

2.5L VM DIESEL

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GENERAL SPECIFICATION	
T y p e	425CLIEE (36B)
Displacement	2.5L (2499 cc)
Bore	92.00 mm
Stroke	94.00 mm
Compression Ratio	20.95:1
Vacuum at Idle	6 0 0 mm/Hg (23.6 In/Hg)

Thermostat Opening 80°C 62°C
 Generator Rating Bosch 50/120 Amp
 Cooling System Capacity 9 . 5 Liter T y p e 425CLIEE (36B)
 Power Steering Capacity 0.75 Liter
 Engine Oil Capacity 6 . 8 Liters With
 Oil Filter Change
 Timing System . Pushrod Operated Overhead valves,
 With Chain-Driven Camshaft.
 Air Intake D r y Filter
 Fuel Feed V acuum Pump Incorporated
 in Injection Pump.
 Fuel System Indirect Fuel Injection
 (Precombustion Chamber)
 Combustion Cycle 4 Stroke
 Cooling System W ater Cooled 9 - 36 ENGINE NS/GS
 T y p e 425CLIEE (36B)
 Injection Pump Rotary Pump
 Electronically Controlled.
 Lubrication Pressure Lubrication by
 Rotary Pump, Full-Flow Filtration.
 Engine Rotation Clockwise Viewed
 From Front Cover.

ENGINE IDENTIFICATION

The engine model code (3-digit number/letter code)
 and serial number are stamped on the forward facing side of the engine block (Fig. 1).

DESCRIPTION AND OPERATION

LUBRICATION SYSTEM

The pressurized system (Fig. 2) uses a rotary pump

(3) located in the front of the engine block, driven by a gear which meshes directly with the crankshaft gear. All the oil sent to every lubricated part is filtered. The pump sends the oil through a pressure relief valve (2) to the filter (7) and through galleries in the crankcase to the crankshaft bearings (8), cam-shaft bearings (11) and turbocharger (10). The piston pins, connecting rod small ends and insides of the pistons are lubricated and cooled by oil sprayed out from jets (9) in the crankshaft mounting blocks. The

lubricating oil is sent to the rockers (12) through an external pipe (Fig. 3). A valve in the filter cartridge enables the oil to be circulated even when the cartridge is clogged.

Sump inlet (1). Pressure relief valve (2). Oil pump

(3). Oil cooler (6). Filter cartridge (7). Crankshaft bearings (8). Jet valve (9). Turbocharger bearings (10). Camshaft bearings (11). Rockers (12).

Fig. 1 Engine Code Location

Fig. 2 Lubrication System

Fig. 3 Lubrication LinesNS/GS ENGINE 9 - 37

GENERAL INFORMATION (Continued)

DIAGNOSIS AND TESTING

ENGINE DIAGNOSIS—PERFORMANCE

CONDITION POSSIBLE CAUSES CORRECTION

ENGINE WILL NOT CRANK OR

CRANKS SLOWLY1. Starting motor operating, but not cranking

the engine.1. Remove the starter motor. Check for broken

flywheel teeth or a broken starter motor spring.

2. Crankshaft rotation restricted. 2. Rotate the engine to check for rotational resistance.

3. Starting circuit connections loose or corroded.3. Clean and tighten connections.

4. Neutral safety or starter relay inoperative. 4. Check starter relay supply voltage and proper operation of neutral safety switch (if equipped). Replace defective parts.

5. Battery charge low. 5. Check Battery voltage. Replace battery if a charge cannot be held.

6. No voltage to starter solenoid. 6. Check voltage to solenoid. If necessary, replace the solenoid.

7. Solenoid or starter motor inoperative. 7. Replace starter motor.

ENGINE CRANKS, BUT WILL

NOT START, NO SMOKE1. No fuel in supply tank. 1. Fill fuel supply.

2. Electrical fuel shutdown solenoid not operating.2. Check for loose wires and verify that the fuel shutdown solenoid is functioning. Check for fault codes in the ECU.

3. Fuel injection system defective: Cranking speed sensor. Loose connection between ECU and harness. No power supply to the ECU. Loose connection between injection pump and harness.3. Check for fault codes at ECU. Refer to Group 14, Fuel System for repairs procedures.

4. Air intake or exhaust plugged. 4. Remove the obstruction.

5. Fuel filter plugged. 5. Drain fuel/water separator and replace fuel filter.

6. Excessive fuel inlet restriction. 6. Check for restriction. Correct cause.7. Injection pump not getting fuel or fuel is

aerated.7. Check fuel flow/bleed fuel system.

8. One or more injectors worn or not operating properly.8. Check/replace bad or improperly operating injectors.

9. Camshaft out of time. 9. Check/correct timing chain sprocket alignment.

ENGINE HARD TO START, OR

WILL NOT START, SMOKE FROM EXHAUST

1. Incorrect starting procedure. 1. The fuel shutoff solenoid control must be in

the run position. Ensure the proper procedure is being used.

2. Cranking speed too slow. 2. Check the battery, starter motor and look for loose or corroded wiring connections.

3. Cylinder head heater plugs defective. 3. Verify system is working. Verify connection between heater plug relay and ECU. Repair/replace inoperative parts.

4. Insufficient intake air 4. Inspect or replace air filter and check for obstruction in air supply.

5. Air in fuel system or the fuel supply is inadequate. 5. Check the fuel flow through the filter and bleed system. Locate and eliminate the air source.

6. Contaminated fuel. 6. Verify by operating the engine with clean fuel from a temporary tank. Check for the presence of gasoline. Drain and flush fuel supply tank. Replace fuel/water separator filter.

7. Fuel screen plugged. 7. Check fuel screen. 8. One or more injectors worn or not operating properly. 8. Check/replace improperly operating injectors.

9. Injector pump out of time. 9. Check pump timing. Refer to Group 14, Fuel System for procedure.

10. Engine compression low. 10. Check compression to identify the problem.

11. Fuel injection system defective. 11. Vacuum modulator defective causing EGR to open in cold condition. Check for fault codes in the ECU.

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CONDITION POSSIBLE CAUSES CORRECTION

LUBRICATING OIL PRESSURE

LOW

1. Low oil level. 1a. Check and fill with clean engine oil.

1b. Check for severe external oil leaks that could reduce the pressure.

2. Oil viscosity thin, diluted, or wrong specification. 2. Verify the correct oil is being used. Check for oil dilution.

3. Improperly operating pressure switch/gauge 3. Verify the pressure switch is functioning correctly. If not, replace switch/gauge.

4. Relief valve stuck open. 4. Check/replace valve. 5. Plugged oil filter. 5. Change oil filter. Oil filter change interval

may need to be revised.

6. Oil cooler was replaced, shipping plugs left

in cooler.6. Check/removed shipping plugs.

7. Worn oil pump. 7. Check/replace oil pump.

8. Suction tube loose or seal leaking. 8. Check and replace seal.9. Worn bearing or wrong bearing installed. 9. Inspect and replace connecting rod or main

bearings. check and replace piston cooling oiljet.

10. Oil jets under piston loose or bad fit. 10. Check oil jets position.

LUBRICATING OIL LOSS 1. External oil leaks. 1. Visually inspect for oil leaks. Repair as required.

2. Crankcase being overfilled. 2. Verify that the correct dipstick is being used.3. Incorrect oil specification or viscosity. 3a. Make sure the correct oil is being used.

3b. Look for reduced viscosity from dilution with fuel.

3c. Review/reduce the oil change intervals.

4. Oil cooler leak. 4. Check and replace the oil cooler.5. High blow-by forcing oil out the breather. 5. Check the breather tube area for signs of oil

loss.

LUBRICATING OIL LOSS (CONT.) 6. Turbocharger leaking oil into the air intake. 6. Inspect air duct for evidence of oil transfer.

7. Piston rings not sealing (oil being consumed by the engine).7. Perform blow-by check. Repair as required.

COMPRESSION KNOCKS 1. Air in fuel system. 1. Bleed the fuel system (refer to Group 14, Fuel System).

2. Poor quality fuel or water/gasoline contaminated fuel.2. Verify by operating from a temporary tank with good fuel. Clean and flush the fuel supply tank. Replace fuel/water separator.

3. Engine Overloaded. 3. Verify the engine load rating is not being exceeded.

4. Improperly operating injectors. 4. Check and replace injectors.5. Fuel injection system defective. 5a. Instrumented injection. 5b. Timing solenoid

of the fuel pump. 5c. Pre and post heat time of the glow plugs. Check the fault codes in the ECU.

EXCESSIVE ENGINE NOISES 1. Drive belt squeal, insufficient tension or abnormally high loading.1. Inspect the drive belts. Make sure water pump pulley, generator and power steering all turn freely.

2. Intake air and exhaust leak. 2. Refer to excessive exhaust smoke. (Engine Diagnosis and Testing)

3. Excessive valve lash. 3. Make sure the rocker arms are not bent. Defective hydraulic lash adjuster.

4. Turbocharger noise. 4. Check turbocharger impeller and turbine wheel for housing contact.

5. Power function knock. 5. Check and replace rod and main bearings. 6. Fuel injection system defective. 6a. Instrumented injection. 6b. Timing solenoid of the fuel pump. 6c. Pre and post heat time of the glow plugs. Check the fault codes in the ECU.

HYDRAULIC TAPPETS

Before disassembling any part of the engine to cor-

rect tappet noise, check the oil pressure. If vehicle has no oil pressure gauge, install a reliable gauge at the pressure sending unit. The pressure should be

between 3.5 bars to 5.0 bars at 4000 RPM.

Check the oil level after the engine reaches normal

operating temperature. Allow 5 minutes to stabilize NS/GS ENGINE 9 - 39

DIAGNOSIS AND TESTING (Continued)

oil level, check dipstick. The oil level in the pan

should never be above the FULL mark or below the ADD OIL mark on dipstick. Either of these 2 conditions could be responsible for noisy tappets.

OIL LEVEL HIGH

If oil level is above the FULL mark, it is possible

for the connecting rods to dip into the oil. With the engine running, this condition could create foam in the oil pan. Foam in oil pan would be fed to the hydraulic tappets by the oil pump causing them to lose length and allow valves to seat noisily.

OIL LEVEL LOW

Low oil level may allow oil pump to take in air.

When air is fed to the tappets, they lose length which allows valves to seat noisily. Any leaks on intake side of oil pump through which air can be drawn will create the same tappet action. Check the lubrication system from the intake strainer to the pump cover, including the relief valve retainer cap. When tappet noise is due to aeration, it may be intermittent or constant, and usually more than 1 tappet will be noisy. When oil level and leaks have been corrected, operate the engine at fast idle. Run engine for a sufficient time to allow all of the air inside the tappets to be bled out.

TAPPET NOISE DIAGNOSIS

(1) To determine source of tappet noise, operate engine at idle with cylinder head covers removed.

(2) Feel each valve spring or rocker arm to detect

noisy tappet. The noisy tappet will cause the affected spring and/or rocker arm to vibrate or feel rough in operation.

NOTE: Worn valve guides or cocked springs are

sometimes mistaken for noisy tappets. If such is the case, noise may be dampened by applying side thrust on the valve spring. If noise is not appreciably reduced, it can be assumed the noise is in the tappet. Inspect the rocker arm push rod sockets and push rod ends for wear.

(3) Valve tappet noise ranges from light noise to a

heavy click. A light noise is usually caused by excessive leak down around the unit plunger or by the plunger partially sticking in the tappet body cylinder. The tappet should be replaced. A heavy click is caused by a tappet check valve not seating or by foreign particles becoming wedged

between the plunger and the tappet body. This will cause the plunger to stick in the down position. This heavy click will be accompanied by excessive clearance between the valve stem and rocker arm as valve closes. In either case, tappet assembly should be removed for inspection and cleaning. (4) The valve train generates a noise very much

like a light tappet noise during normal operation. Care must be taken to ensure that tappets are making the noise. In general, if more than one tappet seems to be noisy, it's probably not the tappets.

SERVICE PROCEDURES

CHECKING OIL LEVEL

To assure proper engine lubrication, the engine oil must be maintained at the correct level. Check the oil level at regular intervals, such as every fuel stop.

The best time to check the oil level is about 5 min-

utes after a fully warmed-up engine is shut off, or before starting the vehicle after it has sat overnight.

Checking the oil while the vehicle is on level

ground, will improve the accuracy of the oil level readings (Fig. 4).

CHANGING ENGINE OIL AND FILTER

Change engine oil and filter at mileage and time intervals described in the Maintenance Schedule.

ENGINE OIL CHANGE

WARNING: NEW OR USED ENGINE OIL CAN BE IRRITATING TO THE SKIN. AVOID PROLONGED OR REPEATED SKIN CONTACT WITH ENGINE OIL. CONTAMINANTS IN USED ENGINE OIL, CAUSED BY INTERNAL COMBUSTION, CAN BE HAZARDOUS TO YOUR HEALTH. THOROUGHLY WASH EXPOSED SKIN WITH SOAP AND WATER. DO NOT WASH SKIN WITH GASOLINE, DIESEL FUEL, THINNER, OR SOLVENTS, HEALTH PROBLEMS CAN RESULT. DO NOT POLLUTE, DISPOSE OF USED ENGINE OIL PROPERLY. CONTACT YOUR DEALER OR GOVERNMENT AGENCY FOR LOCATION OF COLLECTION CENTER IN YOUR AREA.

Fig. 4 Checking Engine Oil 9 - 40 ENGINE NS/GS

DIAGNOSIS AND TESTING (Continued)

Run engine until achieving normal operating temperature.

(1) Position the vehicle on a level surface and turn engine off.

(2) Remove oil fill cap. (3) Hoist vehicle. Refer to Hoisting and Jacking Recommendations.

(4) Place a suitable drain pan under crankcase drain.

(5) Remove drain plug from crankcase and allow oil to drain into pan (Fig. 5). Inspect drain plug threads for stretching or other damage. Replace drain plug if damaged.

(6) Install drain plug in crankcase.

(7) Lower vehicle and fill crankcase with specified

type and amount of engine oil.

(8) Install oil fill cap.(9) Start engine and inspect for leaks.(10) Stop engine and inspect oil level.

ENGINE OIL

ENGINE OIL QUALITY

Use only oils conforming to API (American Petro-

leum Institute) quality SG, SG/CD, or CCMC G4. Use only Diesel engine oil meeting standard MIL-2104C or API service classification SG/CD or

CCMM PD1 .

OIL VISCOSITY

Grade 15W-40 is recommended for temperatures

between +35°C to -10°C (95°F to 14°F). Low viscosity oils must have the proper API quality or the CCMC G5 designation. Low viscosity oils are preferred when minimum temperatures consistently fall below -12°C (10°F).

ENGINE OIL FILTER CHANGE

(1) Position a drain pan under the oil filter.(2) Using a suitable oil filter wrench loosen filter.(3) Rotate the oil filter counterclockwise to remove

it from the oil filter base (Fig. 6).

(4) When filter separates from base, tip gasket end upward to minimize oil spill. Remove filter from vehicle.

(5) With a cloth, wipe clean the gasket sealing surface of oil and grime.

OIL FILTER INSTALLATION

(1) Lightly lubricate oil filter gasket with engine oil.

(2) Thread filter onto the base. When gasket makes contact with sealing surface, hand tighten filter one full turn, do not over tighten.

(3) Add oil, verify crankcase oil level and start engine. Inspect filter area for oil leaks.

TIMING PROCEDURE

CAUTION: It could take up to 70 crankshaft revolutions to align sprocket timing marks with the dark chain links. If the chain is removed (Fig. 7) before the sprocket marks are in their proper locations you must first loosen the rocker arm supports before rotating crankshaft or camshaft sprockets. This will prevent the valves from hitting the pistons.

Installing timing chain (Fig. 8). Starting at the

crankshaft align the dark link on the chain to the timing mark on the crankshaft sprocket. Next align

Fig. 5 Oil Drain Plug

Fig. 6 Oil Filter

SERVICE PROCEDURES (Continued)

the second dark link on the chain with the timing

mark on the camshaft sprocket. Third Align the final dark link on the chain to the timing mark on the injection pump sprocket. Last install the chain around the vacuum pump. For injection pump timing refer to Group 14, Fuel for the proper procedure.

VALVE AND SEAT REFACING

VALVE REFACING

(1) Use a valve refacing machine to reface the intake and exhaust valves to the specified angle.

(2) After refacing, a margin of at least 4.52-4.49

mm (.178-.177 inch) must remain (Fig. 9). If the margin is less than 4.49 mm (.177 inch), the valve must be replaced.

VALVE SEAT REFACING

(1) Install a pilot of the correct size in the valve

guide bore. Reface the valve seat to the specified angle with a good dressing stone. Remove only enough metal to provide a smooth finish.

(2) Use tapered stones to obtain the specified seat width when required.

VALVE STAND DOWN

Valve stand down is to maintain the adequate compression ratio.

(1) Invert cylinder head. (2) Fit each valve to its respective valve guide. (3) Using a straight edge and feeler gauge (Fig.

10), check valve head stand down: Inlet valve head stand down .80 to 1.2 mm (.031 to .047 in.) and exhaust valve stand down .79 to 1.19 mm (.031 to .047 in).

(4) If valve head stand down is not in accordance

with above, discard original valves, check stand down with new valves and recut valve seat inserts to obtain correct stand down.

VALVE GUIDE HEIGHT

(1) Valve Guides height requirement. (2) Measurement A (Fig. 11): 13.50 - 14.00 mm.

VALVE STEM-TO-GUIDE CLEARANCE

MEASUREMENT

(1) Measure and record internal diameter of valve

guides. Valve guide internal diameter is 8.0 to 8.015 mm (.3149 to .3155 in.).

(2) Measure valve stems and record diameters.

Intake valve stem diameter 7.94 to 7.96 mm (.3125 to .3133 in). Exhaust valve stem diameter 7.92 to 7.94 mm (.3118 to .3125 in).

(3) Subtract diameter of valve stem from internal

diameter of its respective valve guide to obtain valve stem clearance in valve guide. Clearance of inlet valve stem in valve guide is .040 to .075 mm (.0015 to .0029 in). Clearance of exhaust valve stem in valve guide is .060 to .095 mm (.0023 to .0037 in).

(4) If valve stem clearance in valve guide exceeds tolerances, new valve guides must be installed.

Fig. 7 Alignment Timing Sprockets

Fig. 8 Timing Procedure 9 - 42 ENGINE NS/GS

SERVICE PROCEDURES (Continued)

FITTING PISTON RING

(1) Wipe cylinder bore clean. Insert ring and push

down with piston to ensure it is square in bore. Thering gap measurement must be made with the ringpositioning at least 12 mm (0.50 in.) from bottom ofcylinder bore (Fig. 12). Check gap with feeler gauge. Top compression ring gap .25 to .50mm (.0098 to.0196 in.). Second compression ring gap .25 to .35mm(.0098 to .0137 in.). Oil control ring gap .25 to .58mm(.0098 to .0228 in.).

(2) If ring gaps exceed dimension given, new rings

or cylinder liners must be fitted. Keep piston rings in piston sets.

(3) Check piston ring to groove clearance (Fig. 13).

Top compression ring gap .08 to .130mm (.0031 to.0051 in.). Second compression ring gap .070 to.102mm (.0027 to .0040 in.). Oil control ring gap .040to .072mm (.0015 to .0028 in.).

CRANKSHAFT END PLAY

(1) Attach dial indicator to engine block (Fig. 14). (2) Move crankshaft toward front of engine and zero indicator.

(3) Move crankshaft toward the rear of engine and record measurement.

Fig. 9 Valve Specification

Fig. 10 Checking Valve Stand Down

Fig. 11 Valve Guide HeightNS/GS ENGINE 9 - 43

SERVICE PROCEDURES (Continued)

(4) Subtract specified crankshaft end float from figure obtained. Crankshaft end float 0.08 to0.21mm.

(5) Select thrust washer which will give correct end float.

(6) Refer to crankshaft main bearing Installation if not in specification.

NOTE: If engine is disassembled refer to Crank-

shaft Main Bearing Removal and Installation for thisprocedure.REMOVAL AND INSTALLATION

ENGINE MOUNT—FRONT

(1) Disconnect battery.

(2) Remove lower air dam at front fascia.(3) Remove the bolts holding tow bracket and front mount to the lower crossmember.

(4) Remove thru bolt in engine mount (Fig. 15).

Remove mount.

(5) Reverse removal procedure for installation.(6) Torque engine mount thru bolt to 65 N·m (48 ft. lbs.)

(7) Torque crossmember bolts for tow bracket and engine mount to 54 N·m (40 ft. lbs.)

ENGINE MOUNT—RIGHT

(1) Remove the right engine mount top support

bracket bolt (Fig. 16).

(2) Remove the load on the engine motor mounts

by carefully supporting the engine and transmission assembly with a floor jack.

(3) Remove the engine mount to frame bolts. (4) Remove the thru bolt from the mount assembly.

Remove insulator

(5) If replacing or removing right engine mount

bracket the torque on the mounting bolts is 40 N·m (30 ft. lbs.)

(6) Reverse removal procedure for installation.

Fig. 12 Ring Gap Measurement

Fig. 13 Piston Ring Side Clearance

Fig. 14 Measuring Crankshaft End Play

Fig. 15 Front Engine Mount and Tow Bracket9 - 44 ENGINE NS/GS

SERVICE PROCEDURES (Continued)

(7) Torque engine mount top bolt (Vertical) to 101

N·m (75 ft. lbs.)

(8) Torque engine mount thru bolt (Horizontal) to

145 N·m (107 ft. lbs.)

(9) Torque engine mount to frame bolts to 68 N·m

(50 ft. lbs.)

MOUNT—LEFT SIDE

(1) Raise vehicle on hoist and remove left front

wheel.

(2) Remove inner splash shield. (3) Support the transmission with a transmission

jack.

(4) Remove the insulator thru bolt from the mount

(Fig. 17).

(5) Remove the transmission mount bolts and

remove mount. It may be necessary to lower transmission slightly to remove mount.

(6) Reverse removal procedure for installation. (7) Install mount. Torque transmission mount bolts

to 54 N·m (40 ft. lbs.).

(8) Align mount into frame bracket with transmis-

sion jack, install thru bolt. Torque thru bolt to 71 N·m (53 ft. lbs.).

ENGINE MOUNT—REAR

(1) Raise vehicle on hoist. (2) Support the engine and transmission assembly

with a transmission jack so it will not rotate.

(3) Remove the thru bolt from the insulator at

crossmember connection (Fig. 18).

(4) Remove the bolts holding the mount to the engine and transmission.(5) Disconnect both shifter cables at transmission.

Remove the retainers holding the cables to the mount (Fig. 19).

(6) Remove the mount assembly.(7) Reverse removal procedure for installation.(8) Install mount assembly. Torque bolts at engine

and transmission to 101 N·m (75 ft. lbs.).

(9) Align insulator at crossmember and install thru bolt. Torque to 68 N·m (50 ft. lbs.).

Fig. 16 Right Engine Mount—VM Diesel

Fig. 17 Left Side Mount—VM DieselINS/GS ENGINE 9 - 45

REMOVAL AND INSTALLATION (Continued)

ENGINE ASSEMBLY

REMOVAL

(1) Disconnect the battery.

(2) Remove the air cleaner assembly and inlet hose.

(3) Remove both hoses at intercooler and engine.(4) Disconnect EGR vacuum hose.(5) Disconnect brake booster vacuum hose.(6) Disconnect oil pressure switch connector (Fig.

20).

(7) Disconnect Wiring harness bracket at transaxle shift tower.

(8) Disconnect transaxle wiring at speed sensor, crank sensor, and backup light switch.

(9) Remove both transmission shift cables at transmission.

(10) Remove negative battery cable at cylinder block (Fig. 20).

(11) Remove oil separator.(12) Remove connectors at coolant temperature sensor and A/C compressor.

(13) Disconnect fuel injection pump wiring connectors (Fig. 20).

(14) Disconnect glow plug connectors.(15) Disconnect electrical connector at number 1 fuel injector.

(16) Raise vehicle on hoist.(17) Remove right side splash shield (Fig. 21).

WARNING: THE COOLANT IN A RECENTLY OPER-

ATED ENGINE IS HOT AND PRESSURIZED. USE CARE TO PREVENT SCALDING BY HOT COOLANT.CAREFULLY RELEASE THE PRESSURE BEFORE REMOVING THE RADIATOR DRAIN COCK AND CAP.

(18) Drain the cooling system (refer to Group 7,

Cooling).

(19) Lower vehicle.(20) Remove Coolant pressure bottle and disconnect low coolant level sensor.

(21) Disconnect both heater hoses.(22) Remove the lower radiator hose.(23) Remove the upper radiator hose.

Fig. 18 Rear Engine Mount—VM Diesel

Fig. 19 Shift Cables at Rear Mount

Fig. 20 Component Locations9 - 46 ENGINE NS/GS

REMOVAL AND INSTALLATION (Continued)

(24) Remove fuel line at injector pump and cap.

(25) Remove power steering reservoir and reposition.

(26) Remove upper radiator crossmember.(27) Disconnect cooling fan module connector.(28) Remove radiator support bolts. It is neces-

sary to loosen the receiver/dryer to gain accessto the radiator bolts.

(29) Remove radiator and fans as an assembly.(30) Remove accessory drive belt generator/power steering. Refer to Group 7, for procedure.

(31) Remove both power steering lines at pump, and cap both lines.

NOTE: It is not necessary to discharge A/C system for engine removal.

(32) Remove A/C compressor. Secure compressor away from engine for clearance during engineremoval.

(33) Remove Generator and adjusting bracket.

NOTE: Do not remove the mounting base from the generator. It is aligned at the factory and cannot berealigned in the field.

(34) Hoist vehicle.

(35) Remove exhaust pipe at turbo outlet.(36) Remove connections at starter.(37) Remove power steering high pressure line

bracket at rear of oil pan.

(38) Remove both driveshafts from transaxle. Refer to Group 2, Suspension and Driveshafts.

(39) Disconnect clutch cable at transaxle.(40) Remove reinforcement plate on lower cross-member.

(41) Remove front and rear engine mounts. Refer to procedure outlined in this section.

(42) Drain engine oil and remove oil filter if neces-

sary.(43) Mount both special tool, engine support brackets VM-1026 to cylinder block (Fig. 22).

- (44) Using engine dolly and cradle assembly with 4 adjustable posts align posts with holes in the engine support brackets.
- (45) Lower vehicle so weight of only the engine and transmission is on the dolly and cradle assembly.
- (46) Remove left side splash shield to gain access to thru bolt for left side mount.
- (47) Remove right engine mount and left side mount. Refer to procedure outlined in this section.
- (48) Raise vehicle slowly. It may be necessary to move the engine/transmission assembly on the dolly to allow for removal around body.
- (49) Reverse removal procedure for installation.

CYLINDER HEAD COVER

REMOVAL

- (1) Disconnect the battery cables.(2) Remove generator bracket.(3) Remove breather hose.(4) Remove coolant pressure tank.(5) Remove cylinder head cover.

INSTALLATION

- (1) Install cylinder head cover, torque nuts to 23.5 N·m (208 in. lbs.).
- (2) Install coolant pressure tank.(3) Install breather hose.(4) Install generator bracket, tighten bolts to 7 N·m (4 ft. lbs.).

Fig. 21 Right Side Splash Shield

Fig. 22 Engine RemovalNS/GS ENGINE 9 - 47

REMOVAL AND INSTALLATION (Continued)

- (5) Connect battery cable.

ROCKER ARMS AND PUSH RODS

REMOVAL

- (1) Disconnect the battery cables.
- (2) Remove generator bracket.(3) Remove breather hose.(4) Remove coolant pressure tank.(5) Remove cylinder head cover.(6) Remove rocker retaining nuts (Fig. 23).
- (7) Remove rocker assembly. Place them on a bench in the same order as removed.
- (8) Remove the push rods and place them on a bench in the same order as removed.

INSTALLATION

- (1) Install the push rods in the same order as removed.
- (2) Install rocker arm assemblies in the same

order as removed. Tighten the rocker arm nuts to 29.4 N·m (264 in. lbs.) torque.

(3) Install cylinder head cover, torque nuts to 14.7

N·m (132 in. lbs.).

(4) Install coolant pressure tank. (5) Install breather hose. (6) Install generator bracket, tighten bolts to 7

N·m (4 ft. lbs.).

(7) Connect the service valves to the A/C compressor ports, if equipped with air conditioning.

(8) Connect battery cable. **VALVE SPRINGS—CYLINDER HEAD NOT REMOVED**

This procedure can be done with the engine cylinder head installed on the block.

REMOVAL

Each valve spring is held in place by a retainer

and a set of conical valve locks. The locks can be removed only by compressing the valve spring.

(1) Remove the engine cylinder head cover, refer to cylinder head cover removal in this section.

(2) Remove rocker arms assemblies for access to each valve spring to be removed.

(3) Remove push rods. Retain the push rods, and rocker arms assemblies in the same order and position as removed.

(4) Inspect the springs and retainer for cracks and possible signs of weakening.

(5) Install an air hose adaptor in the fuel injector hole.

(6) Connect an air hose to the adapter and apply air pressure slowly. Maintain at least 621 kPa (90psi) of air pressure in the cylinder to hold the valves against their seats.

(7) Tap the retainer or tip with a rawhide hammer to loosen the lock from the retainer. Use Valve Spring Compressor Tool to compress the spring and remove the locks.

(8) Remove valve spring and retainer. Inspect the valve stems, especially the grooves. An Arkansas smooth stone should be used to remove nicks and high spots.

INSTALLATION

(1) Install valve spring and retainer. (2) Compress the valve spring with Valve Spring Compressor Tool and insert the valve locks. Release the spring tension and remove the tool. Tap the spring from side-to-side to ensure that the spring is seated properly on the engine cylinder head.

(3) Disconnect the air hose. Remove the adaptor from the fuel injector hole and install the fuel injector.

- (4) Repeat the procedures for each remaining valve spring to be removed.
- (5) Install the push rods. Ensure the bottom end of each rod is centered in the plunger cap seat of the hydraulic valve tappet.
- (6) Install the rocker arm assemblies, at their original location.
- (7) Tighten the rocker arm assembly nut to 106 N·m (78 ft. lbs.) torque.
- (8) Install the engine cylinder head cover, refer to cylinder head cover installation in this section.

Fig. 23 Rocker Arm Retaining Nut9 - 48 ENGINE NS/GS

REMOVAL AND INSTALLATION (Continued)

CYLINDER HEAD

REMOVAL

- (1) Disconnect the battery cable.

WARNING: DO NOT REMOVE THE CYLINDER

BLOCK DRAIN PLUGS OR LOOSEN THE RADIATOR DRAIN COCK WITH THE SYSTEM HOT AND PRES-SURIZED BECAUSE SERIOUS BURNS FROM THE COOLANT CAN OCCUR.

- (2) Drain the cooling system. Refer to Group 7, Cooling.
- (3) Remove wiper module. Refer to Group 8K, Windshield Wiper Unit Removal for procedure.
- (4) Remove coolant pressure bottle.(5) Remove intercooler hose at intake manifold (Fig. 24).
- (6) Remove intercooler hose at turbocharger inter-cooler tube.
- (7) Remove the upper radiator hose.
- (8) Remove water manifold.(9) Disconnect the heater hoses and coolant pressure bottle hoses.
- (10) Disconnect EGR tube from EGR valve (Fig. 26).
- (11) Remove exhaust pipe from turbocharger elbow and.
- (12) Disconnect oil feed line from turbo (Fig. 25).(13) Disconnect oil drain line from turbo.(14) Remove Intake manifold. Refer to Group 11, Exhaust System and Intake Manifold.(15) Remove lift eye and brake vacuum tube at rear of exhaust manifold.
- (16) Remove the support strut from block to turbo-charger exhaust elbow.

(17) Remove Exhaust manifold. Refer to Group 11, Exhaust System and Intake Manifold.

(18) Remove oil line at pressure switch.(19) Remove oil feed line for rocker arm assemblies (Fig. 27).

Fig. 24 Intercooler Assembly

Fig. 25 Turbocharger

Fig. 26 EGR Valve and TubeNS/GS ENGINE 9 - 49

REMOVAL AND INSTALLATION (Continued)

(20) Remove Crankcase breather hose from valve cover

(21) Remove the engine cylinder head cover.(22) Remove the injector sensor wire at the connector, and glow plug Connectors.

NOTE: The attachment point for the injector sensor

wire at the injector is not a connector. The connector is located in the wire 4 to 6 inches away from the injector.

(23) Remove injector fuel lines from injectors to pump.

(24) Remove fuel injectors with tool VM-1012A

(Fig. 28) and (Fig. 29) Refer to Group 14, Fuel System.(25) Remove rocker retaining nuts (Fig. 30).

(26) Remove rocker assemblies. Place them on a bench in the same order as removed.

(27) Remove the push rods and place them on a bench in the same order as removed.

(28) Mark cylinder heads to ensure installation in their original position.

(29) Remove the engine cylinder head bolts with special tool VM-1018 and VM-1019.

Fig. 27 Rocker Arm Oil Feed Lines

Fig. 28 Fuel Injector Tool VM-1012A

Fig. 29 Fuel Injector

Fig. 30 Rocker Arm Retaining Nut9 - 50 ENGINE NS/GS

REMOVAL AND INSTALLATION (Continued)

(30) Remove the engine cylinder heads and gasket.

NOTE: A single steel head gasket is used for 4 cylinder heads (Fig. 33).

(31) Stuff clean lint free shop towels into the cylinder bores.

CYLINDER HEAD GASKET

NOTE: If cylinder wall liners have not been removed; the same thickness head gasket removed, may be used.

CAUTION: Piston protrusion must be measured, to determine cylinder head gasket thickness, if one or more cylinder wall liners have been replaced.

Cylinder head gaskets are available in three thicknesses. The different thicknesses are marked with identification holes (one, two or none) (Fig. 33). The gasket is to be installed DRY. DO NOT use a gasket sealing compound on the gasket.

(1) Use special tool VM-1010 with dial indicator special tool VM-1013 (Fig. 31).

(2) Bring the piston of cylinder no. 1 exactly to top dead center.

(3) Zero the dial indicator on the cylinder block mating surface.

(4) Setup the dial indicator on the piston crown

(above the center of the piston pin) 5mm (1/8 in.) from the edge of the piston and note the measurement (Fig. 32).

(5) Repeat the procedure with the rest of the cylinders.

(6) Establish the thickness of the gasket for all

four cylinder heads on the basis of the greatest piston protrusion (Fig. 33).
INSTALLATION
CYLINDER HEAD

(1) Remove the shop towels from the cylinder bores. Coat the bores with clean engine oil.

(2) Install cylinder head alignment studs (VM-1009).

(3) After determining the correct head gasket

thickness, clean the block and head mating surfaces, place the engine cylinder head gasket over the dowels.

(4) Place the engine cylinder head over the dowels.

CAUTION: Engine cylinder head bolts can be reused up to three times.

Fig. 31 Measuring Piston Protrusion

Fig. 32 Piston Protrusion Chart

Fig. 33 Head Gasket Identification

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REMOVAL AND INSTALLATION (Continued)

(5) Tighten the engine cylinder head bolts in sequence according to the following procedure (Fig. 34):

a. The threads and underside heads of the bolts

should be lubricated. Use the cylinder head alignment studs tool number VM-1009. Position the head on the block and secure with the ten large centerbolts and spacers (clamps), finger tight only.

b. Ensure that the various clamps are installed

correctly and the head gasket remain in their proper position, completely covered. Then, lubricate and install the eight small bolts, also finger tight.

(6) Loosen assembly oil feed line for rocker arm assemblies

(7) Install the intake and exhaust manifolds with

new gaskets, partially tightening the nuts to a maximum of 5 N·m (44 in. lbs.). This will align the heads (refer to Group 11, Exhaust System and Intake Manifold for the proper procedures). Install lift eye and brake vacuum tube at this time.

(8) Then, tighten the 12mm bolts with special tool

VM-1019 in the following manner:

(9) 1st Phase: Tightening Head Bolts (Fig. 34).

Central bolts (A-L): Tighten all bolts, starting with bolt A then B-C-D-E-F-G-H-I-L, to 30 N·m. Repeat the operation with the same torque. Following the same sequence rotate each bolt through an angle of 70° using angle torque tool. Then rotate the bolts an additional 70° following tightening sequence.

(10) Then, tighten the 14mm bolts with special

tool VM-1018 in the following manner: (11) Side bolts (M1-M2): Tighten M1 bolts to 30

N·m, then rotate them 85° (65). Tighten M2 bolts to

30 N·m, then rotate them 85° (65).

(12) 2nd Phase: After 20 minutes of engine oper-

ation at operating temperature, allow engine to cool down completely. Then retorque the head bolts as follows:

(13) Central bolts A-L: Starting from bolt A,

slacken and retorque it immediately to 30 N·m + 65°. Rotate the bolt an additional 65°. Then proceed in the same way, bolt by bolt, following alphabetical order, as indicated.

(14) Side bolts M1-M2: Without slackening,

torque bolts M1 then bolts M2 to 90 N·m (66 ft. lbs.).

(15) Tighten intake nuts to 30 N·m (22 ft. lbs.) and

exhaust manifolds nuts to 30 N·m (22 ft. lbs.) specified torque after completing Phase 2.

(16) If the engine cylinder head is to be replaced

and the original valves used, measure the valve stem diameter. Only standard size valves can be used with a service replacement engine cylinder head unless the replacement head valve stem guide bores are

reamed to accommodate oversize valve stems.

Remove all carbon buildup and reface the valves.

(17) Tighten oil feed lines for rocker arm assem-

blies and oil pressure switch to 13 N·m (112 in. lbs.).

(18) Install push rods and rocker arm assemblies,

tighten nut to 29.4 N·m (264 in. lbs.).

(19) Install fuel injectors use tool VM-1012 (refer to Group 14, Fuel System).

(20) Install valve cover, tighten nuts to 14.7 N·m (132 in. lbs.).

Fig. 34 Engine Cylinder Head Bolt Tightening Sequence9 - 52 ENGINE NS/GS
REMOVAL AND INSTALLATION (Continued)

(21) Connect crankcase breather hose.

(22) Connect the injector sensor wire connector, and the glow plug connectors.

(23) Install oil feed line, tighten banjo bolts to 12.7 N·m (108 in. lbs), and oil drain line to turbo.

(24) Install water manifold tighten bolts to 12 N·m (106 in. lbs.).

(25) Install exhaust pipe to turbo elbow, tighten bolts to 28 N·m (250 in. lbs.).

(26) Install the support strut from block to turbo-charger exhaust elbow.

(27) Install EGR tube to EGR valve, tighten bolts to 26 N·m (19 ft. lbs.).

(28) Install intercooler hoses at intake manifold.(29) Install coolant pressure bottle and hoses.(30) Install wiper module. Refer to Group 8K,

Windshield Wiper Unit Installation for procedure.

(31) Install intercooler hose at turbocharger tube.(32) Install fuel injector lines from the pump to injectors, tighten nuts to 17.6 N·m (156. lbs.).

(33) Connect the upper radiator hose.(34) Connect negative cable to battery.(35) Fill the cooling system. Check for leaks.

WARNING: USE EXTREME CAUTION WHEN THE

ENGINE IS OPERATING. DO NOT STAND IN DIRECTLINE WITH THE FAN. DO NOT PUT HANDS NEARTHE PULLEYS, BELTS OR FAN. DO NOT WEARLOOSE CLOTHING.

(36) Operate the engine with the radiator cap off.

Inspect for leaks and continue operating the engineuntil the thermostat opens. Add coolant, if required.

VALVES AND VALVE SPRINGS—HEAD OFF

This procedure is done with the engine cylinder head removed from the block.

REMOVAL

(1) Remove the engine cylinder head from the cylinder block. Refer to cylinder head removal in thissection.

(2) Use Valve Spring Compressor Tool and com-

press each valve spring.

(3) Remove the valve locks, retainers, and springs.(4) Use an Arkansas smooth stone or a jewelers file to remove any burrs on the top of the valve stem, especially around the groove for the locks.

(5) Remove the valves, and place them in a rack in the same order as removed.

INSTALLATION

(1) Fit each valve to its respective valve guide.

NOTE: If valves and valve seats have been refaced

refer to Service Procedures in this section. Follow The Valve Stand Down procedure.(2) Install lower, washer and spring.

(3) Install upper spring collar, and compress valve spring with spring compressor tool. Install split cone retainers.

HYDRAULIC TAPPETS

REMOVAL

(1) Remove coolant pressure bottle.(2) Remove cylinder head cover. Refer to cylinder head cover removal in this section.

(3) Remove rocker assembly and push rods. Identify push rods to ensure installation in original location (Fig. 35).

(4) Remove cylinder head, intake manifold, and exhaust manifold. Refer to cylinder head removal in this section.

(5) Remove yoke retainer and aligning yokes (Fig. 36).

(6) Slide Hydraulic Tappet Remover/Installer Tool through opening in block and seat tool firmly in the head of tappet.

(7) Pull tappet out of bore with a twisting motion.

If all tappets are to be removed, identify tappets to ensure installation in original location.

(8) If the tappet or bore in cylinder block is scored, scuffed, or shows signs of sticking, ream the bore to next oversize. Replace with oversize tappet.

Fig. 35 Tappet and Rocker Arm Assembly

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REMOVAL AND INSTALLATION (Continued)

CAUTION: The plunger and tappet bodies are not

interchangeable. The plunger and valve must always be fitted to the original body. It is advisable to work on one tappet at a time to avoid mixing of parts. Mixed parts are not compatible. DO NOT dis-assemble a tappet on a dirty work bench.

INSTALLATION

(1) Lubricate tappets.(2) Install tappets and yoke retainers in their orig-

inal positions. Ensure that the oil feed hole in the side of the tappet body faces up (away from the crankshaft).

(3) Install cylinder head, intake manifold, and

exhaust manifold. Refer to cylinder head installation in this section.

(4) Install push rods in original positions. (5) Install rocker arms in original positions. (6) Install cylinder head cover. Refer to cylinder

valve cover installation in this section.

(7) Start and operate engine. Warm up to normal operating temperature.

CAUTION: To prevent damage to valve mechanism,

engine must not be run above fast idle until all hydraulic tappets have filled with oil and have become quiet.

VIBRATION DAMPER

REMOVAL

(1) Disconnect the battery cable. (2) Raise vehicle on hoist. (3) Remove right side lower splash shield. (4) Remove generator, power steering belt. Refer to

Group 7, Cooling.

(5) Remove water pump belt. Refer to Group 7,

Cooling. (6) Remove engine starter. Refer to Group, 8B for procedure

(7) Install flywheel locking tool VM.1014 to prevent engine rotation.

NOTE: Crankshaft damper nut is left handed thread.

(8) Remove vibration damper nut.

(9) Remove vibration damper. No special tool is needed for removal.

CAUTION: If thread sealant is used it is important to remove all the old thread sealant from the threads on the crankshaft.

INSTALLATION

NOTE: Before installing damper be sure the O-ring inside the center of the damper is in its groove.

(1) Install vibration damper.

CAUTION: Correct torque on the vibration damper nut is important or engine damage can occur.

(2) Install vibration damper nut and tighten to 441 N-m (325 ft. lbs.).

(3) Remove flywheel locking tool, and install engine starter.

(4) Install both accessory drive belts. Refer to Group 7, Cooling.

(5) Install right splash shield. (6) Lower vehicle. (7) Connect the battery cable.

TIMING CHAIN COVER OIL SEAL

REMOVAL

(1) Disconnect the battery cable.(2) Remove vibration damper. Refer to vibration damper removal in this section.

(3) Pry out seal (Fig. 37).

INSTALLATION

Remove the oil seal ring. The seating diameter must be 68.000 - 68.030 mm.

(1) Install new seal using special tool VM-1015.(2) Install vibration damper. Refer to vibration damper installation in this section.

(3) Connect the battery cable.

INJECTION PUMP

For removal and installation of injection pump refer to Group 14, Fuel.

Fig. 36 Tappet and Yoke9 - 54 ENGINE NS/GS

REMOVAL AND INSTALLATION (Continued)

TIMING CHAIN COVER

REMOVAL

(1) Disconnect the battery cable.

(2) Raise vehicle on hoist.(3) Remove right splash shield.(4) Remove accessory drive belts. Refer to Group 7,

Cooling.

(5) Remove vibration damper nut.

NOTE: Crankshaft damper nut is left handed thread.

(6) Remove vibration damper.

(7) Remove power steering/air conditioning pulley nut. Remove pulley.

CAUTION: Remove old loctite from threads on pump.

(8) Remove pump shaft support bracket assembly.

(9) Disconnect the water drain pipe hose at the timing cover.

CAUTION: When separating the timing chain cover

from the block take care not to damage the mating surface of the timing chain cover or block. Also take care not to damage the timing chain or components located inside the timing chain cover near the edge.

(10) Remove timing chain cover.

INSTALLATION

(1) Apply a continuous 3 mm bead of Silicone

Sealer to timing cover, install within 10 minutes, tighten Torx bolts to 11 N·m (96 in. lbs) (Fig. 38).

(2) Install pump shaft support bracket assembly, tighten nuts to 24.5 N·m (216 in. lbs.). (3) Install Power steering/air conditioning pulley, tighten to 170 N·m (125 ft. lbs.).

CAUTION: Correct torque on the power steering/air conditioning pulley nut is important or engine damage can occur.

(4) Connect water drain pipe hose at the timing cover.

NOTE: Before installing damper be sure O-ring on inside center of damper is in place.

(5) Install vibration damper.

CAUTION: Correct torque on the vibration damper nut is important or engine damage can occur.

(6) Tighten vibration damper nut to 441 N·m (325 ft. lbs.).

(7) Install accessory drive belts. Refer to Group 7, cooling for procedure.

(8) Install splash shield. (9) Lower vehicle. (10) Connect battery cable.

TIMING CHAIN

REMOVAL

(1) Disconnect battery. (2) Raise vehicle on hoist. (3) Remove right splash shield (Fig. 39). (4) Remove both accessory drive belts. Refer to

Group 7, Cooling.

Fig. 37 Front Cover Seal

Fig. 38 Front Cover Sealer Location NS/GS ENGINE 9 - 55

REMOVAL AND INSTALLATION (Continued)

(5) Remove crankshaft vibration damper. Refer to removal procedure outlined in this section.

(6) Remove power steering/air conditioning pulley nut. Remove pulley.

CAUTION: Remove old thread sealant from threads on pump.

(7) Remove pump shaft support bracket assembly (Fig. 40).

(8) Remove timing chain cover. Refer to removal procedure outlined in this section.

(9) Remove oil pump drive gear attached to crankshaft (Fig. 41).

(10) Rotate crankshaft to align timing marks on

injection pump sprocket, camshaft sprocket, and crankshaft sprocket with three dark plated links on timing chain (Fig. 42).

CAUTION: It could take up to 70 crankshaft revolutions

to align sprocket timing marks with the dark chain links. If the chain is removed (Fig. 43) before the sprocket marks are in their proper locations you

must first loosen the rocker arm supports before rotating crankshaft or camshaft sprockets. This will prevent the valves from hitting the pistons.

(11) Remove lower chain guide (Fig. 44).

(12) Remove hydraulic tensioner blade (Fig. 45). (13) Remove hydraulic tensioner oil feed line (Fig. 46).

(14) Remove hydraulic tensioner.

Fig. 39 Splash Shield

Fig. 40 Pump Shaft Support Bracket

Fig. 41 Oil Pump Drive Gear

Fig. 42 Timing Marks 9 - 56 ENGINE NS/GS

REMOVAL AND INSTALLATION (Continued)

(15) Remove timing chain.

INSTALLATION

(1) Install timing chain. Starting at the crankshaft

align the dark link on the chain to the timing mark on the crankshaft sprocket. Next align the second dark link on the chain with the timing mark on the camshaft sprocket. Third Align the final dark link on the chain to the timing mark on the injection pump sprocket. Last install the chain around the vacuum

pump (Fig. 47).

(2) Install hydraulic tensioner. (3) Install hydraulic tensioner oil feed line tighten to 16.7 N·m (145 in. lbs.).

(4) Install hydraulic tensioner blade. Tighten Bolt to 28 N·m (260 in. lbs.)

(5) Install lower chain guide. (6) Install oil pump drive gear on crankshaft.

Fig. 43 Alignment Timing Sprockets

Fig. 44 Lower Chain Guide

Fig. 45 Tensioner Blade

Fig. 46 Hydraulic Tensioner and Oil Feed Line NS/GS ENGINE 9 - 57

REMOVAL AND INSTALLATION (Continued)

(7) Install timing chain cover. Refer to installation procedure outlined in this section.

(8) Install pump shaft support bracket assembly.

Tighten nuts to 24.5 N·m (216 in. lbs.).

(9) Install power steering/air conditioning pulley.

Tighten nut to 170 N·m (125 ft. lbs.).

CAUTION: Correct torque on the power steering/air conditioning pulley nut is important or engine damage can occur.

(10) Install crankshaft vibration damper. Torque to 441 N·m (325 ft. lbs.)

CAUTION: Correct torque on the crankshaft vibration damper nut is important or engine damage can occur.

(11) Install both accessory drive belts. Refer to Group 7, Cooling.

(12) Install splash shield.(13) Lower vehicle.(14) Connect battery.

CRANKSHAFT SPROCKET

REMOVAL

(1) Remove vibration damper. Refer to procedure in this section.

(2) Remove timing chain cover. Refer to procedures in this section.

(3) Remove oil pump drive gear on crankshaft.(4) Remove oil pump.(5) Remove timing chain. Refer to procedure in this section.

(6) Remove vacuum pump.(7) Install crankshaft sprocket remover VM.1000A and remove sprocket (Fig. 48).

INSTALLATION

(1) Install crankshaft sprocket alignment pin VM.1030 into hole in crankshaft (Fig. 49).

(2) Heat new crankshaft sprocket.

Fig. 47 Timing Chain Procedure

Fig. 48 Crankshaft Sprocket—Removal

Fig. 49 Crankshaft Sprocket—Installation9 - 58 ENGINE NS/GS

REMOVAL AND INSTALLATION (Continued)

(3) Align notch in sprocket with alignment pin in crankshaft.

(4) Using crankshaft sprocket installer VM.1029 press on the new sprocket.

(5) Remove alignment pin.(6) Install vacuum pump.

CAUTION: The vacuum pump must be centered in the block and tighten with two bolts. Ensure that the pump spins freely. If vacuum pump does not spin freely loosen bolts and perform procedures again.

(7) Install timing chain.

(8) Install oil pump.(9) Install oil pump drive gear on crankshaft.(10) Install timing chain cover.(11) Install vibration damper.

CAUTION: Correct torque on the crankshaft vibration damper nut is important or engine damage can occur.

HYDRAULIC TENSIONER

Refer to Timing Chain Removal and Installation in this section.

CAMSHAFT

REMOVAL

(1) To service camshaft (Fig. 50) the engine must be removed from vehicle.

(2) Remove valve cover. Refer to valve cover removal in this section.

(3) Remove rocker arms and push rods. Identify push rods to ensure installation in their original location.

(4) Remove cylinder head. Refer to cylinder head removal in this section.

(5) Remove hydraulic tappets. Refer to tappet removal in this section.(6) Remove vibration damper. Refer to vibration damper removal in this section.

(7) Remove power steering pulley.(8) Remove pump shaft support bracket.(9) Remove timing chain cover. Refer to timing chain cover removal in this section.

(10) Remove timing chain. Refer to removal procedure in this section.

(11) Install camshaft sprocket holding tool VM.1031 to lock the camshaft sprocket in place.

(12) Remove camshaft sprocket bolt and remove sprocket (Fig. 50).

(13) Remove locating plate, and reinstall sprocket and bolt finger tight.

(14) Remove camshaft.

INSTALLATION

(1) Coat the camshaft journals with clean engine oil and carefully install the camshaft.

(2) Install camshaft locating plate alignment tool on block then install locating plate (Fig. 51).

(3) Tighten locating bolt to 11 N·m (96 in. lbs.) torque. Be sure to align the timing marks as shown in timing chain installation procedure.

(4) Install camshaft sprocket center bolt and

tighten to 19.6 N·m + 60° (170 in. lbs. + 60°). Remove sprocket holding tool.

(5) Install hydraulic tappets and retaining yokes. (6) Install cylinder heads. (7) Push rods, and rocker arm assemblies. In their

original location.

(8) Install valve cover. (9) Install Timing case cover.

Fig. 50 Camshaft Assembly

Fig. 51 Locating Plate Alignment NS/GS ENGINE 9 - 59

REMOVAL AND INSTALLATION (Continued)

(10) Install Vibration damper.

(11) Reinstall Engine.

CAMSHAFT BEARINGS

This procedure requires that the engine is removed from the vehicle.

REMOVAL

(1) With engine completely disassembled, drive out rear cam bearing core hole plug.

(2) Install proper size adapters and horseshoe

washers (part of Camshaft Bearing Remover/Installer Tool) at back of each bearing shell. Drive out bearing shells (Fig. 50).

INSTALLATION

(1) Install new camshaft bearings with Camshaft

Bearing Remover/Installer Tool by sliding the new camshaft bearing shell over proper adapter.

(2) Position rear bearing in the tool. Install horse-

shoe lock and by reversing removal procedure, carefully drive bearing shell into place.

(3) Install remaining bearings in the same man-

ner. Bearings must be carefully aligned to bring oilholes into full register with oil passages from the main bearing. If the camshaft bearing shell oil holes are not in exact alignment, remove and install them correctly. Install a new core hole plug at the rear of camshaft. Be sure this plug does not leak.

CRANKSHAFT MAIN BEARINGS

REMOVAL

(1) Disconnect battery cable.

(2) Remove engine from vehicle, refer to engine removal in this section.

(3) Install engine to engine stand. (4) Remove accessory drive system. (5) Remove cylinder head cover, refer to cylinder

head cover removal in this section.

(6) Remove rocker arm and push rods, refer to rocker arm and push rod section in this section.

- (7) Remove intake, exhaust manifold and turbo-charger, refer to Group 11, Exhaust System and Intake Manifold.
- (8) Remove water manifold. (9) Remove oil feed lines to rocker arms. (10) Remove cylinder heads. (11) Remove oil pan and oil pick-up. (12) Remove piston and connecting rods from crankshaft journals.
- (13) Remove pistons and connecting rods from block.
- (14) Remove vibration damper. Refer to procedure in this section.
- (15) Remove front cover. Refer to procedure in this section. (16) Remove oil pump drive gear.
- (17) Remove timing chain. Refer to procedure in this section.
- (18) Install special tool VM-1004 onto crankshaft over gear (Fig. 52).
- (19) Remove main bearing oil feed and carrier locators from block.
- (20) Remove flywheel and adaptor plate from engine block.
- (21) Remove thrust bearings from rear main bearing carrier (Fig. 53).
- (22) Slide crankshaft and bearing carriers rearward to rear of block. If you encounter difficulty in removing the complete assembly as previously described, slide the assembly rearward sufficiently to gain access to the main bearing carrier bolts. Mark the carriers for assembly and remove the bolts, two for each carrier (Fig. 54).
- (23) Separate the two halves of each carrier, remove from the crankshaft and temporarily re-assemble the carriers (Fig. 55). Withdraw the crankshaft through the rear of the crankcase.

INSTALLATION

NOTE: Assemble engine according to sequence described, thus saving time and preventing damages to engine components. Clean parts with a suitable solvent and dry them with compressed air before assembly. Use new gaskets where applicable and torque wrenches for correct tightening of components.

Fig. 52 Crankshaft Special Tool VM.10049 - 60 ENGINE NS/GS

REMOVAL AND INSTALLATION (Continued)

- (1) Thoroughly clean crankcase and oil passages, and blow dry with compressed air.
- (2) Install new main bearing shells in each of the carrier halves. Assemble the carriers to the crankshaft journals, ensuring that the carriers are installed in their original locations. Secure each carrier with the two bolts tightening evenly to 42 N-m (31 ft. lbs.) (Fig. 55).

(3) Slide special tool (VM-1002) over the crank-

shaft gear and, insert the crankshaft and carrier assembly into the crankcase in the same manner used for removal.

(4) Align the holes in the lower carriers, with the

center of the crankcase webs (Fig. 56). (5) Secure each carrier assembly to the crankcase with the main bearing oil feed and carrier locators and tighten them to 54 N·m (40 ft. lbs.).

(6) Install rear main bearing carrier onto crank-

shaft ensuring arrow on bearing carrier aligns with vertical web in center of crankcase.

(7) Install rear oil seal. (8) Install new O-rings in adaptor plate.

Fig. 53 Crankshaft and Bearings

Fig. 54 Carrier Bolts

Fig. 55 Crankshaft and Carrier Bearing Assembly NS/GS ENGINE 9 - 61

REMOVAL AND INSTALLATION (Continued)

(9) Install adaptor plate and tighten bolts to 47

N·m (35 ft. lbs.).

(10) Install bolts to main bearing carrier and

tighten to 26.5 N·m (20 ft. lbs.).

(11) Position flywheel and O-ring on crankshaft

and align bolt holes.

NOTE: For purposes of checking crankshaft end

play used flywheel bolts may be used. Final assembly requires new flywheel bolts.

(12) Install 2 flywheel bolts, 180° apart, and

tighten bolts to 20 N·m plus 60° (15 ft. lbs.) plus 60°.

(13) Attach dial indicator to engine block. (14) Move crankshaft toward front of engine and zero indicator.

(15) Move crankshaft toward the rear of engine

and record measurement.

(16) Subtract specified crankshaft end play from

figure obtained. Crankshaft end play 0.08 to 0.21 mm (0.0032 to 0.0083 in.).

(17) Select thrust washers which will give correct

end play.

(18) Remove tools and flywheel. (19) Lubricate thrust washer halves and fit them into the rear main bearing carrier.

(20) To verify correct end play, install 2 flywheel

bolts 180° apart, and tighten bolts to 20 N·m plus 60° (15 ft. lbs. plus 60°).

(21) Measure crankshaft end play with a dial

gauge. Crankshaft end play should not exceed 0.08-0.21 mm (0.0032 to 0.0083 in.) (Fig. 57). If end clearance exceeds these values install oversize thrust washer. CAUTION: Use NEW flywheel bolt for the following

procedure.

(22) Install new O-ring on flywheel. Install flywheel. The 6 flywheel bolts must be tightened as follows:

- a. Torque the 6 flywheel bolts to 60 N·m (44 ft. lbs.).
- b. Loosen 2 of the 6 bolts, 180° apart. Torque the 2 bolts to 20 N·m (180 in. lbs.). Then using a torque angle gauge rotate the 2 bolts 65° additional.
- c. Loosen the next 2 bolts, 180° apart and follow the same procedure.
- d. Loosen the last 2 bolts, 180° apart and follow the same procedure.

(23) Install Transmission. Refer to procedure in Group 21, Transmission.

(24) Install pistons and connecting rod assemblies, refer to piston and connecting rods in this section.

(25) Install oil pick up tube and tighten bolts to 25 N·m (18 ft. lbs.).

(26) Install oil pan, refer to oil pan installation in this section.

(27) Install timing chain. Refer to procedure in this section.

(28) Install vacuum pump. Tighten retaining screws to 20 N·m (15 ft. lbs.).

Fig. 56 Main Bearing Carrier Alignment

Fig. 57 Measuring Crankshaft End Play 9 - 62 ENGINE NS/GS

REMOVAL AND INSTALLATION (Continued)

CAUTION: The vacuum pump must be centered in the block and tighten with two bolts. Ensure that the pump spins freely. If vacuum pump drags or does not spin freely loosen bolts and perform procedures again.

(29) Before installing oil pump check pump bore depth in block (A) and pump body height (B) (Fig. 58). Difference between A and B should be 0.020-0.082 mm (.0007 to .0032 in.).

(30) Install oil pump and tighten retaining screws to 27 N·m (20 ft. lbs.). Check for normal backlash between pump and crankshaft gears.

(31) Install oil pump drive Gear. (32) Install front cover. Refer to procedure in this section.

(33) Install vibration damper. Refer to procedure in this section.

(34) Install cylinder heads. Refer to procedure in this section.

(35) Install rocker arms and push rods. Refer to procedure in this section.

(36) Install cylinder head cover. Refer to procedure in this section.

(37) Install accessory drive system.(38) Install engine in vehicle. Refer to procedure in this section.

(39) Fill engine with the correct amount of fluids specified.

(40) Connect battery cable.OIL PAN

REMOVAL

(1) Disconnect battery cable.(2) Raise vehicle on hoist.(3) Drain oil.(4) Remove oil pan bolts (Fig. 59).(5) Remove oil pan.

INSTALLATION

(1) Install oil pan. Apply a continuous 3 mm bead of Silicone Sealer to oil pan, install within 10 min-utes.

(2) Install oil pan bolts and torque bolts to 11 N·m (8 ft. lbs.).

(3) Install oil drain plug tighten to 79 N·m (58 ft. lbs).

(4) Lower vehicle.(5) Fill engine with proper amount of oil.(6) Connect battery cable.

OIL PUMP

REMOVAL

(1) Raise vehicle on hoist.(2) Remove right splash shield.(3) Remove both accessory drive belts. Refer to

Group 7, Cooling.

(4) Remove pump shaft support bracket assembly.(5) Remove vibration damper. Refer to Vibration Damper Removal in this section.

NOTE: Crankshaft damper nut is left handed thread.

(6) Remove front cover. Refer to Timing Chain Cover Removal in this section.

(7) Remove oil pump drive gear at crankshaft (Fig. 60).

(8) Remove oil pump.

Fig. 58 Oil Pump Bore Depth

Fig. 59 Oil PanNS/GS ENGINE 9 - 63

REMOVAL AND INSTALLATION (Continued)

INSTALLATION

(1) Install new O-ring and lubricate with clean engine oil.

(2) Install oil pump and tighten retaining screws to 27.5 N·m (240 in. lbs.).

(3) Install oil pump drive gear on crankshaft.(4) Install front cover. Refer to Timing Chain Cover Installation in this section.

(5) Install pump shaft support bracket assembly.

CAUTION: Correct torque on the vibration damper nut is important or engine damage can occur.

(6) Install vibration damper. Torque nut to 441 N·m (325 ft. lbs.)

(7) Install both accessory drive belts. Refer to Group 7, Cooling.

(8) Install right splash shield.

OIL PUMP PRESSURE RELIEF VALVE

REMOVAL

(1) Remove oil pan.(2) Remove clip retaining relief valve.(3) Remove relief valve cap, spring, and plunger

(Fig. 61).

(4) Check relief valve spring length. Relief valve spring free length is 57.5mm (2.263 in.). If springlength is less or spring is distorted it must bereplaced.

(5) Check plunger for scoring, replace if necessary.INSTALLATION

(1) Thoroughly clean all components and relief valve pocket in cylinder block.

(2) Fit plunger, spring and cap into block.(3) Compress spring and install retaining clip. Ensure clip is completely seated in groove.

OIL FILTER ADAPTER AND OIL COOLER

REMOVAL

(1) Remove oil filter.(2) Remove oil cooler adapter bolt.(3) Remove oil cooler (Fig. 62).

INSTALLATION

(1) Install oil cooler with new gasket, tighten oil cooler adapter bolt to 60 N·m (44 ft. lbs.).

(2) Install oil filter adapter to oil cooler and tighten to 49 N·m (36. lbs.).

(3) Install oil filter and tighten to 9.8 N·m (85 in. lbs.) and add oil.

VACUUM PUMP

REMOVAL

(1) Disconnect the battery cable.(2) Raise vehicle on hoist.(3) Remove right splash shield (Fig. 63).(4) Remove accessory drive belts. Refer to Group 7,

Cooling.

(5) Remove vibration damper nut.

NOTE: Crankshaft damper nut is left handed thread.

Fig. 60 Oil Pump Drive Gear

Fig. 61 Oil Pressure Relief Valve9 - 64 ENGINE NS/GS

REMOVAL AND INSTALLATION (Continued)

(6) Remove vibration damper.

(7) Remove power steering/air conditioning pulley nut. Remove pulley.

CAUTION: Remove old thread sealant from threads on pump.

(8) Remove pump shaft support bracket assembly (Fig. 64).

CAUTION: When separating the timing chain cover from the block take care not to damage the mating surface of the timing chain cover.

(9) Remove timing chain cover.(10) Remove oil pump drive gear on crankshaft (Fig. 65).

(11) Remove lower chain guide (Fig. 68).(12) Rotate crankshaft to align timing marks on injection pump sprocket, camshaft sprocket, and crankshaft sprocket with three dark plated links on timing chain (Fig. 66).

CAUTION: It could take up to 70 crankshaft revolutions to align sprocket timing marks with the dark chain links. If the chain is removed (Fig. 67) before the sprocket marks are in their proper locations you must first loosen the rocker arm supports before rotating crankshaft or camshaft sprockets. This will prevent the valves from hitting the pistons.

Fig. 62 Oil Cooler

Fig. 63 Splash Shield

Fig. 64 Pump Shaft Support Bracket

Fig. 65 Oil Pump Drive GearNS/GS ENGINE 9 - 65

REMOVAL AND INSTALLATION (Continued)

(13) Remove hydraulic tensioner blade (Fig. 69).

(14) Remove hydraulic tensioner oil feed line (Fig. 70).

(15) Remove hydraulic tensioner.(16) Remove timing chain.(17) Remove vacuum pump (Fig. 71).

INSTALLATION

(1) Install vacuum pump with new O-ring (Fig.

72).CAUTION: The vacuum pump must be centered in

the block and tighten with two bolts. Ensure that the pump spins freely. If vacuum pump drags or does not spin freely loosen bolts and perform procedures again.

(2) Install timing chain. Starting at the crankshaft

align the dark link on timing chain to the timing mark on the crankshaft sprocket. Next align the second dark link on the chain with the timing mark on

Fig. 66 Timing Marks

Fig. 67 Alignment Timing Sprockets

Fig. 68 Lower Chain Guide

Fig. 69 Hydraulic Tensioner Blade9 - 66 ENGINE NS/GS

REMOVAL AND INSTALLATION (Continued)

the camshaft sprocket. Third align the final dark link

on the chain to the timing mark on the injection pump sprocket. Last install the chain around the vacuum pump (Fig. 73).

(3) Install hydraulic tensioner.(4) Install hydraulic tensioner oil feed line.(5) Install hydraulic tensioner blade. Torque bolt to

28 N·m (260 in. lbs.).

(6) Install lower chain guide.(7) Install oil pump drive gear on crankshaft.(8) Install timing chain cover. Refer to installation

procedure outlined in this section.

(9) Install pump shaft support bracket assembly.

Tighten nuts to 24.5 N·m (216 in. lbs.).

CAUTION: Correct torque on the power steering/air conditioning pulley nut is important or engine damage can occur.

Fig. 70 Hydraulic Tensioner and Oil Feed Line

Fig. 71 Vacuum Pump—Removal

Fig. 72 Vacuum Pump Assembly

Fig. 73 Timing Chain ProcedureNS/GS ENGINE 9 - 67

REMOVAL AND INSTALLATION (Continued)

(10) Install power steering/air conditioning pulley.

Tighten nut to 170 N·m (125 ft. lbs.).

CAUTION: Correct torque on the crankshaft vibration damper nut is important or engine damage can occur.

(11) Install crankshaft vibration damper. Torque to 441 N·m (325 ft. lbs.)

(12) Install both accessory drive belts. Refer to Group 7, Cooling.

(13) Install splash shield.(14) Lower vehicle.(15) Connect battery.

PISTONS AND CONNECTING ROD

REMOVAL

(1) Disconnect the battery cable.(2) Remove cylinder heads, refer to cylinder head removal in this section.

(3) Raise vehicle on host.(4) Remove oil pan, refer to oil pan removal in this section.

(5) Remove top carbon ridge of cylinder bores with a reliable ridge reamer before removing pistons from cylinder block. Be sure to keep tops of pistons covered during this operation . Mark piston with matching cylinder number.

(6) Pistons and connecting rods must be removed from top of cylinder block. Rotate crankshaft so that each connecting rod is centered in cylinder bore.

(7) Remove connecting rod cap. Push each piston and rod assembly out of cylinder bore.

CAUTION: During piston and rod removal. DO NOT

rotate piston and connecting rod or damage to the oil jets extending out into the cylinder bore will occur (Fig. 74).NOTE: Be careful not to nick crankshaft journals.

(8) After removal, install bearing cap on the mating rod.

PISTON PIN—REMOVAL

(1) Secure connecting rod in a soft jawed vice.(2) Remove 2 clips securing piston pin (Fig. 75).(3) Push piston pin out of piston and connecting rod.

PISTON RING—REMOVAL

(1) Identification (ID) mark on face of upper and intermediate piston rings must point toward piston crown.

(2) Using a suitable ring expander, remove upper and intermediate piston rings (Fig. 76).

(3) Remove the upper oil ring side rail, lower oil ring side rail and then oil ring expander from piston.

(4) Carefully clean carbon from piston crowns, skirts and ring grooves ensuring the 4 oil holes in the oil control ring groove are clear.

FITTING PISTON RINGS

(1) Wipe cylinder bore clean. Insert ring and push down with piston to ensure it is square in bore. The ring gap measurement must be made with the ring positioning at least 12 mm (0.50 in.) from bottom of

Fig. 74 Oil Jets

Fig. 75 Piston Assembly9 - 68 ENGINE NS/GS

REMOVAL AND INSTALLATION (Continued)

cylinder bore. Check gap with feeler gauge (Fig. 77).

Top compression ring gap .25 to .50 mm (.0098 to .0196 in.). Second compression ring gap .25 to .35mm (.0098 to .0137 in.). Oil control ring gap .25 to .58 mm (.0098 to .0228 in.).

(2) If ring gaps exceed dimension given, new rings

or cylinder liners must be fitted. Keep piston rings in piston sets.

(3) Check piston ring to groove clearance (Fig. 78).

Top compression ring gap .08 to .130 mm (.0031 to .0051 in.). Second compression ring gap .070 to .102mm (.0027 to .0040 in.). Oil control ring gap .040 to .072 mm (.0015 to .0028 in.).

PISTON RINGS—INSTALLATION

(1) Install rings on the pistons using a suitable ring expander (Fig. 76).

(2) Top compression ring is tapered and chromium

plated. The second ring is of the scraper type and must be installed with scraping edge facing bottom of the piston. The third is an oil control ring (Fig. 79). Ring gaps must be positioned, before inserting piston

into the liners, as follows (Fig. 80).

(3) Top ring gap must be positioned at 30 degrees

to the right of the combustion chamber recess (look-ing at the piston crown from above).

(4) Second piston ring gap should be positioned on

the opposite side of the combustion chamber recess.

(5) Oil control ring gap to be located 30 degrees to

the left of combustion chamber recess.

(6) When assembling pistons check that compo-

nents are installed in the same position as before dis-assembly, determined by the numbers stamped on the crown of individual pistons. Engine cylinders are numbered starting from gear train end of the engine. Face chamber recess side of piston towards camshaft. Therefore, the numbers stamped on con

Fig. 76 Piston Rings—Removing and Installing

Fig. 77 Ring Gap Measurement

Fig. 78 Piston Ring Side Clearance

Fig. 79 Piston Ring Identification NS/GS ENGINE 9 - 69

REMOVAL AND INSTALLATION (Continued)

rod big end should also face in the same direction. To

insert piston into cylinder, use a ring compressor as shown in (Fig. 81).

PISTON PIN—INSTALLATION

(1) Secure connecting rod in soft jawed vice. (2) Lubricate piston pin and piston with clean oil. (3) Position piston on connecting rod.

CAUTION: Ensure combustion recess in piston

crown and the bearing cap numbers on the connecting rod are on the same side.

(4) Install piston pin.

(5) Install clips in piston to retain piston pin. (6) Remove connecting rod from vice.

PISTON—INSTALLATION

(1) Before installing pistons, and connecting rod

assemblies into the bore, be sure that compression ring gaps are staggered so that neither is in line with oil ring rail gap (Fig. 80).

(2) Before installing the ring compressor, make sure the oil ring expander ends are butted and the rail gaps located as shown in (Fig. 80).

(3) Immerse the piston head and rings in clean

engine oil, slide the ring compressor, over the piston and tighten with the special wrench (Fig. 81). Ensure position of rings does not change during this operation.

(4) Face chamber recess side of piston towards camshaft.

(5) Install connecting rod bolt protectors on rod bolts.

(6) Rotate crankshaft so that the connecting rod

journal is on the center of the cylinder bore. Insert rod and piston into cylinder bore and guide rod over the crankshaft journal.

CAUTION: During piston and rod installation. DO

NOT rotate piston and connecting rod or damage to the oil jets extending out into the cylinder bore will occur (Fig. 74).

(7) Tap the piston down in cylinder bore, using a

hammer handle. At the same time, guide connecting rod into position on connecting rod journal.

(8) Install rod caps. Install nuts on cleaned and

oiled rod bolts and tighten nuts to 29.5 N-m (22 ft.lb.) plus 60°.

CYLINDER LINER

REMOVAL

(1) Remove cylinder heads (refer to cylinder head removal in this section).

(2) Remove Oil pan (refer to oil pan removal in this section).

(3) Remove pistons (refer to piston removal in this section).

(4) Use tool VM-1001 to remove liners (Fig. 82). (5) Remove shims from cylinder liner or cylinder block recess. Keep shims with each cylinder liner.

INSTALLATION

(1) Carefully clean residual sealer from liner and

crankcase, and degrease the crankcase where it comes into contact with the liners. Referring to (Fig. 83), install the liners in the crankcase as shown (A), rotating them back and forth by 45° in order to guarantee correct positioning.

(2) Measure the liner recess relative to block deck

with a dial indicator mounted on a special tool VM-1010 A. All the measurements must be taken on camshaft side. Zero dial gauge on block deck.

(3) Move dial gauge to cylinder liner record reading on dial gauge.

(4) Remove liner and special tool.

Fig. 80 Piston Ring Gap Location

Fig. 81 Installing Piston

REMOVAL AND INSTALLATION (Continued)

(5) Then select the correct shim thickness to give proper protrusion (0.01 - 0.06 mm).

(6) Fit the shim and the O-rings onto the liner. (7) Lubricate the lower liner location in the block.

Apply LOCTITE 275 to the corner of the liner seat. Apply LOCTITE 275 uniformly to the upper part of the liner at area.

(8) Fit the liners in the crankcase making sure

that the shim is positioned correctly in the seat. Lock the liners in position using special tool (VM-1016) and bolts (Fig. 84). Clean the residual LOCTITE on the upper surface of the block deck.

(9) Recheck the liner protrusion. It should be 0.01 - 0.06 mm.

NOTE: A period of six hours must elapse between

the liners being installed and engine start-up. If engine assembly is not continued after liner installation, the liners need to be clamped for twelve hours minimum.

(10) Refer to Cylinder Head Removal and Installation

procedure in this section. To measure piston protrusion for installation of proper head gasket thickness.

CRANKSHAFT—REMOVAL

Refer to CRANKSHAFT MAIN BEARING

REMOVAL in this section.

REAR CRANKSHAFT OIL SEAL

REMOVAL

(1) Remove transmission. Refer to Group 21, Transmission for removal procedure.

(2) Remove flywheel.

NOTE: Inspect O-ring in flywheel (Fig. 85).

(3) Remove rear crankshaft oil seal from retainer (Fig. 86).

CAUTION: When removing seal from retainer take care not to damage retainer.

INSTALLATION

(1) Install crankshaft oil seal.

CAUTION: Use NEW flywheel bolt for the following procedure.

(2) Install new O-ring on flywheel. Install fly-

wheel. The 6 flywheel bolts must be tightened as follows:

- a. Torque the 6 flywheel bolts to 60 N·m (44 ft. lbs.).
- b. Loosen 2 of the 6 bolts, 180° apart. Torque the 2 bolts to 20 N·m (180 in. lbs.). Then using a torqueangle gauge rotate the 2 bolts 65° additional.
- c. Loosen the next 2 bolts, 180° apart and follow the same procedure.
- d. Loosen the last 2 bolts, 180° apart and follow the same procedure.

(3) Install Transmission. Refer to procedure in Group 21, Transmission.

DISASSEMBLY AND ASSEMBLY

HYDRAULIC TAPPETS

DISASSEMBLE AND ASSEMBLE

(1) Pry out plunger retainer spring clip.

(2) Clean varnish deposits from inside of tappet body above plunger cap.

(3) Invert tappet body and remove plunger cap,

plunger, check valve, check valve spring, check valveretainer and plunger spring. Check valve could be flat or ball.

Assemble tappets in reverse order.

Fig. 82 Cylinder Liner—Removal

INS/GS ENGINE 9 - 71 REMOVAL AND INSTALLATION (Continued)

CLEANING AND INSPECTION

CYLINDER HEAD COVERS

Remove any original sealer from the cover sealing surface of the engine cylinder head.

Remove all residue from the sealing surface using a clean, dry cloth.

ROCKER ARMS AND PUSH RODS

CLEANING

Clean all the components (Fig. 87) with cleaning solvent.

Use compressed air to blow out the oil passages in the rocker arms and push rods.

INSPECTION

Inspect the pivot surface area of each rocker arm.

Replace any that are scuffed, pitted, cracked or excessively worn. Inspect the valve stem tip contact surface of each

rocker arm and replace any rocker arm that is deeply pitted.

Inspect each push rod end for excessive wear and

replace as required. If any push rod is excessively worn because of lack of oil, replace it and inspect the corresponding hydraulic tappet for excessive wear.

Inspect the push rods for straightness by rolling

them on a flat surface or by shining a light between the push rod and the flat surface.

A wear pattern along the length of the push rod is

not normal. Inspect the engine cylinder head for obstruction if this condition exists.

CYLINDER HEAD

CLEANING

Thoroughly clean the engine cylinder head and cyl-

inder block mating surfaces. Clean the intake and exhaust manifold and engine cylinder head mating surfaces. Remove all gasket material and carbon.

Fig. 83 Cylinder Liner—Installation 9 - 72 ENGINE NS/GS

Check to ensure that no coolant or foreign material has fallen into the tappet bore area.

Remove the carbon deposits from the combustion chambers and top of the pistons.

Fig. 84 Liner Clamp Location

Fig. 85 Flywheel

Fig. 86 Crankshaft Seal

Fig. 87 Rocker Arm Components NS/GS ENGINE 9 - 73

CLEANING AND INSPECTION (Continued)

INSPECTION

Use a straightedge and feeler gauge to check the flatness of the engine cylinder head and block mating surfaces (Fig. 88).

Minimum cylinder head thickness 89.95mm (3.541 in.)

CAUTION: If only one cylinder head is found to be distorted and requires machining, it will also be necessary to machine the remaining cylinder heads and end plates by a corresponding amount to maintain correct cylinder alignment.

VALVE GUIDE HEIGHT

(1) Valve Guides height requirement. (2) Measurement A (Fig. 89): 13.50 - 14.00 mm.

VALVE STEM-TO-GUIDE CLEARANCE

MEASUREMENT

(1) Measure and record internal diameter of valve guides. Valve guide internal diameter is 8.0 to 8.015mm (.3149 to .3155 in.).

(2) Measure valve stems and record diameters.

Intake valve stem diameter 7.94 to 7.96 mm (.3125 to .3133 in). Exhaust valve stem diameter 7.92 to 7.94 mm (.3118 to .3125 in).

(3) Subtract diameter of valve stem from internal

diameter of its respective valve guide to obtain valve stem clearance in valve guide. Clearance of inlet

valve stem in valve guide is .040 to .075 mm (.0015 to .0029 in). Clearance of exhaust valve stem in valve guide is .060 to .095 mm (.0023 to .0037 in).

(4) If valve stem clearance in valve guide exceeds

tolerances, new valve guides must be installed.

TIMING CHAIN COVER

Be sure mating surfaces of chain case cover and cylinder block are clean and free from burrs.

VALVES AND VALVE SPRINGS

VALVE CLEANING

Clean all carbon deposits from the combustion chambers, valve ports, valve stems, valve stem guides and heads.

Clean all grime and gasket material from the engine cylinder head machined gasket surfaces.

INSPECTION

Inspect for cracks in the combustion chambers and valve ports.

Inspect for cracks on the exhaust seat. Inspect for cracks in the gasket surface at each coolant passage.

Inspect valves for burned, cracked or warped heads.

Inspect for scuffed or bent valve stems. Replace valves displaying any damage. Check valve spring height. (Fig. 90).

Fig. 88 Checking Cylinder Head Flatness

Fig. 89 Valve Guide Height

Fig. 90 Valve Spring Chart 9 - 74 ENGINE NS/GS

CLEANING AND INSPECTION (Continued)

HYDRAULIC TAPPETS

(1) Clean all tappet parts in a solvent that will remove all varnish and carbon.

(2) Replace tappets that are unfit for further service with new assemblies.

(3) If plunger shows signs of scoring or wear, install a new tappet assembly. If valve is pitted, or valve seat on end of plunger is prevented from seating, install a new tappet assembly.

OIL PUMP

CLEANING

Wash all parts in a suitable solvent and inspect carefully for damage or wear (Fig. 92).

INSPECTION

(1) Before installing oil pump check pump bore depth in block (A) and pump body height (B) (Fig.91). Difference between A and B should be 0.020-0.082 mm.

(2) Check clearance between rotors (Fig. 93).

PISTON AND CONNECTING ROD

PISTONS

(1) Piston Diameter: Size Group A: 91.93-91.94mm

(3.6191-3.6196 in.) Size Group B: 91.94-91.95mm(3.6196-3.6200 in.). Maximum wear limit .05mm(.0019 in.).

(2) Check piston pin bores in piston for roundness.

Make 3 checks at 120° intervals. Maximum out of roundness .05mm (.0019in.). (3) The piston diameter should be measured

approximately 15 mm (.590 in.) up from the base.

(4) Skirt wear should not exceed 0.1 mm (.00039 in.).

(5) The clearance between the cylinder liner and piston should not exceed 0.25 mm (.0009 in.).

(6) Make sure the weight of the pistons does not differ by more than 5 g.

CONNECTING ROD

(1) Assemble bearing shells and bearing caps to

their respective connecting rods ensuring that the serrations on the cap and reference marks are aligned.

(2) Tighten bearing cap bolts to 29 N·m (21 ft. lbs.) plus 60°.

(3) Check and record internal diameter of crank end of connecting rod.

Fig. 91 Oil Pump Bore Depth

Fig. 92 Oil Pump Inner and Outer Rotors

Fig. 93 Checking Rotor Clearance

CLEANING AND INSPECTION (Continued)

Note: When changing connecting rods, all four

must have the same weight and be stamped with the same number. Replacement connecting rods will

only be supplied in sets of four.

(4) Connecting rods are supplied in sets of four

since they all must be of the same weight category. Max allowable weight difference is 18 gr. NOTE: On

one side of the big end of the con-rod there is a two-digit number which refers to the weight category. On the other side of the big end there is a four digit number on both the rod and the cap. These numbers must both face the camshaft as well as the recess on the piston crown (Fig. 94). Lightly heat the piston in oven. Insert piston pin in position and secure it with provided snap rings. The Four digit numbers

marked on con rod big end and rod cap must be on the same side as the camshaft (Fig. 94) .

After having coated threads with Molyguard, tighten con rod bolts to 29 N·m (21 ft. lbs.) plus 60°.

PISTON PIN

(1) Measure the diameter of piston pin in the center and both ends (Fig. 95).

(2) Piston pin diameter is 29.990 to 29.996mm (1.1807 to 1.1809 in.).

CRANKSHAFT

CRANKSHAFT JOURNALS

(1) Using a micrometer, measure and record crankshaft connecting rod journals, take reading of each journal 120° apart. Crankshaft journal diameter is 53.84 to 53.955mm (2.1196 to 2.1242 in.).

(2) Crankshaft journals worn beyond limits or show signs of out of roundness must be reground or replaced. Minimum reground diameter is 53.69mm (2.1137 in.). BEARING-TO-JOURNAL CLEARANCE

Compare internal diameters of connecting rod with crankshaft journal diameter. Maximum clearance between connecting rod and crankshaft journals .022 to .076mm (.0008 to .0029 in.) (Fig. 96).

CRANKSHAFT MAIN BEARING

INSPECTION

(1) Fit main bearing carriers together and torque to 42 N·m (31 ft. lbs.)

Fig. 94 Connecting Rod Identification

Fig. 95 Piston, Connecting Rod and Pin

Fig. 96 Bearing Clearance 9 - 76 ENGINE NS/GS

CLEANING AND INSPECTION (Continued)

(2) Check internal diameter of bearings.

(3) If internal diameter of original bearing is being checked and figures are not within specifications, new bearings must be used.

(4) Check crankshaft main bearing journals to bearing clearances. Clearances of main bearings is .03 to .088mm (.0011 to .0035 in.).

OIL PAN

Remove all gasket material from cylinder block. Be

careful not gouge pan sealing surface.

CYLINDER LINER

INSPECTION

The cylinder walls should be checked for out-of-

round and taper with dial bore gauge. The cylinder bore out-of-round is 0.100 mm (.0039 inch) maximum and cylinder bore taper is 0.100 mm (0.0039 inch) maximum. If the cylinder walls are badly scuffed or scored, new liners should be installed and honed, and new pistons and rings fitted.

Measure the cylinder bore at three levels in direc-

tions A and B (Fig. 97). Top measurement should be 10 mm (3/8 inch) down and bottom measurement should be 10 mm (3/8 inch.) up from bottom of bore.

SPECIFICATIONS

2.5L VM DIESEL

DESCRIPTION SPECIFICATIONS

Type 425CLIEE (36B)

Number of Cylinder 4

Bore 92 mm

Stroke 94 mm

Capacity 2499.5 cm³

Injection Order 1-3-4-2

Compression Ratio 21:1 (60.5)

Crankshaft Front Journal Diameter

Nominal 62.985–63.000 mm

–0.25 62.735–62.750 mm

–0.125 62.860–62.875 mm

Front Bearing Diameter

Nominal 63.043–63.088 mm

–0.25 62.793–62.838 mm

–0.125 62.918–62.963 mm

Clearance Between Journal and Bearing:

0.043–0.103 mm

Center Journal Diameter

Nominal 63.005–63.020 mm

–0.25 62.755–62.770 mm

–0.125 62.880–62.895 mm

Center Bearing Diameter

Nominal 63.050–63.093 mm

–0.25 62.800–62.843 mm

–0.125 62.925–62.968 mm

Clearance Between Journal and Bearing:

0.030–0.088 mm

Rear Journal Diameter

Nominal 79.980–80.000 mm

–0.25 79.730–79.750 mm

–0.125 79.855–79.875 mm

Rear Bearing Diameter

Nominal 80.045–80.070 mm

–0.25 79.795–79.820 mm

–0.125 79.920–79.945 mm

Clearance Between Journal and Bearing:

0.045–0.090 mm (Wear Limit: 0.200 mm)

Connecting Rod Journal

Nominal 53.940–53.955 mm

–0.25 53.690–53.705 mm

–0.125 53.815–53.830 mm

Connecting Rod Bearing

Nominal 53.977–54.016 mm

–0.25 53.727–53.766 mm

–0.125 53.852–53.891 mm

Clearance Between Journal and Bearing:

0.022–0.076 mm (Wear Limit: 0.200 mm)

Crankshaft End Play

End Play 0.08–0.21 mm

Adjustment Thrust Washers

Thrust Washers Available 2.31–2.36 mm

Thrust Washers Available 2.41–2.46 mm

Thrust Washers Available 2.51–2.56 mm

Main Bearing Carriers

Front 67.025–67.050 mm

Center 66.670–66.690 mm

Rear 85.985–86.005 mm

Liners

Internal Diameter 92.000–92.010 mm

Fig. 97 Liner InspectionNS/GS ENGINE 9 - 77

CLEANING AND INSPECTION (Continued)

DESCRIPTION SPECIFICATIONS

Protrusion 0.01–0.06 mm

Adjustment Shims

Available Shims: 0.15 mm

Available Shims: 0.17 mm

Available Shims: 0.20 mm

Available Shims: 0.23 mm

Available Shims: 0.25 mm

Cylinder Head

Minimum Thickness 89.95–90.05 mm

Gasket Steel

Gasket thickness: 1.42 60.1 mm 0 Holes

Gasket thickness: 1.62 60.1 mm 1 Holes

Gasket thickness: 1.52 60.1 mm 2 Holes

End Plates

Height 89.02–90.00 mm

Connecting Rods

Weight

(Without the crank bearing) . . . 1129–1195 grams

Small End Bearing Internal DiameterMinimum 30.035 mm

Maximum 30.050 mm

Crankshaft Bearings

Standard Internal Diameter . . 53.997–54.016 mm

Pistons

Skirt Diameter 91.935–91.945 mm

(Measured at approximately

15 mm above the bottom of the skirt)

Piston Clearance 0.055–0.075 mm

Top of Piston to Cylinder Head 0.80–0.89 mm

Piston Protrusion 0.53–0.62 mm Fit Gasket

(1.42), 0 Holes

Piston Protrusion 0.73–0.82 mm Fit Gasket

(1.62), 1 Holes

Piston Protrusion 0.63–0.72 mm Fit Gasket

(1.52), 2 Holes

Piston Pins

T y p e Full Floating

Pin Diameter 29.990–29.996 mm

Clearance 0.004–0.014 mm

Piston Rings (Clearance in Groove)

T o p 0.080–0.130 mm

Second 0.070–0.102 mm

Oil Control 0.040–0.072 mm

Piston Rings (Fitted Gap)

T o p 0.25–0.50 mm

Second 0.20–0.35 mm

Oil Control 0.25–0.58 mm

Camshaft

Journal Diameter Front 53.460–53.480 mm

Bearing Clearance 0.06–0.13 mm

Journal Diameter Center 53.460–53.480 mm

Bearing Clearance 0.06–0.13 mm

Journal Diameter Rear 53.460–53.480 mm

Bearing Clearance 0.06–0.13 mm

Tappets

Outside Diameter 22.195–22.212 mm

Rocker Gear

Shaft Diameter 21.979–22.00 mm

Bushing internal diameter . . . 22.020–22.041 mm

Valves (Intake)

Opens 2 6 ° B . T . D.C.

Closes 5 8 ° A.B.D.C.

Valves (Exhaust)

Opens 6 4 ° B.B.D.C.

Closes 3 8 ° A . T . D.C.

Valve Face Angle

Intake 55°30'– 55°50'

Exhaust 45°25'– 45°35'

Valve Head Diameter

Intake 40.05–40.25 mm

Exhaust 33.8–34.0 mm

Valve Head Stand Down

Intake 1.08–1.34 mm

Exhaust 1.99–1.25 mm

Valve Stem Diameter

Intake 7.940–7.960 mm

Exhaust 7.922–7.940 mm

Valve Clearance in Guide

Intake 0.040–0.075 mm

Exhaust 0.060–0.093 mm

Valve Guide

Inside Diameter 8.0–8.015 mm

Fitted Height 13.5–14.0 mm

Valve Spring

Free Length 44.65 mm

Fitted Length 38.6 mm

Load at Fitted Length 3.466 Kg

Load at Top of Lift 92.564 Kg

Number of Coils 5.33 Valve Timing

Oil Pressure

at 4000 rpm 3.0 to 4.5 bar

(Oil at 90–100°C)

Pressure Relief Valve Opens 6.38 bar

Pressure Relief Valve–Free Length 57.5 mm

Oil Pump

Outer Rotor End Float 0.03–0.09 mm

Inner Rotor End Float 0.03–0.09 mm

Outer Rotor to Body

Diameter Clearance 0.130–0.230 mm

Rotor Body to Drive Gear Clearance

(Pump Not Fitted) 3.27–3.73 mm

TORQUE

DESCRIPTION TORQUE

Generator Mounting Bracket

Bolts 4 7N · m (3.5 ft . lbs.) 9 - 78 ENGINE NS/GS

SPECIFICATIONS (Continued)

DESCRIPTION TORQUE

Camshaft Locating Plate

Bolt 1 1N · m (9.6 in . lbs.)

Camshaft Sprocket

Bolt 19.6 N·m + 60° (170 in. lbs. + 60°)

Cylinder Head

Bolts . . See Cylinder Head Installation Procedure

Connecting Rod

Bolts 29.5 N·m +60° (22 ft. lbs. +60°)

Crankshaft Bearing Carrier

Bolts 4 4N · m (3.2 ft . lbs.)

Crankshaft damper (Pulley)

N u t4 4 1N · m (325 ft. lbs.)

EGR Valve to Intake Manifold

T u b e2 6N · m(1 9f t . lbs.)

EGR Tube to EGR Valve

Bolts2 6N · m(1 9f t . lbs.)

Engine Mount—Front

Support Bracket Engine Bolts . 68 N·m (50 ft. lbs.)Support Bracket Transmission Bolts1 0 1N · m
(75 ft. lbs.)

Support Cushion Crossmember Bolts5 4N · m
(40 ft. lbs.)

Support Cushion Thru Bolt . . . 65 N·m (48 ft. lbs.)

Engine Mount—Rear

Support Bracket Transmission Bolts1 0 1N · m
(75 ft. lbs.)

Support Bracket to Engine Bracket . 101 N·m (75 ft.
lbs.)

Support Cushion Thru Bolt . . . 68 N·m (50 ft. lbs.)

Engine Mount—Left

Transmission Mounting Bolts . 54 N·m (40 ft. lbs.)Support Cushion Thru Bolt . . . 71 N·m (53 ft. lbs.)

Engine Mount—Right

Mount to Frame Rail Bolts . . . 68 N·m (50 ft. lbs.)Mount Bolt (Horizontal) . . . 145 N·m (107 ft.
lbs.)Mount Bolt (Vertical)1 0 1N · m(7 5f t . lbs.)

Right Engine Mount Bracket

Bolts4 0N · m(3 0f t . lbs.)

Exhaust Pipe to Turbocharger

Bolts2 8N · m (250 in. lbs.)

Exhaust Manifold Outlet to Turbo

Nuts3 2N · m(2 4f t . lbs.)

Exhaust Elbow to Turbo

Bolts3 0N · m(2 2f t . lbs.)

Exhaust Manifold Mounting

Nuts3 0N · m(2 2f t . lbs.)

Flywheel

BoltsS e e Rear Crankshaft Seal Installation

Procedure

Engine Adaptor Plate

Bolts4 7N · m(3 5f t . lbs.)

Front Timing Chain Cover

Bolts1 1N · m(9 6i n . lbs.)

Fuel FilterDESCRIPTION TORQUE

Nuts2 8N · m (250 in. lbs.)

Glow Plugs

Plugs1 4N · m (120 in. lbs.)

Idler Pulley Pump Support Bracket

Nuts2 6N · m (228 in. lbs.)

Idler Pulleys (left handed threads)

Bolts4 7N · m(3 5f t . lbs.)

Injector Pump fuel lines

Nuts 17.6 N·m (156 in. lbs.)

Injector Pump Sprocket

N u t..... 86.3 N·m (63 ft. lbs.)

Injector Pump Mounting

Nuts 27.5 N·m (240 in. lbs.)

Injector

Tighten to6 5N · m(4 8f t . lbs.)

Intake Manifold Mounting

Nuts3 0N · m (264 in. lbs.)

Main Bearing Oil Delivery Union

Bolts5 4N · m(4 0f t . lbs.)

Oil Feed Line To Rocker Arms

Bolts 12.7 N·m (108 in. lbs.)

Oil Feed Line to Block

Bolts 12.7 N·m (108 in. lbs.)

Oil Feel Line to Vacuum Pump

Bolts 16.7 N·m (145 in. lbs.)

Oil Filter

Tighten to9 . 8N · m(8 5i n . lbs.)

Oil Filter Adaptor

Fastener4 9N · m(3 6f t . lbs.)

Oil Filter Base

Fastener4 9N · m(3 6f t . lbs.)

Oil Pan Mounting

Bolts1 2N · m (108 in. lbs.)

Oil Pickup Tube

Bolts1 1 . 3N · m (100 in. lbs.)

Oil Pump Mounting

Bolts 27.5 N·m (240 in. lbs.)

Oil Pan Drain

Plug 5.4 N·m (40 ft. lbs.)

Power Steering Pressure Hose

Fastener 2.8 N·m (240 in. lbs.)

Power Steering Pulley

Nut 17.0 N·m (125 ft. lbs.)

Rear Crankshaft Bearing Carrier

Bolts 10.8 N·m (95 in. lbs.)

Rocker Arm Cover

Bolts 14.7 N·m (132 in. lbs.)

Rocker Arm Mounting

Nuts 29.4 N·m (264 in. lbs.)

Power Steering Pump Mounting

Nuts 24.5 N·m (216 in. lbs.)

Turbocharger Mounting

Nuts 3.2 N·m (288 in. lbs.) NS/GS ENGINE 9 - 79

SPECIFICATIONS (Continued)

DESCRIPTION TORQUE

Turbocharger Oil Delivery

Bolt 27.5 N·m (240 in. lbs.)

Turbocharger Oil Drain

Bolts 10.8 N·m (95 in. lbs.)

Vacuum Pump Mounting

Bolts 10.8 N·m (95 in. lbs.)

Water Manifold Mounting

Bolts 11.8 N·m (108 in. lbs.)

Water Pump Pulley

Bolts 27.5 N·m (240 in. lbs.) SPECIAL TOOLS

2.5L VM DIESEL

Crankshaft Sprocket Remover VM.1000A

Cylinder Liner Puller VM.1001

Crankshaft Bearing Remover/Installer VM.10029 - 80 ENGINE NS/GS

SPECIFICATIONS (Continued)

Crankshaft Remover/Installer Sleeve VM.1004

Torque Angle Gauge VM.1005

Cylinder Head Bolt Wrench VM.1006A

Cylinder Head Guide Studs VM.1009
Cylinder Liner Protrusion Tool VM.1010
Injector Socket Remover/Installer VM.1012ANS/GS ENGINE 9 - 81
SPECIAL TOOLS (Continued)
Dial Indicator Gauge VM.1013
Flywheel Locking Tool VM.1014
Timing Cover Oil Seal Installer VM.1015
Cylinder Retainers VM.1016
Cylinder Head Bolt Wrench M12 VM.1018
Cylinder Head Bolt Wrench M14 VM.10199 - 82 ENGINE NS/GS
SPECIAL TOOLS (Continued)
Adapter Oil Filter VM.1020
Adapter Cylinder Leakage Tester VM.1021
Support Brackets Engine Removal/Installation
VM.1026
Camshaft Locating Plate Alignment VM.1028
Crankshaft Sprocket Installer VM.1029NS/GS ENGINE 9 - 83
SPECIAL TOOLS (Continued)
Locating Pin Crankshaft Sprocket VM.1030
Camshaft Sprocket Locking Tool VM.1031
Injection Pump Sprocket Locking Tool VM.10329 - 84 ENGINE NS/GS
SPECIAL TOOLS (Continued)