shell may be heated and stuck. In this case, bearing shell should be extracted and scrapped. When handling cooled bearing shell, be sure to put on protecting gloves.

Pin

G31000

Description

The piston is made of special LDFV31100

forged alloy steel. It is a two-piece type comprising a steel crown and box type Nci skirt. Two compression rings and one oil scraper ring are fitted in hardened ring grooves, which need careful overhaul inspection.

The connecting rod is made of LDFV32000

special die-forged steel, which is composed with a three-piece marine head type. All fasteners are tightened by hydraulic tension for better reliability and maintenance.

The big end bearing and the main LDFV32000

bearing are plain bearing type made LDFV13250

of aluminum material. These are adequate for the hydrodynamic oil film peak pressure with a wide range of oil temperatures.

G31000

The piston and connecting rod are connected by piston pin, which can be dismantled outside cylinder liner. Therefore, when dismantling piston, shank part of connecting rod should be dismantled in advance. Dismantling of big end part of connecting rod is not necessary and not recommended only for dismantling piston. The lubricating oil is supplied for cooling and lubrication from crankshaft to piston as shown in fig. 1. The piston crown is cooled by shaking effect of lubricating oil and flows out through the center of joint screw. Then lubricating oil scatters on t he wall of cylinder liner and flows down to the oil sump while cooling cylinder liner wall.

Section No. M310000

Pistonn

nn & Connec

cting Rod

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1A A

DDismountingg a Piston

DDismountingg

& Connectting Rod

1..2..3..4..5..6..

Dismountt

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eengine.

M21000

(See “Diss

issmounting oo

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head from

the

engine” inn

M2100 00

M21000

Take out

the flame ri

iing and cleaa

eaan the thread

aded

hole on thh

thhe piston croo

oown

Removal device :

91.270

Turn the cc

ccrankshaft too

oo BDC.

91.170091.19091.210

91.858

91.

99500

991.220

Fig.1 Loo

Figg

igg.2 Installing oo

oof turning bracc

accket

Install claa

laamping suppp

pport on connee

eecting rod sh

haft

and big eClamping

end part as shhown in fig.1

91.220

91.22

support :

91.220

Loosen ff

ffour nuts ff

ffor connectt

ctting rod stu

tuds

hydraulicaa

caally, and dismm

mmount nuts.

G09500

Looseningg procedure

Looseningg

G0950 00

G0950 0

(max. 1150 bar)

Looseningg

ngg pressure : 11

11100 bar (maa

maax. 1150bar)

91.

.420 91.44

.4490 91.55

5510

Hydraulic

tool :

911.420 91

911

.49091.510

.49091.

Turn the cc

ccrankshaft too

oo TDC as shoow

oown in fig. 2.

91.270

G099

Looosening of th

he nuts for con

nnecting rod sttuds

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7. Install lifting jig on the piston crown as shown in fig. 2.

91.170

Lifting jig :

91.170

91.220

8. Dismantle the clamping support.

91.220

9. Install guide bar for connecting rod as shown in

fig. 2.

91.190

10. Install turning bracket on big end part and counter weight.

Turning bracket :

91.210

11. Lift up the piston together with connecting rod shaft slowly and carefully.

12. Move and place the piston together with connecting rod shaft at stable working stand (Optional) as shown in fig. 3. Take care not to damage cylinder liner wall during removing the piston together with connecting rod shaft from cylinder liner. Put a tape on the crank pin oil holes.

Mounting a Piston & Connecting Rod into the Cylinder Liner Remounting procedure is basically reverse order of dismounting procedure. Make sure that covering tapes or the like removed. 1. Before assembling, install guiding jig on the cylinder liner for preventing piston rings from any damage as shown in fig. 4.

Guiding jig : 91.160 91.160

2. Install lifting jig on the piston 91.170

crown, and hook up onto a crane. Into the engine block

3. Lift up the piston together with connecting rod shaft from working stand, and clean them and engine block.

4. Check the position of crankshaft. Otherwise, turn the crankshaft to be in TDC.
5. Move and lower the piston together with connecting rod shaft slowly down through the bore of engine block. Be careful not to be damaged by touching adjacent parts.

6. Dismount the turning bracket.

91.210

7. Dismount the guide bar for con- 91.190necting rod.

7. Dismount the guide bar for con- 91.190

8. Install clamping support on connecting rod shaft and big end part.

91.220

Clamping support :

91.220

9. Turn the crankshaft to BDC. 10. Check pre tightening of four studs for connecting rod shaft, and tighten them, if needed. Pre tightening torque : 50 Nm (with molycote) 11. Tighten two diagonal nuts for connecting rod upper studs hydraulically at the same time and repeat for the other two nuts.

Tightening procedure : G09500Tightening pressure : 1000 bar (repeat 3 times)

12. Dismount the clamping support

and the guiding jig.

13. Clean and mount the flame ring. 14. Mount the cylinder head on the engine. (See “Mounting a cylinder head on the cylinder

liner and water jacket” in M21000

Dismounting a Big End Parts 1. Turn the crankshaft to TDC as shown in fig. 5.

2. Loosen and dismount four nuts for big end part studs hydraulically at the same time.

G09500

Loosening procedure :

G09500

Loosening pressure : 1100 bar (max. 1150 bar)

91.420 91.490

Hydraulic tool : 91.420 91.49091.510 91.510

Hydraulic tool :

91.420 91.490

91.183 91.200

3. Install guide support on bottom of the engine

as shown in fig. 6.

91.200

4. Turn the crankshaft to 115˚.

5. Dismount the turning bracket.

91.210

6. Use conrod support, big-end upper guide bar and big-end lower support and dismantle the big end upper and lower part, and take out them from the engine block as shown in fig. 7.

91.180 91.183

Conrod support for crank pin brg. :

91.180

91.184

Big-end lower support : Big-end upper guide bar :

91.18391.184

7. Take out the upper and lower bearings from their housings carefully.
Be careful not to drop or damage the bearings during taking out from the engine.

Inspection of Big End Parts, Bearings and Journal 1. Inspect the journal carefully by turning the crankshaft. 2. Put tapes on the oil hole of journal to keep clean against dirt. Be sure to put off the tape before reassembling. 3. Inspect any damages in the joint faces between the connecting rod shaft and big end upper part. Take care to handle connecting rod shaft and big end parts. 4. Inspect any damages in threads of studs and nuts for tightening the connecting rod shaft and the big end parts. If studs/nuts have heavy damages in threads and/or on contact surface, then they should be changed to new ones. 5. Inspect bearings and measure the thickness of bearings by means of a ball anvil micrometer

and check the wear limit. G09200 G09200

6. Keep the record of the measurements and inspection results. If there is any sign of abnormality on the journal or bearings, it should be investigated and repaired by experienced specialists. Poor repair works deteriorate the condition and may cause serious damage on crankshaft.

Mounting Big End Parts Remounting procedure is basically reverse order of dismounting procedure. Big end parts and bearings should be cleaned and coated with clean lubricating oil before mounting. 1. Mount upper and lower bearings on the their bearing housings. 2. Assemble the big end upper and lower part. 3. Install turning bracket on big end part and counter weight.

Turning bracket : 91.210 91.210

4. Turn the crankshaft to TDC. 5. Check pre tightening of four studs for big end parts and tighten them, if needed. Pre tightening torque : 50 Nm (with molykote) 6. Tighten two diagonal nuts for connecting rod upper studs hydraulically at the same time and repeat for the other two nuts.

G09500

Tightening procedure : G09500Tightening pressure : 1000 bar (repeat 3 times)

7. Dismount the turning bracket 91.210

and the guide support.

LDFV31100

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002

Section view Part List Item No. Description Q’ty / Cyl. Weight(kg) Remarks / See Note 110 Piston complete 1 Item no. 001~006 001 Crown 1 002 Skirt 1 003 Bolt 1 004 Expansion Connector 1 005 Thrust piece 1 006 Position pin 1

LDFV31100

Item No. Description Q’ty / Cyl. Weight(kg) Remarks / See Note 120 Piston pin complete 1 Approx.33.6 130 Retaining ring 2 151 Piston ring - top 1 152 Piston ring - second 1 153 Piston ring - oil scraper ring 1

M31100

Dismantling a Piston Pin and Piston Rings 1. Dismount the piston together with connecting rod shaft from the engine. (See “Dismounting of a piston and connecting rod ”

in)) M31000 2. Install lifting jig on the piston crown, and hook up onto a crane.

Lifting jig : 91.170 91.170

3. Lift up the piston together with connecting rod shaft from working stand, and slow down the joint faces of connecting rod shaft on the wooden table or the likes carefully. 91.170

4. Dismantle circlips for piston pin by means of plier as shown in fig. 1.

Plier : 91.240 91.240

5. Take out the piston pin to the opposite side during lifting the piston.

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6. Dismantle piston rings by means of plier.

Plier : 91.250 91.250

Be sure to use the plier for piston ring. Otherwise, piston rings may damage.

7. Remove burned carbon deposits from piston and piston ring grooves, and clean all the parts carefully. 8. Inspect the piston for any abnormal marks carefully. 9. Inspect the piston pin and the small end bush.

(See “Small end bush overhaul” in M

Inspection of Piston Bolt Tension 1. Loosen piston bolt by using a torque spanner and dismount piston crown as shown in fig. 2.

Torque spanner : (Optional) 91.810 2. Coat thread and contact surface of bolt with “Molycote-paste Gn plus”, and then tighten the bolt with a torque of 300 Nm. If only the length of bolt is less than 99 mm, reuse the piston bolt.

M12

M31100

3. Loosen the bolt again, and tighten the bolt with a torque of 80 Nm. 4. Continue tighten the piston bolt by additional 135˚ . Make sure that the bolt is not rotated by application of test torque 300 Nm to tightening direction.
If the bolts can turn any more, replace by new one. Assembling of Piston Pin and Piston Rings 1. Coat the surface of piston pin and small end bush with clean lubricating oil before assembling piston and connecting rod shaft, and t hen mount piston pin into small end bush. Make sure that the mark “E” on the top of the piston should be positioned in exhaust side. 2. Mount circlips for piston pin by means of plier.

Plier : 91.240 91.240

3. Lift up the piston together with connecting rod shaft by means of a crane.

M31100

4. Mount piston rings into its grooves by means of the plier.

91.250

Plier :

91.250

“Top” mark of piston rings should be assembled in upper side of groove.
The end gap of each piston ring should be arranged in 120˚ in relation to each other. 5. Inspect the piston rings for wear carefully as

G09200

shown in fig. 3.

G09200

If piston rings exceed the wear limit and/or if the piston has any abnormal mark, then replace by new one. 6. Mount the piston together with connecting rod shaft into the engine. (See “Mounting of a piston and connecting rod into

the cylinder liner” in

M31000

Measurement of Big-end Bore Maintenance Procedure

All type Section No.

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M31101

Measurement of Big-end Bore 1. For Check of ovality for the big-end bore, the connecting rod should be assembled completely without big-end bearing shell. (Tighten the bolts according to the G09510 and M32120) 2. Measure five position diameters and record the measurement in the table A. (Measuring has to be carried out center position except the oil groove) 3. Calculate the maximum ovality as the difference between largest and smallest diameter measured. 4. If

maximum ovality is over the limit value in the table A, the connecting rod complete (shaft, big end, stud, nut, small end bush) without big-end bearing shell should be renewed. But, if maximum ovality is within the limit value, the connecting rod can be reused.

Ship No. : Engine Type :

Sketch For Connecting Rod

Connecting RodBig End Bore MeasurementCylinder No.①Nominal Diameterfor Big End②③H17/28 : Φ185mmH21/32 : Φ200mmH25/33 : Φ240mmH32/40 : Φ355mm④H35/40DF : ø355mm H21C : ø200mm Ovality limit : 0.15mm⑤Maximum Ovality (Max. - Min.)

Engine No.:

Eng. Running Hours :

Signature :Meas. Date :

[Table A]

Connecting Rod Assembly Assembly Drawing & Part List

H35DFV Section No.

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LDFV32000

Part List

Item No. Description Q’ty / Cyl. Weight (kg) Remarks / See Note

Item No. Description Q’ty / Cyl. Weight (kg)

100 Connecting rod complete 1 111 Connecting rod Shaft 1 Approx.71.36 112 Connecting rod Big end 1 Approx.112.0 113 Big end bearing 1 Approx.7.5 114 Small end bearing 1 Approx.4.0 191 Stud 4 Approx.2.48 192 Nut 8 Approx.0.45 193 Cylindrical pin 4 Approx.0.04 194 Stud 4 Approx.1.38 195 Shim plate 1 Approx.0.75

Dismounting a Big End Bearing 1. Turn the crankshaft to BDC as shown in fig. 1.

Fig. 1 Installing of conrod support for crank pin bearngon big end parts

2. Install conrod supports for crank pin bearing on both side of big end housing.

Conrod support for crank pin bearing : 91.180 91.180

3. Connect chain blocks to conrod support. 4. Loosen four nuts for big end parts studs hydraulic-ally and then dismount the nuts and studs.

Loosening procedure : G09500 G09500

Loosening procedure : G09500 G09500

Loosening pressure : 1120 bar (max. 1155 bar)

Hydraulic tool : 91.420 91.490 91.420 91.49091.51091.510

5. Install extension pipe, guide pipe, supporting device and screw-on plate as shown in fig. 2.

Extension pipe : Guide pipe :

Supporting device : Screw-on plate :

6. Lower down big end lower housing as shown in fig. 2. 7. Take out lower bearing from the housing carefully. Be careful not to drop or damage the under bearing during taking out from the engine.

91.180

91.182

91.181

91.185

G09.500

91.186

91.185

91.185

91.186

91.186

91.181

91.181

91.182

91.182

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8. Lift up the big end upper housing to approx. 20mm.

9. Install support on the big end upper 91.18791.187

9. Install support 91.18791.187

housing as shown in fig 3. 10. Take out upper bearing from the housing carefully. (2 worker required, A and B-bank respectively) Be careful not to drop or damage the upper bearing during taking out from the engine. 11. Inspect the big end bearings. (See “Inspection of big end parts, bearings and

journal ” in) M31000

Mounting the Big End Bearings Remounting procedure is basically reverse order of dismounting procedure. All components must be cleaned before remounting and coat the journal and running surface of the bearing with clean lubricating oil. (Back

side of the bearing keeps dry without oil). D. Engine & Machinery Division 2018.02/CGW

91.187

M31000

M31000

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1. Mount an upper bearing shell to its housing. (2 workers required, A and B-bank respectively) 1. Before mounting the upper bearing shell, it housing should be positioned in center of crank pin journal. 2. Make sure that a lug of the upper bearing shell should be positioned in the groove of its housing.

2. After removing support lower down 91.187

the upper bearing housing on the crank pin journal carefully. Be careful not to damage the upper bearing shell. Be careful not to damage workers (especially their fingers). 3. Mount a lower bearing shell to its housing. 4. Connect chain blocks to conrod support on big end lower housing. 5. Lift up lower bearing housing to upper one. Be careful not to damage the lower bearing shell. Be careful not to damage workers 6. Dismount the extension pipe, guide pipe, supporting device and screw-on plate.

Extension pipe : Guide pipe :

Supporting device : 91.182 91.181

Screw-on plate :

7. Check pre-tightening of four studs for big end parts and tighten them, if needed. Pre-tightening torque : 50 Nm (with molycote) 8. Tighten two diagonal nuts for big end part studs hydraulically at the same time and repeat for the other two nuts.

Tightening procedure : G0950

Tightening pressure : 1100 bar (repeat 3 times)

9. Dismount con-rod support

91.185

91.186

91.185

91.181

91.186

91.182

G09500

G09500

91.180

91.180

Small End Bush Overhaul 1. Check surface of piston pin and small end bush.

2. Measure the clearance between G09200

piston pin and small end bush. If the specified clearance is exceeded, contact HHI’s Diesel Engine A/S for replacement. In case of replacing the bush, use the

removal device as shown in fig 4. 91.910

This tool (optional) can be ordered from engine maker. During removing a bush, make sure that the bore should not be damaged. 91.910 Coat Lubricant

Connecting rod shaft Small end bush LDFV32000 LDFV32000

LDFV32000 LDFV32000 tid h ft

3. Insert the bush to bore correctly after the bush is shrink fitted.
Clean and coat the bore with clean lubricating oil before inserting.

G33000

Description The crankshaft is made of continuous grain flow dieforged alloy steel. The crankshaft has two counter weights for balancing the mass forces on eac h crank throw, which are fastened with two manually torque bolts. The lubricating oil flows through oil channel in the engine block to center hole of each cylinder. And then it supplied to each journal hole of crankshaft, main bearing, crank pin, big end bearing of connecting rod, and piston. At the free end of crankshaft, there is a gear wheel

for driving of camshaft as well as a LDFV35000 gear wheel for driving of pumps such as lubricating oil pump and c ooling water pumps. And a v ibration

LDFV33400

damper , which reduce torsional vib- LDFV33400 ration of crankshaft is also assembled at the free end of crankshaft. At the driving end of crankshaft, there is a flywheel, which is fastened by tightened two type of bolts with torque wrench.

The flywheel is made of spheroidal LDFV33300

graphite iron. The flywheel has gear teeth for turning gear. The crank shaft can be t urned slowly by a m anual turning device through gear on flywheel.

Crankshaft Assembly Assembly Drawing & Part List

H35DFV Section No.

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LDFV33000

Part List

Q’ty / Eng. Weight

Item No. Description 116 Crankshaft 117 Crankshaft 118 Crankshaft 119 Crankshaft 120 Crankshaft

Remarks / See Note

Remarks / See

12 Cyl 14 Cyl 16 Cyl 18 Cyl 20 Cyl

Weigh(kg)

190 Plug 6 7 8 9 10 210 Counter weight 12 14 16 18 20 Approx.211.9 291 Stud 24 28 32 36 40 Approx.5.5 292 Nut 24 28 32 36 40 Approx.1.61 293 Parallel pin 12 14 16 18 20 Approx.0.24 294 Spring pin 12 14 16 18 20 Approx.0.01

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1. Mount dial gage between two crank webs of last cylinder nearest flywheel as shown in fig.1

Dial gage :

The amount of deflection may vary with measuring conditions, which need to be as

same as possible for more exact comparison. The measuring should always be carried out at cold engine. Before measuring, the temperature of the dial gage should be nearly the same as that of the engine.

2. Rotate the crankshaft to measuring position 1 as shown in fig.2 3. Set the dial gage to zero. 4. Rotate the crankshaft and read the values of dial gage at measuring position 2 to 5, and then record these readings. Only the deviation from zero setting of dial gage must be recorded.

91.310

91.310

91.310

/G

A-bank (2) B-bank

5. Evaluate these readings. (1) A reading at measuring position 5 should be nearly the same as reading at measuring position 1. If larger differences, repeat steps 2 to 5. (2) Vertical and horizontal deflections are as follows. □ Vertical deflection: dv = T – (X+Y)/2 □ Horizontal deflection: dh = P–S If vertical and horizontal deflections exceed the permissible limits, realign the engine and the driven machinery. Before realigning, main bearing metals should be check for the abnormal wear. Be sure to contact the Hyundai Global Service for realigning. 6. After realigning the crankshaft, repeat steps 1 to 5.

/GHL

Each pin location (viewed from the front end) Turn clockwise

(4)

A-bank

(5)

(1)

(3)

New or recently overhauled engine, permissible - 22 ~ +16 Operating engine, contact engine maker (check alignment immediately) - 23≥ or+17≤ New or recently overhauled engine, permissible ± 16 Operating engine, check alignment immediately - 17≥ or+17≤

For the crank nearest the flywheel (Cold Condition) For the other cranks (Cold Condition)

MEASURING POSITIONS AND POINTS

B-bank A-bank

Turn Clockwise Gage location on crank webs

/GHL

* Cold condition:5 hours after engine has stopped *The values measured under hot condition are only for referencedue to the following reason; - If the values measured under cold condition satisfy the above mentioned specification, we guarantee any values measured under hot condition.

Each pin location (viewed from the front end)

** If the deflection value is over the above specifications, you should contact the engine maker immediately.

M33200

Dismounting a Counter Weight 1. Install the lifting rope to the crank web as shown in fig. 1. 2. Turn the crankshaft to approximately 30˚in either direction. 3. Loosen and dismount two nuts for counter weight studs hydraulically at the same time

Loosening procedure : G09500 G09500

Loosening pressure : 1220bar (max. 1260 bar)

91.400 91.460

Hydraulic tool :

91.400 91.460

G09500

4. Dismount the counter weights. Clean the seating surfaces on the crankshaft and counter weights. And then inspect any damages on seating surfaces. If studs/nuts have heavy damages in threads and/or on contact surface, then they should be changed to new ones.

M33200

Mounting a Counter Weight Remounting procedure is basically reverse order of dismounting procedure. Counter weight should be cleaned and coated with clean lubricating oil before mounting. 1. Prior to mount counter weights, place locating pin into the crank web. 2. Mount counter weight to the crankshaft. 3. Check pre tightening of two studs for counter weight and tighten them, if needed. Pre tightening torque : 50 Nm (with molycote) 4. Tighten two nuts for counter weight studs hydraulically at the same time.

Tightening procedure : G09500 G09500

Tightening pressure : 1200 bar (repeat 3 times)

LDFV33500

LDFV33100

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Part List Item No. Description Q’ty / Eng. Weight (kg) Remarks /See Note12Cyl14Cyl16Cyl18Cyl20CYI 331 Fitted Stud 2 2 2 2 2 Approx.1.8 332 Coupling Stud 22- 22- 22 22 22 Approx.1.5 333 Nut 48 48- 48 48 48 Approx.0.47 334 Hex. Soc. Head bolt 2 2 2 2 2 Approx.0.35 335 Cylindrical pin 1 1 1 1 1 316 Flywheel (720/750rpm) - - 1 - - Approx.1,31 317 Flywheel (720/750rpm) - - - 1 - Approx.2,02 318 Flywheel (720/750rpm) 1 - - - - Approx.1,31 319 Flywheel (720/750rpm) - 1 - - - Approx.2,02 320 Flywheel (720/750rpm) - - - - 1 Approx.2,79 *) Depending on project specification

335

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Part List Item No. Description Q’ty / Cyl. Weight (kg) Remarks / See Note 12Cyl14Cyl16Cyl18Cyl20Cyl*)401 Vibration damper 1 1 1 1 1 402 Stud 20 20 20 20 20 Approx.0.72 403 Flange nut 40 40 40 40 40 Approx.0.22 *) Depending on project specification

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Part List Item No. Description Q’ty / Cyl. Weight (kg) Remarks / See Note 12Cyl14Cyl16Cyl18Cyl20Cyl*)510 Flexible coupling 1 1 1 1 1 Approx.612.9 520 Bolt 32 32 32 32 32 521 Washer 32 32 32 32 32 Approx.0.03 *) Depending on project specification

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Description The timing gear arrangement consists of a crankshaft gear, two idling gear assembly, and two camshaft driving gears located A & B bank. When the crankshaft rotates one time, the A-bank camshaft rotates a half in the same direction and the B-bank camshaft rotates the opposite direction through the idle gear.

The camshaft drive gear are LDFV35310

fixed to the camshaft through shaft and fastened by bolt

The idling gear can be LDFV35210,220

taken upward, after the camshaft gear is dismantled.

The crankshaft gear can be LDFV35110dismantled through the side cover of engine block.

LDFV35310 LDFV35110

LDFV35210

LDFV35220

Timing gear Assembly Assembly Drawing & Part List

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191 193

Part List

Item No. Description Q’ty / Eng. Weight(kg) Remarks / See Note 110 Crankshaft gear (v-type) 1 Approx.30.30 111 Intermediate Shaft 1 Approx.8.00 191 Bolt 16 Approx.0.48 192 Cylindrical pin 3 Approx.0.04 193 Washer 16 Approx.0.02 194 Socket head bolt 2 Approx.0.07 195 Socket head bolt 2 Approx.0.04

Timing gear Assembly Assembly Drawing & Part List

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Part List Item No. Description Q’ty / Eng. Weight(kg) Remarks / See Note 210 Idle Gear Assembly(A-bank) 1 Approx.39.50 Incl.item 211~212 211 Idle gear (A-bank) 1 Approx.37.62 212 Bearing bush 1 220 Idle Gear Assembly(B-bank) 1 Approx.30.00 Incl.item 221~222 221 Idle gear (B-bank) 1 Approx.28.19 222 Bearing bush 1 230 Shaft assembly 1 Approx.20.70 Incl.item 231~232 231 Shaft 1 Approx.20.67 232 Plug 4 Approx.0.01 235 Shaft cover 2 Approx.1.50 237 Bolt 12 Approx.0.50 238 Washer 12 Approx.0.01 240 Shaft assembly 1 Approx.22.80 Incl.item 241~242 241 Shaft 1 Approx.22.72 242 Plug 4 Approx.0.01 290 Stud 2 Approx.5.30 291 Nut 2 Approx.1.30 292 Closing cap 2 Approx.2.51 293 O-ring 2 294 Hydraulic nut 2 Approx.0.70 295 O-ring 8 310 Camshaft gear (A-bank) 1 Approx.87.57 311 TDC pick up gear 1 Approx.15.10 320 Camshaft gear 1 Approx.82.72 333 Bearing disc 2 Approx.27.80

391 Parallel pin 4 Approx.0.01 392 Bolt 32 Approx.0.19 395 Washer 32 Approx.0.01 396 Socket head bolt 4 Approx.0.04 397 Socket head bolt 12 Approx.0.03 405 Pump drive gear 1 Approx.61.53

For 14H35DFV, 18H35DFV, 20H35DFV H35DFV

Camshaft Gear Assembly Maintenance Procedure

Section No.

M35300

Alignment of Timing Gears The timing gears control the timing of fuel injection and movements of intake and exhaust valves, which is critical for the engine performance and reliability. The timing of the gears is slight adjustable but only needs correct alignment when remounting of the gears after maintenance. Misalignment of even one tooth causes touching of piston and valves which results serious damage of the total engine. Therefore, the procedures below should be kept exactly. 1. Turn the crankshaft so that no.1 crank pin journal shall be in TDC(top dead center). In this case, the pin for crankshaft gear of crankshaft end should be located at 11.5 degree toward A-bank side from the perpendicular line as shown in fig. 1.

Position Pin(No.1 Crank Pin Journal in TDC)

B-bank

A-bank

For 14H35DFV, 18H35DFV, 20H35DFV H35DFV

Camshaft Gear Assembly Maintenance Procedure

Section No.

M35300

2. Mount idle gears if disassembled. The crank gear and idle gear A-bank/B-bank should be mounted coincident with markings on each gears. Tighten idle gear stud while the end of stud is coincident with each shaft ends. Stud ends to be coincident with each shaft ends Tightening procedure of nuts for idle gear : G09500 -Tightening pressure : 1000bar(repeat 3 times) Loosening procedure of nuts for idle gear : G09500 -Loosening pressure :1020bar(max.1050bar)

Oil Spray Nozzle

Markings

Hyraulic tool :

91.420 91.490 91.510

3. Lift the camshaft gear A-bank and insert it through the side opening of the engine block carefully while avoiding not touching the teeth with adjacent parts as well as oil spray nozzle as shown in fig. 3. 4. Lay the camshaft gear on the idle gear and roll down to the mounting position of the bearing disc for camshaft gear as shown in fig.3. 5. Check marking on t he camshaft gear which should be aligned with an incline surface of engine block and it should be located the same point with the marking of the idle gear as shown in fig. 3. If not aligned, rotate the camshaft gear by lifting slightly and change the mating point of the teeth. Repeat this procedure until the incline markings aligned.

For 14H35DFV, 18H35DFV, 20H35DFV H35DFV

Camshaft Gear Assembly Maintenance Procedure

Section No.

M35300

6. Check position of camshaft and rotate camshaft to match the positioning pin on shaft for camshaft gear coincident with hole of camshaft gear as shown in View A of fig. 3. 7. Push camshaft gear toward camshaft to fit in positioning pin and assemble the gear and shaft temporarily by two sets of joint screws diagonally. 8. Check alignment of camshaft gear again. The incline marks of camshaft gear should be as shown View A of fig. 3. Incline markings mean after TDC 25° of A-bank No. 1 cylinder.

Positioning Pin(shown displaced) TDC Camshaft Gear

After TDC 25° Markings

Intermediate Shaft Shaft for Camshaft Gear Bearing Disc for Camshaft Gear

9. The camshaft gear located B-bank should be aligned with incline surface of engine block of the B-bank side and the marking of the idle gear. Then assemble the same method with the cam shaft located A-bank as shown in fig.4. If assembled right way, the pin hole of B-bank is located 5° below from horizontal, and incline markings mean before TDC 25° of B-bank No.1 cylinder.

View A

For 14H35DFV, 18H35DFV, 20H35DFV H35DFV

Camshaft Gear Assembly Maintenance Procedure

Section No.

M35300

10. Check the gear backlash. If gear backlash is out of specification, stud/nut of idle gear shaft to be loosen and adjust the backlash then tighten

G09200 If the gear backlash is out of

again.

specification, it may cause serious damages on the gears. 11. Assemble all sets of joint screws and tighten

them one by one diagonally. G09400 G09400

Cam gear bolt tightening torque : 230 Nm+Molykote Coat Molykote or Loctite on the thread before assembling bolts and nuts. Check the condition of bolts and nuts. Do not reuse damaged bolts or nuts. Use only new genuine parts. Otherwise, loosened or broken parts may cause serious damages on the engine.

For 14H35DFV, 18H35DFV, 20H35DFV H35DFV

Camshaft Gear Assembly Maintenance Procedure

Section No.

M35300

12. Turn the flywheel and check status of the rotation. If any abnormal resistance is detected during turning, stop the turning immediately and return to previous position. Then, recheck gear markings and the above procedures. Check markings for the connection of every camshaft. (See “Fig. 2 According TDC markings on both

camshafts” in

M25000

Checking Fuel Injection Timing The fuel injection timing at each cylinder can be compared with other cylinders’ by means of reading a crank angle when fuel ports at fuel injection pump’s barrel are closed by its plunger. 1. Close ball valves in fuel supply/return line and remove fuel oil inside the pipe by means of dismantling a plug from end block (Item no. A53000-109). (See Fig.1) 2. Dismantle two deflectors from fuel injection pump in order to check its fuel ports then remove the rest fuel oil in pump using compressed air and open the window for flywheel scale. (See Fig.2) 3. See inside a deflector hole by using a mirror and give a light into the opposite deflector hole. (See Fig.3) 4. Turn the crankshaft at engine rotating direction until the light is cut out due to closing fuel ports by its lifting plunger. 5. Stop the crankshaft just after cutting the light and mark the flywheel scale indicated by flywheel indicator. (See Fig.4) 6. Count the deviation crank angle between the mark and its cylinder TDC. If it is 10.0, the cylinder’s fuel injection timing becomes BTDC 10.0. (BTDC = Before Top Dead Center) 7. If all cylinders’ fuel injection timing is needed, it is recommended to read in order of firing.

Adjusting Fuel Injection Timing The fuel injection timing can be adjusted but is recommended NOT to do because this work gives a sensitive influence to engine performance. However it can be done according to a result of enough discussing with HHI Customer Support Department. In any case, maximum combustion pressure should be kept within specified value. 1. Open the gear-case cover (up) (item no. A19300-350) and the window for flywheel scale. 2. Turn crankshaft (anticlockwise if it is required to advance fuel injection timing) by means of a turning gear in order to see position marks on disc for camshaft gear and camshaft gear. (See Fig.5) 3. Loosen all mounting bolts for camshaft gear (item no. A35000-393) by about 1 turns. 4. Mark on the flywheel scale indicated by flywheel indicator. (See Fig.6) 5. Watching flywheel scale, turn the crankshaft by a needed crank angle (anticlockwise if it was turned anticlockwise at the above number 2) and mark on the flywheel position indicated by indicator. 6. Tighten all mounting bolts for camshaft gear with the torque specified by G094000. After tightening bolt by bolt, mark the bolt with any sign to confirm all bolt tightened.

7. Confirm whether the gap of two marks on flywheel is the aimed value and also coincides with the movement of position mark of camshaft gear. (Camshaft gear position mark is adjustable only in the range of ‘-’ index and ‘+’ index. Crank angle 2 degree corresponds to cam angle 1 degree) 8. Close the gear-case cover (up) and the window for flywheel scale. 9. If you turned anticlockwise at the above number 5, the position mark on camshaft gear would move the ‘+’ direction on the disc for camshaft gear and maximum combustion pressure would be increased by 6 bar per 1° crank angle. 10. The adjustable range of fuel injection timing is depending on engine type as followings: H17/28: (-)2.0° ~ (+)2.0° crank angle H21/32: (-)2.0° ~ (+)2.0° crank angle H25/33: (-)1.6° ~ (+)0.6° crank angle H32/40(V): (-)2.0° ~ (+)2.0° crank angle H35DF(V): (-)2.0° ~ (+)2.0° crank angle H27DF : (-)1.6° ~ (+)0.6° crank angle

View ‘A’ Position mark

CamshaftDisc for camshaft gear Camshaft Gear

If adjusting fuel injection timing of some cylinders is needed, see M51101.

‘ A’

(Gear side) (Disc side)

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Vol.II

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200 145 146 144 148 153 154 147 155 500 600 Part List Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note 144 Lever 1 Approx.0.75 145 Gov. terminal lever 1 Approx.0.23 146 Grip 1 147 Bolt 1 Approx.0.03 148 Spring pin 1 153 Bolt 1 Approx.0.02 154 Locking plate 1 155 Locking plate Approx.0.25 200 Push rod assembly 1 Incl.item 201~216 500 Control shaft arrangement 1 Approx.74.08 Incl.item 501~573 600 Regulating system arrange 1 Approx.2.17 Incl.item 601~622

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209 213 210 Part List Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note 201 Tube 1 Approx.1.23 202 Rod 1 Approx.0.50 203 Rod guide 1 Approx.0.76 204 Spring 1 205 Ball joint-female 1 Approx. 0.11 206 Nut 2 Approx.0.01 207 Set screw 4 208 Bolt 2 Approx.0.06 209 Washer 4 Approx.0.01 210 Nut 2 Approx.0.02 211 Locking plate 1 Approx.0.44 213 Ball joint-male 1 Approx.0.09 214 Spring pin 2 215 Washer 1 216 Screw plug 1 Approx.0.08

H35DFV Section No. LDFV41000 556

Speed Control System Assembly Assembly Drawing & Part List

Speed Control System

554 555 506 553 552 551

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506 532

505 550

534 540

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Speed Control System

<B-bank>

556 556 561

520 516

513 514 533

553 552 004

002 001

517

532 519 531 551 512

003

554

Speed Control System Assembly Assembly Drawing & Part List

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Speed Control System

Part List

Item No. Description

Q’ty / Eng. Weight (kg) Remarks / See Note 12Cyl 14Cyl 16Cyl 18Cyl 20Cyl

501 Control shaft (a-bank) 1 1 1 1 1 Incl.item 502~503 502 Control shaft 1 1 1 1 1 Approx.17.00 503 Control shaft 1 1 1 1 1 Approx.19.00 504 Shaft coupling assembly 2 2 2 2 2 Incl.item001~007 001 Shaft coupling 1 1 1 1 1 Approx.1.33 002 Shaft coupling connector 2 2 2 2 2 Approx.0.20 003 Socket head bolt 12 12 12 12 12 Approx.0.01 004 Spring pin 2 2 2 2 2 Approx.0.01 505 Distance piece 2 2 2 2 2 Approx.0.10 506 Distance piece 1 1 1 1 1 Approx.0.30 507 Control shaft (b-bank) 1 1 1 1 1 Incl.item 502~508 502 Control shaft 1 1 1 1 1 Approx.17.00 508 Control shaft 1 1 1 1 1 Approx.18.40 510 Linkage lever assembly 12 14 16 18 20 Approx.1.64 Incl.item 511~520 511 Linkage guide 1 1 1 1 1 Approx.0.53 512 Shaft guide 1 1 1 1 1 Approx.0.67 513 Linkage guide block 1 1 1 1 1 Approx.0.32 514 Tension spring 1 1 1 1 1 Approx.0.01 516 Pin 2 2 2 2 2 Approx.0.03 517 Spring pin 3 3 3 3 3 Approx.0.01 519 Socket head bolt 1 1 1 1 1 Approx.0.04 520 Split pin 2 2 2 2 2 530 Shaft support assembly 12 14 16 18 20 Approx.3.80 Incl.item 531~533 531 Support 1 1 1 1 1 Approx.3.66 532 Bush 1 1 1 1 1 Approx.0.01 533 Socket head

bolt 2 2 2 2 2 Approx.0.07 534 Shaft support assembly 2 2 2 2 2 Approx.4.04 Incl.item 532~535 532 Bush 1 1 1 1 1 Approx.0.01

Item No. Description

Q’ty / Eng. Weight (kg) Remarks / See Note 12Cyl 14Cyl 16Cyl 18Cyl 20Cyl

533 Socket head bolt 2 2 2 2 2 Approx.0.07 535 Shaft support 1 1 1 1 1 Approx.3.88 540 Stopper assembly 2 2 2 2 2 Approx.0.60 Incl.item 541~544 541 Stopper 1 1 1 1 1 Approx.0.71 542 Bolt 1 1 1 1 1 Approx.0.04 543 Spring pin 1 1 1 1 1 544 Locking plate 1 1 1 1 1 Approx.0.25 550 Stopper assembly 1 1 1 1 1 Approx.1.28 Incl.item 551~556 551 Stopper-over load 1 1 1 1 1 Approx.1.00 552 Bolt 1 1 1 1 1 Approx.0.06 553 Nut 2 2 2 2 2 Approx.0.01 554 Bolt 1 1 1 1 1 Approx.0.04 555 Spring pin 1 1 1 1 1 556 Locking plate 1 1 1 1 1 Approx.0.25 560 Stopper assembly (b-bank) 1 1 1 1 1 Approx.1.02 552 Bolt 1 1 1 1 1 Approx.0.05 553 Nut 1 1 1 1 1 Approx.0.01 554 Bolt 1 1 1 1 1 Approx.0.04 555 Spring 1 1 1 1 1 556 Locking 1 1 1 1 1 Approx.0.25 561 Stopper (b-bank) 1 1 1 1 1 Approx.0.91 570 Stopper assembly 2 2 2 2 2 Approx.0.26 Incl.item 571~503 571 Stopper 1 1 1 1 1 Approx.0.25 572 Socket head bolt 1 1 1 1 1 Approx.0.01 573 Spring pin 1 1 1 1 1 Approx.0.01

Detail “B” 611 614 620 621 622 607 609 610 622

611 614 620 621

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606 609 610

613 614 620 621 622

614 612 Detail “A” Detail “B” 615 622 622

622

613 614 622

620 618 617 603 604 605 View “D”

601 602

613 614 Detail “C”

Speed Control System

Part List

Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note 601 Bearing stud 1 Approx.0.35 602 Washer 1 Approx.0.01 603 Arm complete 1 Incl.item 001~002 001 Balance arm 1 Approx.0.45 002 Bushing 1 Approx.0.01 604 Washer 1   605 Split pin 1   606 Arm(a-bank) 1 Approx.0.45 607 Arm(b-bank) 1 Incl.item 001 001 Socket head bolt 1   609 Bolt 2 Approx.0.04 610 Parallel pin 2   611 Ball joint-female 1 Approx.0.11 612 Pull rod 2 Approx.0.95 Incl.item 001~003 001 Pipe 2 Approx.0.83 002 Pull rod end 4 Approx.0.11 003 Parallel pin 4   613 Ball joint-female 3 Approx.0.11 614 Nut 6 Approx.0.02 615 Adjusting screw 1 Approx.0.52 616 Nut m12 1 Approx.0.01 617 Pin for ball head 2 Approx.0.04 618 Nut 2 Approx.0.02 620 Washer 5 Approx.0.01 621 Bolt 2 Approx.0.05 622 Locking plate 5 Approx.0.44

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401 411421 331 404

313 402 412 403 413

403 413 461

312 402 412

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Arr. Of Starting Air Piping Assembly Drawing & Part List

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Part List

Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note 101 MAIN STARTING AIR 1 Approx.14.92 102 STARTING AIR INLET PIPE 1 Approx.7.89 201 MAIN STARTING VALVE 1 Approx.1.37 202 SILENCER 1 Approx.0.03 203 RING 2 Approx.0.14 312 CLAMP 1 Approx.2.85 313 CLAMP 1 Approx.6.38 331 PLATE 1 Approx.2.88 401 BOLT 4 402 BOLT 4 403 BOLT 12 Approx.0.12 404 BOLT 2 Approx.0.06 411 WASHER 4 Approx.0.51 412 WASHER 4 Approx.0.01 413 WASHER 12 Approx.0.01 421 NUT 4 Approx.0.02 451 PLUG 1 Approx.0.05 461 SQUARE PACKING 1 Approx.0.03 462 GASKET 1

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403102,463,004104,461

301

402105,462,002 401

103,461,005

Detail "A"

Arr. Of Control Air Piping Assembly Drawing & Part List

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317 403 413 104 501 500 326 200 408 465 463 103 300

301, 402, 410

464

103 461 311 104 315

314 105 204 405 462 504 463 319 202 323 405 407 411 462 464

316

205 206 463 502 302 400 412

311 201 462 505 460 325

406 413 421

203 324 403

503 Detail "A" Detail "B" 106 464

503

106 464

Arr. Of Control Air Piping Assembly Drawing & Part List

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102 Detail "C" 312 401 403 413 463 Detail "D"

315

321 403 413 101 310 401 410 420

313 401 410

LDFV42003

Part List Item No. Description

Q’ty / Eng. Weight (kg) Remarks / See Note 12CYL 14CYL 16CYL 18CYL 20CYL

Q’ty / Eng. Weight

g(kg)

100 Turning gear piping 1 1 1 1 1 Approx.7.04 101 Emergency stop air piping 1 1 1 1 1 Approx.4.23 102 Gas vent v/v control air piping 1 1 1 1 1 Approx.1.25 103 DVT control air piping 1 1 1 1 1 Approx.4.89 104 Control air piping 1 1 1 1 1 Approx.7.67 105 Control air pipe for waste gate v/v 1 1 1 1 1 Approx.1.04 106 Pipe 1 1 1 1 1 Approx.0.21 200 Solenoid valve assembly 1 1 1 1 1 Approx.38.31 201 Pressure regulating valve 1 1 1 1 1 202 3/2-way solenoid valve 1 1 1 1 1 203 Shuttle valve 1 1 1 1 1 204 3/2-way magnet valve 1 1 1 1 1 205 3/2 way valve 1 1 1 1 1 206 Silencer 1 1 1 1 1 Approx.0.03 300 Band 1 1 1 1 1 301 Band 3 4 5 6 7 302 Band 1 1 1 1 1 Approx.0.33 310 Clamp 3 3 3 3 3 Approx.0.08 311 Clamp 3 3 3 3 3 Approx.0.12 312 Clamp 2 2 2 2 2 Approx.0.15 313 Clamp 1 1 1 1 1 Approx.0.14 314 Clamp 2 2 2 2 2 Approx.0.28 315 Clamp 4 4 4 4 4 Approx.0.38 316 Clamp 1 1 1 1 1 Approx.0.54 317 Clamp 2 2 2 2 2 Approx.0.18 318 Clamp 2 2 2 2 2 Approx.0.30 319 Clamp 1 1 1 1 1 Approx.0.53 321 Clamp 2 2 2 2 2 Approx.0.19 323 Plate 1 1 1 1 1 Approx.2.03 324 Support 1 1 1 1 1 Approx.0.09

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Item No. Description

Q’ty / Eng. Weight

Q’ty / Eng. Weight (kg) Remarks / See Note 12CYL 14CYL 16CYL 18CYL 20CYL

g(kg)

325 Clamp 1 1 1 1 1 Approx.0.17 326 Clamp 1 1 1 1 1 400 Bolt 1 1 1 1 1 401 Bolt 6 6 6 6 6 402 Bolt 3 4 5 6 7 403 Bolt 7 7 7 7 7 405 Bolt 8 8 8 8 8 406 Bolt 2 2 2 2 2 407 Socket head bolt 4 4 4 4 4 Approx.0.04 408 Bolt 16 16 16 16 16 410 Washer 3 4 5 6 7 Approx.0.18 411 Washer 4 4 4 4 4 Approx.0.09 412 Washer 1 1 1 1 1 Approx.0.01 413 Washer 7 7 7 7 7 Approx.0.21 420 Nut 3 3 3 3 3 Approx.0.01 421 Nut 2 2 2 2 2 460 Gasket 1 1 1 1 1 461 Gasket 1 1 1 1 1 462 Gasket 7 7 7 7 7 463 Gasket 10 10 10 10 10 464 Gasket 9 9 9 9 9 465 Gasket 1 1 1 1 1 500 Name plate 1 1 1 1 1 501 Name plate 1 1 1 1 1 502 Name plate 1 1 1 1 1 503 Name plate 1 1 1 1 1 504 Name plate 1 1 1 1 1 505 Name plate 1 1 1 1 1

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Arr. Of Slow Turing Control ping Assembly Drawing & Part List

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312 332,402 202,203,502

103,461 105,003

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Part List

Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note 101 Slow turn pipe 1 Approx.4.47 102 Slow turn pipe 1 Approx.2.82 103 Slow turn pipe 1 Approx.3.83 104 Slow turn pipe 1 Approx.2.91 105 Slow turn pipe 1 Approx.1.12 003 Non-return valve 1 Approx.2.85 106 Slow turn pipe 1 Approx.5.69 007 Non-return valve 1 Approx.1.12 107 Slow turn pipe 1 Approx.0.23 201 Throttle valve 1 202 Pressure governor 1 203 Pressure gauge 1 Approx.0.05 311 Clamp 1 Approx.0.58 312 Clamp 1 Approx.0.58 313 Clamp 1 Approx.0.38 330 Support 1 Approx.5.23 331 Support 1 Approx.2.76 332 Support 2 Approx.2.68 401 Bolt 2 Approx.0.02 402 Bolt 4 Approx.0.08 403 Bolt 4 404 Bolt 1 Approx.0.25 405 Bolt 1 Approx.0.04 411 Washer 4 Approx.0.01 412 Washer 1 Approx.0.40 413 Washer 2 Approx.0.18 414 Washer 4 Approx.0.31 415 Washer 1 Approx.0.51 421 Nut 4 Approx.0.01 422 Nut 4 Approx.0.03 461 Gasket 2

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Arr. Of Slow Turing Control ping Assembly Drawing & Part List

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Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note

Item No. Description Q’ty / Eng. Weight (kg)

462 Gasket 463 Gasket 464 Gasket 501 Name plate 502 Name plate

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Mount of Turning Gear Assembly Drawing & Part List

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Part List Item No. Description Q’ty / Eng. Weight(kg) Remarks / See Note 001 Turning gear complete 1 Approx.300 003 Bolt 4 Approx.0.23 006 Washer 4 Approx.0.02 007 Washer 4 Approx.0.02

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12A

120 (SE111)

120 (SE112)

120 (SE113)

() 120 (SE114)

Section “A”

Detail “B”

Part List Item No. Description Q’ty / Eng.Weight (kg) Remarks / See Note 110 Speed pickup sensor 2 0.7 SE111,112 11A Engine rpm pick-up cable 2 7.5 11B Constant force spring for grounding 5 0.1 120 Position pickup sensor 4 0.7 SE121~124 12A Cable with connector 4 7.5 14A Small junction box 2 1

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920 92A

Part List

Detail “A”

Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note 12cyl. 14cyl. 16cyl. 18cyl. 20cyl. 920 Oil mist detector 6 7 8 9 10 0.6 LS92 92A Detector cable (one side 10m) 2 2 2 2 2 5 92B Detector cable (both side 1m) 5 6 7 8 9 0.5 92C Oil mist monitor 1 1 1 1 1 2.2 92D Electric cable 11 12 13 14 15 0.5

Detail “A” Detail “C” Part List Item No. Description Q’ty / Eng.Weight (kg) Remarks / See Note 210 Temperature sensor 2 0.6 TE211,212 290 Temperature sensor 1 0.6 TE29 580 Temperature sensor 2 0.6 TE58-A,B 640 Temperature sensor 2 0.6 TE64-A,B 710 Temperature sensor 1 0.6 TE71 720 Temperature sensor 1 0.6 TE72 750 Temperature sensor 1 0.6 TE75

720

(TE58-A)710 720 580 720

(TE58-A)

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210 760 (TE211)

(TE58-B)580

620 Part List

Detail “F”

Detail “D” Detail “E”

520

Item No. Description Q’ty / Eng.Weight (kg) Remarks / See Note 520 Temperature sensor 1 0.6 TE52 620 Temperature sensor 1 0.6 TE62 760 Temperature sensor 1 0.6 TE76 770 Temperature sensor 1 0.6 TE77

770

Detail “A”

Detail “A1”

Part List Item No. Description Q’ty / Eng.Weight (kg) Remarks / See Note 270 Temperature sensor 2 0.6 TE27-A,B 27A Thermocouple cable (20,000mm) 2 10 27B Pocket 2 0.6

Part List

Section “A”

Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note 12cyl.14cyl.16cyl.18cyl.20cyl.050 Temperature sensor 7 8 9 10 11 0.6 TE05 05A Support for main bearing 7 8 9 10 11 0.1 05B Hex.bolt with wire hole 14 16 18 20 22 0.1 05C Cable gland 7 8 9 10 11 0.1 05G Wire *1x3000 1 1 1 1 1 0.1

490

400 410 41A

Detail “A”

Detail “B” Detail “D”

(PT211) 210 620

630 (TE63-A)

630

Detail “E”

Part List Item No. Description Q’ty / Eng.Weight (kg) Remarks / See Note 210 Pressure transmitter 2 1.5 PT211,212 400 Pressure transmitter 1 1.5 PT40 410 Pressure transmitter 1 1.5 PT41 41A Test valve 1 1.5 430 Pressure transmitter 1 1.5 PT43 43A Test valve 1 1.5 490 Pressure switch 1 1.5 PS49 620 Pressure transmitter 1 1.5 PT62 630 Pressure transmitter 2 1.5 PT63-A,B 710 Pressure transmitter 1 1.5 PT71 870 Pressure transmitter 1 1.5 PT87

43A (PT212)210

Detail “C”

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630 (TE63-B)750 Detail “G”

660

510 520 Detail “F”Detail “H”

030

52C 52B 52D

Part List Item No. Description Q’ty / Eng.Weight (kg) Remarks / See Note 030 Pressure transmitter 1 1.5 PT03 510 Pressure transmitter 1 1.5 PT51 520 Pressure transmitter 1 1.5 PT52 52B Hex. bolt 10 0.1 52C Washer 10 0.1 52D PS_PT plate 1 5.95 660 Pressure transmitter 1 1.5 PT66 66A Test valve 1 1.5 750 Pressure transmitter 1 1.5 PT75

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350 35A Detail “A” 300 310 Detail “B”

311

Part List Item No. Description Q’ty / Eng.Weight (kg) Remarks / See Note 300 Pressure transmitter 1 1.5 PT30 310 Pressure transmitter 1 1.5 PT31 311 Temperature sensor 1 1.5 TE31 320 Pressure transmitter 1 1.5 PT32 350 Pressure transmitter 1 0.5 PT35 35A Test valve 1 1

24A 24B 24C 24D 24E

240

Detail “A” Part List Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note 12cyl.14cyl. 16cyl. 18cyl. 20cyl. 240 Pressure transmitter 1214 16 18 20 0.2 PT24 24A Cable (15,000mm) 1214 14 16 18 7.5 24B Cable (20,000mm) - - 2 2 2 10 24C Clamp 2428 32 36 40 0.1 24D Hex. bolt 4856 64 72 80 0.1 24E Nut 4856 64 72 80 0.1

The engine fuel system is designed for a reliable combustion of heavy fuel oil as well as diesel fuel oil. However, it should be flushed by diesel fuel oil before maintenance to avoid clogging of the system. Fig 1 shows the internal fuel oil system. The main fuel injection equipment comprises an injection pump, a connection block, an fuel high pressure block and an injection valve, which are installed on each cylinder in line. Pilot injection valves on individual cylinders, a pilot injection pump, high pressure double-walled pipe are main components of micro pilot fuel injection system.

The fuel injection pump has a LDFV51000

roller tappet with built-in roller. The fuel injection pump should be overhauled partly or totally at regular intervals. The pilot injection pump, which is motor-driven, compresses pilot fuel to 1000 bar. The pressurized pilot fuel is transferred to each pilot injection valve. If finding Any problem about fuel oil pump, please contact HHI’s EMD A/S for the information.

The fuel injection valve is fitted LDFV52000

in the center of cylinder head. The pressure of valve opening should be checked periodically. The pilot injection valve, which is solenoid-operated, is controlled by the engine control system in order to adjust injection timing and duration. The lubricating oil is supplied to each injection pump via connected pipe of engine frame and returned as dirty oil, which is mixed oil of fuel and lubricating oil. Lubricating oil is supplied to the pilot injection pump and out through connecting pipe into base frame.

The safety filter can be mounted LDFV56000

on engine on request of the customer. The safety filter is a duplex filter of the split type with a filter fineness of 50 micron. The filter is equipped with a common three-way cock for manual change of both the inlet and outlet side.

The pilot filter is installed on the engine and duplex filter with a filter fineness of 5 micron. During normal operation both filters should be in operation. Single operation only to be used when dismantling one of the filters for manual cleaning or inspection. The quality of fuel oil is vital for the

reliability of fuel system (See). G05100

The filtration of fuel influences directly on the lifetime of fuel injection pumps and valves. If any part of fuel system is dismantled, be sure to check the cleanliness before remounting. The engine fuel system is designed for a reliable combustion of natural gas. Fig 2 shows the internal fuel gas system. The fuel gas is injected by gas admission valve into the intake port of each cylinder with

suitable timing and duration. To regulate the power and speed of engine, the amount of fuel gas fed into each cylinder is individually controlled by the gas admission valves which are received signal from engine control system.

To protect the gas admission valve, a safety filter with a fineness of approx. 80㎛ is installed at downstream of each valve. The gas ventilation valve purges the residual gas from the fuel gas feed pipes to outside of the engine room. The valve is actuated pneumatically and controlled by engine control system.

Fuel Injection Pump Ass’y Assembly Drawing & Part List

H35DFV Section No.

Page 1/6 Rev.

LDFV51000

LDFV52300 LDFV25000

100 911 912 200

Part List Item No. Description Q’ty / Cyl. Weight (kg) Remarks / See Note 100 Fuel injection pump 1 Approx.34.5 Incl.item 101~131 200 Fuel pump drive assembly 1 Approx.0.47 Incl.item 202~315 911 Bolt 4 Approx.0.14 912 Washer 4 Approx.0.01

Fuel Injection Pump Ass’y Assembly Drawing & Part List

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Fuel Injection Pump Ass’y Assembly Drawing & Part List

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Page 3/6 Rev.

LDFV51000

Part List

Item No. Description Q’ty / Cyl. Weight (kg) Remarks / See Note 101 Pump housing 1 Set 105 Snap ring 1 106 Plunger assembly 1 Set 107 Seal ring 2 109 O-ring 1 110 O-ring 1 111 Delivery valve assembly 1 Set Incl.item 181~186 181 Delivery valve case 1 182 Delivery valve 1 183 Delivery valve spring 1 184 Constant pressure valve 1 185 Constant pressure valve spring 1 186 Dowel pin 1 112 Socket head bolt 6 113 Socket head bolt 6 114 Control rack 1 115 Control sleeve 1 116 Pointer 1 117 Cover for control rack 1 118 Bolt 2 119 Seal ring 1 120 Plug 1 121 Gasket 1 122 Deflector 2 Approx.0.30 123 Gasket 2 Approx.0.10 124 Spring seat 1 125 Plunger spring 1 126 Spring seat 1 127 Plunger guide 1 129 Socket head bolt 2 130 Plug 1 131 Gasket 1

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Fuel Injection Pump Ass’y Assembly Drawing & Part List

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LDFV51000

301 207 209302 214,215 304213 303 208 202 211

306 312 212 204 206 205 305 313 313

210 400-410

315 311 310

View “A” View “B”

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Fuel Injection Pump Ass’y Assembly Drawing & Part List

H35DFV Section No.

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LDFV51000

Part List

Item No. Description Q’ty / Cyl. Weight (kg) Remarks / See Note 202 Housing 1 Approx.17.0 203 Roller guide 1 Approx.4.70 204 Roller 1 Approx.1.60 205 Roller pin 1 Approx.1.34 206 Roller bush 1 Approx.0.33 207 Upper housing 1 Approx.16.8 208 Shaft Lower 1 Approx.3.20 209 Plunger 1 Approx.1.25 210 Thrust washer 1 Approx.0.16 211 Spring 1 212 Pin 1 Approx.0.06 213 Cover 1 Approx.0.35 214 Gasket 2 215 Acrill cover 1 Approx.0.05 301 O-ring 1 302 O-ring 1 303 O-ring 1 304 Socket head bolt 4 Approx.0.03 305 Set screw 1 306 Plug 1 Approx.0.03 310 Socket head bolt 4 Approx.0.16 311 Hex. bolt 8 Approx.0.11 312 Gasket 1 313 Parallel pin 2 Approx.0.01 315 O-ring 1 400 Thrust washer 2 401 Thrust washer 2 402 Thrust washer 2 403 Thrust washer 2 404 Thrust washer 2

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Fuel Injection Pump Ass’y Assembly Drawing & Part List

H35DFV Section No.

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LDFV51000

Item No. Description Q’ty / Cyl. Weight (kg) Remarks / See Note

Item No. Description Q’ty / Cyl. Weight (kg)

405 Thrust washer 406 Thrust washer 407 Thrust washer 408 Thrust washer 409 Thrust washer 410 Thrust washer

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H35DFV Page 1/3

Dismounting a Fuel Injection Pump from the engine 1. Disconnect small pipes. (Fuel oil drain pipe, etc) 2. Disconnect the fuel rack and the fuel control lever by taking out the connecting pin as shown in Fig. 1.

3. Detach the block for fuel feed LDFV52300

pipes by unscrewing two nuts LDFV52300

and two bolts.

Prepare and attach clean rag around fuel injection pump against fuel oil dropping from feed pipes. 4 2LDFV53318 LDFV53319 LDFV53362 LDFV53363

4. Unscrew eight bolts of the feed LDFV53300

LDFV53318

pipe connecting.

LDFV53318

LDFV53319 LDFV53362 LDFV53363

LDFV53319LDFV53362 LDFV53363

5. Unscrew four bolts of the fuel LDFV51911injection pump. 6. Lift up the fuel injection pump slowly and carefully. Be careful not to be damaged by touching adjacent parts. 7. Move and place the fuel infection pump on a working stand.

M51000

Mounting a Fuel Injection Pump on the engine Remounting procedure is basically reverse order of dismounting procedure. The fuel injection pump should be maintained completely and ready for normal service. 1. Lift up the fuel injection pump from working table and clean the fuel injection pump and engine block. 2. Move

and lower the fuel injection pump down slowly through the bore of the engine block. Be careful not to be damaged by touching adjacent parts. 3. Tighten the bolts for fuel injection pump with increasing torque step by step and one by one diagonally. Tightening torque : 200 Nm (with molykote)

M51000

LDFV52300

4. Tighten two nuts and two bolts LDFV52300

LDFV52300

LDFV52300

for high pressure block with

increasing torque step by step alternatively. Tightening torque : 20 -> 50 -> 80 Nm by three steps (with molykote)

M52300

Tightening orders :

M52300

When mounting high pressure block, tighten the bolts carefully not to leak fuel oil. 5. Connect small pipes and fuel rack and fuel control lever. Check movement of rack. 6. Close all covers. Whenever driven parts are replaced with new ones, open the cam side door and make sure that lubrication oil comes out from tappet to roller by operating the pre-lubricating oil pump before engine running.

M51100

Disassembling a Fuel Injection Pump Before attempting to disassemble the fuel injection pump, make certain that working table, tools and fixtures are clean. Cover the working table with clean paper or soft cloth. After disassembly, all the parts must be cleaned using clean kerosene (or gas oil) and a h and brush (not a s teel brush). 1. Unscrew the socket head bol ts and loosen the socket head bol ts with using hexagonal wrench. [Fig 1] [Fig 2] 2. Unscrew two deflectors and remove them with gaskets. [Fig 3] [Fig 4]

Fig. 1 Fig. 2 Fig. 3 Fig. 4

3. Turn over the fuel injection pump. Press the plunger guide into the pump housing and remove the snap ring with snap ring pliers. [Fig 5] [Fig 6]

4. Remove the plunger guide with plunger, spring seat and plate out of the pump housing. Unscrew the bolts and r emove plunger with spring seat. [Fig 7] [Fig 8]

Be sure not to damage the plunger and keep it separately to prevent damage.

M51100

Fig. 6 Fig. 7 Fig. 8 Fig. 5

5. Remove the plunger spring and the control sleeve with the upper spring seat out of the pump housing. [Fig 9] [Fig 10] 6. Remove the control rack out of the pump housing. [Fig 11] 7. Remove the two plugs with gaskets. Unscrew the bolts and remove the cover with the pointer and seal ring out of the pump housing. [Fig 12]

Fig. 9

Fig. 10 Fig. 11 Fig. 12

M51100

8. Let fuel injection pump lay down and ha mmer the barrel out by using soft material bar etc. Throw away the O-rings. [Fig 13] 9. Unscrew the bolts with a hexagonal wrench. Remove the delivery valve case, delivery valve, constant pres-sure valve and springs. [Fig 14] [Fig 15] Be sure not to damage the sealing surface of the barrel, and keep it away separately to prevent damage.

Fig. 13 Fig. 14 Fig. 15

M51100

Inspection of parts Inspect all dismantled parts according to the following mentioned criteria, and replace the parts with new ones if necessary.

Depth : 0.7 mm

Replace the pump housing if symptoms of heavy abrasion or damage can be observed on sliding bore diameter. 2. Tappet assembly Replace the guide piston if 1. The indentation on the plunger and the plate onto tappet’s assembly seating surface is more than 0.25 mm in total.

5-3

5-2

5-1

2-1

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2. Symptoms of heavy abrasion or damage can be observed on bearing on sliding outside diameter. 3. Delivery valve and others Replace the delivery valve if symptoms of heavy abrasion or damage can be obs erved on t he seating. 4. Deflector assembly Replace the deflector if the depth of the erosion is more than 0.5 mm. 5. Plunger assembly Replace the plunger assembly if 1. The clearance between the plunger and the barrel is more than 15 µm. 2. The erosion of the plunger is marked less than 0.8 mm from notch. 3. The depth of the erosion marked on the plunger is more than 0.7 mm. 4. The depth of the erosion marked on the port of the barrel is more than 1.0 mm. 5. Symptoms of heavy abrasion or damage can be observed. The plunger and t he barrel are matched and cannot be r eplaced individually. 6. Control sleeve and control rack Replace the control sleeve and c ontrol rack if

1. The control rack’s movement is more than 0.2 mm on condition that the control sleeve is firmed. 2. The control rack’s movement is more than 0.5 mm on condition that the plunger is firmed.

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7. Plunger spring Replace the plunger spring if 1. Cracked or nicked. 2. Corroded. 3. Surface coating is damaged. 8. Delivery valve spring Replace the delivery valve spring if

1. Cracked or nicked. 2. Corroded. 9. O-rings Replace all these o-rings in every disassembly in addition to the specified overhauls. 10. Other parts Replace if 1. Cracked or nicked. 2. Corroded. 3. Symptoms of heavy abrasion or damage can be observed.

Assembling the Fuel Injection Pump Before attempting to assemble the fuel injection pump, make certain that working table, tools and fixtures are clean. Cover the working table with clean paper or soft cloth. Before assembly, all the parts must be c leaned using clean kerosene (or gas oil) and a han d brush (not a steel brush). Protective oil from new plunger assembly should be removed in kerosene thoroughly, when these parts are replaced. And dip them in clean filtered fuel oil before assembly. Replace all the O-rings with new ones. And apply grease to the O-rings and seal-rings before installing them. Coat all the threads with anti-seize product (Molykote or similar). Wipe and dry with paper the sealing surface of the barrel, the delivery valve, the constant pressure valve and the delivery valve case. Do not damage the sealing surface. Tighten the bolts in several steps up to a torque of 100 Nm with a torque wrench.

Socket head bolt (L51000-112) Socket head bolt (L51000-113) Fig. 17 Bolt tightening order

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1. Install new O-rings on t he barrel. Insert new seal-rings into the groove of barrel by using the special tools if it is damaged. When install seal-ring on bar rel, be careful to the direction of the seal rings. Apply grease to the O-rings and seal-rings before installing barrel to fuel pump housing. [Fig 18] 2. Set the delivery valve, constant pressure valve and springs on t he barrel. [Fig 19] 3. Set the delivery valve case on t he barrel. Tighten the six socket head b olt to fix the barrel to delivery valve case. [Fig 20] 4. Install the barrel with the delivery valve assembly into the pump housing. The barrel is located by means of dowel pin and hole of the delivery valve case. After the barrel is lowered to its seat, examine that the hole of the delivery valve case and t he dowel pin on t he pump housing are in the same position. [Fig 21]

Fig. 18 Fig. 19 Fig. 20 Fig. 21

5. Tighten the socket head bolts up to a t orque of 100Nm with a t orque wrench. Refer to bolt tightening order. [Fig 17] [Fig 22] [Fig 23]

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6. Install the seal ring into pump housing, when be careful to the direction of the seal ring. Install the control rack into the pump housing. Screw the plug with gasket. [Fig 24]

Fig. 22 Fig. 23 Fig. 24

7. When installing the control rack into the pump housing, rotate it until the tooth becomes visible through the bottom opening of the pump housing. 8. Lower the control sleeve into the pump housing and e ngage the control rack so that the location of the teeth of the control rack and control sleeve is indicated location in. [Fig 25] [Fig 26]

Fig. 25 Fig. 26

9. Install the upper spring seat and plunger spring. [Fig 27] 10. Hang the lower spring seat on t he plunger, and install the plunger with lower spring seat and plate into the plunger guide. Tighten the socket head bolts. [Fig 28]

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Fuel Injection Pump Maintenance Procedure

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M51100

11. Install the plunger into the barrel so that the vane of the plunger engages the slots in the control sleeve. [Fig 29] [Fig 30]

Fig. 27 Fig. 28 Fig. 29 Fig. 30

12. Force the plunger guide down against the plunger spring pressure making certain that the plunger vane engages the slots in the control sleeve. And install the snap ring into the groove of the pump housing. [Fig 31] [Fig 32] 13. Screw the deflectors with gaskets into the pump housing, and tighten them to a t orque of 250Nm with a t orque wrench. [Fig 33] 14. Attach the cover and pointer. Tighten the bolt into pump housing and install the plug with gasket. [Fig 34] 15. After assembling the smooth motion of the control rack must be checked and the plunger must be m oved from the no-load stop to full-load

Fig. 31 Fig. 32 Fig. 33 Fig. 34

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H35DF(V) Page.1/1

The fuel pump drive is located between camshaft and fuel injection pump and comprises housing, roller, bush, spring, thrust piece, and so on. The fuel injection pump drive converts rotation motion of cam shaft to transverse motion of the plunger for fuel injection pump. The fuel pump drive is installed management of control air for engine start and damage preventable device of cam shaft and pump drive when fuel injection pump is stuck. Engine is to be operated without any damage of cam shaft and pump drive if the cam shaft has enough space by inserting fixed bolt ① while fuel injection pump is stuck.

Pag 361
Fuel Pump Drive Maintenance Procedure

M51201

Adjustment of Fuel Injection Timing Fuel injection timing influences the maximum cylinder pressure which is set properly by engine maker and normally recommended not to be adjusted. However, if new fuel injection pump has been installed or if the deviation of each cylinder pressure is out of tolerance, the injection timing should be checked and adjusted, which can be adjusted by the thickness of thrust washer as shown in Fig 1. When inserting thrust washer (increasing thickness), the injection timing advances and maximum cylinder pressure increases. □ Thrust washer thickness+0.1mm=Cyl.pressure+2 bar Thrust plate thickness can be changed. But, please contact Hyundai Global Service. Co., Ltd for it. Thrust washer for adjusting fuel injection timing

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Pag 362
Fuel Pump Drive Maintenance Procedure

M51201

Description 1. Place the cylinder to adjust fuel injection timing to the T.D.C by rotating camshaft. 2. Unscrew the plug(306) and fix a plunger(209) by fixing bolts(307) not to move down. 3. Rotate the camshaft to the B.D.C to give space between shaft(208) and plunger(209). 4. Unscrew bolts of inspection window(304), cover and gasket(213)(214). 5. Pull out the thrust disk(210) with tweezers and inset thrust washer to the up side of shaft(208) and insert thrust disk(210) back to original position. Do not put your hands into the inspection window. 6. Rotate the camshaft to the T.D.C. 7. Unscrew the fixing bolt(307). 8. Fix the cover(213) and gasket(214) by bolts(304) after wiping with a piece of clean cloth.

Pag 363
Fuel Injection Valve Assembly Drawing & Part List

LDFV52000

LDFV52300

Part List Item No. Description Q’ty / Cyl. Weight(kg) Remarks / See Note 100 Fuel injection valve complete 1 193 Stud 2 Approx.0.18 194 Spacer 2 Approx.0.03 195 Nut 2 Approx.0.03 196 Gasket 1

195

100

193

194

196

LDFV52000

LDFV52000

Part List

Item No. Item No. Description Q’ty / Cyl. Weight (kg) 1 101 Fuel injection valve 1 Approx.7.5 2 102 Dowel pin 4 3 103 Nozzle nut 1 Approx.0.3 4 104 Spindle 1 Approx.0.03 5 105 Spring 1 Approx.0.1 6 106 Adjust bolt 1 Approx.0.6 7 107 Nut 1 Approx.0.04 8 108 O-ring 2 9 109 O-ring 2 10 110 O-ring 1 11 111 Atomizer assembly 1 Approx.0.4 12 112 Attachment 1 Approx.1.0

Remarks / See Note

M52000

In case that the exhaust temperature of a particular cylinder deviates considerably from the others, dismount and inspect the fuel injection valve carefully. The possible causes are an incorrect mounting of fuel injection valve, or uneven injection of fuel oil to combustion chamber, or wrong valve opening pressure. In order to check correct operation of the fuel injection valve, functional test should be performed by means of the hand pump before mounting the fuel injection valve. Dismantling Fuel Injection Valve from Cyl. Head 1. Install the removal device on the fuel injection valve as shown in fig 1.

Removal device : 91.130 91.130

2. Pull out the fuel injection valve from the cylinder head by rotating the nut (L) of removal device.

Fuel Injection Valve

M52000

Function Test of Fuel Injection Valve 1. Mount the fuel injection valve on the testing device as shown in fig 2.

M52000

2. Connect the high pressure pipe to the fuel injection valve. 3. Pump slowly by hand, and check the valve opening pressure and spray pattern. Valve opening pressure : 375 bar Don’t put hands near spray area during testing. High injection pressure may damage to the human body. Adjustment of Valve Opening Pressure If the valve opening pressure is not 375 bar, adjust opening pressure as following process. 1. Loosen the locking nut (F). 2. Turn the adjusting screw (G) slowly and check valve opening pressure while pumping. 3. Adjust the valve opening pressure by the step of 10 bar. 4. When pressure setting is finished, tighten the nut (F) with a t orque spanner to fix the adjusting screw. Tightening torque : 150 Nm (with Molykote) Dismantling of Fuel Valve Nozzle Though the testing device can be us ed for dismantling nozzles of fuel valve, it is convenient to use atomizer removal tool. 1. R emove carbon deposit on t he surface of nozzle body. 2. Fix the tool on support. 3. Insert fuel valve on the tool as fig.3.

Atomizer removal tool : 91.390 91.390

5. Loosen the locking nut(F). 6. L oosen the adjusting screw (G) and set the valve opening pressure to 0 bar. 7. Remove the sealing gasket(K)(refer to fig.4) 8. Loosen the nozzle nut(J) with a torque spanner.

M52000

Carbon between nozzle and nozzle nut can make Dowel pin broken when dismantling nozzle. Be careful of damage of dowel pin.

91.390 91.390 Nozzle

91.390 91.390

Dowel pin

If some of holes are clogged, the nozzle should be dismantled and cleaned.

Cleaning tool for nozzle : 91.370 91.370

After cleaning the nozzle, reassemble the fuel valve and repeat the above function test. If the spray pattern is not normal or still clogged, scrap the nozzle and replace with new ones. Remove carbon, and clean the nozzle nut and nozzle. Especially clean surface for contact between the nozzle nut and nozzle as fig.7 in order to prevent leakage of gas by abnormal contact Assembling of Fuel Valve Nozzle Though the testing device can be us ed for assembling nozzles of fuel valve, it is convenient to use atomizer removal tool. 1. Insert fuel valve on the tool as fig.3. 2. Loosen the locking nut(F). 3. Insert Dowel pin(to be supplied with spare nozzles) in pin hole. 4. Connect the nozzle nut with nozzle in fuel valve body 5. Tighten the nozzle nut(J) with a torque spanner.

(with SW41 Deep impact socket)(refer to fig.5)

91.630 91.630

Tightening torque : 250 Nm (with Molykote 1000 or copaslip) 6. Install sealing gasket(K) on nozzle(refer to fig.4) Sealing Gasket should be replaced after overhauling fuel injection valve. Valve body and bush could be stuck and damaged by leakage exhaust gas, if re-use deformed gasket.

Lapping of Fuel Injection Valve Bush As shown in Fig.7, remove carbon and clean

the bush before mounting the fuel injection valve on the cylinder head.

Lapping tool for bush : 91.350 91.350   Lapping Position

Lapping tool for bush : 91.350 91.350

Fig. 6 Lapping Tool for H32/40(V)

Fig.7 Position of The Fuel Injection Valve Lapping Tool

Fuel Injection Valve Maintenance Procedure

H35DF(V) Section No.

M52000

Mounting Fuel Injection Valve on Cyl. Head 1. Replace the O-rings with new ones, and clean fuel injection valve and cylinder head. 2. Mount the fuel injection valve on the cylinder head, and tighten the nuts (A) slightly. Take care not to damage the nozzle and O-rings during mounting. 3. Tighten the nuts (A) Tightening torque : 200 Nm (with Molykote) 4. Insert the injection pipe correctly as shown in fig. 9, and tighten the nut (H). Tightening torque : 20 Nm → 50 Nm → 80 Nm by three steps (with Molykote)

Tightening orders : M52300 M52300 A   Nozzle

Tightening orders : M52300 M52300

Contact surface Contact surface Nozzle nut

Fuel Injection Valve Reconditioning of Fuel Injection valve

All Type Section No. M52001

Fuel Injection Valve Reconditioning of Fuel Injection valve

It is generally recognized that atomization pattern deteriorates gradually due to seat wear after a certain period of diesel engine-running. Though mal-injection pattern was observed, its phenomena can be reconditioned by lapping in order to revive the performance for continuous re-use. In this news, the details are described as below. How to Lap on Seat 1. Necessary tools and material Drilling machine or electric drill Lapping powder No. 1500 ~ No. 1800 Cleaning oil, gas oil, lube. oil and compressed air 2. Procedure Fit needle valve into drill chuck. Apply lapping powder dissolved in lube. oil to needle valve seat. Insert needle valve into nozzle body. Fit them by rotating for minimum lapping (approx. 15 seconds) to find circumferential contact-trace on needle seat. When circumferential contact trace was not found and/or demanded area due to foreign substance was still remained, lapping is more necessary. When circumferential contact-trace on needle seat was found, clean by oil and do air-blow. Then apply lube.oil to needle seat and assemble it back. Reconditioning of fuel injection valve could be available once or twice.

Pag 373
Fuel Injection Valve Reconditioning of Fuel Injection valve

All Type Section No. M52001

Page 2/2 Rev. 1A

Fuel Injection Valve Reconditioning of Fuel Injection valve

Photos of needle valve seat before/after fit Refer to the following photos.

Before After

Pag 374
Fuel Injection Valve Checking Atomizing Condition

All Type Section No.

Page 1/3 Rev.

M52002

As atomizing condition of F.O has much effect on the engine combustion, maintenance

should be observed according to regulated schedule.

Maintenance schedule:

G09100

Procedure of Checking Atomizing Condition Carry out checking atomizing condition of fuel injection valve according to the standard maintenance procedure.

Maintenance procedure:

M52000

Heavy fuel oil residues in injection valves may adversely affect the test results and impede cleaning. So we recommend operating the engine on Diesel oil for approx. one hour prior to dismantling injection valves. If this is not possible and the engine has to be shut down from operation on heavy fuel oil, the injection valve has to be disassembled and cleaned before the checks described here can be carried out. DMB Grade oil regulated by ISO-8217 or the equivalent oil should be used for testing the injection valves. During the fuel injection valve test, the test criteria are nozzle hole clogging and leaking F.O. according to the checking point in the next page. When the abnormal condition occurs after checking atomizing condition, the fuel injection nozzle should be changed by a new one.

M52002

Checking Atomizing Condition (1) – The Nozzle Bores 1. Checking procedure 1) Open the pressure relief valve. 2) Loosen the hexagon nut of fuel injection valve, and turn back the setting screw until the tension of the compression spring has been released. 3) Close the pressure relief valve. Actuate the hand pump evenly, and adjust the opening pressure to 30 bars by means of the setting screw. 2. Criterion of decision – All nozzle holes open 1) All nozzle holes open: normal 2) Partly clogged: Disassemble the fuel injection valve and cleaning or changing to the new one.

Maintenance procedure: M52000 M52000

Checking Atomizing Condition (2) – Keeping the tightness 1. Checking procedure 1) Actuate the hand pump evenly until the pressure gauge shows 250 bars. 2) The injection nozzle can be considered tight if no drop falls within a period of 5 seconds. 2. Criterion of decision – All nozzle holes open 1) Keeping the tightness: normal 2) Dripping on nozzle: re-conditioning or changing to a new one.

Re-conditioning procedure: M52001 M52001

Fig.1 Judging the nozzle bores. (left : open, right : partly clogged)

M52002

When testing injection valves, it may show the pattern of penetration because the nozzle’s behavior during engine operation cannot be equal by means of the nozzle tester. It is because the pressure gap between the cylinder chamber and the atmosphere, and using the hand pump is hard to make the similar pattern such as fuel injection pump during the engine running. If there is no dripping on the tip of atomizer and no closed holes, and the exhaust gas temperature and maximum pressure in each cylinder is in the normal condition, the nozzle can be expected to make appropriate engine performance.

Fig.2 Judging the tightness (left : tight, right : dripping)

M52003

Fuel injection valve checking should be carried out according to below procedure. Procedure of Checking Fuel Injection Valve Be well-informed of M52000 and M52002 before checking fuel injection valves.

Maintenance procedure: M52000 M52000 M52002 M52002

Check List for Fuel Injection Valve Carry out checking fuel injection valves according to below list, then fill in the check table. ① Clogging test Carry out at 30 bar, fill in the table ‘Number’ when there are clogged holes and ‘N’ when no clogged hole. ② Sealing test There should be no dropping at 250bar during 5 seconds, fill in the table ‘N’ when there are no dropping and ‘Y’ when dropping. ③ Opening pressure adjustability Fill in the table ‘Y’ when possible to adjust opening pressure from 0 bar to setting value for each engine type and ‘N’ when impossible. ④ Sealing test at setting value There should be no dropping from 0 bar to setting value, fill in the table ‘N’ when there are no dropping and ‘Y’ when dropping. ⑤ Atomization test Fill in the table ‘Good’, ‘Normal’, ‘NG (No Good)’ after checking atomization. Check Result of Fuel Injection Valve Reusing of fuel injection valve should be judged from above ①②③④ results. ⑤ is just reference and if ①②③④ results are good, the engine performance will be normal after installation at the engine.

FIV CHECK SHEET Check Sheet

M52003

When the engine has normal exhaust gas temperature and maximum pressure in cylinder it is a normally usable fuel injection valve, even though the above test result is not good. Refer to the check table on the next page.

FIV CHECK SHEET Check Sheet

M52003

◈ VESSEL No. : _____

Engine No. : , Engine Type : , Engine Total Running hrs : . Cyl. List123456789FIV Running hrs① Clogging or Not② Sealing at 250 bar③ O/P Adjustability④ Sealing at S/V.⑤ AtomizationEngine No. : , Engine Type : , Engine Total Running hrs : . Cyl. List123456789FIV Running hrs① Clogging or Not② Sealing at 250 bar③ O/P Adjustability④ Sealing at S/V.⑤ AtomizationEngine No. : , Engine Type : , Engine Total Running hrs : . Cyl. List123456789FIV Running hrs① Clogging or Not② Sealing at 250 bar③ O/P Adjustability④ Sealing at S/V.⑤ AtomizationEngine No. : , Engine Type : , Engine Total Running hrs : . Cyl. List123456789FIV Running hrs① Clogging or Not② Sealing at 250 bar③ O/P Adjustability④ Sealing at S/V.⑤ Atomization

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H35DFV Section No. LDFV52002 400 410

Micro Pilot System(High Pressure) Assembly Drawing & Part List

Micro Pilot System(High

460 401

603 602

201

901 202

Detail “C” 311 910 920 Detail “B”

H35DFV Section No. LDFV52002

Page 2/2 Rev. 1A

Micro Pilot System(High

Part List

Q’ty / Eng. Weight

Item No. Description 100 M.P. system

Q’ty / Eng. Weight (kg) Remarks / See Note 12cly. 14cly. 16cly. 18cly. 20cly.

g(kg)

200 M.P. injector assembly 1 1 1 1 1 Incl.item 201~603 201 Drain block 10 12 14 16 18 Approx.0.29 202 Drain block(last) 2 2 2 2 2 Approx.0.32 400 Bolt 24 28 32 36 40 Approx.0.05 401 Bolt 24 28 32 36 40 Approx.0.01 410 Washer 24 28 32 36 40 460 O-ring 24 28 32 36 20 602 Gasket 12 14 16 18 20 603 O-ring 12 14 16 18 20 311 Clamp 2 2 2 2 2 Approx.0.15 330 Support 2 2 2 2 2 Approx.1.80 331 Support 1 1 1 1 1 Approx.0.49 810 Bolt 1 1 1 1 1 811 Bolt 8 8 8 8 8 820 Washer 1 1 1 1 1 821 Washer 8 8 8 8 8 901 O-ring 26 30 34 38 42 902 O-ring 24 38 32 36 40 903 O-ring 4 4 4 4 4 904 O-ring 4 4 4 4 4

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H35DFV Section No. LDFV52003 318 406 415

Micro Pilot System (Low Pressure) Assembly Drawing & Part List

Micro Pilot System

317 406 415 319 406 415 319 406 415 319 406 415 312 314

Detail “B” 310 461 100,201,400 410,420,460 202,401 410,420,460 200,402,413

View “D”

Detail “C” 203,403 411,421

316,404,414

111 106

109 500 107 114 462 Detail “A”

113 462 463501 315,405 412,422

113 462

463 101

H35DFV Section No. LDFV52003 104

Micro Pilot System (Low Pressure) Assembly Drawing & Part List

Micro Pilot System

Part List

Item No. Description

Q’ty / Eng. Weight

Q’ty / Eng. Weight (kg) Remarks / See Note 12cly. 14cly. 16cly. 18cly. 20cly.

g(kg)

100 Mp filter inlet pipe 1 1 1 1 1 Approx.0.91 003 Micro pilot system 1 1 1 1 1 Approx.0.91 Incl.item 201~603 101 M.p pump inlet pipe 1 1 1 1 1 Approx.3.56 102 M.p return pipe -1 10 12 14 16 18 Approx.0.17 103 M.p return pipe -2 1 1 1 1 1 Approx.0.58 104 M.p return pipe -3 1 1 1 1 1 Approx.0.31 105 M.p return pipe -4 1 1 1 1 1 Approx.0.85 106 M.p return pipe -5 1 1 1 1 1 Approx.1.14 107 M.p return pipe -6 1 1 1 1 1 Approx.0.31 108 M.p recycling pipe 1 1 1 1 1 Approx.0.13 109 M.p leakage pipe 1 1 1 1 1 Approx.0.19 110 M.p l.o inlet pipe -1 1 1 1 1 1 Approx.0.76 111 M.p l.o inlet pipe -2 1 1 1 1 1 Approx.0.94

Q’ty / Eng. Weight

Item No. Description

Q’ty / Eng. Weight (kg) Remarks / See Note 12cly. 14cly. 16cly. 18cly. 20cly.

Weigh(kg)

112 M.p l.o outlet pipe 1 1 1 1 1 Approx.0.36 113 M.p leakage pipe 1 1 1 1 1 Approx.0.47 114 M.p leakage pipe 1 1 1 1 1 Approx.0.59 200 Duplex filter 1 1 1 1 1 Approx.48.00 201 Connection piece 1 1 1 1 1 Approx.2.80 202 Connection piece 1 1 1 1 1 Approx.2.74 203 Fo. Leakage alarm tank 1 1 1 1 1 Approx.4.87 310 Clamp -6 1 1 1 1 1 Approx.0.40 311 Clamp for m.p pipe 2 2 2 2 2 Approx.0.35 312 Clamp for m.p pipe 1 1 1 1 1 Approx.0.22 314 Clamp for m.p pipe 1 1 1 1 1 Approx.0.20 315 Pipe clamp 2 2 2 2 2 Approx.0.26 316 Clamp ass'y 3 3 3 3 3 Approx.0.30 317 Clamp for m.p pipe 1 1 1 1 1 Approx.0.31 318 Clamp for m.p pipe 1 1 1 1 1 Approx.0.34 319 Clamp for m.p pipe 3 3 3 3 3 Approx.0.30 400 Bolt 4 4 4 4 4 Approx.0.09 401 Bolt 4 4 4 4 4 Approx.0.08 402 Bolt 4 4 4 4 4 403 Bolt 4 4 4 4 4 404 Bolt 3 3 3 3 3 Approx.0.03 405 Bolt 2 2 2 2 2 Approx.0.02 406 Bolt 5 5 5 5 5 410 Washer 8 8 8 8 8 Approx.0.51 411 Washer 2 2 2 2 2 Approx.0.32 412 Washer 2 2 2 2 2 Approx.0.18 413 Washer 4 4 4 4 4 Approx.0.01 414 Washer 5 5 5 5 5 Approx.0.41 415 Washer 5 5 5 5 5 Approx.0.21 420 Nut 8 8 8 8 8 Approx.0.02

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Micro Pilot System (Low Pressure) Assembly Drawing & Part List

H35DFV Section No. LDFV52003

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Micro Pilot System

Item No. Description

Q’ty / Eng. Weight

Q’ty / Eng. Weight (kg) Remarks / See Note 12cly. 14cly. 16cly. 18cly. 20cly.

g(kg)

421 Nut 4 4 4 4 4 Approx.0.01 422 Nut 2 2 2 2 2 Approx.0.01 460 Packing 3 3 3 3 3 461 Gasket 5 5 5 5 5 462 Gasket 5 5 5 5 5 463 Gasket 1 1 1 1 1 500 Name plate 1 1 1 1 1 501 Name plate 1 1 1 1 1

Pag 386
Fuel Injection Pipe Assembly Assembly Drawing & Part List

H35DFV Section No.

LDFV52300

108 107 118

108 1

Detail “A”

Pag 387
Fuel Injection Pipe Assembly Assembly Drawing & Part List

H35DFV Section No.

LDFV52300

Part List

Item No. Description Q’ty / Cyl. Weight (kg) Remarks / See Note 100 Fuel high pressure block assembly 1 Approx.5.00 Incl.item 101~118 101 High pressure block 1 Approx.3.53 104 Piece for fuel pump 1 Approx.0.06 105 Connection piece 1 Approx.0.83 106 Stud for hp block 2 Approx.0.10 107 Washer 2 Approx.0.02 108 Washer 2 Approx.0.03 109 Plugging piece 1 Approx.0.01 111 Set screw 1 Approx.0.01 114 Socket head bolt 2 Approx.0.12 116 O-ring 1 117 O-ring 1 118 Nut 2 Approx.0.03

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Arr. Of F.O Feed Piping Assembly Drawing & Part List

H35DFV Section No.

LDFV53000

<A-Bank> B A 121,129

107,135,139

113,138,142 108,138 113,138 129

118,124,125,128 127

103

102

159 106

156

104

101

110

122,132

109,136,141   Detail "A"

105

143

LDFV53000

Detail "C" 117,123

119,124 154,155

148,149,150 144

139,157

158

111,137

147,151,153

146,151,152

Detail "B"

LDFV53000

Part List (A-bank) Item No. Description

Q’ty / Eng. Weight (kg) Remarks / See Note 12CYL. 14CYL. 16CYL. 18CYL. 20CYL.

Q’ty / Eng. Weight

g(kg)

101 F.O pipe 10 12 14 16 18 Approx.4.18 102 F.O inlet pipe 1 1 1 1 1 Approx.1.54 103 F.O outlet pipe 1 1 1 1 1 Approx.1.92 104 F.O leakage main pipe 1 1 1 1 1 Approx.2.81 105 N.C.O inlet main pipe 1 1 1 1 1 Approx.6.58 106 N.C.O outlet main pipe 1 1 1 1 1 Approx.6.58 107 F.O drain branch pipe 6 7 8 9 10 Approx.0.40 108 L.O inlet branch pipe 6 7 8 9 10 Approx.0.32 109 L.O inlet branch pipe 6 7 8 9 10 Approx.0.55 110 L.O inlet branch pipe 5 6 7 8 9 Approx.0.22 111 L.O inlet branch pipe 1 1 1 1 1 Approx.0.15 113 N.C.O inlet branch pipe 6 7 8 9 10 Approx.0.09 114 N.C.O outlet branch pipe 6 7 8 9 10 Approx.0.16 115 F.O connection block 6 7 8 9 10 Approx.1.74 116 F.O block 5 6 7 8 9 Approx.1.79 117 End block 1 1 1 1 1 Approx.1.32 118 Side flange 24 28 32 36 40 Approx.0.40 119 Flange 1 1 1 1 1 Approx.0.58 120 Plate 6 7 8 9 10 Approx.0.11 121 Clamp 1 1 1 1 1 Approx.2.24 122 Clamp 7 8 9 10 11 Approx.0.20 123 O-ring 12 14 16 18 20 124 O-ring 26 30 34 38 42 125 O-ring 24 28 32 36 40 126 Bolt 24 28 32 36 40 Approx.0.05 127 Bolt 3 3 3 3 3 Approx.0.03 128 Bolt 4 4 4 4 4 Approx.0.03 129 Bolt 9 10 11 12 13 Approx.0.03 131 Bolt 48 56 64 72 80 Approx.0.01 132 Bolt 7 8 9 10 11 Approx.0.01 133 Bolt 12 14 16 18 20 Approx.0.01

LDFV53000

Item No. Description

Q’ty / Eng. Weight

Q’ty / Eng. Weight (kg) Remarks / See Note 12CYL. 14CYL. 16CYL. 18CYL. 20CYL.

g(kg)

134 Nut 24 28 32 36 40 Approx.0.01 135 Gasket 6 7 8 9 10 136 Gasket 6 7 8 9 10 137 Gasket 6 7 8 9 10 138 Gasket 18 21 24 27 30 139 Gasket 12 14 16 18 20 141 Gasket 6 7 8 9 10 142 Connector 6 7 8 9 10 Approx.0.12 143 Support 2 2 2 2 2 144 F.O inlet shock absorber pipe 1 1 1 1 1 Approx.6.79 145 Shock absorber 1 1 1 1 1 Approx.17.74 146 Support 1 1 1 1 1 Approx.5.32 147 Support 1 1 1 1 1 Approx.1.70 148 Bolt 4 4 4 4 4 Approx.0.13 149 Nut 4 4 4 4 4 Approx.0.03 150 Washer 4 4 4 4 4 Approx.0.01 151 Bolt 6 6 6 6 6 Approx.0.03 152 Washer 4 4 4 4 4 Approx.0.51 153 Washer 2 2 2 2 2 Approx.0.01 154 F.O in/outlet connection pipe 1 1 1 1 1 Approx.0.36 155 Gasket 1 1 1 1 1 156 DVT control air main pipe 1 1 1 1 1 Approx.3.60 157 DVT control air pipe 6 7 8 9 10 Approx.0.11 158 F.O recycling pipe 1 1 1 1 1 Approx.0.14 159 Gasket 2 2 2 2 2

Arr. Of F.O Feed Piping Assembly Drawing & Part List

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LDFV53000

<B-Bank>

211,241 221,233 231 218,226, 227,232

214,242 208,242

214,242

204

201 223,228

207,243 209,245

210 222,229

224,236

205,264

Detail "E"

203 259

206,264

LDFV53000

Detail "F"

251,252,253 250,254,256

247,226 240 257,258

219,226 243,260 217,225

249,254,255

232,236

Detail "D"

LDFV53000

Part List (B-bank) Item No. Description

Q’ty / Eng. Weight (kg) Remarks / See Note 12CYL. 14CYL. 16CYL. 18CYL. 20CYL.

Q’ty / Eng. Weight

g(kg)

201 F.O pipe 10 12 14 16 18 Approx.4.18 202 F.O inlet pipe 1 1 1 1 1 Approx.3.50 203 F.O outlet pipe 1 1 1 1 1 Approx.3.13 204 F.O leakage main pipe 1 1 1 1 1 Approx.3.60 205 N.C.O inlet main pipe 1 1 1 1 1 Approx.6.58 206 N.C.O outlet main pipe 1 1 1 1 1 Approx.6.58 207 F.O drain branch pipe 6 7 8 9 10 Approx.0.40 208 L.O inlet branch pipe 6 7 8 9 10 Approx.0.32 209 L.O inlet branch pipe 6 7 8 9 10 Approx.0.55 210 L.O inlet branch pipe 5 6 7 8 9 Approx.0.22 211 L.O inlet branch pipe 1 1 1 1 1 Approx.0.15 213 N.C.O inlet branch pipe 6 7 8 9 10 Approx.0.09 214 N.C.O outlet branch pipe 6 7 8 9 10 Approx.0.16 215 F.O connection block 5 6 7 8 9 Approx.1.74 216 F.O block 6 7 8 9 10 Approx.1.79 217 End block 1 1 1 1 1 Approx.1.45 218 Side flange 24 28 32 36 40 Approx.0.40 219 End flange 1 1 1 1 1 Approx.0.60 220 Plate 6 7 8 9 10 Approx.0.11 221 Clamp 1 1 1 1 1 Approx.2.13 222 Support 5 6 7 8 9 Approx.1.35 223 Support 5 6 7 8 9 Approx.0.32 224 Clamp 5 6 7 8 9 Approx.0.20 225 O-ring 12 14 16 18 20 226 O-ring 26 30 34 38 42 227 O-ring 24 28 32 36 40 228 Bolt 5 6 7 8 9 Approx.0.04 229 Bolt 5 6 7 8 9 Approx.0.03 230 Bolt 24 28 32 36 40 Approx.0.05 231 Bolt 3 3 3 3 3 Approx.0.03 232 Bolt 4 4 4 4 4 Approx.0.03

Arr. Of F.O Feed Piping Assembly Drawing & Part List

H35DFV Section No.

LDFV53000

Item No. Description

Q’ty / Eng. Weight

Q’ty / Eng. Weight (kg) Remarks / See Note 12CYL. 14CYL. 16CYL. 18CYL. 20CYL.

g(kg)

233 Bolt 4 4 4 4 4 Approx.0.03 235 Bolt 48 56 64 72 80 Approx.0.01 236 Bolt 5 6 7 8 9 Approx.0.01 237 Bolt 12 14 16 18 20 Approx.0.01 238 Nut 24 28 32 36 40 Approx.0.01 239 Gasket 6 7 8 9 10 240 Gasket 6 7 8 9 10 241 Gasket 6 7 8 9 10 242 Gasket 18 21 24 27 30 243 Gasket 12 14 16 18 20 245 Gasket 6 7 8 9 10 246 Connector 6 7 8 9 10 Approx.0.12 247 F.O inlet shock absorber pipe 1 1 1 1 1 Approx.6.26 248 Shock absorber 1 1 1 1 1 Approx.17.74 249 Support 1 1 1 1 1 Approx.5.32 250 Support 1 1 1 1 1 Approx.2.62 251 Bolt 4 4 4 4 4 Approx.0.13 252 Nut 4 4 4 4 4 Approx.0.03 253 Washer 4 4 4 4 4 Approx.0.01 254 Bolt 6 6 6 6 6 Approx.0.03 255 Washer 4 4 4 4 4 Approx.0.51 256 Washer 2 2 2 2 2 Approx.0.01 257 F.O in/outlet connection pipe 1 1 1 1 1 Approx.0.37 258 Gasket 1 1 1 1 1 259 DVT control air main pipe 1 1 1 1 1 Approx.3.60 260 DVT control air pipe 6 7 8 9 10 Approx.0.11 261 Connector 1 1 1 1 1 Approx.0.15 262 Connector 1 1 1 1 1 Approx.0.25 263 Gasket 2 2 2 2 2

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Arr. Of Gas Feed Piping Assembly Drawing & Part List

H35DFV Section No.

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<A-Bank>

109

450,465

333

108

406,412 Detail "A"

405,412,422,461

334

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Arr. Of Gas Feed Piping Assembly Drawing & Part List

H35DFV Section No.

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LDFV53001

404,412,422,464 404,412,422,464

400,410,420,462

400,410,420,462 101 404,412,422,464 107 408 201 470 Detail "C"

404,412,422,464

102 100

103

Detail "B"

Arr. Of Gas Feed Piping Assembly Drawing & Part List

H35DFV Section No.

LDFV53001

401,410,420,462 106 402,411,421,463 332,403,413 105 402,411,421,463 104 331,403,413 450,465

330,403,413 View "D"

Arr. Of Gas Feed Piping Assembly Drawing & Part List

H35DFV Section No.

LDFV53001

Part List Item No. Description

Q’ty / Eng. Weight (kg) Remarks / See Note 12CYL. 14CYL. 16CYL. 18CYL. 20CYL.

Q’ty / Eng. Weight

g(kg)

100 Main gas pipe 1 1 1 1 1 Approx.80.14 A-bank 101 Main gas pipe 1 1 1 1 1 Approx.96.69 A-bank 102 Main gas pipe 1 1 1 1 1 Approx.80.14 B-bank 103 Main gas pipe 1 1 1 1 1 Approx.102.57 B-bank 104 Gas feed connection pipe 1 1 1 1 1 Approx.26.57 105 Gas feed connection pipe 1 1 1 1 1 Approx.28.37 106 Gas feed connection pipe 1 1 1 1 1 Approx.67.48 107 Flexible hose 12 14 16 18 20 Approx.7.37 108 Gas venting pipe 1 1 1 1 1 Approx.4.20 109 Gas venting pipe 1 1 1 1 1 Approx.5.88 200 Gas venting valve 2 2 2 2 2 Approx.12.59 201 Gas safety filter 12 14 16 18 20 Approx.0.19 330 Support 1 1 1 1 1 Approx.10.50 331 Support 1 1 1 1 1 Approx.19.76 332 Support 1 1 1 1 1 Approx.16.02 333 Clamp 1 1 1 1 1 Approx.1.37 334 Clamp 1 1 1 1 1 Approx.0.84 335 Clamp 1 1 1 1 1 Approx.1.07 400 Bolt 16 16 16 16 16 Approx.0.29 401 Bolt 16 16 16 16 16 Approx.0.24 402 Bolt 16 16 16 16 16 Approx.0.12 403 Bolt 8 8 8 8 8 404 Bolt 48 56 64 72 80 Approx.0.05 405 Bolt 4 4 4 4 4 406 Bolt 12 12 12 12 12 407 Bolt 12 12 12 12 12 Approx.0.03

408 Bolt 48 56 64 72 80 410 Washer 32 32 32 32 32 Approx.0.02 411 Washer 24 24 24 24 24 Approx.0.01 412 Washer 76 84 92 100 108 Approx.0.51

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Arr. Of Gas Feed Piping Assembly Drawing & Part List

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LDFV53001

Q’ty / Eng. Weight

Item No. Description

Q’ty / Eng. Weight (kg) Remarks / See Note 12CYL. 14CYL. 16CYL. 18CYL. 20CYL.

g(kg)

413 Washer 8 8 8 8 8 Approx.0.01 420 Nut 32 32 32 32 32 Approx.0.06 421 Nut 16 16 16 16 16 Approx.0.03 422 Nut 52 60 68 76 84.* Approx.0.01 450 Plug 6 6 6 6 6 Approx.0.09 460 Packing 2 2 2 2 2 461 Packing 1 1 1 1 1 462 Packing 6 6 6 6 6 463 Packing 2 2 2 2 2 464 Packing 12 14 16 18 20 465 Gasket 6 6 6 6 6 470 O-ring 12 14 16 18 20

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SOGAV Assembly Assembly Drawing & Part List

H35DFV Section No.

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LDFV53002

Part List Item No. Description

Q’ty / Eng. Weight (kg) Remarks / See Note 12CYL. 14CYL. 16CYL. 18CYL. 20CYL.

Q’ty / Eng. Weight

g(kg)

102 Gas mixer pipe 12 14 16 18 20 Approx.0.36 103 Bolt 48 56 64 72 80 Approx.0.03 104 Washer 48 56 64 72 80 Approx.0.02 105 Bolt 24 28 32 36 40 Approx.0.09 106 O-ring 12 14 16 18 20 107 O-ring 12 14 16 18 20

103

LDFV56000

A <A-Bank> B <B-bank> 203,404,405,415

331,405,419

331,405,419 104 105411,415,460 205 412

104

105

412,415,463

0,405,415 411,415,460 204,404,405,415 103 106 Detail “A”

LDFV56000

336,405,419 202,413,461 413,461 335,405,419

201,403,414,462,501 310,409,417,424

113 339

100

102,400,414 107,416,423 114 340,408,410,420,425 101,400,414 338,405,419 109
337,402,418

332,406,419,422

334 342,408,428 108,400,401,414,424,462

333 201,403,414,462,500 Detail “B”

333 201,403,414,462,500

112 3

LDFV56000

110 111,407,416,423 Part List

View "C"

Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note 100 F.O inlet connection pipe 2 Approx.4.24 101 F.O inlet pipe 1 Approx.5.30 102 F.O inlet pipe 1 Approx.6.26 103 F.O inlet pipe 1 Approx.5.94 104 F.O cross over inlet pipe 2 Approx.4.57 105 F.O cross over return pipe 2 Approx.4.68 106 F.O return pipe 1 Approx.4.77

LDFV56000

Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note 107 F.O return pipe 1 Approx.8.02 108 F.O in/out connection pipe 2 Approx.7.01 109 Drain pipe 1 Approx.0.42 110 F.O leakage pipe 1 Approx.3.69 111 F.O recycling pipe 1 Approx.24.21 112 Pipe for DPI 1 Approx.0.15 113 Pipe from DPI 1 Approx.0.18 114 PT51/52 pipe 1 Approx.1.35 201 Compact ball valve 2 202 Orifice 1 Approx.0.14 203 F.O connection block 1 Approx.40.08 A-bank 204 F.O connection block 1 Approx.31.80 B-bank 205 F.O block 1 Approx.5.50 310 Clamp 1 Approx. 330 Support 1 Approx.3.22 331 Support 2 Approx.3.95 332 Support 1 Approx.0.65 333 Support 1

Approx.0.60 334 Support 1 Approx.0.99 335 Support 1 Approx.3.48 336 Support 1 Approx.2.99 337 Support 1 Approx.45.77 338 F.O filter drain trap 1 Approx.10.64 339 Support 1 Approx.0.42 340 Support 1 Approx.0.34 342 Support 2 Approx.2.64 400 Bolt 14 Approx.0.12 401 Bolt 2 Approx.0.12 402 Bolt 4 Approx.0.01 403 Bolt 16 Approx.0.01 404 Bolt 12 Approx.0.05

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Arr. Of F.O Connection Piping Assembly Drawing & Part List

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Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note 405 Bolt 19 Approx.0.01 406 Bolt 1 Approx.0.01 407 Bolt 2 Approx.0.01 408 Bolt 5 Approx.0.02 409 Bolt 1 Approx.0.01 410 Bolt 2 Approx.0.62 411 Bolt 24 Approx.0.03 412 Bolt 20 Approx.0.03 413 Bolt 8 Approx.0.04 414 Washer 32 Approx.0.01 415 Washer 62 Approx.0.51 416 Washer 11 Approx.0.31 417 Washer 1 Approx.0.18 418 Washer 4 Approx.0.01 419 Washer 14 Approx.0.01 420 Washer 2 Approx.0.11 421 Nut 8 Approx.0.03 422 Nut 5 Approx.0.01 423 Nut 11 Approx.0.01 424 Nut 1 Approx.0.01 425 Nut 2 Approx.0.01 428 Washer 4 Approx.0.40 460 O-ring 6   461 Packing 3   462 Packing 6   463 O-ring 4   500 Name plate 1 Approx.0.01 501 Name plate 1 Approx.0.01

Pag 407
Lubricating Oil System General Instruction

H35DFV Section No.

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G60000

Description The engine has its own internal lubricating oil system with wet type oil sump. Most of the oil passages are incorporated into the engine components and the equipments of the system are mounted directly on feed block without pipe connections. L.O. cooler can be installed on the outside of engine separately. The lubricating oil (L.O) is pressurized by L.O pump from oil sump and flows into thermostat valve directly (un-cooled) or via L.O cooler (cooled). The cooled and un-cooled oil is mixed at the thermostat valve; hence the temperature of L.O is set to the pre-specified value as shown in fig. 1. There are 2 f ilters as shown in Figure 1. Filtered and pressure controlled L.O flows into engine block and turbocharger. Then L.O supplied to all moving parts of the engine as lubricant as well as coolant. Finally, L.O returns to the oil sump.

L.O Pump with Pressure control valve L.O. Auto Filter L.O Thermostatic Valve Supply from sump

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G60000

LDFV61000

The lubricating oil pump is of a LDFV61000

LDFV61000

gear type, mounted on the feed module of the engine. The pump is dimensioned to provide the sufficient flow even at low speed. It is driven by the pump drive gear which is attached by the crank shaft.

The lubricating oil cooler is LDFV62000 applicable to the plate type, mounted on the base frame of the engine or can be installed on the external of the engine separately. The L.O is cooled down by means of the cooling water. The number of plate is determined according to the lubricating oil temperature required. Details for the lubricating oil cooler are found in a separate manual.

The lubricating oil filter consists of LDFV63000 the primary filter which is the candle type with a fineness of 34μm, and the secondary filter which is the safety net with a fineness of 60μm. The high pressure drop can be indicated by the pressure transmitters which are fitted before and after filter. When the differential pressure is higher than the setting value, the alarm system is activated. Fig. 2 s hows the connections and internal structure of the lubricating oil filter. Details for the lubricating oil auto filter are found in a separate manual.

The centrifugal oil filter can be mounted on the engine on request of the customers. A centrifugal force is taken from the oil pressure. Details for the centrifugal oil filter are found in a separate manual. The L.O relief valve adjusts outlet pressure of L.O pump under 7 bar and is mounted on L.O pump of the engine. In addition, this valve should be checked about all moving parts for wear and any damage, and replaced if they are worn and damaged.

The thermostat valves are of the LDFV64000

wax element type, working at the fixed temperature range of 60℃~69℃, and they are mounted on the feed module of the engine. The thermostatic valve cannot be adjusted, and normally no maintenance is required. However, in some cases it is necessary to clean or replace valve elements. Fig. 3 s hows the lubricating oil flow in thermostatic valve. To L.O Filter

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Be careful not to mount incorrectly thermostat valve. The sizes of thermostat valve are same for H.T.W and Lubricating oil.

The pre-lubricating oil pump is of LDFV6500

the electric motor driven gear type pump, which is operated automatically when engine stopped. Pre-lubrication is recommended during engine stop period if fuel

oil is circulating. In case that the automatic pre-lubrication has been switched off, the engine must be pre-lubricated sufficiently before starting-up. Details for the pre-lubricating oil pump are found in a separate manual. Always make sure of checking all connections for leaks and al l o-rings for any damage during maintenance.

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Lub Oil Pump Assembly Assembly Drawing & Part List

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LDFV61000

191 193

Detail “A” 100

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Lub Oil Pump Assembly Assembly Drawing & Part List

H35DFV Section No.

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LDFV61000

201 217 230 228 231 233 219 18 232 222 223 225 29 220 221 226 224 213 235

262 208 209

227

Part List

Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note 100 Lub. oil pump complete 2 Approx.172 Incl.item 201~273 191 Bolt 16 Approx.0.11 193 Taper pin 4 Approx.0.02 201 Pump housing 1 202 Pump cover 1 203 Spur gear 1 204 Gear wheel 1 205 Gear wheel 1 208 Parallel pin 2 Approx.0.05 209 O-ring 1 210 O-ring 1 213 Pusher 1 214 Bolt 5 Approx.0.18 215 Main poppet 1 Approx.2.83

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Lub Oil Pump Assembly Assembly Drawing & Part List

LDFV61000

Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note

Item No. Description Q’ty / Eng. Weight (kg)

216 Spring 1 Approx.0.18 217 O-ring 1 218 Parallel pin 2 Approx.0.02 219 Housing 1 Approx.11.62 220 Pilot poppet 1 Approx.0.04 221 Spring 1 Approx.0.02 222 O-ring 1 223 O-ring 1 224 O-ring 1 225 Cover 1 Approx.0.87 226 Nut 1 Approx.0.11 227 Socket head bolt 8 Approx.0.05 228 Plug 2 Approx.0.02 229 O-ring 1 230 Name plate 1 231 Orifice 1 Approx.0.01 232 Orifice 1 Approx.0.01 233 Packing 2 234 Power lock 1 235 Retaining ring 1 Approx.0.29 261 Bush housing 2 262 Bush housing 1 263 Bush housing 1 271 Bush 3 272 Bush 1 273 Bush 1

M61000

Inspect all parts of lubricating oil pump for wear periodically and replace worn parts. Inspection of the bearing is also essential for lubricating oil pump. Overhaul of Lubricating Oil Pump 1. Loosen the bolt (A) as shown in fig. 1, and dismount the spur gear. 2. Loosen the bolts (B), and dismount the bolts and the cover.

Clean all parts thoroughly. 4. Inspect the bearing bush and bush housing for any dirt and damage. 5. For assembling the lubricating oil pump, follow in reverse order 4 to 1. Replace O-rings with new ones.

M61000

Be sure to fit the oil hole of bush housing in the correct position. It is recommended to mark the parts before disassembly in order to avoid confusion during assembly. closer to the inner dia.

Fig.2 The hole position of bush housings

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Lub. Oil Filter Assembly Assembly Drawing & Part List

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Lub. Oil Filter Assembly Assembly Drawing & Part List

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Part List

Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note 102 Intermediate piece 4 Approx.0.88 103 O-ring 8 104 Lubricating oil auto filter drain pipe 1 Approx.4.06 105 Lubricating oil auto filter drain pipe 1 Approx.4.06 106 Lubricating oil auto filter drain pipe 1 Approx.5.25 107 Lubricating oil auto filter drain pipe 1 Approx.8.77 108 Lubricating oil auto filter drain pipe 1 Approx.1.66 109 Lubricating oil auto filter drain pipe 1 Approx.1.81 110 Lubricating oil auto filter drain pipe 1 Approx.4.53 111 Clamp 1 Approx.1.20 112 Clamp 1 Approx.0.68 113 Clamp 2 Approx.2.00 114 Clamp 1 121 Bolt 4 Approx.0.03

122 Bolt 20 Approx.0.03 123 Bolt 8   124 Bolt 8   125 Bolt 36   126 Nut 28 Approx.0.01 127 Parallel pin 4 Approx.0.05 131 Packing 3   132 Packing 2   133 Packing 1   134 Gasket 2   135 Washer 2 Approx.0.01 136 Washer 4 Approx.0.01 137 Washer 4 Approx.0.01 138 Packing 2

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L.O Thermostatic Valve Ass'y Assembly Drawing & Part List

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L.O Thermostatic Valve Ass'y Assembly Drawing & Part List

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Part List

Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note 102 Thermostatic valve element 6 Approx.1.20 105 O-ring 6 Approx.0.01 124 Valve guide plate 6 Approx.0.38 125 Spacer 6 Approx.0.20 803 Cover 1 Approx.22.02 804 Gasket 1 Approx.0.14 901 Bolt 6 Approx.0.03 902 Bolt 18 Approx.0.01 903 Washer 18 Approx.0.08 904 Bolt 12 Approx.0.04 905 Plug 1 Approx.0.09 906 Gasket 1   907 Plug 1 Approx.0.02 908 Gasket 1   909 Name plate 1

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Arr. Of T/C L.O Piping Assembly Drawing & Part List

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400 462

104 401 420 460

106 400 462 <B-Bank> <A-Bank>

313 403 421 107 461

421 107 461 101 200 500 200 500 301 102

101

301 404 421

102

312 403 421

103

108 461 463 110 461 463

201 405 420 464

109 461 463

105 401 420 460

105 401 420

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Part List Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note 100 T/C L.O inlet pipe (A-bank) 1 Approx.1.92 101 T/C L.O inlet pipe 1(A-bank) 1 Approx.1.69 102 T/C L.O inlet pipe 1(B-bank) 1 Approx.1.25 103 T/C L.O inlet pipe 2(B-bank) 1 Approx.1.59 104 T/C L.O inlet pipe from filter(A-bank) 1 Approx.3.92 105 T/C L.O inlet pipe from filter(B-bank) 1 Approx.3.65 106 T/C L.O drain pipe 1 Approx.16.65 107 T/C L.O inlet pipe to t/c(B-bank) 1 Approx.1.34 108 NCO inlet pipe (A-bank) 1 Approx.1.21 109 NCO inlet pipe (B-bank) 1 Approx.1.14 110 NCO outlet pipe (A-bank) 1 Approx.1.61 111 NCO outlet pipe

(B-bank) 1 Approx.1.59 200 Orifice 2 201 Square flange 2 300 Clamp 1 Approx.1.28 301 Clamp 1 Approx.0.06 310 Clamp 3 Approx.0.46 312 Clamp 1 Approx.0.71 313 Clamp 1 Approx.0.49 400 Socket head bolt 8 Approx.0.04 401 Bolt 8 Approx.0.05 402 Bolt 2 Approx.0.02 403 Bolt 2 Approx.0.01 404 Bolt 4 Approx.0.01 405 Bolt 8 Approx.0.04 420 Washer 16 Approx.0.51 421 Washer 8 Approx.0.18 450 Plug 6 Approx.0.10 460 Packing 2 Approx.0.03 461 Gasket 6 462 Packing 2 463 Gasket 6 464 Packing 2 500 Name plate 2

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Arr. Of Pre-L.O Pump Piping Assembly Drawing & Part List

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402 411 462

201 404 411 421

450 460

100 401 411 461

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Arr. Of Pre-L.O Pump Piping Assembly Drawing & Part List

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Part List

Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note 100 Pre lub. Oil inlet pipe 1 101 Pre lub. Oil outlet pipe 1 Approx.9.05 102 Pre lub. Oil outlet pipe 1 Approx.7.58 103 Pre lub. Oil by-pass inlet pipe 1 Approx.10.18 200 Pre lubricating oil pump 1 Approx.206.00 201 Flat back press type non-return valve 1 330 Support 1 Approx.38.66 331 Support 1 Approx.1.38 400 Bolt 4 Approx.0.05 401 Bolt 8 Approx.0.09 402 Bolt 11 Approx.0.11 403 Bolt 4 Approx.0.14 404 Bolt 8 405 Bolt 1 Approx.0.04 406 Bolt 3 Approx.0.15 410 Washer 4 411 Washer 28 412 Washer 10 Approx.0.01 413 Washer 1 Approx.0.01 420 Nut 4 Approx.0.026 421 Nut 15 Approx.0.03 450 Plug 1 Approx.0.03 460 Gasket 1 461 Square packing 2 462 Square packing 2 463 Packing 1

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<A-Bank>

<B-bank>

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Detail “B” Part List

Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note 100 Block for L.O. nozzle 1 Approx.6.02 101 Bolt 4 Approx.0.12 102 Wire 2 Approx.0.01 110 Connector 2 Approx.0.25 111 Gasket 2 112 Gasket 2 120 L.O. nozzle pipe 1 Approx.0.25 A-bank 130 L.O. nozzle pipe 1 Approx.0.30 B-bank 140 Connector 2 Approx.0.79 150 L.O. pipe 1 A-bank 160 L.O. pipe 1 B-bank

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Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note

Item No. Description Q’ty / Eng. Weight (kg)

200 L.O. nozzle 1 Approx.0.20 210 L.O. nozzle 1 Approx.0.18 220 L.O. nozzle 1 Approx.0.70 230 L.O. nozzle 1 Approx.0.18 240 L.O. nozzle 1 Approx.0.54 300 Gasket 4 301 Bolt 13 Approx.0.24 302 Gasket 1

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404,413, 421,462 104 405,414,461 Detail "B" 406,414, 422,462 102 103 404,413, 421,462 201 403,413,462

464 101 312,402,412 View "A"

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Part List

Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note 101 Generator lubricating oil inlet pipe 1 Approx.15.01 102 Generator lubricating oil inlet pipe 1 Approx.5.92 103 Generator lubricating oil drain pipe 1 Approx.4.27 104 Generator lubricating oil drain pipe 1 Approx.12.65 201 Metallic flexible hose 1 Approx.5.84 312 Clamp 2 Approx.0.48 402 Bolt 4 Approx.0.02 403 Bolt 4 404 Bolt 12 Approx.0.05 405 Bolt 4 Approx.0.08 406 Bolt 4 Approx.0.12 412 Washer 4 Approx.0.40 413 Washer 16 Approx.0.51 414 Washer 8 Approx.0.01 421 Nut 12 Approx.0.01 422 Nut 4 Approx.0.03 461 Packing 1 462 Packing 4 463 Packing 1 464 Gasket 1

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Oil Vapour Discharge Arr’t Assembly Drawing & Part List

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<A-Bank>

106 803 <B-bank> 953 904 92953 105 801 802 104 953 702,903 90903

951 103 903 951

903

921 701,905

921

101,901 102,901 952 952

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Oil Vapor Discharge Arr’t Assembly Drawing & Part List

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Part List

Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note 101 L.O vapour discharge pipe 1 Approx.38.60 A-bank 102 L.O vapour discharge pipe 1 Approx.38.60 B-bank 103 Oil vapour discharge pipe 2 Approx.13.82 104 Oil vapour discharge common pipe 1 Approx.12.03 105 Oil vapour discharge common pipe 1 Approx.63.66 106 Oil vapour discharge connection pipe 1 Approx.28.03 701 Blind flange 2 Approx.0.64 702 Blind flange 1 Approx.3.33 801 Support 1 Approx.16.82 802 Support 1 Approx.10.33 803 Clamp 1 Approx.8.22 901 Bolt 28 Approx.0.04 902 Bolt 2 Approx.0.09 903 Bolt 20 Approx.0.12 904 Bolt 8 Approx.0.12 905 Bolt 8 Approx.0.03 921 Nut 28 Approx.0.03 941 Washer 2 Approx.0.11 951 Gasket 4 952 Packing 2 953 Packing 3

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The engine has two cooling water circuits internally, which are low temperature (LT) system and high temperature (HT) system. The elements of the circuits are mounted on the feed module and pipes located on the outside of engine. The cooling water system is designed for using normal fresh water with corrosion inhibitor. Both the low and the high temperature system are cooled by fresh water. The low temperature cooling water circulates by L.T pump and flows through charge air cooler (CAC) and lubricating oil cooler (LOC) internally as shown in fig. 1.

HT In HT Out

Engine Out Engine In Engine Out Engine In HT In LT In HT Out LT O t

LT Out

(b) No Installation of L.T.W Pump(a) Installation of L.T.W Pump (Option)

The high temperature cooling water circulates by H.T pump internally and flows through cylinder head and water jacket under normal operation. H.T thermostat valve controls the water temperature by exchanging water with external circuit.

The cooling water pumps are of a M.71.000

centrifugal type and are driven by the gear wheel at the free end of the engine. These pumps are identical, but one is for circulating high temperature cooling water and the other is for low temperature cooling water (option). Also these pumps can be decided selectively whether mounted on engine or external engine by the customers. Sealing rings are provided to avoid leakage between water side and oil side in the pump housing. Cooling water pump has a check hole against leakage as shown in fig. 2. Watch the check hole frequently. If there is any leakage of cooling water or lubricating oil, overhaul the cooling water pump. Sealing rings

Check hole for leakage (Water or Oil)

Outlet

Inlet

L.O Water

The H.T.W thermostat valve for M.74.000

H.T water circuit is mounted in the housing on the side of feed module. This is of the wax element type and cannot be adjusted. The thermostat valve controls the flow direction of the cooling water depending on the water temperature in the engine block appropriately as shown in fig. 3. The thermostat valve cannot be adjusted, and normally no maintenance is required. However, in some cases it is necessary to clean or replace valve elements. Engine Outlet Engine Inlet Charge Air Cooler Cover

Be careful of hot water. All the valves for H.T.W and lubricating oil have same dimensions and mountable on the other one. Check control temperature range marked on each valve

HT Pump Inlet

HT In Engine Out

The temperature control valve can Th M.74.000be installed beside the engine separately on

The temperature control valve can Th M.74.000

request of customers. This is of the 3-way electric motor actuator type and can be adjusted. The temperature control valve controls the flow direction of the cooling water depending on the temperature of water from the engine appropriately as shown in fig. 3. Details for the temperature control valve are found in a separate manual. Engine Outlet Engine Inlet Charge Air Cooler Cover HT In HT

Out

Be careful of hot water.

HT In

Cooling Water Pump Assembly Drawing & Part List

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520 500 509 510 509

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100 293

Detail “A”

Cooling Water Pump Assembly Drawing & Part List

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211 220 202 225 216

216 2 212

215 2218217 228

216

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Part List Item No. Description Q’ty / Eng. Weight(kg) Remarks / See Note 100/200 Cooling water pump 2 Incl.item 201~230 201 Bearing housing 2 202 Pump cover 2 203 Impeller 2 204 Spur gear 2 205 Shaft 2 206 Bearing 2 207 Bearing 2 208 Oil seal 2 209 Mechanical seal 2

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Cooling Water Pump Assembly Drawing & Part List

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Item No. Description Q’ty / Eng. Weight(kg) Remarks / See Note 210 Washer 2 211 Bolt 10 Approx.0.22 212 Socket head bolt 12 Approx.0.09 214 Retaining ring 2 215 O-ring 6 216 O-ring 4 217 Set screw 2 Approx.0.01 218 Plug 2 219 Plug 4 Approx.0.02 220 O-ring 2 221 Bolt 2 Approx.0.22 222 Spring pin 2 Approx.0.01 223 Packing 4 224 Gasket 2 225 Cover 2 226 Socket head bolt 12 Approx.0.01 227 Power lock 2 228 Plug 2 Approx.0.04 230 Packing 2 293 Taper pin 4 Approx.0.02 500 Intermediate piece 1 Approx.2.59 509 O-ring 2 510 Non return valve 1 Approx.2.77 520 Non return valve blank 1 Approx.2.71

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H35DF(V) Page 1/6

Assembly of engine driven C.W.pump (※Disassemble it in reverse order) 1. After spraying the grease on the inner bearing, assemble the bearing on the press machine with considering squareness.

2. After applying ‘Loctite 648’ to the plug, two-plugging as shown in figure below, after assemble the spring pin.

Impeller Side

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3. Assemble the Oil-seal to the pump housing by using special assembly jig as shown

in figure below, the direction of the groove must facing up Apply grease to the outside diameter of the oil seal during assembly and Figure 3 but excessive fitting assembly is like using a rubber mallet do not be.

4. The shaft which is sub-assembled together with bearing is mounted on pump housing by rubber hammer as shown in Fig.4. Pay attention to the assembling direction.

---

5. Using the press machine, sub-assembled shaft (Assembled at paragraph 1) to the pump housing as shown in figure below, and then equip the Snap-ring

6. Verify that the shaft and the inner surface of the Spur gear are clean and lightly oiled. Do not use silicone or molybdenum lubricants. Otherwise, friction coefficient will reduce, and standard torque will not be achieved. After removing the tightened bolts, it is assembled in the shaft. If power lock does not fit well, loosen fastening bolts a little loose or lightly tapping. Do not hit the product with a hammer. This will severely damage the product and possibly lead to accidents. 6-1. After removing the tightening bolts from power lock, using hand wrench for assemble it lightly. Tighten the bolts diagonally with a wrench tool. 6-2. The shaft is fixed so as not to rotate. Using torque wrench to tighten the fastening bolts to the1/4(9.3N·m) of the specified torque first, and torque it as shown in figure 6.

6-3. Tighten 1/2(18.5 N·m) of the specified torque. As a same way with 6-2, repeat tightening process 6-4. Fully tighten to the specified torque(37N·m) with torque wrench, and repeat the tightening process in the same way as 6-3. 6-5. Once again, torque the all bolts to the specified torque in the circumferential direction completely make sure the bolt does not go back anymore. Be careful not to have the locking element deformed and its bolts sagged after being assembled and disassembled. The deformation or sagging will make the lock become obsolete, so it must be replaced with new one.

7. Assemble the fixing seal and rotating seal of the mechanical seal as shown in the figure below.

8. Assemble the Impeller as a bolt tightening procedure by specified torque using assembly jig as a below. (1) Before assembly, apply ‘Loctite 242’ on the bolt that using at the Impeller.

9. Attach the connector to the drain hole section.

10.Install it with care for prevent the damage to the specified o-ring.

Air & Condensation Water Drain Assembly Drawing & Part List

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Air & Condensation Water Drain Assembly Drawing & Part List

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Part List

Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note 101 Air cooler drain pipe 1 Approx.2.78 B-bank 102 Air cooler drain pipe 1 Approx.2.86 A-bank 103 Air cooler drain pipe 1 Approx.1.61 B-bank 104 Air cooler drain pipe 1 Approx.1.61 A-bank 105 Air cooler drain pipe 1 Approx.1.14 B-bank 106 Air cooler drain pipe 1 Approx.1.14 A-bank 107 Air cooler drain pipe 1 Approx.3.53 B-bank 108 Air cooler drain pipe 1 Approx.3.53 A-bank 109 Air cooler drain pipe 2 Approx.1.91 110 Air cooler drain pipe 1 Approx.5.45 111 Air cooler drain pipe 2 Approx.7.04 112 Air cooler vent pipe 1 Approx.19.86 113 Charging air drain pipe 1 Approx.5.94 201 Valve 2 Approx.2.00 202 Valve 2 Approx.0.70 311 Clamp 2 Approx.0.45 312 Clamp 2 Approx.0.78 313 Clamp 2 Approx.0.68 314 Clamp 1 Approx.1.22 331 Support 2 Approx.0.98 401 Bolt 2 Approx.0.11 402 Bolt 8 Approx.0.04 403 Bolt 4 Approx.0.03 404 Bolt 8 Approx.0.03 405 Bolt 2 Approx.0.02 406 Bolt 12 Approx.0.01 407 Bolt 2 Approx.0.11 411 Washer 12 Approx.0.51 412 Washer 2 Approx.0.31 421 Nut 8 Approx.0.01

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Air & Condensation Water Drain Assembly Drawing & Part List

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Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note

Item No. Description Q’ty / Eng. Weight (kg)

422 Nut 12 Approx.0.01 461 Packing 2 462 Packing 2 463 Gasket 4

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Arr. Of Cooling Water Connection Piping Assembly Drawing & Part List

Arr. Of Cooling Water

205,404,411,451,465,467 451,467 207,406,411,465 115,406,411,465

451,467 207,406,411,465 115,406,411,465

View "A"

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114,204,403,405,411,464,466 102,203,403,405,411, 464,46 451,467 101,405,411,465
451,467 335,407,413

206,404,466 113,204,403,405,411,464,466 103,405,411,466 451,467 334,409,412
201,401,402,411,421,462 104 207,406,411,465 View "B"

<B-Bank> 114,204,403,405,411,464,466 113,204,403,405,411,464,466 112,405,411,466

114,204,403,405,411,464,466 202,405,411,465 109,405,411,466
108,203,403,405,411,464, 465,466 451,467 408,412,422,463 201,402,411,421,462 111
333,407,413 107,408,412,461 332 451,467 331,408,412

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Arr. Of Cooling Water Connection Piping Assembly Drawing & Part List

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Arr. Of Cooling Water

Part List

Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note 101 L.T.C.W inlet pipe 1 Approx.50.49 102 L.T.C.W inlet pipe 1 Approx.14.13 103 L.T. air cooler outlet pipe 1 Approx.32.36 104 L.T. air cooler outlet pipe 1 Approx.33.71 107 H.T.C.W inlet connection pipe 1 Approx.40.92 108 H.T.C.W inlet pipe 1 Approx.15.37 109 H.T.C.W outlet pipe 1 Approx.31.38 110 H.T.C.W outlet pipe 1 Approx.29.47 111 J.W pre-heating pipe 1 Approx.5.45 112 H.T.C.W outlet pipe 1 Approx.15.83 113 Cooling water connection pipe 2 Approx.17.53 114 Cooling water connection pipe 7 Approx.9.47 115 L.O cooler inlet pipe 2 Approx.9.52 201 Orifice 2 Approx. 202 Blind flange 1 Approx.3.93 203 Square flange 2 Approx.3.17 204 Square flange 9 Approx.3.67 205 Blind flange 1 Approx.5.45 206 Blind flange 1 Approx.5.52 207 Blind flange 4 Approx.4.38 331 Support 1 Approx.9.83 332 Support 1 Approx.9.85 333 Support 1 Approx.10.05 334 Support 1 Approx.14.16 335 Support 1 Approx.13.97 401 Bolt 4 Approx.0.25 402 Bolt 12 Approx.0.23 403 Bolt 52 Approx.0.12 404 Bolt 8 Approx.0.11 405 Bolt 64

Arr. Of Cooling Water Connection Piping Assembly Drawing & Part List

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Arr. Of Cooling Water

Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note 406 Bolt 16 Approx.0.09 407 Bolt 4 Approx.0.08 408 Bolt 15 409 Bolt 3 411 Washer 152 Approx.0.01 412 Washer 18 Approx.0.51 413 Washer 4 Approx.0.01 421 Nut 16

Approx.0.03 422 Nut 4 Approx.0.01 451 Plug 25 Approx.0.09 461 Packing 1 Approx.0.01 462 Packing 4 463 Packing 1 464 O-ring 11 465 Packing 11 Approx.0.04 466 Packing 24 Approx.0.04 467 Gasket 25

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Arr. Of Jacket Water In/out Piping Assembly Drawing & Part List

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<B-bank> A 110,462 471 2 106,114,403 105 404,411

113,115,401,421 112,462 109 111,462 402 451461 422 402,422,461 1108 461

<A-Bank> 471 461 422 462 451 451,462 471 114,403

402,422,461 404,411

101 461 402,422,461

471 102

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Arr. Of Jacket Water In/out Piping Assembly Drawing & Part List

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Part List

Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note 101 H.T.W. ENG. inlet pipe 1 Approx.18.17 A-bank 102 Connection piece 2 Approx.9.01 103 H.T.W. ENG. inlet pipe 3 Approx.17.68 B-bank 104 Connection piece 1 Approx.5.00 A-bank 105 Jacket water outlet 1 Approx.24.78 A-bank 106 Connection piece 1 Approx.5.00 B-bank 107 H.T.W. outlet pipe 1 Approx.44.93 108 H.T.W. outlet pipe 1 Approx.9.23 109 H.T.W. outlet venting pipe 1 Approx.8.36 110 H.T.W. venting pipe 1 Approx.1.72 A-bank 111 H.T.W. venting pipe 1 Approx.1.03 B-bank 112 H.T.W. venting pipe 1 Approx.0.55 113 Non-return valve 1 Approx.1.45 114 Stop piece 8 Approx.0.37 115

Cover flange 1 401 Bolt 4 Approx.0.08 402 Bolt 28 Approx.0.12 403 Bolt 8 Approx.0.02 404 Bolt 8 Approx.0.09 411 Washer 8 Approx.0.01 421 Nut 4 Approx.0.01 422 Nut 28 Approx.0.03 451 Plug 4 Approx.0.09 461 Packing 8 462 Gasket 7 471 O-ring 4

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723 725

715 721 Detail “A”714,722724,731741

716 731

717,722724,731741

Detail “B”

732

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Item No. Description Q’ty / Eng. Weight(kg) Remarks / See Note
12cyl.14cyl.16cyl.18cyl.20cyl.711 Housing 10 12 14 16 18 712*) Housing 2 2 2 2 2 713 Connection piece 10 12 14 16 18 Approx.10.50 714 End cover 2 2 2 2 2 Approx.3.21 715 Stop piece 50 60 70 80 90 Approx.0.37 716 Connection piece 10 12 14 16 18 Approx.8.67 717 End cover 2 2 2 2 2 Approx.3.16 718 Inter piece 12 14 16 18 20 721 Socket head bolt 50 60 70 80 90 Approx.0.035 722 Socket head bolt 14 14 14 14 14 Approx.0.04 723 Socket head bolt 48 56 64 72 80 Approx.0.18 724 Plug 4 4 4 4 4 Approx.0.09 725 Washer 48 56 64 72 80 Approx.0.02 731 O-ring 44 52 60 68 76 732 O-ring 12 14 16 18 20 741 Gasket 4 4 4 4 4 *) Item no.712 : A-bank 4th cylinder and B-bank 5th cylinder.

G80000

Description The air required for combustion is taken from the engine room through a filter fitted on the turbocharger. It is imperative that the combustion air is free from sea water, dust and fumes etc. The turbocharger is a radial type with high efficiency and mounted on the feed block of the engine. And the water washing systems for the compressor and turbine are supplied as standard. The turbocharger is cooled and lubricated with lubricating oil from the main lubricating oil system. For detailed description, inspection and maintenances of the turbocharger, see a separate manual.

Exhaust Gas Outlet Water Drain

Charger Air Inlet

Cyl. 1

Charger Air Cooler With Water Mist Catcher

M80000

During operation, compressor of turbocharger may accumulate deposits of dirt. Therefore the compressor should be cleaned while in operation by water injection at regular intervals. Hereby the deposits are removed mechanically by the impact of the droplets. The combustion of heavy fuel oil in diesel engines causes contamination of turbine blades and nozzle rings of turbocharger. The results are low turbine efficiency, increased exhaust gas temperature, higher charging and firing pressures and lower engine output. Therefore wet cleaning of the turbine blades and nozzle rings should be done at regular intervals. Cleaning of Compressor 1. In order to cleaning the compressor wheel, unscrew the plug in the side cover of water container as shown in fig 1. 2. Fill the water container with cleaning water, and screw the plug. In order to prevent corrosion, use only pure water and never salt water.   Air Pipe   Water Pipe

---

3. Open the valve for about 20 seconds in air pipe. 4. Close the valves in air pipe after cleaning the compressor side. Compressor cleaning should be done between the engine load 50~85%. Re-cleaning process can be repeated after interval of 10 minutes at the earliest, if necessary one more. As a rule cleaning should be performed every 24 to 48 hours of operation. After cleaning compressor, engine should run under load for at least 10 to 15 minutes. Cleaning of Turbine Components 1. Supply the pipe arrangement for cleaning the turbine components by the engine maker Connect the fresh water line. Clean fresh water without cleaning agents or solvents should be used. 2. Before cleaning the turbine blade, make sure that the necessary settings of the cleaning parameters in table 1 as below should be made during a preliminary test and wait 10minutes Wait for approx. 10 minutes. 3. Open the drain valve of turbine outlet. 4. Slowly open the valve, check water pressure at pressure gauge.(For water pressure, washing period refer to table) 5. Close the valve. Wait for approx. 3 minutes so that the injected water can evaporate. 6. Repeat step 4 and 5 twice or three times. 7. Close the drain valve of turbine outlet.

---

8. Run dry the exhaust gas turbocharger at constant load for approx. 10 minutes. Subsequently, increase engine load slowly.

turbocharger is affected by vibrations which did not occur before.

Exhaust gas temperature Before turbine

Water pressure (gauge)

Water pressure

Total washing time

Total

350 ~ 430℃ 2.5 ~ 4.5 bar 3 ~ 4 x 30sec

Hot exhaust gas can escape from the drain - Risk of burning. Continue to operate the engine for at least 60 minutes after water injection. Washing is ineffective in case of hardened deposits, thus perform washing at regular intervals. The recommended turbine washing interval is approx. 150 operating hours, depending on the operating condition it could be adjusted within 25 to 600 hours. The recommended temp range for the washing water is 20℃ to 40℃.

Due to the update of turbocharger maker’s manual, the information in this manual could be different with turbocharger maker’s recommendation in the instruction book volume Ⅱ. In this case, please follow the turbocharger maker’s manual in the instruction book volume Ⅱ.

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<B-bank> 922 923 170

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Intake Air Duct Ass’y Assembly Drawing & Part List

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Part List Item No. Description Q’ty / Eng Weight(kg) Remarks / See Note 100 Air inlet box with protection cover 1 Approx.412.91 Incl.item 140~927 140 Intake air pipe a-bank 1 Approx.190.19 150 Intake air pipe b-bank 1 Approx.188.45 160 Protection cover a-bank 1 170 Protection cover b-bank 1 920 Plug 2 Approx.0.09 921 Gasket 2 922 Plug 2 Approx.0.03 923 Gasket 2 924 Bolt 6 Approx.0.03 925 Washer 6 Approx.0.01 926 Bolt 18 Approx.0.02 927 Washer 18 Approx.0.41 141 Packing 2 Approx.0.44 200 Axial compensator 2 Approx.18.65 901 Bolt 48 Approx.0.10 902 Bolt 16 Approx.0.12 903 Bolt 16 Approx.0.14 904 Nut 32 Approx.0.03 905 Washer 2 Approx.0.01 906 Parallel pin 4 Approx.0.06

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Exhaust Pipe Assembly Assembly Drawing & Part List

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909 922

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913 922

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907 921

909 922

Detail “A”

431 Detail “A”

281 915 922

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904 914 922 927

432

904 910 922 927

904 913 922 927

433 Detail “B”

444 705 293 351 902 928 D t il “B”

444

901

Detail “B”

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430 101 103 958 967 113 953 966 971 106 953 956 966 971 972

908 921

907 921

909 922

501 340

501

Detail “B” 10 52 101 969696 Detail “C”

102 957 958 967 109 956

107 954 955 972

111

112 953 966 971

104 956 959 972

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Part List (for 18,20H35DFV(ST7))

Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note 280 Exhaust pipe main duct(A-bank) 9 Approx.53.71 281 Exhaust pipe main duct(B-bank) 9 Approx.53.74

282 Exhaust main duct last cylinder (A-bank) 1 Approx.57.03 283 Exhaust main duct last cylinder (B-bank) 1 Approx.57.05 284 Square gasket 20 Approx.0.02 287 Gasket 2 Approx.0.20 288 Blind flange 2 Approx.11.37

291 Exhaust pipe A-bank (new front end block) 1 Approx.137.64 293 Exhaust pipe B-bank (new front end block) 1 Approx.105.60 340 Axial compensator 20 Approx.10.20 350 Axial compensator 2 Approx.16.25 351 Axial compensator 2 Approx.15.44 425 Main support 4 Approx.30.44 426 Exhaust pipe support 14 Approx.7.13 427 Support 2 Approx.8.07 429 Exhaust pipe support 19 Approx.3.84 430 Support 1 Approx.30.86 431 Exhaust pipe support 5 Approx.6.18 432 Support (A-bank) 1 Approx.12.47 433 Support (B-bank) 1 Approx.4.69 436 Main support 1 Approx.47.36 437 Support assembly 1 Approx.14.85 438 Support (A-bank) 1 Approx.8.11 444 Improved support assembly 1 Approx.205.66 450 Support for exhaust Main duct 1 Approx.10.48 501 V-profile clamp 40 Approx.1.24 600 Insulation cover assembly 1 Approx.564.14 700 Arr. Of waste gate pipe (st7, front end block) 1 Approx.155.33 Incl.item 101~972 101 Waste gate valve piping 1 Approx.68.11

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Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note

Item No. Description Q’ty / Eng. Weight (kg)

102 Axial compensator 2 Approx.6.60 103 Axial compensator 1 Approx.6.80 104 Support 1 Approx.4.90 106 Support -2 1 Approx.8.51 107 Support -1 1 Approx.11.53 108 Gasket 2 Approx.0.30 109 Square gasket 1 Approx.0.10 110 Square gasket 1 Approx.0.08 111 Exhaust waste gate waste valve assembly 1 Approx.29.0 112 Support 1 Approx.2.03 113 Support 1 Approx.2.21 952 Bolt 4 Approx.0.05 953 Bolt 6 954 Bolt 4 955 Bolt 3

Approx.0.08 956 Bolt 10 Approx.0.09 957 Bolt 4 Approx.0.10 958 Bolt 18 Approx.0.12 959 Bolt 2 Approx.0.15 960 Bolt 6 Approx.0.22 961 Bolt 2 Approx.0.27 966 Nut 6 Approx.0.02 967 Nut 28 Approx.0.03 971 Washer 6 Approx.0.01 972 Washer 13 Approx.0.01 705 O-ring 1 Approx.1.90 901 High temperature Socket bolt 16 Approx.0.30 902 High temperature Socket bolt 16 Approx.0.20 904 Bolt 8 905 Bolt 4 Approx.0.09

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Exhaust Pipe Assembly Assembly Drawing & Part List

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Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note

Item No. Description Q’ty / Eng. Weight (kg)

907 Bolt 28 Approx.0.07 908 Bolt 54 Approx.0.09 909 Bolt 64 Approx.0.09 910 Bolt 2 Approx.0.14 911 Bolt 30 Approx.0.22 912 Bolt 80 913 Bolt 8 Approx.0.13 914 Bolt 4 Approx.0.15 915 Bolt 138 Approx.0.09 916 Bolt 18 Approx.0.10 921 Washer 90 Approx.0.01 922 Washer 228 Approx.0.01 926 Nut 4 Approx.0.02 927 Nut 8 Approx.0.03 928 Nut 63 Approx.0.07

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Turbocharger Mounting Assembly Drawing & Part List

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Turbocharger Mounting Assembly Drawing & Part List

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190 120 180 110 Part List (for 18,20H35DFV(ST7))

Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note 110 Support 1 Approx.8 B-bank 120 Support 1 Approx.8 A-bank 180 Main support 1 Approx.101.31 A-bank 190 Main support 1 Approx.94.05 B-bank

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Turbocharger Mounting Assembly Drawing & Part List

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Item No. Description Q’ty / Eng. Weight (kg) Remarks / See Note

Item No. Description Q’ty / Eng. Weight (kg)

201 O-ring 2 202 O-ring 2 203 O-ring 2 Approx.0.01 204 Distance piece 30 Approx.0.01 904 Parallel pin 2 Approx.0.06 905 Parallel pin 2 Approx.0.02 906 Stud bolt 8 Approx.2 907 Nut 8 Approx.0.17 908 Socket head bolt 30 Approx.0.12 909 Bolt 8 Approx.0.09 910 Bolt 6 911 Nut 6 Approx.0.02 912 Washer 6 Approx.0.01 913 Plug 6 Approx.0.06 914 Gasket 6

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Air Cooler Mounting Assembly Drawing & Part List

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Air Cooler Mounting Assembly Drawing & Part List

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Pag 477
Charge Air Cooler Maintenance Procedure

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The air flowing between fins is cooled by cooling water in the tube. It is important to check and clean the heat exchange side plates and t ubes to transfer the heat properly. Also be sure to inspect the gasket condition in the charge air cooler. Inspect the charger air cooler at regular intervals for a long service life of the engine. Overhaul of Charge Air Cooler 1. Drain the cooling water (L.T and H.T) 2. Unscrew the bolts for the air cooler as shown in fig. 1. 3. Dismount the air cooler using the lifting tool.

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Charge Air Cooler Maintenance Procedure

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4. Clean and put the cooler elements on air and water sides in the cleaning bath with detergent. Pay attention that the fins are not damaged during the maintenance. Damaged fins result in an increased the pressure drop across air cooler. Check for corrosion. Make sure that fouling and deposits in the intermediate piece should be removed. 5. Mount the air cooler in reverse order 2 to 5. Coat the intermediate piece with the grease. Make sure that new gasket should be replaced before reassembling the air cooler. Before the engine starting, check the

tightening of the bolts. See

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102 460

103 460

Part List Item No. Description Q’ty / Eng.Weight(kg) Remarks / See Note 100 Compressor air pipe 1 1 Approx.2.76 101 Compressor air pipe 2 1 Approx.5.51 102 Compressor air pipe (A-bank) 1 Approx.3.28 103 Compressor air pipe (B-bank) 1 Approx.2.19 330 Support 2 Approx.1.44 331 Support 1 Approx.0.53 332 Support 3 Approx.0.46 400 Bolt 2 Approx.0.01 401 Bolt 4 410 Washer 2 Approx.0.01 411 Washer 4 Approx.0.21 460 Gasket 2 461 Gasket 1

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