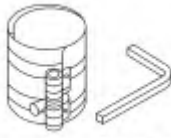


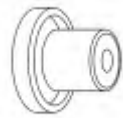
SECTION 303-01B: Engine — 3.7L
ASSEMBLY

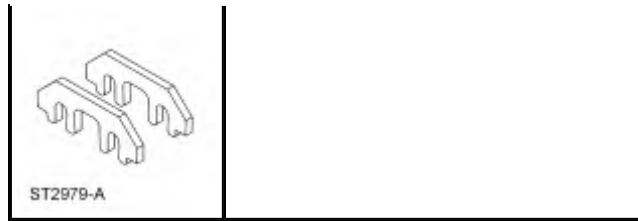
2014 F-150 Workshop Manual
Procedure revision date: 10/25/2013

Engine

Special Tool(s)

 ST1341-A	2,200# Floor Crane, Fold Away 300-OTC1819E
 ST3101-A	Bar, Engine Spreader 303-1454
 ST1376-A	Compressor, Piston Ring 303-D032 (D81L-6002-C)
 ST1214-A	Dial Indicator Gauge with Holding Fixture 100-002 (TOOL-4201-C)
 ST2976A	Eye, Engine Lift 303-1245
 ST1326-A	Handle 205-153 (T80T-4000-W)
	Hold Down, Secondary Chain 303-1530

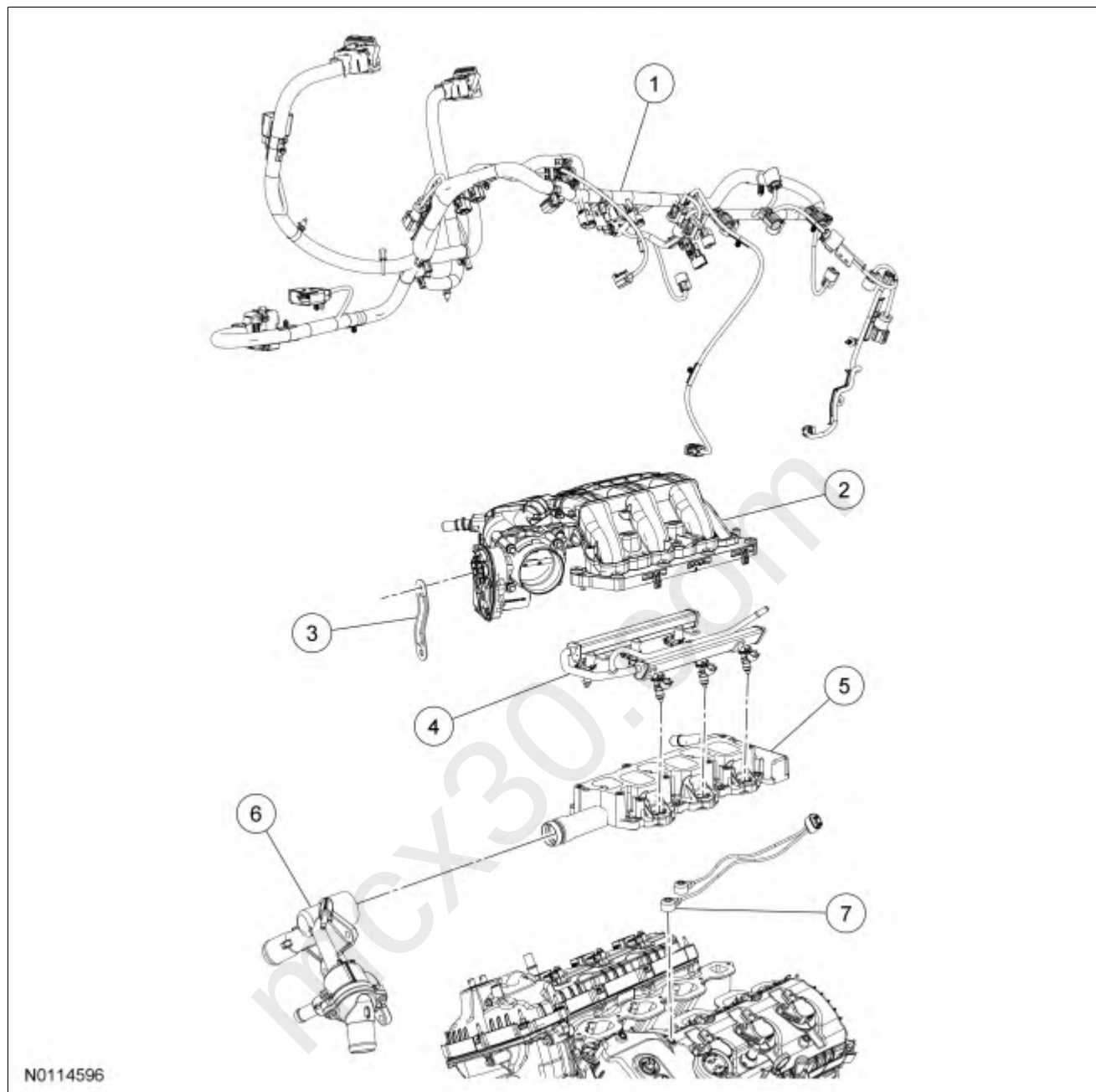
 ST3234-A	
 ST2212-A	Installer, Differential Bearing Cone 205-142 (T80T-4000-J)
 ST1804-A	Installer, Spindle Bearing 205-149 (T80T-4000-R)
 ST1287-A	Installer, Crankshaft Vibration Damper 303-102 (T74P-6316-B)
 ST2296-A	Installer, Front Cover Oil Seal 303-335
 ST2981-A	Installer, Front Crankshaft Seal 303-1251
 ST2983-A	Installer, VCT Spark Plug Tube Seal 303-1247/2
 ST1438-A	Strap Wrench 303-D055 (D85L-6000-A)
	Tool, Camshaft Holding 303-1248



Material

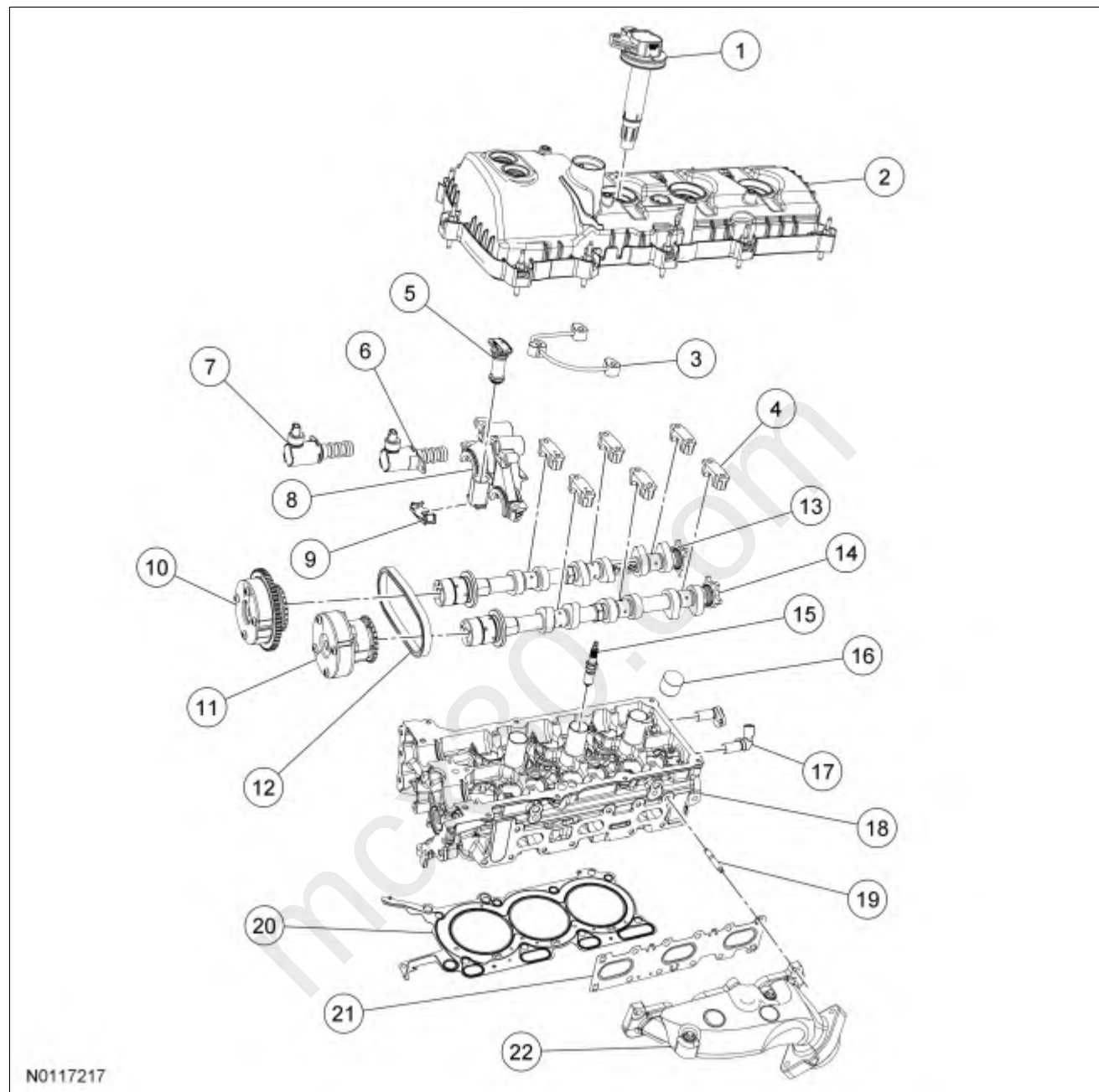
Item	Specification
Motorcraft® High Performance Engine RTV Silicone TA-357	WSE-M4G323-A6
Motorcraft® Metal Surface Prep ZC-31-A	—
Motorcraft® SAE 5W-20 Premium Synthetic Blend Motor Oil (US); Motorcraft® SAE 5W-20 Super Premium Motor Oil (Canada) XO-5W20-QSP (US); CXO-5W20-LSP12 (Canada)	WSS-M2C945-A
Motorcraft® Orange Antifreeze/Coolant Concentrated VC-3-B (US); CVC-3-B2 (Canada)	WSS-M97B44-D
Motorcraft® Silicone Gasket Remover ZC-30	—

Engine Upper



Item	Part Number	Description
1	14A411	Engine control harness
2	9424	Upper intake manifold
3	9J444	Upper intake manifold support bracket
4	9F797	Fuel rail
5	9424	Lower intake manifold
6	8A586	Thermostat housing
7	12A699	Knock Sensor (KS)

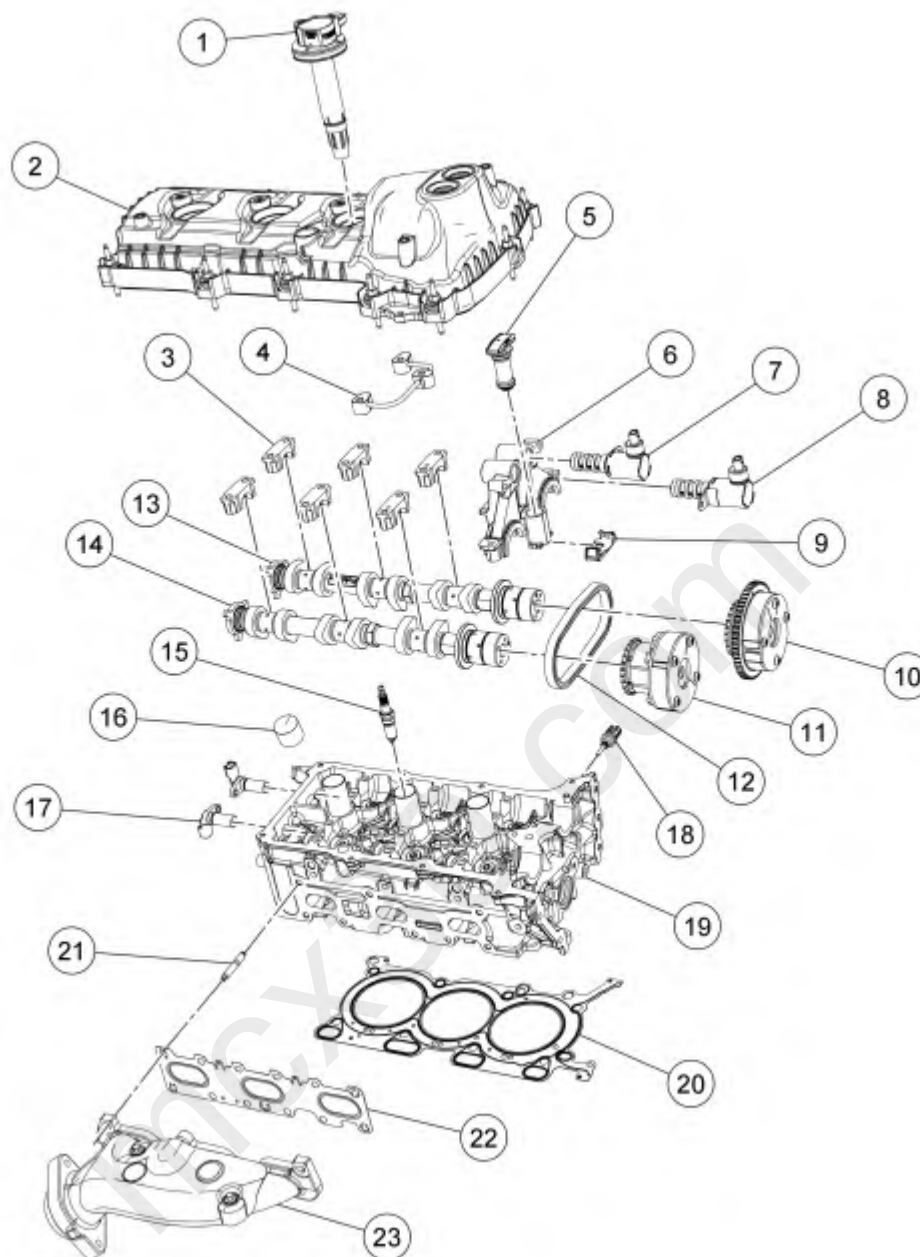
Engine Upper — LH Cylinder Head



Item	Part Number	Description
1	12029	Ignition coil-on-plug (3 required)
2	6582	LH valve cover
3	6K602	Valve train oil feed tube
4	6A258	LH camshaft cap (6 required)
5	6K254	LH secondary timing chain tensioner
6	6M280	Intake camshaft Variable Camshaft Timing (VCT) oil control solenoid

7	6M280	Exhaust camshaft <u>VCT</u> oil control solenoid
8	6B280	Camshaft mega cap
9	6K297	LH secondary tensioner shoe
10	6256	Intake camshaft <u>VCT</u> assembly
11	6C525	Exhaust camshaft <u>VCT</u> assembly
12	6268	LH secondary timing chain
13	6250	LH intake camshaft
14	6250	LH exhaust camshaft
15	12405	Spark plug (3 required)
16	6500	Valve tappet (32 required)
17	6B288	LH cylinder head Camshaft Position (CMP) sensor (2 required)
18	6049	LH cylinder head
19	W712244	LH exhaust manifold stud (6 required)
20	6051	LH cylinder head gasket
21	9448	LH exhaust manifold gasket
22	9431	LH exhaust manifold

Engine Upper — RH Cylinder Head

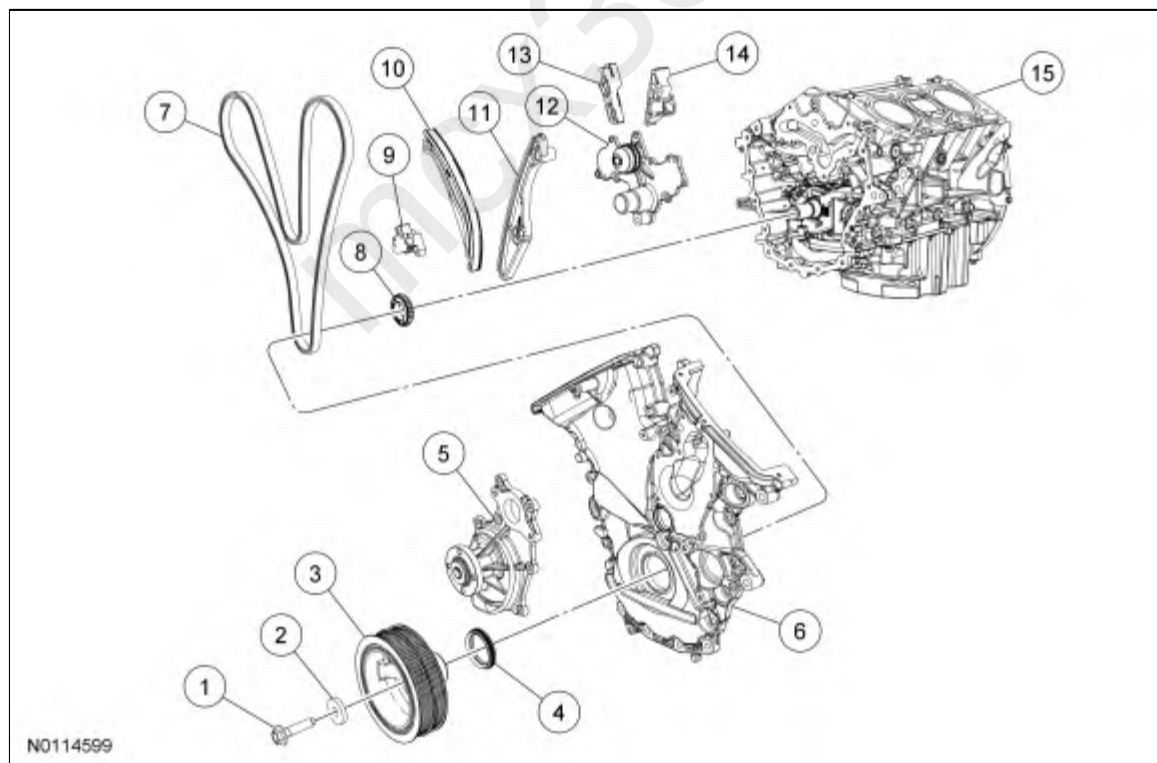


N0117218

Item	Part Number	Description
1	12029	Ignition coil-on-plug (3 required)
2	6582	RH valve cover
3	6A258	RH camshaft cap (6 required)
4	6K602	Valve train oil feed tube
5	6K254	RH secondary timing chain tensioner
6	6B280	Camshaft mega cap
7	6M280	Intake camshaft Variable Camshaft Timing (VCT) oil control solenoid
8	6M280	Exhaust camshaft <u>VCT</u> oil control solenoid

9	6K297	RH secondary tensioner shoe
10	6256	Intake camshaft <u>VCT</u> assembly
11	6C525	Exhaust camshaft <u>VCT</u> assembly
12	6268	RH secondary timing chain
13	6250	RH intake camshaft
14	6250	RH exhaust camshaft
15	12405	Spark plug (3 required)
16	6500	Valve tappet (32 required)
17	6B288	RH cylinder head Camshaft Position (CMP) sensor (2 required)
18	6G004	Cylinder Head Temperature (CHT) sensor
19	6049	RH cylinder head
20	6051	RH cylinder head gasket
21	W712244	RH exhaust manifold stud (6 required)
22	9448	RH exhaust manifold gasket
23	9430	RH exhaust manifold

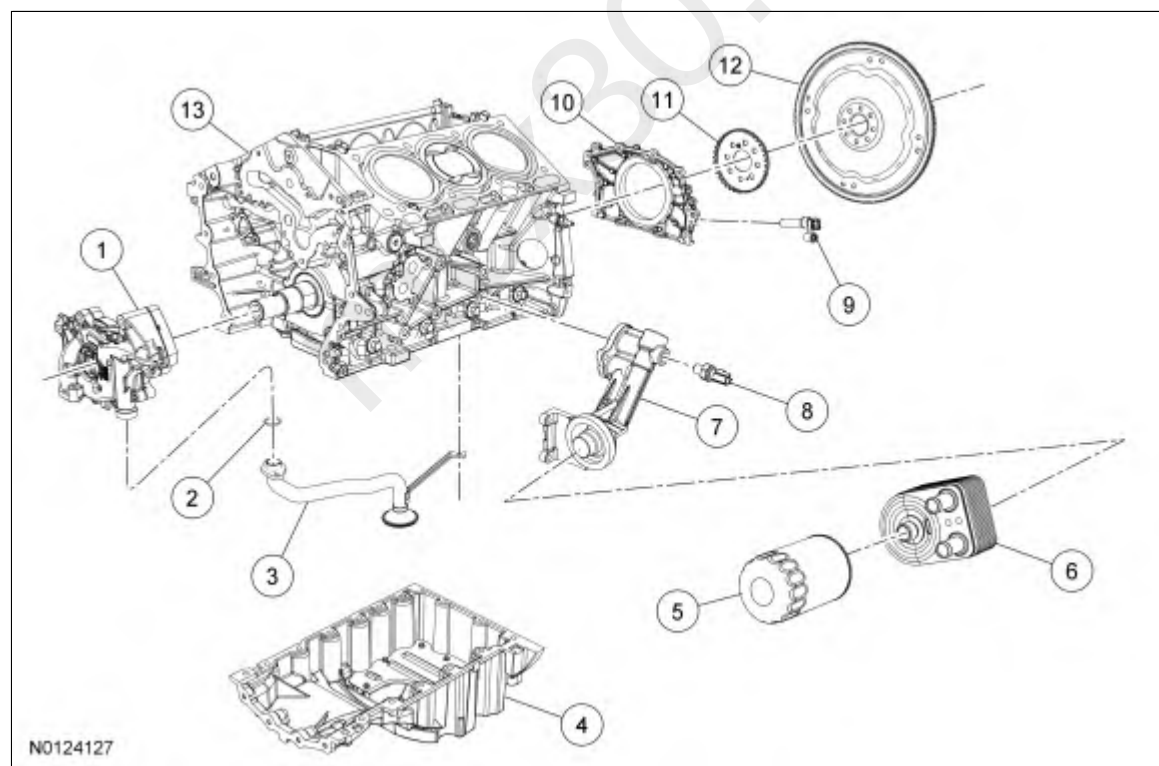
Engine Front



Item	Part Number	Description
1	6A340	Crankshaft pulley bolt

2	6378	Crankshaft pulley washer
3	6312	Crankshaft pulley
4	6700	Crankshaft front seal
5	8501	Coolant pump
6	6019	Engine front cover
7	6268	Timing chain
8	6306	Crankshaft timing sprocket
9	6K254	Primary timing chain tensioner
10	6K255	Primary timing chain tensioner arm
11	6B274	LH lower primary timing chain guide
12	8501	Channel cover plate
13	6M256	RH primary timing chain guide
14	6K297	LH upper primary timing chain guide
15	6010	Cylinder block

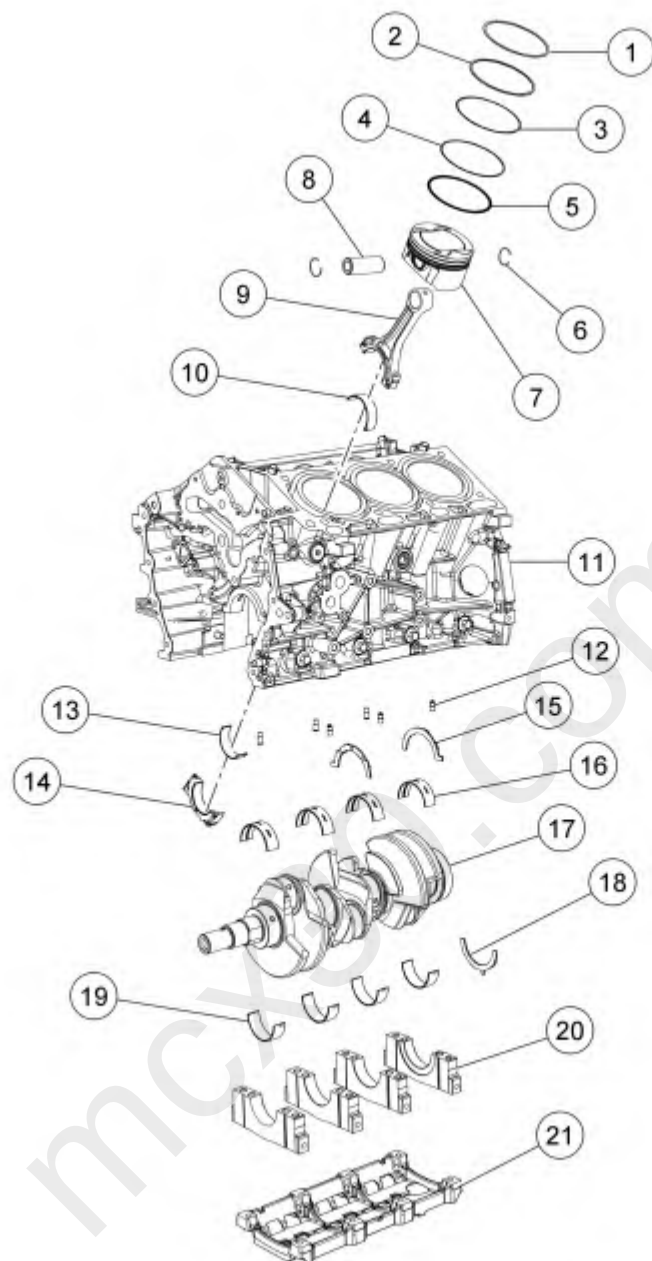
Lower Engine Block (View 1)



Item	Part Number	Description
1	6600	Oil pump
2	6625	Oil pump screen and pickup tube O-ring seal

3	6622	Oil pump screen and pickup tube
4	6675	Oil pan
5	6731	Engine oil filter
6	6A642	Oil cooler
7	6881	Oil filter adapter
8	9278	Engine Oil Pressure (EOP) switch
9	6C315	Crankshaft Position (CKP) sensor
10	6K301	Crankshaft rear seal retainer
11	12A227	Crankshaft sensor ring
12	6375	Flexplate
13	6010	Cylinder block

Lower Engine Block (View 2)



N0114601

Item	Part Number	Description
1	—	Piston compression upper ring (part of 6148) (6 required)
2	—	Piston compression lower ring (part of 6148) (6 required)
3	—	Piston oil control upper segment ring (part of 6148) (6 required)
4	—	Piston oil control spacer (part of 6148) (6 required)
5	—	Piston oil control lower segment ring (part of 6148) (6 required)
6	6140	Piston pin retainer (12 required)

7	6110	Piston (6 required)
8	6135	Piston pin (6 required)
9	6200	Connecting rod (6 required)
10	6211	Connecting rod upper bearing (6 required)
11	6010	Cylinder block
12	6K868	Piston oil cool valve (6 required)
13	6211	Connecting rod lower bearing (6 required)
14	6200	Connecting rod cap (6 required)
15	6A341	Crankshaft upper thrust washer (2 required)
16	6D309	Cylinder block crankshaft main bearing (4 required)
17	6303	Crankshaft
18	6K302	Crankshaft lower thrust washer
19	6D309	Lower crankshaft main bearing (4 required)
20	6325	Lower crankshaft main bearing cap (4 required)
21	6C364	Main bearing cap support brace

NOTICE: During engine repair procedures, cleanliness is extremely important. Any foreign material, including any material created while cleaning gasket surfaces that enters the oil passages, coolant passages or the oil pan, may cause engine failure.

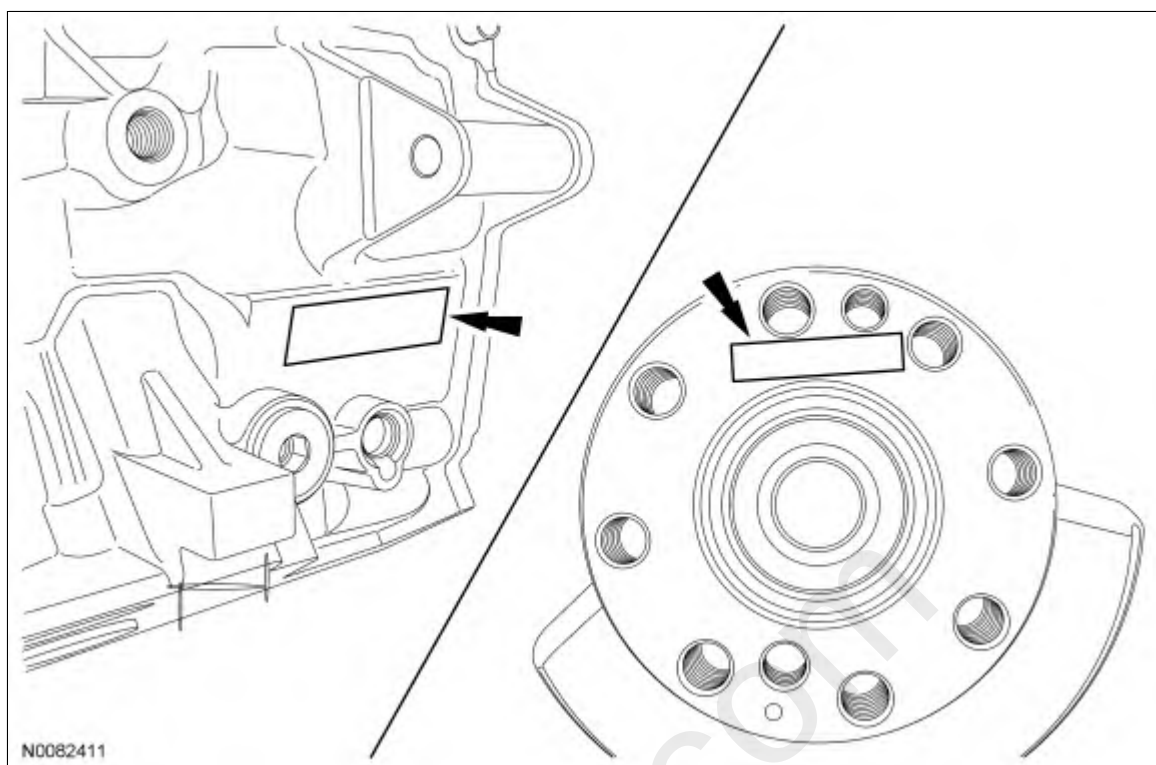
NOTE: Assembly of the engine requires various inspections/measurements of the engine components. These inspections/measurements will aid in determining if the engine components will require replacement. For additional information, refer to [Section 303-00](#).

All engines

1. **NOTE:** This procedure is for selecting bearings using a new crankshaft.

Select the crankshaft main bearings for each crankshaft journal.

- Read the code on the crankshaft flange.
- Read the code on the cylinder block face.
 - The first letter after the first asterisk makes up the code for main No. 1 and the next letter for main No. 2. The first letter after the second asterisk makes up the code for main No. 3 and the last letter for main No. 4.



2. **NOTE:** This chart is for selecting main bearings 1 and 4 only, the remaining bearings will be selected using a different chart in the next step.

Using the data recorded earlier and the Bearing Select Fit Chart, Standard Bearings, determine the required bearing grade for main bearings 1 and 4.

- Read the first letter of the engine block main bearing code and the first letter of the crankshaft main bearing code.
- Read down the column below the engine block main bearing code letter and across the row next to the crankshaft main bearing code letter, until the 2 intersect. This is the required bearing grade(s) for the No. 1 crankshaft main bearing.
- As an example, if the engine block code letter is "F" and the crankshaft code letter is "P", the correct bearing grade for this main bearing is a "1" for the upper bearing and a "2" for the lower bearing.
- Repeat the above steps using the fourth letter of the block and crankshaft codes to select the No. 4 bearing.

MAIN HOUSING BORE DIAMETER

CRANKSHAFT DIAMETER

		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
		72.488	72.491	72.493	72.493	72.494	72.495	72.498	72.497	72.495	72.496	72.498	72.499	72.501	72.502	72.503	72.504	72.506	72.507	72.508	72.509	72.510	72.511	72.512	72.513	72.514
U	67.563	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
T	67.562	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
S	67.561	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
R	67.560	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
Q	67.559	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
P	67.558	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
O	67.557	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
N	67.556	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
M	67.555	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
L	67.554	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
K	67.553	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
J	67.552	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
I	67.551	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
H	67.550	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
G	67.549	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
F	67.548	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
E	67.547	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
D	67.546	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
C	67.545	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
B	67.544	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
A	67.543	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1

FOR MAINS #1 AND #4 ONLY

UPPER MAIN GRADE (BLOCK SIDE) / LOWER MAIN GRADE (CAP SIDE)

N0135245

3. **NOTE:** This chart is for selecting main bearings 2 and 3 only.

Using the data recorded earlier and the Bearing Select Fit Chart, Standard Bearings, determine the required bearing grade for main bearings 2 and 3.

- Read the second letter of the engine block main bearing code and the second letter of the crankshaft main bearing code.
- Read down the column below the engine block main bearing code letter and across the row next to the crankshaft main bearing code letter, until the 2 intersect. This is the required bearing grade for the No. 2 crankshaft main bearing.
- As an example, if the engine block code letter is "F" and the crankshaft code letter is "P", the correct bearing grade for this main bearing is "1".
- Repeat the above steps using the third letter of the block and crankshaft codes to select the No. 3.

		MAIN HOUSING BORE DIAMETER																									
CRANKSHAFT DIAMETER		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	
	U	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2
	T	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2
	S	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2
	R	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2
	Q	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2
	P	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	O	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3
	N	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3
	M	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3
	L	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3
	K	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3
	J	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3
	I	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3
	H	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3
	G	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3
	F	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3
	E	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3
	D	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3
	C	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	B	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	A	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

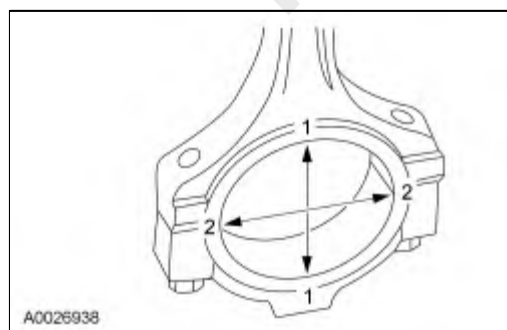
FOR MAINS #2 AND #3 ONLY

N0135244

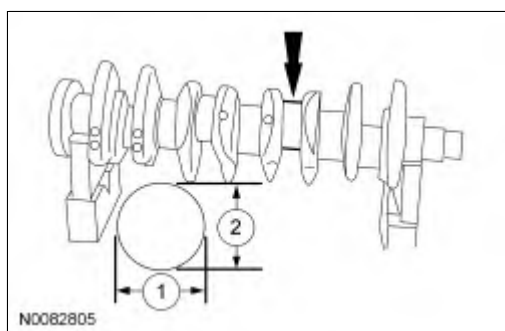
4. **NOTICE:** The rod cap installation must keep the same orientation as marked during disassembly or engine damage may occur.

Using the original connecting rod cap bolts, install the connecting rod caps and bolts.

- Tighten the bolts in 3 stages:
 - Stage 1: Tighten to 23 Nm (17 lb-ft).
 - Stage 2: Tighten to 43 Nm (32 lb-ft).
 - Stage 3: Tighten an additional 90 degrees.
5. Measure the connecting rod large end bore in 2 directions.
- Remove the bolts and the rod cap.
 - Discard the connecting rod cap bolts.



6. Measure each of the crankshaft connecting rod bearing journal diameters in at least 2 directions.



7. Using the chart, select the correct connecting rod bearings for each crankshaft connecting rod journal.

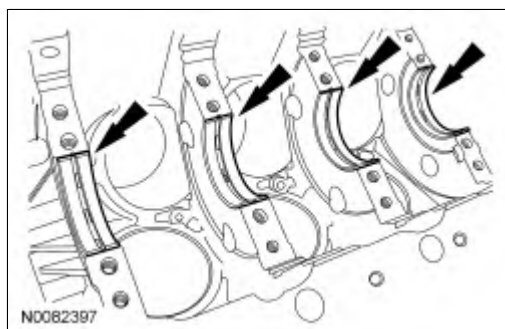
		CONNECTING ROD LARGE END BORE (59.XXX)																											
		1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3
		.866	.867	.868	.869	.870	.871	.872	.873	.874	.875	.876	.877	.878	.879	.880	.881	.882	.883	.884	.885	.886							
CRANK JOURNAL	56.003	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3
	56.002	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3
	56.001	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3
	56.000	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3
	55.999	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3
	55.998	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3
	55.998	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3
	55.996	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3
	55.994	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3
	55.993	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3
	55.992	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3
	55.991	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3
	55.990	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3
	55.989	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3
	55.988	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3
	55.987	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3
	55.986	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3
	55.985	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3
	55.984	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3
	55.983	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3

		MINIMUM	MAXIMUM	NOMINAL
WALL GRADES	1	1.918 mm	1.924 mm	1.921 mm
	2	1.921 mm	1.927 mm	1.924 mm
	3	1.925 mm	1.931 mm	1.928 mm

N0082806

8. **NOTE:** Before assembling the cylinder block, all sealing surfaces must be free of chips, dirt, paint and foreign material. Also, make sure the coolant and oil passages are clear.

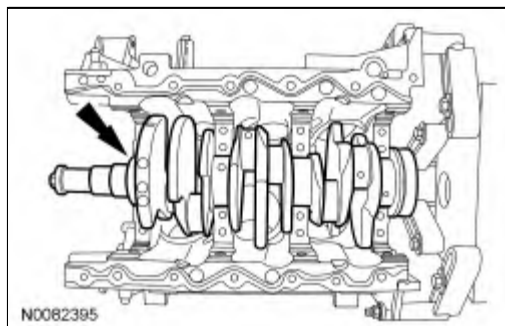
Lubricate the upper crankshaft main bearings with clean engine oil and install the 4 crankshaft main bearings in the cylinder block.



9. **NOTE:** Do not install the upper thrust bearings until the crankshaft is installed.

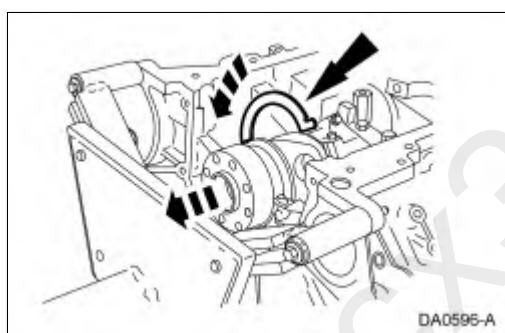
NOTE: Lubricate the thrust surfaces of the crankshaft with clean engine oil.

Install the crankshaft onto the upper main bearings.



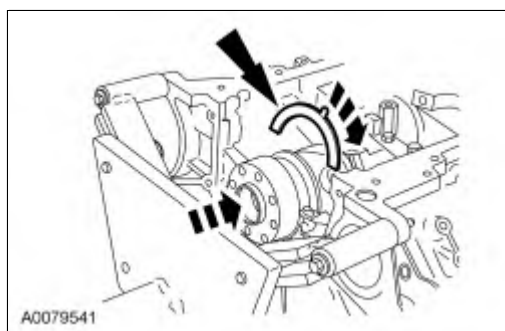
10. **NOTE:** Make sure the side of the thrust washer, with the wide oil grooves, faces the crankshaft thrust surface.

Push the crankshaft rearward and install the rear crankshaft upper thrust washer at the back of the No. 4 rear bulkhead.

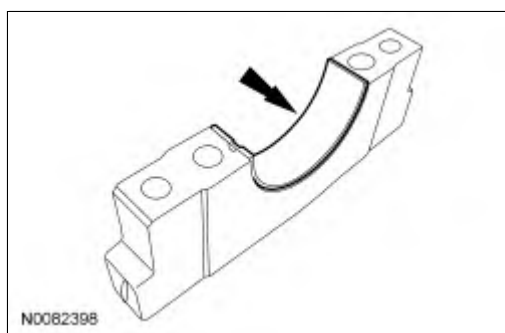


11. **NOTE:** Make sure the side of the thrust washer, with the wide oil grooves, faces the crankshaft thrust surface.

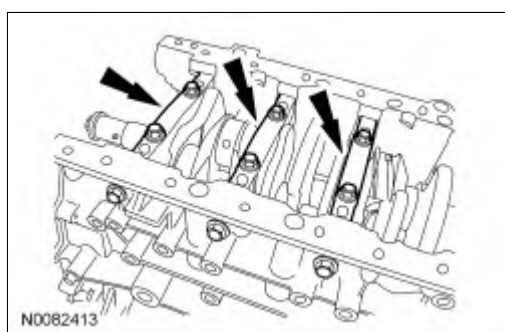
Push the crankshaft forward and install the front crankshaft upper thrust washer at the front of the No. 4 rear bulkhead.



12. Lubricate the crankshaft lower main bearings with clean engine oil and install them into the main bearing caps. Visually check seating and squareness of the bearings to make sure of proper seating in caps.



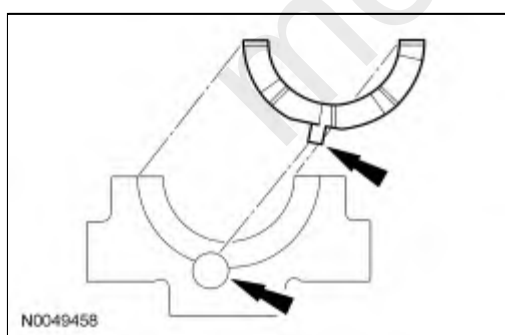
13. Position the No. 1, No. 2 and No. 3 main bearing caps on the cylinder block and, keeping the caps as square as possible, alternately draw the caps down evenly using the new bolts until the main bearing caps are seated.



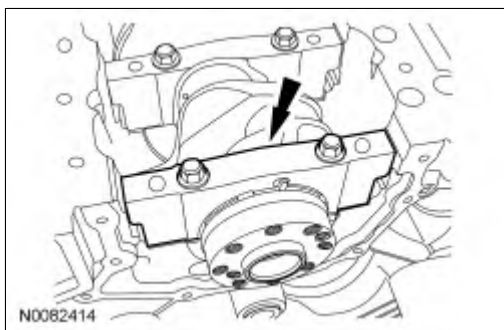
14. **NOTE:** Make sure the side of the thrust washer, with the wide oil grooves, faces the crankshaft thrust surface.

NOTE: To aid in assembly, apply petroleum jelly to the back of the crankshaft thrust washer.

Install the lower crankshaft thrust washer to the back side of the No. 4 rear main bearing cap, with the tab aligned with the cutout in the main bearing cap.



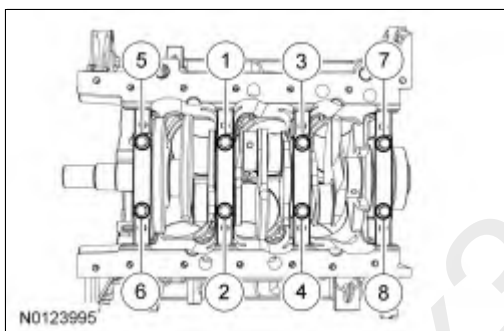
15. Position main bearing cap No. 4 on the cylinder block and keeping the cap as square as possible, alternately draw the cap down evenly using the new bolts until the main bearing cap is seated.



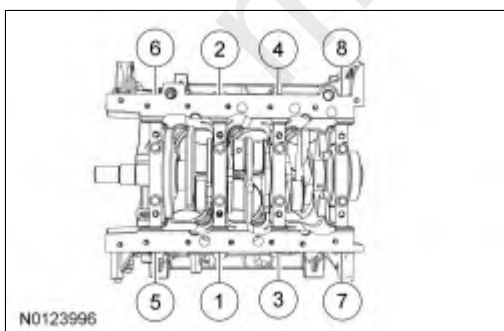
16. Loosen the No. 4 main bearing cap bolts.
17. **NOTE:** While tightening the main bearing vertical bolts, push the crankshaft forward and the No. 4 main bearing cap rearward to seat the crankshaft thrust washers.

Tighten the main bearing bolts in the sequence shown in 2 stages:

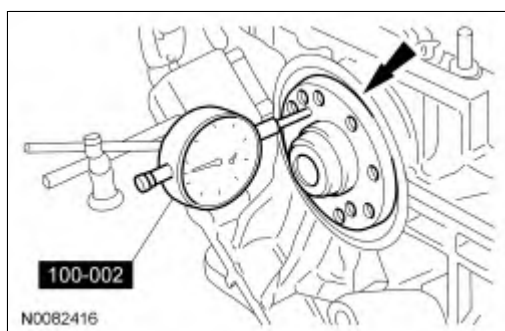
- Stage 1: Tighten fasteners 1 through 8 to 33 Nm (24 lb-ft).
- Stage 2: Tighten fasteners 1 through 8 an additional 135 degrees.



18. Install the new 8 main bearing cap side bolts. Tighten in the sequence shown in 2 stages:
 - Stage 1: Tighten fasteners 1 through 8 to 24 Nm (18 lb-ft).
 - Stage 2: Tighten fasteners 1 through 8 an additional 180 degrees.



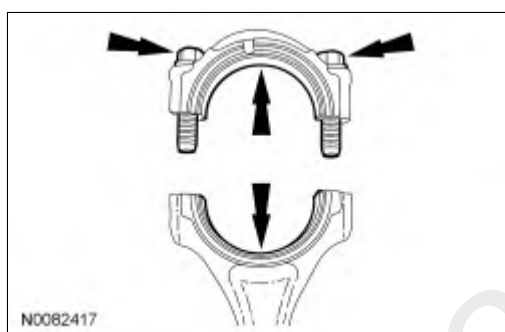
19. Using the Dial Indicator Gauge with Holding Fixture, measure crankshaft end play.
 - Position the crankshaft to the rear of the cylinder block.
 - Zero the Dial Indicator Gauge.
 - Move the crankshaft to the front of the cylinder block. Note and record the crankshaft end play.



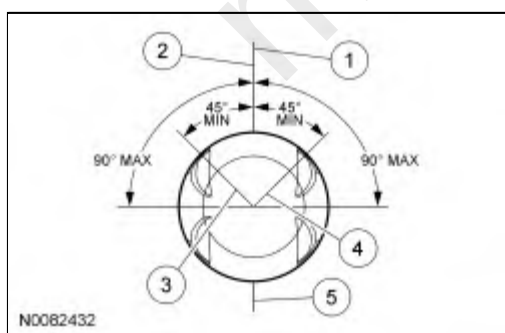
20. **NOTICE:** The rod cap installation must keep the same orientation as marked during disassembly or engine damage may occur.

Prepare the connecting rod and cap.

- Insert the new bolts in the rod cap.
- Insert the upper and lower rod bearings into the rod and cap.



21. Before installing the pistons into the cylinder block, verify proper ring gap location.
1. Center line of the piston parallel to the wrist pin bore
 2. Upper compression ring gap location
 3. Upper oil control segment ring gap location
 4. Lower oil control segment ring gap location
 5. Expander ring and lower compression ring gap location



22. **NOTICE:** Be sure not to scratch the cylinder wall or crankshaft journal with the connecting rod. Push the piston down until the connecting rod bearing seats on the crankshaft journal.

NOTE: The next 3 steps are for all 6 connecting rods, rod caps and pistons. Only 1 connecting rod, rod cap and piston is shown.

NOTE: Lubricate the pistons, piston rings, connecting rod bearings and the entire cylinder bores with

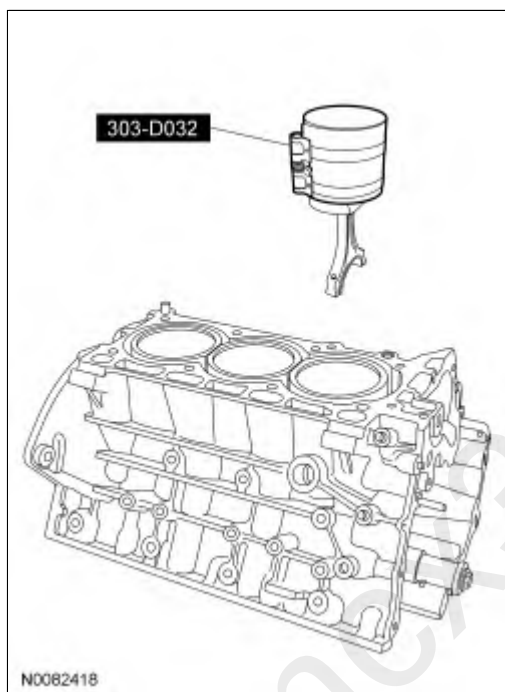
clean engine oil.

NOTE: Make sure the piston rings are positioned to specifications for installation. For additional information, refer to Disassembly and Assembly of Subassemblies - Piston in this section.

NOTE: If the piston and/or connecting rod are being installed new, the piston rod orientation marks and the arrow on the top of the dome of the piston should be facing toward the front of the engine block.

NOTE: If the piston and connecting rod are to be reinstalled, they must be installed in the same orientation as disassembled.

Using the Piston Ring Compressor, install the piston and connecting rod assemblies.



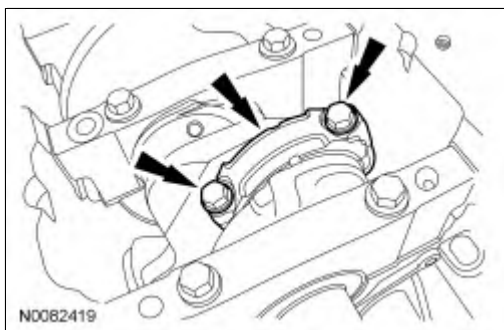
23. Seat the connecting rod on the crankshaft journal.

24. **NOTICE:** The rod cap installation must keep the same orientation as marked during disassembly or engine damage may occur.

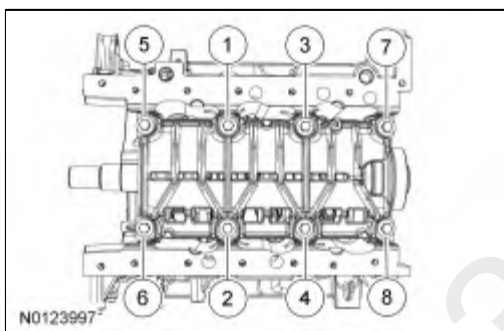
NOTE: After installation of each piston, connecting rod, rod cap and bolts, rotate the crankshaft to verify smooth operation.

Install the connecting rod cap and bolts.

- Tighten the bolts in 3 stages:
- Stage 1: Tighten to 23 Nm (17 lb-ft).
- Stage 2: Tighten to 43 Nm (32 lb-ft).
- Stage 3: Tighten an additional 90 degrees.



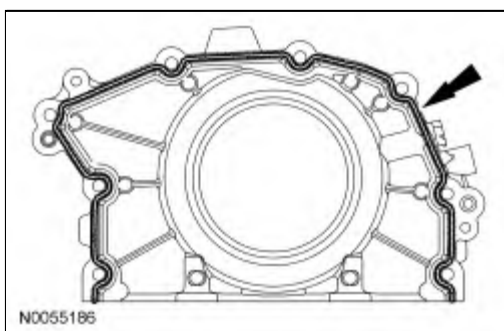
25. Repeat the previous 3 steps until all 6 piston, connecting rod and connecting rod cap assemblies are installed.
26. Install the main bearing cap support brace and the new bolts. Tighten in the sequence shown in 2 steps.
 - Stage 1: Tighten fasteners to 20 Nm (177 lb-in).
 - Stage 2: Tighten fasteners an additional 180 degrees.



27. **NOTICE:** Failure to use Motorcraft® High Performance Engine RTV Silicone may cause the engine oil to foam excessively and result in serious engine damage.

NOTE: The crankshaft rear seal retainer must be installed and the bolts tightened within 10 minutes of sealant application.

Apply a 3 mm (0.11 in) bead of Motorcraft® High Performance Engine RTV Silicone to the sealing surface of the crankshaft rear seal retainer.

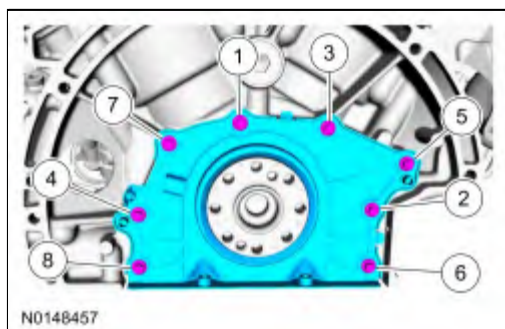


28. **NOTE:** Lubricate the crankshaft rear seal with clean engine oil.

NOTE: Use the 2 handles during installation to avoid touching the sealant.

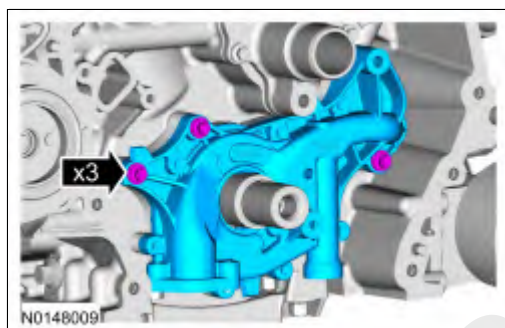
Install the 8 crankshaft rear seal retainer plate bolts. Tighten in the sequence shown.

- Tighten to 10 Nm (89 lb-in).



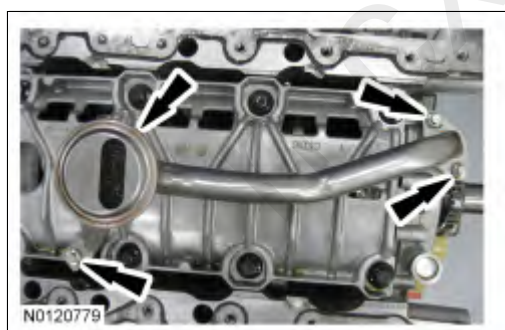
29. Install the oil pump and the 3 bolts.

- Tighten to 10 Nm (89 lb-in).



30. Using a new O-ring seal, install the oil pump screen and pickup tube and the 3 bolts.

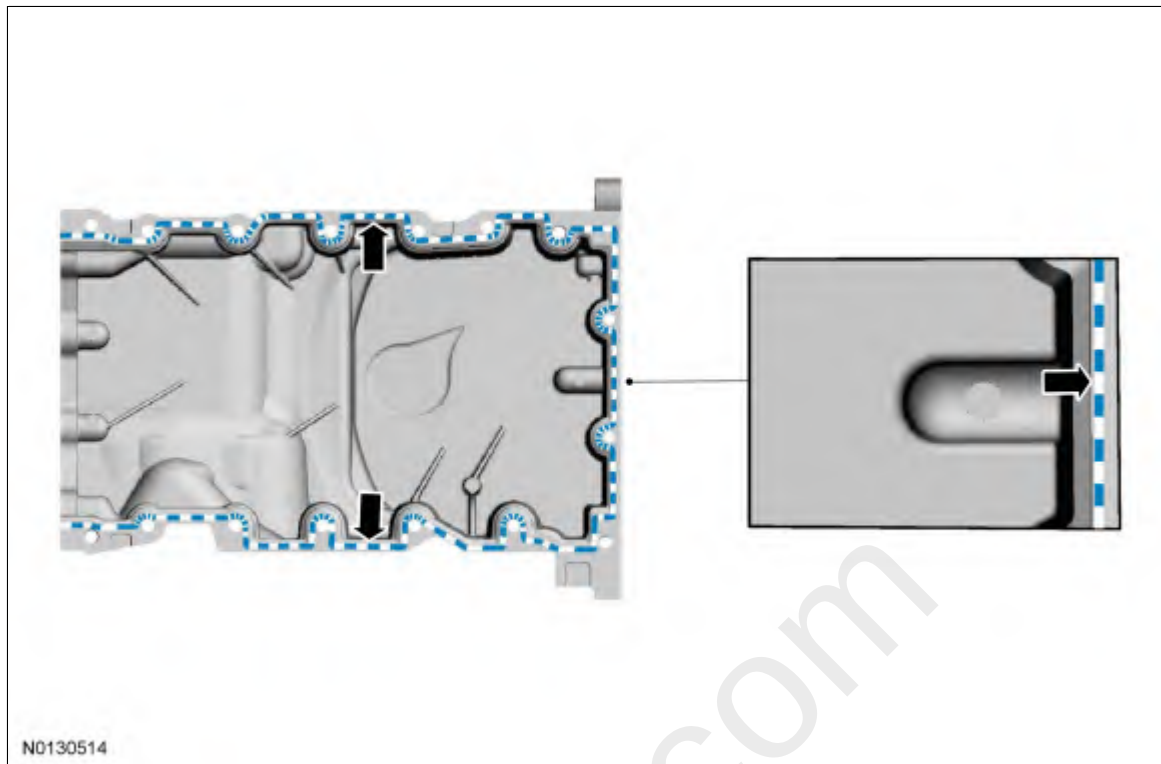
- Tighten to 10 Nm (89 lb-in).



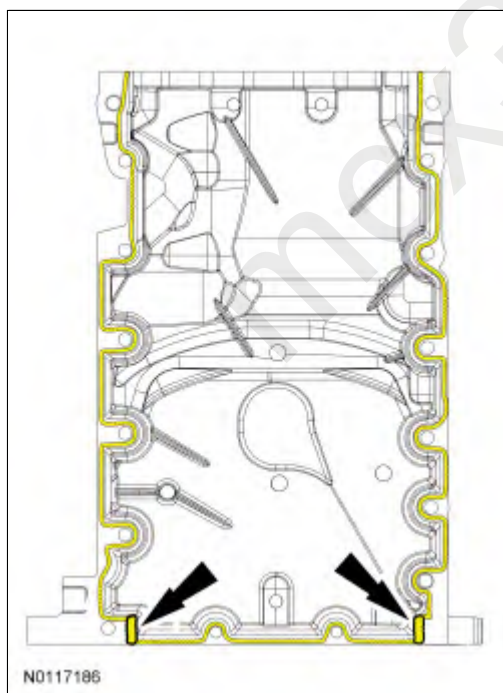
31. **NOTICE:** Failure to use Motorcraft® High Performance Engine RTV Silicone may cause the engine oil to foam excessively and result in serious engine damage.

NOTE: The oil pan and the 4 specified bolts must be installed and the oil pan aligned to the cylinder block within 4 minutes of sealant application. Final tightening of the oil pan bolts must be carried out within 60 minutes of sealant application.

Apply a 3 mm (0.11 in) bead of Motorcraft® High Performance Engine RTV Silicone on the inside edge of the oil pan to the sealing surface of the oil pan-to-engine block mating surface.

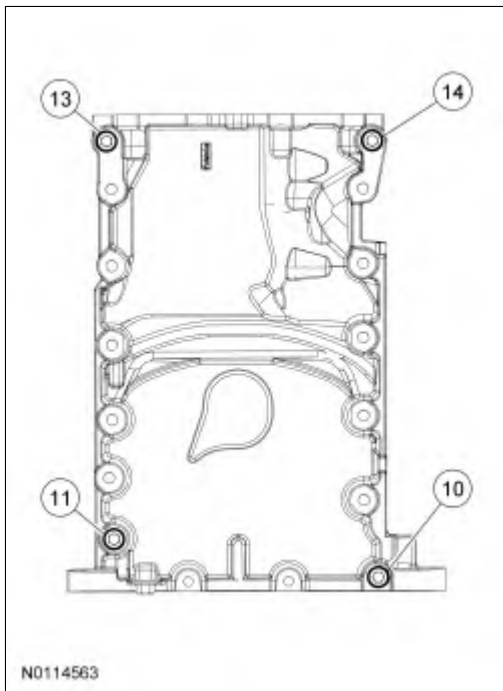


32. Apply a 5.5 mm (0.21 in) bead of Motorcraft® High Performance Engine RTV Silicone to the 2 crankshaft seal retainer plate-to-cylinder block joint areas on the sealing surface of the oil pan.

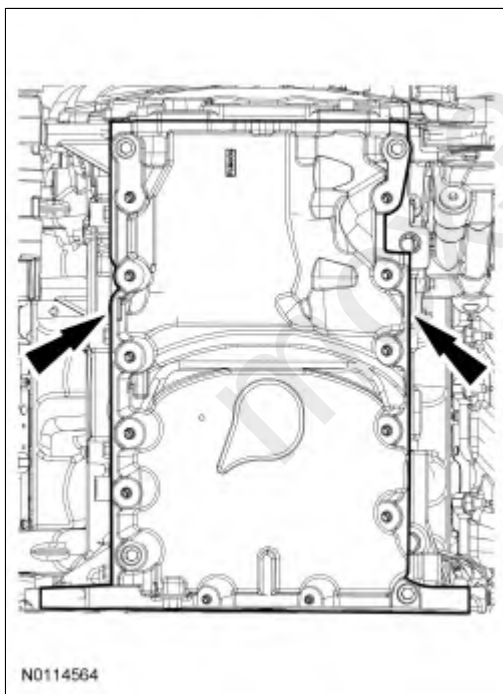


33. **NOTE:** The oil pan and the 4 specified bolts must be installed within 4 minutes of the start of sealant application.

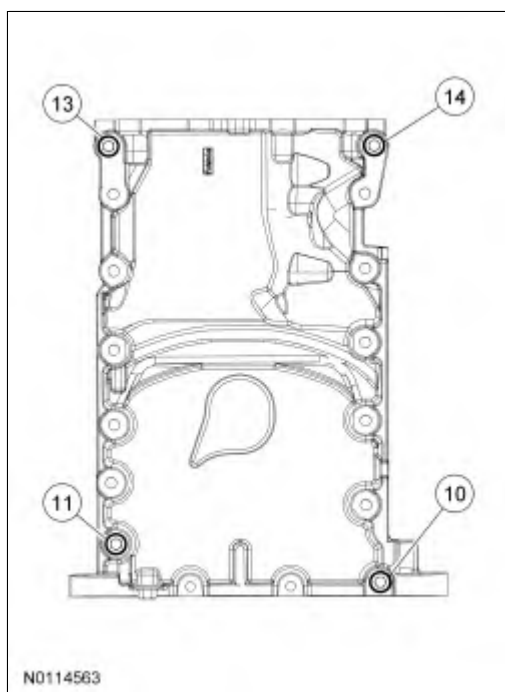
Install the oil pan and bolts 10, 11, 13 and 14 finger tight.



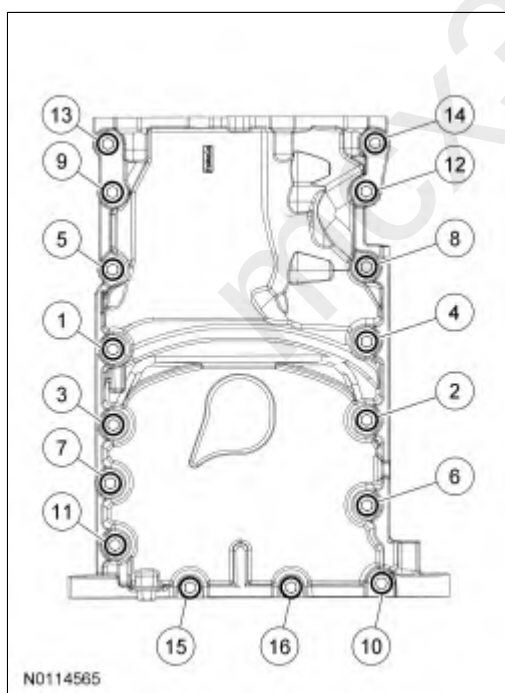
34. Laterally align the oil pan to the block. Make sure the oil pan is flush with the block at these 2 points.



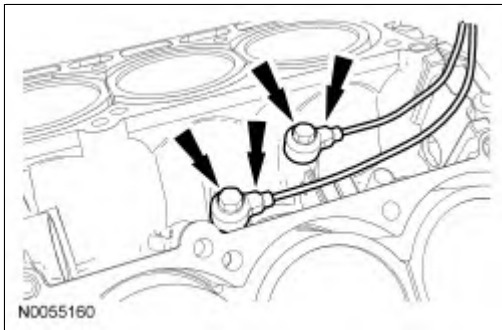
35. Tighten bolts 10, 11, 13 and 14 in the sequence shown to 3 Nm (27 lb-in).



36. Install the remaining oil pan bolts and tighten in the sequence shown.
- Tighten bolts 1-9 and 11-14 to 20 Nm (177 lb-in), then rotate an additional 45 degrees.
 - Tighten bolts 15 and 16 to 10 Nm (89 lb-in), then rotate an additional 45 degrees.
 - Tighten bolt 10 to 20 Nm (177 lb-in), then rotate an additional 90 degrees.

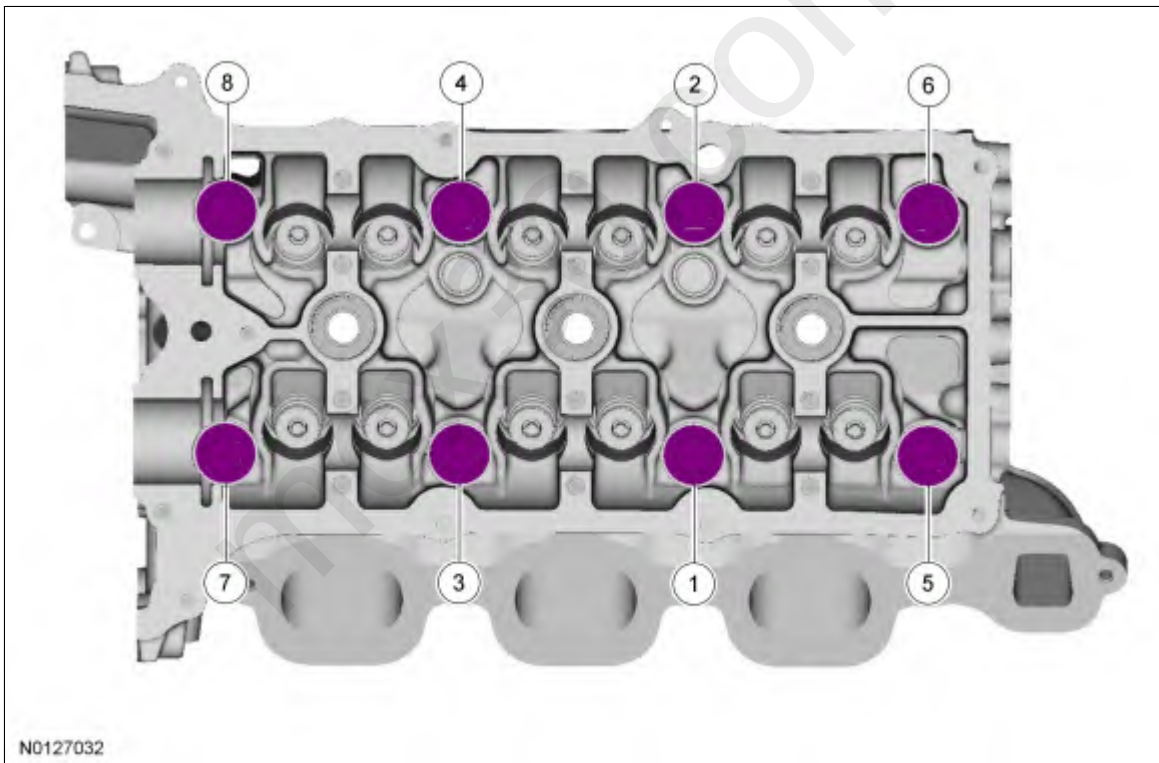


37. Install the Knock Sensor (KS) and the 2 bolts.
- Tighten to 20 Nm (177 lb-in).



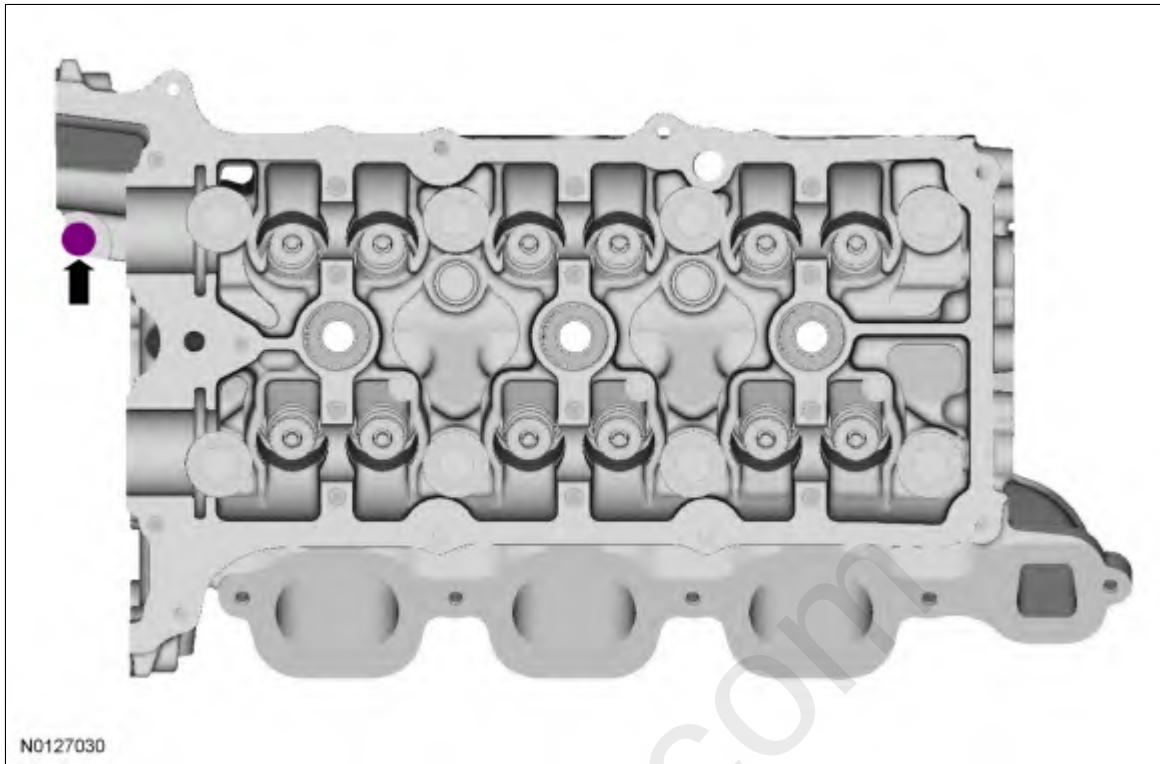
38. Install a new gasket, the RH cylinder head and 8 new bolts. Tighten in the sequence shown in 5 stages:

- Stage 1: Tighten to 20 Nm (177 lb-in).
- Stage 2: Tighten to 35 Nm (26 lb-ft).
- Stage 3: Tighten 90 degrees.
- Stage 4: Tighten 90 degrees.
- Stage 5: Tighten 45 degrees.

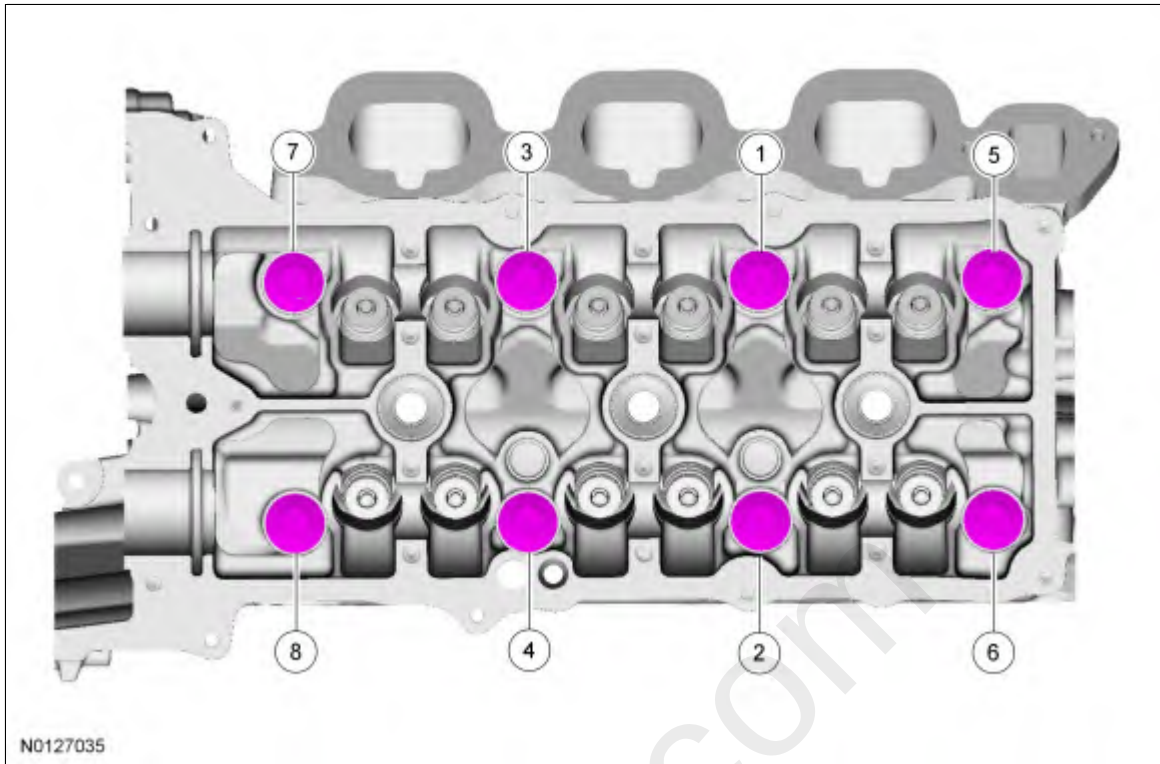


39. Install the RH M6 bolt.

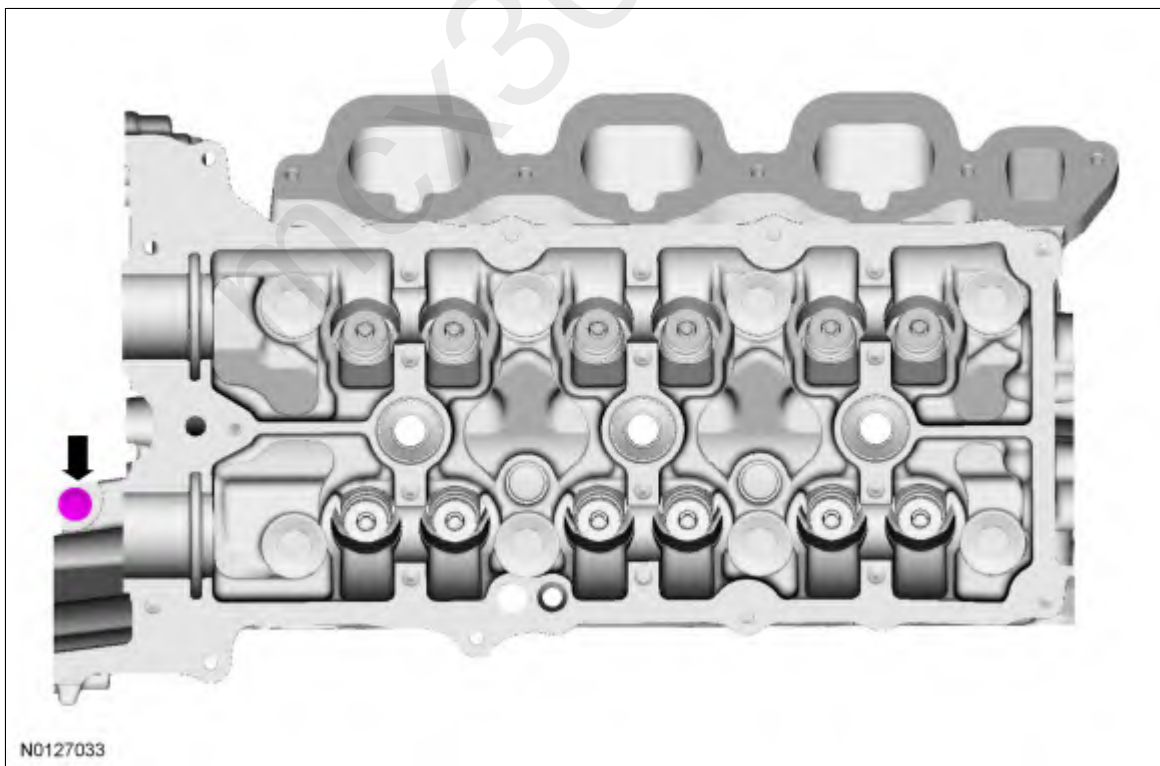
- Tighten to 10 Nm (89 lb-in).



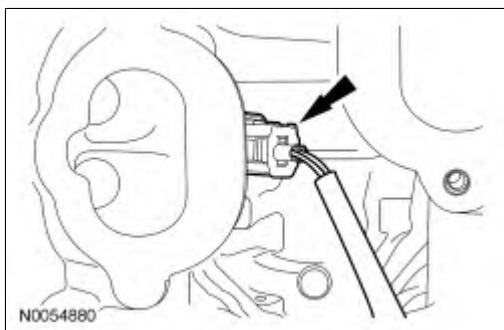
40. Install a new gasket, the LH cylinder head and 8 new bolts. Tighten in the sequence shown in 5 stages:
- Stage 1: Tighten to 20 Nm (177 lb-in).
 - Stage 2: Tighten to 35 Nm (26 lb-ft).
 - Stage 3: Tighten 90 degrees.
 - Stage 4: Tighten 90 degrees.
 - Stage 5: Tighten 45 degrees.



41. Install the LH M6 bolt.
- Tighten to 10 Nm (89 lb-in).



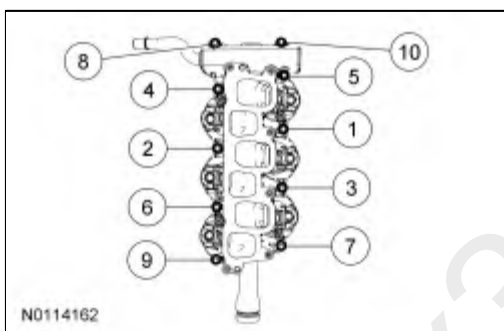
42. Connect the Cylinder Head Temperature (CHT) sensor jumper harness.



43. **NOTICE:** If the engine is repaired or replaced because of upper engine failure, typically including valve or piston damage, check the intake manifold for metal debris. If metal debris is found, install a new intake manifold. Failure to follow these instructions can result in engine damage.

Using new lower intake manifold gaskets, install the lower intake manifold and the 10 bolts and tighten in the sequence shown.

- Tighten to 10 Nm (89 lb-in).

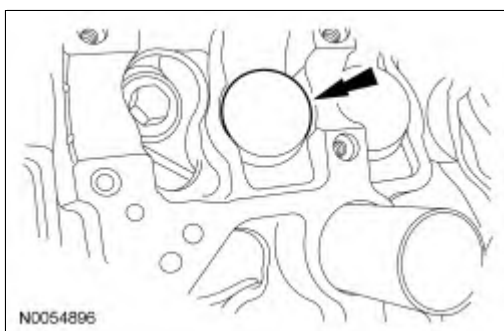


44. **NOTE:** The valve tappets must be installed in their original positions.

NOTE: Coat the valve tappets with clean engine oil prior to installation.

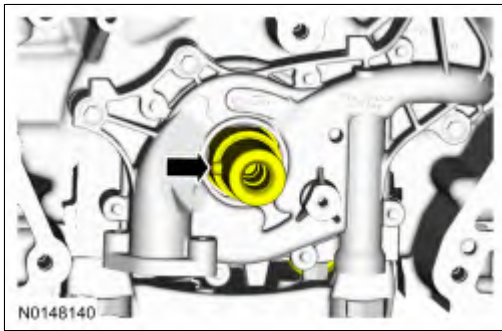
NOTE: LH shown, RH similar.

Install the valve tappets.



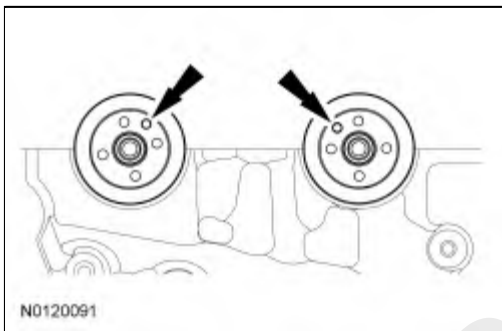
45. **NOTICE:** The crankshaft must remain in the freewheeling position (crankshaft dowel pin at 9 o'clock) until after the camshafts are installed and the valve clearance is checked/adjusted. Do not turn the crankshaft until instructed to do so. Failure to follow this process will result in severe engine damage.

Position the crankshaft dowel pin in the 9 o'clock position.



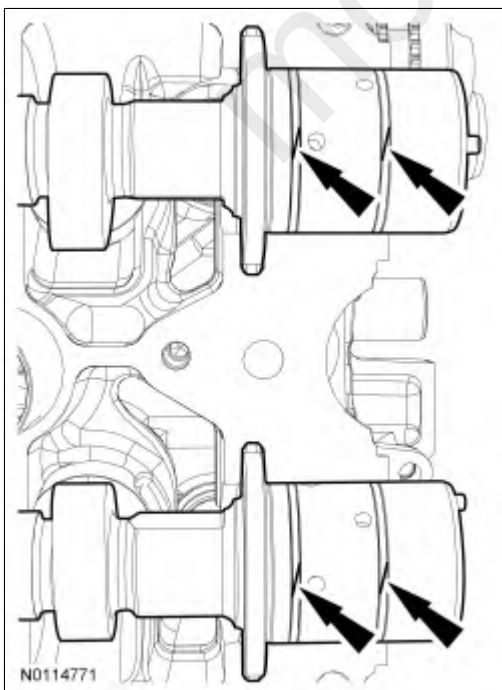
46. **NOTE:** Coat the camshafts with clean engine oil prior to installation.

Position the camshafts onto the RH cylinder head in the neutral position as shown.



47. **NOTICE:** The camshaft seal gaps must be at the 12 o'clock position or damage to the engine may occur.

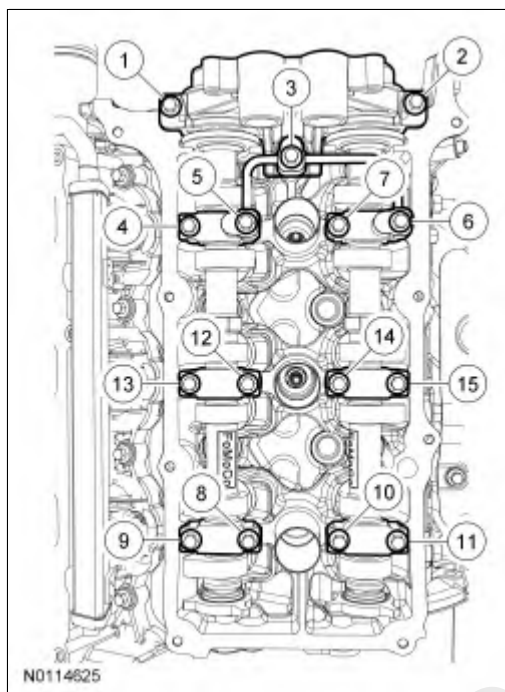
Position the 4 camshaft seals gaps as shown.



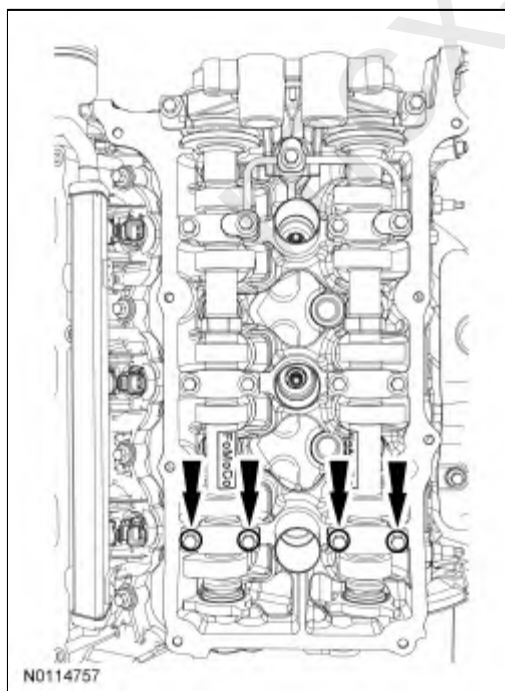
48. **NOTE:** Cylinder head camshaft bearing caps are numbered to verify that they are assembled in their original positions.

Install the 6 camshaft caps, mega cap, valve train oil tube and the 15 bolts in the sequence shown.

- Tighten to 8 Nm (71 lb-in) then an additional 45 degrees.

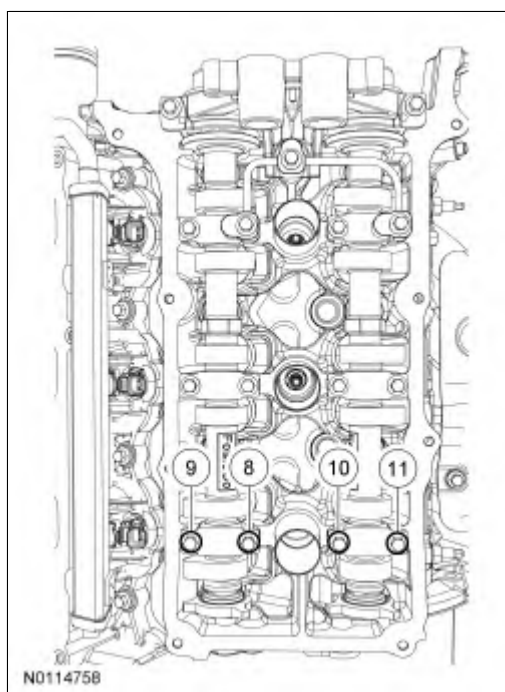


49. Loosen the 4 camshaft caps bolts.



50. Tighten the 4 camshaft caps bolts in the sequence shown.

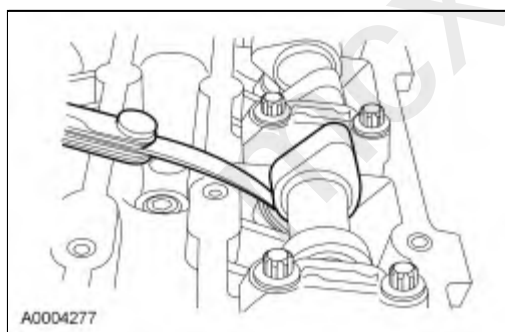
- Tighten bolts 8, 9, 10 and 11 to 8 Nm (71 lb-in) then an additional 45 degrees.



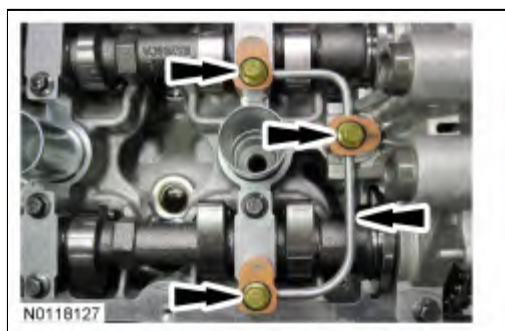
51. **NOTICE:** If any components are installed new, the engine valve clearance must be checked/adjusted or engine damage may occur.

NOTE: Use a camshaft sprocket bolt to turn the camshafts.

Using a feeler gauge, confirm that the valve tappet clearances are within specification. If valve tappet clearances are not within specification, the clearance must be adjusted by installing new valve tappet (s) of the correct size. For additional information, refer to [Valve Clearance Check](#) in this section.



52. Remove the 3 bolts and the RH valve train oil tube.



53. Rotate the RH camshafts to the Top Dead Center (TDC) position as shown.



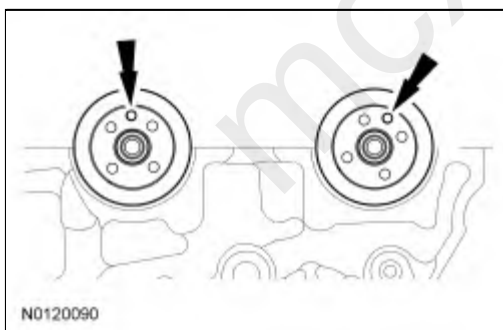
54. **NOTE:** The Camshaft Holding Tool will hold the camshafts in the TDC position.

Install the Camshaft Holding Tool onto the flats of the RH camshafts.



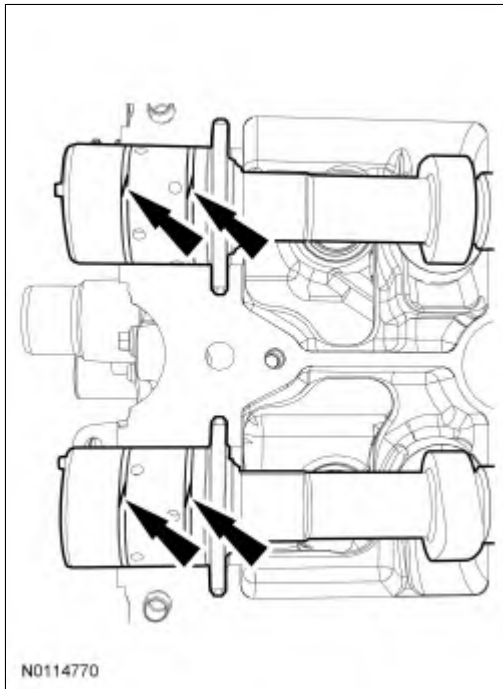
55. **NOTE:** Coat the camshafts with clean engine oil prior to installation.

Position the camshafts onto the LH cylinder head in the neutral position as shown.



56. **NOTICE:** The camshaft seal gaps must be at the 12 o'clock position or damage to the engine may occur.

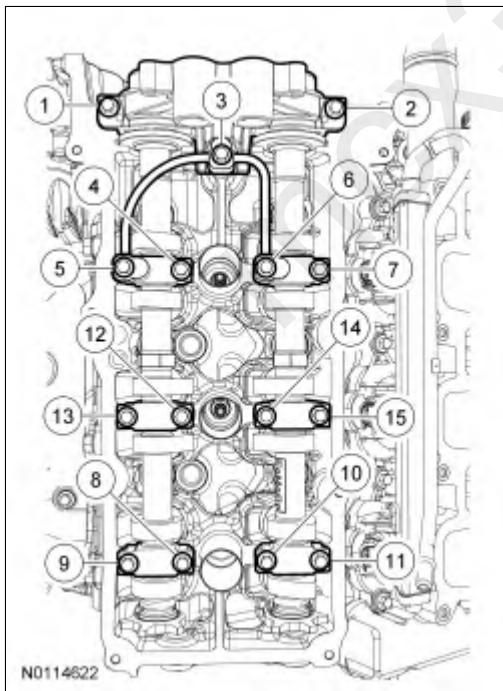
Position the 4 camshaft seals gaps as shown.



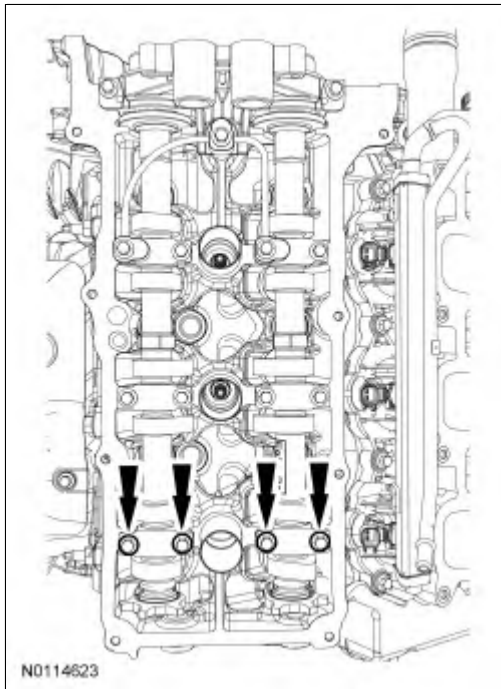
57. **NOTE:** Cylinder head camshaft bearing caps are numbered to verify that they are assembled in their original positions.

Install the 6 camshaft caps, mega cap, valve train oil tube and the 15 bolts in the sequence shown.

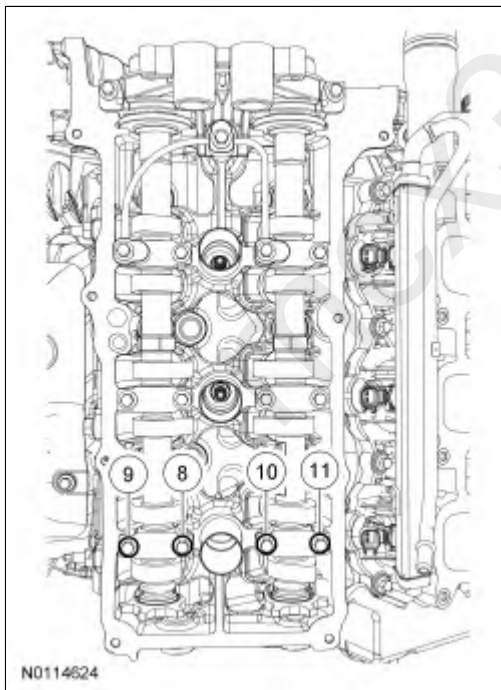
- Tighten to 8 Nm (71 lb-in) then an additional 45 degrees.



58. Loosen the 4 camshaft caps bolts.



59. Tighten the 4 camshaft caps bolts in the sequence shown.
- Tighten bolts 8, 9, 10 and 11 to 8 Nm (71 lb-in) then an additional 45 degrees.

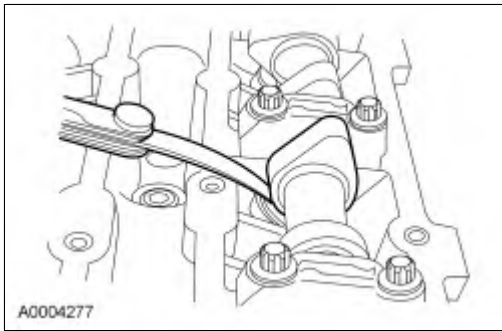


60. **NOTICE:** If any components are installed new, the engine valve clearance must be checked/adjusted or engine damage may occur.

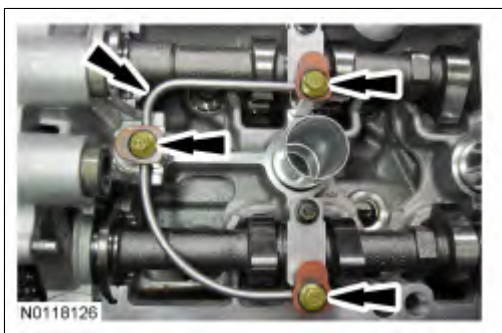
NOTE: Use a camshaft sprocket bolt to turn the camshafts.

Using a feeler gauge, confirm that the valve tappet clearances are within specification. If valve tappet clearances are not within specification, the clearance must be adjusted by installing new valve tappet

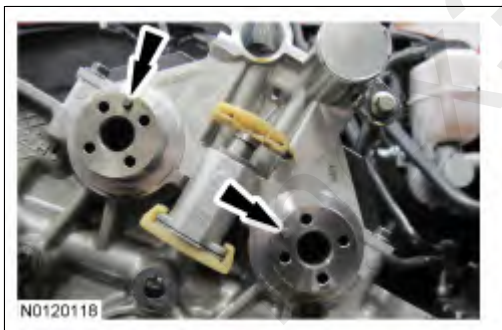
(s) of the correct size. For additional information, refer to [Valve Clearance Check](#) in this section.



61. Remove the 3 bolts and the LH valve train oil tube.



62. Rotate the LH camshafts to the TDC position as shown.

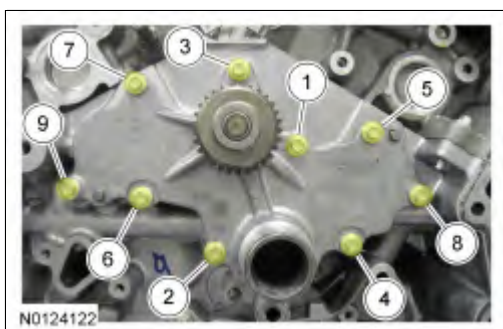


63. **NOTE:** The Camshaft Holding Tool will hold the camshafts in the TDC position.

Install the Camshaft Holding Tool onto the flats of the LH camshafts.



64. Using new gaskets, install the channel cover plate and the 9 bolts. Tighten in the sequence shown in 2 stages:
- Stage 1: Tighten to 10 Nm (89 lb-in).
 - Stage 2: Tighten an additional 45 degrees.



65. Install the RH primary timing chain guide and the bolt.
- Tighten to 10 Nm (89 lb-in).



Engines with secondary timing chain tensioner removed

NOTICE: The following steps are only for the replacement of the secondary timing chain tensioners. Do not reuse the secondary timing chain tensioners if removed or damage to the engine may occur.

66. **NOTE:** Apply clean engine oil to the secondary timing chain tensioner O-ring seals and mega cap bore.

NOTE: Do not remove the secondary timing chain tensioner shipping clip, until instructed to do so.

Install the RH secondary timing chain tensioner by pushing it down all the way until a snap is heard and the tensioner is seated all the way down the mega cap bore.



67. Install the RH secondary timing chain tensioner shoe.



68. Remove and discard the RH secondary timing chain tensioner shipping clip.



69. Assemble the RH Variable Camshaft Timing (VCT) assembly, the RH exhaust camshaft sprocket and the RH secondary timing chain.
- Align the colored links with the timing marks.



70. **NOTE:** It may be necessary to rotate the camshafts slightly, to install the RH secondary timing assembly.

Position the 2 RH VCT assemblies and secondary timing chain onto the camshafts by aligning the holes in the VCT assemblies with the dowel pins in the camshafts.



71. Install the 2 new RH VCT bolts and tighten in 4 stages:

- Stage 1: Tighten to 40 Nm (30 lb-ft).
- Stage 2: Loosen one full turn.
- Stage 3: Tighten to 25 Nm (18 lb-ft).
- Stage 4: Tighten an additional 180 degrees.



72. Activate the RH secondary timing chain tensioner by pressing down on the secondary tensioner shoe until it bottoms out, let go of the tensioner and it will spring up putting tension on the chain.



73. **NOTICE:** Do not use excessive force when installing the Variable Camshaft Timing (VCT) oil control solenoid. Damage to the mega cap could cause the cylinder head to be inoperable. If difficult to install the VCT oil control solenoid, inspect the bore and VCT oil control solenoid to ensure there are no burrs, sharp edges or contaminants present on the mating surface. Only clean the external surfaces as necessary.

NOTE: A slight twisting motion will aid in the installation of the VCT oil control solenoid.

NOTE: Keep the VCT oil control solenoid clean of dirt and debris.

Install the RH exhaust VCT oil control solenoid.

- Tighten to 8 Nm (71 lb-in) then an additional 20 degrees.



74. **NOTE:** Apply clean engine oil to the secondary timing chain tensioner O-ring seals and mega cap bore.

NOTE: Do not remove the secondary timing chain tensioner shipping clip, until instructed to do so.

Install the LH secondary timing chain tensioner by pushing it down all the way until a snap is heard and the tensioner is seated all the way down the mega cap bore.



75. Install the LH secondary timing chain tensioner shoe.



76. Remove and discard the LH secondary timing chain tensioner shipping clip.



77. Assemble the 2 LH VCT assemblies and the LH secondary timing chain.
- Align the colored links with the timing marks.



78. **NOTE:** It may be necessary to rotate the camshafts slightly, to install the LH secondary timing assembly.

Position the 2 LH VCT assemblies and secondary timing chain onto the camshafts by aligning the holes in the VCT assemblies with the dowel pins in the camshafts.



79. Install the 2 new LH VCT bolts and tighten in 4 stages:
- Stage 1: Tighten to 40 Nm (30 lb-ft).
 - Stage 2: Loosen one full turn.
 - Stage 3: Tighten to 25 Nm (18 lb-ft).
 - Stage 4: Tighten an additional 180 degrees.



80. Activate the LH secondary timing chain tensioner by pressing down on the secondary tensioner shoe until it bottoms out, let go of the tensioner and it will spring up putting tension on the chain.



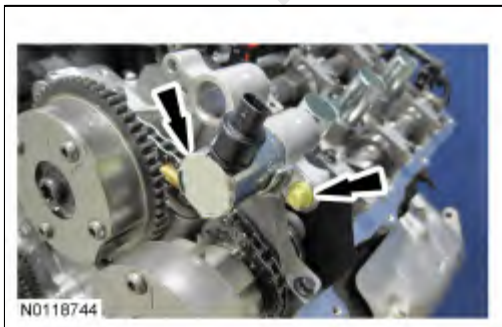
81. **NOTICE:** Do not use excessive force when installing the Variable Camshaft Timing (VCT) oil control solenoid. Damage to the mega cap could cause the cylinder head to be inoperable. If difficult to install the VCT oil control solenoid, inspect the bore and VCT oil control solenoid to ensure there are no burrs, sharp edges or contaminants present on the mating surface. Only clean the external surfaces as necessary.

NOTE: A slight twisting motion will aid in the installation of the VCT oil control solenoid.

NOTE: Keep the VCT oil control solenoid clean of dirt and debris.

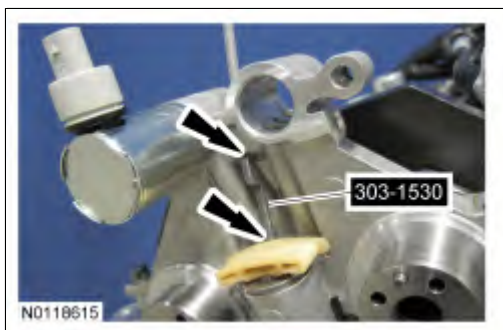
Install the LH exhaust VCT oil control solenoid.

- Tighten to 8 Nm (71 lb-in) then an additional 20 degrees.



Engines with secondary timing chain tensioner not removed

82. Compress the RH secondary timing chain tensioner and install the Secondary Chain Hold Down to retain the tensioner in the collapsed position.



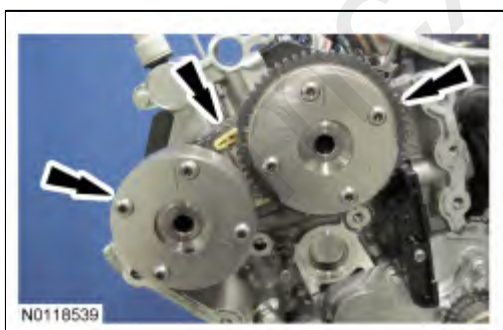
83. Assemble the RH VCT assembly, the RH exhaust camshaft sprocket and the RH secondary timing chain.

- Align the colored links with the timing marks.



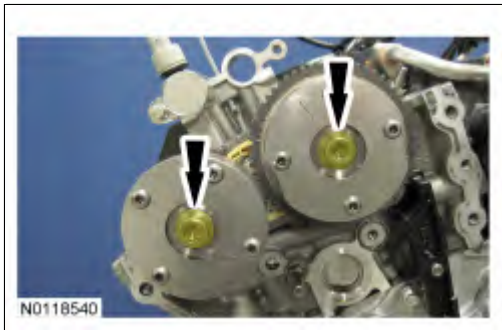
84. **NOTE:** It may be necessary to rotate the camshafts slightly, to install the RH secondary timing assembly.

Position the 2 RH VCT assemblies and secondary timing chain onto the camshafts by aligning the holes in the VCT assemblies with the dowel pins in the camshafts.



85. Install the 2 new RH VCT bolts and tighten in 4 stages:

- Stage 1: Tighten to 40 Nm (30 lb-ft).
- Stage 2: Loosen one full turn.
- Stage 3: Tighten to 25 Nm (18 lb-ft).
- Stage 4: Tighten an additional 180 degrees.



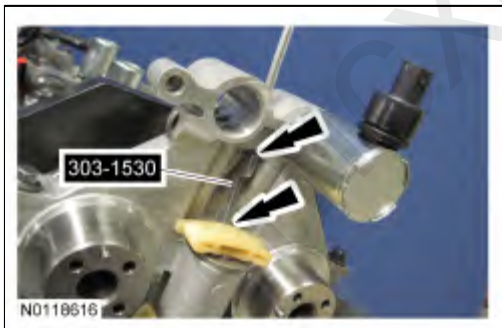
86. **NOTE:** The 2 VCT oil control solenoids are removed for clarity.

Compress the RH secondary timing chain tensioner and remove the Secondary Chain Hold Down.

- Make sure the secondary timing chain is centered on the timing chain tensioner guides.



87. Compress the LH secondary timing chain tensioner and install the Secondary Chain Hold Down to retain the tensioner in the collapsed position.



88. Assemble the 2 LH VCT assemblies and the LH secondary timing chain.
- Align the colored links with the timing marks.

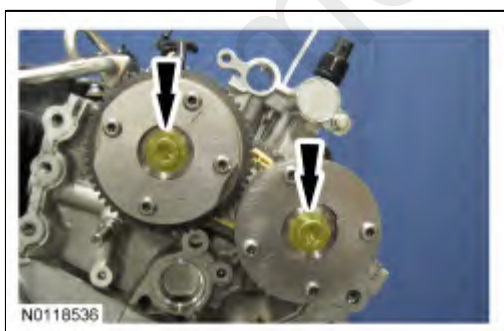


89. **NOTE:** It may be necessary to rotate the camshafts slightly, to install the LH secondary timing assembly.

Position the 2 LH VCT assemblies and secondary timing chain onto the camshafts by aligning the holes in the VCT assemblies with the dowel pins in the camshafts.



90. Install the 2 new LH VCT bolts and tighten in 4 stages:
- Stage 1: Tighten to 40 Nm (30 lb-ft).
 - Stage 2: Loosen one full turn.
 - Stage 3: Tighten to 25 Nm (18 lb-ft).
 - Stage 4: Tighten an additional 180 degrees.



91. **NOTE:** The 2 VCT oil control solenoids are removed for clarity.

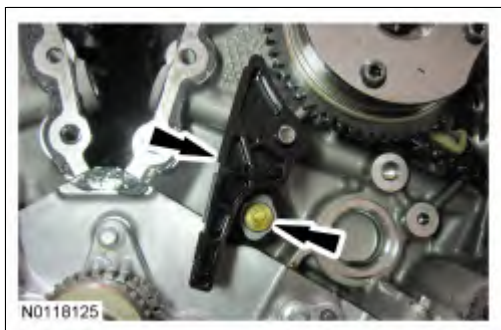
Compress the LH secondary timing chain tensioner and remove the Secondary Chain Hold Down.

- Make sure the secondary timing chain is centered on the timing chain tensioner guides.

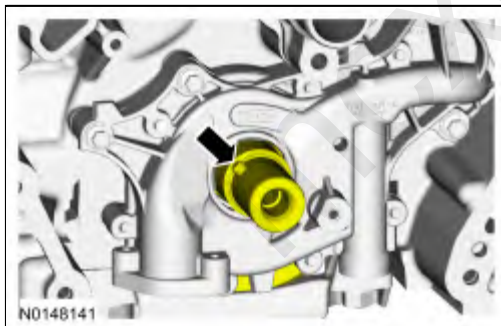


All engines

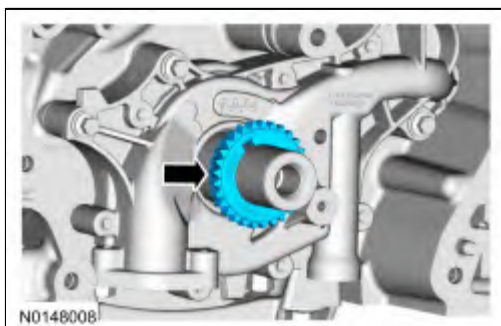
92. Install the upper LH primary timing chain guide and the bolt.
- Tighten to 10 Nm (89 lb-in).



93. Rotate the crankshaft clockwise 60 degrees to the Top Dead Center (TDC) position (crankshaft dowel pin at 11 o'clock).



94. Install the crankshaft timing chain sprocket with timing dot mark out.

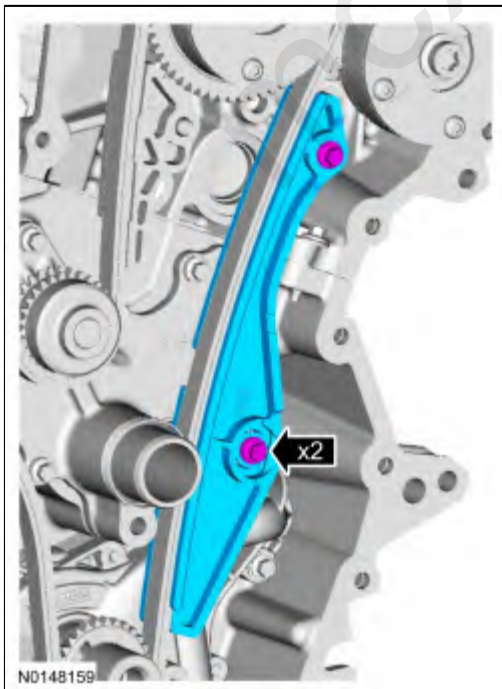


95. **NOTE:** It may be necessary to rotate the camshafts slightly, to align the timing marks.

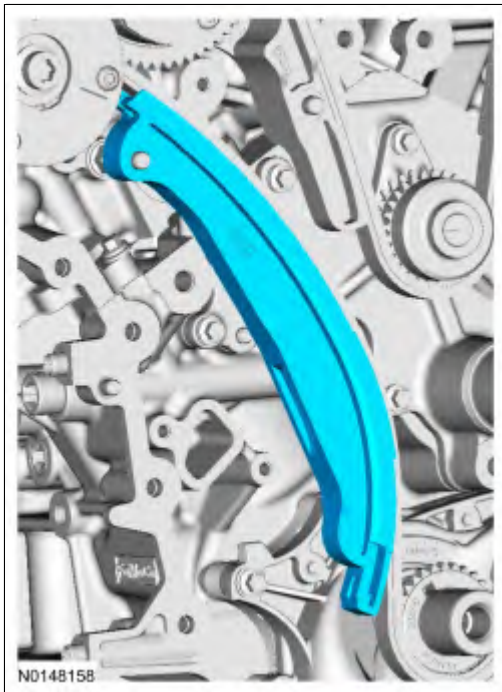
Install the primary timing chain with the colored links aligned with the timing marks on the VCT assemblies and the crankshaft sprocket.



96. Install the lower LH primary timing chain guide and the 2 bolts.
- Tighten to 10 Nm (89 lb-in).



97. Install the primary timing chain tensioner arm.



98. Reset the primary timing chain tensioner.

- Release the ratchet detent.
- Using a soft-jawed vise, compress the ratchet plunger.
- Align the hole in the ratchet plunger with the hole in the tensioner housing.
- Install a suitable lockpin.

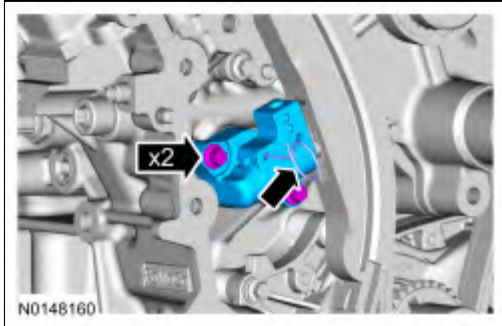


99. **NOTE:** It may be necessary to rotate the camshafts slightly to remove slack from the timing chain to

install the tensioner.

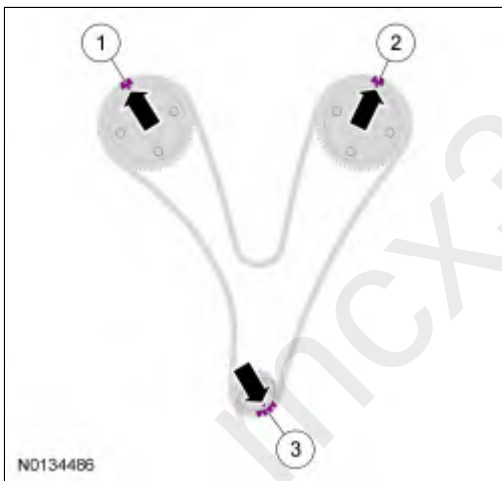
Install the primary tensioner and the 2 bolts.

- Tighten to 10 Nm (89 lb-in).
- Remove the lockpin.



100. As a post-check, verify correct alignment of all timing marks.

- There are 48 links in between the RH intake VCT assembly colored link (1) and the LH intake VCT assembly colored link (2).
- There are 35 links in between LH intake VCT assembly colored link (2) and the 2 crankshaft sprocket links (3).



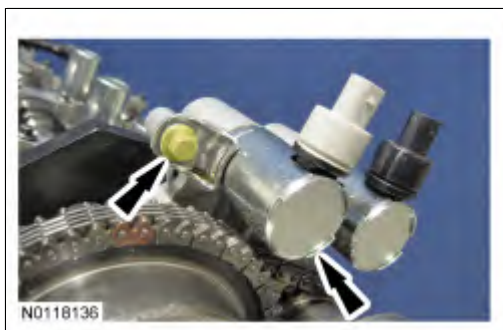
101. **NOTICE:** Do not use excessive force when installing the Variable Camshaft Timing (VCT) oil control solenoid. Damage to the mega cap could cause the cylinder head to be inoperable. If difficult to install the VCT oil control solenoid, inspect the bore and VCT oil control solenoid to ensure there are no burrs, sharp edges or contaminants present on the mating surface. Only clean the external surfaces as necessary.

NOTE: A slight twisting motion will aid in the installation of the VCT oil control solenoid.

NOTE: Keep the VCT oil control solenoid clean of dirt and debris.

Install the LH intake VCT oil control solenoid and the bolt.

- Tighten to 8 Nm (71 lb-in) then an additional 20 degrees.



102. **NOTICE:** Do not use excessive force when installing the Variable Camshaft Timing (VCT) oil control solenoid. Damage to the mega cap could cause the cylinder head to be inoperable. If difficult to install the VCT oil control solenoid, inspect the bore and VCT oil control solenoid to ensure there are no burrs, sharp edges or contaminants present on the mating surface. Only clean the external surfaces as necessary.

NOTE: A slight twisting motion will aid in the installation of the VCT oil control solenoid.

NOTE: Keep the VCT oil control solenoid clean of dirt and debris.

Install the RH intake VCT oil control solenoid and the bolt.

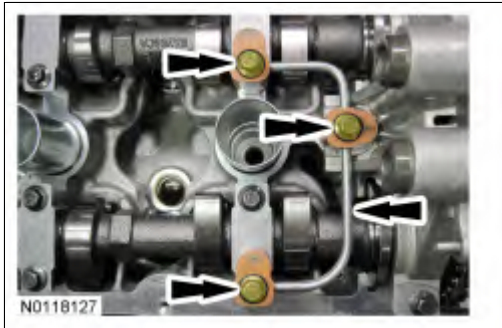
- Tighten to 8 Nm (71 lb-in) then an additional 20 degrees.



103. Remove the RH Camshaft Holding Tool.



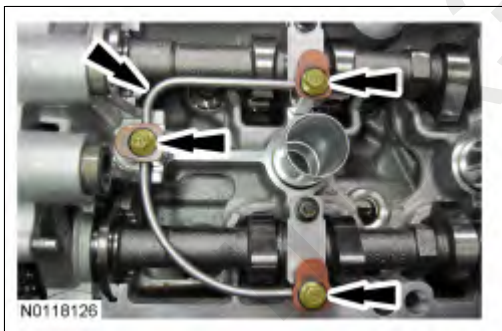
104. Install the RH valve train oil tube and the 3 bolts and tighten in 2 stages:
- Stage 1: Tighten to 8 Nm (71 lb-in).
 - Stage 2: Tighten an additional 45 degrees.



105. Remove the LH Camshaft Holding Tool.



106. Install the LH valve train oil tube and the 3 bolts and tighten in 2 stages:
- Stage 1: Tighten to 8 Nm (71 lb-in).
 - Stage 2: Tighten an additional 45 degrees.



107. **NOTE:** Use Spindle Bearing Installer 205-149 to install the seal.

If removed, using the Spindle Bearing Installer, install the front cover radial seal from the rear side of the front cover.



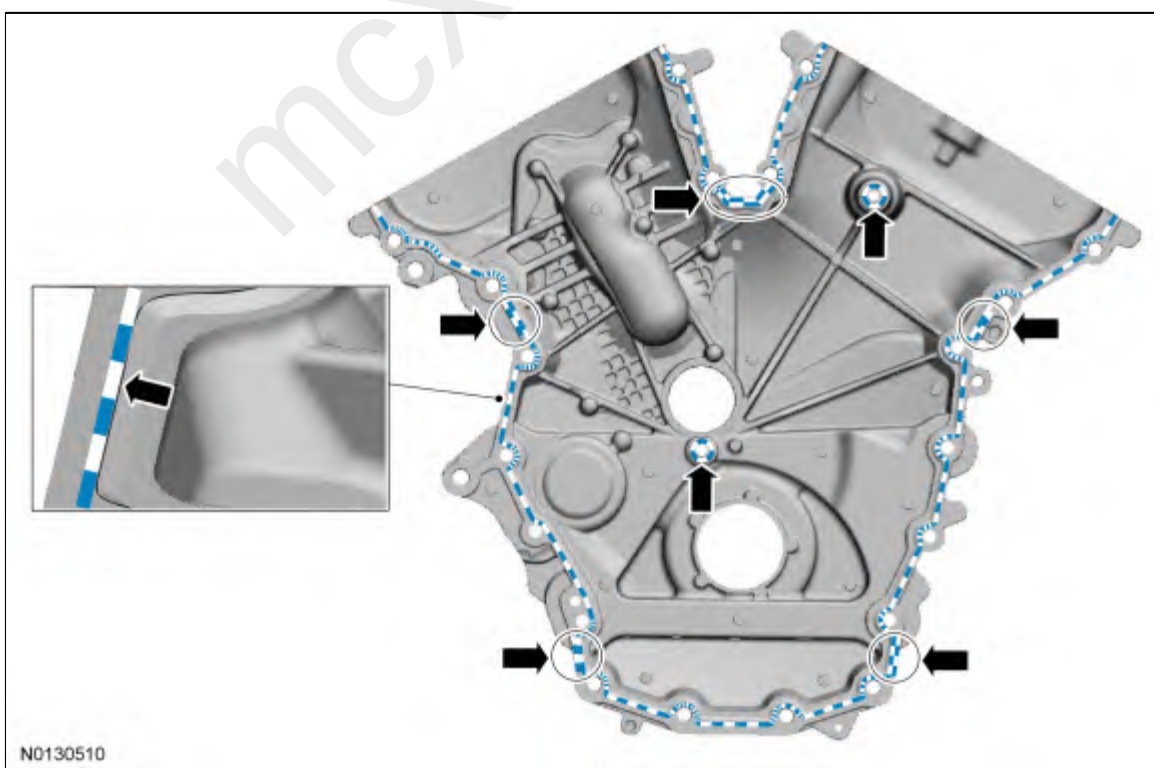
108. **NOTICE:** Failure to use Motorcraft® High Performance Engine RTV Silicone may cause the engine oil to foam excessively and result in serious engine damage.

NOTICE: Do not expose the Motorcraft® High Performance Engine RTV Silicone to engine oil for at least 90 minutes after installing the engine front cover. Failure to follow these instructions may cause engine oil leakage.

NOTE: The engine front cover and bolts 1, 2, 7, 8, 15, 17, 18, 19, 20 and 21 must be installed within 10 minutes of the initial sealant application. The remainder of the engine front cover bolts and the engine mount bracket bolts must be installed and tightened within 35 minutes of the initial sealant application. If the time limits are exceeded, the sealant must be removed, the sealing area cleaned and sealant reapplied. To clean the sealing area, use silicone gasket remover and metal surface prep. Failure to follow this procedure can cause future oil leakage.

Apply a 3.0 mm (0.11 in) bead of Motorcraft® High Performance Engine RTV Silicone on the inside edge of the engine front cover to the engine front cover sealing surfaces including the 2 engine front cover bolt bosses.

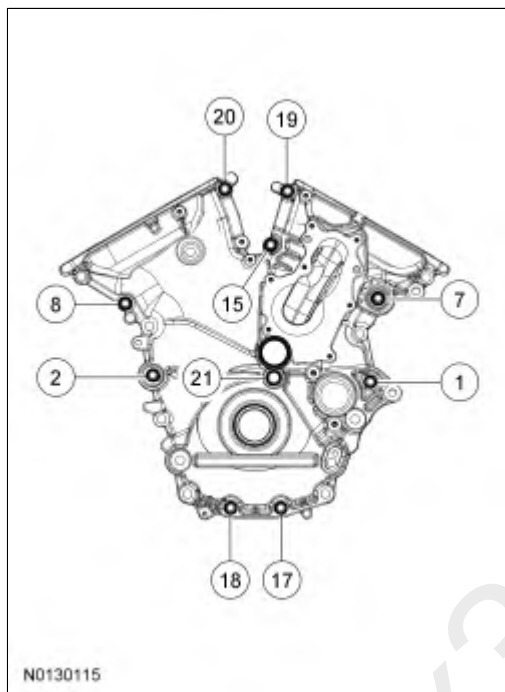
- Apply a 5.5 mm (0.21 in) bead of Motorcraft® High Performance Engine RTV Silicone to the oil pan-to-cylinder block joint and the cylinder head-to-cylinder block joint areas of the engine front cover in 5 places as indicated.



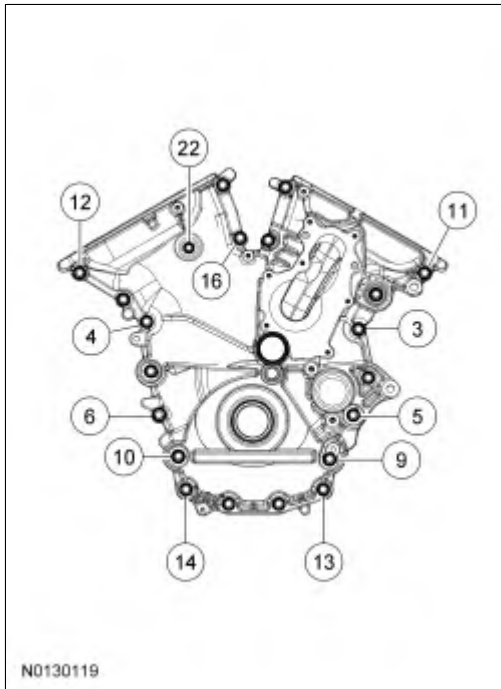
109. **NOTE:** Make sure the 2 locating dowel pins are seated correctly in the cylinder block.

Install the engine front cover and bolts 1, 2, 7, 8, 15, 17, 18, 19, 20 and 21 and tighten sequence shown in 3 stages:

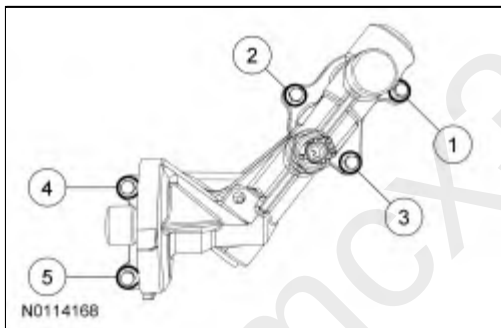
- Stage 1: Tighten bolts 1, 2, 7, 8, 15, 17, 18, 19, 20 and 21 in sequence to 10 Nm (89 lb-in).
- Stage 2: Tighten bolts 1, 2, 7, 8, 15, 17, 18, 19 and 20 in sequence to 20 Nm (177 lb-in) then an additional 45 degrees.
- Stage 3: Tighten bolt 21 to 20 Nm (177 lb-in) then an additional 90 degrees.



110. Install the remaining 12 engine front cover bolts 3, 4, 5, 6, 9, 10, 11, 12, 13, 14, 16 and 22. Tighten all of the engine front cover bolts in the sequence shown in 3 stages:
- Stage 1: Tighten bolts 3, 4, 5, 6, 9, 10, 11, 12, 13, 14 and 16 to 10 Nm (89 lb-in).
 - Stage 2: Tighten bolts 3, 4, 5, 6, 9, 10, 11, 12, 13, 14 and 16 to 20 Nm (177 lb-in) then an additional 45 degrees.
 - Stage 3: Tighten bolt 22 to 10 Nm (89 lb-in) then an additional 45 degrees.



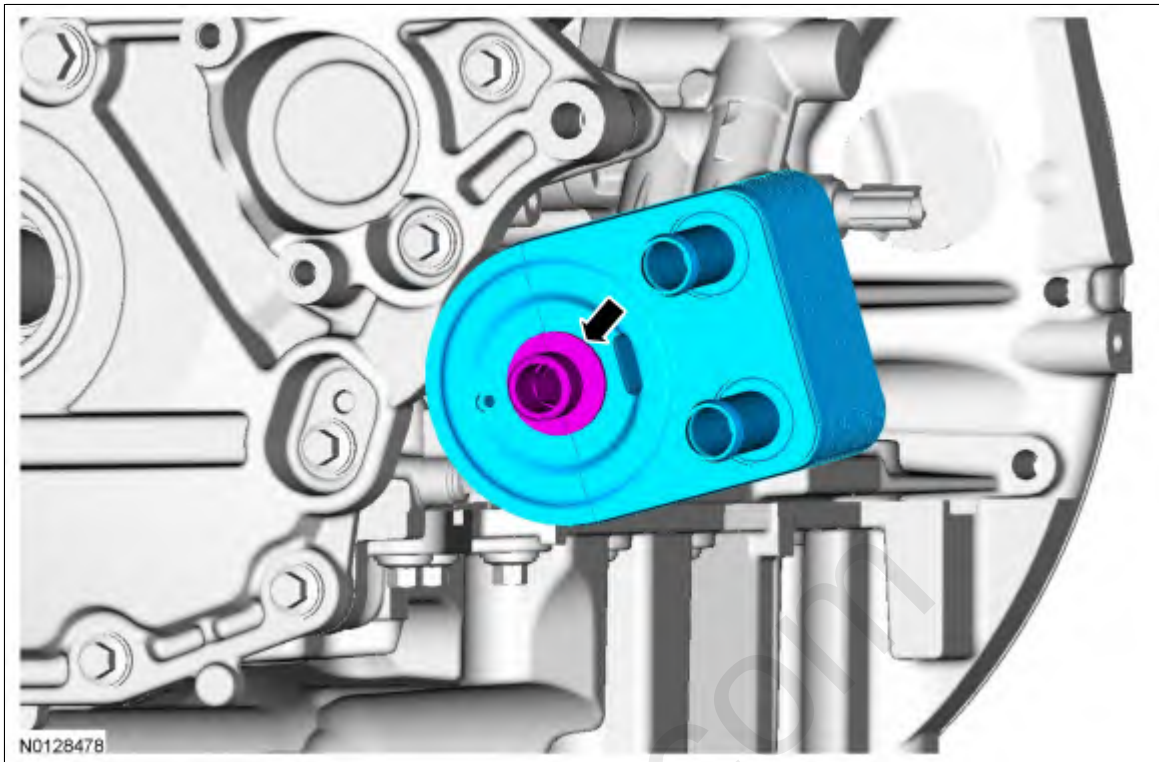
111. Using a new gasket, install the oil filter adapter and the 5 bolts and tighten in sequence shown.
- Tighten to 10 Nm (89 lb-in) and then an additional 45 degrees.



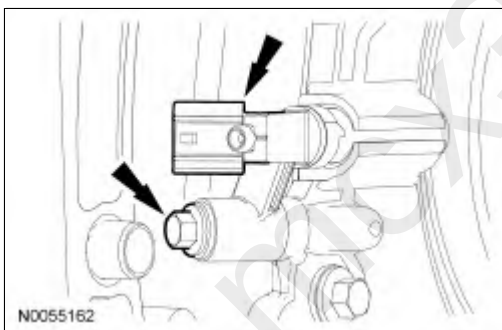
112. **NOTICE:** A new oil cooler must be installed or severe damage to the engine can occur.

If equipped, install the new oil cooler and the mounting bolt.

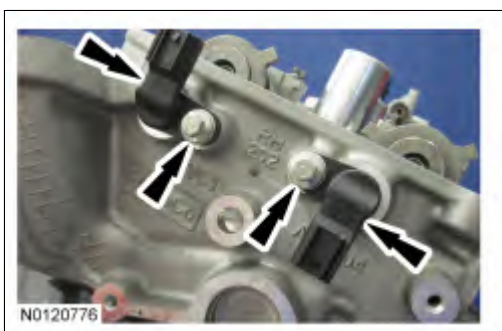
- Tighten to 58 Nm (43 lb-ft).



113. Install the Crankshaft Position (CKP) sensor and install the bolt.
- Tighten to 10 Nm (89 lb-in).

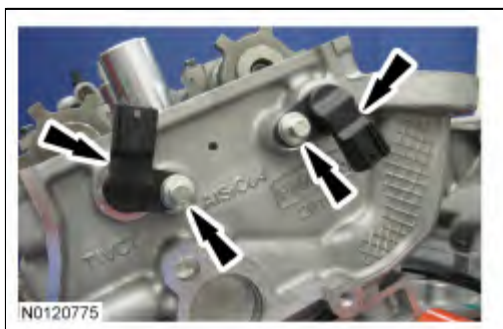


114. Install the 2 RH Camshaft Position (CMP) sensors and the bolts.
- Tighten to 10 Nm (89 lb-in).

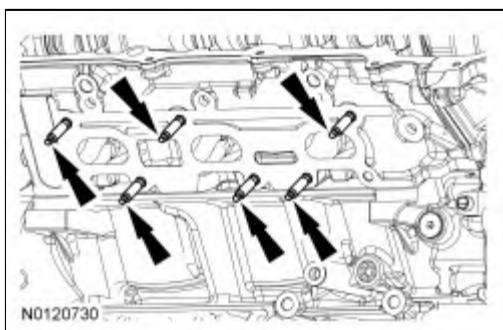


115. Install the 2 LH CMP sensors and the bolts.

- Tighten to 10 Nm (89 lb-in).



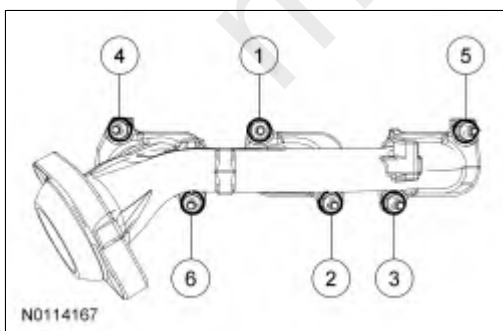
116. Install 6 new RH exhaust manifold studs.
- Tighten to 12 Nm (106 lb-in).



117. **NOTICE:** Failure to tighten the exhaust manifold nuts to specification a second time will cause the exhaust manifold to develop an exhaust leak.

Using a new gasket, install the RH exhaust manifold and 6 new nuts. Tighten in 2 stages in the sequence shown:

- Stage 1: Tighten to 19 Nm (168 lb-in).
- Stage 2: Tighten to 25 Nm (18 lb-ft).



118. Install the RH exhaust manifold heat shield and the 2 bolts.
- Tighten to 10 Nm (89 lb-in).



119. **NOTE:** Installation of new seals is only required if damaged seals were removed.

Using the VCT Spark Plug Tube Seal Installer and Handle, install new spark plug tube seals.



120. **NOTE:** Installation of new seals is only required if damaged seals were removed.

Using the Differential Bearing Cone Installer and Handle, install new VCT solenoid seal(s).



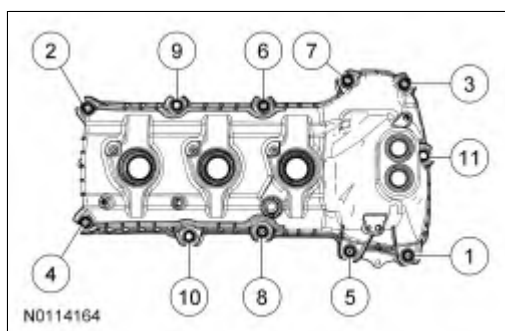
121. **NOTICE:** Failure to use the correct Motorcraft® High Performance Engine RTV Silicone may cause the engine oil to foam excessively and result in serious engine damage.

NOTE: If the valve cover is not installed and the fasteners tightened within 4 minutes, the sealant must be removed and the sealing area cleaned. To clean the sealing area, use silicone gasket remover and metal surface prep. Failure to follow this procedure can cause future oil leakage.

Apply an 8 mm (0.31 in) bead of Motorcraft® High Performance Engine RTV Silicone to the engine front cover-to-RH cylinder head joints.



122. Using a new gasket, install the RH valve cover and tighten the 3 bolts and 8 stud bolts in the sequence shown.
- Tighten to 10 Nm (89 lb-in).



123. Ensure the VCT seals in the valve cover are below the top of the VCT oil control solenoid electrical connector or the VCT seal may leak oil.

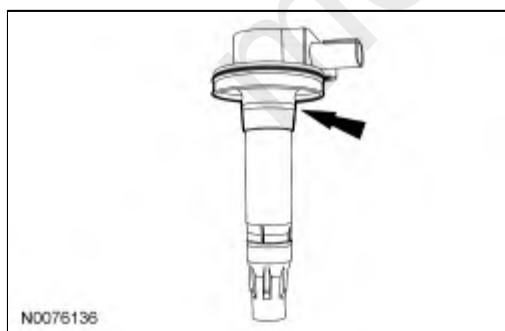


124. **NOTICE:** Only use hand tools when installing the spark plugs, or damage may occur to the cylinder head or spark plug.

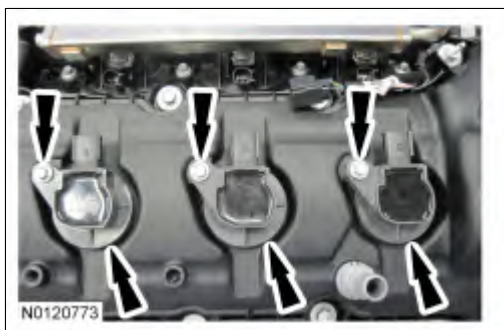
Install the 3 RH spark plugs.

- Tighten to 15 Nm (133 lb-in).

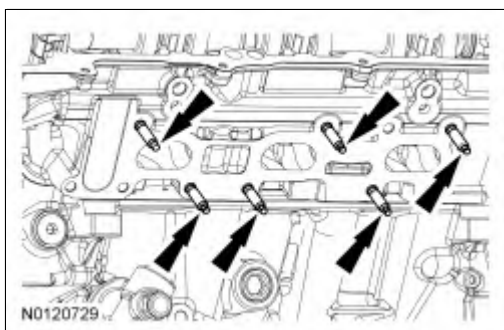
125. Inspect the coil seals for rips, nicks or tears. Remove and discard any damaged coil seals.
- To install, slide the new coil seal onto the coil until it is fully seated at the top of the coil.



126. Install the 3 RH ignition coil-on-plug assemblies and the 3 bolts.
- Tighten to 7 Nm (62 lb-in).



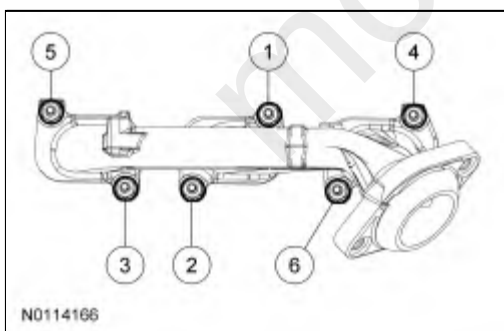
127. Install 6 new LH exhaust manifold studs.
- Tighten to 12 Nm (106 lb-in).



128. **NOTICE:** Failure to tighten the exhaust manifold nuts to specification a second time will cause the exhaust manifold to develop an exhaust leak.

Using a new gasket, install the LH exhaust manifold and 6 new nuts. Tighten in 2 stages in the sequence shown:

- Stage 1: Tighten to 19 Nm (168 lb-in).
- Stage 2: Tighten to 25 Nm (18 lb-ft).



129. Install the LH exhaust manifold heat shield and the 2 bolts.
- Tighten to 10 Nm (89 lb-in).



130. **NOTE:** Installation of new seals is only required if damaged seals were removed.

Using the VCT Spark Plug Tube Seal Installer and Handle, install new spark plug tube seals.



131. **NOTE:** Installation of new seals is only required if damaged seals were removed.

Using the Differential Bearing Cone Installer and Handle, install new VCT solenoid seal(s).



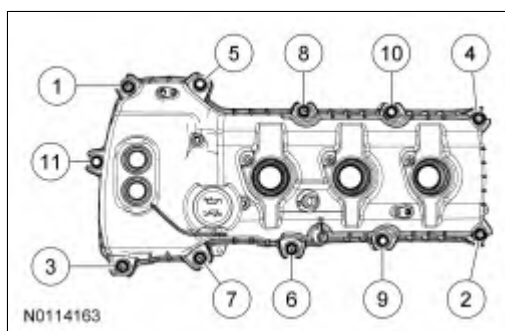
132. **NOTICE:** Failure to use the correct Motorcraft® High Performance Engine RTV Silicone may cause the engine oil to foam excessively and result in serious engine damage.

NOTE: If the valve cover is not installed and the fasteners tightened within 4 minutes, the sealant must be removed and the sealing area cleaned. To clean the sealing area, use silicone gasket remover and metal surface prep. Failure to follow this procedure can cause future oil leakage.

Apply an 8 mm (0.31 in) bead of Motorcraft® High Performance Engine RTV Silicone to the engine front cover-to-LH cylinder head joints.



133. Using a new gasket, install the LH valve cover and tighten the 4 bolts and 7 stud bolts in the sequence shown.
- Tighten to 10 Nm (89 lb-in).



134. Ensure the VCT seals in the valve cover are below the top of the VCT oil control solenoid electrical connector or the VCT seal may leak oil.

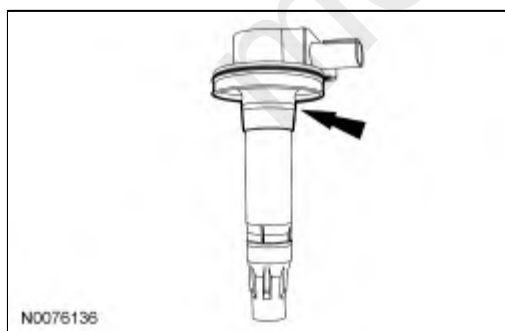


135. **NOTICE:** Only use hand tools when installing the spark plugs, or damage may occur to the cylinder head or spark plug.

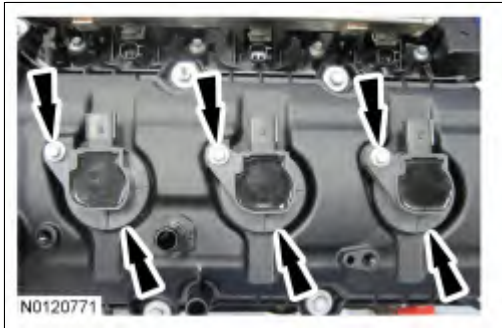
Install the 3 LH spark plugs.

- Tighten to 15 Nm (133 lb-in).

136. Inspect the coil seals for rips, nicks or tears. Remove and discard any damaged coil seals.
- To install, slide the new coil seal onto the coil until it is fully seated at the top of the coil.



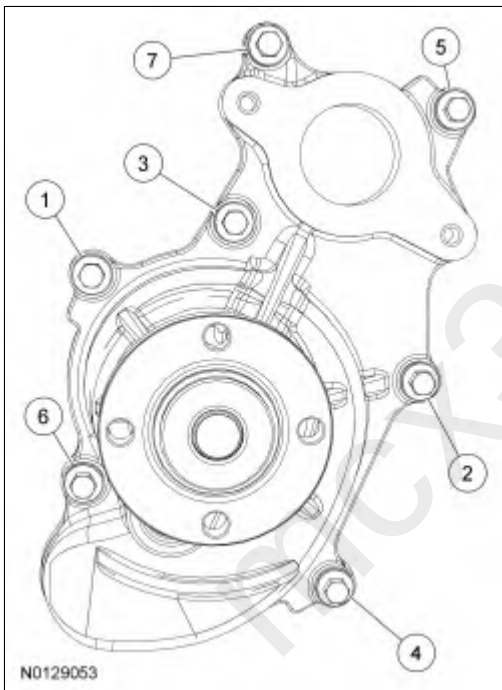
137. Install the 3 LH ignition coil-on-plug assemblies and the 3 bolts.
- Tighten to 7 Nm (62 lb-in).



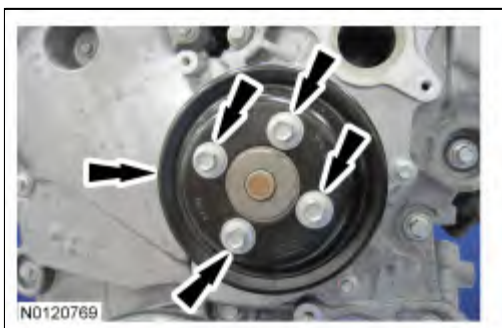
138. **NOTE:** Lubricate the O-ring seal with clean engine coolant.

Using new coolant pump gasket and coolant pump O-ring seal, install the coolant pump and the 7 bolts and tighten in the sequence shown in 2 stages:

- Stage 1: Tighten to 10 Nm (89 lb-in).
- Stage 2: Tighten an additional 45 degrees.



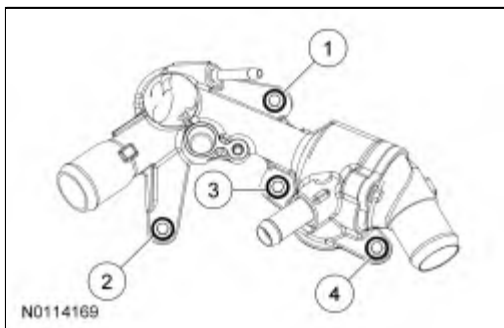
139. Install the coolant pump pulley and the 4 bolts.
- Tighten to 24 Nm (18 lb-ft).



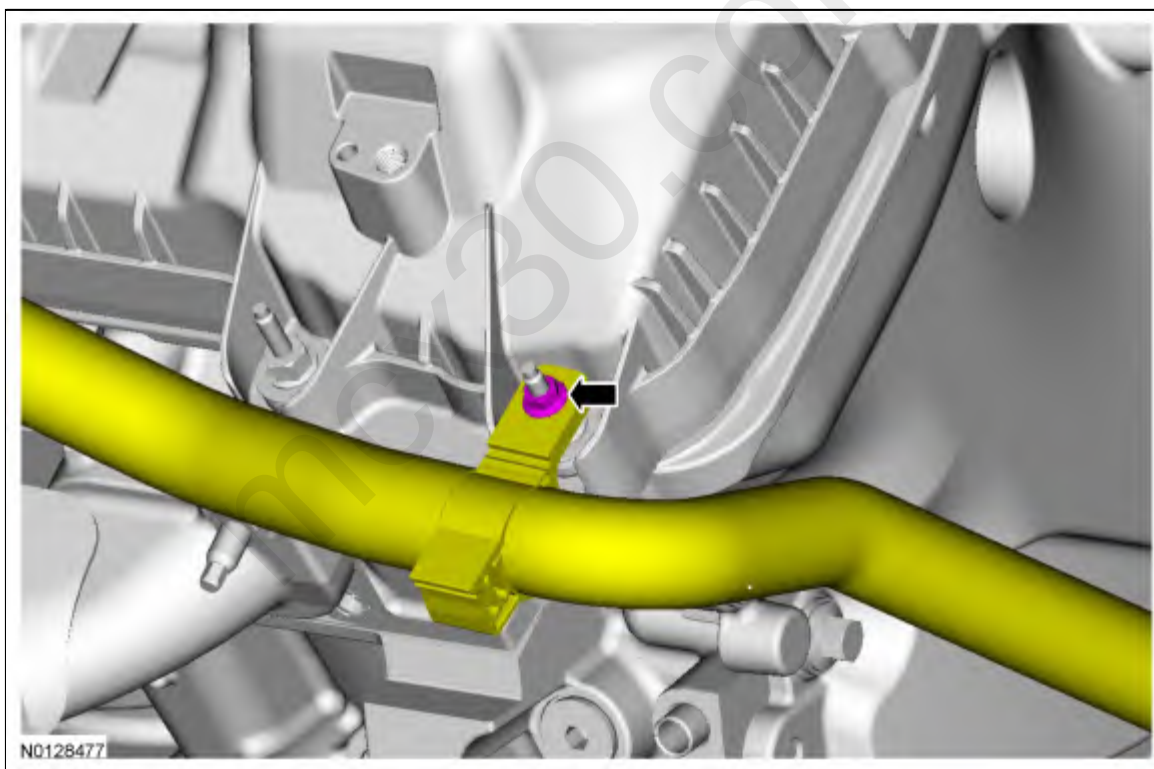
140. **NOTE:** Lubricate the coolant inlet tube O-ring seal with clean engine coolant.

Install the thermostat housing and the 4 bolts and tighten in the sequence shown in 2 stages:

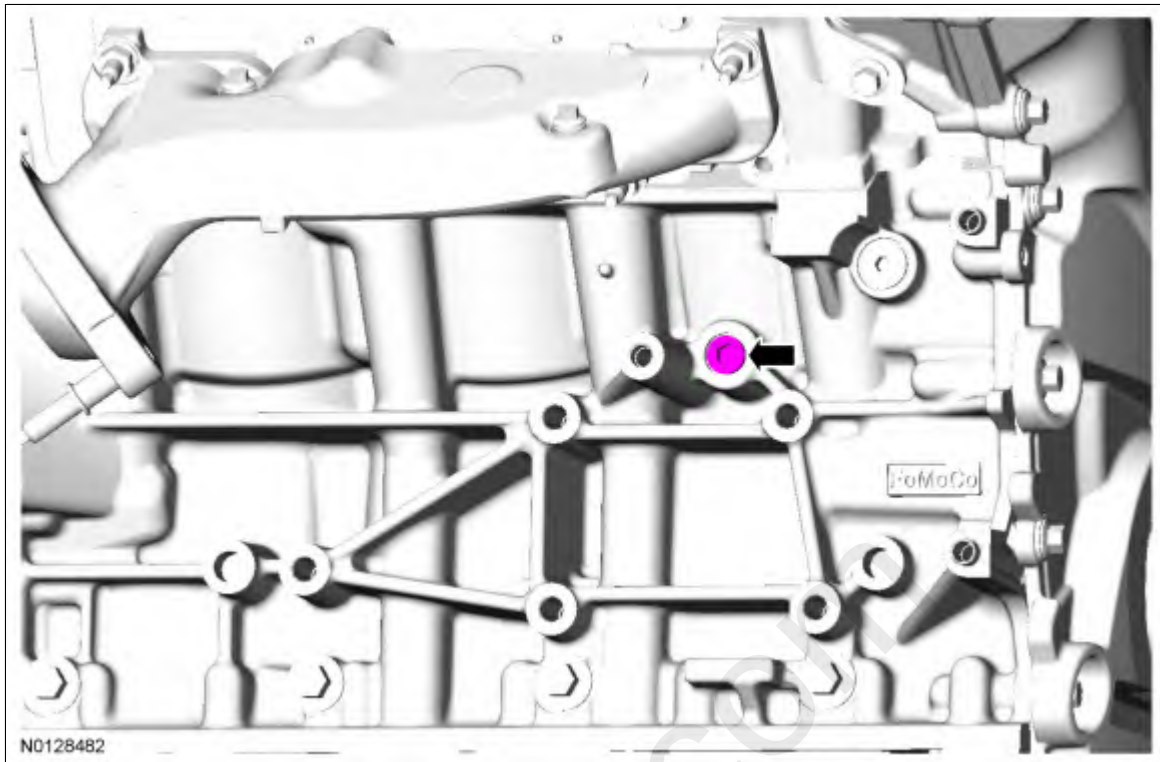
- Stage 1: Tighten to 8 Nm (71 lb-in).
- Stage 2: Tighten an additional 45 degrees.



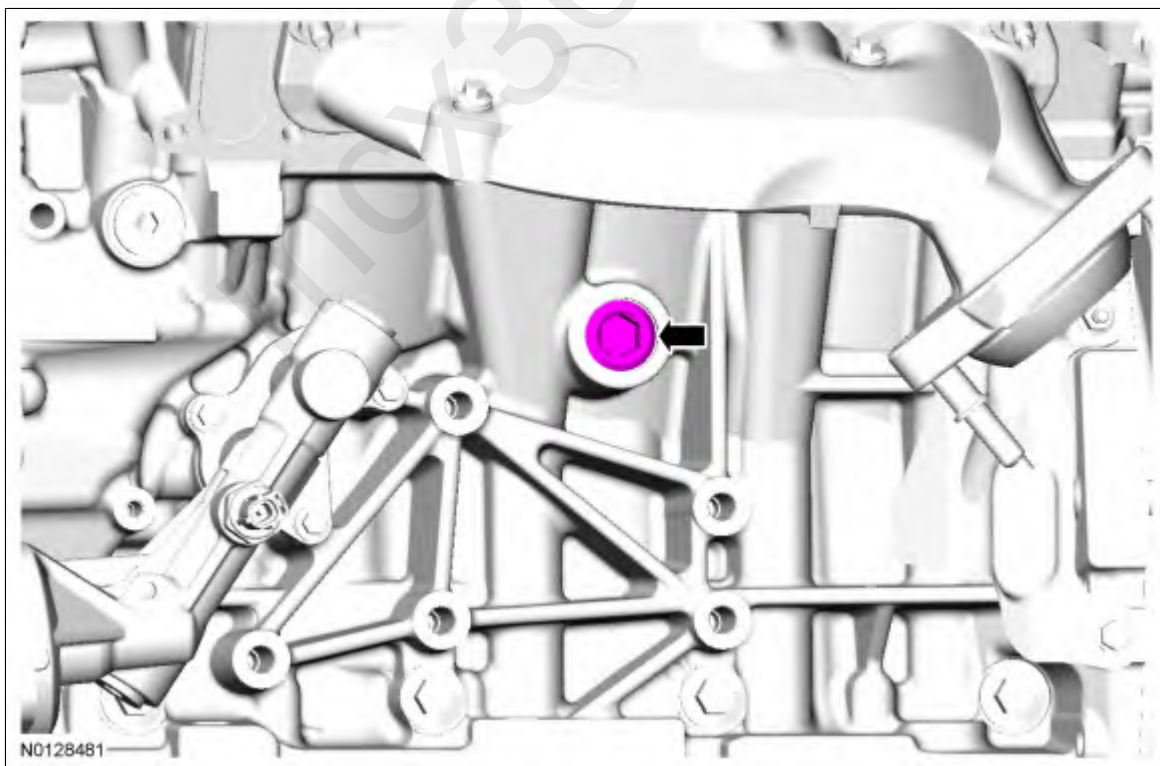
141. Install the heater hose bracket on the valve cover stud bolt and install the nut.
- Tighten to 8 Nm (71 lb-in).



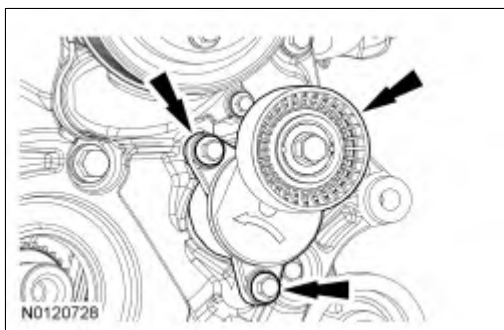
142. Install the RH cylinder block drain plug.
- Tighten to 16 Nm (142 lb-in) plus an additional 180 degrees.



143. Install the LH cylinder block drain plug.
- Tighten the cylinder block drain plug to 10 Nm (89 lb-in) plus an additional 720 degrees.

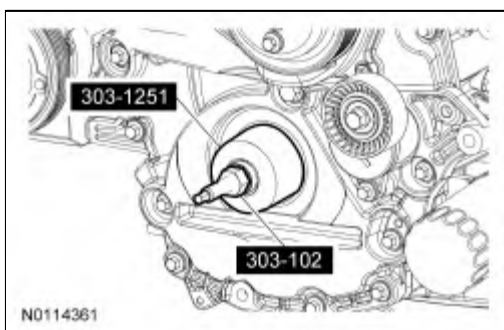


144. Install the accessory drive belt tensioner and the 2 bolts.
- Tighten to 25 Nm (18 lb-ft).



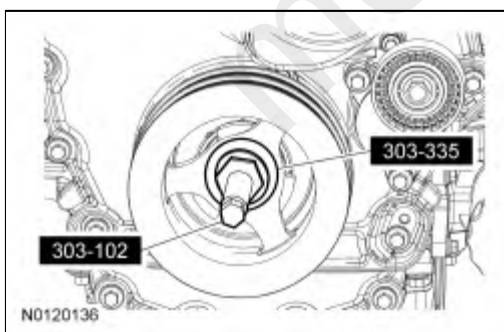
145. **NOTE:** Apply clean engine oil to the crankshaft front seal bore in the engine front cover.

Using the Front Crankshaft Seal Installer and Crankshaft Vibration Damper Installer, install a new crankshaft front seal.

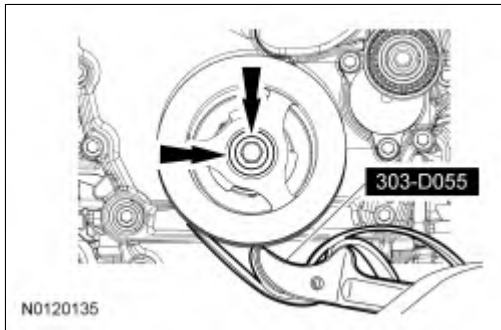


146. Lubricate the crankshaft front seal inner lip with clean engine oil.
147. **NOTE:** Lubricate the outside diameter sealing surfaces with clean engine oil.

Using the Front Cover Oil Seal Installer and Crankshaft Vibration Damper Replacer, install the crankshaft pulley.

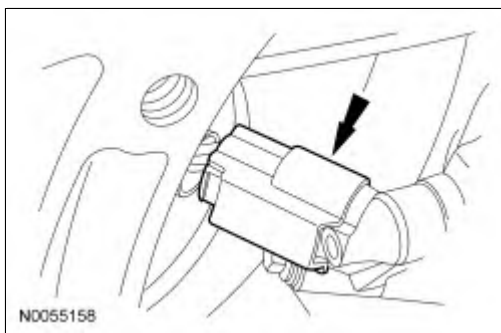


148. Using the Strap Wrench, install the crankshaft pulley washer and new bolt and tighten in 4 stages:
- Stage 1: Tighten to 120 Nm (89 lb-ft).
 - Stage 2: Loosen one full turn.
 - Stage 3: Tighten to 50 Nm (37 lb-ft).
 - Stage 4: Tighten an additional 90 degrees.

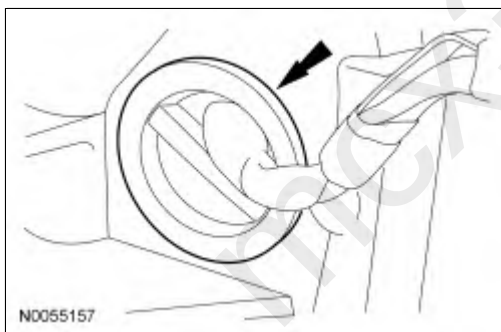


149. Attach all of the wiring harness retainers to the LH cylinder head, valve cover and stud bolts.

150. Connect the CKP sensor electrical connector.

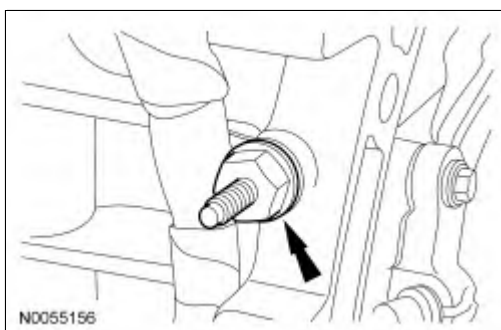


151. Install the wiring harness grommet.

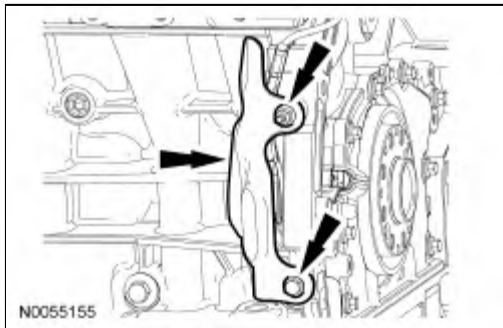


152. Install the wiring harness retainer stud bolt.

- Tighten to 10 Nm (89 lb-in).



153. Install the heat shield, the nut and the bolt.
- Tighten to 10 Nm (89 lb-in).



154. Connect the 2 LH CMP sensors electrical connectors.
- Attach the wiring harness retainer to the rear of the cylinder head.



155. Connect the KS electrical connector.



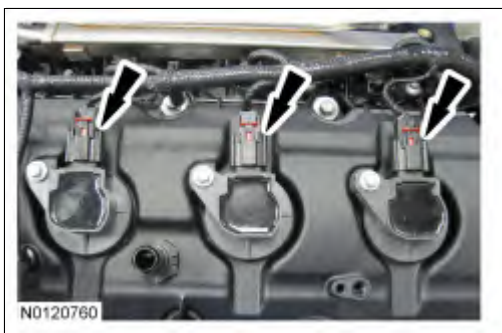
156. Connect the 2 LH VCT solenoid electrical connectors.



157. Connect the 3 LH fuel rail electrical connectors.



158. Connect the 3 LH ignition coil-on-plug electrical connectors.



159. Connect the Engine Oil Pressure (EOP) switch electrical connector.
- Attach the EOP switch wiring harness retainer to the cylinder head.



160. Attach all of the wiring harness retainers to the RH cylinder head, valve cover and stud bolts.
161. Connect the 2 RH CMP sensors electrical connectors.



162. Connect the 2 RH VCT solenoid electrical connectors.



163. Connect the 3 RH fuel rail electrical connectors.



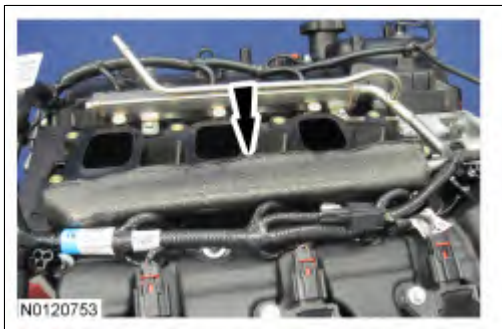
164. Connect the CHT sensor wiring harness jumper electrical connector.



165. Connect the 3 RH ignition coil-on-plug electrical connectors.



166. Install the RH fuel rail insulator.



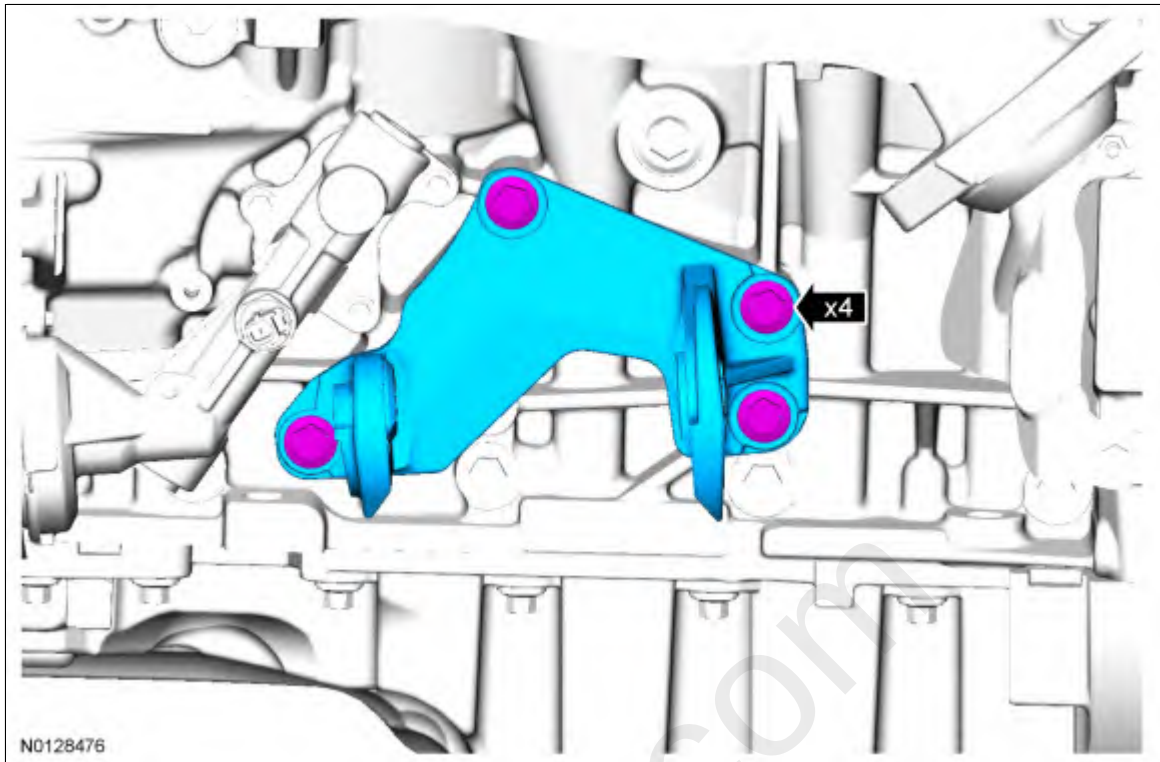
167. Install the LH fuel rail insulator.



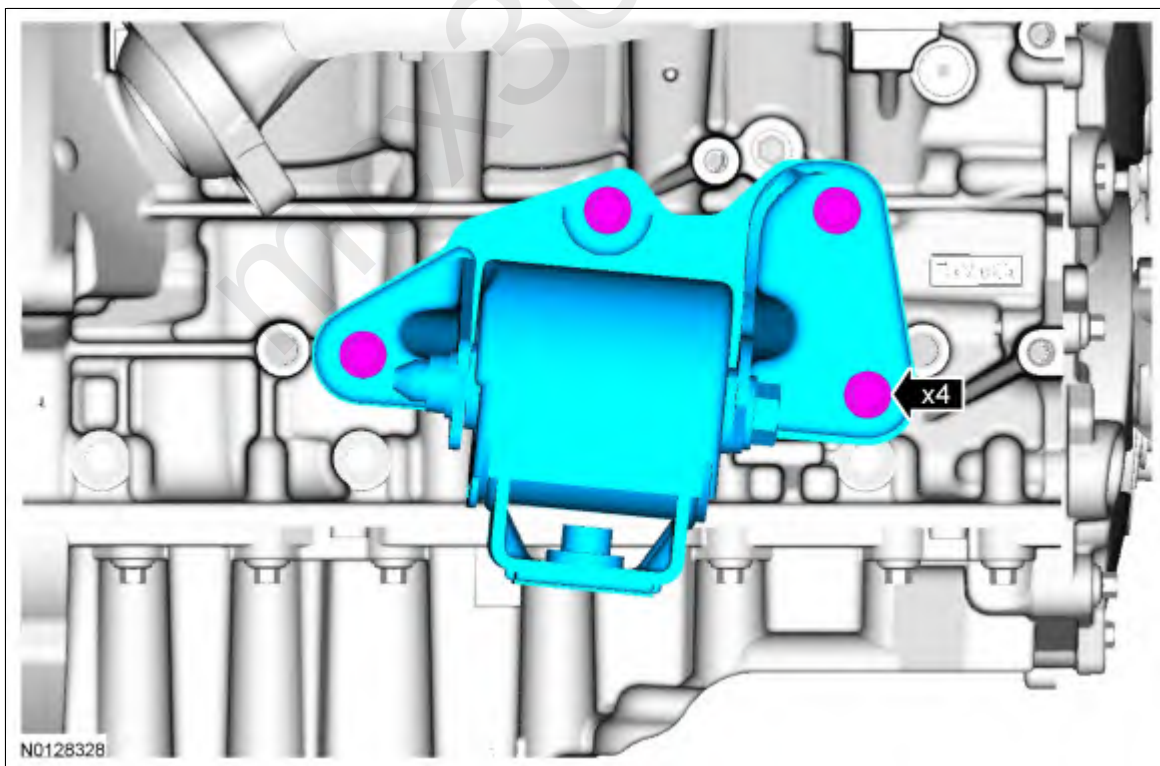
168. Install the engine oil level indicator.



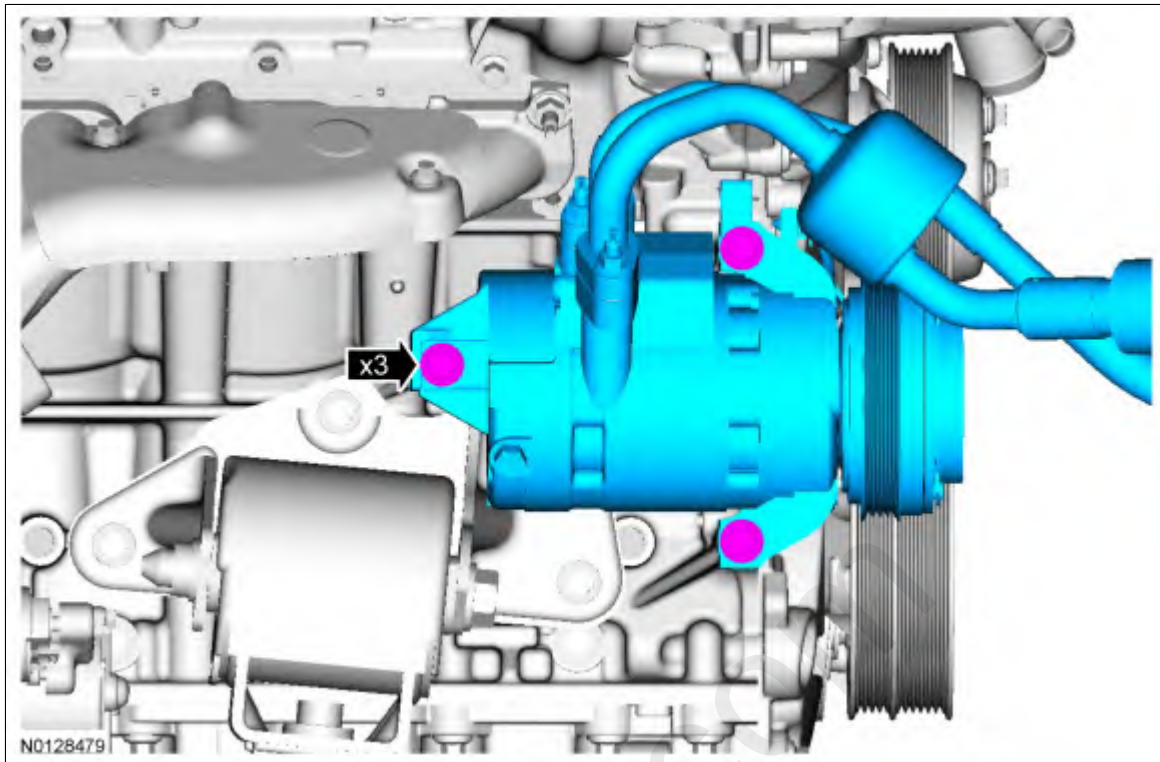
169. Install the LH engine support insulator-to-cylinder block bracket and the 4 bolts.
- Tighten to 63 Nm (46 lb-ft).



170. Install the RH engine support insulator and the 4 bolts.
- Tighten to 63 Nm (46 lb-ft).



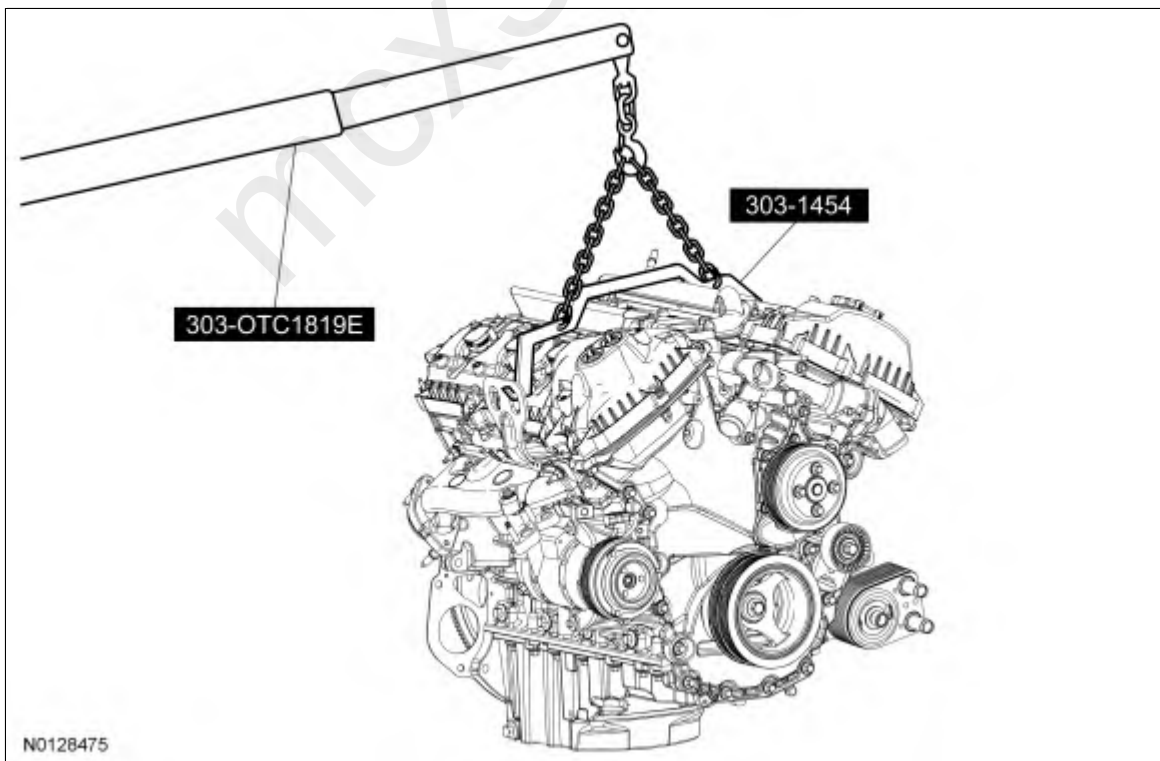
171. Install the A/C compressor and the 3 bolts.
- Tighten to 25 Nm (18 lb-ft).



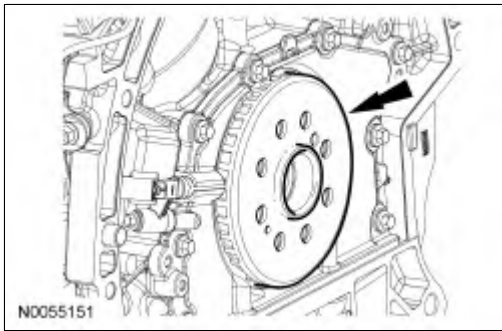
172. Install the LH and RH engine lift eyes.

- Tighten to 25 Nm (18 lb-ft).

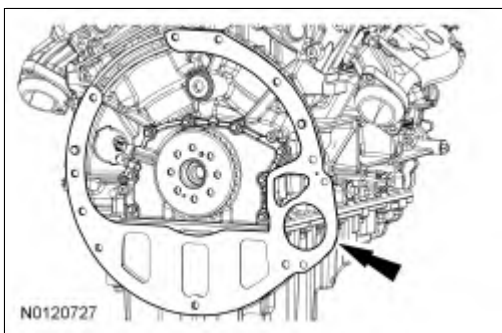
173. Using the Heavy Duty Floor Crane and Spreader Bar, remove the engine from the stand.



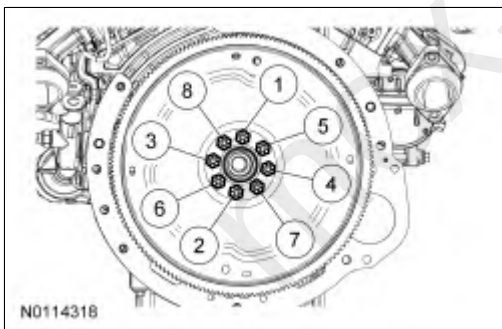
174. Install the crankshaft sensor ring.



175. Install the spacer plate.



176. Install the flexplate and the 8 bolts and tighten in sequence shown.
- Tighten to 80 Nm (59 lb-ft).



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