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Service Information Bulletin

SUBJECT	DATE	
Crankshaft and Bearings	December 2015	

Additions, Revisions, or Updates

Publication Number / Title	Platform	Section Title	Change
DDC-SVC-MAN-0081 DDC-SVC-MAN-0181 DDC-SV		Description and Operation of the Crankshaft	Changed title and made minor terminology improvements.
	EPA07/10/	Removal of the Crankshaft	Added step regarding removing engine accessories and mounting engine to a stand. Added notice regarding removal of connecting rod bearing caps.
	Inspection of the Crankshaft	Made several improvements.	
	Installation of the Crankshaft	Added notice regarding debris during installation. Added main cap bolt measurement step.	
		Inspection of the Main and Connecting Rod Bearings in Chassis	Made several improvements.



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2 Description and Operation of the Crankshaft

The crankshaft is made out of induction-hardened steel. The crankshaft bearing journals and connecting rod journals are hardened in the boundary layer and then ground. In order to avoid vibrations, counterweights are cast onto the guide-ways. The crankshaft is mounted with seven crankshaft main bearing journals in the cylinder block. There are oil holes located at the crankshaft main bearing journal and the connecting rod journal for lubrication.



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- 1. Crankshaft Main Bearing Journals
- 2. Connecting Rod Bearing Journals

Figure 1. Crankshaft

- 3. Counterweights (Number Varies By Engine Model)
- 4. Arrows Show Lubricating Oil Passage Locations



- 1. Bolt
- 2. Main Bearing Caps
- 3. Lower Crankshaft Main Bearing Shells
- 4. Lower Connecting Rod Bearing Shells
- 5. Upper Connecting Rod Bearing Shells

- 8. Upper Crankshaft Main Bearing Shells 9. Thrust Washer
- 10. Crankshaft
- 11. Thrust Washer

7. Vibration Damper

6. Cylinder Block Figure 2. Crankshaft with Four Counterweights used in DD13 Engines (All), DD15 Engines (Later EPA10 and all GHG14), and DD16 Engines (Later EPA10 and all GHG14)



5. Connecting Rod Bearings 10. Crankshaft Figure 3. Crankshaft with Eight Counterweights used in all EPA07 and Early EPA10 DD15 and DD16

Engines

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3 Removal of the Crankshaft

This procedure requires removal of the engine from the chassis. Refer to section "Removal of the Complete Powertrain Assembly".

Remove as follows:



WARNING: FALLING ENGINE

To avoid injury from a falling engine, ensure the engine is securely attached to the engine overhaul stand before releasing the lifting sling.

- 1. Remove all of the accessories and assemblies to allow a suitable, properly rated cylinder block adaptor to be bolted to the cylinder block. Mount the adaptor and engine to a suitable, properly rated engine stand.
- 2. Remove the oil pan. Refer to section "Removal of the Oil Pan".
- **3**. Remove the oil pump, oil suction manifold, and oil lines. Refer to section "Removal of the Oil Pump, Oil Suction Manifold, and Oil Lines".
- 4. Remove the flywheel. Refer to section "Removal of the Flywheel".
- 5. Remove the flywheel housing. Refer to section "Removal of the Flywheel Housing".
- 6. Remove idler gear No. 1 and idler gear No. 4, if equipped.

NOTICE: Use care when removing the vibration damper. If the damper is allowed to fall, damage to the internal components of the damper may result.

- 7. Loosen and remove two of the vibration damper mounting bolts 180 degrees apart and install flywheel guide studs (J-36235) in their place. Then loosen and remove the remaining six mounting bolts.
- 8. Remove the vibration damper.
- 9. Remove the front engine cover.

NOTICE: Paint-mark the connecting rod bearing caps for position so they can be installed to their respective connecting rods.

NOTICE: The connecting rod assembly is a cracked rod design. When removed, ensure that the connecting rod bearing cap is placed on its side. Damage to the connecting rod bearing cap will occur if it is placed on end. The connecting rod assembly will need to be replaced if the connecting rod bearing cap is damaged.

- 10. Remove all six connecting rod bearing caps. Discard the bolts.
- 11. Remove connecting rod and piston assemblies, if necessary. Refer to section "Removal of the Piston and Connecting Rod Assembly".

NOTICE: Paint-mark the main bearing caps so that they can be installed to their respective, original positions. The main bearing caps must be kept in sequence.

- 12. Loosen and remove the main bearing cap bolts.
- 13. Using the appropriate main bearing cap puller tool, remove the main bearing caps.
- 14. Remove the thrust washers from each side of the No. 6 main bearing cap.
- 15. Using an appropriately rated lifting device, carefully remove the crankshaft.
- 16. Remove the crankshaft gear and place the crankshaft on a suitable surface.

4 Inspection of the Crankshaft

Inspect as follows:

- 1. Clean out the oil passages thoroughly with a stiff wire brush.
- 2. Clean the crankshaft with a suitable degreaser and solvent.



WARNING: EYE INJURY

To avoid injury from flying debris when using compressed air, wear adequate eye protection (face shield or safety goggles) and do not exceed 276 kPa (40 psi) air pressure.

- 3. Dry the crankshaft with compressed air.
- 4. Inspect the crankshaft journals, flanges and counterweights for cracks. Replace the crankshaft if cracks are found.

NOTE: Light scratching or visible marks on the crankshaft journals is considered normal wear.

- 5. Inspect the crankshaft journals for excessive scoring that can be felt with a fingernail. Replace the crankshaft if excessive scoring is found.
- 6. Inspect the front crankshaft oil seal contact surface for scoring that can be felt with a fingernail. Replace the crankshaft if the sealing surface is damaged to the point of causing an oil leak.

NOTE: Excessive wear at the crankshaft thrust surfaces can be caused by improper transmission clutch adjustment.

- 7. Check the crankshaft thrust surfaces for excessive wear. If excessively worn, replace the crankshaft.
- 8. Measure crankshaft main journal run-out. Replace as necessary.
 - Set main journals number 1 and number 7 on a pair of non-marring V-blocks
 - Rotate crankshaft and carefully measure main journals with a dial indicator. Record the results. The maximum is shown below.

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Journal 1	Journal 2	Journal 3	Journal 4	Journal 5	Journal 6	Journal 7
On V-block	0.040 mm	0.060 mm	0.090 mm	0.060 mm	0.040 mm	On V-block
	(0.0015 in.)	(0.0024 in.)	(0.0035 in.)	(0.0024 in.)	(0.0015 in.)	

- 9. Clean and inspect bolt holes in crankshaft for the flywheel and vibration damper mounting bolts. Check for damaged threads. Repair as necessary.
- 10. Measure the main cap bolts for reuse. The maximum allowable length is listed below.

Table 2.

	DD13	DD15	DD16
Main Bearing Cap Bolt	175.5 mm (6.909 in.)	200.5 mm (7.894 in.)	200.5 mm (7.894 in.)

- 11. Inspect the cylinder block main journals for damage. Repair as necessary.
- 12. If the crankshaft is reusable but will not be installed the same day, coat the crankshaft and main journals of the cylinder block with a rust prevention solution such as fogging oil.

5 Installation of the Crankshaft

Install as follows:

1. Steam clean the crankshaft to remove any rust preventive or residual oil.



WARNING: EYE INJURY

To avoid injury from flying debris when using compressed air, wear adequate eye protection (face shield or safety goggles) and do not exceed 276 kPa (40 psi) air pressure.

2. Clean out the oil passages and dry the crankshaft with compressed air.

NOTICE: The cylinder block, main bearing caps, crankshaft journals and bearing shells must be clean and free from debris before bearing and crankshaft installation. Any debris trapped behind the backside of the bearing shell can cause severe engine damage.

- **3**. Clean any rust preventative material from the main bearing journals in the cylinder block and from the main bearing caps.
- 4. Install new upper main bearing shells into the cylinder block.
- 5. Install new thrust washer upper halves into the counter bores on either side of the No. 6 bearing saddle. Coat the backs of the thrust washers (without oil grooves) with petroleum jelly and install with the oil-grooved sides facing away from the saddle.
- 6. Apply clean engine oil 360 degrees around all crankshaft bearing journals and carefully install the crankshaft into the cylinder block.
- 7. Install the lower main bearing shells in the main bearing caps by aligning the tang on the lower main bearing shell with the groove in the main bearing cap. Install the bearing shell to the main bearing cap.
- 8. Measure the main cap bolts for reuse. The maximum allowable length is listed below.

Table 3.

	DD13	DD15	DD16
Main Bearing Cap Bolt	175.5 mm (6.909 in.)	200.5 mm (7.894 in.)	200.5 mm (7.894 in.)

Table 4.

NOTICE: The main bearing caps are machined in position and stamped with the position number. They must be installed in their original locations with the marked (numbered) side of each cap toward the LH (cold) side of the cylinder block. See illustration below. There are also locating dowels in the main caps to prevent assembly errors.



- 9. Ensure the locating dowels are positioned in the main bearing caps before reassembly.
- 10. Install the main bearing caps, with bearing shells, onto the cylinder block in their correct locations.
- 11. Apply a small amount of clean engine oil to the bearing cap bolt threads and underside of the bolt heads. Install the main bearing cap bolts and draw them up snug.
- 12. Torque the main bearing cap bolts to $50 \text{ N} \cdot \text{m} (37 \text{ lb} \cdot \text{ft})$.
- **13**. Measure the crankshaft end play as follows. Mount a dial indicator to the cylinder block with the probe positioned on a vertical surface of the crankshaft.
- 14. Move the crankshaft toward the dial indicator with a small 304 mm (less than 12 in.) pry bar. Keep a constant pressure on the pry bar and zero the pointer on the dial indicator.
- 15. Remove and insert the pry bar on the other side of the bearing cap. Force the crankshaft in the opposite direction and note the measurement on the dial.
- **16.** The end play specification is 0.099 to 0.419 mm (0.0039 to 0.0165 in.). Insufficient end play can be the result of a misaligned No. 6 main bearing, a misaligned upper thrust washer or debris on the inner face of one or more of the thrust washers.
- 17. Correct the end play, if necessary.

NOTE: If the main bearings have been installed properly, the crankshaft will turn freely with all of the main bearing cap bolts drawn to the specified torque.

- **18.** For the DD13: torque all of the main bearing cap bolts, in three steps, using the sequence shown below. Torque the main bearing cap bolts to:
 - a. 150 N·m (111 lb·ft)
 - b. 300 N·m (221 lb·ft)

- c. 90° torque turn
- **19.** For the DD15 and DD16; torque all of the main bearing cap bolts, in four steps, using the sequence shown below. Torque the main bearing cap bolts to:
 - a. 150 N·m (111 lb·ft)
 - b. 250 N·m (184 lb·ft)
 - c. 1st 90° torque turn
 - d. 2nd 90° torque turn



- 20. Install the piston and connecting rod assemblies, if removed. Refer to section "Installation of the Piston and Connecting Rod Assembly".
- 21. Install idler gear No. 1 and idler gear No. 4, if equipped. Refer to section "Installation of the Gear Train".
- 22. Install the flywheel housing with a new crankshaft rear oil seal. Refer to section "Installation of the Flywheel Housing".
- 23. Install the flywheel. Refer to section "Installation of the Flywheel".
- 24. Install the oil pump, oil suction manifold, and oil lines. Refer to section "Installation of the Oil Pump, Oil Suction Manifold, and Oil Lines".
- 25. Install the front cover with a new crankshaft oil seal. Refer to section "Installation of the Front Crankshaft Oil Seal".
- 26. Install the crankshaft pulley and vibration damper assembly. Refer to section "Installation of the Vibration Damper".
- 27. Install the oil pan. Refer to section "Installation of the Oil Pan".



WARNING: PERSONAL INJURY

To avoid injury when removing or installing a heavy engine component, ensure the component is properly supported and securely attached to an adequate lifting device to prevent the component from falling.

- 28. Attach an appropriately rated lifting device to the engine.
- **29**. Lift and support the engine to remove it from the engine stand.
- **30**. Remove the engine stand adaptor from the cylinder block.
- 31. Install any accessories that were removed.
- 32. Install the engine back into the chassis. Refer to section "Installation of the Complete Powertrain Assembly".
- 33. Prime engine lubrication system. Refer to section "Priming the Engine Lubrication System".
- 34. Fill the cooling system. Refer to section "Cooling System Fill Procedure".

6 Inspection of the Main and Connecting Rod Bearings in Chassis

Inspect as follows:

NOTICE: All of the connecting rod and main bearings must be inspected using this procedure. Failure to inspect all bearings may result in an improper diagnosis, additional downtime, or severe engine damage.

NOTICE: A number of conditions can cause connecting rod and/or main bearing failures. Failure analysis must be performed to determine the root cause.

NOTICE: The engine lubricating oil can be reused if it is not contaminated and has been properly maintained.

- 1. Drain the engine lubricating oil into a suitable container.
- 2. Remove the oil pan. Refer to section "Removal of the Oil Pan".
- 3. Remove the oil pump, oil suction manifold, and oil lines. Refer to section "Removal of the Oil Pump, Oil Suction Manifold, and Oil Lines".
- 4. Using engine barring tool (J-46392 or W904589046300), position the crankshaft for each piston and connecting rod assembly to be removed at Bottom Dead Center (BDC).

NOTICE: The connecting rod assembly is a cracked rod design. Ensure when the connecting rod bearing cap is removed that it is placed on its side. Damage to the connecting rod bearing cap will occur if it is placed on end. The connecting rod assembly will need to be replaced if the connecting rod bearing cap is damaged.

NOTICE: When removed, the connecting rod bearing cap and the connecting rod bearing must be assembled to its original connecting rod before another connecting rod bearing cap is removed.

- 5. Remove the connecting rod bearing cap with the connecting rod bearing. Discard the connecting rod cap bolts.
- 6. Inspect the connecting rod bearing for damage. Refer to the illustrations below. If the connecting rod bearing is damaged with no damage to the connecting rod or crankshaft, replace all main and connecting rod bearings. Determine the root cause of the bearing failure.



Table 6.



- 7. Inspect the connecting rod and connecting rod cap for damage. If the bearing spun in its location or there is physical damage to the connecting rod, it must be replaced.
- 8. Inspect the connecting rod journal on the crankshaft for scoring that can be felt with a fingernail or bearing material transfer. If any of these conditions are found, the crankshaft will need to be replaced.
- 9. Clean the mating surfaces of the connecting rod and the connecting rod cap to ensure there is no debris that will be trapped during reassembly.

NOTICE: Connecting rod cap number (2) and connecting rod number (2) must match. See illustration below.

10. Install the connecting rod bearing cap with bearing onto the connecting rod so that the connecting rod cap machined side (3) is mated to the connecting rod machined side (1).



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NOTICE: Connecting rod bearing cap bolts are not reusable.

- 11. Using new connecting rod bearing cap bolts, install bolts and tighten by hand.
- 12. Torque the connecting rod bearing cap bolts alternately to the following: For the DD13: 190 N·m (140 lb·ft) + 90° torque turn For the DD15 and DD16: 115 N·m (85 lb·ft) + 180° torque turn
- **13.** Check the connecting rod side clearance by moving the connecting rod from side to side on the crankshaft journal. If there is no clearance, check for proper connecting rod bearing cap and bearing installation.
- 14. Repeat the previous inspection steps for the remaining connecting rod bearings.

NOTICE: When removed, the crankshaft main bearing cap and the main bearing must be assembled to its original location before another main bearing cap is removed.

- 15. Remove one pair of main bearing cap bolts.
- 16. Using the appropriate main cap puller tool, remove the main bearing cap from the cylinder block.
- 17. Inspect the main bearing for damage. Refer to the illustrations below. If the main bearing is damaged with no damage to the crankshaft or cylinder block, replace all main bearings. Determine the root cause of the bearing failure.





Table 8.



- 18. Inspect the main journal on the crankshaft for scoring that can be felt with a fingernail or bearing material transfer. If any of these conditions are found, the crankshaft will need to be replaced.
- **19**. Inspect the main bearing cap for damage. If the bearing spun in its location or there is physical damage to the bearing surface of the main cap, the engine will need to be replaced. The main bearing caps are machined with the cylinder block and cannot be replaced individually.
- **20**. Clean the mating surfaces of the main bearing cap and the cylinder block to ensure there is no debris that will be trapped during reassembly.
- 21. Measure the main bearing cap bolt length. Replace as necessary.

Table 9.

Main Bearing Cap Bolt Maximum Length			
DD13	175.5 mm (6.909 in.)		
DD15 and DD16	200.5 mm (7.894 in.)		

Table 10.



- 22. Ensure the locating dowels are positioned in the main bearing caps before reassembly.
- 23. Install the main bearing cap, with bearing shell, onto the cylinder block.
- 24. Apply a small amount of clean engine oil to the bearing cap bolt threads and underside of the bolt heads. Install the main bearing cap bolts and draw them up snug.
- 25. For the DD13, torque the main bearing cap bolts, in three steps. Torque the main bearing cap bolts, alternately, to:
 - a. 150 N·m (111 lb·ft)
 - b. 300 N·m (221 lb·ft)
 - c. 90° torque turn
- **26**. For the DD15 and DD16, torque the main bearing cap bolts, in four steps, using the sequence shown below. Torque the main bearing cap bolts, alternately, to:
 - **a**. 150 N·m (111 lb·ft)
 - b. 250 N·m (184 lb·ft)
 - c. 1st 90° torque turn
 - d. 2nd 90° torque turn

NOTE: If the bearings have been installed properly, the engine will rotate freely with all of the main bearing cap bolts drawn to the specified torque.

- 27. Repeat the previous inspection steps for the remaining main bearings.
- 28. Install the oil pump, oil suction manifold, and oil lines. Refer to section "Installation of the Oil Pump, Oil Suction Manifold, and Oil Lines".
- 29. Install the oil pan. Refer to section "Installation of the Oil Pan".
- 30. Prime engine lubrication system. Refer to section "Priming the Engine Lubrication System".

31. Start the engine and verify proper engine oil pressure.