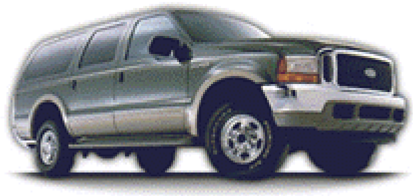
Workshop Manual

1999

F-Super Duty 250-550



3: Powertrain

1999 F-Super Duty 250-550 Contents/Index

GROUP 03: Engine

Engine

Engine Description

The 7.3L diesel engine is:

- a four-cycle turbocharged V-8 with overhead valves.
- 7.3 liter (444 cubic inch) displacement.
- separated into two banks, the right bank numbered 1, 3, 5, 7 and the left bank numbered 2, 4, 6, 8.
- rated at 215 horsepower at 3000 rpm.

The cylinder block (6010) has been designed to withstand the loads of diesel operations by using:

- four-bolt main bearing caps.
- internal piston cooling oil jets (6C327).
- a forged steel crankshaft (6303).
- heavy-duty forged steel connecting rods (6200).

The piston and rings are:

- made of aluminum alloy.
- fitted with an upper keystone compression ring.
- fitted with a lower rectangular compression ring.
- fitted with oil control rings.

The piston pins (6135) are:

- a free-floating type permitting the piston pin to move/float freely in the piston pin bore.
- retained in the piston and rings by piston pin retainers (6140).

The camshaft (6250) is:

- supported by five insert-type camshaft bearings (6A251).
- of the roller camshaft design.
- driven by the crankshaft through the use of the crankshaft gear and the camshaft gear.

The hydraulic valve tappets (6500):

- minimize engine noise.
- maintain zero valve lash.
- incorporate camshaft follower guides.

- incorporate a roller follower design that reduces camshaft wear.

The cylinder heads (6049) are designed:

- to incorporate electronically controlled/hydraulically actuated fuel injectors (9F593).
- to locate the fuel injectors in the center of the combustion chambers between the rocker arms (6564).
- with integral high-pressure oil galleries.

The glow plug system is:

- designed to preheat the cylinders for faster cold weather starts.
- controlled by the powertrain control module (PCM) (12A650).
- mounted directly into the cylinder heads.
- activated by the glow plug control module (12B533).

The optional block heater (6A051) is:

- designed to heat the engine coolant and oil for improved cold weather starts.
- located near the oil filter (6731) in the oil cooler (6A642).
- powered by a 120-volt external power source.
- replaceable but not repairable.

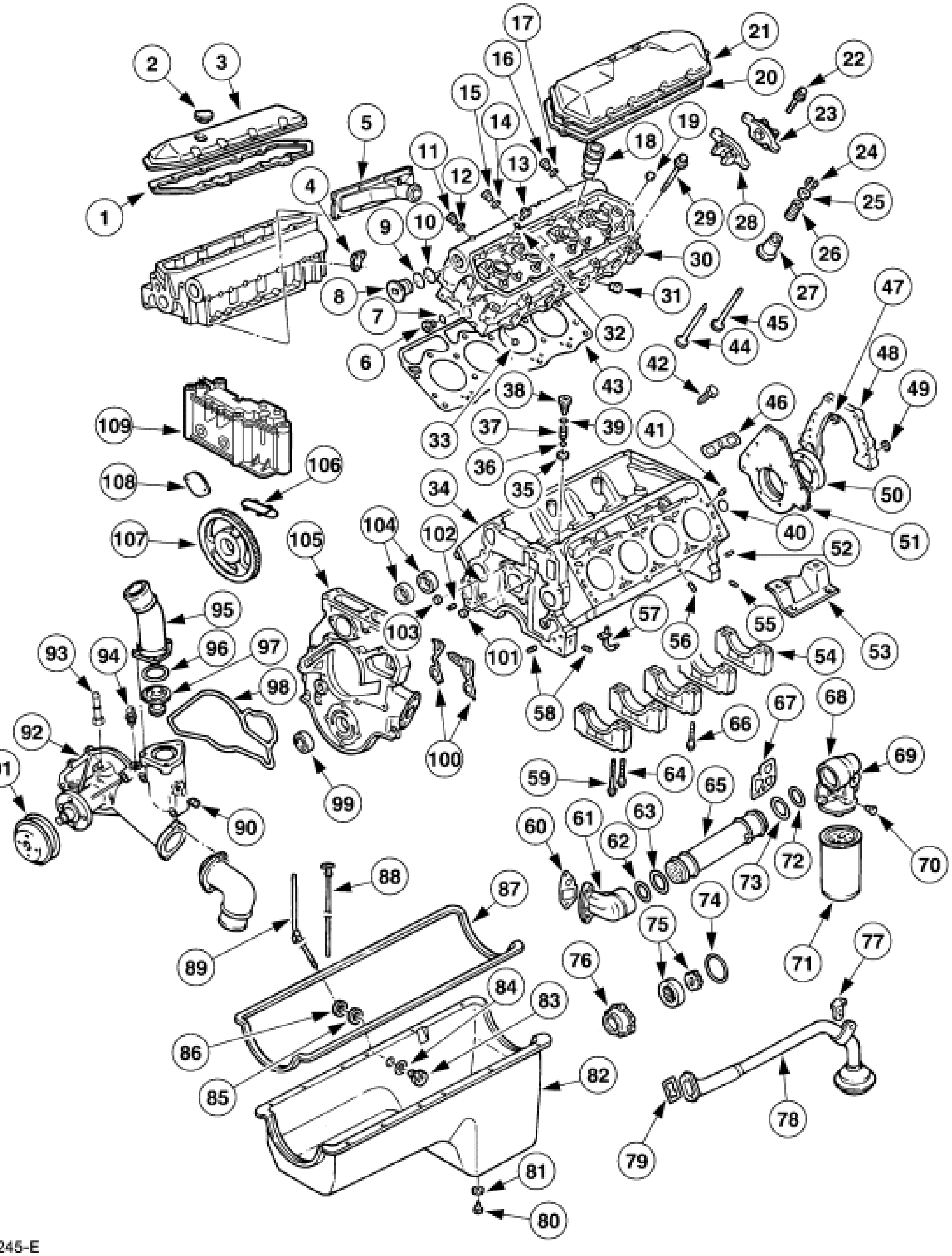
The fuel injection system used on the engine:

- is controlled by the powertrain control module.
- utilizes an electric in-line fuel pump (9350).
- circulates through a combination fuel filter, fuel heater and water separator assembly.
- uses eight electronically controlled/hydraulically actuated fuel injectors.
- maintains operating pressures between 275-448 kPa (40-65 psi).

The engine lubrication system:

- is divided into two systems: the low-pressure system lubricates the engine (6007), the high-pressure system actuates the fuel injectors.
- maintains pressures between 69-414 kPa (10-60 psi) for the low-pressure system and 4137-20,685 kPa (600-3,000 psi) for the high-pressure system.
- is cooled by an engine oil cooler.
- utilizes an oil pressure sensor (9278) and an oil pressure regulator.
- actuates the exhaust back-pressure warm-up system integral to the turbocharger.

1998 7.3L (DIT) Engine



Item	Part Number	Description
1	6584	Valve cover gasket
2	6766	Oil filler cap

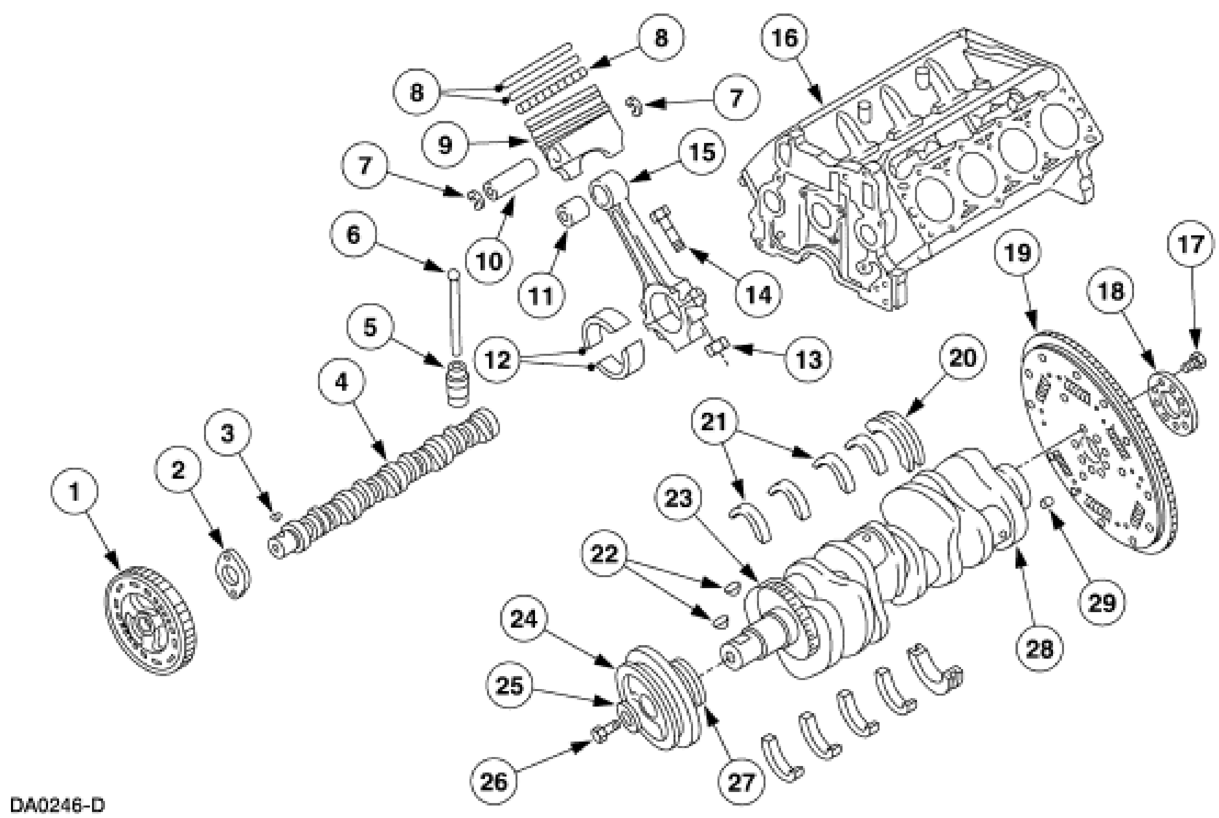
3	6582	Valve cover
4	1822844C1	Lifting eye
5	9E434	Intake manifold cover
6	1818188C1	Plug, fuel rail drain
7	1815734C1	O-ring seal, fuel rail drain plug
8	1818186C1	Plug, oil supply rail
9	1814546C1	Ring, backup supply rail
10	1815873C1	O-ring seal, oil supply rail
11	9410357	Plug
12	9N693	O-ring seal
13	1815944C1	Plug, oil rail drain
14	9N693	O-ring seal
15	9410357	Plug
16	9410357	Plug
17	9N693	O-ring seal
18	9F538	Sleeve, fuel injector
19	6026	Plug, cup
20	6584	Valve cover gasket
21	6582	Valve cover
22	6A527	Rocker arm bolt
23	6564	Rocker arm
24	6518	Valve spring retainer key
25	6514	Valve spring rotator
26	6513	Valve spring
27	6571	Valve stem seal
28	6564	Rocker arm
29	6065	Cylinder head bolt
30	6049	Cylinder head
31	445751	Plug, pipe
32	1815887C1	O-ring seal
33	6026	Ball, steel (plug)
34	6010	Cylinder block
35	6674C	Seat, ball (part of kit 6674)
36	13722D	Ball, 1/2-inch metal (part of kit 6674)
37	6670	Oil pump relief valve spring

38	6666	Oil pump relief valve plug
39	6674A	O-ring seal (part of kit 6674)
40	6026	Engine block plug
41	6A008	Cylinder head to block dowel
42	—	Bolt and spring washer assy (part of 6C329)
43	6051	Head gasket
44	6507	Exhaust valve
45	6505	Intake valve
46	6C329	Guide, camshaft follower
47	437157 R1	Ring, flywheel adapter housing retaining
48	6A369	Transmission adapter
49	437157 R1	Ring, flywheel adapter housing retaining
50	6701	Crankshaft rear oil seal
51	6L080	Cover, engine rear
52	20640 R1	Pin, dowel
53	6031	Bracket, front engine support mounting
54	—	Cap, main bearing (part of 6010)
55	445684	Plug, oil cooler drain, 3/8 NPTF
56	444619	Plug, 1/4-18
57	6C327	Piston cooling oil jet
58	445684	Plug, oil drain, 3/8 NPTF
59	6345	Crankshaft main bearing cap stud
60	6A636	Gasket, oil cooler front header
61	6881	Header, oil cooler front
62	6K649	O-ring seal, oil cooler inner
63	6C610	O-ring seal, oil cooler outer
64	6345	Crankshaft main bearing cap bolt
65	6A642	Oil cooler
66	6345	Crankshaft main bearing cap bolt
67	6A636	Gasket, oil cooler rear header
68	6881	Header, oil cooler rear
69	6A051	Block heater
70	444814	Plug
71	6731	Oil filter
72	6K649	O-ring seal, oil cooler outer

73	6C610	O-ring seal, oil cooler inner
74	6619	O-ring seal, oil pump housing
75	6608	Gerotor oil pump
76	6616	Oil pump housing
77	6A661	Bracket, oil pump screen cover and tube
78	6622	Oil pump screen cover and tube
79	6626	Oil pump inlet tube gasket
80	6730	Oil pan drain plug
81	6734	Oil pan drain plug gasket
82	6675	Oil pan
83	6754F	Adapter, oil level indicator tube (part of 6754)
84	6754E	O-ring seal, oil level indicator tube adapter retainer (part of 6754)
85	6754D	Flange, oil level indicator tube adapter retainer (part of 6754)
86	6754C	O-ring seal, oil level indicator tube (part of 6754)
87	E2AZ-19562-B	Gasket maker
88	6750	Oil level indicator
89	6754	Oil level indicator tube
90	—	Plug, pipe (part of 8501)
91	8509	Water pump pulley
92	8501	Pump, water
93	1822716C1	Nipple — heater return hose
94	12A648	Engine coolant temperature (ECT) sensor
95	8592	Outlet, water pump
96	8255	Gasket, water outlet
97	8575	Water thermostat
98	8507	Water pump housing gasket
99	6700	Crankshaft front seal
100	6020	Engine front cover gasket
101	444776	Plug, tappet oil gallery
102	6B041	Pin, dowel (engine front cover)
103	444776	Plug, tappet oil gallery
104	6A251	Camshaft bearing

105	6019	Engine front cover
106	6619	Gasket, oil reservoir
107	6655	Gear, high-pressure oil pump drive
108	6B070	Cover, oil pump drive gear access
109	6658	Reservoir, high-pressure oil pump supply and cover

7.3l (dit) crankshaft, camshaft and piston



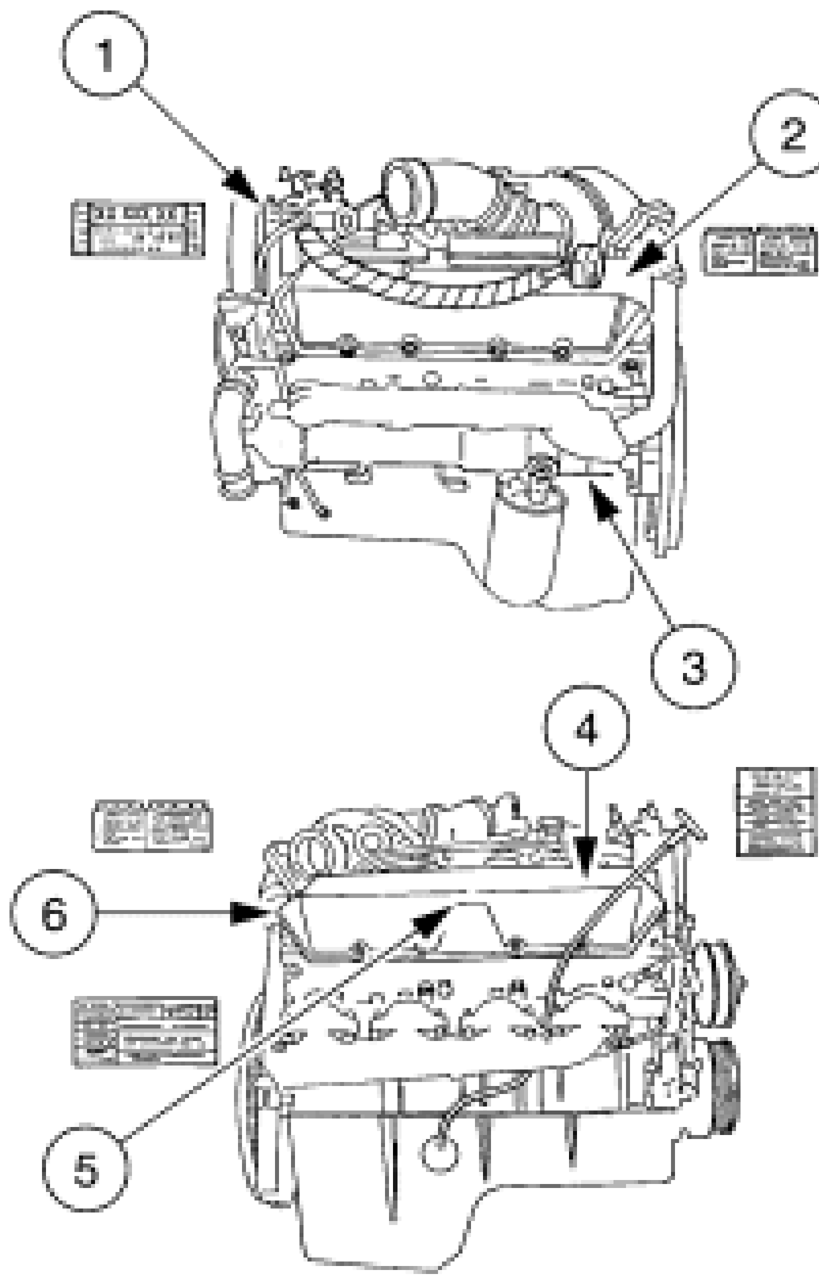
Item	Part Number	Description
1	6256	Camshaft drive gear
2	6269	Camshaft thrust plate
3	6L269	Camshaft drive gear key
4	6250	Camshaft
5	6500	Valve tappet
6	6565	Push rod
7	6140	Piston pin retainer
8	6148	Partial piston ring set (8 req'd)
9	6102	Piston

10	6135	Piston pin
11	6207	Connecting rod bushing
12	6211	Connecting rod bearing
13	6212	Connecting rod nut
14	6214	Connecting rod bolt
15	6200	Connecting rod
16	6010	Cylinder block
17	6379	Flywheel retaining bolt
18	6A366	Flywheel reinforcing plate
19	6375	Flywheel — (automatic transmission) (not shown)
20	6337	Crankshaft thrust main bearing
21	6333	Crankshaft main bearing
22	6B316	Crankshaft key
23	—	Crankshaft sprocket (part of 6303)
24	6316	Crankshaft vibration damper
25	6332	Washer, crankshaft vibration damper
26	6A340	Crankshaft pulley bolt
27	6310	Crankshaft damper wear ring
28	6303	Crankshaft
29	20024 R1	Pin, dowel

Engine Identification

Vehicle identification, the location of the vehicle rating and data plates, and engine code information is fully covered in Section 100-01. For specific and exact engine identification, an engine calibration code label is affixed to the B-pillar. Refer to the following illustration for examples of engine identification labeling.

Engine Labels



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Item	Part Number	Description
1	—	Engine code label (part of 6007)
2	—	Electrical system caution

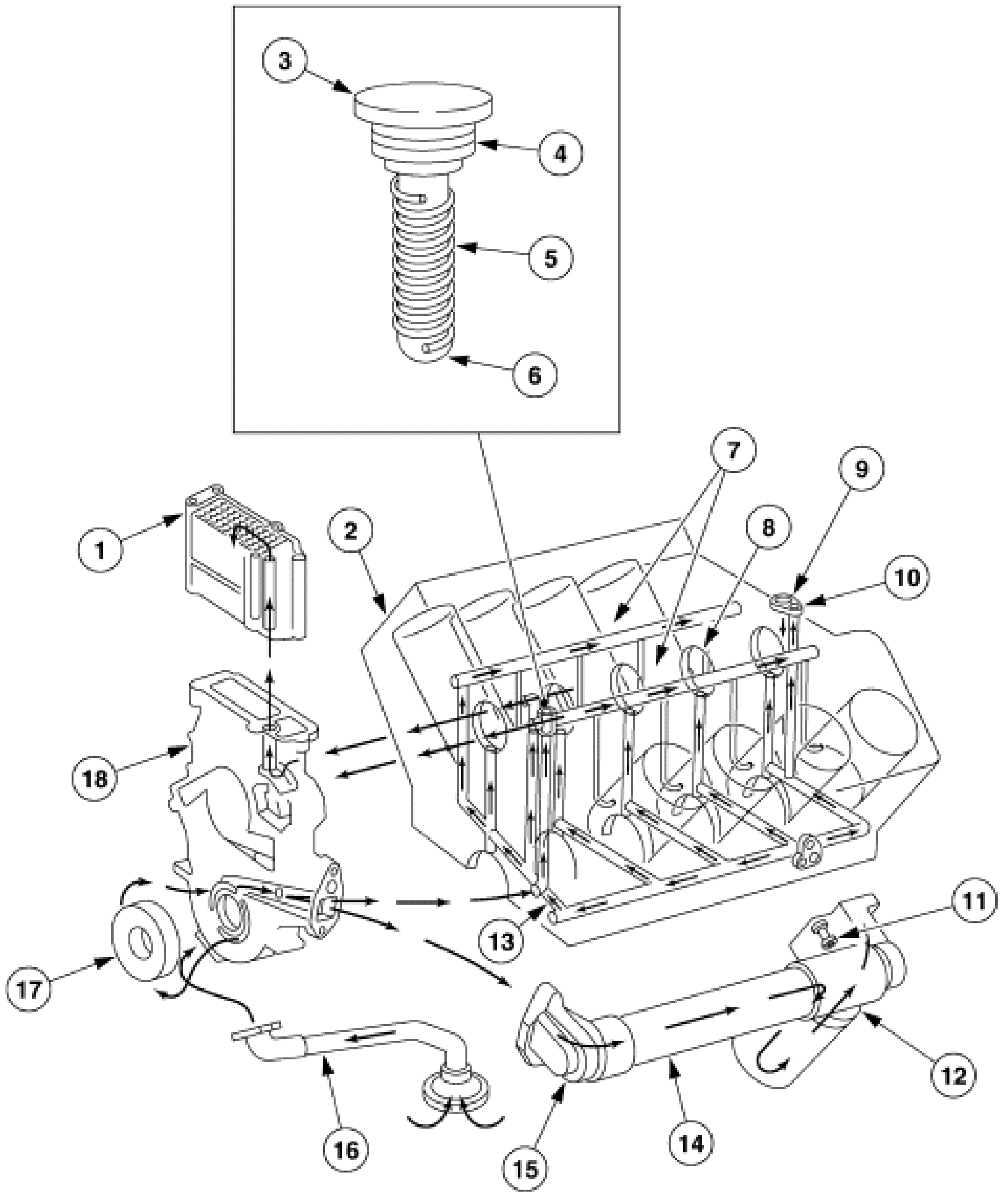
		(part of 6007)
3	—	Stamped serial number (on crankcase) (part of 6007)
4	—	Oil change label (part of 6007)
5	—	Emission label (part of 6007)
6	—	Electrical system caution (part of 6007)

Calibration Code Label

Refer to the Powertrain Control/Emissions Diagnosis (PC/ED) manual.

Lubrication System — Low-Pressure

Low-Pressure Oil Flow



Item	Part Number	Description
1	6658	High-pressure oil pump reservoir
2	6010	Cylinder block
3	—	Anti-drain check ball cap (part of 6658)
4	—	O-ring seal (part of 6658)
5	—	Spring (part of 6658)
6	—	Check ball (part of 6658)

7	—	Valve lifter oil galleries (part of 6010)
8	6C327	Piston cooling oil jet
9	—	Turbocharger oil return gallery (part of 6010)
10	—	Turbocharger oil supply gallery (part of 6010)
11	—	Pressure relief/regulator valve (part of 9155)
12	—	Oil filter bypass drain (part of 6881)
13	—	Main oil gallery (part of 6010)
14	6A642	Oil cooler
15	6881	Oil cooler header
16	6622	Oil pump screen cover and tube
17	6608	Gerotor oil pump
18	6019	Engine front cover

The lubrication system is comprised of a low-pressure system and a high-pressure system. The low-pressure system provides primary engine lubrication while the high-pressure system provides the hydraulic pressure required to actuate the fuel injectors.

The gerotor oil pump draws oil from the engine oil pan (6675) through the oil pump screen cover and tube (6622) into the oil inlet passage in the front cover. The gerotor oil pump then pumps the oil back out through the outlet passage in the front cover. The oil separates into two paths.

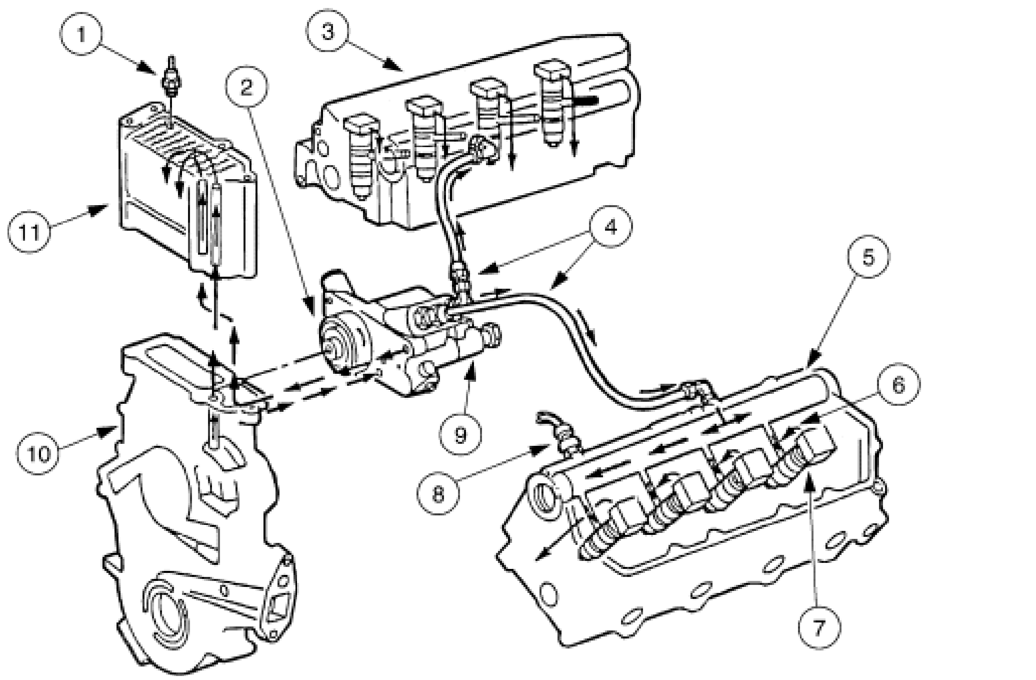
One flow path sends oil into the high-pressure pump reservoir possibly through the anti-drainback check ball during cold start. One feed leaves the check ball and enters the front cover. From there it enters the high-pressure oil reservoir. The second feed exits the check ball and enters the left bank valve lifter oil gallery.

After leaving the front cover outlet passage, the second oil path sends the oil through the oil cooler and filter assembly. Once inside the filter housing, the oil filter bypass valve may open to vent excess pressure and oil back into the oil pan. After the oil has been circulated through the oil filter, the oil feed then enters the main oil gallery (integral to the cylinder block). Once in the main oil gallery, the oil is routed to the five crankshaft main bearings (6333) through five drilled and machined feed galleries (integral to the cylinder block). The five camshaft bearings receive the oil feed through five vertically drilled and machined feed galleries connected to the main bearing feed galleries. The front main bearing feed gallery also supplies oil to the right bank valve lifter oil gallery through a vertically drilled and machined oil feed gallery (integral to the cylinder block). The rear main bearing oil feed gallery also supplies oil to the turbocharger assembly through a vertically drilled and machined oil feed gallery (integral to the cylinder block).

Pressurized oil entering the turbocharger assembly is utilized to actuate the exhaust back-pressure warm-up system. The oil drains back through the turbocharger mounting pedestal and back into the oil pan. The valve lifter oil gallery supplies pressurized oil to the valve tappets and to the piston cooling oil jets. Oil from the valve tappets is routed upward to the cylinder head valve train through hollow push rods (6565). Once in the cylinder head, the oil drains back to the oil pan through return ports at each end of the cylinder head.

Lubrication System — High-Pressure

High-Pressure Oil Flow



Item	Part Number	Description
1	9278	Oil pressure sensor
2	6600	High-pressure oil pump
3	6049	Cylinder head
4	9A332	High-pressure oil feed hoses
5	—	High-pressure oil rail (part of 6049)
6	—	Injector oil feed galleries (part of 6049)
7	9F593	Fuel injectors (8 req'd)
8	9F838	Oil pressure sensor
9	7A139	Injection pressure regulator (IPR)
10	6019	Engine front cover
11	6658	High-pressure oil pump reservoir

During initial start or cold start, the high-pressure oil pump (6600) receives oil from the left side valve lifter oil gallery possibly through the anti-drain back check ball valve. Once the engine starts or during warm engine starts, the check ball closes and the high-pressure oil pump receives filtered oil from the high-pressure oil pump reservoir. The high-pressure oil pump pumps the oil under extremely high pressures (4,115-20,577 kPa [600-3,000 psi]) through the left and right side high-pressure supply hoses to the high-pressure oil rails (integral to the cylinder heads). Once in the oil rail, the oil is fed to the fuel injector bores through four oil feed galleries drilled and machined in the cylinder head. The high-pressure oil then actuates the fuel injectors.

SECTION 303-01C: Engine — 7.3L Diesel — 1999 F-Super Duty 250-550 Workshop Manual
SPECIFICATIONS — Procedure revision date: 08/23/2002

Engine Specifications

Bore and Stroke	Firing Order	Oil Pressure, Normal Operating Temperature @ 3,300 rpm kPa (PSI)	Engine Type and Number of Cylinders	Compression Ratio
4.11 in x 4.18 in	1-2-7-3-4-5-6-8	276-482 kPa (40-70)	O.H.V. V-8	17.5 to 1

Drive Belt Tension

Tensioning Method	Belt Tension
Automatic	378 N (85 Lbs.) Min.

Cylinder Head

Valve Guide Bore Diameter		Valve Seat Width		Valve Seat Runout TIR Maximum	Valve Arrangement Front to Rear	Gasket Surface Flatness	Deck to Deck Dimension
Intake	Exhaust	Intake	Exhaust				
0.3141 in-0.3151 in[a]	0.3141 in-0.3151 in[a]	1.651-2.413 mm (0.065 in-0.095 in)[b]	1.651-2.413 mm (0.065 in-0.095 in)[b]	0.05 mm (0.002 in)	LH I-E-I-E-I-E-I-E RH E-I-E-I-E-I-E-I	0.025 mm (0.001 in) in 2 in 0.10 mm (0.004 in) overall[c]	129.41-129.67 mm (5.095 in-5.105 in)

[a] Maximum 0.3180 in.
[b] Valve seat angle — intake 30° and exhaust 37.5°.

[c] Gasket surface finish — 63-125 RMS.

Rocker Arm Shaft, Push Rods and Valve Tappets					
Type	Push Rod Runout TIR Maximum	Valve Tappet or Lifter			Collapsed Tappet Gap (Clearance)
		Standard Diameter	Clearance to Bore	Hydraulic Lifter Leak-Down Rate	
Hydraulic Roller Follower	0.5 mm Max. (0.02 in)	23.391-23.411 mm (0.9209 in-0.9217 in)	0.027-0.086 mm (0.0011 in-0.0034 in)[a]	18-90 Sec. for 3.17 mm (0.125 in) Travel[b]	4.69 mm (0.185 in) Max.[c]

[a] Service limit — 0.005.
[b] Time required for plunger to move 0.125 in. under load of 50 lbs. with test fluid at room temperature.
[c] Measured at valve tip to rocker arm.

Valve Springs						
Valve Spring Compression Pressure Lbs. @ Specified Height		Valve Spring Free Length (Approximate)		Valve Spring Assembled Height		Valve Spring Out of Square Maximum
Intake	Exhaust	Intake	Exhaust	Intake	Exhaust	
32-35 kg @ 46.55 mm (71-79 lbs. @ 1.833 in) 102-112 kg @ 34.35 mm (225-249 lbs. @ 1.352 in)	32-35 kg @ 46.55 mm (71-79 lbs. @ 1.833 in) 102-112 kg @ 34.35 mm (225-249 lbs. @ 1.352 in)	52.70 mm ± 3.8 mm (2.075 in ± 0.150 in)	44.881 mm (1.767 in)	46.558 mm (1.833 in)	1.981 mm (0.078 in)	

Valves				
Valve Stem-to-Guide Clearance (Max.)		Valve Face Angle		Valve Face Runout TIR Maximum
Intake	Exhaust	Intake	Exhaust	
0.140 mm (0.0055 in)[a]	0.140 mm (0.0055 in)[a]	30 Degrees	37.5 Degrees	0.050 mm (0.002 in)

[a] Service clearance — .0055.

Valves (Continued)				
Minimum Valve Face Margin —Intake Valves	Minimum Valve Face Margin —Exhaust Valves	Valve Stem Diameter	Valve Head Recession Relative to Deck Surface	
			Intake	Exhaust

1.67 mm (0.066 in)	1.37 mm (0.054 in)	7.921-7.939 mm (0.31185-0.31255 in)	1.17-1.47 mm (0.046-0.058 in)	1.32-1.63 mm (0.052-0.064 in)

Camshaft					
				Camshaft Thrust Plate Thickness	
End Play	**Camshaft Journal to Bearing Clearance**	**Intake — Lobe Lift**	**Exhaust — Lobe Lift**	**Thrust Area**	**Outside of Thrust Area**
0.051-0.203 mm (0.002-0.008 in)	0.051-0.165 mm (0.002-0.006 in)	6.44 mm (0.2535 in) Max.	6.43 mm (0.2531 in) Max.	3.910-3.961 mm (0.154-0.156 in)	3.784-3.987 mm (0.149-0.157 in)

Camshaft Drive						
Camshaft Bearing Inside Diameter					**Camshaft Front Bearing Location**	**Gear Backlash**
No. 1	**No. 2**	**No. 3**	**No. 4**	**No. 5**		
53.39-53.48 mm (2.102-2.105 in)[a]	53.39-53.48 mm (2.102-2.105 in)	53.39-53.48 mm (2.102-2.105 in)	53.39-53.48 mm (2.102-2.105 in)	53.39-53.48 mm (2.102-2.105 in)	0.020-0.050 in[b]	0.140-0.256 mm (0.0055-0.0101 in)

[a] All camshaft journals are 53.31-53.34 mm (2.099-2.100 in.).
[b] Distance in inches that front edge of the bearing is installed below the front face of the cylinder block.

Cylinder Block		
Cylinder Bore Diameter	**Head Gasket Surface Flatness**	**Bore Size**
Standard[a]	0.001 in any 2 in 0.004 in. overall	104.384-104.402 mm (4.1096-4.1103 in)
0.010 Oversize	0.001 in any 2 in 0.004 in overall	104.502 mm (4.11425 in)
0.020 Oversize	0.001 in any 2 in 0.004 in overall	104.756 mm (4.12425 in)
0.030 Oversize	0.001 in any 2 in 0.004 in overall	105.010 mm (4.13425 in)

[a] Maximum out-of-round — 0.051 mm (0.002 in.); maximum taper — 0.076 mm (0.003 in.).

Crankshaft and Flywheel							
Crankshaft Diameter	**Main Bearing Journal Diameter**	**Main Bearing Journal Out-of-Round Maximum**	**Main Bearing Thrust Face Runout TIR Maximum**	**Main Bearing Journal Taper Maximum per Inch**	**Thrust Bearing Journal Width**	**Main and Rod Bearing Journal Finish RMS Maximum**	**Main Bearing Thrust Face Finish RMS Maximum**
Standard	79.139-79.340 mm (3.1228-3.1236 in)	0.0056 mm (0.00022 in)	0.025 mm (0.001 in)	0.0038 mm (0.00015 in)	31.509-31.585 mm (1.2405-1.2435 in)	10	20
0.010 Undersize	79.065-79.085 mm (3.1128-3.1136 in)	0.0056 mm (0.00022 in)	0.025 mm (0.001 in)	0.0038 mm (0.00015 in)	31.509-31.585 mm (1.2405-1.2435 in)	10	20
0.020 Undersize	78.811-78.831 mm (3.1028-3.1036 in)	0.0056 mm (0.00022 in)	0.025 mm (0.001 in)	0.0038 mm (0.00015 in)	31.509-31.585 mm (1.2405-1.2435 in)	10	20
0.030 Undersize	78.557-78.577 mm (3.0928-3.0936 in)	0.0056 mm (0.00022 in)	0.025 mm (0.001 in)	0.0038 mm (0.00015 in)	31.509-31.585 mm (1.2405-1.2435 in)	10	20

Crankshaft and Flywheel (Continued)					
Crankshaft Diameter	**Connecting Rod Journal Diameter**	**Connecting Rod Journal Taper per Inch Maximum**	**Crankshaft End Play**	**Flywheel and Ring Gear Runout**	**Flywheel and Ring Gear Concentricity**
Standard	63.45-63.47 mm (2.4980-2.4990 in)[a]	0.0066 mm (0.00026 in)	0.063-0.216 mm (0.0025-0.0085 in)[b]	0.203 mm (0.008 in)	0.203 mm (0.008 in)
0.010 Undersize	63.20-63.22 mm (2.488-2.489 in)	0.0066 mm (0.00026 in)	0.063-0.216 mm (0.0025-0.0085 in)	0.203 mm (0.008 in)	0.203 mm (0.008 in)
0.020 Undersize	62.94-62.96 mm (2.478-2.479 in)	0.0066 mm (0.00026 in)	0.063-0.216 mm (0.0025-0.0085 in)	0.203 mm (0.008 in)	0.203 mm (0.008 in)
0.030 Undersize	62.69-62.71 mm (2.468-2.469 in)	0.0066 mm (.00026 in)	0.063-0.216 mm (0.0025-0.0085 in)	0.203 mm (0.008 in)	0.203 mm (0.008 in)

[a] Maximum out-of-round — 0.0056 mm (0.00022 in).
[b] Service limit — 0.51 mm (0.020 in).

Crankshaft Bearings	
Connecting Rod Bearing to Crankshaft Clearance	**Main Bearing to Crankshaft Clearance**
0.038-0.114 mm (0.0015-0.0045 in)	0.046-0.117 mm (0.0018-0.0046 in)

Connecting Rod				
Rod Bearing I.D.	**Rod Length Center to Center**	**Connecting Rod Alignment Maximum Total Difference**		**Rod to Crankshaft Assembled Side Clearance**
		Twist/Inch	**Bend/Inch**	
63.513-63.564 mm (2.5005-2.5025 in)[a b]	181.10 mm (7.130 in)	0.05 mm (0.002 in)	0.025 mm (0.001 in)	0.30-0.61 mm (0.012-0.024 in)

[a] Connecting rod bearing bore maximum out-of-round — 0.0005 and maximum bore taper — 0.0005.
[b] With bearing caps tightened in place.

Connecting Rod (Continued)				
			Bearing Bore	
Engine	**Piston Pin Bushing I.D.**	**Crankpin Bearing Bore Diameter**	**Max.Out-of-Round**	**Max.Taper per Inch**
7.3L	33.23-33.25 mm (1.308-1.309 in)	68.339-68.364 mm (2.6905 in-2.6915 in)	0.013 mm (0.0005 in)	0.013 mm (0.0005 in)

Piston			
Available Pistons	**Skirt Diameter[a b]**	**Piston Pin Bore Diameter**	**Piston Height Above Crankcase**
Standard	104.26065 mm (4.10475 in)	33.235-33.248 mm (1.3085-1.3088 in)	0.254-0.787 mm (0.010-0.031 in)
.010 in Oversize	104.51465 mm (4.11475 in)	33.235-33.248 mm (1.3085-1.3088 in)	0.254-0.787 mm (0.010-0.031 in)
.020 in Oversize	104.76865 mm (4.12475 in)	33.235-33.248 mm (1.3085-1.3088 in)	0.254-0.787 mm (0.010-0.031 in)
0.030 in Oversize	105.02265 mm (4.13475 in)	33.235-33.248 mm (1.3085-1.3088 in)	0.254-0.787 mm (0.010-0.031 in)

[a] Service piston specification are all +/- 0.00635 mm (0.00025 in).
[b] Measured at 90° to the pin, at 42.77 mm (1.684 in) below the oil ring grooves at room temperature.

Piston Pin			
Length	**Diameter**	**To Piston Pin Bore Clearance**	**To Connecting Rod Bushing Clearance**
75.9-76.2 mm (2.99-3.00 in)	33.220-33.226 mm (1.3079-1.3081 in)	0.007-0.018 mm (0.0003-0.0007 in)[a]	0.010-0.023 mm (0.0004-0.0009 in)

[a] Selective fit.

Piston Rings				
Ring Side Clearance (Second Ring Only)	**Ring Gap**			**Oversize**
	Compression		**Oil**	
	Top	**Second**		
—	0.35-0.61 mm (0.014-0.024 in)	1.57-1.83 mm (0.062-0.072 in)	0.30-0.61 mm (0.012-0.024 in)	0.010 in 4.120 in
0.05-0.10 mm (0.002-0.004 in)	0.35-0.61 mm (0.014-0.024 in)	1.57-1.83 mm (0.062-0.072 in)	0.30-0.61 mm (0.012-0.024 in)	0.020 in 4.130 in
0.05-0.10 mm (0.002-0.004 in)	0.35-0.61 mm (0.014-0.024 in)	1.57-1.83 mm (0.062-0.072 in)	0.30-0.61 mm (0.012-0.024 in)	0.030 in 4.140 in

Exhaust Manifold	
Maximum Allowable Warpage	0.13 mm (0.005 in) Between Ports 0.25 mm (0.010 in) Total
Maximum Allowable Removal of Material	0.25 mm (0.010 in)

Drive Gear Backlash	
mm	**Inch**
0.035-0.038	0.0012-0.0015

Oil Pump, Oil Cooler and Oil Capacity					
Oil Pump Pressures		**Engine Oil Capacity**		**Oil Pump Drive Gear Radial Clearance**	**Oil Pump Drive Gear End Clearance**
Engine at Normal Operating Temperature		**Liters**	**U.S. Qts.**		
Curb Idle	**3,300 rpm**				
69 kPa (10 psi)	276-482 kPa (40-70 psi)	12.3	13.0	0.71-0.81 mm (0.028-0.032 in)	0.02-0.08 mm (0.001-0.003 in)

General Specifications	
Item	**Specification**
Lubricants	
Ford Engine Assembly Lubricant D9AZ-19579-D	ESR-M99C80-A
Multi-Purpose Grease D0AZ-19584–AA	ESR-M1C159–A and ESB-M1C93–A
Rust Penetrant and Inhibitor F2AZ-19A501-A	ESR-M99C56-A
Sealants	
RTV Silicone Sealant F5TZ-19G204-AB	NAVSTR SLR
Perfect Seal Sealing Compound F2AZ-19554-AA	ESR-M18P2-A and ESE-M4G115-A

Torque Specifications			
Description	**Nm**	**lb-ft**	**lb-in**
Vehicles Built Before 12/7/98			
A/C compressor mounting bracket to engine	47	35	—
A/C manifold line to compressor	17-23	13-17	—
Crankshaft vibration damper bolt/crankshaft pulley bolt	287	212	—
Cylinder head bolts	[a]	—	—
Connecting rod nuts	[a]	—	—
Engine front cover bolts	20	15	—
Engine mount nuts	96-127	71-94	—
Engine rear cover bolts	20	15	—
Exhaust manifold and exhaust adapter pipe nuts and bolts, RH[b]	24	18	—
Exhaust manifold and exhaust adapter pipe nuts and bolts, LH[b]	24	18	—
Flywheel mounting bolt (automatic transmission)	31-53	23-40	—
Flywheel housing cover mounting screws	18-23	14-17	—
Fuel injector hold-down bolts	13.6	—	120
Generator bracket to cylinder head	47	35	—
Generator bracket to cylinder head, lower	40-55	30-41	—
High-pressure oil pump bolts	24	18	—
Camshaft thrust plate to engine retaining bolts	24	18	—

Description	Nm	lb-ft	lb-in
Oil level gauge tube adapter nut	33	25	—
Valve cover retaining bolts and nuts	11	8	—
Oil level indicator tube adapter nut	33	25	—
Oil pan to cylinder block	24	18	—
Oil pump screen cover and tube flange screws	24	18	—
Oil supply line to cylinder head fitting	26	20	—
Oil pump housing bolts	14	10	—
Rear oil seal retaining bolts	[c]	—	—
Rocker arm pedestal attaching bolts	27	20	—
Transmission to engine bolts	52-70	39-52	—
Turbocharger exhaust inlet pipe-to-exhaust manifold bolts	28	21	—
Rocker arm cover bolts	11	—	98
Torque converter to flywheel retaining nuts	30-40	23-30	—
Oil pump retaining bolts	24	18	—
Oil pump screen cover and tube retaining nut	40-64	30-48	—
Camshaft position (CMP) sensor to engine front cover	24	18	—
Access cover bolts	21-32	16-24	—
Vehicles Built After 12/7/98			
A/C compressor mounting bracket to engine	47	35	—
A/C manifold line to compressor	17-23	13-17	—
Access cover bolts	27	20	—
Camshaft position (CMP) sensor to engine front cover	24	18	—
Camshaft thrust plate to engine retaining bolts	24	18	—
Connecting rod nuts	[a]	—	—
Crankshaft vibration damper bolt/crankshaft pulley bolt	287	212	—
Cylinder head bolts	[a]	—	—
Engine front cover bolts	20	15	—
Engine mount bolts	150	111	—
Engine mount nuts	96-127	71-94	—
Engine rear cover bolts	20	15	—
Exhaust manifold and exhaust adapter pipe bolts[b]	24	18	—
Exhaust manifold and exhaust adapter pipe nuts[b]	24	18	—
Flywheel housing cover mounting screws	18-23	14-17	—
Flywheel mounting bolt (automatic transmission)	31-53	23-40	—
Fuel filter housing bolts	31	23	—

Description	Nm	lb-ft	lb-in
Generator bracket to cylinder head	47	35	—
Generator bracket to cylinder head, lower	47	35	—
High-pressure oil pump retaining bolts	24	18	—
Lifter retaining plate retaining bolt	20	15	—
Main bearing cap bolts	[a]	—	—
Oil cooler front header retaining bolts	24	18	—
Oil cooler rear header retaining bolts	24	18	—
Oil deflector retaining bolts	14	10	—
Oil level gauge tube adapter nut	33	25	—
Oil level indicator tube adapter nut	33	25	—
Oil pan to cylinder block	24	18	—
Oil pump housing bolts	14	10	—
Oil pump screen cover and tube flange screws	24	18	—
Oil pump screen cover and tube retaining nut	24	18	—
Oil supply line to cylinder head fitting	26	20	—
Piston oil cooling jet retaining bolt	11	—	98
Rear oil seal retaining bolts	[c]	—	—
Rocker arm cover bolts	11	—	98
Rocker arm pedestal attaching bolts	27	20	—
Torque converter to flywheel retaining nuts	30-40	23-30	—
Transmission to engine bolts	52-70	39-52	—
Turbocharger pedestal mounting bolts	24	18	—
Turbocharger exhaust inlet pipe-to-exhaust manifold bolts	28	21	—
Valve cover retaining bolts and nuts	11	—	98
Class 9.8 Metric Fasteners			
M4	3	—	27
M5	7	—	62
M6	11	8	—
M8	27	20	—
M10	52	38	—
M12	78	58	—
M14	125	92	—
M16	193	142	—
Class 10.9 Metric Fasteners			
M6	14	10	—

Description	Nm	lb-ft	lb-in
M10	68	50	—
M12	100	74	—
M14	160	118	—
M16	248	183	—
M20	483	357	—
M24	835	618	—
Grade 5 UNC Fasteners			
1/4-inch	9	—	80
5/16-inch	20	15	—
Grade 5 UNF Fasteners			
1/4-inch	12	9	—
5/16-inch	23	17	—
Grade 8 UNC Fasteners			
3/8-inch	55	41	—
7/16-inch	90	66	—
1/2-inch	130	96	—
9/16-inch	190	140	—
5/18-inch	255	188	—
3/4-inch	460	339	—
7/8-inch	745	550	—
Grade 8 UNF Fasteners			
3/8-inch	60	44	—
7/16-inch	95	70	—
1/2-inch	150	111	—
9/16-inch	210	155	—
5/18-inch	290	214	—
3/4-inch	515	380	—
7/8-inch	825	616	—
Pipe Threads			
1/8 x 27	9	—	80
1/4 x 18	20	15	—
3/8 x 18	37	27	—
1/2 x 14	40	30	—

[a] Refer to the procedure in this section.

[b] Apply Threadlock® and Sealer E0AZ-19554-AA or equivalent meeting ford specification WSK-M2G351-A5 and ESE-M4G204-A2 to all threads prior to assembly.

[c] Refer to Standard Torque — English or Standard Torque — Metric chart in the Specifications portion of this section.

Engine—Vehicles Built After 12/7/98

Engine Description

The 7.3L diesel engine is:

- a four-cycle turbocharged V-8 with overhead valves.
- 7.3 liter (444 cubic inch) displacement.
- separated into two banks, the right bank numbered 1, 3, 5, 7 and the left bank numbered 2, 4, 6, 8.
- rated at 215 horsepower at 3000 rpm.

The cylinder block (6010) has been designed to withstand the loads of diesel operations by using:

- four-bolt main bearing caps.
- internal piston cooling oil jets (6C327).
- a forged steel crankshaft (6303).
- heavy-duty forged steel connecting rods (6200).

The piston and rings are:

- made of aluminum alloy.
- fitted with an upper keystone compression ring.
- fitted with a lower rectangular compression ring.
- fitted with oil control rings.

The piston pins (6135) are:

- a free-floating type permitting the piston pin to move/float freely in the piston pin bore.
- retained in the piston and rings by piston pin retainers (6140).

The camshaft (6250) is:

- supported by five insert-type camshaft bearings (6A251).
- driven by the crankshaft through the use of the crankshaft gear and the camshaft gear.

The hydraulic valve tappets (6500):

- minimize engine noise.
- maintain zero valve lash.
- incorporate camshaft follower guides.
- incorporate a roller follower design that reduces camshaft wear.

The cylinder heads (6049) are designed:

- to incorporate electronically controlled/hydraulically actuated fuel injectors (9F593).
- to locate the fuel injectors in the center of the combustion chambers between the rocker arms (6564).
- with integral high-pressure oil galleries.

The glow plug system is:

- designed to preheat the cylinders for faster cold weather starts.
- controlled by the powertrain control module (PCM) (12A650).
- mounted directly into the cylinder heads.
- activated by the glow plug control module (12B533).

The manifold intake air heater:

- is designed to preheat intake air to reduce smoke and odor during cold weather starts.
- is controlled by the powertrain control module (PCM).
- is mounted into the compressor manifold to heat intake air.

The optional block heater (6A051) is:

- designed to heat the engine coolant and oil for improved cold weather starts.
- located near the oil filter (6731) in the oil cooler (6A642).
- powered by a 120-volt external power source.
- not repairable; a new block heater must be installed.

The fuel injection system used on the engine:

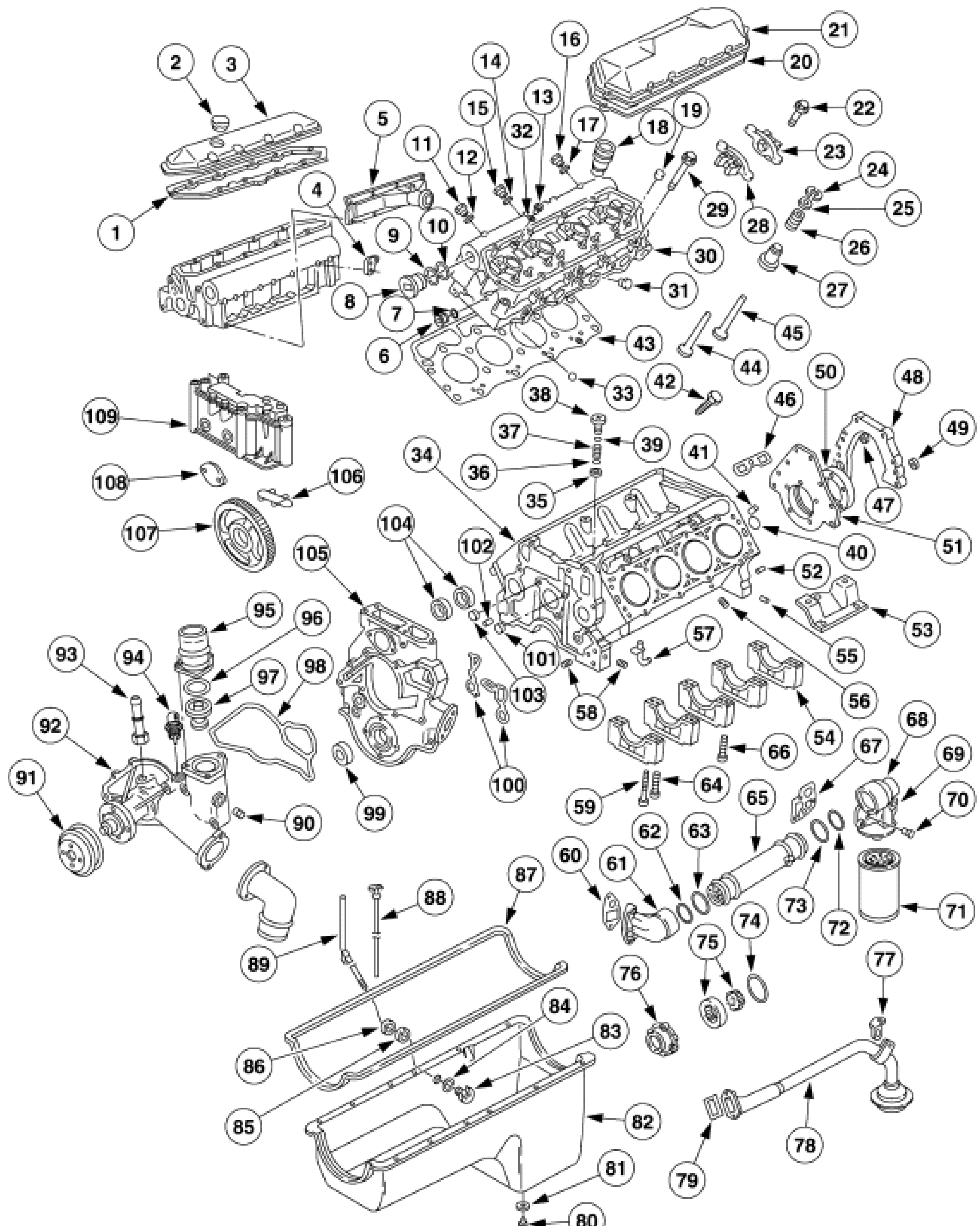
- is controlled by the powertrain control module.
- utilizes an electric in-line fuel pump (9350).
- circulates through a combination fuel filter, fuel heater and water separator assembly.
- uses eight electronically controlled/hydraulically actuated fuel injectors.
- maintains operating pressures between 448-482 kPa (65-70 psi).

The engine lubrication system:

- is divided into two systems: the low-pressure system lubricates the engine (6007), the high-pressure system actuates the fuel injectors.
- maintains pressures between 69-414 kPa (10-60 psi) for the low-pressure system and 2,758-20,685 kPa (400-3,000 psi) for the high-pressure system.
- is cooled by an engine oil cooler.

- in the high-pressure system uses an injection control pressure (ICP) sensor (9F838) and injection pressure regulator (IPR) valve (7A139) to maintain and control pressure.
- actuates the exhaust back-pressure warm-up system integral to the turbocharger.
- in the high-pressure system is used to inject fuel.

7.3L (DIT) Engine



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Item	Part Number	Description
1	6584	Valve cover gasket
2	6766	Oil filler cap
3	6582	Valve cover
4	1822844C1	Lifting eye
5	9E434	Intake manifold cover

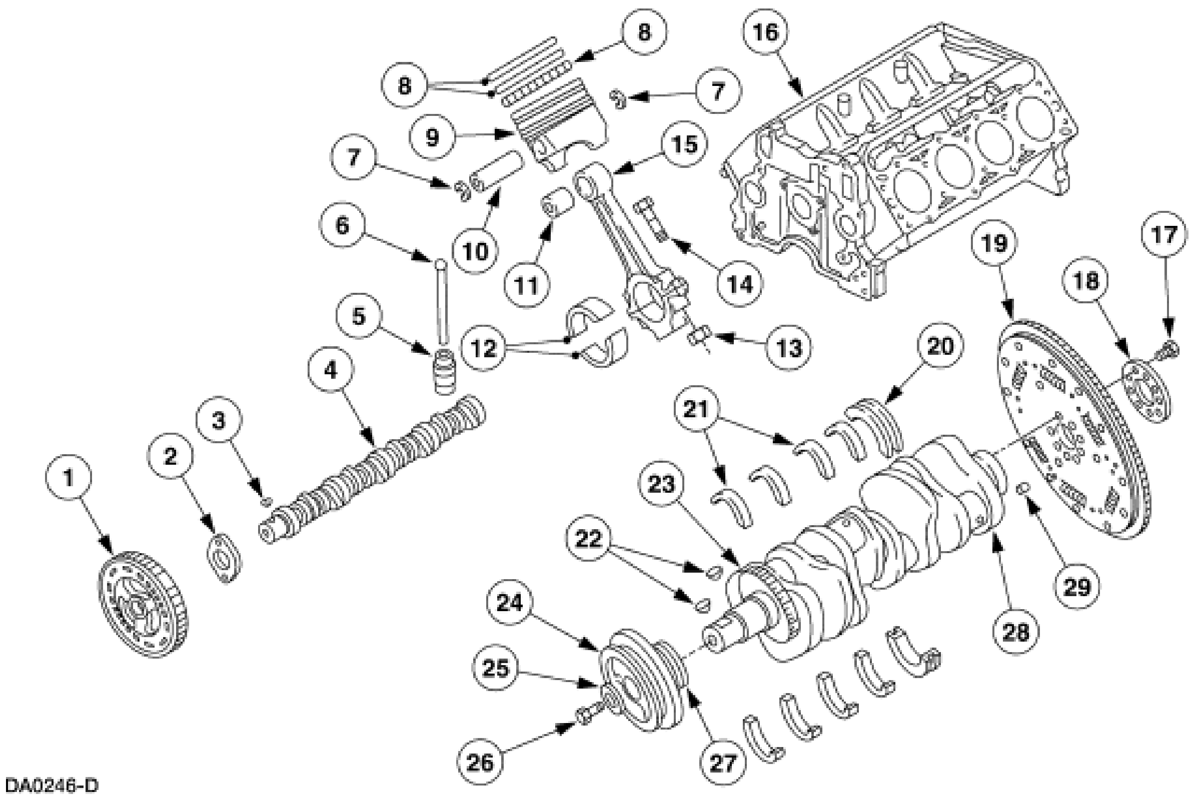
6	1818188C1	Plug, fuel rail drain
7	1815734C1	O-ring, fuel rail drain plug
8	1827535C91	Plug, oil supply rail
9	1814546C1	Ring, backup supply rail
10	1815873C1	O-ring, oil supply rail
11	9410357	Plug
12	9N693	O-ring
13	1815944C1	Plug, oil rail drain
14	9N693	O-ring
15	9410357	Plug
16	9410357	Plug
17	9N693	O-ring
18	9F538	Sleeve, fuel injector
19	6026	Plug, cup
20	6584	Valve cover gasket
21	6582	Valve cover
22	6A527	Rocker arm bolt
23	6564	Rocker arm
24	6518	Valve spring retainer key
25	6514	Valve spring rotator
26	6513	Valve spring
27	6571	Valve stem seal
28	6564	Rocker arm
29	6065	Cylinder head bolt
30	6049	Cylinder head
31	445751	Plug, pipe
32	1815887C1	O-ring
33	6026	Ball, steel (plug)
34	6010	Cylinder block
35	6674C	Seat, ball (part of kit 6674)
36	13722D	Ball, 1/2-inch metal (part of kit 6674)
37	6670	Short circuit valve spring
38	6666	Short circuit valve plug
39	6674A	O-ring (part of kit 6674)
40	6026	Engine block plug

41	6A008	Cylinder head to block dowel
42	—	Bolt (part of 6C329)
43	6051	Head gasket
44	6507	Exhaust valve
45	6505	Intake valve
46	6C329	Guide, camshaft follower
47	437157 R1	Ring, flywheel adapter housing retaining
48	6A369	Transmission adapter
49	437157 R1	Ring, flywheel adapter housing retaining
50	6701	Crankshaft rear oil seal
51	6L080	Cover, engine rear
52	20640 R1	Pin, dowel
53	6031	Bracket, front engine support mounting
54	—	Cap, main bearing (part of 6010)
55	445684	Plug, oil cooler drain, 3/8 NPTF
56	444619	Plug, 1/4-18
57	6C327	Piston cooling oil jet
58	445684	Plug, oil drain, 3/8 NPTF
59	6345	Crankshaft main bearing cap stud
60	6A636	Gasket, oil cooler front header
61	6881	Header, oil cooler front
62	6K649	O-ring, oil cooler inner
63	6C610	O-ring, oil cooler outer
64	6345	Crankshaft main bearing cap bolt
65	6A642	Oil cooler
66	6345	Crankshaft main bearing cap bolt
67	6A636	Gasket, oil cooler rear header
68	6881	Header, oil cooler rear
69	6A051	Block heater
70	444814	Plug
71	6731	Oil filter
72	6K649	O-ring, oil cooler outer
73	6C610	O-ring, oil cooler inner
74	6619	O-ring, oil pump housing
75	6608	Gerotor oil pump

76	6616	Oil pump housing
77	6A661	Bracket, oil pump screen cover and tube
78	6622	Oil pump screen cover and tube
79	6626	Oil pump inlet tube gasket
80	6730	Oil pan drain plug
81	6734	Oil pan drain plug gasket
82	6675	Oil pan
83	6754F	Adapter, oil level indicator tube (part of 6754)
84	6754E	O-ring, oil level indicator tube adapter retainer (part of 6754)
85	6754D	Flange, oil level indicator tube adapter retainer (part of 6754)
86	6754C	O-ring, oil level indicator tube (part of 6754)
87	E2AZ-19562-B	Gasket maker
88	6750	Oil level dipstick
89	6754	Oil level indicator tube
90	—	Plug, pipe (part of 8501)
91	8509	Water pump pulley
92	8501	Pump, water
93	1822716C1	Nipple — heater return hose
94	12A648	Engine coolant temperature sensor (ECT sensor)
95	8592	Outlet, water pump
96	8255	Gasket, water outlet
97	8575	Water thermostat
98	8507	Water pump housing gasket
99	6700	Crankshaft front seal
100	6020	Engine front cover gasket
101	444776	Plug, tappet oil gallery
102	6B041	Pin, dowel (engine front cover)
103	444776	Plug, tappet oil gallery
104	6A251	Camshaft bearing
105	6019	Engine front cover
106	6619	Gasket, oil reservoir
107	6655	Gear, high-pressure oil pump drive
108	6B070	Cover, oil pump drive gear access

109	6658	Reservoir, high-pressure oil pump supply and cover

7.3L (DIT) Crankshaft, Camshaft and Piston



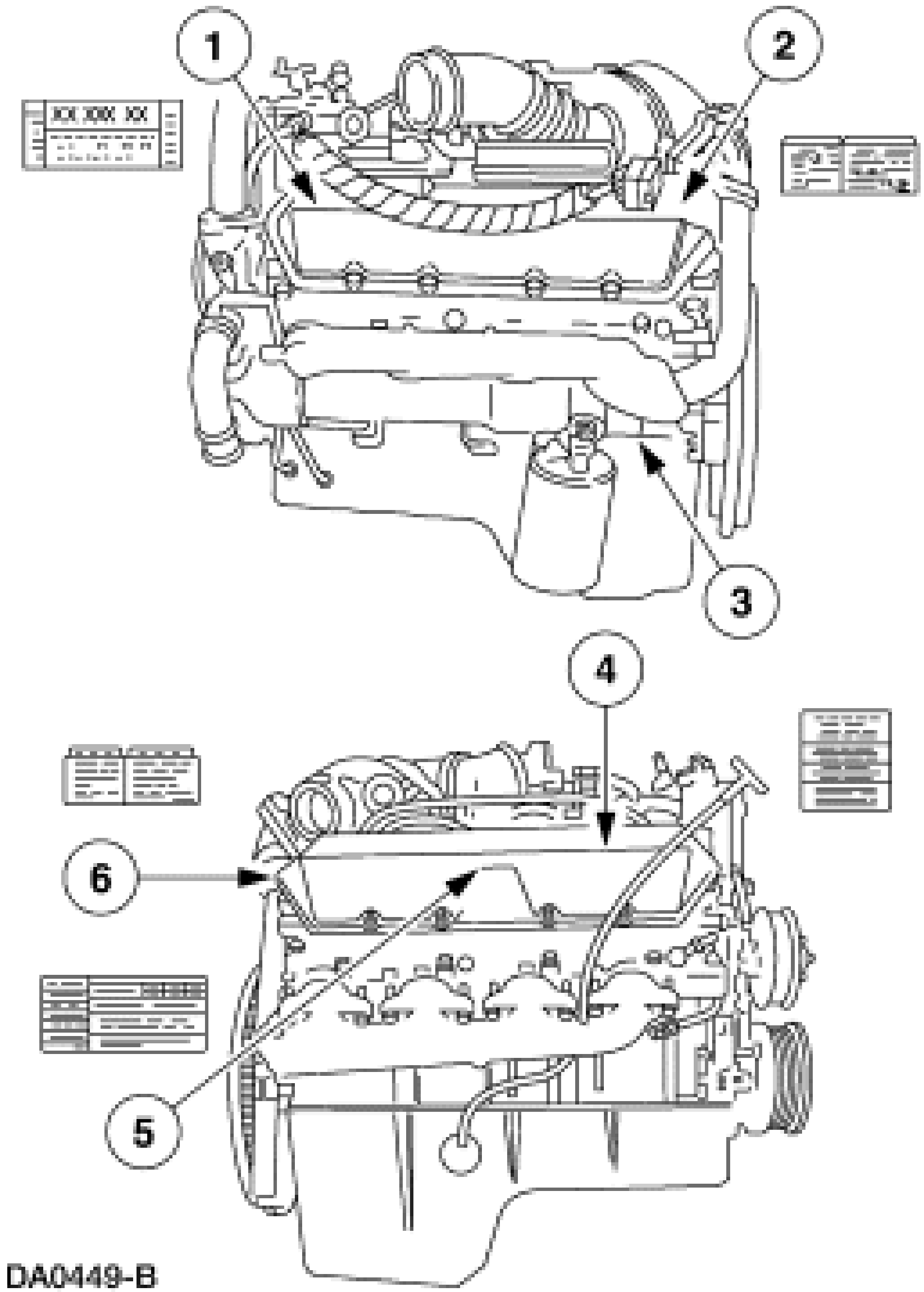
Item	Part Number	Description
1	6256	Camshaft drive gear
2	6269	Camshaft thrust plate
3	6L269	Camshaft drive gear key
4	6250	Camshaft
5	6500	Valve tappet
6	6565	Push rod
7	6140	Piston pin retainer
8	6148	Partial piston ring set (8 req'd)
9	6102	Piston
10	6135	Piston pin
11	6207	Connecting rod bushing
12	6211	Connecting rod bearing
13	6212	Connecting rod nut

14	6214	Connecting rod bolt
15	6200	Connecting rod
16	6010	Cylinder block
17	6379	Flywheel retaining bolt
18	6A366	Flywheel reinforcing plate
19	6375	Flywheel — (automatic transmission) (not shown)
20	6337	Crankshaft thrust main bearing
21	6333	Crankshaft main bearing
22	6B316	Crankshaft key
23	—	Crankshaft sprocket (part of 6303)
24	6316	Crankshaft vibration damper
25	6332	Washer, crankshaft vibration damper
26	6A340	Crankshaft pulley bolt
27	6310	Crankshaft damper wear ring
28	6303	Crankshaft
29	20024 R1	Pin, dowel

Engine Identification

Vehicle identification, the location of the vehicle rating and data plates, and engine code information is fully covered in Section 100-01. For specific and exact engine identification, an engine calibration code label is affixed to the B-pillar. Refer to the following illustration for examples of engine identification labeling.

Engine Labels



Item	Part Number	Description
1	—	Engine code label (part of 6007)
2	—	Electrical system caution (part of 6007)
3	—	Stamped serial number (on crankcase) (part of 6007)
4	—	Oil change label

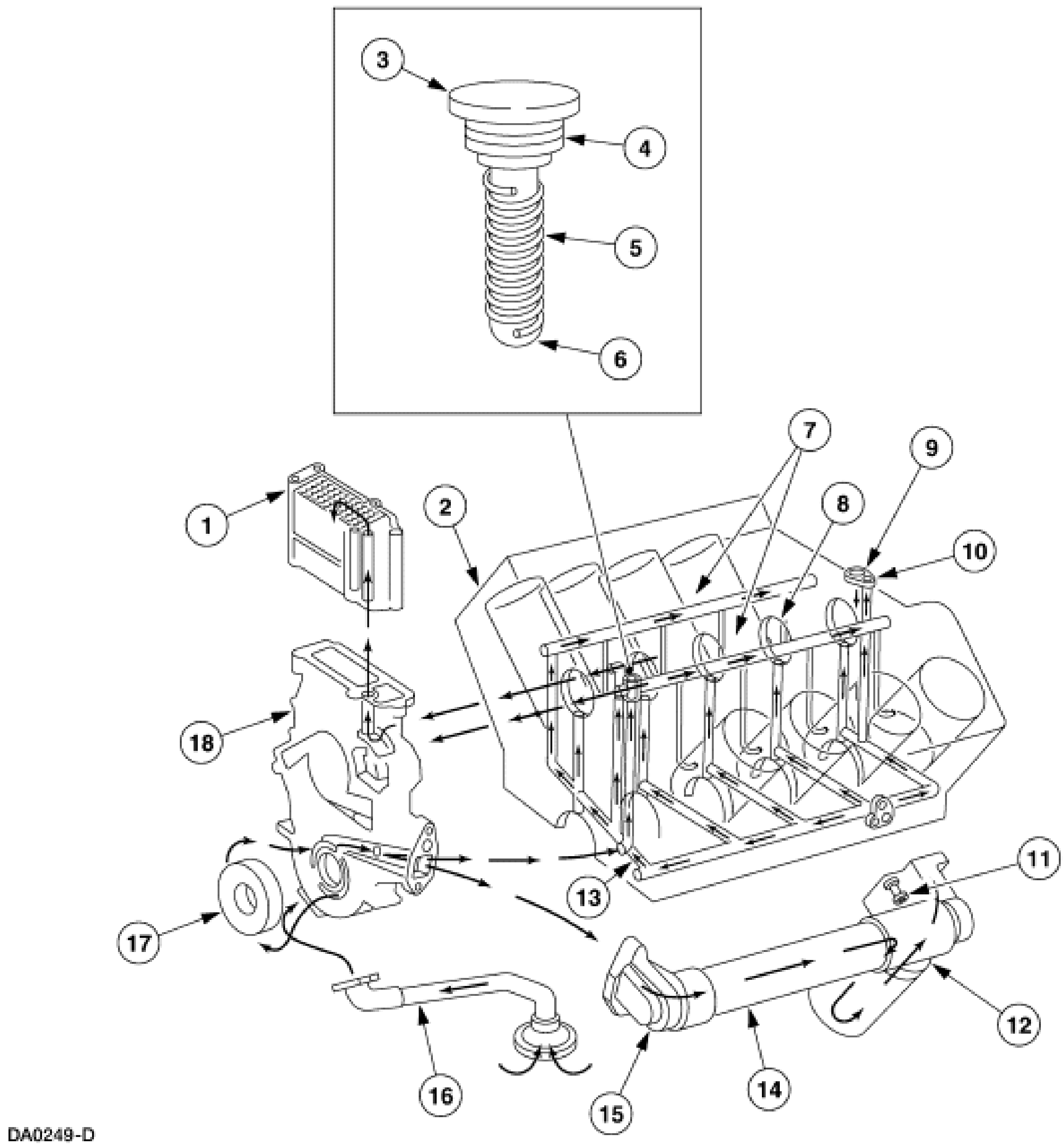
		(part of 6007)
5	—	Emission label (part of 6007)
6	—	Electrical system caution (part of 6007)

Calibration Code Label

Refer to the Powertrain Control/Emissions Diagnosis (PC/ED) manual.

Lubrication System — Low-Pressure

Low-Pressure Oil



Flow

Item	Part Number	Description
1	6658	High-pressure oil pump reservoir
2	6010	Cylinder block
3	—	Short circuit valve ball cap (part of 6658)
4	—	O-ring seal (part of 6658)
5	—	Spring (part of 6658)
6	—	Check ball (part of 6658)
7	—	Valve lifter oil galleries (part of 6010)
8	6C327	Piston cooling oil jet
9	—	Turbocharger oil return gallery (part of 6010)
10	—	Turbocharger oil supply gallery (part of 6010)
11	—	Pressure relief/regulator valve (part of 9155)
12	—	Oil filter bypass drain (part of 6881)
13	—	Main oil gallery (part of 6010)
14	6A642	Oil cooler
15	6881	Oil cooler header
16	6622	Oil pump screen cover and tube
17	6608	Gerotor oil pump
18	6019	Engine front cover

The lubrication system is comprised of a low-pressure system and a high-pressure system. The low-pressure system provides primary engine lubrication while the high-pressure system provides the hydraulic pressure required to actuate the fuel injectors.

The gerotor oil pump draws oil from the engine oil pan (6675) through the oil pump screen cover and tube (6622) into the oil inlet passage in the front cover. The gerotor oil pump then pumps the oil back out through the outlet passage in the front cover. The oil separates into two paths.

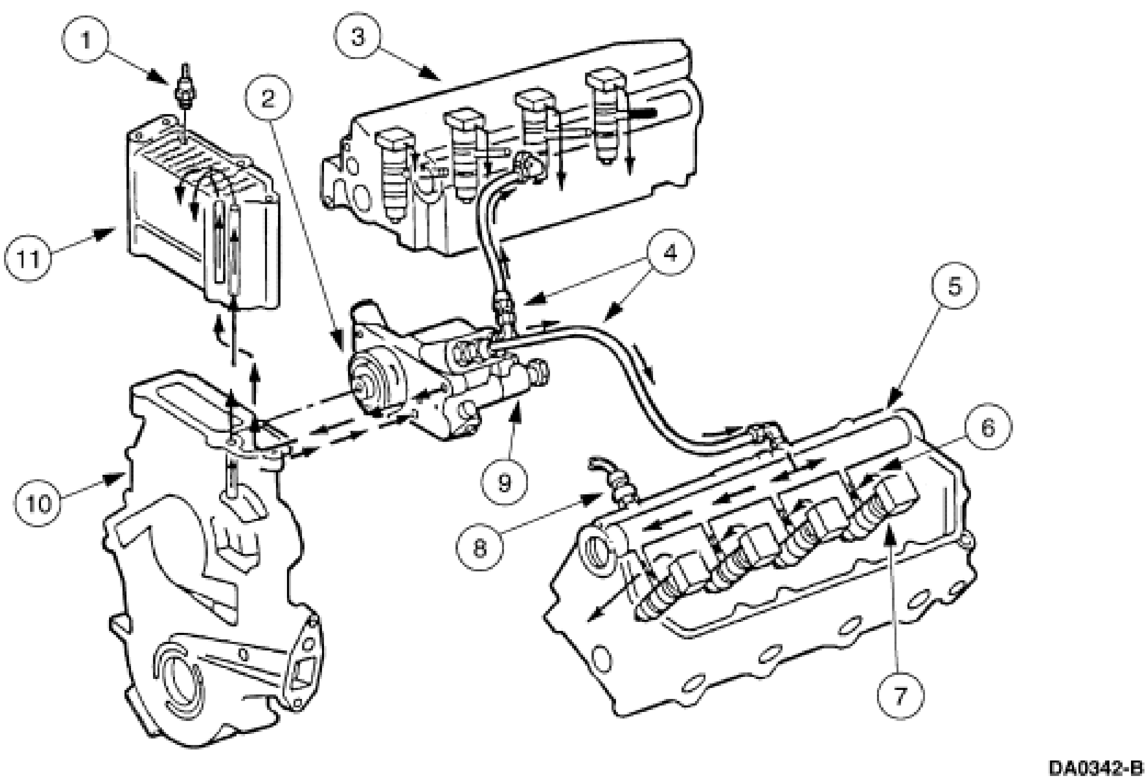
One flow path sends oil into the high-pressure pump reservoir possibly through the short circuit valve during cold start. One feed leaves the short circuit valve and enters the front cover. From there it enters the high-pressure oil reservoir. The second feed exits the short circuit valve and enters the left bank valve lifter oil gallery.

After leaving the front cover outlet passage, the second oil path sends the oil through the oil cooler. Once inside the rear oil cooler housing, the pressure relief/regulator valve may open to vent excess pressure and oil back into the oil pan. After the oil has been circulated through the oil filter, the oil feed then enters the main oil gallery (integral to the cylinder block). Once in the main oil gallery, the oil is routed to the five crankshaft main bearings (6333) through five drilled and machined feed galleries (integral to the cylinder block). The five camshaft bearings receive the oil feed through five vertically drilled and machined feed galleries connected to the main bearing feed galleries. The front main bearing feed gallery also supplies oil to the right bank valve lifter oil gallery through a vertically drilled and machined oil feed gallery (integral to the cylinder block). The rear main bearing oil feed gallery also supplies oil to the turbocharger assembly through a vertically drilled and machined oil feed gallery (integral to the cylinder block).

Pressurized oil entering the turbocharger assembly is utilized to actuate the exhaust back-pressure warm-up system. The exhaust back pressure regulator controls the oil leaving the turbocharger to actuate the back pressure device during cold ambient temperatures. The oil drains back through the turbocharger mounting pedestal and back into the oil pan. The valve lifter oil gallery supplies pressurized oil to the valve tappets and to the piston cooling oil jets. Oil from the valve tappets is routed upward to the cylinder head valve train through hollow push rods (6565). Once in the cylinder head, the oil drains back to the oil pan through return ports at each end of the cylinder head.

Lubrication System — High-Pressure

High-Pressure Oil Flow



Item	Part Number	Description
1	9278	Oil pressure sensor
2	6600	High-pressure oil pump
3	6049	Cylinder head
4	9A332	High-pressure oil feed hoses

5	—	High-pressure oil rail (part of 6049)
6	—	Injector oil feed galleries (part of 6049)
7	9F593	Fuel injectors (8 req'd)
8	9F838	Injection control pressure (ICP) sensor
9	7A139	Injection pressure regulator (IPR) valve
10	6019	Engine front cover
11	6658	High-pressure oil pump reservoir

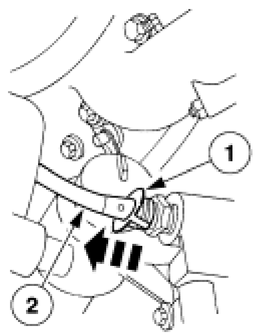
During cold start, the high-pressure oil pump (6600) receives oil from the left side valve lifter oil gallery possibly through the short circuit valve. Once the engine starts or during warm engine starts, the short circuit valve closes and the high-pressure oil pump receives filtered oil from the high-pressure oil pump reservoir. The high-pressure oil pump pumps the oil under extremely high pressures (2,758-20,577 kPa [400-3,000 psi]) through the left and right side high-pressure supply hoses to the high-pressure oil rails (integral to the cylinder heads). Once in the oil rail, the oil is fed to the fuel injector bores through four oil feed galleries drilled and machined in the cylinder head. The high-pressure oil then actuates the fuel injectors. The IPR valve controls and maintains the high-pressure oil. The PCM uses the information from ICP sensor to adjust the pressure in the system.

SECTION 303-01C: Engine — 7.3L Diesel 1999 F-Super Duty 250-550 Workshop Manual
IN-VEHICLE REPAIR Procedure revision date: 01/26/2000

Oil Cooler

Removal

1. Drain the radiator. For additional information, refer to Section 303-03.
2. Raise and support the vehicle. For additional information, refer to Section 100-02.
3. Remove the oil filter.
4. Disconnect the block heater.
    1. Disconnect the retainer.
    2. Disconnect the cable.



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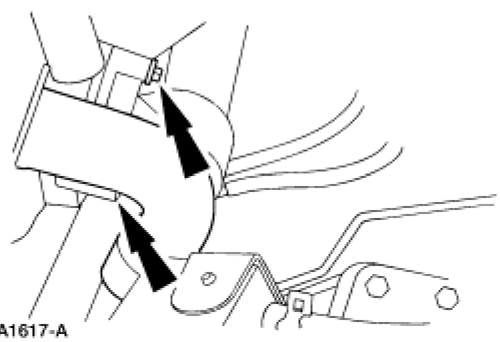
5. Remove the two bolts from the oil cooler front header.



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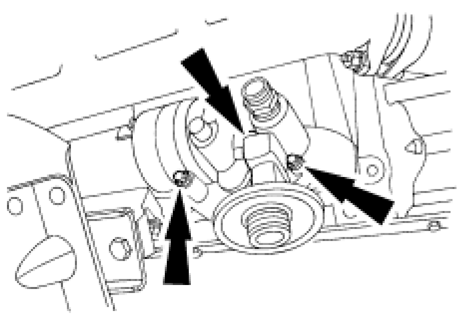
6. Remove the three bolts from the oil cooler rear header.



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7. Remove the oil cooler.

8. Remove the oil cooler front and rear header gaskets from the engine.

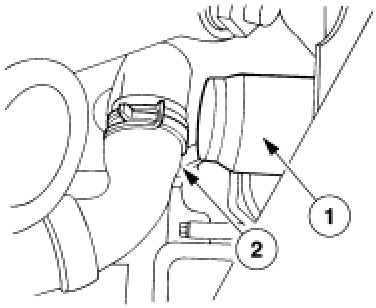
9. Clean the gasket mating surface on the engine and the oil cooler.

Installation

1. Position the oil cooler in the vehicle.

2. Install the oil cooler front header.
    1. Position the front header gasket; then place the front header against the engine.

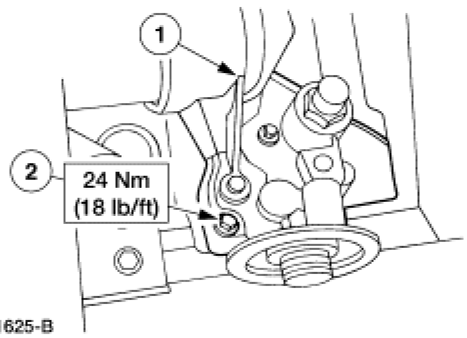
    2. Install the front header mounting bolts. Do not tighten the bolts at this time.



DA1624-A

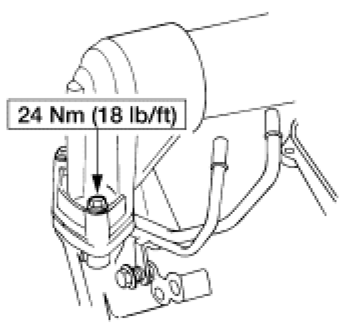
3. Install the oil cooler rear header.
    1. Position the rear header gasket, then place the rear header against the engine.

    2. Install the rear header mounting bolts.



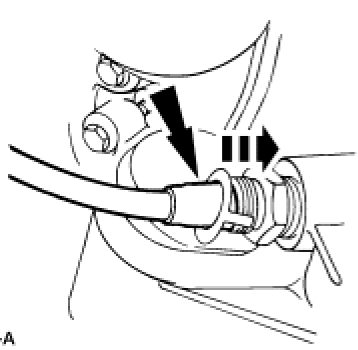
DA1625-B

4. Tighten the oil cooler front header bolt.



DA1626-B

5. Connect the block heater.



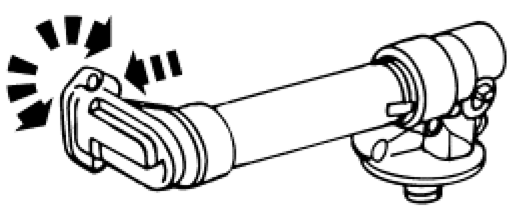
DA1627-A

6. Install the oil filter.
7. Lower the vehicle. For additional information, refer to Section 100-02.
8. Fill the radiator. For additional information, refer to Section 303-03.
9. Start the engine and check for leaks.

Oil Cooler

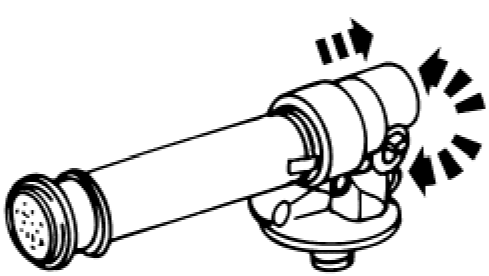
Disassembly

1. Gently rap on the front header to loosen up the O-ring. Twist the front header while pulling on it until the header comes free from the oil cooler housing.



DA1594-A

2. Gently rap on the rear header to loosen up the O-rings. Twist the rear header while pulling on it until the header comes free from the oil cooler housing.



DA1595-A

3. Remove the four O-rings from the oil cooler housing. Discard the O-rings.

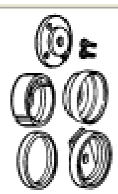
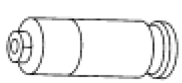
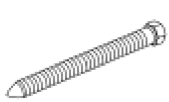
Assembly

1. **NOTE:** Install new O-rings on the oil cooler housing.

   Follow the disassembly procedure in reverse order.

SECTION 303-01C: Engine — 7.3L Diesel 1999 F-Super Duty 250-550 Workshop Manual
IN-VEHICLE REPAIR Procedure revision date: 01/26/2000

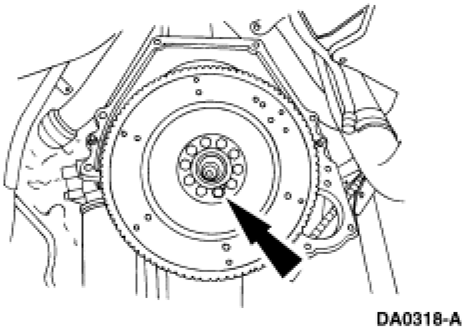
Crankshaft Rear Oil Seal

Special Tool(s)	
 ST1255-A	Driver Handle 205-153 (T80T-4000-W)
 ST1728-A	Rear Crank Service Set 303-474 (T94T-6701-AH)
 ST2321-A	Remover and Replacer Tube 308-052 (T77J-7025-B)
 ST1304-A	Forcing Screw 308-092 (T84T-7025-B)

Removal

1. Remove the transmission. For additional information, refer to Section 307-01 for automatic transmission, or Section 308-03B for manual transmission.

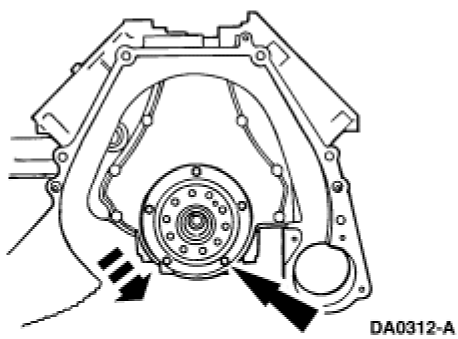
2. Remove the bolts, spacers and flexplate (for automatic transmission) or flywheel (for manual transmission).



3. **NOTE:** Use extreme care when removing the flywheel front adapter to prevent damage to the alignment dowel pins.

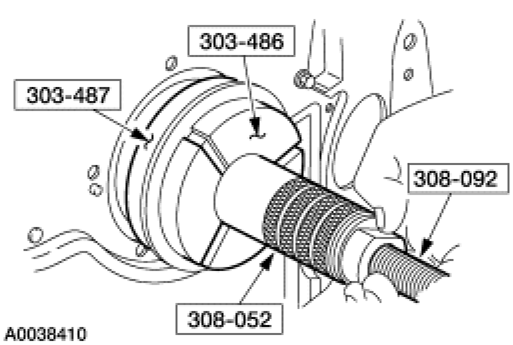
   Remove the flywheel front adapter.

4. Remove the crankshaft rear oil seal retaining bolts and the crankshaft rear oil seal.



5. Inspect the crankshaft rear oil seal, wear sleeve and alignment dowel pins for damage. Install new components as necessary.

6. If equipped with a crankshaft wear sleeve, use the special tools to remove the crankshaft rear wear sleeve.

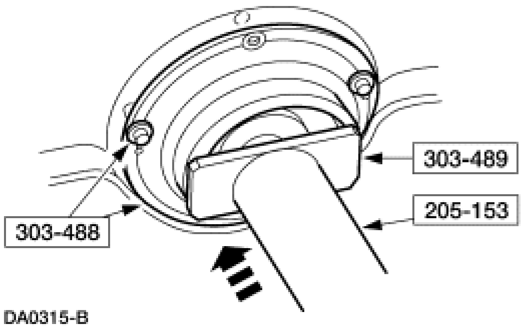


Installation

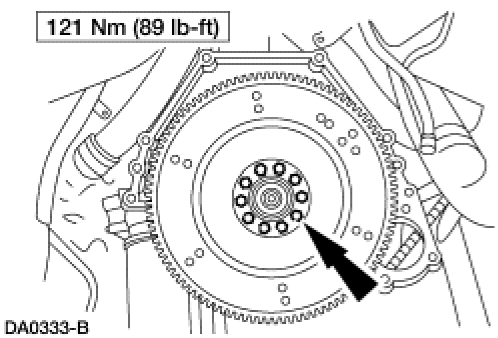
1. **NOTE:** The crankshaft rear oil seal and wear sleeve are installed as an assembly.

   Apply RTV Silicone Sealant F5TZ-19G204-AB, or equivalent meeting Ford specification NAVSTR SLR to the rear oil seal retaining ring and the crankshaft rear oil seal retaining bolts.

2. Using the special tools, install the crankshaft rear oil seal.



3. Install the flexplate (for automatic transmission), flywheel (for manual transmission), spacers and bolts.

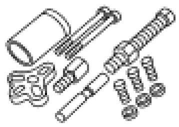
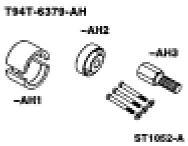
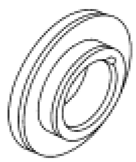
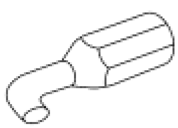


4. Install the transmission. For additional information, refer to Section 307-01 for automatic transmission, or Section 308-03B for manual transmission.

SECTION 303-01C: Engine — 7.3L Diesel 1999 F-Super Duty 250-550 Workshop Manual
IN-VEHICLE REPAIR Procedure revision date: 01/26/2000

Oil Pump

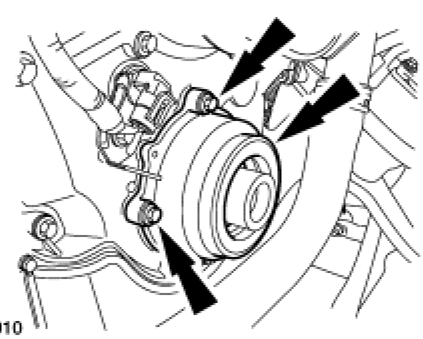
Special Tool(s)

 ST2325-A	Crankshaft Damper Tool 303-144 (T79T-6316-A)
	Damper Service Set 303-S479 (T94T-6379-AH)
 ST2324-A	Front Crankshaft Seal Replacer 303-484 (T94T-6700-AH)
 ST1187-A	Impact Hammer 307-005 (T59L-100-B)
 ST2322-A	Lube Tube Remover 307-160 (T86P-70001-A)

Removal

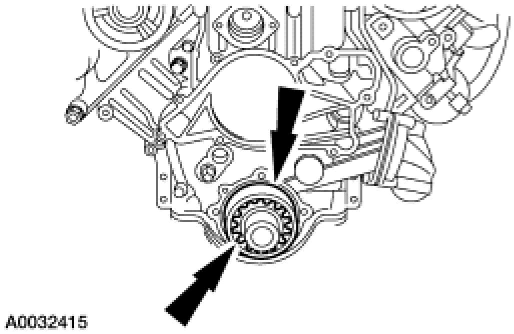
1. Remove the crankshaft vibration damper. For additional information, refer to Crankshaft Vibration Damper in this section.

2. Remove the bolts and the oil pump body plate (6616). Remove and discard the O-ring seal.



A0009910

3. Remove the outer and inner gerotors.



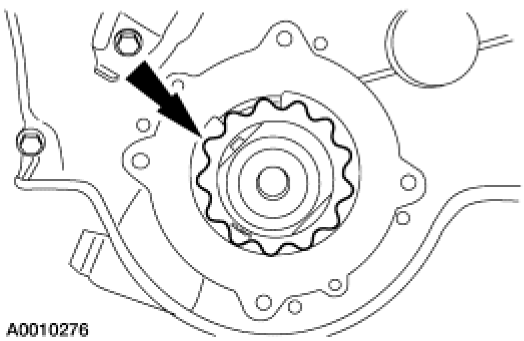
4. Refer to General Procedures in this section for pump component inspection.

Installation

1. **CAUTION: The inner gerotor must be installed with the words "OUT" or "DAMPER" facing away from the engine.**

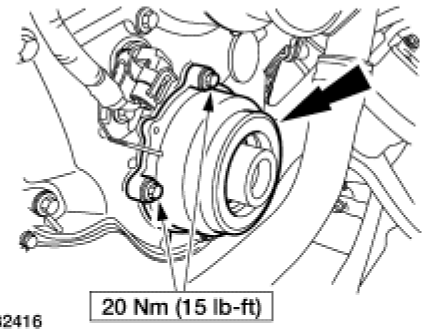
   NOTE: The inner gerotor must be installed onto the crankshaft nose before the oil pump is installed onto the engine front cover.

   Install the inner gerotor.

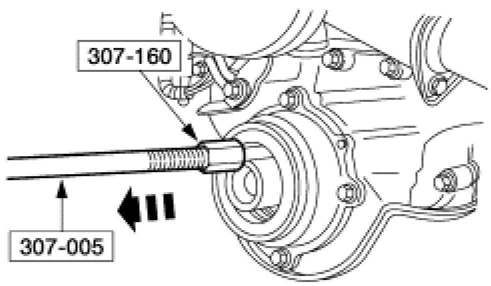
2. **CAUTION: The outer gerotor must be installed with the words "OUT" or "DAMPER" facing away from the engine.**

   Lubricate the oil pump with clean engine oil. Position the outer gerotor in the oil pump body plate. Install a new O-ring seal. Position the oil pump body plate and outer gerotor on the crankshaft nose. Install the bolts.



A0032416

3. Using the special tools, carefully remove and discard the crankshaft front seal.



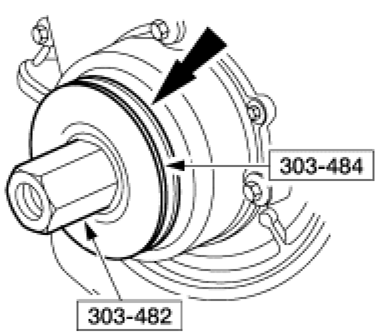
A0010278

4. Thoroughly clean the crankshaft front seal mounting surface.

5. Coat the lip of the oil seal with Multi-Purpose Grease D0AZ-19584-AA or equivalent meeting Ford specification ESB-M1C93-B. Apply a coating of sealant on the outside surface of the seal.

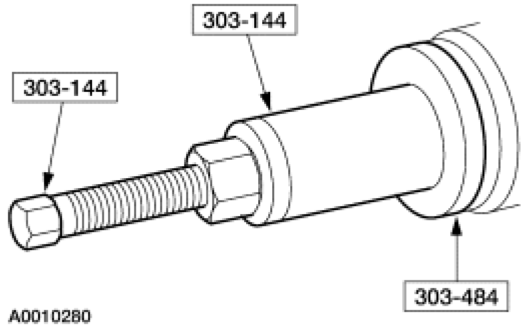
6. **NOTE:** If necessary, rotate special tool 303-484 (T94T-6700-AH) to align it with the crankshaft key.

   Position the crankshaft front oil seal. Install the special tools.



A0010279

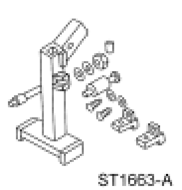
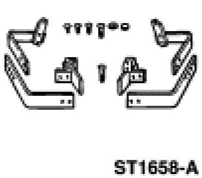
7. Using the special tools, install the new crankshaft front oil seal until it is fully seated.

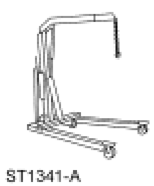


8. Restore the vehicle to operating condition.
    1. Install the crankshaft vibration damper. For additional information, refer to Crankshaft Vibration Damper in this section.
    2. Install a new engine oil filter.
    3. Fill the engine with the correct amount and type of engine oil.
    4. Start the vehicle and check for leaks. Repair as necessary.

SECTION 303-01C: Engine — 7.3L Diesel 1999 F-Super Duty 250-550 Workshop Manual
REMOVAL Procedure revision date: 01/26/2000

Engine

Special Tool(s)	
	Diesel Engine Lifting Bracket (D83T-6000-B) 303-D043
	Engine Mounting Bracket (D94T-6000-A) 303-D097

	Fuel Line Tool (T90T-9550-S) 310-5039
	Fuel/Oil/Turbo Protector Cap Set (T94T-9395-AH) 303-493
	Heavy Duty Floor Crane 014-00071
	Lifting Eye (D94T-6000-C) 303-D099

Removal

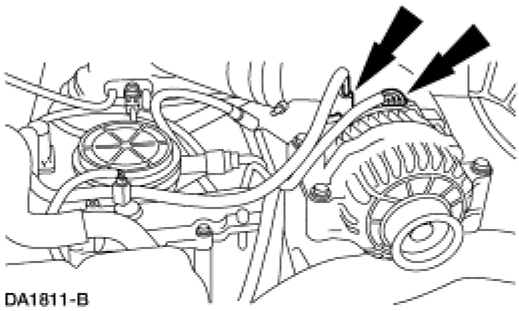
1. Disconnect both battery ground cables; for additional information, refer to Section 414-01.
2. **NOTE:** On vehicles equipped with manual transmissions, the transmission must be removed before the engine can be removed.

   Remove the transmission; for additional information, refer to Section 308-03B.
3. Remove the air inlet duct; for additional information, refer to Section 303-12.
4. Remove the turbocharger; for additional information, refer to Section 303-04D.
5. Remove the radiator; for additional information, refer to Section 303-03.
6. Remove the charge air cooler; for additional information, refer to Section 303-12.
7. Remove the A/C condenser assembly, if so equipped; for additional information, refer to Section 412-03.
8. Remove the parking lamp and the headlamp assemblies; for additional information, refer to Section 417-01.
9. Remove the radiator grille, the radiator grille opening panel, and the upper and lower radiator core supports; for additional information, refer to Section 501-02.

10. Remove the front bumper.

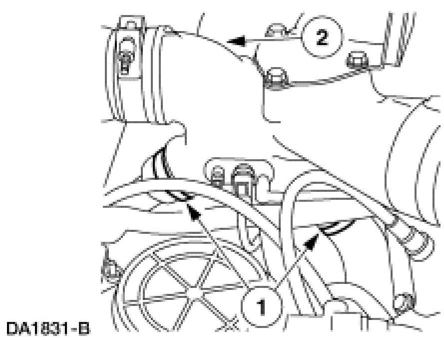
11. Remove the accessory drive belt; for additional information, refer to Section 303-05.

12. Disconnect the generator electrical connectors.



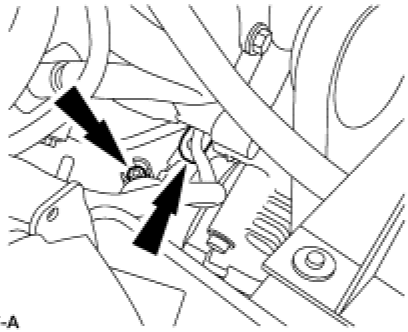
13. Disconnect the manifold absolute pressure (MAP) sensor hose from the turbocharger compressor manifold.

14. Remove the compressor manifold.
    1. Loosen the clamps.
    2. Remove the compressor manifold.



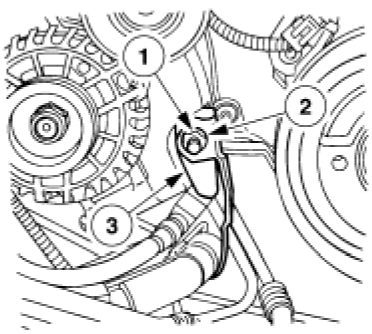
15. **NOTE:** Steps 15 and 16 apply only to vehicles equipped with a dual generator system.

    Disconnect the lower generator electrical connectors.



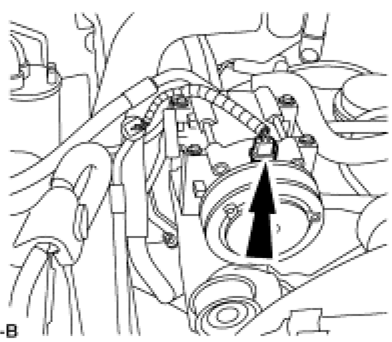
DA1697-A

16. Remove the engine ground cable from the right side of the engine block.
    1. Remove the nut.
    2. Remove the starter wire retaining bracket.
    3. Remove the engine ground cable.



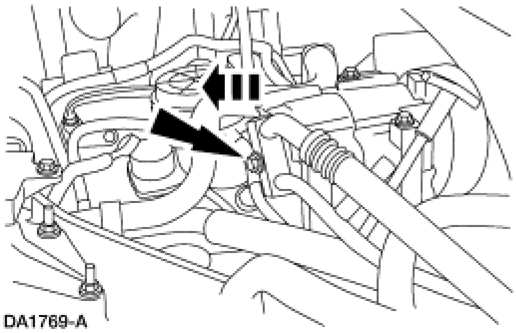
DA1359-A

17. Disconnect the electrical connector from the A/C compressor, if so equipped.



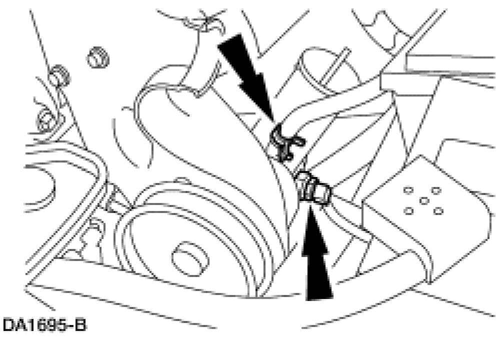
DA1690-B

18. Disconnect the air conditioning manifold lines from the A/C compressor, if so equipped.

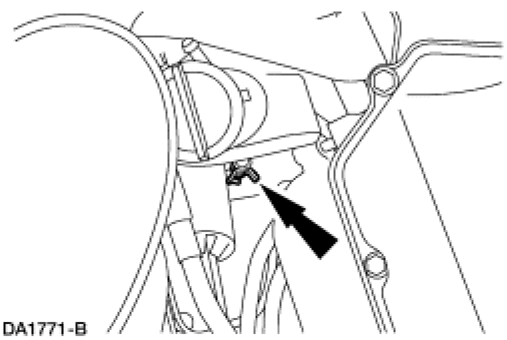


DA1769-A

19. Disconnect the power steering lines.



DA1695-B

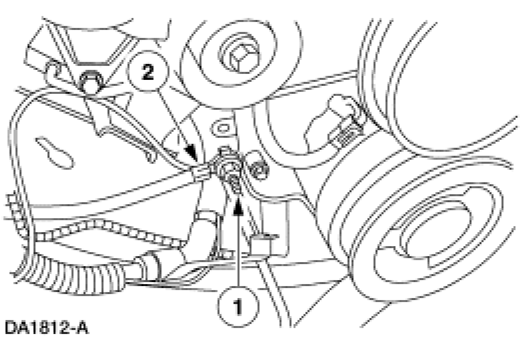


DA1771-B

20. **NOTE:** Step 20 applies only to vehicles equipped with a single generator.

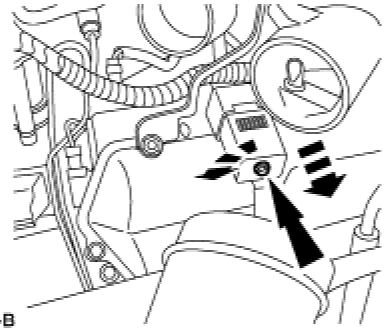
    Remove the ground cable from the right side of the engine block.

    1. Remove the stud bolt.
    2. Remove the ground cable.



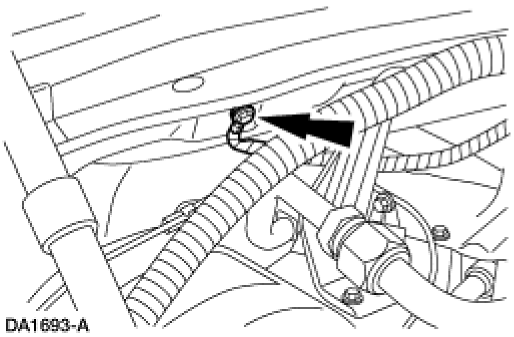
DA1812-A

21. Disconnect the engine control sensor wiring.



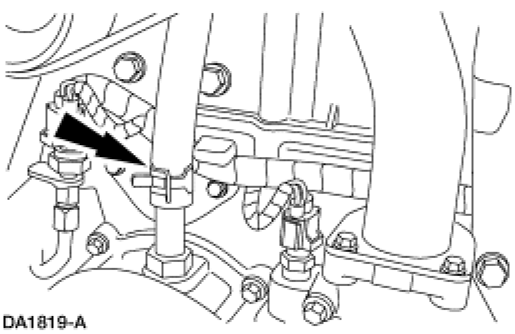
DA1807-B

22. Disconnect the ground strap.



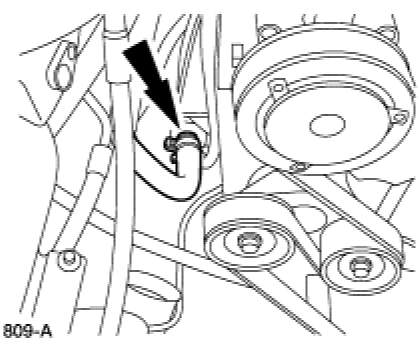
DA1693-A

23. Disconnect the heater return hose.



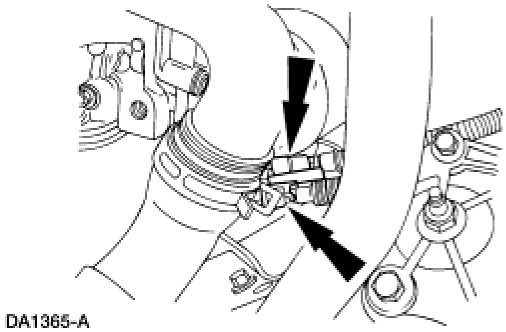
DA1819-A

24. Disconnect the heater supply hose.



DA1809-A

25. Using the Fuel Line Tool, disconnect the fuel lines.

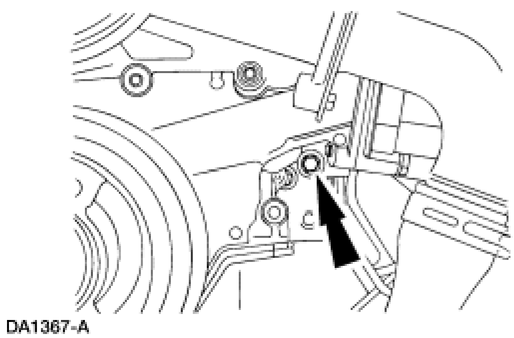


26. **NOTE:** Step 26 applies only to vehicles equipped with automatic transmissions.

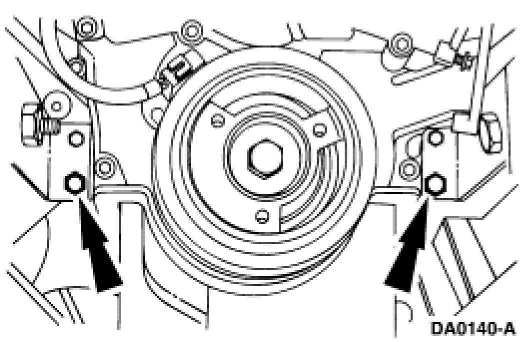
    Remove the transmission sensor harness retaining bolt and the harness.

27. **NOTE:** The fuel line retaining bolt must be removed before the engine lift adapters can be installed.

    Remove the fuel line retaining bolt.



28. Install the two engine lift adapters.

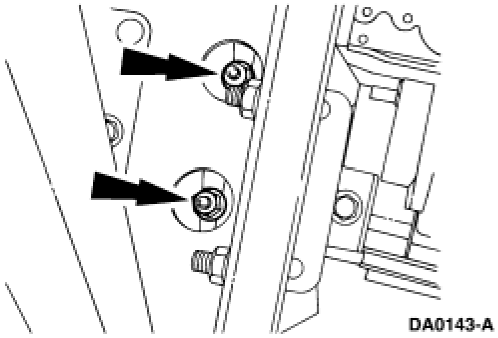


29. Install the engine Lifting Eye on the right side cylinder head, if required.

30. Raise and support the vehicle; for additional information, refer to Section 100-02.

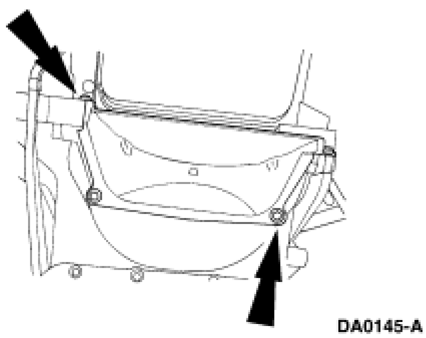
31. Remove the starter motor; for additional information, refer to Section 303-06B.

32. Remove the engine mount nuts.

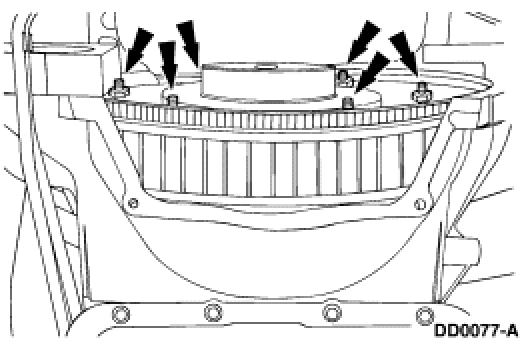


33. **NOTE:** Steps 33 and 34 apply only to vehicles equipped with automatic transmissions.

Remove the flywheel housing cover.

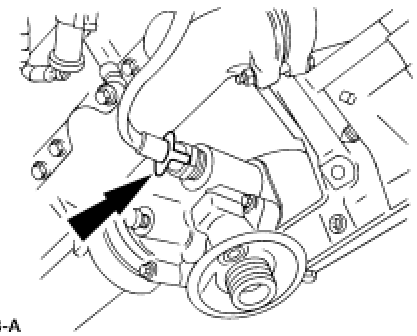


34. Remove the torque converter-to-flywheel retaining nuts.



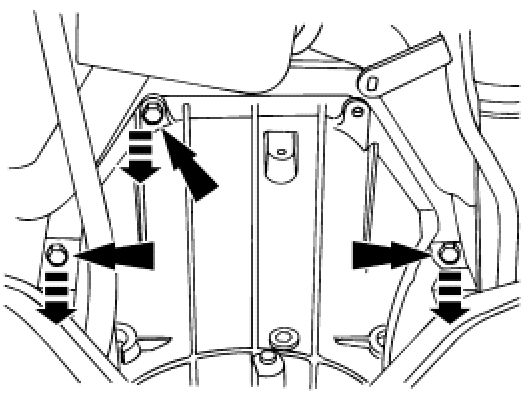
35. Remove the oil filter.

36. Disconnect the block heater.


DA1368-A

37. **NOTE:** Steps 37 through 40 apply only to vehicles equipped with automatic transmissions.

    Remove the transmission-to-engine bolts.


DD0075-A

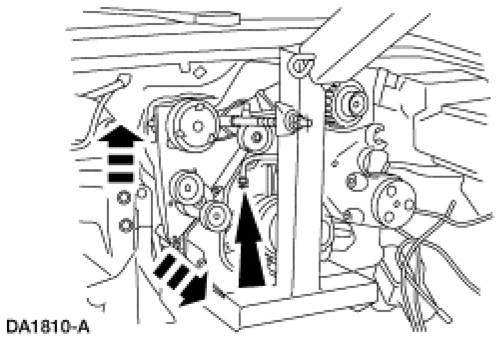
38. Lower the vehicle.

39. Position a suitable jack under the transmission.

40. Remove the transmission fill tube.

41. Install the Heavy Duty Floor Crane and Diesel Engine Lifting Bracket on the engine.

42. Raise the engine high enough to clear the No. 1 cross member and pull the engine forward.

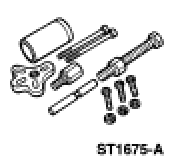
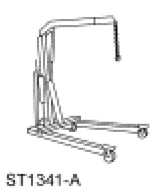


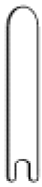
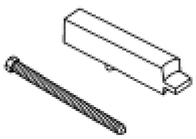
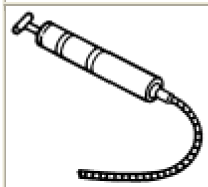
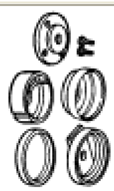
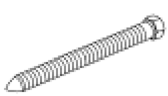
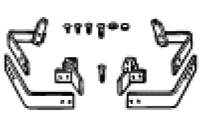
43. Remove the engine lifting equipment from the engine.

44. Remove the flywheel.

45. Mount the engine on a work stand, using the Engine Mounting Brackets.

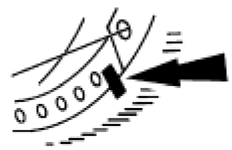
Engine—Vehicles Built After 12/7/98

Special Tool(s)	
	Cylinder Head Lifting Tool (D94T-6000-B) 303-D098
	Damper Remover/Replacer Tool (T83T-6316-A) 303-S215
	Heavy Duty Floor Crane 014-00071

 ST2247-A	High Pressure Line Disconnect Tool 303-625
 ST2049-A	Injector Remover/Replacer Set (T94T-9000-AH) 303-S490
 ST1526-A	Oil Suction Gun (D94T-9000-A) 303-D104
 ST1728-A	Service Set, Crankshaft Rear Oil Seal 303-S485 (T94T-6701-H)
 ST2321-A	Remover/Replacer Tube 308-052 (T77J-7025-B)
 ST1304-A	Forcing Screw 308-092 (T84T-7025-B)
 ST1658-A	Engine Mounting Bracket 303-D097 (D94T-6000-A)

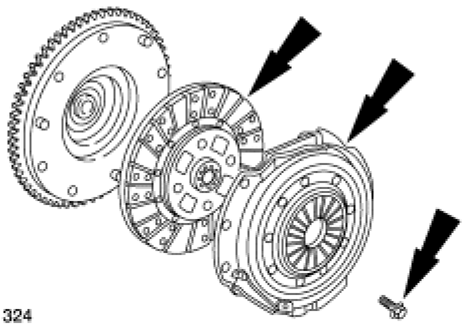
All vehicles

1. Index-mark the clutch pressure plate (7563) and the flywheel (6375), if reinstalling these parts.



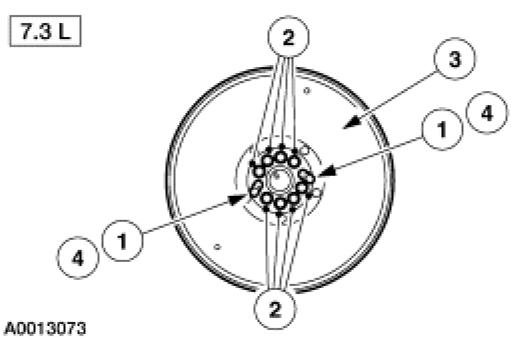
GC1088-A

2. Remove the bolts, the clutch pressure plate and the clutch disc (7550).



A0011324

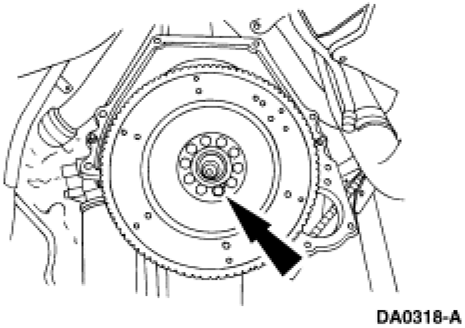
3. Remove the flywheel.
    1. Remove the bolts. Install the guide studs.
    2. Remove the bolts.
    3. Remove the reinforcing ring (7.3L) and flywheel, and the ring gear assembly.
    4. Remove the guide studs.



A0013073

Vehicles equipped with automatic transmission

4. Remove the bolts, spacers and flexplate.

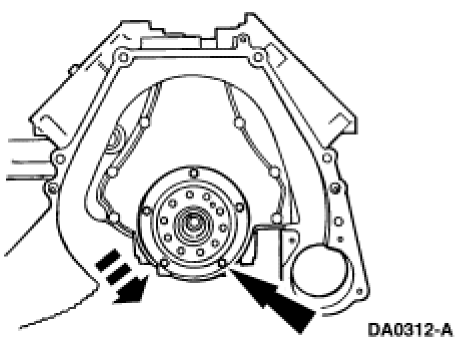


5. **NOTE:** Use extreme care when removing the flywheel front adapter to prevent damage to the alignment dowel pins.

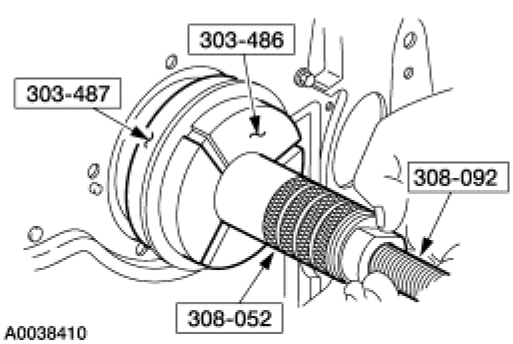
   Remove the flywheel front adapter.

All vehicles

6. Remove the crankshaft rear oil seal retaining bolts and the crankshaft rear oil seal.

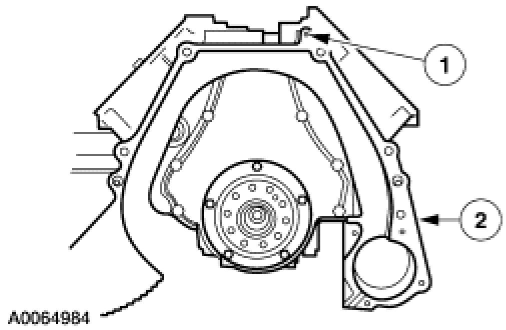


7. Inspect the crankshaft rear seal, wear sleeve and alignment dowel pins for damage. Install new components as necessary.
8. If equipped with a crankshaft wear sleeve, use the special tools to remove the crankshaft wear sleeve.

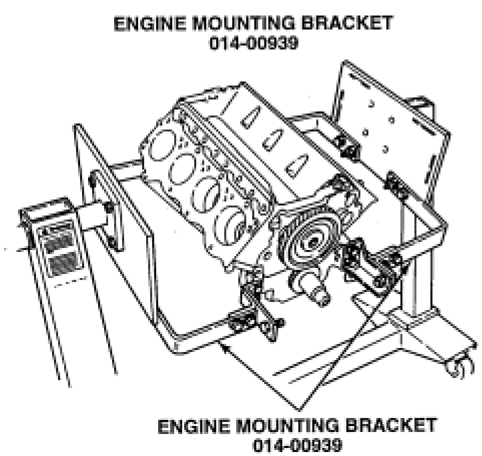


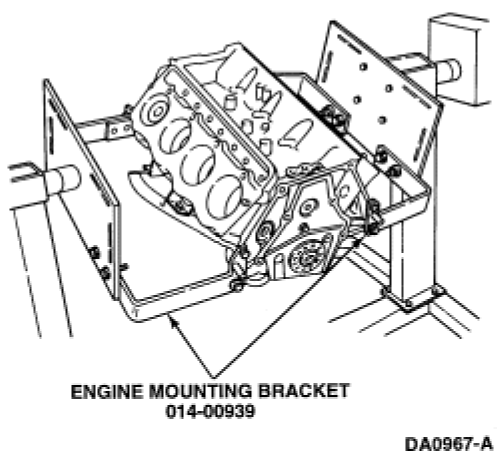
9. Remove the engine adapter plate.
   1. Remove the retainer.

2. Remove the adapter plate.



10. Mount the engine on a work stand using the engine mounting brackets.

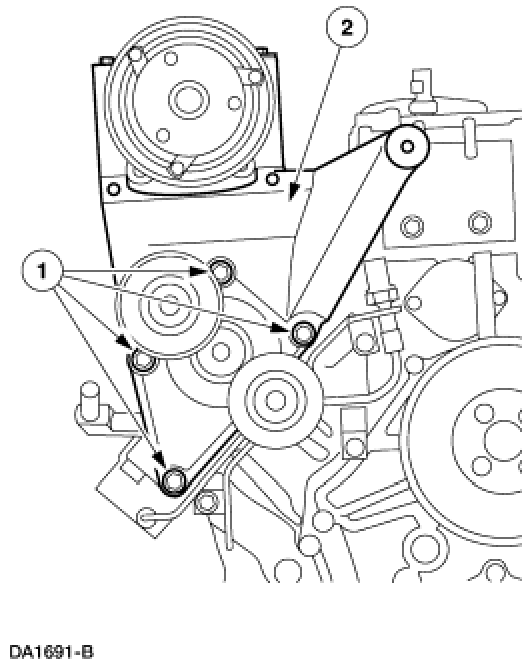




Vehicles with air conditioning

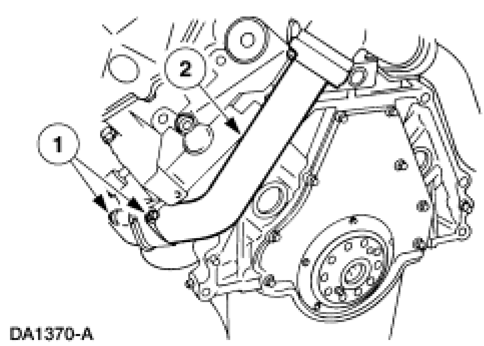
11. Remove the A/C compressor mounting bracket.
    1. Remove the mounting bolts.

    2. Remove the mounting bracket.



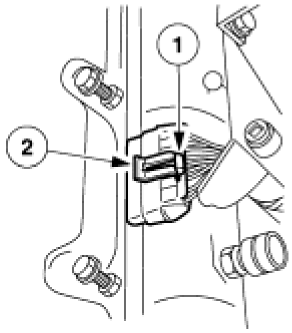
12. Remove the exhaust adapter pipes.
    1. Remove the four mounting bolts and nuts.

    2. Remove the exhaust adapter pipes.



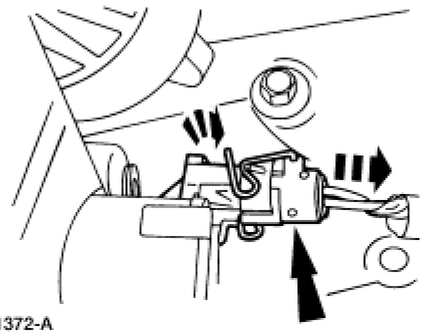
13. Disconnect the fuel injector/glow plug nine pin connectors.
    1. Disconnect the retaining clip.

    2. Disconnect the nine pin connector.



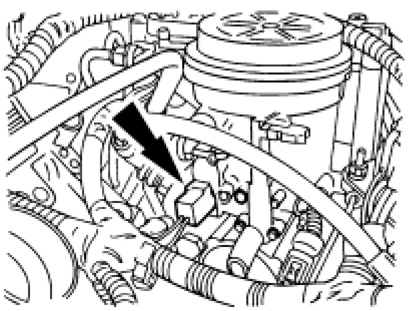
DA1371-B

14. Disconnect the exhaust back pressure solenoid electrical connector.



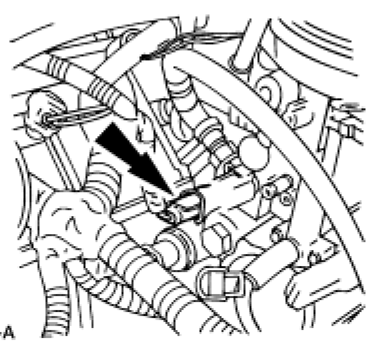
DA1372-A

15. Disconnect the fuel heater/water sensor electrical connector.



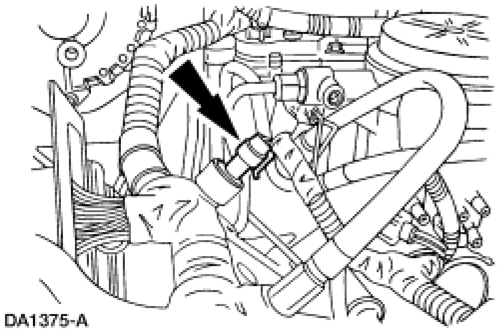
DA1373-A

16. Disconnect the injection pressure regulator electrical connector.

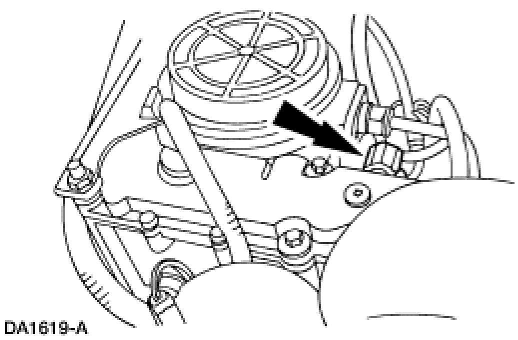


DA1374-A

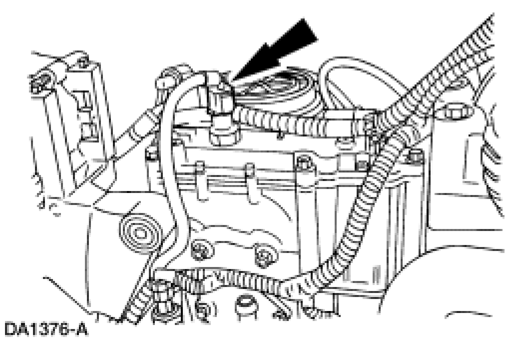
17. Disconnect the injection oil pressure sensor electrical connector.



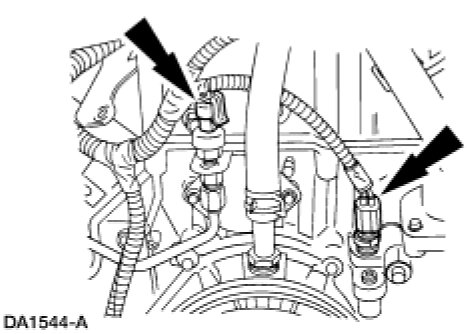
18. Disconnect the engine oil temperature sensor electrical connector.



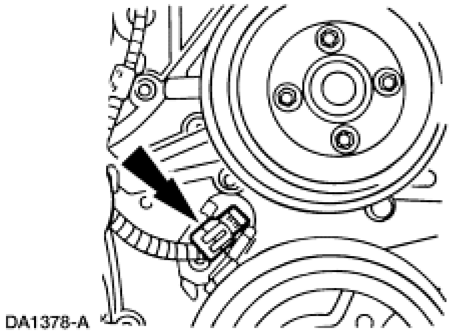
19. Disconnect the engine oil pressure sensor electrical connector.



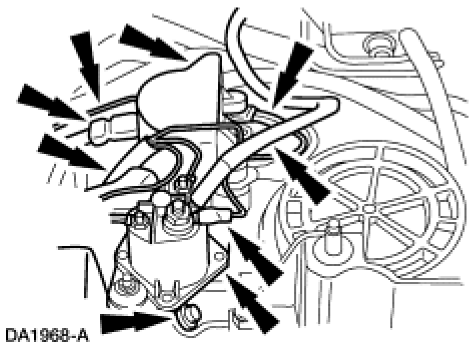
20. Disconnect the exhaust back pressure sensor and engine coolant temperature (ECT) sensor electrical connector.



21. Disconnect the camshaft position (CMP) sensor electrical connector.

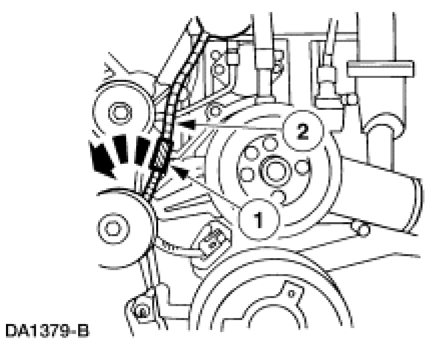


22. If equipped, remove the cover. Label and disconnect the electrical leads. Remove the two nuts and the glow plug relay/intake air heater relay and bracket as an assembly.



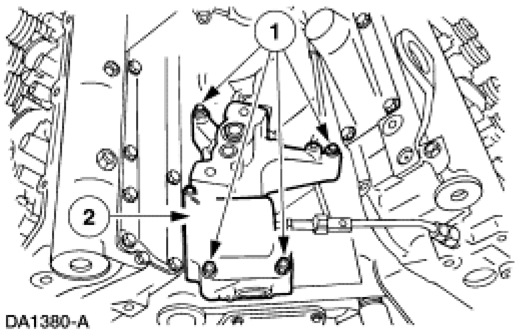
23. Remove the engine electrical harness.
    1. Disconnect the pushpin retainer.

    2. Remove the engine harness.

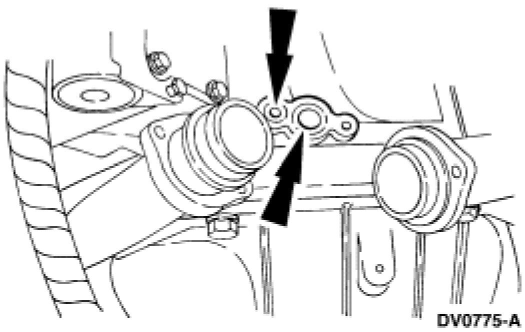


24. Remove the turbocharger pedestal.
    1. Remove the bolts.

    2. Remove the pedestal.

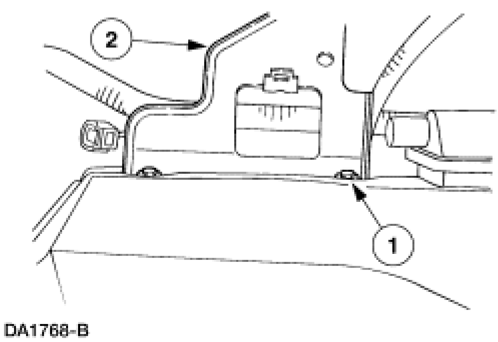


25. Remove and discard the two O-ring seals.



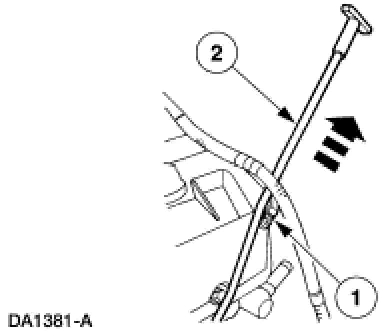
26. Remove the air inlet duct tube mounting bracket.
    1. Remove the nuts.

    2. Remove the bracket.



27. Remove the oil level indicator tube.
    1. Remove the nut.

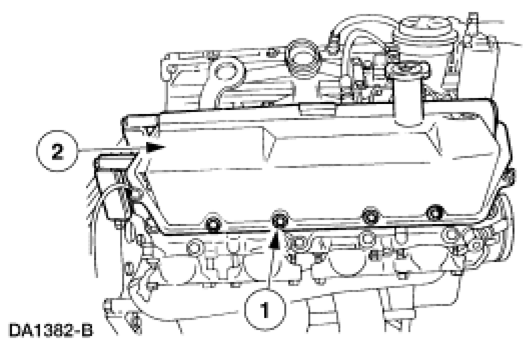
    2. Pull upward and remove the oil level indicator tube.



28. **NOTE:** Both the left side and the right side valve covers are removed the same way. Only the right side valve cover is shown.

    Remove the valve covers.

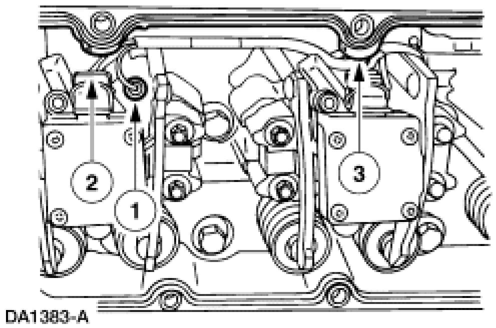
    1. Remove the mounting bolts.
    2. Remove the valve cover.



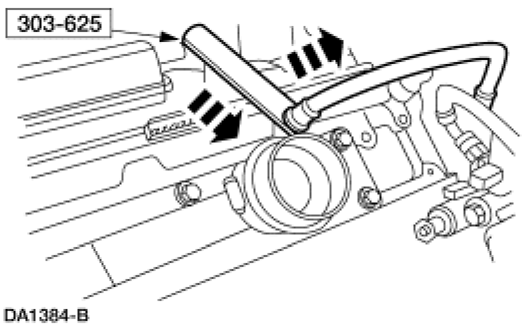
29. **NOTE:** Both the left side and the right side valve cover gaskets are removed the same way. Only the right side valve cover gasket is shown.

    Remove the valve cover gaskets.

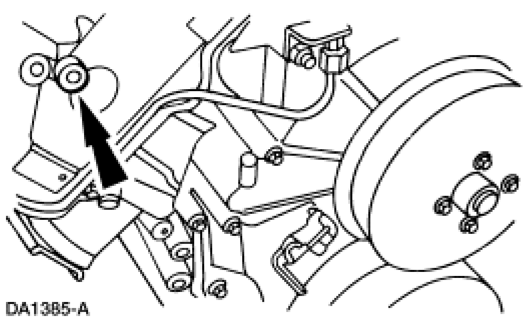
    1. Disconnect the four fuel injector electrical connectors.
    2. Disconnect the four glow plug electrical connectors.
    3. Remove the valve cover gasket.



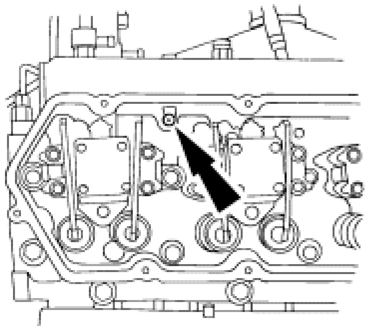
30. Using the special tool, remove the two high pressure oil hoses.



31. Drain the fuel galleries in the cylinder heads.
    - Loosen the fuel gallery plug and drain the fuel.
    - After the fuel has drained, tighten the fuel gallery plug.

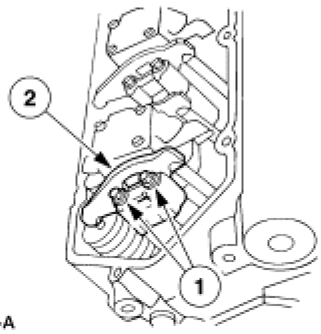


32. Drain the cylinder head oil galleries.
    - Remove the two oil gallery plugs.
    - After the oil has drained, tighten the oil gallery plugs.


DA1386-A

33. Remove the rocker arms.
    1. Remove the bolts.

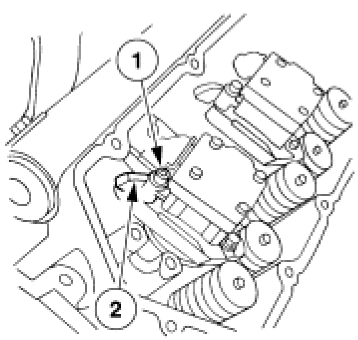
    2. Remove the rocker arms and the push rods.



DA1387-A

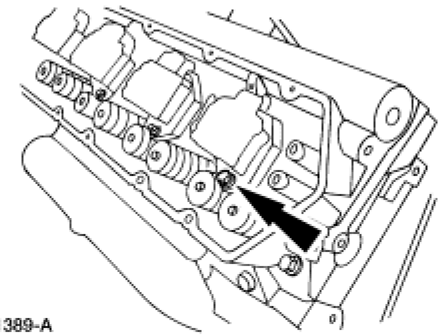
34. Remove the oil deflectors.
    1. Remove the bolt.

    2. Remove the oil deflector.



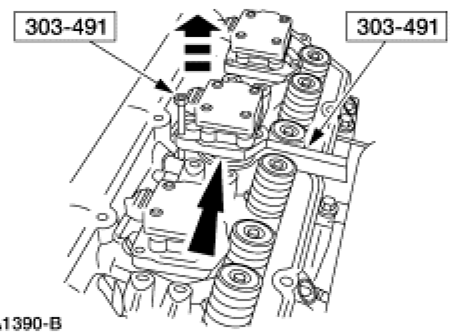
DA1388-A

35. Remove the four fuel injector hold-down mounting bolts.



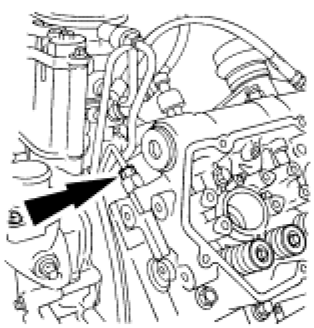
DA1389-A

36. Using the special tool, remove the four fuel injectors.



DA1390-B

37. Remove the two fuel tubes from the cylinder heads.

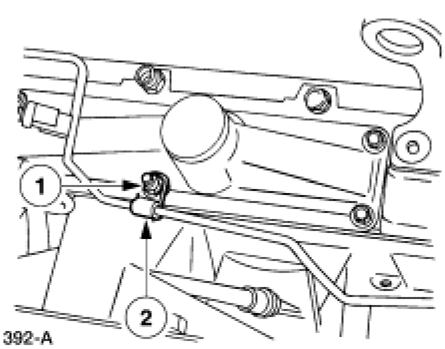


DA1391-A

38. Remove the fuel tube and clamp.

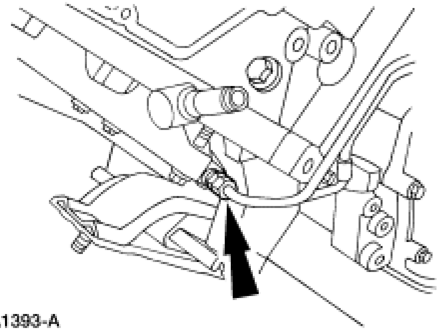
    1. Remove the nut.

    2. Remove the fuel line and clamp from the stud bolt.



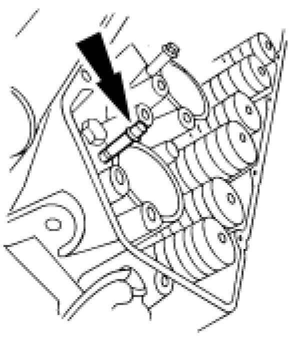
DA1392-A

39. Disconnect the exhaust back pressure tube.



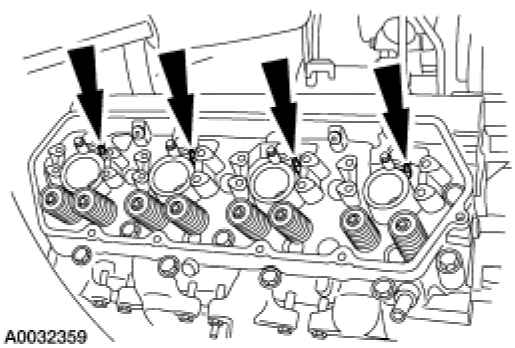
DA1393-A

40. Remove the fuel injector hold-down bolts.



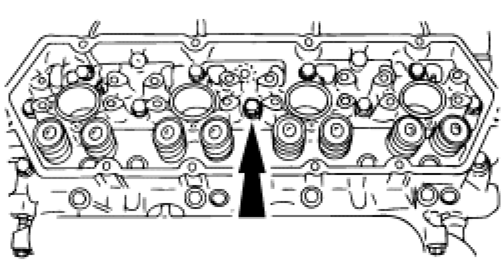
DA1394-A

41. Remove the glow plugs.



A0032359

42. Remove the 18 cylinder head bolts.

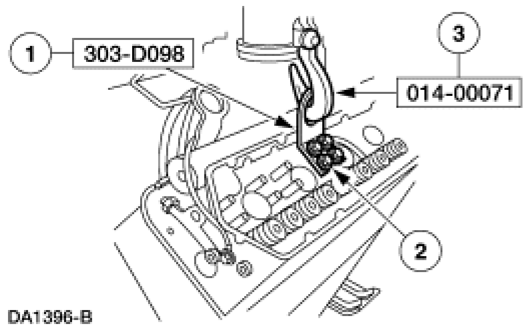


DA1395-A

43. Remove the cylinder heads.
    1. Position the special tool.

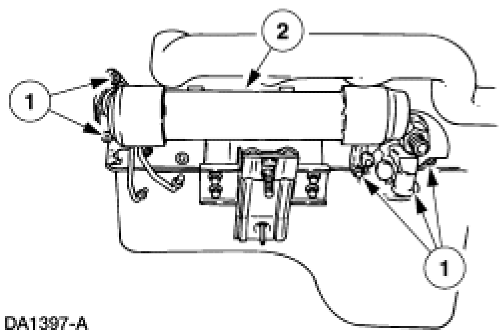
    2. Install the four bolts.

    3. Attach the special tool and remove the cylinder head.

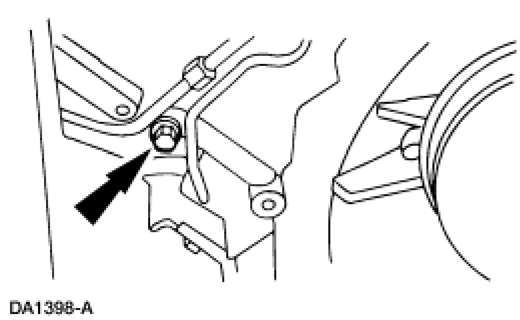


44. Remove the oil cooler.
    1. Remove the bolts.

    2. Remove the oil cooler and the gaskets.

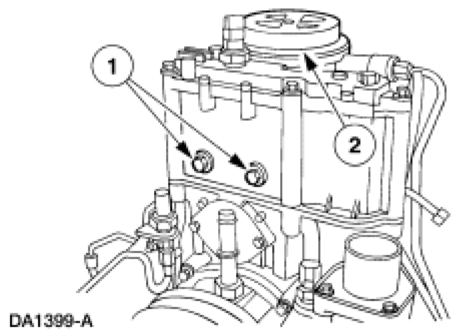


45. Remove the bolt from the fuel drain tube retainer clamp.

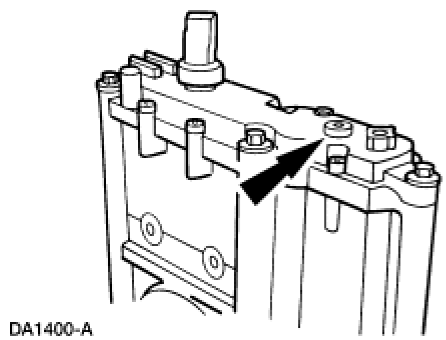


46. Remove the fuel filter/water separator assembly.
    1. Remove the bolts.

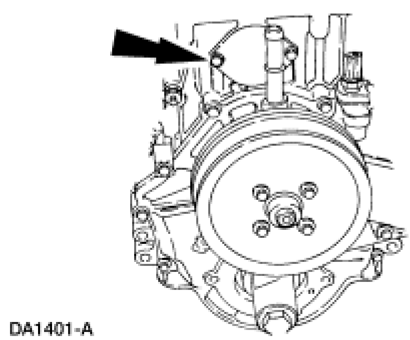
    2. Remove the fuel filter/water separator assembly.



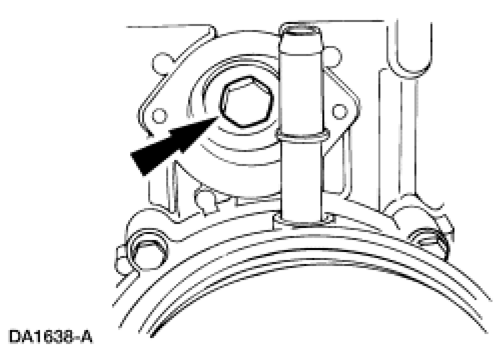
47. Remove the plug and, using special tool 303-D104 (D94T-9000-A), draw the oil from the reservoir.



48. Remove the bolts and the access cover.

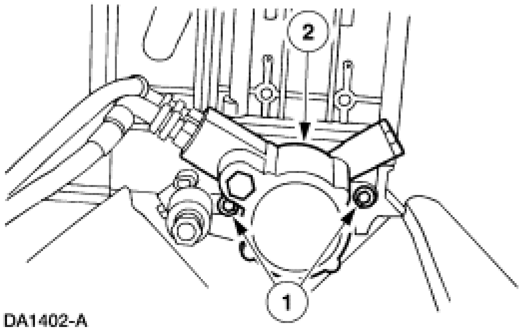


49. Remove the high pressure oil pump drive gear retaining bolt and washer.



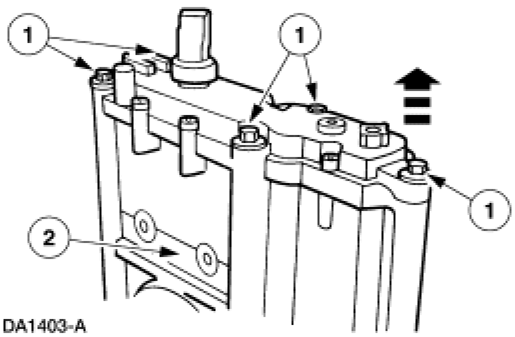
50. Remove the high pressure oil pump.

1. Remove the bolts.
2. Remove the high pressure oil pump and the gasket.



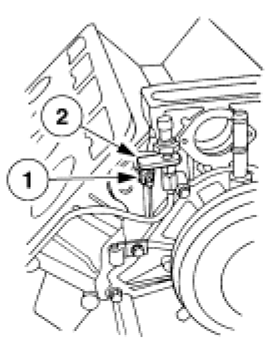
DA1402-A

51. Remove the high pressure oil pump reservoir.
    1. Remove the bolts.
    2. Remove the reservoir and the gasket. Remove the high pressure oil pump drive gear.



DA1403-A

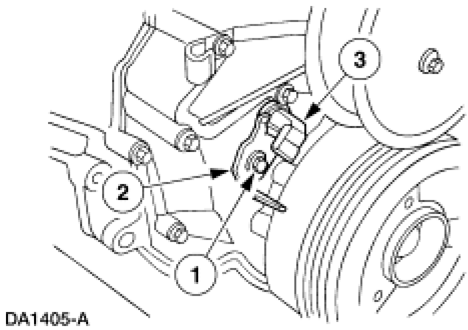
52. Remove the exhaust back pressure sensor and tube.
    1. Remove the nut.
    2. Remove the sensor and tube.



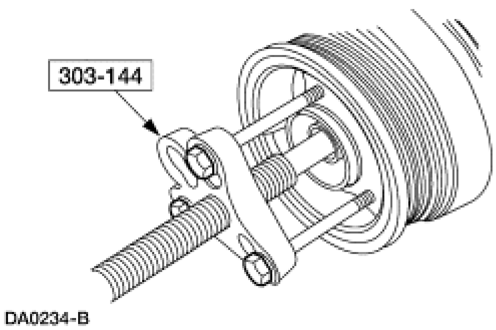
DA1404-A

53. Remove the camshaft position (CMP) sensor.
    1. Remove the bolt.
    2. Remove the camshaft position (CMP) sensor retainer clamp.

3. Remove the camshaft position (CMP) sensor.

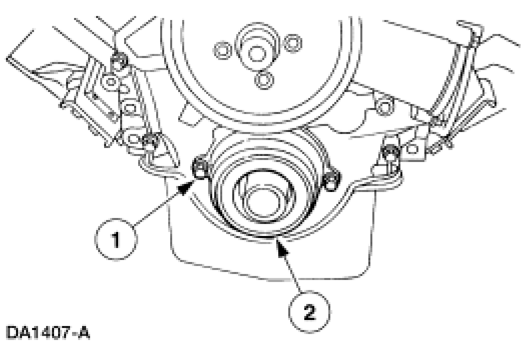


54. Remove the bolt. Using the special tool, remove the crankshaft vibration damper.

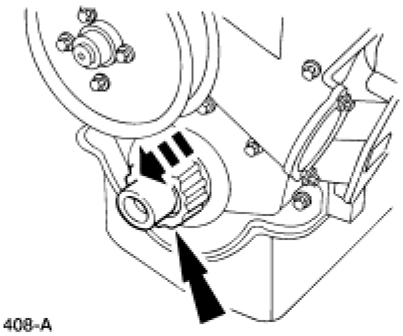


55. Remove the oil pump.
    1. Remove the bolts.

    2. Remove the oil pump housing and the O-ring seal.

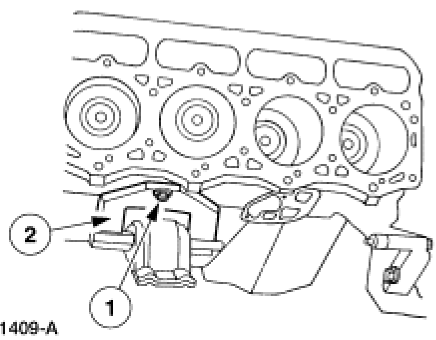


56. Remove the inner gerotor gear.

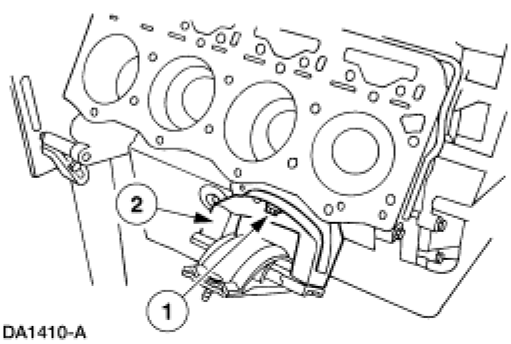


DA1408-A

57. Remove the engine mounts.
    1. Remove the three bolts.
    2. Remove the mounts.



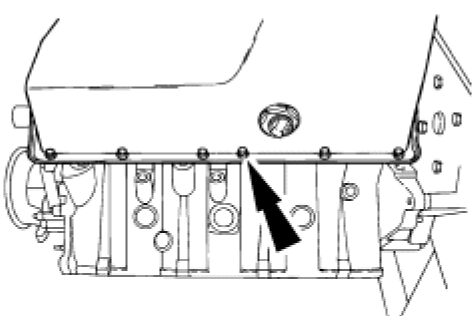
DA1409-A



DA1410-A

58. Drain the engine oil pan.

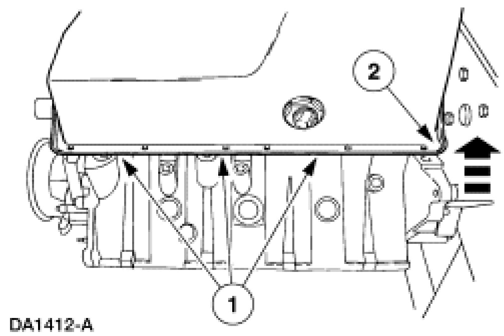
59. Remove the oil pan bolts.



DA1411-A

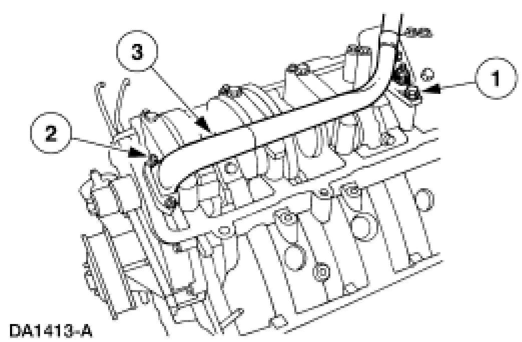
60. Remove the oil pan.

1. Cut the oil pan sealant all the way around the oil pan.
2. Carefully pry the oil pan up and away from the engine block.

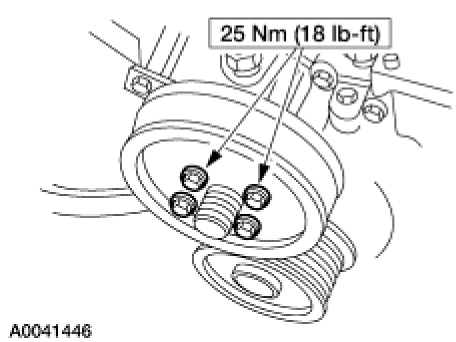


61. Remove the oil pickup tube.

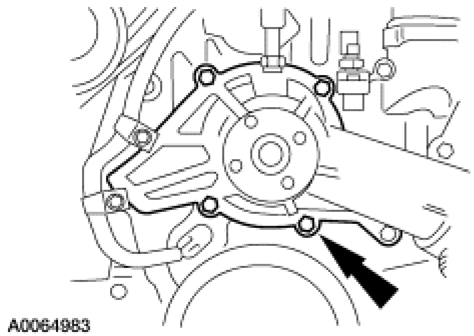
1. Remove the nut.
2. Remove the two bolts.
3. Remove the pickup tube and gasket.



62. Remove the four bolts and the water pump pulley.

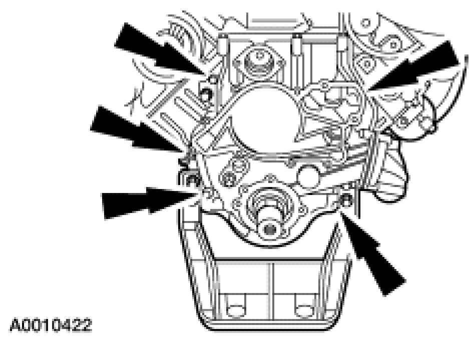


63. Remove the six bolts and the water pump.



64. Clean the water pump gasket surfaces.

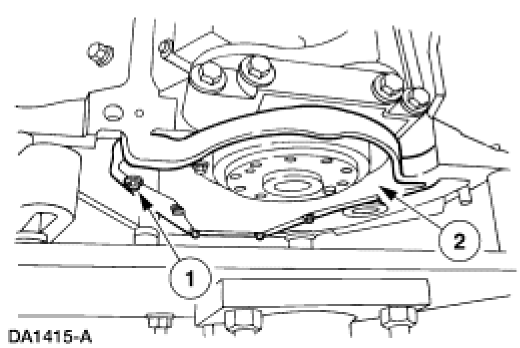
65. Remove the bolts, the engine front cover and gasket.



66. **CAUTION: Do not bend the engine rear cover. If the rear cover is bent, it will not reseal causing engine oil leaks.**

    Remove the engine rear cover.

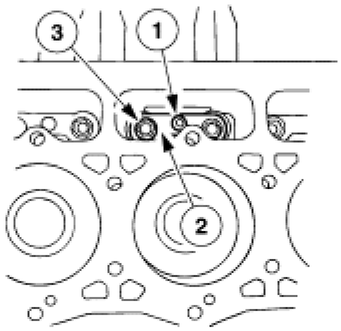
    1. Remove the bolts.
    2. Using a putty knife, carefully cut the sealant between the engine rear cover and the engine. Remove the cover.



67. **NOTE:** All sixteen lifters are removed the same way. Only two lifters are shown.

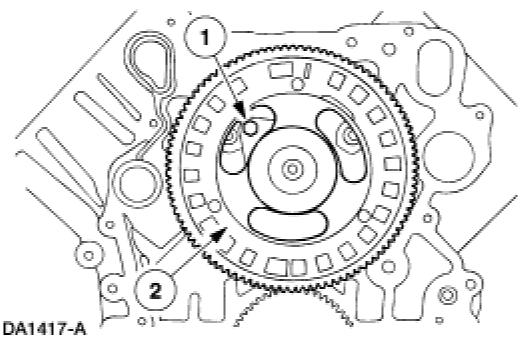
    Remove the lifters.

1. Remove the bolt.
2. Remove the lifter retainer.
3. Remove the lifters.



DA1416-A

68. Remove the camshaft.
    1. Remove the two retainer bolts.
    2. Remove the camshaft and the drive gear.



DA1417-A

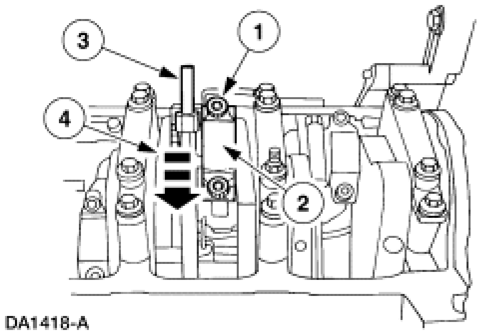
69. Remove the carbon ridge from the top of the cylinder bores.

70. **NOTE:** Mark and record all eight piston rods to make sure that they are installed into their correct cylinder bores during assembly.

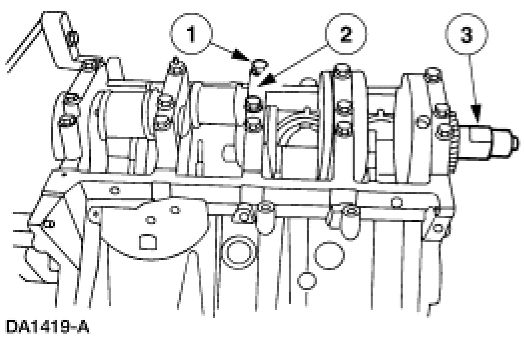
    NOTE: All eight pistons and rod assemblies are removed the same way. Only one piston and rod assembly is shown.

    Remove the piston and rod assemblies.

    1. Remove the nuts.
    2. Remove the rod cap and bearing half.
    3. Install the rod bolt protector sleeves.
    4. Push the rod and piston assembly down and out of the engine block.



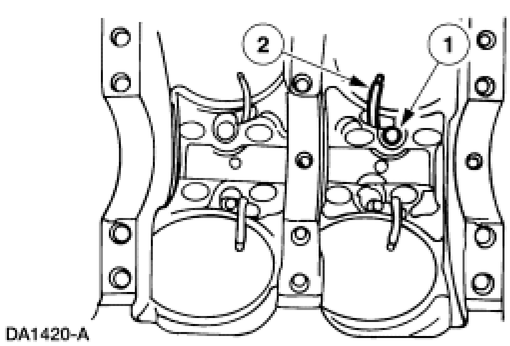
71. Remove the crankshaft.
    1. Remove the bolts.
    2. Remove the main bearing caps and the bearing halfs.
    3. Using a suitable sling and special tool 014-00071, remove the crankshaft.



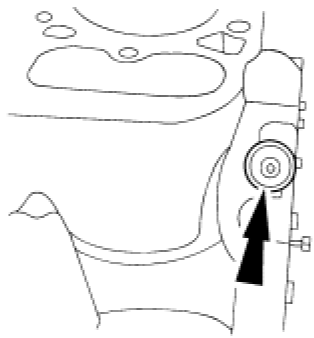
72. **NOTE:** All eight piston oil cooling jets are removed the same way. Only one jet is shown.

    Remove the piston oil cooling jets.

    1. Remove the bolt.
    2. Remove the cooling jet.

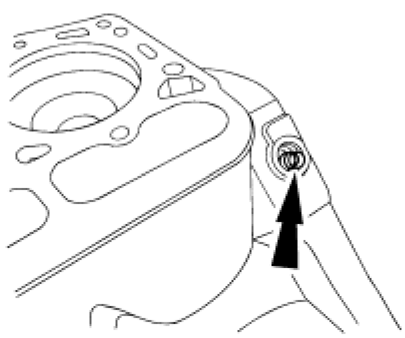


73. Remove the anti-drainback check ball retainer cap.



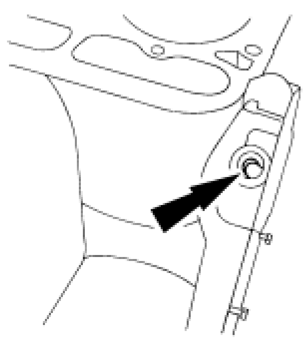
DA1421-A

74. Remove the spring.



DA1422-A

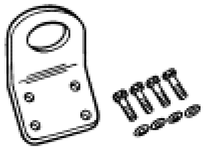
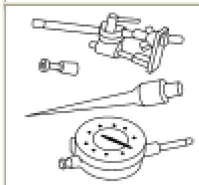
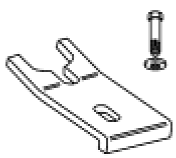
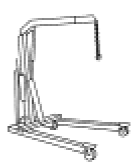
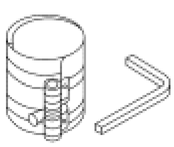
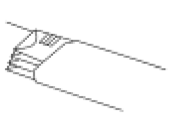
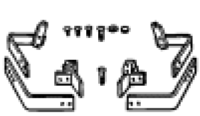
75. Remove the anti-drainback check ball.

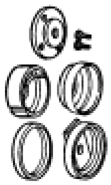
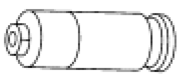
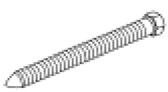
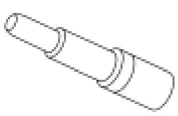


DA1423-A

Engine—Vehicles Built After 12/7/98

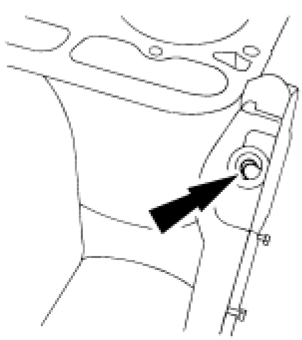
Special Tool(s)

 ST1660-A	Cylinder Head Lifting Tool (D94T-6000-B) 303-D098
 ST1675-A	Damper Remover/Replacer Tool (T83T-6316-A) 303-S215
 ST1214-A	Dial Indicator with Bracketry 100-002 (D78P-4201-B) or Equivalent
 ST2050-A	Fuel Injector Installer Tool 303-492 (T94T-9000-A)
 ST1341-A	Heavy Duty Floor Crane 014-00071
 ST1376-A	Piston Ring Compressor (D81L-6002-C) 303-D032
 ST1280-A	Plastigage® (D81L-6002-B) 303-D031
 ST1658-A	Engine Mounting Bracket 303-D097 (D94T-6000-A)

 ST1255-A	Driver Handle 205-153 (T80T-4000-W)
 ST1728-A	Service Set, Crankshaft Rear Oil Seal 303-S485 (T94T-6701-AH)
 ST2321-A	Remover/Replacer Tube 308-052 (T77J-7025-B)
 ST1304-A	Forcing Screw 308-092 (T84T-7025-B)
 ST1469-A	Clutch Aligner (6-Speed) 308-421

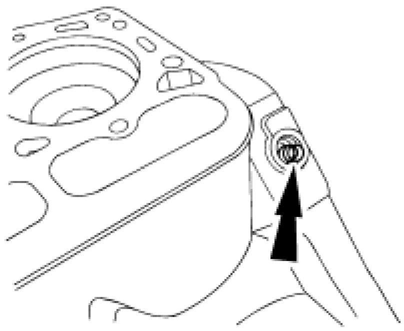
All vehicles

1. Install the anti-drainback check ball.



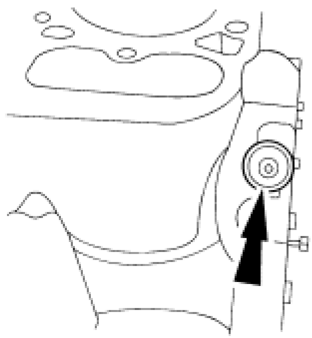
DA1423-A

2. Install the spring.



DA1422-A

3. Install the anti-drainback check ball retainer cap.

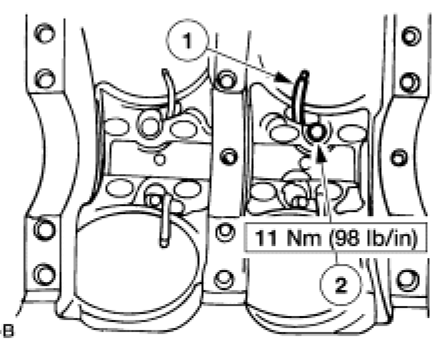


DA1421-A

4. **NOTE:** All eight piston oil cooling jets are installed the same way. Only one jet is shown.

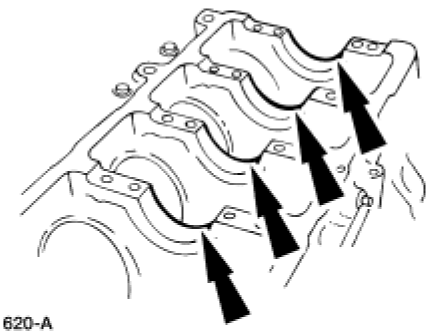
   Install the piston oil cooling jets.

   1. Install the cooling jet.
   2. Install the bolts.



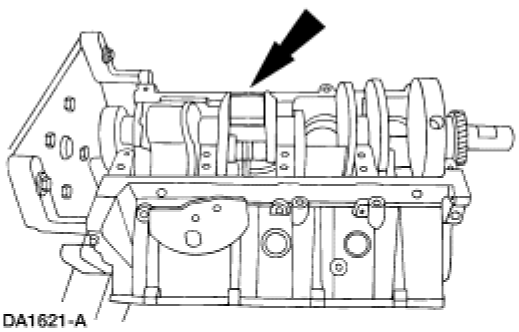
DA1571-B

5. Install the upper halves of the main bearing into the bearing bores.
   - Coat the main bearing halves with Ford Engine Assembly Lubricant D9AZ-19579-D or equivalent meeting Ford specification ESR-M99C80-A after installing them into the bearing bores.



DA1620-A

6. Install the crankshaft into the cylinder block.



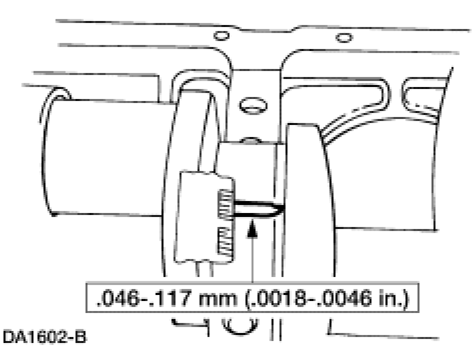
DA1621-A

7. **NOTE:** Do not turn the crankshaft while performing the main bearing clearance check.

   Install the special tool 303-D031 (D81L-6002-B).

   1. Install the lower main bearing halves into the main bearing caps.
   2. Place a piece of special tool in the center of each main bearing journal on the crankshaft, and install the main bearing caps.
   3. Tighten the main bearing cap bolts to specification.

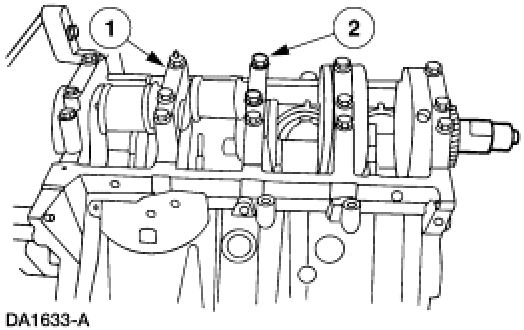
8. Remove the main bearing caps and measure the clearance.
   - Install a new main bearing if not within specification.



DA1602-B

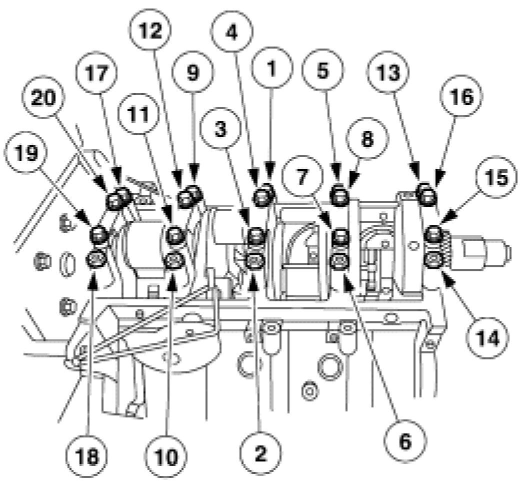
9. Install the main bearing caps.

   1. Coat the main bearing halves with Ford Engine Assembly Lubricant D9AZ-19579-D or equivalent meeting Ford specification ESR-M99C80-A. Position the main bearing caps.
   2. Install the bolts.



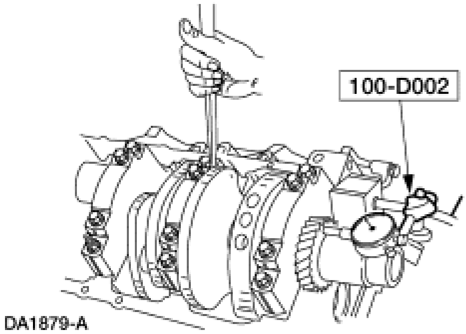
DA1633-A

10. Tighten the main bearing cap bolts in the sequence shown in two stages.
    - Stage 1: Tighten the bolts to 102 Nm (76 lb-ft).
    - Stage 2: Tighten the bolts to 129 Nm (96 lb-ft).

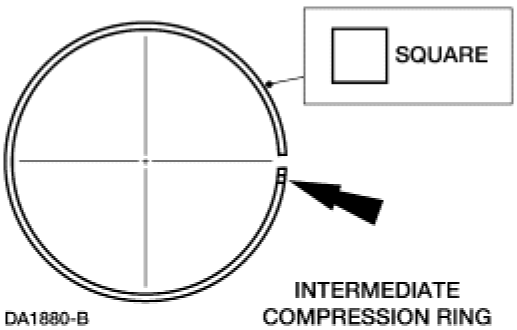


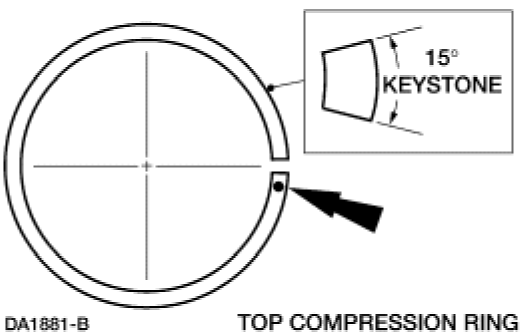
DA1630-C

11. Using the special tool, measure the crankshaft end play by prying the crankshaft forward and back.



12. Install new piston rings.
    - The intermediate compression ring is identified with two indentation marks and a square profile.
    - The top compression ring is identified with one indentation mark and has a 15-degree keystone profile.



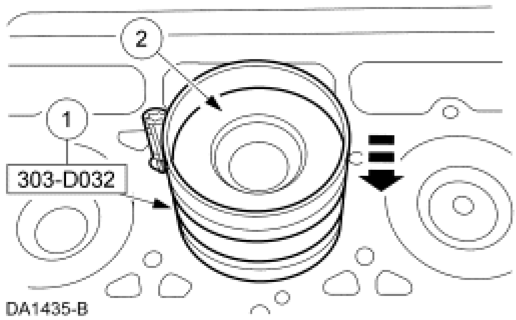


13. **NOTE:** All eight piston and connecting rods are installed into the cylinder block the same way. Only one piston and connecting rod is shown.

    Install the piston and rod assemblies.

    1. Using the special tool, insert the piston into the Piston Ring Compressor. Position the piston, connecting rod and Piston Ring Compressor into the correct cylinder bore.

    2. Coat the inside diameter of the ring compressor with clean engine oil. Using a wood or plastic hammer handle, push the connecting rod and piston assembly down into the cylinder bore.

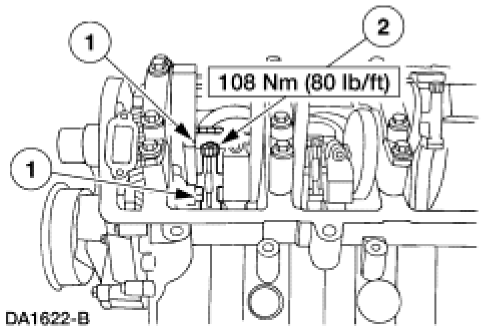


14. **NOTE:** Do not turn the crankshaft while performing the rod bearing clearance check.

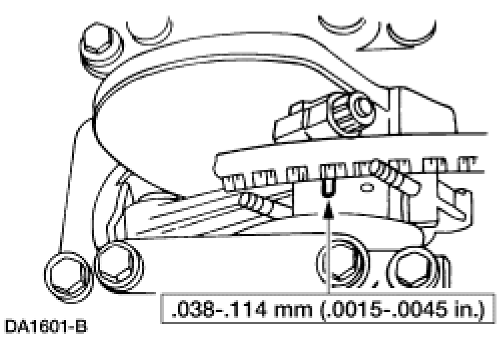
    NOTE: All eight rod bearings are checked the same way. Only one rod bearing is shown.

    Check the rod bearing clearance.

    1. Insert the upper rod bearing half into the connecting rod. Install the lower rod bearing half into the rod cap.
    2. Place a piece of special tool 303-D031 (D81L-6002-B) in the center of the rod bearing journal on the crankshaft. Install the connecting rod cap and nuts.



15. Remove the rod bearing cap and measure the clearance. Install a new rod bearing if not within specification.

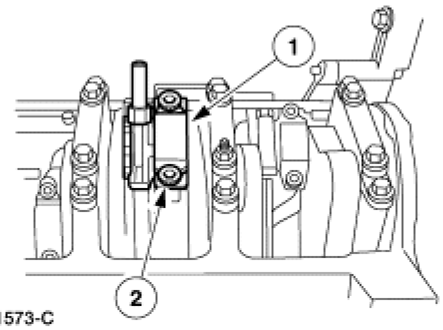


16. **NOTE:** All eight connecting rod caps are installed the same way. Only one rod cap is shown.

    Install the connecting rod cap.

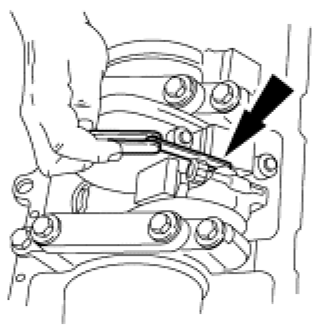
1. Coat the connecting rod bearing half with Ford Engine Assembly Lubricant D9AZ-19579-D or equivalent meeting Ford specification ESR-M99C80-A. Position the connecting rod cap onto the connecting rod and seat the cap onto the crankshaft journal.

2. Install the nuts. Tighten the nuts in two stages.
   - Stage 1: Tighten the nuts to 71 Nm (53 lb-ft).
   - Stage 2: Tighten the nuts to 108 Nm (80 lb-ft).



DA1573-C

17. Using a feeler gage, measure connecting rod to crankshaft assembled side clearance.


DA1882-A

18. **NOTE:** Thoroughly coat the camshaft bearing journals with Ford Engine Assembly Lubricant D9AZ-19579-D or equivalent meeting Ford specification ESR-M99C80-A before installing the camshaft into the engine block.

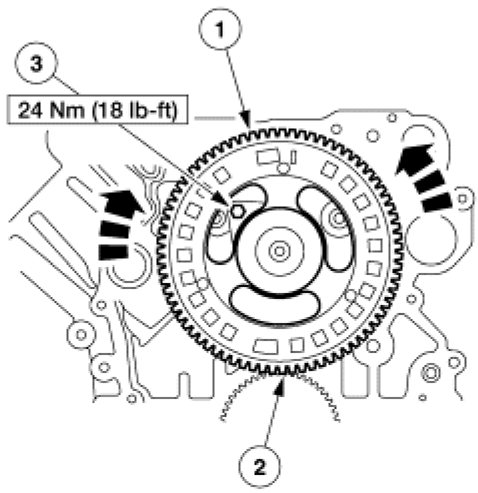
    Install the camshaft.

    1. Gently insert the camshaft into the engine block.

    2. **NOTE:** It may be necessary to rotate the camshaft during installation to aid in inserting the camshaft through the camshaft bearings.

       Before seating the camshaft drive gear with the crankshaft driven gear, rotate the crankshaft driven gear until the timing mark is in the 12 O'clock position. Align the timing mark on the camshaft drive gear with the timing mark on the crankshaft driven gear. Seat the camshaft drive gear with the crankshaft driven gear.

    3. Install the two camshaft retaining bolts.



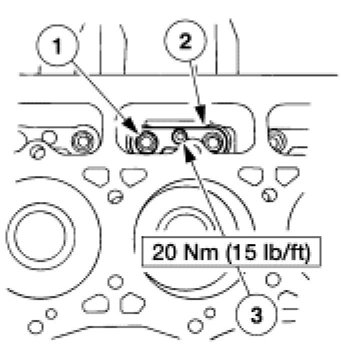
DA1574-C

19. **NOTE:** All sixteen lifters are installed the same way. Only two lifters are shown.

    NOTE: Before installing the lifters into the lifter bores, thoroughly coat the lifters using Ford Engine Assembly Lubricant D9AZ-19579-D or equivalent meeting Ford specification ESR-M99C80-A.

    Install the lifters.

    1. Insert the lifters into the lifter bores.
    2. Install the retainer plate.
    3. Install the retaining bolt.



DA1575-B

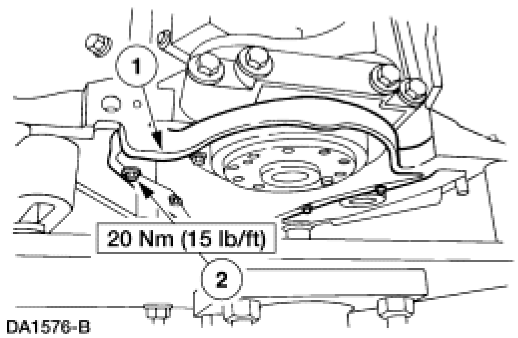
20. **CAUTION: Use caution when installing the engine rear cover. If the cover is bent, engine oil leaks will occur.**

CAUTION: Use care not to use too much RTV sealant on the engine rear cover. Too much sealant can cause engine oil contamination and engine failure.

NOTE: The engine rear cover must be installed within three minutes after applying the RTV sealant to it. If the cover is not installed within three minutes, the RTV sealant must be removed and a new bead of RTV sealant must be applied.

Install the engine rear cover.

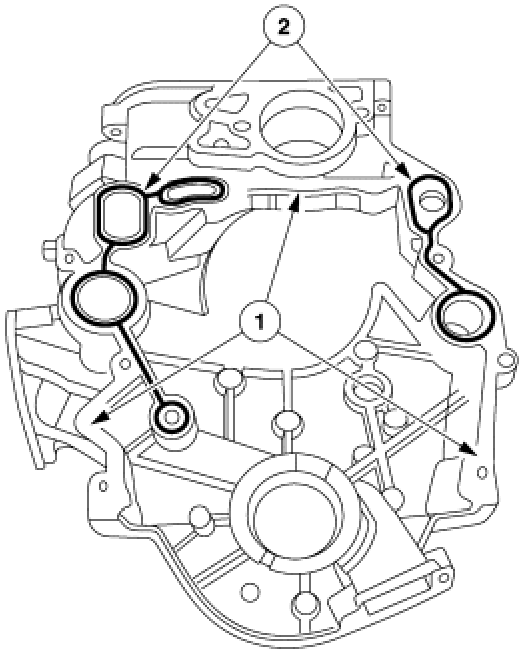
1. Apply a bead of RTV Silicone Sealant F5TZ-19G204-AB or equivalent meeting Navistar specification D15-5012 Type 2. Position the engine rear cover and install the bolts finger tight.
2. Tighten the bolts.



21. **NOTE:** The engine front cover must be installed within three minutes after applying the RTV sealant to it. If the cover is not installed within three minutes, the RTV sealant must be removed and a new bead of RTV sealant must be applied.

    Install the engine front cover gasket.

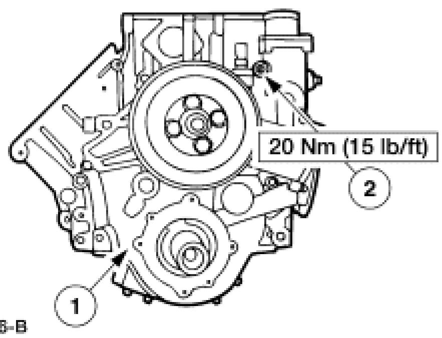
    1. Apply the RTV Silicone Sealant F5TZ-19G204-AB or equivalent meeting Navistar specification D15-5012 Type 2, to the engine front cover.
    2. Install the engine front cover gaskets.



DA1439-C

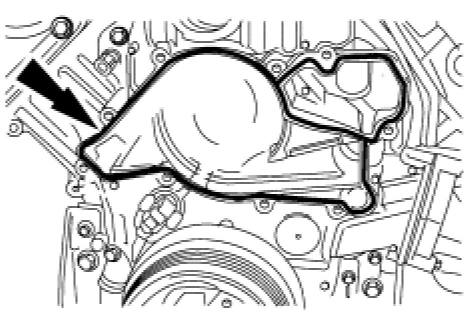
22. Install the engine front cover.
    1. Position the engine front cover onto the engine block.

    2. Install the bolts.



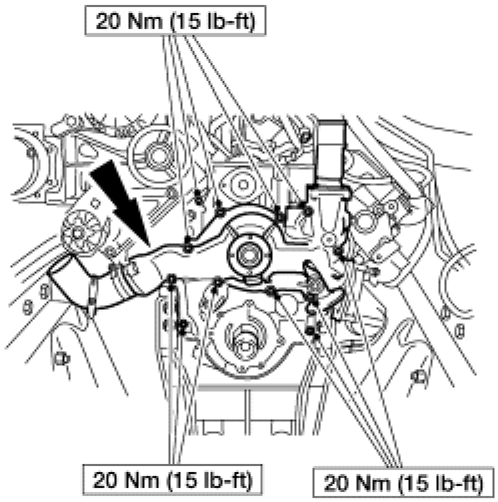
DA1436-B

23. Install a new seal.



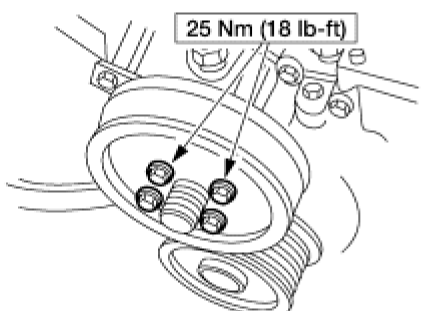
DA2006-A

24. Install the water pump and bolts as noted during removal. Tighten the water pump and the front cover bolts.



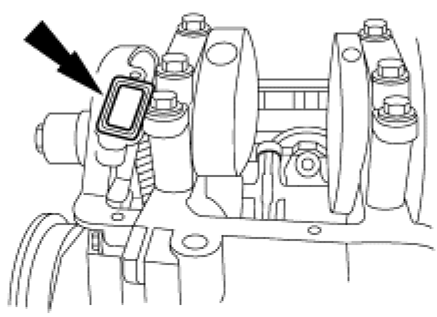
A0010423

25. Install the water pump pulley.



A0041446

26. Install the oil pickup tube gasket.

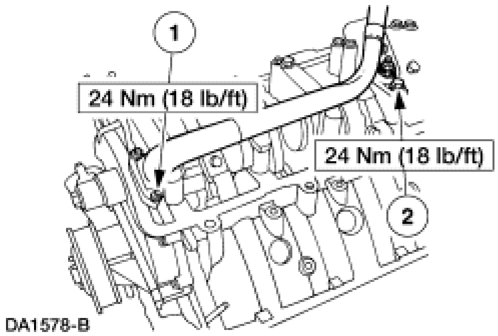


DA1438-B

27. Install the oil pickup tube.

1. Position the oil pickup tube and install the bolts.

2. Install the nut.



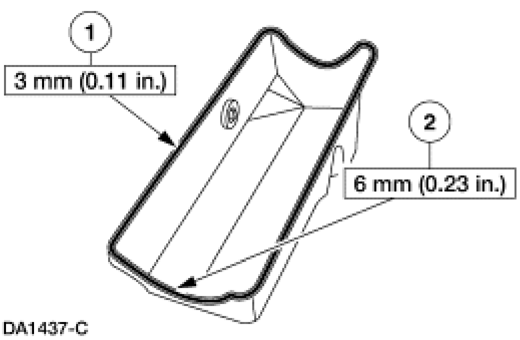
28. **NOTE:** The oil pan must be installed within three minutes after applying the RTV sealant. If the oil pan is not installed within three minutes, the RTV sealant must be removed and a new bead of RTV sealant must be applied.

    NOTE: A larger amount of RTV Silicone Sealant will be required on the front and rear areas of the oil pan.

    Apply RTV Silicone Sealant F5TZ-19G204-AB or equivalent meeting Ford specification NAVSTR SLR, to the oil pan.

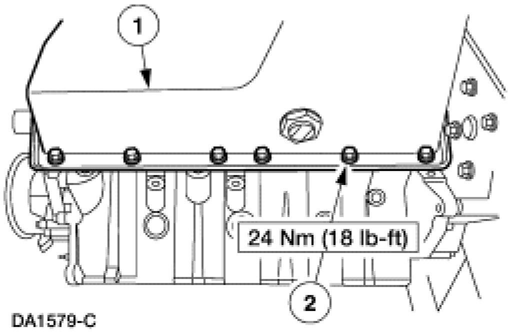
    1. Apply a bead of sealant.

    2. Apply a bead of sealant.



29. Install the oil pan.
    1. Position the oil pan.

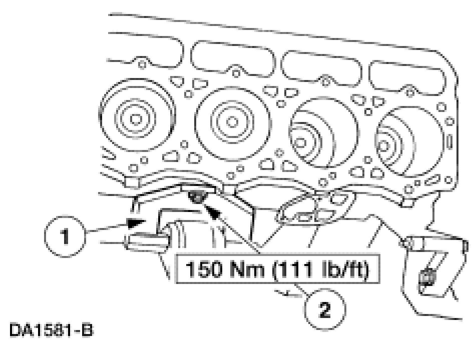
    2. Install the oil pan bolts.



30. **NOTE:** Both the left and the right engine mounts are installed the same way. Only the left side is shown.

    Install the engine mounts.

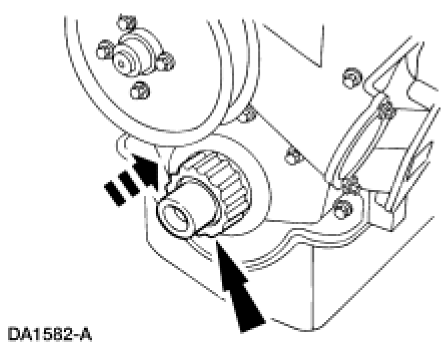
    1. Position the engine mounts.
    2. Install the three bolts.



31. ⚠ **CAUTION: The inner gerotor must be installed with the words "Out" or "Damper" facing away from the engine.**

    NOTE: The outer gerotor gear must be installed into the oil pump housing before the oil pump is installed onto the engine front cover.

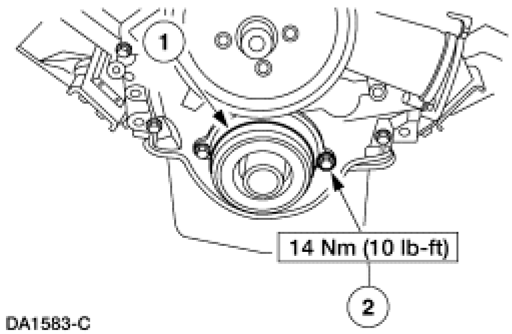
    Install the oil pump inner gerotor.



32. Install the oil pump.

1. Lubricate the oil pump with clean engine oil. With a new O-ring, position the oil pump housing with the outer gerotors onto the engine front cover.

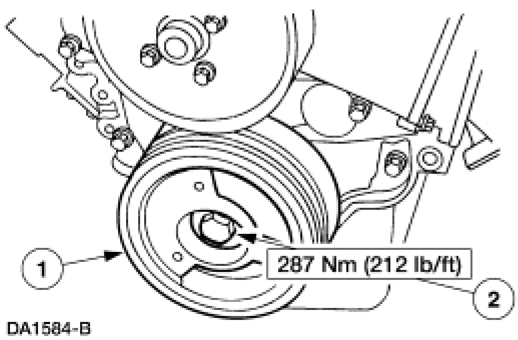
2. Install the four bolts.



33. Install the crankshaft vibration damper.
    1. Using a Damper Remover/Replacer Tool, install the vibration damper onto the crankshaft.

    2. Install the vibration damper bolt and washer.

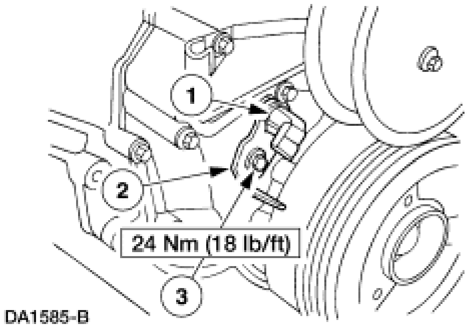
    - Apply RTV Silicone Sealant, F5TZ-19G204-AB or equivalent meeting Ford specification NAVSTR SLR to the washer.



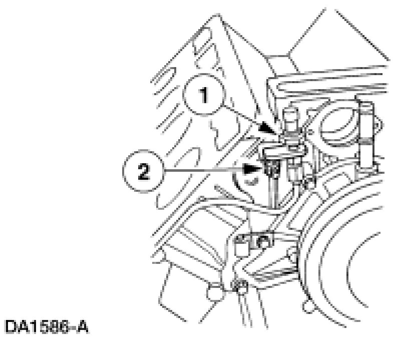
34. Install the camshaft position (CMP) sensor.
    1. Install the sensor into the engine front cover.

    2. Install the sensor retaining bracket.

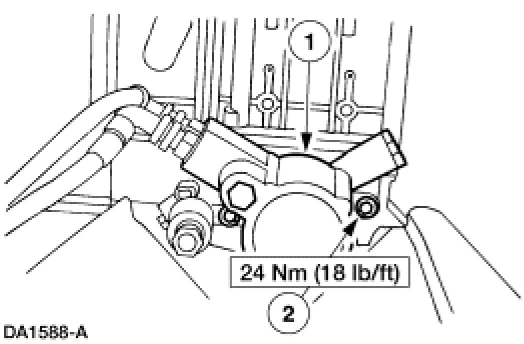
    3. Install the bolt.



35. Install the exhaust back pressure sensor and tube.
    1. Position the sensor and tube.
    2. Install the nut.



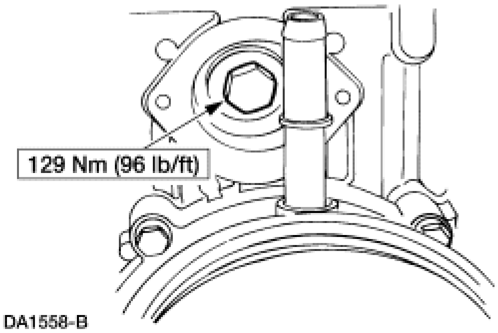
36. Install the high pressure oil pump.
    1. With a new gasket, position the high pressure oil pump.
    2. Install the bolts.



37. **CAUTION: Make sure that the drive gear is fully seated on the high-pressure oil pump before installing the bolt and washer. Otherwise, the drive gear may not seat correctly, causing binding or slippage resulting in a no oil flow condition.**

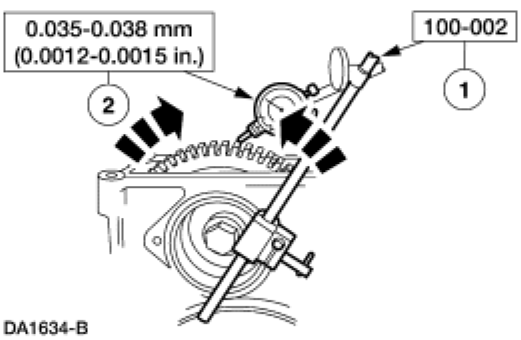
    Install the high pressure oil pump drive gear.

    - Position the drive gear onto the high pressure oil pump. Install the bolt and washer.

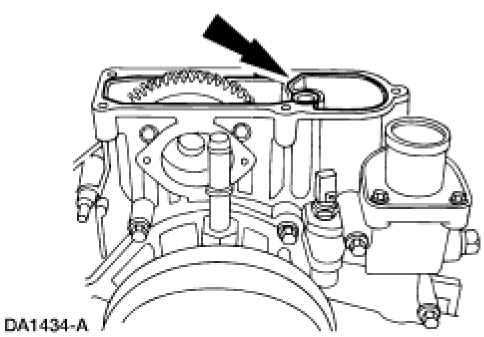


38. Check the high pressure oil pump drive gear backlash.
    1. Position the special tool onto the drive gear.

    2. Rock the drive gear and record the reading.
        - Install a new drive gear if not within specification.

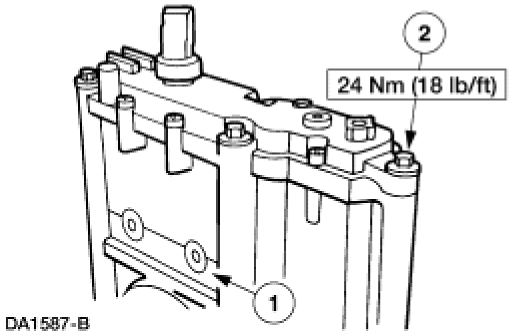


39. Install the gasket onto the engine front cover.

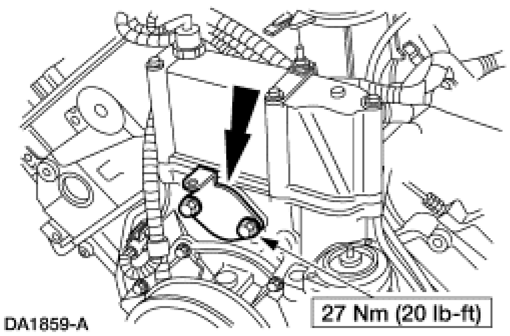


40. Install the high pressure oil pump reservoir.
    1. Position the reservoir onto the engine front cover.

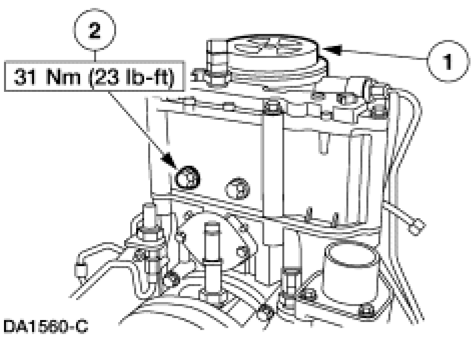
    2. Install the bolts.



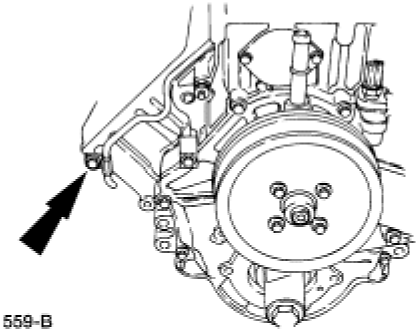
41. Install the access cover and bolts.
    - Apply RTV Silicone Sealant F5TZ-19G204-AB or equivalent meeting Ford specification NAVSTR SLR, to the access cover.



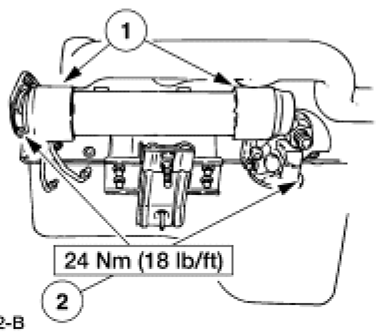
42. Install the fuel filter/water separator assembly.
    1. Position the fuel filter/water separator assembly.
    2. Install the bolts.



43. Position the fuel drain tube and install the bolt.

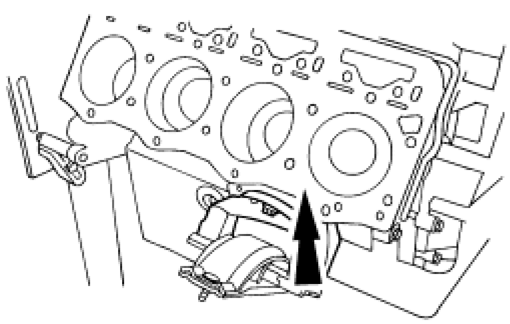

DA1559-B

44. Install the engine oil cooler.
    1. Position the two header gaskets and the oil cooler.
    2. Install the five bolts.



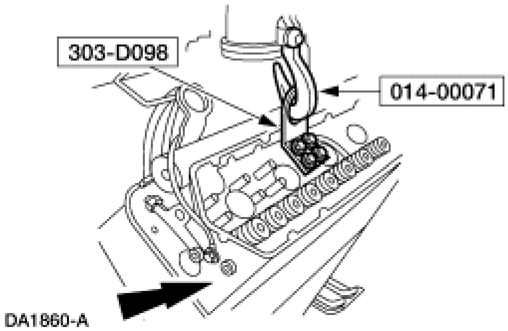
DA1562-B

45. Position the cylinder head gaskets onto the engine block.


DA1580-A

46. **NOTE:** Both the left side and right side heads are installed in the same way. Only the right side cylinder head is shown.

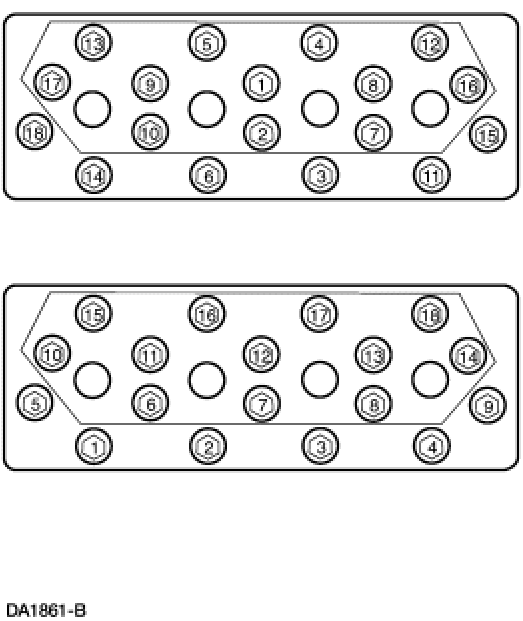
    Using the special tools, install the cylinder head.



47. **CAUTION: Do not use too much engine oil on the threads of the cylinder head bolts, or damage to the threads and poor sealing can result. Do not use anti-seize compounds, grease or any other lubricants except engine oil on the cylinder head bolt threads because they will affect the true torque value reading of the bolts.**

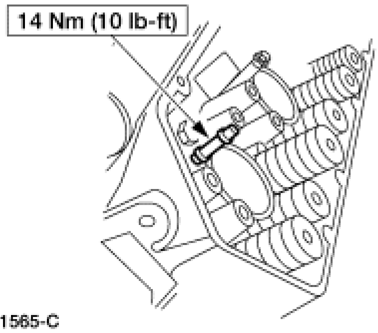
Install the 18 cylinder head bolts.

- Lightly lubricate the cylinder head bolt threads and flanges with clean engine oil.
- Tighten the bolts in the sequence shown in three stages.
- Stage 1: Using the first sequence, tighten the bolts to 88 Nm (65 lb-ft).
- Stage 2: Using the first sequence, tighten the bolts to 115 Nm (85 lb-ft).
- Stage 3: Using the second sequence, tighten the bolts to 129 Nm (95 lb-ft).



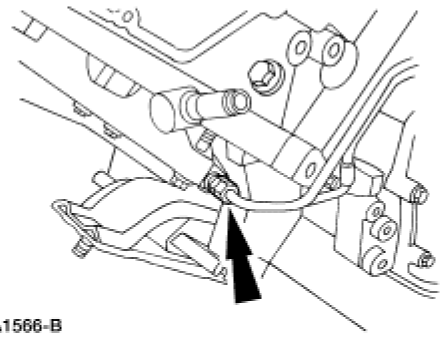
48. **NOTE:** Make sure the bolt holes are clean of oil prior to bolt installation.

Install the fuel injector hold-down shoulder bolts.



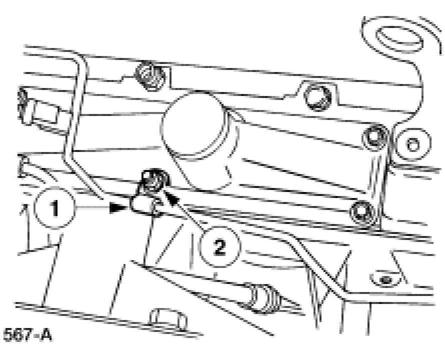
DA1565-C

49. Connect the exhaust back pressure tube.



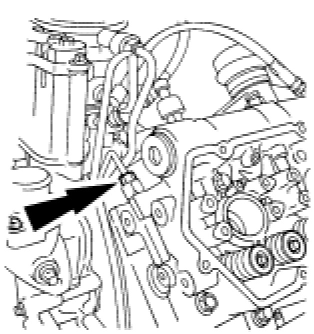
DA1566-B

50. Install the fuel tube.
    1. Position the fuel tube clamp onto the right hand cylinder head stud bolt.
    2. Install the nut.

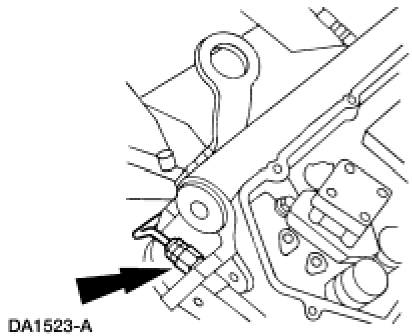


DA1567-A

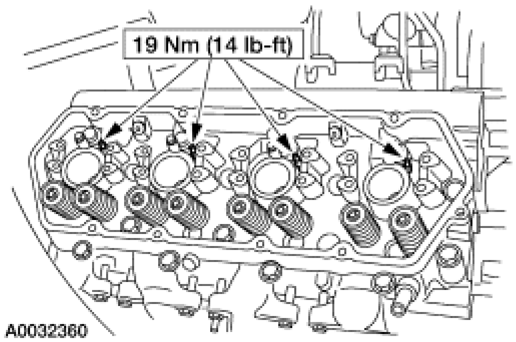
51. Install the fuel supply tubes onto the cylinder heads.



DA1391-A



52. Install the glow plugs.



53. Install new O-ring seals and new copper gaskets on the fuel injectors. Lubricate fuel injectors, O-ring seals and copper gaskets with clean engine oil.

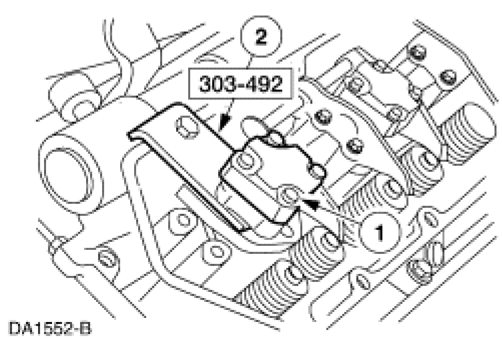
54. **NOTE:** All eight fuel injectors are installed the same way. Only one fuel injector is shown.

    NOTE: Thoroughly coat the fuel injector O-ring seal with clean engine oil to aid in installation.

    Install the fuel injector.

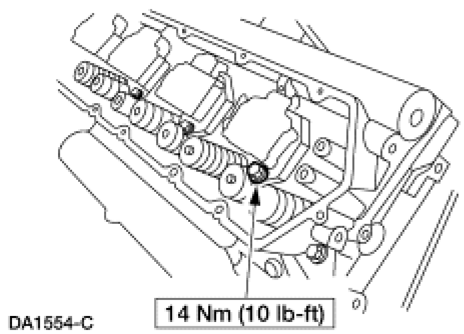
    1. Insert the fuel injector into the cylinder head fuel injector bore.

    2. Using the special tool, seat the fuel injector into the cylinder head fuel injector bore.



55. **NOTE:** Make sure the bolt holes are clean of oil prior to bolt installation.

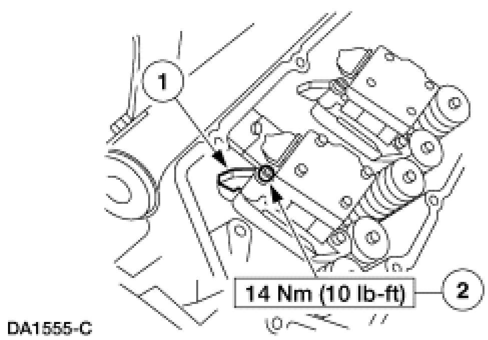
Install the fuel injector hold-down bolts.



56. **NOTE:** All eight oil deflectors are installed the same way. Only one oil deflector is shown.

    Install the oil deflector.

    1. Position the oil deflector.
    2. Install the bolt.



57. **CAUTION: Make sure to follow the next step of this procedure to prevent bent valves.**

    Rotate the engine until the mark on the crankshaft damper is at 11 o'clock, to prevent damage when installing the intake rocker arm and exhaust rocker arm.

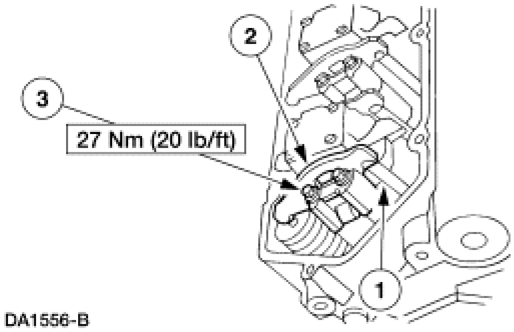
58. **NOTE:** All 16 push rods and rocker arms are installed the same way. Only one push rod and rocker arm is shown.

    NOTE: Install the push rods with the copper end up.

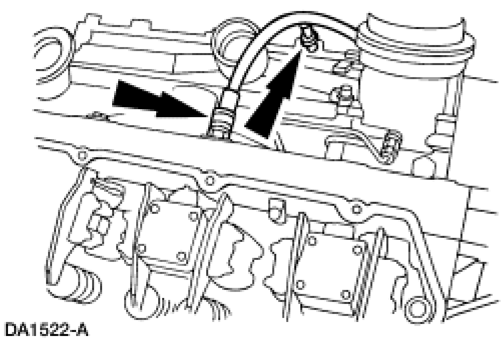
    Install the rocker arms.

    1. Apply clean engine oil to the push rod, and insert the push rod, with the copper end up, into the engine. Make sure the push rod seats onto the lifter.
    2. Position the rocker arm onto the cylinder head.

3. Install the bolts.



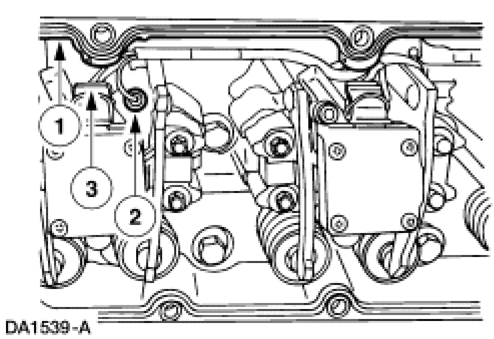
59. Install the high pressure oil hoses.
    - Pull on the high pressure oil hoses to make sure the fitting is correctly connected.



60. **NOTE:** Both the left side and the right side valve cover gaskets are installed the same way. Only the right side gasket is shown.

    Install the valve cover gasket.

    1. Position the gasket onto the cylinder head.
    2. Install the four glow plug electrical leads.
    3. Install the four fuel injector electrical connectors.

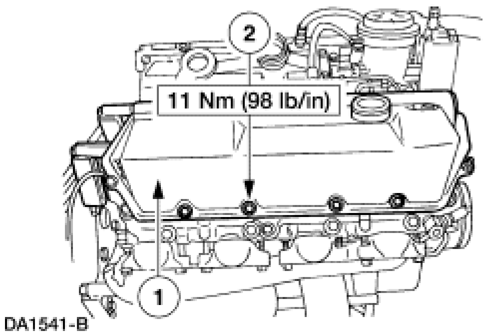


61. **NOTE:** Both the left side and the right side valve covers are installed the same way. Only the right side valve cover is shown.

Install the valve cover.

1. Position the valve cover onto the cylinder head.

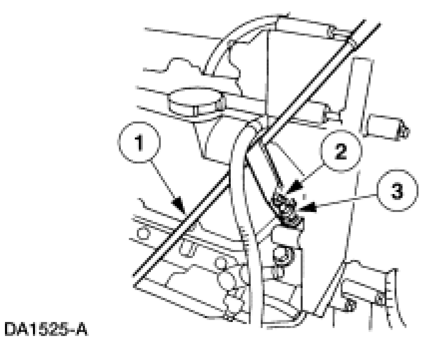
2. Install the bolts.



62. Install the oil level indicator tube.
    1. Position the indicator tube into the oil pan.

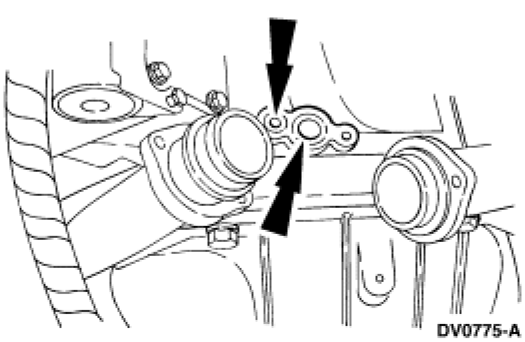
    2. Position the indicator tube retainer into the stud bolt.

    3. Install the nut.



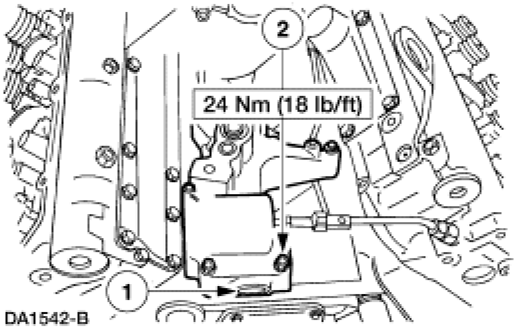
63. Install the air inlet duct tube mounting bracket.

64. Install two new O-ring seals onto the engine.



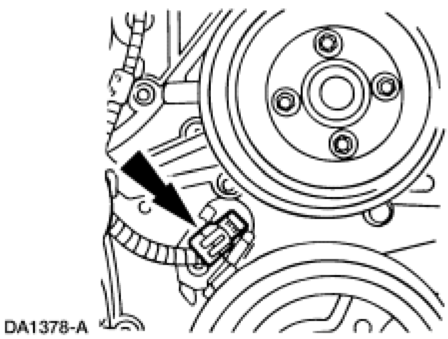
65. Install the turbocharger pedestal.

1. Position the turbocharger pedestal.
2. Install the bolts.

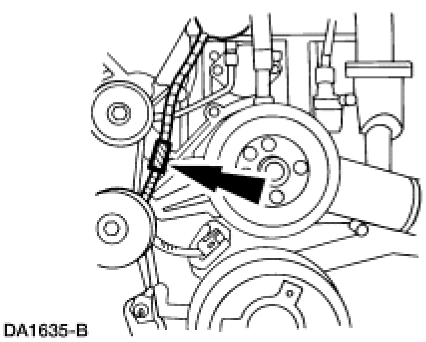


66. Position the engine harness onto the engine.

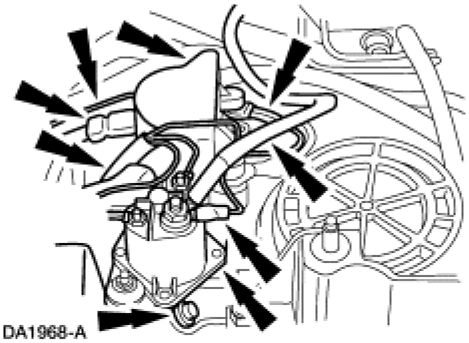
67. Connect the camshaft position (CMP) sensor electrical connector.



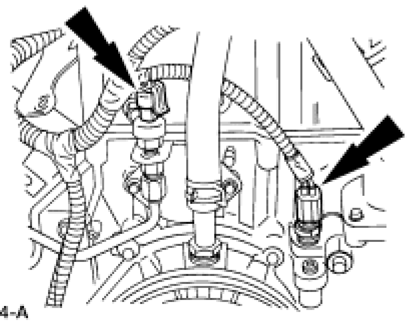
68. Position the engine harness and attach the pushpin retainer.



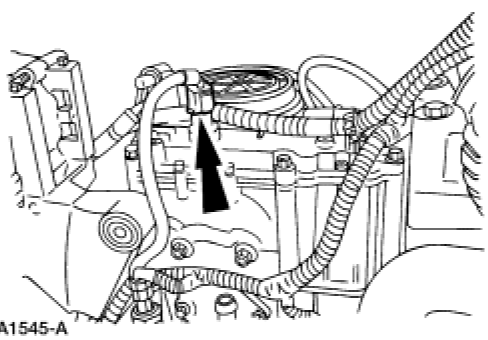
69. Install the glow plug relay/intake air heater relay and bracket assembly and two nuts. Connect the electrical leads.
    - If equipped, install the cover.


DA1968-A

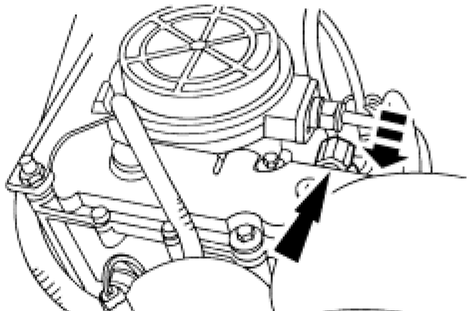
70. Connect the exhaust back pressure sensor and engine coolant temperature (ECT) sensor electrical connectors.


DA1544-A

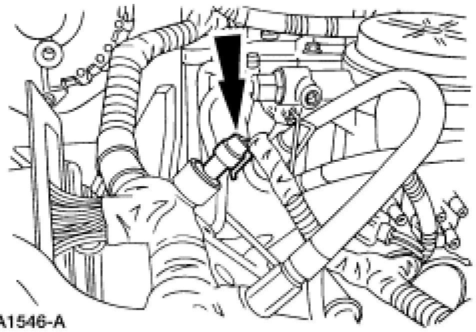
71. Connect the engine oil pressure sensor electrical connector.


DA1545-A

72. Connect the engine oil temperature sensor electrical connector.

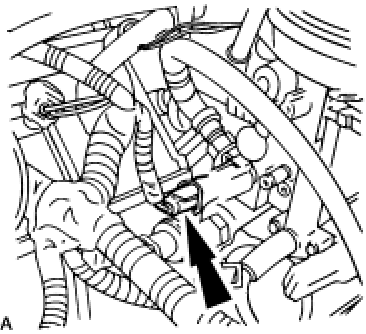

DA1639-A

73. Connect the injection oil pressure sensor electrical connector.



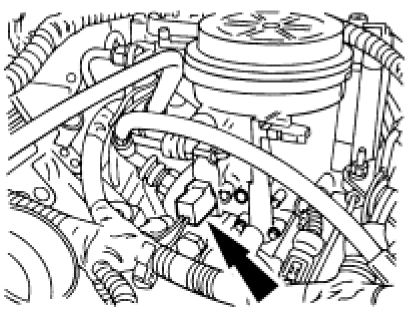
DA1546-A

74. Connect the injection pressure regulator (IPR) electrical connector.



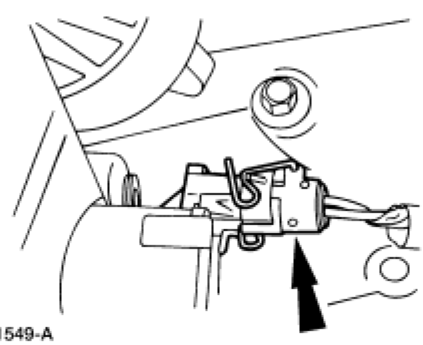
DA1547-A

75. Connect the fuel heater/water separator electrical connector.



DA1548-A

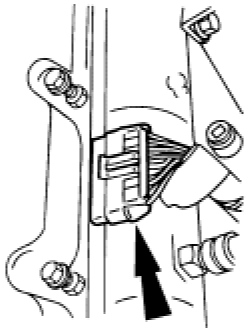
76. Connect the exhaust back pressure solenoid electrical connector.



DA1549-A

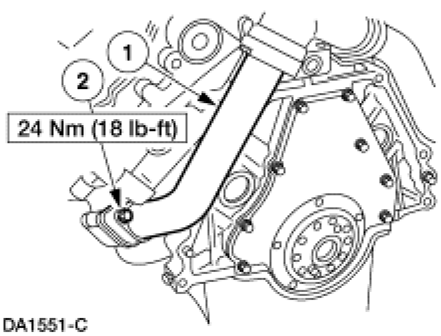
77. **NOTE:** Both the left side and the right side nine pin connectors are installed the same way. Only the right side is shown.

Connect the fuel injector/glow plug nine pin connector, engage the retaining clip.



DA1550-A

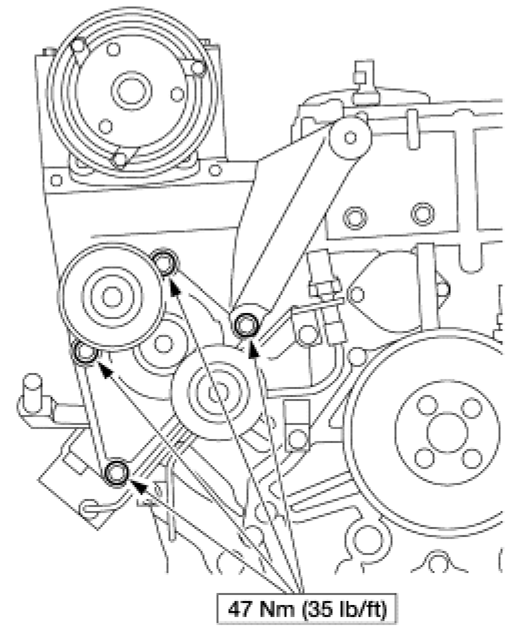
78. Install the exhaust adapter pipes.
    1. Position the pipes.
    2. Install the four mounting bolts and nuts.



DA1551-C

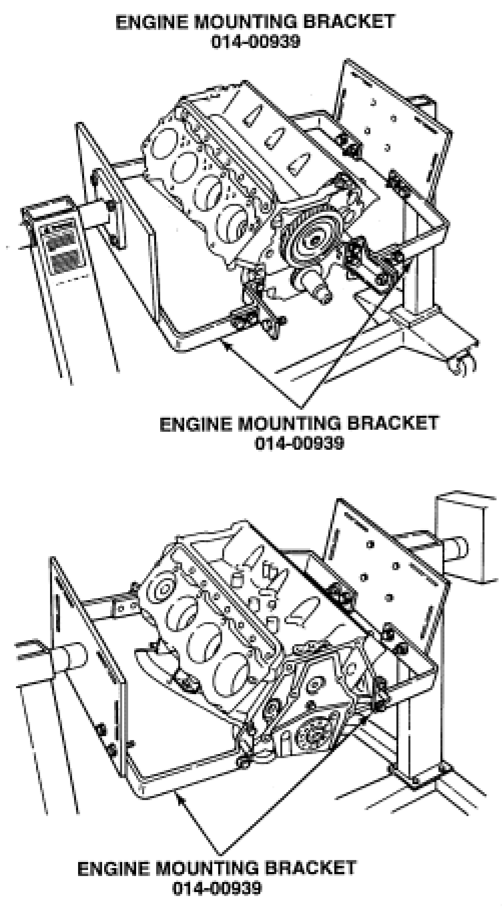
Vehicles with air conditioning

79. Install the A/C compressor mounting bracket and the mounting bolts.



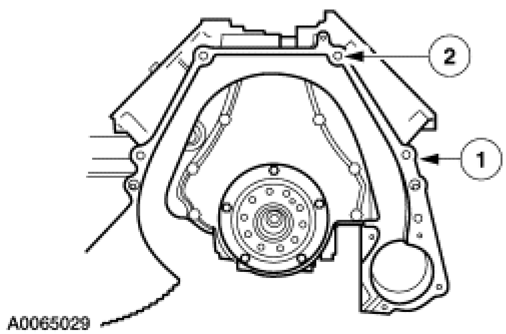
DA1828-B

80. Remove the engine from the work stand and remove the engine mounting bracket.



DA0967-A

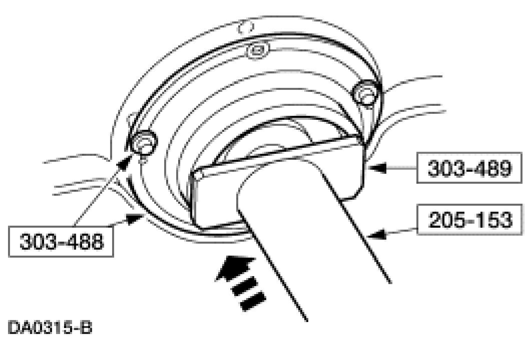
81. Install the engine adapter plate.
    1. Install the adapter plate.
    2. Install the retainer.



82. **NOTE:** The crankshaft rear oil seal and wear sleeve are installed as an assembly.

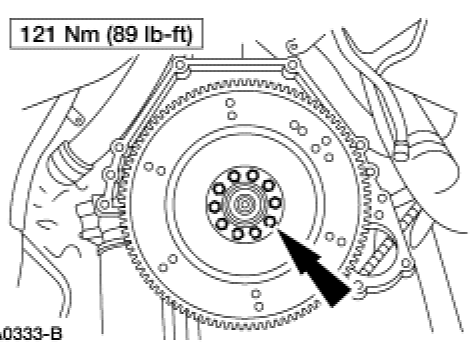
    Apply RTV Silicone Sealant F5TZ-19G204-AB, or equivalent meeting Ford specification NAVSTR SLR to the rear oil seal retaining ring and the crankshaft rear oil seal.

83. Using the special tool, install the crankshaft rear oil seal.



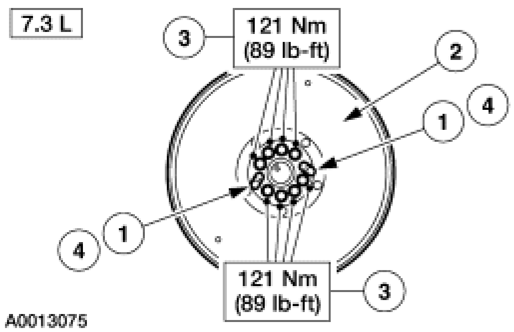
Vehicles with automatic transmission

84. Install the flexplate, spacers and bolts.



Vehicles with manual transmission

85. Install the flywheel.
    1. Install the guide studs.
    2. Install the flywheel and ring gear assembly, and the reinforcing ring (7.3L).
    3. Install the bolts.
    4. Remove the guide studs. Install and tighten the bolts to specification.

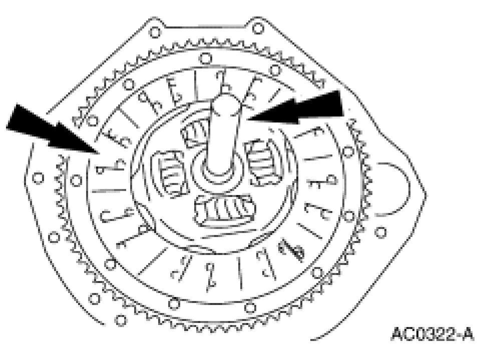


86. **CAUTION: Sometimes, when removing the transmission, the input shaft will remove a considerable amount of lubricant from the transmission input shaft pilot bearing.**

    Lubricate the transmission input shaft pilot bearing, as necessary.

    - Use High-Temperature 4x4 Front Axle and Wheel Bearing Grease E8TZ-19590-A or equivalent meeting Ford specification ESA-M1C198-A.

87. Position the clutch disc on the flywheel and the special tool in the pilot bearing to align the clutch disc.
    - Use tool 308-421 for 6-speed applications.
    - The 7.3L engines accept a 1-3/8" input shaft.



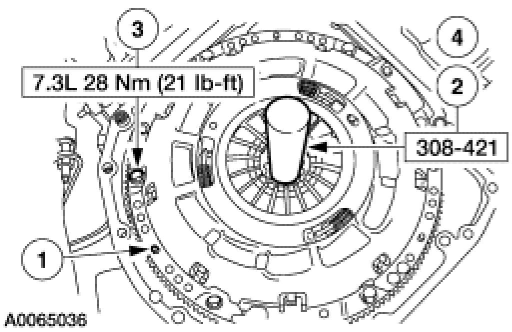
88. **NOTE:** Align the index marks if installing the original clutch pressure plate and flywheel.

    Install the clutch pressure plate.

    1. Position the clutch pressure plate on the dowels.

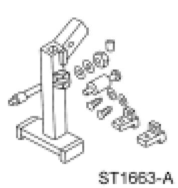
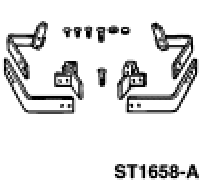
- The diesel engine flywheel has two dowels.

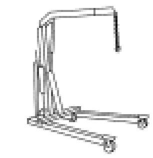
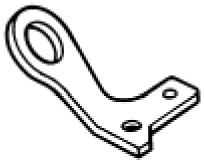
2. Using the special tool, align the clutch disc and the pressure plate.
3. Install the bolts and tighten in a star pattern sequence.
4. Remove the special tool.



SECTION 303-01C: Engine — 7.3L Diesel 1999 F-Super Duty 250-550 Workshop Manual
INSTALLATION Procedure revision date: 01/26/2000

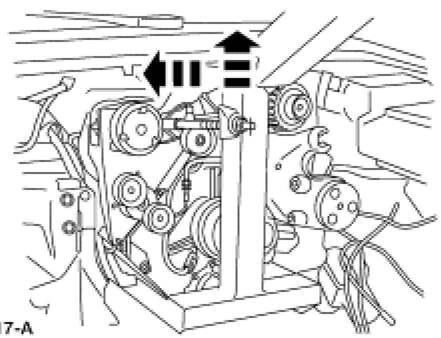
Engine

Special Tool(s)	
	Diesel Engine Lifting Bracket (D83T-6000-B) 303-D043
	Engine Mounting Bracket (D94T-6000-A) 303-D097
	Fuel/Oil/Turbo Protector Cap Set (T94T-9395-AH) 303-493

 ST1341-A	Heavy Duty Floor Crane 014-00071
 ST1659-A	Lifting Eye (D94T-6000-C) 303-D099

Installation

1. Remove the engine from the work stand.
2. Install the Engine Lifting Bracket and the Heavy Duty Floor Crane.
3. Raise the engine high enough to clear the No. 1 cross member, then position the engine into the vehicle.


DA1817-A

4. **NOTE:** This step applies to vehicles equipped with automatic transmissions only.

   Align the torque converter studs with the holes in the engine flywheel, then lower the engine onto the engine mount towers.

5. **NOTE:** This step applies to vehicles equipped with manual transmissions only.

   Lower the engine onto the engine mount towers.

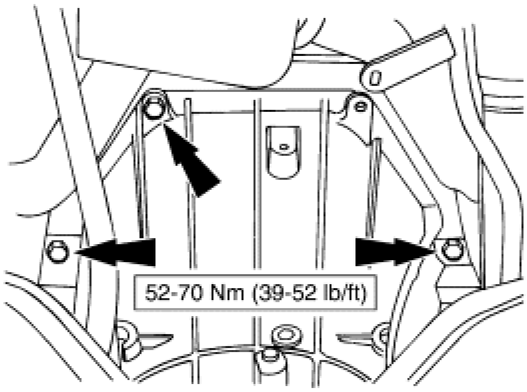
6. Remove the Heavy Duty Floor Crane and the lifting fixture from the engine.
7. **NOTE:** This step applies only to vehicles equipped with automatic transmissions.

   Position the transmission fill tube into the transmission.

8. Raise and support the vehicle; for additional information, refer to Section 100-02.

9. **NOTE:** This step applies to vehicles equipped with automatic transmissions only.

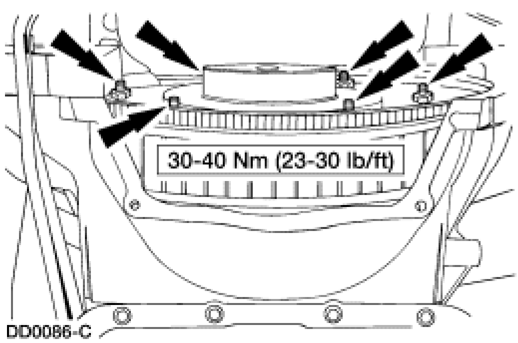
   Install the transmission-to-engine mounting bolts.



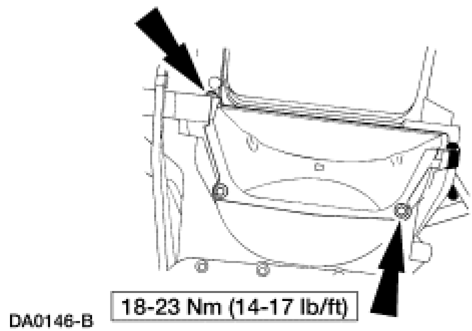
DD0094-B

10. **NOTE:** Steps 10 and 11 apply to vehicles equipped with automatic transmissions only.

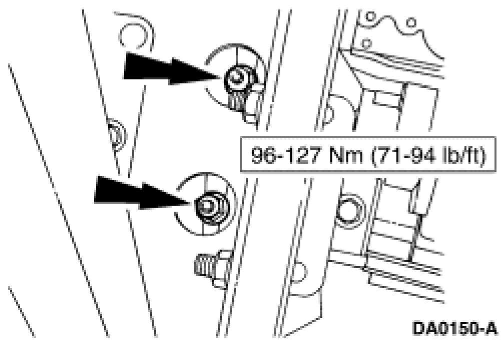
    Install the torque converter-to-flywheel retaining nuts.



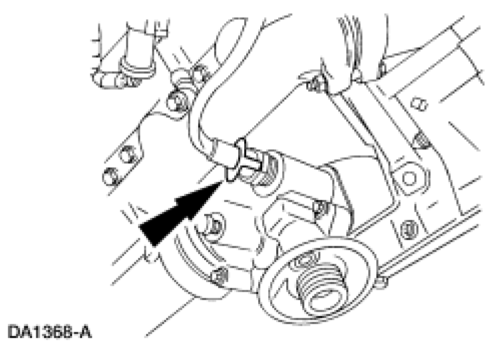
11. Install the flywheel housing cover.



12. Install the left and right side engine mount retaining nuts.



13. Connect the block heater.



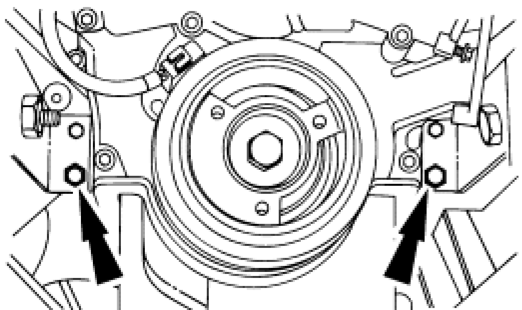
14. Install the oil filter.

15. Install the starter motor; for additional information, refer to Section 303-06B.

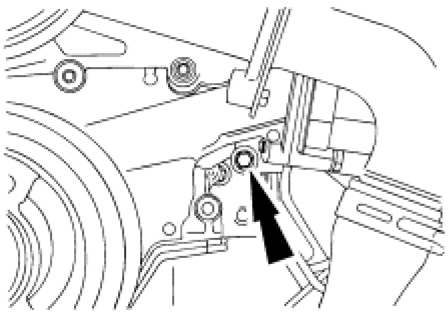
16. Lower the vehicle.

17. Remove the engine lifting eye from the right side cylinder head, if required.

18. Remove the two engine lift adapters.


DA0140-A

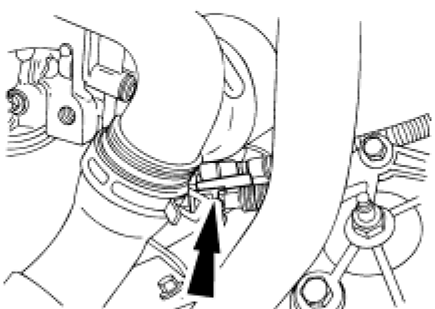
19. Position the fuel line and install the bolt.


DA1367-A

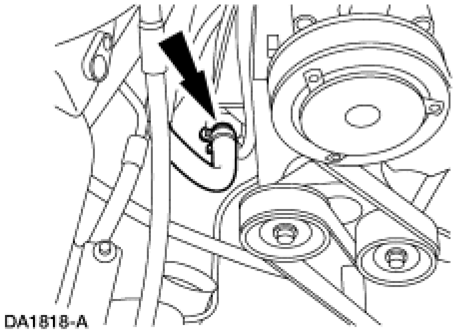
20. **NOTE:** This step applies to vehicles equipped with automatic transmissions only.

    Install the transmission sensor harness and the retaining bolt.

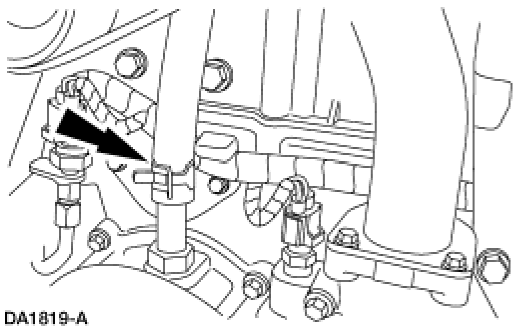
21. Connect the two fuel lines.


DA1536-A

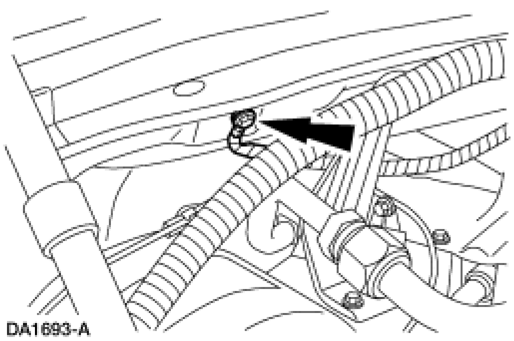
22. Connect the heater supply hose.



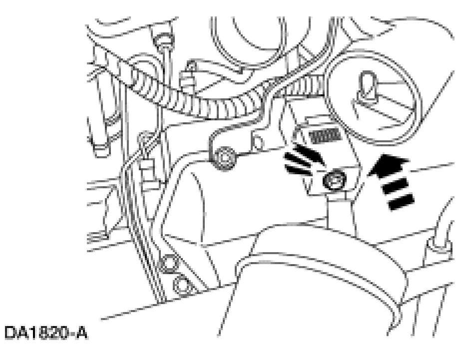
23. Connect the heater return hose.



24. Connect the ground strap.



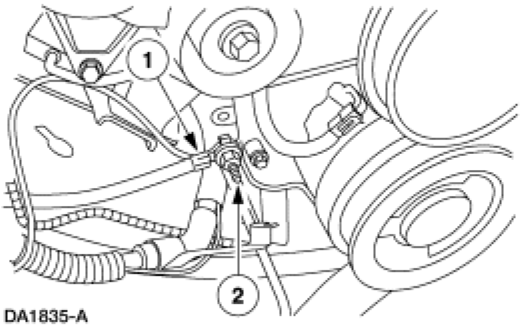
25. Connect the engine control sensor wiring.



26. **NOTE:** This step applies to vehicles equipped with a single generator only.

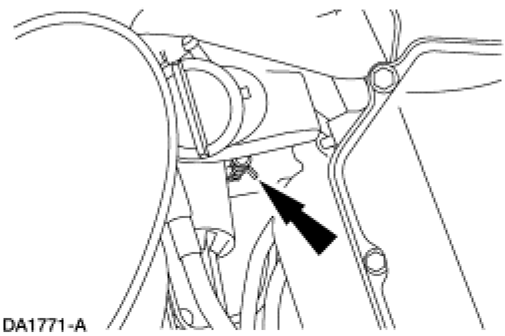
Install the ground cable onto the right side of the engine block.

1. Position the ground cable.
2. Install the stud bolt.

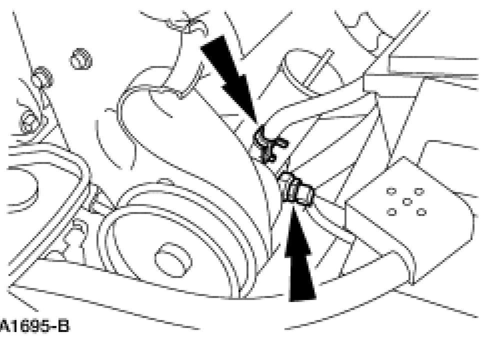


DA1835-A

27. Connect the power steering lines.

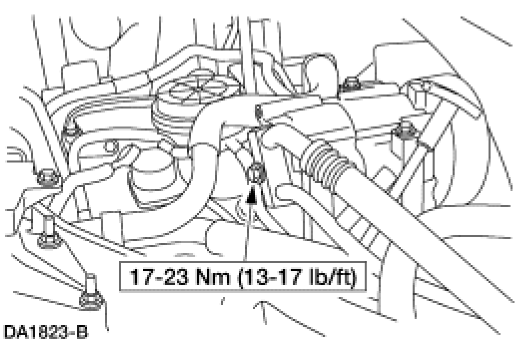


DA1771-A



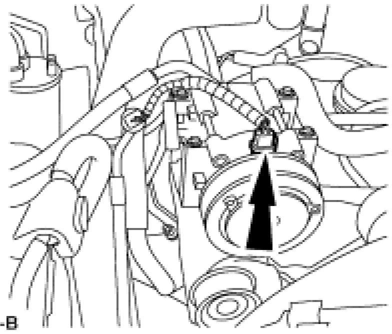
DA1695-B

28. Connect the air conditioning manifold lines to the A/C compressor, if so equipped.



DA1823-B

29. Connect the electrical connector to the A/C compressor, if so equipped.

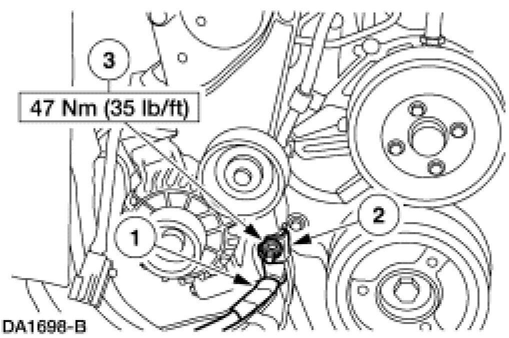


DA1690-B

30. **NOTE:** Steps 30 and 31 apply to vehicles equipped with dual generators only.

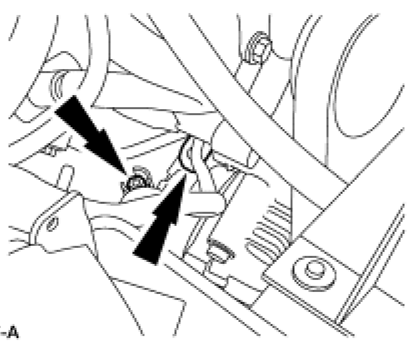
Install the engine ground cable onto the right side of the engine block.

1. Position the engine ground cable.
2. Position the starter wires and bracket.
3. Install the nut.



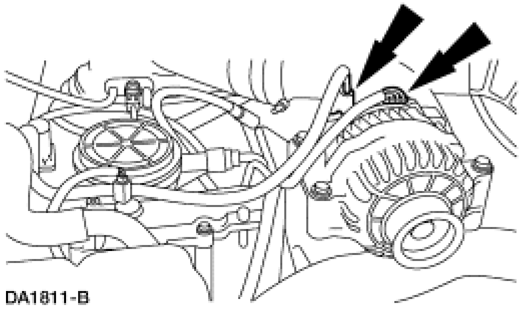
DA1698-B

31. Connect the lower generator electrical connectors.



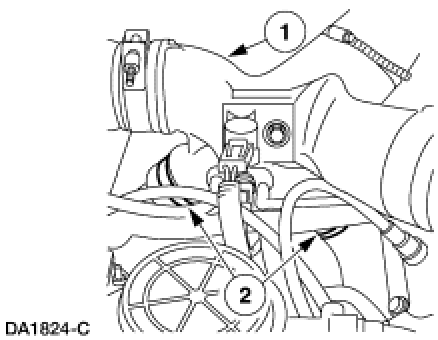
DA1697-A

32. Connect the generator electrical connectors.

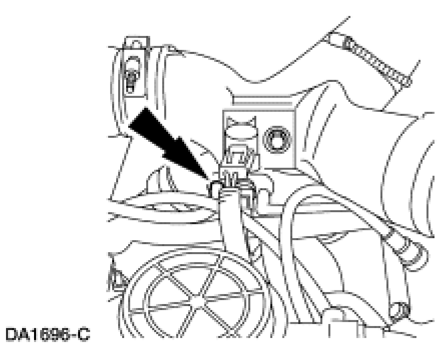


33. Install the compressor manifold.
    1. Position the compressor manifold.

    2. Position and tighten the clamps.



34. Install the manifold absolute pressure (MAP) sensor hose.



35. Install the accessory drive belt; for additional information, refer to Section 303-05.

36. Install the front bumper.

37. Install the upper and lower radiator core supports, radiator grille opening panel and the radiator grille; for additional information, refer to Section 501-02.

38. Install the headlamp and the parking lamp assemblies; for additional information, refer to Section 417-01.

39. Install the A/C condenser assembly; for additional information, refer to Section 412-03.

40. Install the charge air cooler; for additional information, refer to Section 303-12.
41. Install the radiator; for additional information, refer to Section 303-03.
42. Install the air inlet duct; for additional information, refer to Section 303-12.
43. **NOTE:** This step applies to vehicles equipped with manual transmissions only.

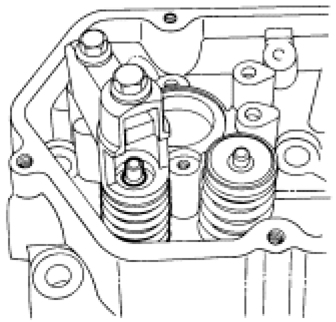
    Install the transmission; for additional information, refer to Section 308-03B.
44. Check and fill the automatic transmission.
45. Connect both battery ground cables; for additional information, refer to Section 414-01.
46. Refill the power steering reservoir; for additional information, refer to Section 211-00.

Cylinder Head

Special Tool(s)	
	Valve Spring Compressor (T94T-6513-AH) 303-483

Disassembly

1. Install the Valve Spring Compressor.



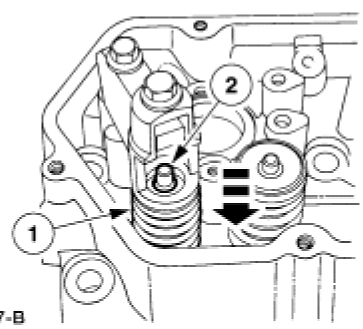
DA0226-A

2. **NOTE:** If necessary, strike the valve stem end with a plastic-tipped hammer to loosen the valve spring retainer keys.

   Remove the valve spring retainer keys.

    1. Compress the valve spring.

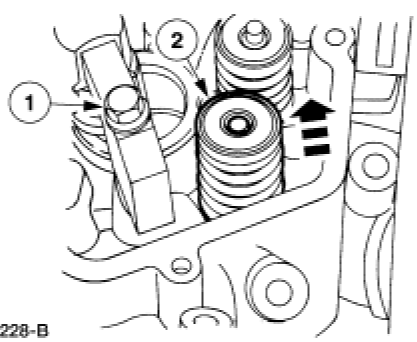
    2. Remove the valve spring retainer keys.



DA0227-B

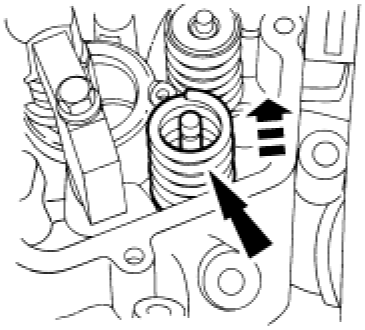
3. Remove the valve spring rotator.
    1. Remove the Valve Spring Compressor.

    2. Remove the spring rotator.

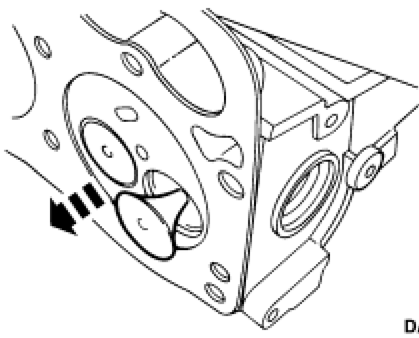


DA0228-B

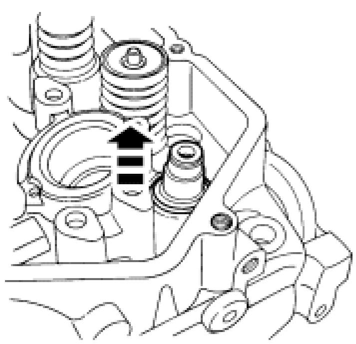
4. Remove the valve spring.


DA0229-A

5. Remove the valve.


DA0230-A

6. Remove the valve stem seal.


DA0231-A

Assembly

1. Follow the disassembly procedure in reverse order.

SECTION 303-03: Engine Cooling

Hose—Lower, Motorhome Chassis

Hose—Constant Tension Clamps

Degas Bottle—Pickup Chassis

Degas Bottle—Motorhome Chassis

Sender Unit—Water Temperature Indicator

Sensor—Engine Coolant Temperature (ECT)

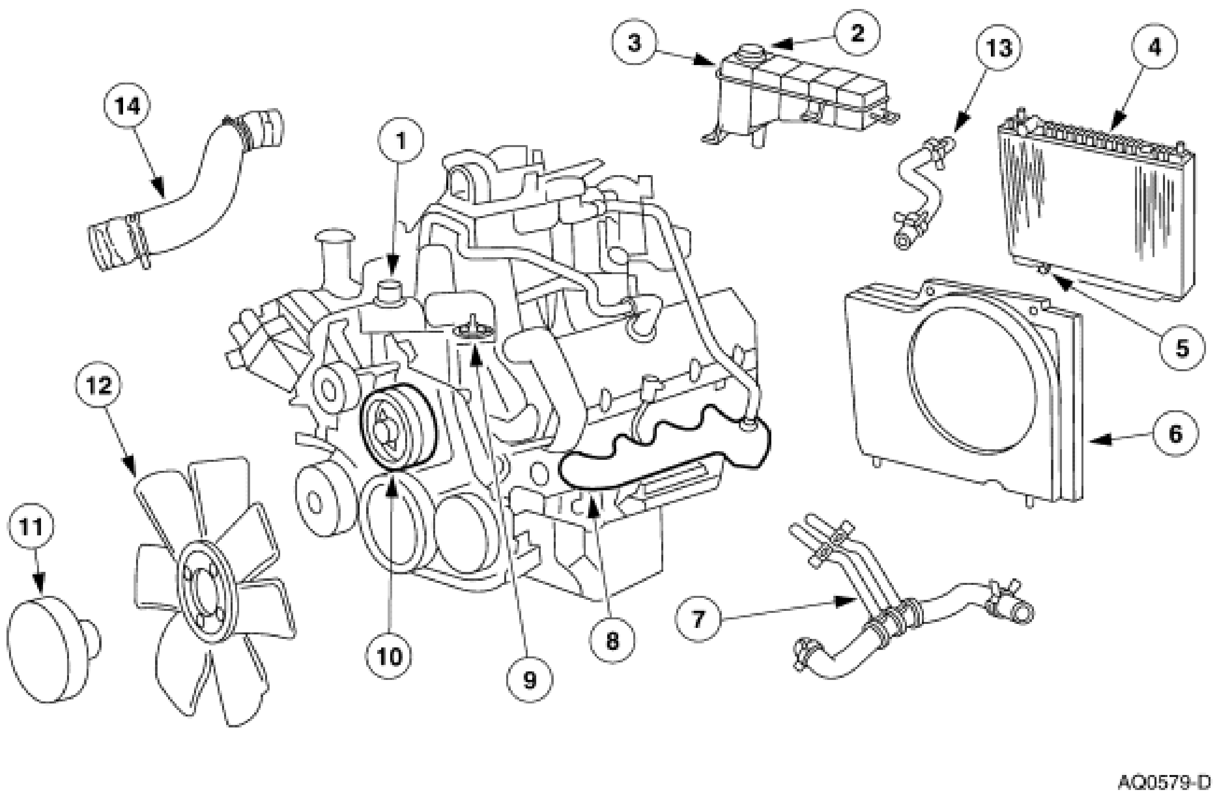
General Specifications

Item	Specification
Premium Cooling System Fluid (Canada Only) E2FZ-19549-AA OR -B CXC-8-B	ESE-M97B44-A
Premium Cooling System Fluid (Oregon Only) F5FZ-19549-CC	ESE-M97B44-A
Premium Cooling System Fluid E2FZ-19549-AA OR B	ESE-M97B44-A
Ford Extended Life Engine Coolant F6AZ-19544-AA	Dex-Cool® WSS-M97B44-D
Stop Leak Powder E6AZ-19558-A	ESE-M99B170-A
Recycled Cooling System Fluid	ESE-M97B44-A
Pipe Sealant with Teflon® D8AZ-19554-A	WSK-M2G350-A2
Silicone Brake Caliper Grease and Dielectric Compound D7AZ-19A331-A	ESE-M1C171-A
Thermostat Opening Temperature	
Initial — 5.4L	86.7-90.6°C (188-195°F)
Fully Open — 5.4L	97.8-101.7°C (208-215°F)
Initial — 6.8L	83-87°C (181-188.6°F)
Fully Open — 6.8L	96.7-100°C (206-213°F)
Initial — 7.3L	88.8°C (192°F)
Fully Open — 7.3L	103.8°C (219°F)

Torque Specifications			
Description	**Nm**	**Lb/Ft**	**Lb/In**
Water Bypass Tube Mounting Bolt	8-11	—	71-97
Water Pump Pulley Mounting Bolts	20-30	15-22	—
Fan Blades to Fan Clutch Mounting Bolts	17-23	12.5-17	—
Fan Clutch Hub to Water Pump	113-153	84-112	—
Radiator Mounting Brackets Retaining Bolts	6-14	—	53-124
Water Temperature Indicator Sender Unit	16-24	12-18	—
A/C Compressor Support Bracket Mounting Bolts	40-55	30-41	—
A/C Compressor Support Bracket Mounting Nuts	20-30	15-22	—
Cylinder Drain Plug	16-24	12-18	—
Transmission Cooler Tube Nuts	16-24	12-18	—
Fan Shroud to Radiator Bolts	9	—	80
Oil Cooler Center Bolt	55-60	40.4-44	—
Oil Filter	14-17	10-12.5	—
Degas Bottle Bolts	9	—	80

Engine Cooling

Component Locations



Item	Part Number	Description
1	10884	Water Temperature Indicator Sender Unit
2	—	Pressure Relief Cap
3	—	Degas Bottle
4	8005	Radiator
5	8115	Radiator Draincock
6	8146	Fan Shroud
7	8286	Lower Radiator Hose
8	6A051	Block Heater
9	8575	Water Thermostat
10	8501	Water Pump
11	8A616	Fan Clutch
12	8600	Fan Blade

13	—	Overflow Hose
14	8260	Upper Radiator Hose

Walter C. Avrea, the owner of patents 3,601,181 and RE 27,965, has granted Ford Motor Company rights with respect to cooling systems covered by these patents.

The cooling system components are the:

- block heater (6A051)
- fan blade (8600)
- fan clutch (8A616)
- fan shroud (8146)
- radiator (8005)
- pressure relief cap
- radiator draincock (8115)
- water pump (8501)
- water temperature indicator sender unit (10884)
- water thermostat (8575)
- oil filter adapter (6881)
- the radiator allows excess engine heat to be transferred to the air.
- radiator tanks cannot be serviced, replace as an assembly.
- upper radiator hose.
- lower radiator hose.

The water pump circulates the coolant.

The water thermostat:

- controls the engine coolant temperature.
- allows quicker engine warm-up.

The degas bottle:

- provides a location for service fill.
- contains coolant expansion and system pressurization.
- provides air separation during operation.
- replenishes the engine coolant to the system.

The fan blade draws air through the radiator to help cool the engine coolant.

The fan clutch is a thermostatically controlled clutch that controls the fan drive.

The engine coolant flows:

- from the lower radiator hose (8286) to the water pump.
- from the water pump to the engine block and the cylinder heads.

A closed water thermostat returns the engine coolant to the water pump; an open water thermostat allows the engine coolant to flow to the radiator.

For vehicles with green coolant:

- Use Ford Premium Engine Coolant E2FZ-19549-AA or an equivalent engine coolant that meets Ford Specification ESE-M97B44-A.
- Ford Premium Engine Coolant protects all metal and rubber in Ford cooling systems for 3 years or 80,000 km (30,000 miles).
- Properly recycled engine coolant may be used in vehicles originally equipped with green coolant.

For vehicles with orange coolant:

- Use Ford Extended Life Engine Coolant F6AZ-19544-AA or an equivalent DEX-COOL® coolant or a coolant meeting Ford specification WSS-M97B44-D.
- Ford Extended Life Engine Coolant is a silicate-free coolant that does not need to be replaced for 6 years or 240,000 km (150,000 miles), whichever occurs first.
- Do not add conventional green coolant or recycled coolant to your vehicle if originally equipped with orange coolant.

Unsatisfactory coolant materials:

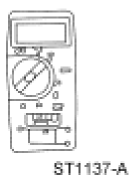
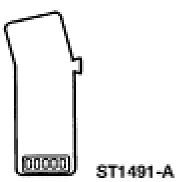
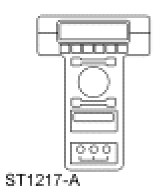
- alcohol-type antifreeze does not provide adequate water pump lubrication
  - has lower boiling point
  - reduced antifreeze protection
- alkaline brine solutions will cause serious engine cooling system damage

The water temperature indicator sender unit provides a signal to the temperature gauge.

The optional block heater:

- electrical heating element is installed in the core plug opening.
  - uses a standard 110V electrical supply
- keeps the engine coolant warm during cold weather.

Engine Cooling

Special Tool(s)	
	Radiator/Heater Core Pressure Tester 014-R1072 or equivalent
	Rotunda 73 Digital Multimeter 105-R0051 or equivalent
	Digital Photoelectric Tachometer 055-00108 or equivalent
	New Generation Star Tester (NGS) 418-F052 (007-00520) or equivalent

Inspection and Verification

1. Verify the customer's concern by operating the engine to duplicate the condition.
2. Inspect to determine if any of the following mechanical or electrical concerns apply.

Visual Inspection Chart	
Mechanical	**Electrical**
• Leaks • Damaged hoses • Loose/damaged hose clamps • Damaged water gasket	• Damaged engine coolant temperature sensor • Damaged wiring

• Damaged head gaskets • Damaged intake manifold gasket • Damaged water pump • Damaged radiator • Damaged degas bottle • Damaged heater core • Restricted airflow through the radiator cooling fins • Damaged fan/fan clutch • Transmission cooler fans obstructed	

3. If the inspection reveals an obvious concern that can be readily identified, repair it as required.

4. If the concern remains after the inspection, determine the symptom(s) and go to the Symptom Chart.

Symptom Chart

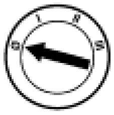
SYMPTOM CHART		
Condition	**Possible Sources**	**Action**
• Loss of Coolant	• Radiator. • Water pump seal. • Radiator hoses. • Heater hoses. • Heater core. • Engine gaskets. • Degas bottle.	• GO to Pinpoint Test A.
• The Engine (6007) Overheats	• Water thermostat (8575). • Water pump. • Internal engine coolant leak. • Radiator. • Heater core. • Cooling fan. • Pressure relief cap. • Insufficient water in coolant mixture. • Fan belt. • Restricted airflow.	• GO to Pinpoint Test B.

• The Engine Does Not Reach Normal Operating Temperature	• Water thermostat.	• GO to Pinpoint Test C.
• The Block Heater (6A051) Does Not Operate Properly	• Block heater power cable. • Block heater.	• GO to Pinpoint Test D.

Pinpoint Tests

PINPOINT TEST A: LOSS OF COOLANT

CONDITIONS	DETAILS/RESULTS/ACTIONS
A1 CHECK THE ENGINE COOLANT LEVEL	
NOTE: Allow the engine to cool before checking the engine coolant level.	
1 	
	2 Visually check the engine coolant level at the degas bottle.
	• **Is the engine coolant level within specification?** → **Yes** GO to A2. → **No** REFILL the engine coolant as necessary. GO to A6 .
A2 CHECK THE PRESSURE RELIEF CAP	
	1 Perform the pressure relief cap test; refer to Cap in this section.
	• **Is pressure relief cap OK?** → **Yes** GO to A3. → **No** REPLACE the damaged pressure relief cap. TEST the system for normal operation.

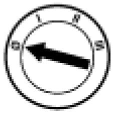
A3 CHECK THE ENGINE COOLANT FOR INTERNAL LEAK	
1 	
	2 Inspect the engine coolant in degas bottle for signs of transmission fluid or engine oil.
	• **Is oil or transmission fluid evident in coolant?** → **Yes** If engine oil is evident, GO to Section 303-00. If transmission fluid is evident, REPAIR or REPLACE the radiator as necessary. → **No** GO to A4.
A4 CHECK THE ENGINE AND THE TRANSMISSION FOR COOLANT	
	1 Remove the oil level dipstick from the engine or remove the fluid filler plug from the manual transmission.
	• **Is coolant evident in oil?** → **Yes** If coolant is in engine, GO to Section 303-00. If coolant is in transmission (7003), REPLACE the radiator; REFER to Radiator—Pickup Chassis or Radiator—Motorhome Chassis in this section. → **No** GO to A5.
A5 PRESSURE TEST THE ENGINE COOLING SYSTEM	
	1 Pressure test the engine cooling system; refer to the Component Tests in this section.
	• **Does the engine cooling system leak?** → **Yes** REPAIR or REPLACE leaking components. TEST the system for normal operation. → **No** The cooling system is operational. RETURN to the Symptom Chart.

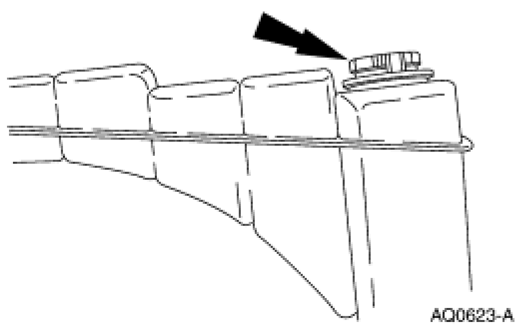
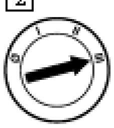
A6 CHECK THE COOLANT RECOVERY SYSTEM	
	1 **WARNING: Never remove the pressure relief cap under any conditions while the engine is operating. Failure to follow these instructions could result in damage to the cooling system or engine and/or personal injury. To avoid having scalding hot coolant or steam blow out of the cooling system, use extreme care when removing the pressure relief cap from a hot degas bottle. Wait until the engine has cooled, then wrap a thick cloth around the pressure relief cap and turn it slowly one turn (counterclockwise). Step back while the pressure is released from the cooling system. When certain all the pressure has been released, remove the pressure relief cap (still with a cloth).** Allow the engine to cool.
	2 Remove the pressure relief cap.
	3 Inspect the pressure relief cap for foreign material between the sealing gasket and the diaphragm.
	• **Is the pressure relief cap OK?** → **Yes** GO to A7. → **No** CLEAN or REPLACE the pressure relief cap. TEST the system for normal operation. GO to A1 .
A7 CHECK THE DEGAS BOTTLE	
	1 **NOTE:** The engine must be cool when coolant is added to the degas bottle. Add coolant to the degas bottle until fluid is between the coolant fill level marks.
	• **Does the degas bottle leak?** → **Yes** REPLACE the degas bottle. TEST the system for normal operation. → **No** PERFORM the cooling system pressure test; REFER to Pressure Test in this section. REPAIR as necessary. TEST the system for normal operation.

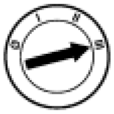
PINPOINT TEST B: THE ENGINE OVERHEATS

CONDITIONS	DETAILS/RESULTS/ACTIONS
B1 CHECK THE ENGINE COOLANT LEVEL	

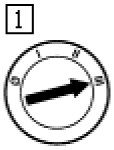
NOTE: If the engine is hot, allow the engine to cool before proceeding.

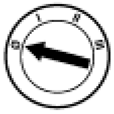
1 	1 **WARNING: Never remove the pressure relief cap under any conditions while the engine is operating. Failure to follow these instructions could result in damage to the cooling system or engine and/or personal injury. To avoid having scalding hot coolant or steam blow out of the cooling system, use extreme care when removing the pressure relief cap from a hot degas bottle. Wait until the engine has cooled, then wrap a thick cloth around the pressure relief cap and turn it slowly one turn (counterclockwise). Step back while the pressure is released from the cooling system. When certain all the pressure has been released, remove the pressure relief cap (still with a cloth).** Allow the engine to cool.
	2 Check the engine coolant level at the degas bottle.
	• **Is the engine coolant OK?** → **Yes** GO to B2. → **No** REFILL the engine coolant at the degas bottle. GO to Pinpoint Test A.
B2 CHECK THE COOLANT CONDITION	
	1 Check the coolant for contaminants such as rust, corrosion, or discoloration.
	• **Is the coolant condition OK?** → **Yes** GO to B3. → **No** FLUSH the engine cooling system; REFER to Flushing—Engine and Radiator in this section. TEST the system for normal operation.
B3 CHECK FOR AN AIRFLOW OBSTRUCTION	
	1 Inspect the A/C condenser core (19712) and

	radiator for obstructions such as leaves or dirt.
	• **Is there an obstruction?** → **Yes** REMOVE the obstruction. CLEAN the A/C condenser core and radiator. TEST the system for normal operation. → **No** GO to B4.
B4 CHECK THE HEATER CORE OPERATION	
1  	1 Install the pressure relief cap.
2 	
	3 As the engine starts to heat up, feel the inlet and outlet heater water hoses (18472). They should feel approximately the same after three or four minutes.
	• **Is the heater water hose approximately the same temperature as the inlet heater water hose ?** → **Yes** GO to B5. → **No** TURN the engine off. REPAIR or REPLACE heater core. REFER to Section 412-02. TEST the system for normal operation.
B5 CHECK THE WATER THERMOSTAT OPERATION	
1	1 Start the engine and allow the engine to run for

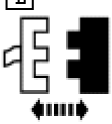
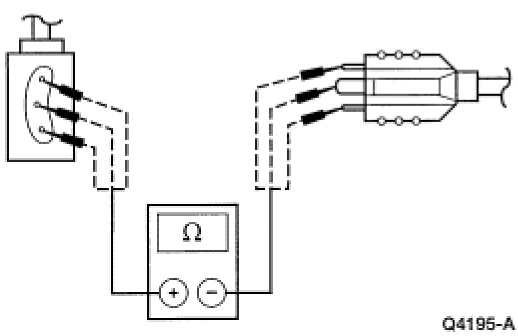
	ten minutes.
	[2] Feel the inlet and outlet heater water hoses and the underside of the upper radiator hose (8260).
	• **Are the upper radiator hose and the heater water hoses cold?** → **Yes** REPLACE the water thermostat; REFER to Thermostat in this section. TEST the system for normal operation. → **No** GO to B6.
B6 CHECK THE COOLING FAN OPERATION	
[1] 	[1] Perform the cooling fan component tests; refer to Fan Clutch Test in this section.
	• **Is the cooling fan operation OK?** → **Yes** GO to Section 303-00 or diagnosis and testing of the engine. → **No** REPLACE the fan component determined; REFER to Thermostat in this section. TEST the system for normal operation.

PINPOINT TEST C: THE ENGINE DOES NOT REACH NORMAL OPERATING TEMPERATURE

CONDITIONS	DETAILS/RESULTS/ACTIONS
C1 CHECK THE ENGINE TEMPERATURE	
[1] 	[1] Start the engine and allow the engine to idle for ten minutes.
[2]	[2] Feel the inlet and heater water hoses and the underside of the upper radiator

	hose.
	• **Are the upper radiator hose and the heater water hoses cold?** → **Yes** REPLACE the water thermostat; REFER to Thermostat in this section. TEST the system for normal operation. → **No** GO to Section 413-01 Instrument Cluster for diagnosis and testing of the engine coolant temperature gauge.

PINPOINT TEST D: THE BLOCK HEATER DOES NOT OPERATE PROPERLY

CONDITIONS	DETAILS/RESULTS/ACTIONS
D1 CHECK THE POWER CABLE	
1 	
2  Block Heater	
3 	3 Check the resistance in Circuits 1, 2, and 3 of the block heater power cable.
	• **Is the resistance 5 ohms in Circuits 1, 2, and 3?** → **Yes**

	REPLACE the block heater. → **No** REPLACE the power cable. TEST the system for normal operation.

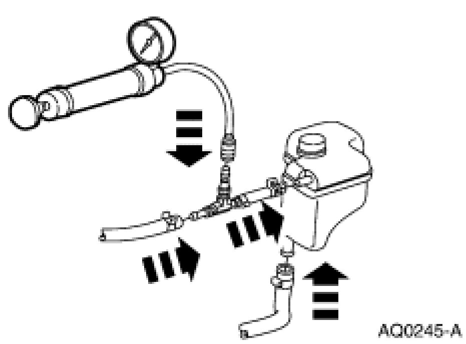
Component Tests

Pressure Test

1. Turn the engine OFF.

2. ⚠ **WARNING: Never remove the pressure relief cap under any conditions while the engine is operating. Failure to follow these instructions could result in damage to the cooling system or engine and/or personal injury. To avoid having scalding hot coolant or steam blow out of the cooling system, never remove the pressure relief cap from a hot degas bottle. Wait until the engine has cooled, then wrap a thick cloth around the pressure relief cap and turn it slowly one turn (counterclockwise). Step back while the pressure is released from the cooling system. When certain all the pressure has been released, remove the pressure relief cap (still with a cloth).**

   Check the engine coolant level; refer to Cooling System Draining, Filling and Bleeding in this section.



3. Connect Radiator Heater Core Pressure Tester to the degas bottle nipple and overflow hose. Install a pressure test pump to the quick-connect fitting of the test adapter.

4. **NOTE:** If the plunger of the pump is depressed too fast, an erroneous pressure reading will result.

   Slowly depress the plunger of the pressure test pump until the pressure gauge reading stops increasing and note the highest pressure reading obtained.

5. If the pressure relief cap does not hold pressure, remove and wash the pressure relief cap in clean water to dislodge all foreign particles from the gaskets. Check the sealing surface in the filler neck.

6. If 89 kPa (13 psi) cannot be reached, replace the pressure relief cap. If more than 12 kPa (18 psi) shows on gauge, replace the pressure relief cap.

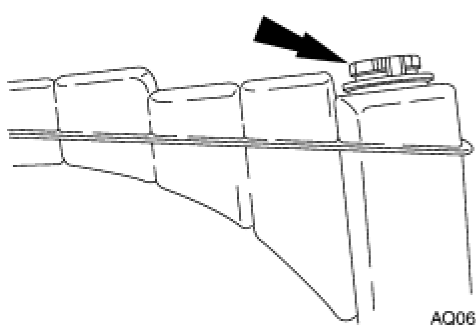
7. **CAUTION: If the pressure drops, check for leaks at the engine to heater core hoses, engine-to-radiator hoses, water valve hose (if applicable), oil cooler return tube gasket (6N789), radiator and heater core or other system components and connections. Any leaks which are found must be corrected and the system rechecked.**

   Pressurize the engine cooling system as described in Step 4 (using a pressure relief cap that operates within the specified upper and lower pressure limits). Observe the gauge reading for approximately two minutes; refer to General Specifications. Pressure should not drop during this time.

8. Release the system pressure by loosening the pressure relief cap. Check the engine coolant level and replenish, if necessary, with the correct engine coolant mixture; refer to Cooling System Draining, Filling and Bleeding in this section.

Cap

WARNING: Never remove the pressure relief cap under any conditions while the engine is operating. Failure to follow these instructions could result in damage to the cooling system or engine and/or personal injury. To avoid having scalding hot coolant or steam blow out of the cooling system, use extreme care when removing the pressure relief cap from a hot degas bottle. Wait until the engine has cooled, then wrap a thick cloth around the pressure relief cap and turn it slowly one turn (counterclockwise). step back while the pressure is released from the cooling system. When certain all the pressure has been released, remove pressure relief cap (still with a cloth).



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1. Remove the pressure relief cap from the degas bottle.

2. Immerse the pressure relief cap in water and install it on the shallow filler neck of Radiator/Heater Core Pressure Tester and Radiator Cap Adapter, part of Radiator/Heater Core Pressure Tester.

3. Immerse the filler neck seal in water and install it in the filler neck adapter.

4. Install the filler neck adapter with the filler neck seal to the Radiator Cap Adapter.

5. Connect the female quick-connect fitting of the pressure test pump to the male quick-connect fitting of the filler neck adapter.

6. **NOTE:** If the plunger of the pump is depressed too fast, an erroneous pressure reading will result.

   Slowly depress the plunger of the pressure test pump until the pressure gauge reading stops increasing and note the highest pressure reading obtained.

7. Release the pressure by turning the relief screw counterclockwise. Then tighten the pressure relief screw and repeat Step 6 (at least twice) to make sure the reading is repeatable within the specifications of the pressure relief cap.

8. If the pressure test gauge readings are not within specifications, replace the pressure relief cap. If the pressure test gauge readings are within specifications, perform the cooling system Pressure Test.

Thermostat—Water

The water thermostat should be replaced only after the following electrical and mechanical tests have been performed.

Thermostat—Electrical Test

CAUTION: Always vent the exhaust to the outside when performing this test.

NOTE: The electrical thermostat test is most accurate if performed indoors at less than 37.8°C (100°F) ambient air. This test may be performed with or without the hood open and with the engine warm or cold.

1. Check the engine coolant level. Fill as needed.

2. With the ignition OFF, remove the engine coolant temperature (ECT) sensor harness connector and attach ECT Sensor "T" Cable as a jumper between the powertrain control module (PCM) (12A650) and the ECT Sensor. Attach the 73 Digital Multimeter to the ECT Sensor "T" Cable. Voltage values (0-5 V) may now be monitored while the sensor retains its connection to the wiring harness.
   New Generation STAR (NGS) Tester or the Service Bay Diagnostic System (SBDS) may be used to monitor the ECT on vehicles equipped with data link connector (DLC). The SBDS sequence to use for the screen is: Toolbox-Electronic Engine Control and DCL-Item.

3. **NOTE:** Running this test with the vehicle in gear or with the A/C compressor clutch engaged (running) will cause improper diagnosis.

Place the transmission in PARK (P) or NEUTRAL (N).

4. Start the engine and allow the engine to idle throughout this test. Allow the engine to run for 2 minutes, then record the ECT voltage. Record the ECT voltage every 60 seconds. When the ECT voltage trend changes direction or only changes slightly (0.03 voltage or less) from the previous reading, record this as the thermostat opening voltage. Use the voltage and corresponding coolant temperature chart listed below.

Coolant Temperature °C (°F)	ECT (Volts)
22 (71)	3.00
43 (109)	2.01
71 (159)	1.01
82 (180)	0.75
91 (195)	0.059
97 (206)	0.050
105 (221)	0.040

5. If the thermostat opening voltage is greater than 0.75 volts and less than 82°C (180°F), replace the water thermostat.

6. If the thermostat opening voltage is less than 0.75 volts and greater than 82°C (180°F), the water thermostat is good and should not be replaced. Refer to the Symptom Chart for further instructions.

Thermostat—Mechanical Test

1. Remove the water thermostat.

2. Check the water thermostat for seating. Hold the water thermostat up to a lighted background. Leakage of light around the thermostat valve at room temperature indicates that the water thermostat should be replaced. Some water thermostats have a small leakage notch at one location on the perimeter of the thermostat valve, which is considered normal.

3. Immerse the water thermostat in a boiling antifreeze and water mixture.

4. See the General Specifications chart for water thermostat opening temperatures.

Radiator Leak Test, Removed From the Vehicle

CAUTION: Never leak test an aluminum radiator in the same water that copper/brass radiators are tested in. Flux and caustic cleaners may be present in the cleaning tank and they will damage aluminum radiators.

NOTE: Always install plugs in the oil cooler fittings before leak-testing or cleaning any radiator.

NOTE: Clean the radiator before leak-testing to avoid contamination of tank.

1. Leak-test the radiator in clean water with 138 kPa (20 psi) air pressure.

Fan Clutch Test

1. Spin the fan blade (8600) by hand. A light resistance should be felt. If there is no resistance or very high resistance, the minimum and maximum fan speeds must be checked as follows:

Fan Clutch Test—Minimum Speed Requirement

1. Use a suitable marker to mark the water pump pulley (8509), one of the fan blade retaining bolts and the crankshaft pulley (6312).
2. Connect a tachometer to the engine.
3. Install a throttle adjusting tool.
4. Connect the Digital Photoelectric Tachometer.
5. **WARNING: To avoid the possibility of personal injury or damage to the vehicle, do not operate the engine until the fan blade has been first examined for possible cracks and separation.**

   Start the engine and run it at approximately 1500 rpm until the normal operating temperature has been achieved.
6. Adjust the engine speed to 2300 rpm.
7. Operate the strobe light at 3000 rpm (on Diesel engines 3600 rpm's) and aim it at the water pump pulley. Adjust the engine speed until the light flash and the water pump pulley mark are synchronized.
8. Aim the strobe light at the fan blade bolts. Adjust the strobe light until the light flash is synchronized with the marked fan blade bolt (the fan blade appears to stand still).
9. The fan blade speed must not be greater than 1500 rpm (on Diesel engines 2000 rpm's) at 3000 water pump rpm.
10. Turn the engine off.
11. If the fan blade speed was greater than 1500 rpm (on Diesel engines 2000 rpm's), replace the fan clutch (8A616).

Fan Clutch Test—Maximum Speed Requirement

1. Perform Steps 1 through 5 of the Fan Clutch Test—Minimum Speed Requirement.

2. **NOTE:** The temperature should be above 96°C (205°F) for maximum fan speed.

   Block off areas on each side of the radiator in the engine compartment and the front of the radiator grille (8200). This will raise the temperature of the air striking the fan clutch and should cause the fan blade to operate at maximum speed.

3. Place the climate control function selector switch in the MAX A/C position and the blower motor switch in the HI position.

4. Adjust the strobe to 3000 rpm (on Diesel engines 3600 rpm's).

5. **WARNING: To avoid the possibility of personal injury or damage to the vehicle, do not operate the engine until the fan blade has been first examined for possible cracks and separation.**

   Start the engine and adjust the engine speed until the strobe light flash and the water pump pulley mark are synchronized.

6. Aim the strobe light at the fan blade retaining bolts. Adjust the strobe light until the light flash is synchronized with the marked fan blade bolt (the fan blade appears to stand still).

7. If the fan blade speed is less than 2300 rpm (on Diesel engines 2950 rpm's), replace the fan clutch.

SECTION 303-03: Engine Cooling	1999 F-Super Duty 250-550 Workshop Manual
REMOVAL AND INSTALLATION	Procedure revision date: 01/26/2000

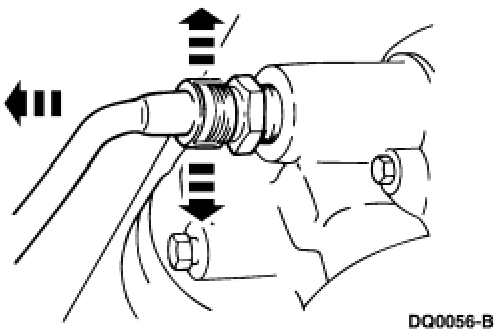
Block Heater—7.3L Diesel Engine

Removal

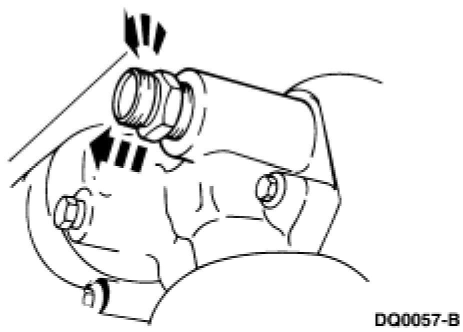
1. Drain the cooling system; refer to Cooling System Draining, Filling and Bleeding in the General Procedures portion of this section.

2. Raise and support the vehicle; refer to Section 100-02.

3. Disconnect the electrical connector from the block heater.



4. Remove the block heater from the oil cooler rear header.



Installation

1. Follow the removal procedure in reverse order.

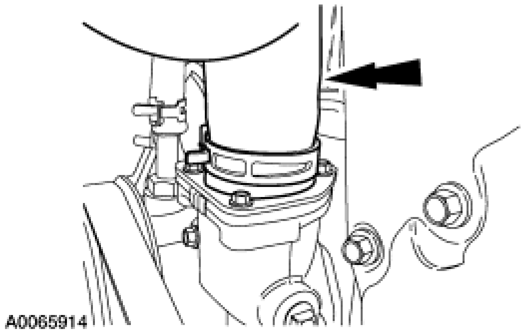
Water Pump—7.3L Diesel Engine

Removal

1. Drain the cooling system. For additional information, refer to Cooling System Draining, Filling and Bleeding in the General Procedures portion of this section.

2. Remove the cooling system fan and fan clutch. For additional information, refer to Fan Blade, Clutch and Shroud, Pickup Chassis in this section.

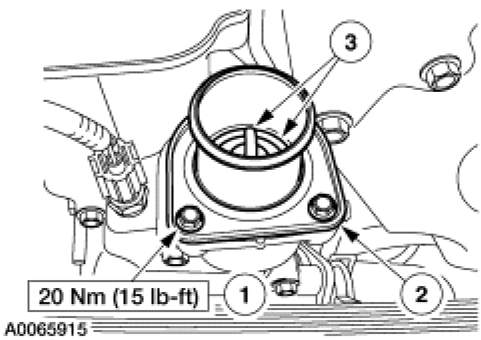
3. Disconnect the upper radiator hose from the water pump outlet tube.



4. Remove the thermostat and housing.
    1. Remove the three water outlet bolts.

    2. Remove the thermostat housing.

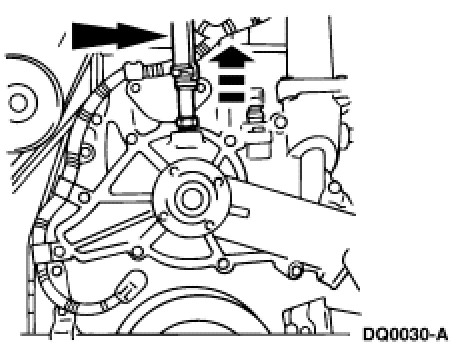
    3. Remove the thermostat and O-ring.



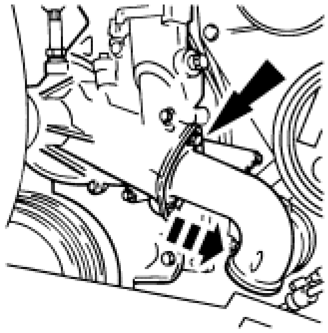
5. Remove the accessory drive belt. For additional information, refer to Section 303-05.

6. **NOTE:** The water pump pulley is removed for clarity.

   Disconnect the heater hose from the water pump.



7. Remove the two bolts and the water outlet tube.



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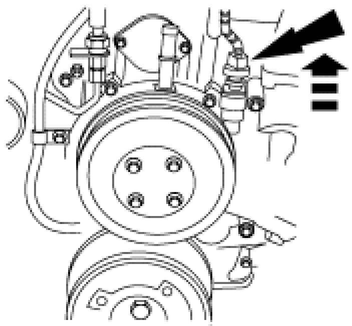
8. Disconnect the engine coolant temperature (ECT) sensor connector.



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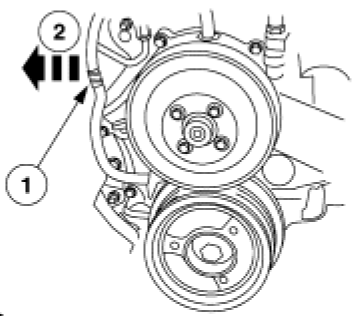
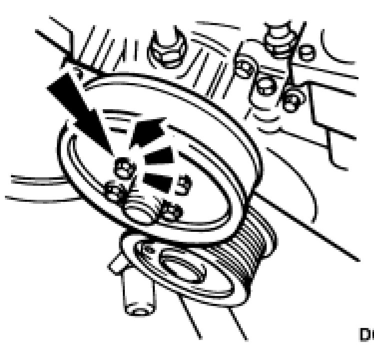
9. Disconnect the camshaft position (CMP) sensor electrical harness from the water pump.
    1. Remove the bolt.
    2. Disconnect the push pin retainer and position the harness away from the water pump.



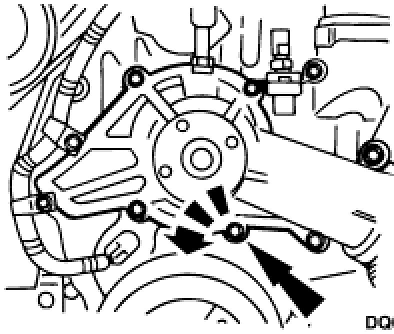
DQ0289-B

10. Remove the four bolts and the water pump pulley.



DQ0027-B

11. Remove the six bolts and the water pump.

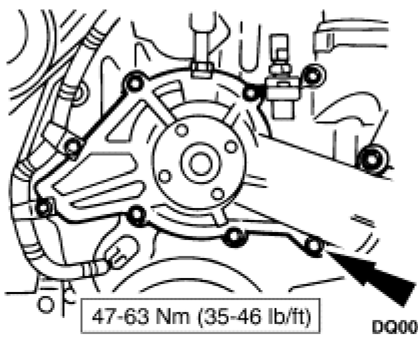


DQ0029-B

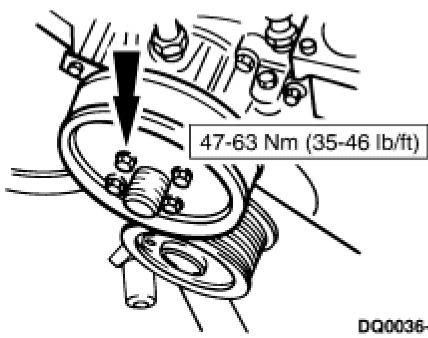
12. Clean the water pump gasket surfaces.

Installation

1. Follow the removal procedure in reverse order.



DQ0037-B



DQ0036-B

SECTION 303-03: Engine Cooling 1999 F-Super Duty 250-550 Workshop Manual
REMOVAL AND INSTALLATION Procedure revision date: 11/20/2002

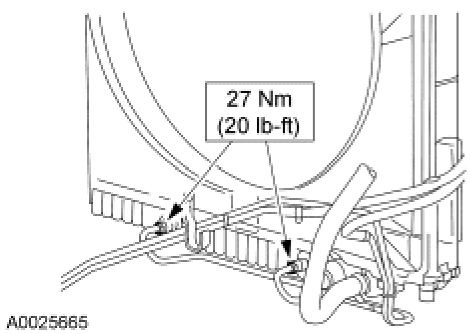
Radiator—Pickup Chassis

Removal

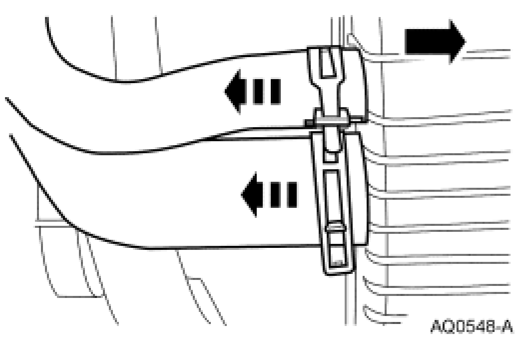
CAUTION: Do not mix Standard (green) Coolant with Extended Life Coolant (orange). If this contamination occurs the service change interval on Extended Life Coolant will be reduced from 6 year / 150,000 miles to 3 years / 30,000 miles.

NOTE: On 7.3L diesel equipped vehicle with the manual transmission, remove oil cooler tubes from the radiator.

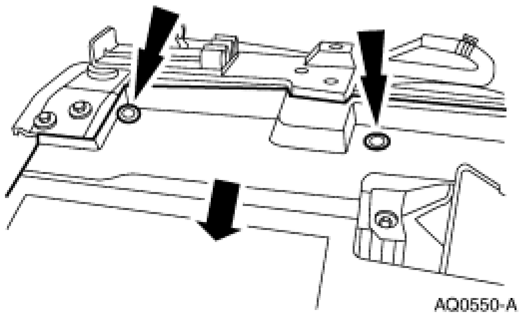
1. Drain the cooling system. For additional information, refer to Cooling System Draining, Filling and Bleeding in this section.
2. Remove the fan blade, clutch and shroud. For additional information, refer to Fan—Blade, Clutch and Shroud, Pickup Chassis in this section.
3. Remove the degas bottle. For additional information, refer to Degas Bottle—Pickup Chassis in this section.
4. Raise the vehicle. For additional information, refer to Section 100-02.
5. Disconnect the transmission cooler lines at the bottom of the radiator.



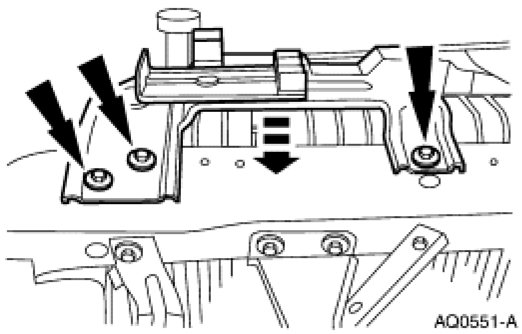
6. Remove the lower radiator hose from the radiator.



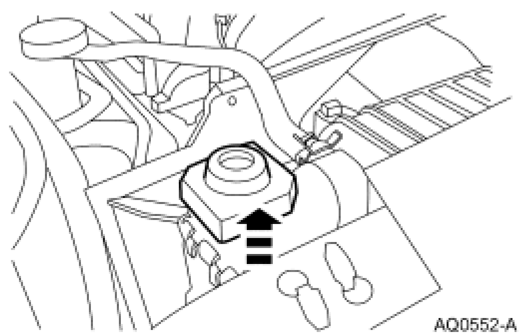
7. Lower the vehicle. For additional information, refer to Section 100-02.
8. Remove the two pushpins and position the radiator sight shield out of the way.



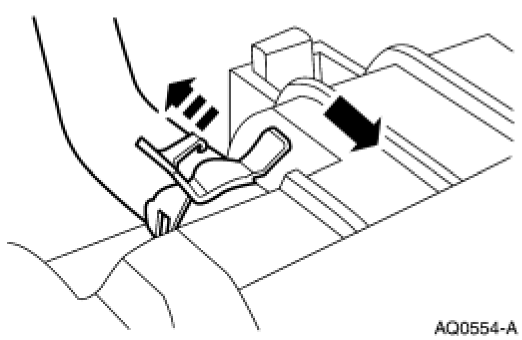
9. Remove the bolts and the right upper radiator support.



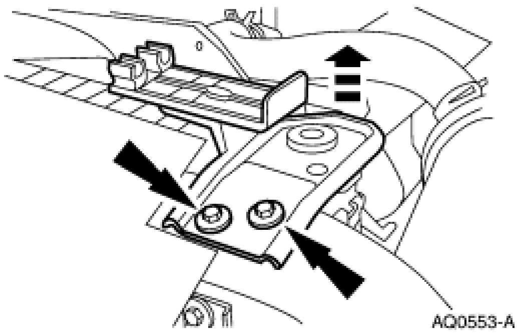
10. Remove the insulator.



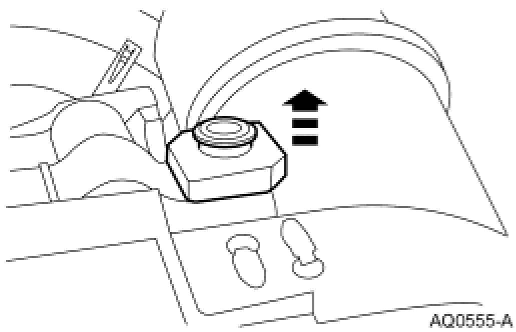
11. Remove the hose from the radiator.



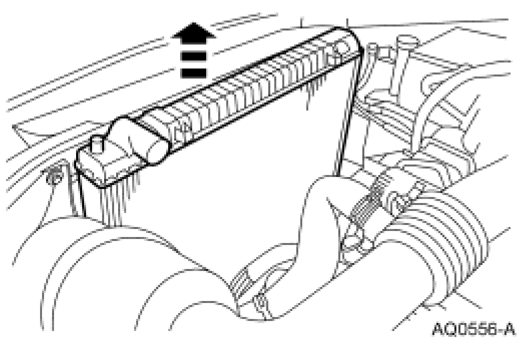
12. Remove the bolts and the left side radiator support.



13. Remove the insulator.

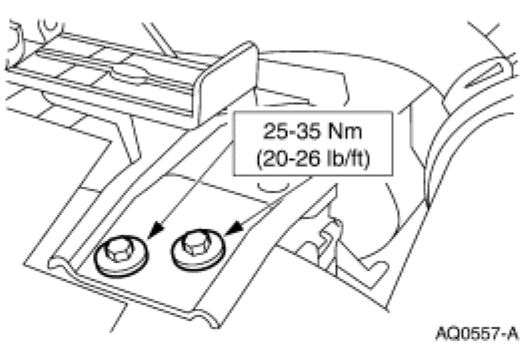


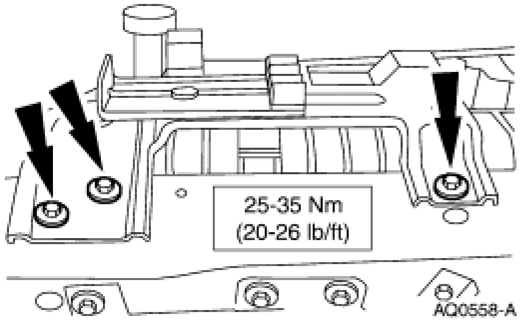
14. Remove the radiator.



Installation

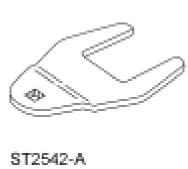
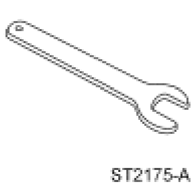
1. Follow the removal procedure in reverse order.





SECTION 303-03: Engine Cooling 1999 F-Super Duty 250-550 Workshop Manual
REMOVAL AND INSTALLATION Procedure revision date: 11/02/2002

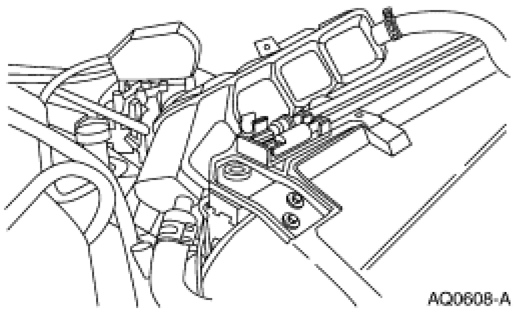
Fan—Blade, Clutch and Shroud, Pickup Chassis

Special Tool(s)	
	Fan Clutch Holding Tool (5.4L) 303-239 (T84T-6312-C)
	Fan Clutch Nut Wrench (5.4L) 303-240 (T84T-6312-D)
	Fan Pulley Holding Wrench (6.8L and 7.3L) 303-478 (T94T-6312-AH)
	Fan Clutch Nut Wrench (6.8L and 7.3L) 303-214 (T83T-6312-B)

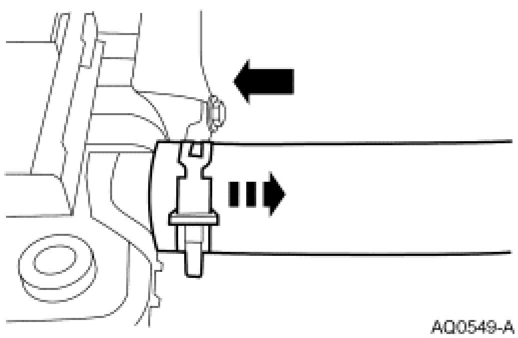
Removal

CAUTION: Do not mix Standard (green) Coolant with Extended Life Coolant (orange). If this contamination occurs the service change interval on Extended Life Coolant will be reduced from 6 years / 150,000 miles to 3 years / 30,000 miles.

1. Remove the three bolts and position the degas bottle out of the way.

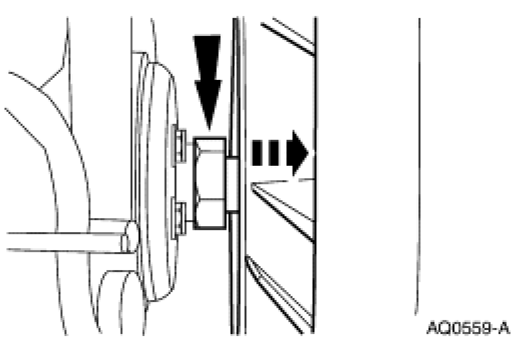


2. Squeeze the clamp, pull the hose off and position the upper radiator hose out of the way.

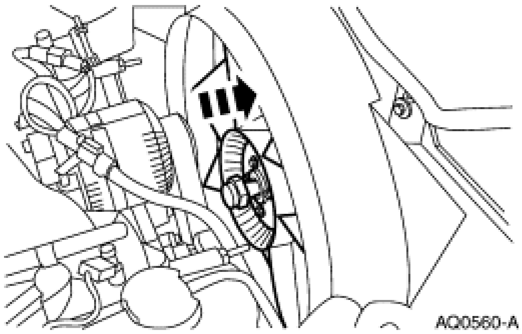


3. **CAUTION: The large clutch assembly nut has a right-hand thread and must be rotated counterclockwise to remove it.**

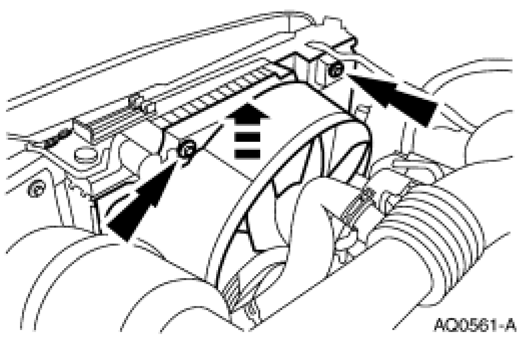
   Remove the fan and fan clutch from the water pump pulley.



4. Carefully position the fan and the fan clutch into the shroud.

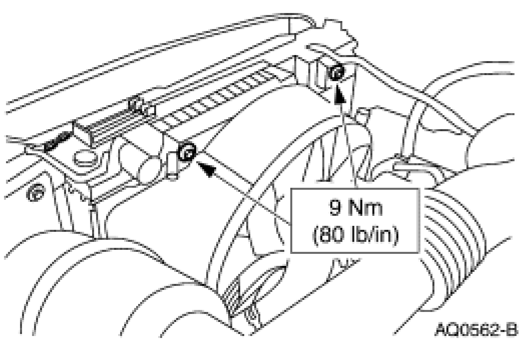


5. Remove the bolts, the shroud, fan and clutch.



Installation

1. Follow the removal procedure in reverse order.



SECTION 303-04C:
Fuel Charging and Controls — 7.3L Diesel

Backlash	
Description	**Specification**

Oil Pump Backlash	0.14-0.256 mm (0.0055-0.0101 Inch)

Pipe Threads			
1/8 x 27	**1/4 x 18**	**3/8 x 18**	**1/2 x 14**
7-11 Nm (5-8 Lb/Ft)	17-24 Nm (12-18 Lb/Ft)	30-44 Nm (22-33 Lb/Ft)	34-47 Nm (25-35 Lb/Ft)

Torque Specifications			
Description	**Nm**	**Lb/Ft**	**Lb/In**
Oil Pump Drive Gear Retaining Bolt	129	96	—
Oil Deflector Retaining Bolt	12	9	—
Fuel Injector Retaining Bolt	13.6	—	120
Oil Drain Plug	6	—	54
Oil Injection Pressure Sensor	29	22	—
Drive Gear Access Cover Retaining Bolts	21-32	16-24	—
High-Pressure Oil Pump Mounting Bolt	24	18	—
Oil Injection Pressure Regulator	6	—	55
Fuel Filter/Water Separator Mounting Bolts	31	23	—
High-Pressure Oil Reservoir Retaining Bolts	24	18	—

Fuel Charging and Controls

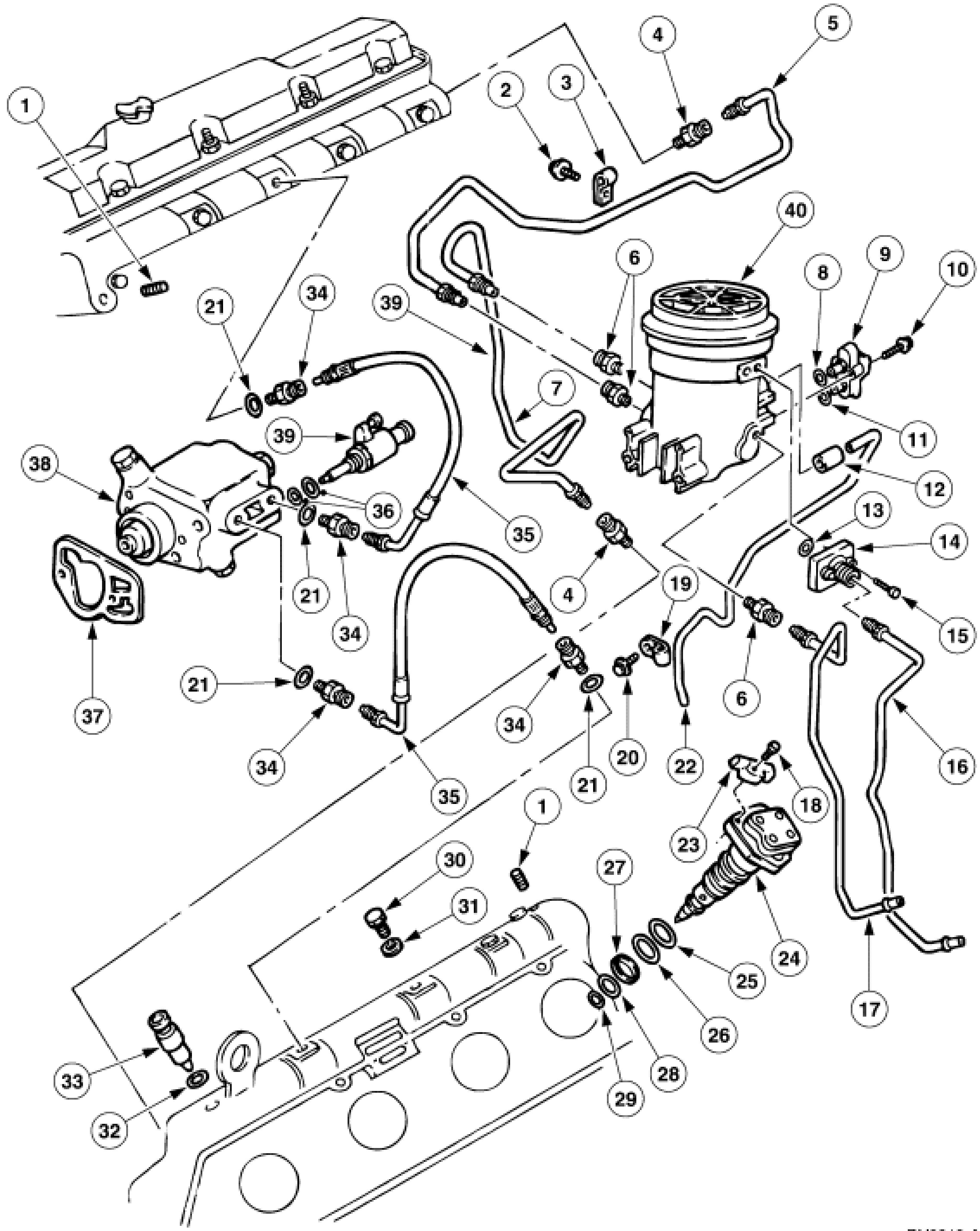
Fuel System

The fuel system used on the 7.3L direct injection (DI) turbo diesel engine is controlled by the powertrain control module (PCM) (12A650).

The fuel system components consist of:

- electric inline fuel pump (9350).
- high-pressure oil pump.
- fuel filter (9155).
- oil pressure regulator.
- oil pressure sensor.
- fuel pressure regulator (9C968).
- high-pressure oil pump reservoir.
- water in fuel switch/fuel heater thermostat.

Fuel System Components



Item	Part Number	Description
1	445684	Plug 1/8 Pipe
2	1820516C1	Stud Bolt
3	299400C1	Clamp Wrap
4	1826714C2	Fitting (One-Way Flow)
5	1830970C91	Fuel Delivery Line (Right Cylinder Head)
6	606885C1	Fitting (2 Req'd)

7	1830969C91	Fuel Delivery Line (Left Cylinder Head)
8	1831211C1	O-Ring
9	1831190C1	Fuel Heater Thermostat/Water Sensor
10	1831208C1	Screw (2 Req'd)
11	1831212C1	O-Ring
12	9324	Hose
13	1831398C1	O-Ring
14	1831187C1	Fuel Regulator Cap
15	1831209C11	Screw (2 Req'd)
16	1825389C91	Fuel Return Line
17	1825389C91	Fuel Supply Line
18	9R551	Screw
19	299402C1	Clamp Wrap
20	1817812C1	Screw
21	—	O-Ring (Part of 1825956C1)
22	9L273	Water Drain Tube
23	9G524	Oil Deflector
24	9F593	Fuel Injector
25	—	Backup O-Ring (Part of 9E527)
26	—	Cushion Ring (Part of 9E527)
27	—	Fuel Injector Middle Seal (Part of 9E527)
28	—	Fuel Injector Lower Seal (Part of 9E527)
29	—	Fuel Injector Gasket (Copper) (Part of 9E527)
30	1822607C91	Pipe Plug
31	—	O-Ring (Part of 1822607C91)
32	—	O-Ring (Part of 1807329C91)
33	1851329C91	Oil Pressure Sensor
34	1825956C1	Quick Connect Fitting (4 Req'd)
35	1831130C1	High-Pressure Oil Lines
36	—	O-Ring (Part of Kit)

37	9417	High-Pressure Oil Pump Flange Gasket
38	9A543	High-Pressure Oil Pump Assy
39	9L968	Injection Pressure Regulator
40	9155	Fuel Filter

Fuel is drawn from the fuel tank (9002) by the electric fuel pump. The fuel is then supplied under low pressure, 352 ± 28 kPa (51 ± 4 psi), to the fuel filter/water separator assembly.

Fuel to be supplied to the combustion chambers passes through the fuel filter/water separator assembly into the cylinder head galleries, then through the hydraulically actuated/electronically controlled fuel injectors.

Excess fuel not used by the engine bypasses the fuel filter/water separator assembly, flows through the fuel pressure regulator assembly, and returns to the fuel tank.

Fuel Pump

The fuel pump is an in-line electric pump mounted on the left hand frame rail. The fuel pump draws fuel from the fuel tank and supplies it to the engine at 352 ± 28 kPa (51 ± 4 psi).

Fuel Injection Timing

The period of time the fuel injector nozzle tips (9E527) are energized is controlled by the powertrain control module.

Fuel Injectors

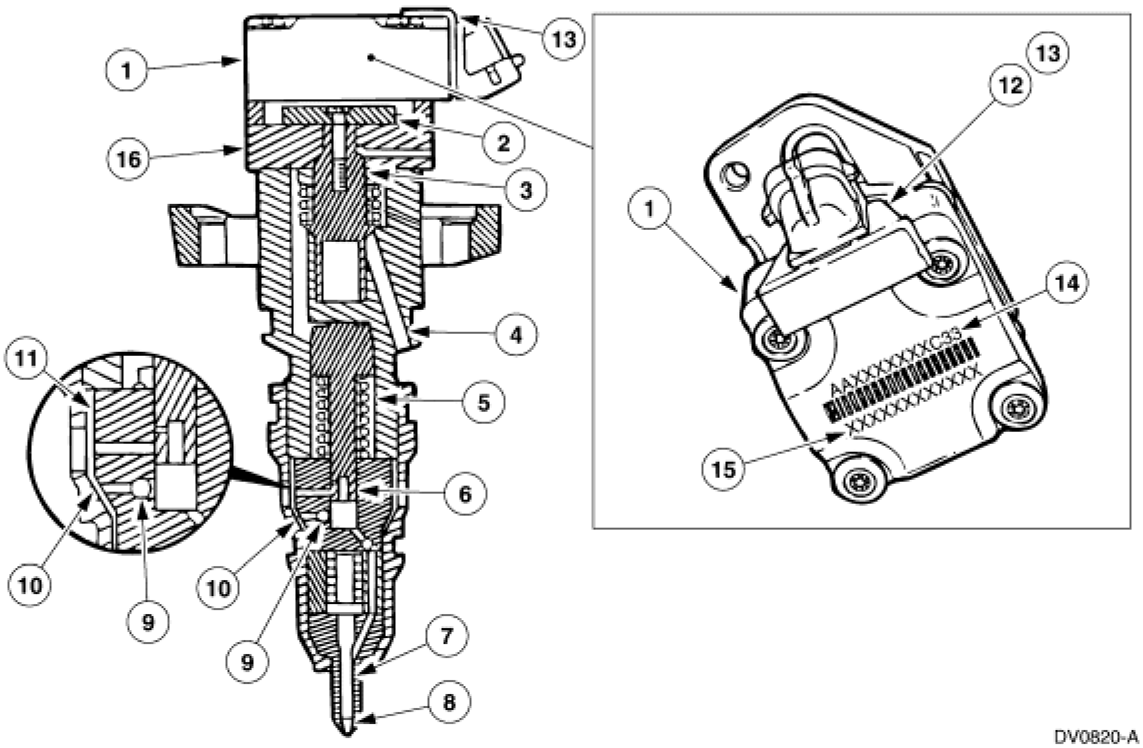
CAUTION: Color of Service Parts identification clip may differ from color of Production identification clip. Verify identification using part number and parts catalog.

CAUTION: Do not interchange fuel injectors. Improper injector installation can cause severe engine damage.

An electronically controlled/hydraulically actuated fuel injector is used. The rate shape fuel injector incorporates a spill control port that helps balance the fuel delivery, reducing the emissions and engine noise.

When the fuel injector is energized, a poppet valve is opened by an electronic solenoid mounted on the fuel injector. High-pressure oil from the high-pressure oil pump flows into the fuel injector and acts on the amplifier piston, forcing the piston plunger downward. As the plunger moves down, the increased fuel pressure closes the fuel inlet check ball. Rising fuel pressure overcomes spring pressure and opens the nozzle check valve. Fuel is then injected into the combustion chamber through the orifices in the nozzle tip at pressures as high as 124, 110 kPa (18,000 psi). When the fuel injector is de-energized, high-pressure oil on top of the amplifier piston is vented by the poppet valve through the top portion of the fuel injector back to the oil pan (6675).

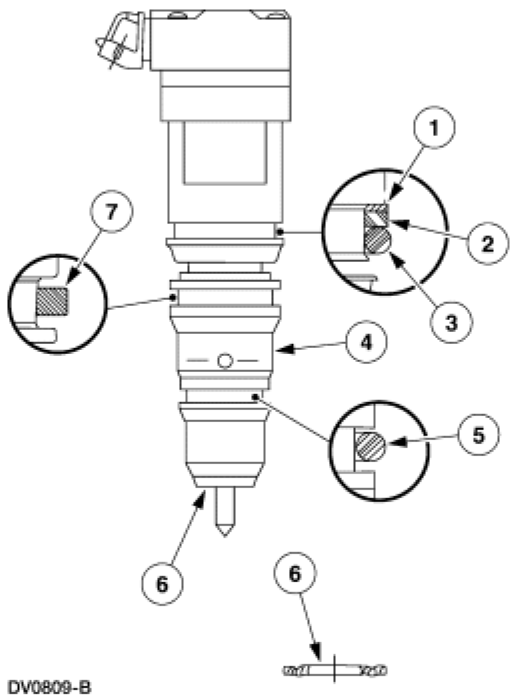
Fuel Injectors



Item	Part Number	Description
1	—	Solenoid (Part of 9E527)
2	—	Armature (Part of 9E527)
3	—	Poppet Valve (Part of 9E527)
4	—	Oil Inlet Port (Part of 9E527)
5	—	Amplifier Piston (Part of 9E527)
6	—	Plunger (Part of 9E527)
7	—	Nozzle Check Valve (Part of 9E527)
8	—	Nozzle Tip (Part of 9E527)
9	—	Fuel Inlet Check Ball (Part of 9E527)
10	—	Fuel Inlet Port (Part of 9E527)
11	—	Spill Control Port (California Only) (Part of

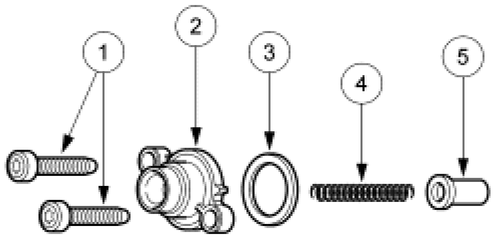
		9E527)
12	—	Identification Clip (Medium Blue) (49-State/Canada)
13	—	Identification Clip (Yellow) (California Only)
14	—	Part Number Identification (Suffix Differs from Federal)
15	—	Serial Number Identification
16	9F593	California Fuel Injector (Rate Shape)

Single Upper O-Ring Orientation



Item	Part Number	Description
1	—	Backup Ring (Steel) (Part of 9E527)
2	—	Cushion Ring (Black) (Part of 9E527)
3	—	Upper Injector Seal (Black) (Part of 9E527)
4	9E527	Fuel Injector
5	—	Lower Injector Seal (Black) (Part of 9E527)
6	—	Injector Gasket (Copper) (Part of 9E527)
7	—	Middle Injector Seal (Blue/Black) (Part of

		9E527)



A0040317

Item	Part Number	Description
1	31536	Screw, Torx M5 (2 Req'd)
2	31520	Cap
3	31538	O-Ring
4	31537	Spring
5	31489	Poppet Valve and O-Ring

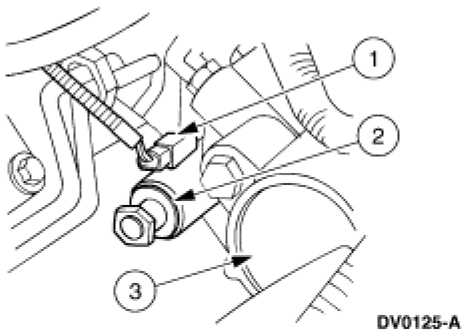
Fuel Pressure Regulator

Fuel pressure in the cylinder head fuel galleries is maintained at 352 ± 28 kPa (51 ± 4 psi) by a fuel pressure regulator. The fuel pressure regulator consists of a spring-loaded poppet valve, which opens to allow excess fuel to exit fuel filter/water separator prior to being cycled through the fuel filter. Fuel exiting the fuel filter/water separator is returned to the fuel tank.

Oil Pressure Regulator

Fuel injection pressure is controlled by the injection control pressure (ICP) system. The ICP system consists of the following:

- injection control pressure (ICP) sensor (located in the cylinder head oil gallery)
- injection pressure regulator (IPR) located in the high-pressure oil pump
- powertrain control module

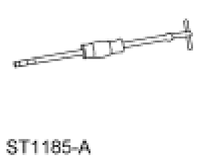


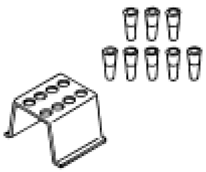
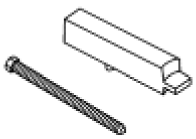
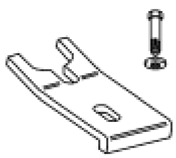
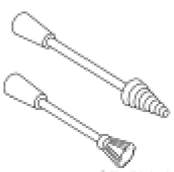
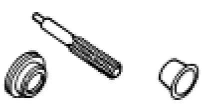
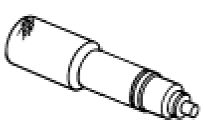
Item	Part Number	Description
1	—	Electrical Connector (Part of 14401)
2	7A139	Oil Pressure Regulator
3	9A543	High-Pressure Oil Pump

Fuel Charging Wiring

The fuel charging wiring connects the engine wire harness to each fuel injector and engine controls such as the injection control pressure (ICP) sensor, injection pressure regulator (IPR) and injector driver module (IDM). The fuel charging wiring receives fuel injector signals from the powertrain control module and the injector driver module then transfers the signals to the fuel injectors.

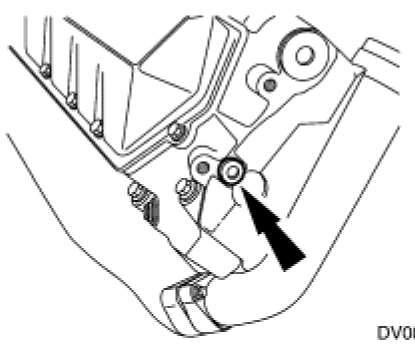
Fuel Injectors

Special Tool(s)	
	Impact Slide Hammer 100-001 (T50T-100-A)

 ST1075-A	Injector Protective Sleeve and Holding Rack 303-D5113 (D94T-9000-E) or equivalent
 ST2049-A	Injector Remover 303-491
 ST2050-A	Injector Replacer 303-492
 ST1529-A	Injector Sleeve Brush Set 303-DS110 (D94T-9000-D) or equivalent
 ST1527-A	Injector Sleeve Remover Set 303-DS105 (D94T-9000-B) or equivalent
 ST1528-A	Injector Sleeve Replacer 303-D109 (D94T-9000-C) or equivalent

Removal

1. Drain the fuel from the cylinder heads.
    - Loosen the drain plugs, located at the rear of each cylinder head.

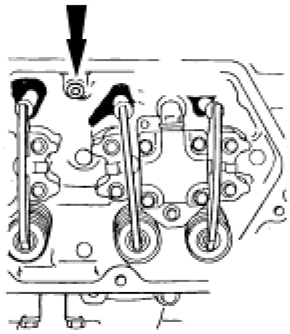


DV0821-A

2. Remove the valve cover. For additional information, refer to Section 303-01C.

3. Remove the fuel charging wiring. For additional information, refer to Wiring Harness—Fuel Charging in this section.

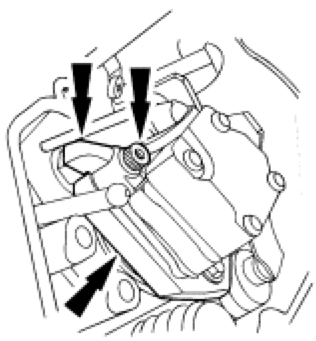
4. Remove the oil drain plugs.



DV0012-A

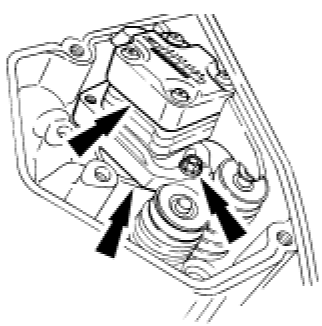
5. **NOTE:** Rocker arm removed for clarity.

   Remove the bolt and the oil deflector from the fuel injector hold-down plate.



DV0120-A

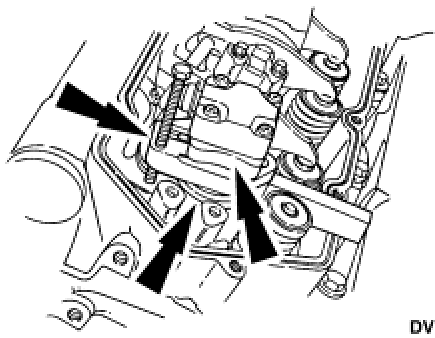
6. Remove the fuel injector outboard retaining bolts.



DV0021-A

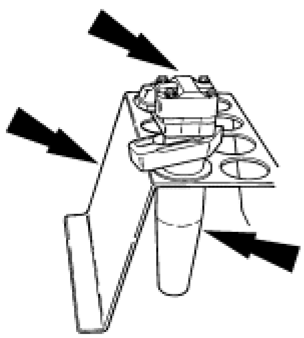
7. **NOTE:** When removing the fuel injectors, it is important that all three injector O-rings and the injector tip copper washer are removed from the injector bore. If the copper washer is not on the injector when removed from the cylinder head, make sure to remove it from the injector bore.

Using the Injector Remover, remove the fuel injector.



DV0005-A

8. Place the fuel injector into the injector protective sleeve.



DV0007-A

9. **NOTE:** If engine oil is found in the engine coolant or engine coolant is found in the combustion chambers new injector sleeves may need to be installed.

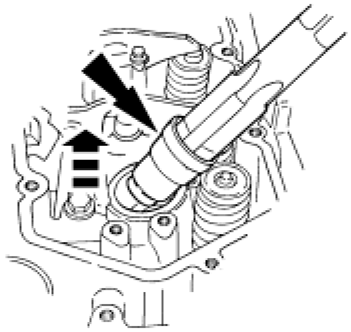
   Place the injector and sleeve into the holding rack.

10. **NOTE:** To install new fuel injector sleeves, the cylinder heads must be removed from the vehicle.

    If required, remove the cylinder heads from the engine. For additional information, refer to Section 303-01C.

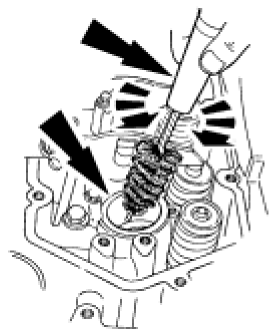
11. **NOTE:** Place a plastic cap or small piece of cork to act as a stop, in the injector sleeve before installing the injector sleeve tap, this will prevent damage to the cylinder head bore.

    Insert the injector sleeve tap and injector sleeve tap pilot into the cylinder head fuel injector bore. Tighten injector sleeve tap 1-1/2 to 2 turns. Attach the Impact Slide Hammer to the injector sleeve tap pilot, and remove the fuel injector sleeve from the cylinder head fuel injector bore. Discard the sleeve.



DV0006-A

12. Remove sealant residue and all foreign material from the cylinder head fuel injector bore, using the injector sleeve brush.

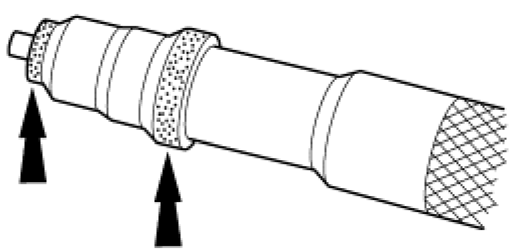


DV0008-A

Installation

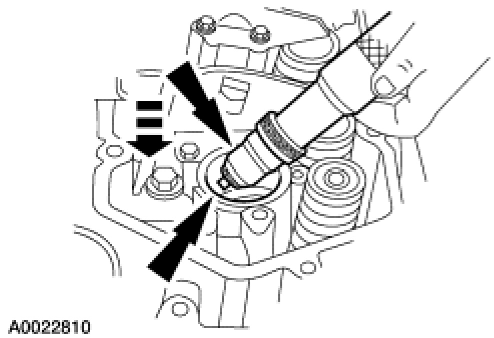
1. **NOTE:** Do not apply Threadlock® 620 or equivalent to angled areas.

   Position the fuel injector sleeve onto the Injector Sleeve Replacer. Apply Threadlock® 620 or equivalent to the very bottom (smallest diameter) and very top (largest diameter) flat areas.

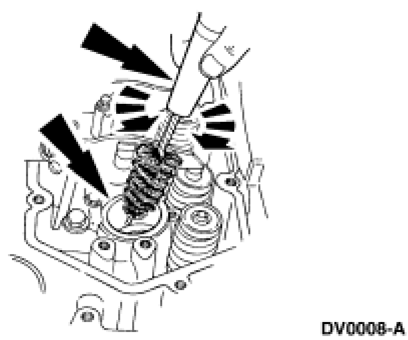


A0022788

2. Position the fuel injector sleeve into the cylinder head fuel injector bore. Seat the fuel injector sleeve in the fuel injector bore, using a rubber mallet. Remove Injector Sleeve Replacer tool from the cylinder head fuel injector bore.



3. Clean the fuel injector sleeve and bore, using the fuel injector sleeve brush. Remove any sealant residue from the fuel injector bore.



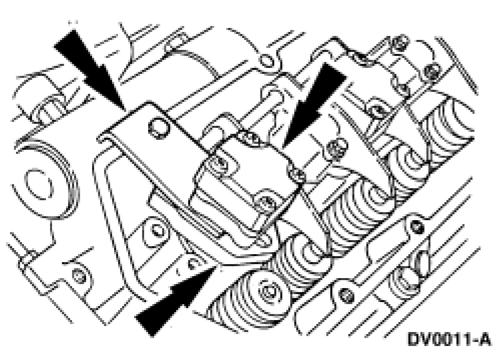
4. Install new O-rings on the fuel injector. Lubricate the fuel injector and O-rings liberally with clean engine oil.

5. If required, install the cylinder heads. For additional information, refer to Section 303-01C.

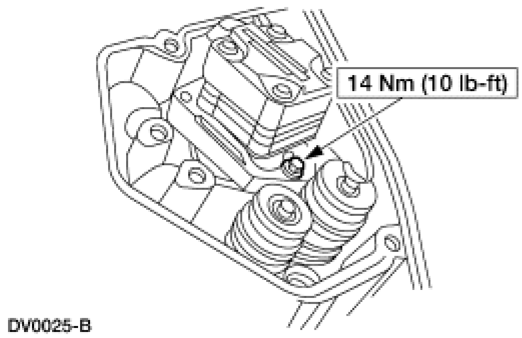
6. **CAUTION: Remove all oil and fuel from the cylinders before installing the fuel injectors. Failure to do so can cause hydrostatic lock, resulting in severe engine damage.**

   CAUTION: Do not strike the top of the fuel injector to seat the injector in the cylinder head fuel injector bore. Damage to the fuel injector can occur. Use hand pressure on the top of the fuel injector until the fuel injector hold-down plate is flush with the cylinder head.

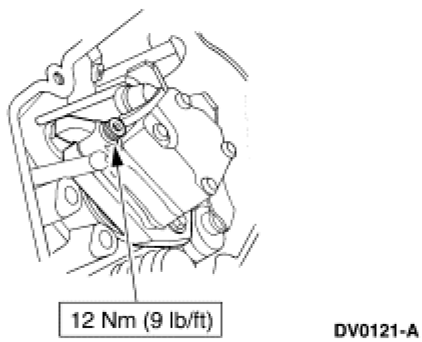
   Using the Injector Replacer, seat the fuel injector into the cylinder head fuel injector bore.



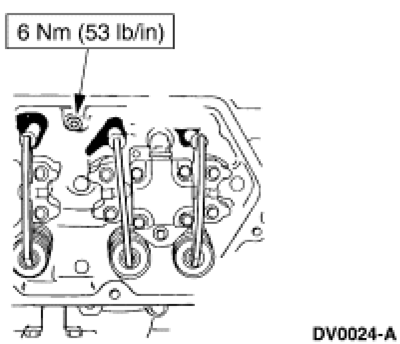
7. Install the fuel injector outboard retaining bolts.



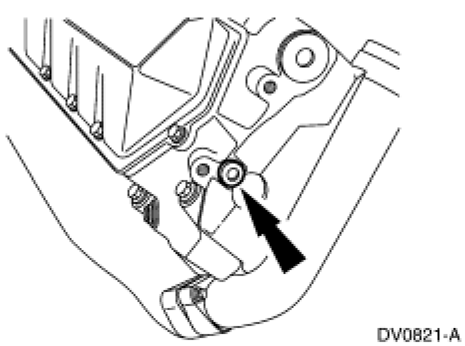
8. Install the oil deflector on the fuel injector hold-down plate.



9. Install the oil drain plugs.



10. Tighten the fuel drain plug located at the rear of each cylinder head.

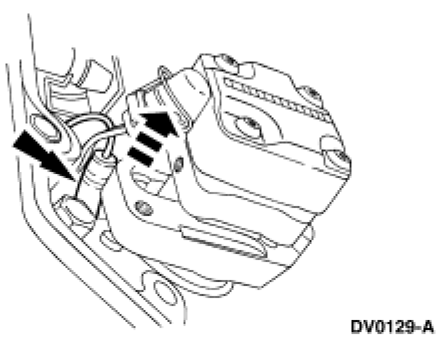


11. Position the valve cover gasket onto the cylinder head.
12. Install the fuel charging wiring. For additional information, refer to Wiring Harness - Fuel Charging in this section.
13. Install the valve covers. For additional information, refer to Section 303-01C.

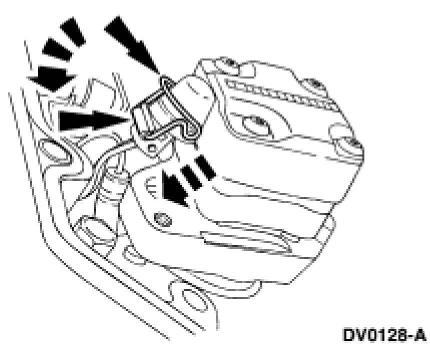
Wiring Harness—Fuel Charging

Removal

1. Remove the valve covers. For additional information, refer to Section 303-01C.
2. Disconnect the electrical connectors from the glow plugs.

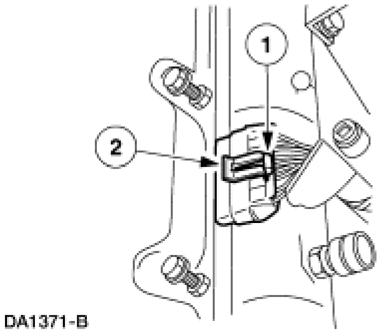


3. Disengage the attaching clip and remove the connectors from the fuel injectors.



4. Disconnect the electrical connectors from the valve cover gasket.

1. Remove the retaining clip.
2. Disconnect and remove the electrical connectors from the valve cover gaskets.



Installation

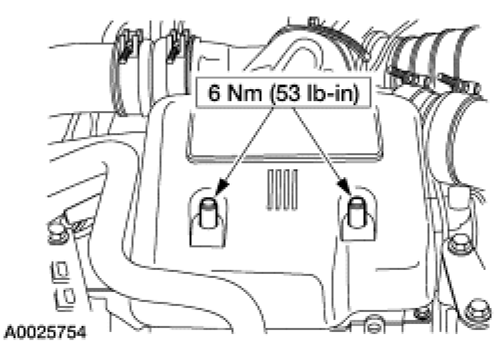
1. Follow the removal procedure in reverse order.

SECTION 303-04C: Fuel Charging and Controls — 7.3L Diesel | 1999 F-Super Duty 250-550 Workshop Manual
REMOVAL AND INSTALLATION | Procedure revision date: 01/26/2000

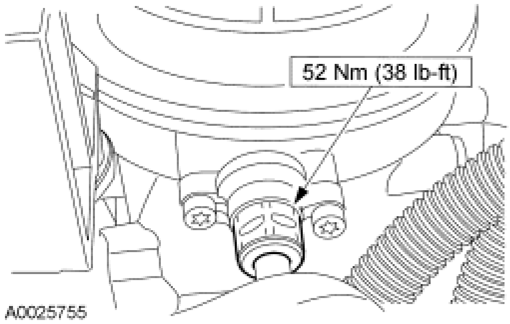
Pressure Regulator - Fuel

Removal and Installation

1. Remove the engine appearance cover.



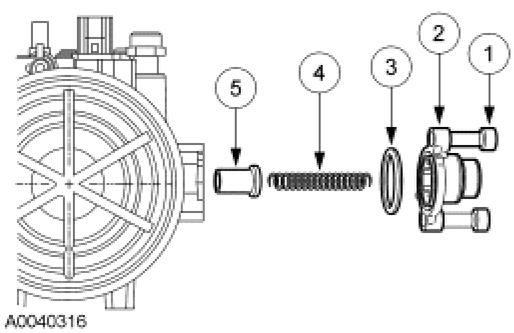
2. Disconnect the fuel return tube from the regulator.



3. ⚠ **WARNING: Clean all fuel residue from the engine compartment. Failure to do so can cause personal injury or damage to the vehicle.**

   Remove the fuel pressure regulator.

   1. Remove the Torx® screws.
   2. Remove the cap.
   3. Remove O-ring.
   4. Remove the spring.
   5. Remove the poppet valve and O-ring.

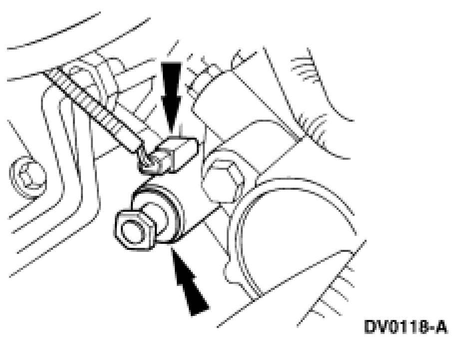


4. Thoroughly clean the fuel pressure regulator bore in the fuel filter/water separator.
5. To install, reverse the removal procedure.

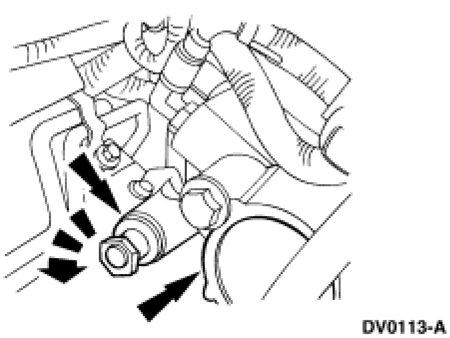
Pressure Regulator—Oil

Removal

1. Remove the turbocharger compressor manifold; for additional information, refer to Section 303-04D.
2. Remove the fuel filter/water separator; for additional information, refer to Section 310-01.
3. Disconnect the electrical connector from the oil pressure regulator.

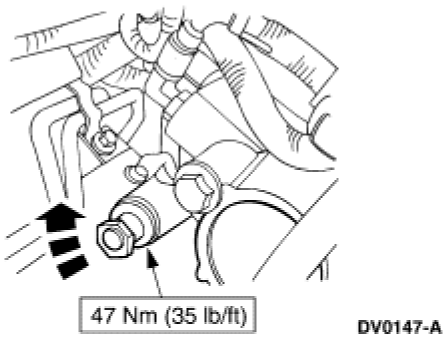


4. Remove the pressure regulator from the high-pressure oil pump.

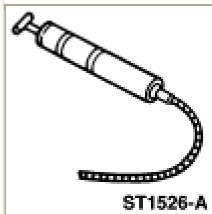


Installation

1. Follow the removal procedure in reverse order.



Oil Pump - High-Pressure

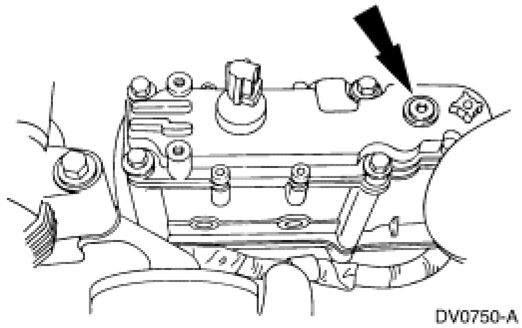
Special Tool(s)	
	Oil Suction Gun 303-D104 (D94T-9000-A) or Equivalent
	High-Pressure Line Disconnect Tool 303-625

Removal

1. Remove the turbocharger compressor manifold; for additional information, refer to Section 303-04D.

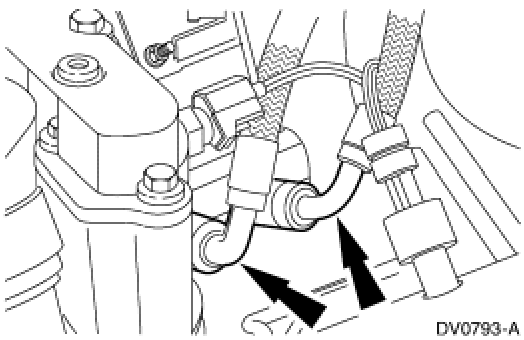
2. Remove the fuel filter/water separator assembly; for additional information, refer to Section 310-01.

3. Remove the high-pressure oil pump reservoir plug.

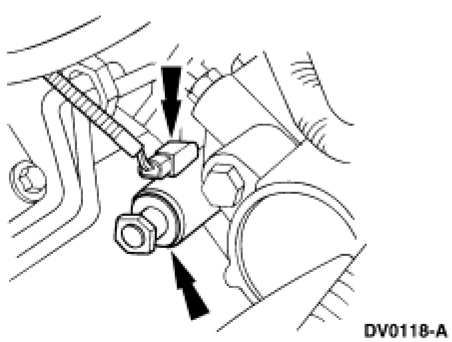


4. Using the Oil Suction Gun, remove the oil from the high-pressure oil pump reservoir.

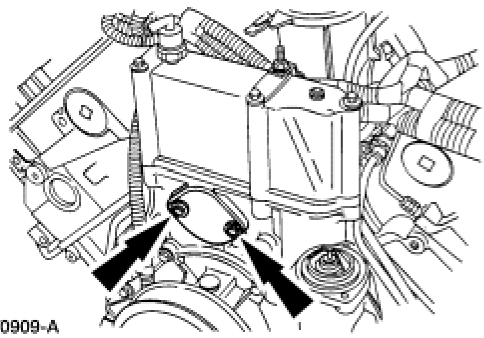
5. Using the High-Pressure Line Disconnect Tool, remove the hoses from the high-pressure oil pump.



6. Disconnect the electrical connector from the oil pressure regulator.



7. Remove the bolts and the cover from the engine front cover. Position the wiring harness aside.



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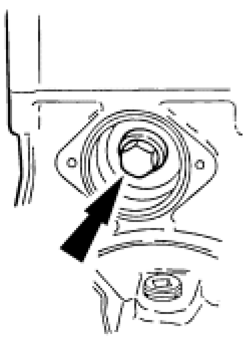
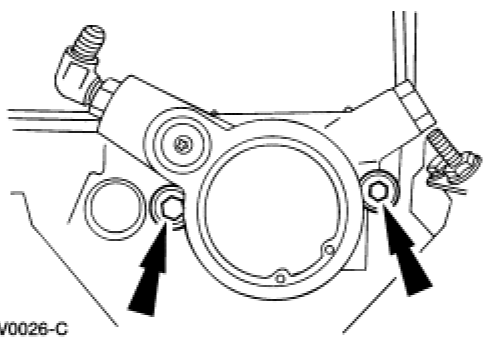
8. Remove the drive gear bolt and washer from the drive gear.



DV0022-C

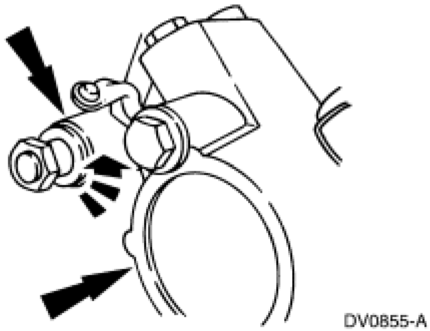
9. Remove the bolts and the high-pressure oil pump from the engine front cover. Remove and discard the gasket.



DV0026-C

10. **NOTE:** If the high-pressure oil pump is to be replaced, remove the oil pressure regulator from the pump.

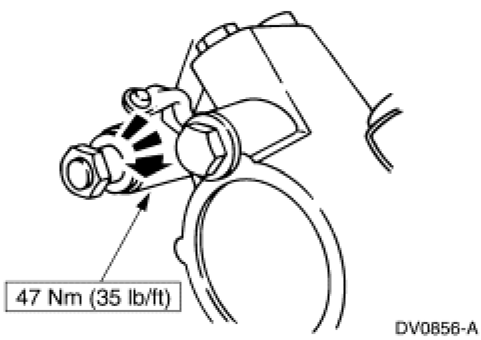
    Remove the oil pressure regulator from the oil pump.

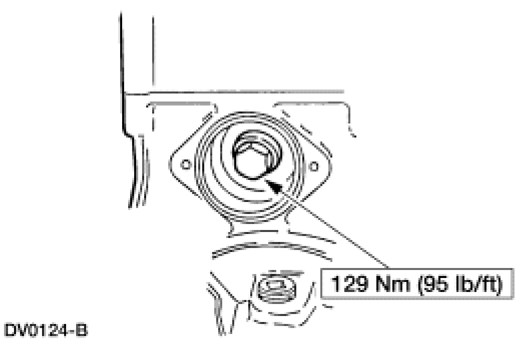


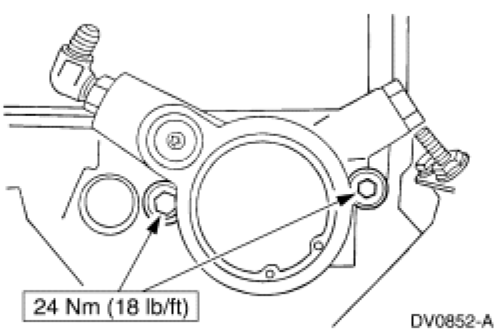
Installation

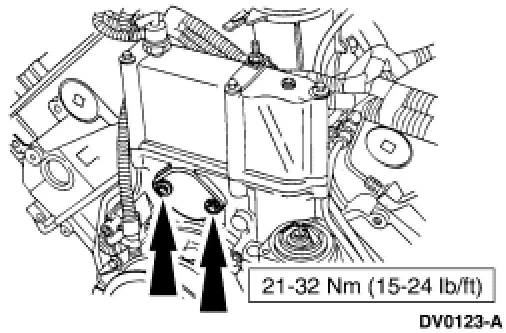
1. **CAUTION: Make sure that the drive gear is fully seated on the high-pressure oil pump before installing the bolt and washer. Otherwise, the drive gear may not seat properly, causing binding or slippage resulting in a no oil flow condition.**

   Follow the removal procedure in reverse order.





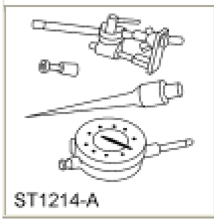




SECTION 303-04C: Fuel Charging and Controls — 7.3L Diesel | 1999 F-Super Duty 250-550 Workshop Manual

REMOVAL AND INSTALLATION | Procedure revision date: 01/26/2000

Oil Pump Drive Gear - High-Pressure

Special Tool(s)	
	Dial Indicator with Bracketry 100-002 (TOOL-4201-C) or Equivalent

Removal

1. Remove the high-pressure oil pump reservoir. For additional information, refer to Oil Pump Reservoir - High-Pressure in this section.

2. Remove the high-pressure oil pump. For additional information, refer to Oil Pump - High-Pressure in this section.

3. Remove the drive gear from the crankcase front cover.

4. Remove all gasket residue from the mating surfaces.

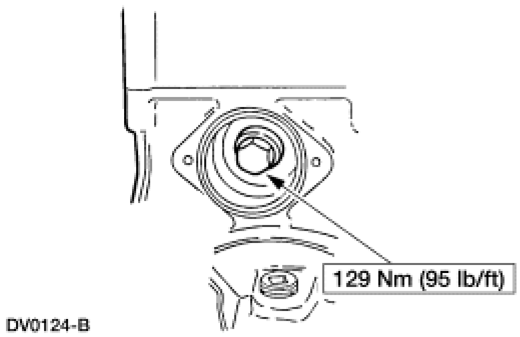
Installation

1. Position the drive gear into the crankcase front cover.

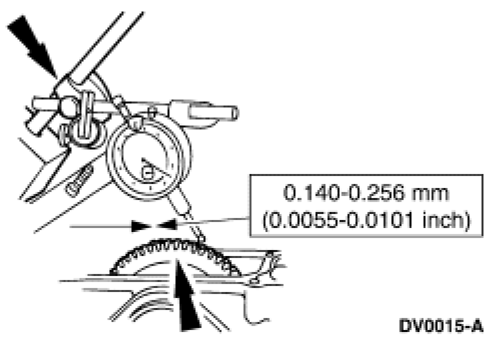
2. Install the high-pressure oil pump. For additional information, refer to Oil Pump - High-Pressure in this section.

3. ⚠ **CAUTION: Make sure that the drive gear is fully seated on the high-pressure oil pump before installing the bolt and washer. Otherwise the drive gear may not seat properly, causing binding or slippage resulting in a no oil flow condition.**

   Position the drive gear onto the oil pump, and install the bolt and washer.



4. Position the Dial Indicator with Bracketry onto the oil pump drive gear, and check the drive gear backlash. If not within specification, replace the drive gear.

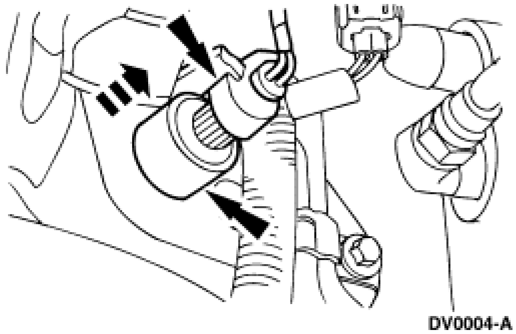


5. Install the high-pressure oil pump reservoir. For additional information, refer to Oil Pump Reservoir - High-Pressure in this section.

Sensor, Oil Pressure

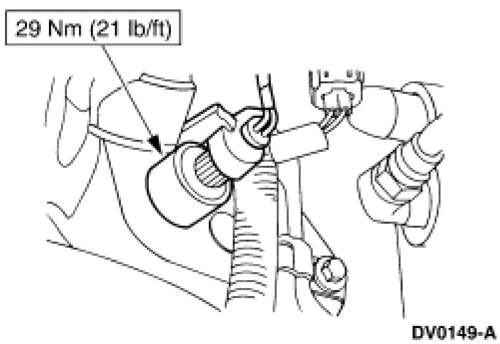
Removal

1. Disconnect the electrical connector and unscrew the pressure sensor from the left-hand cylinder head oil galley.



Installation

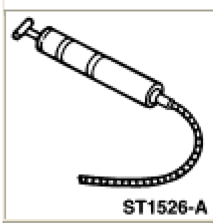
1. Follow the removal procedure in reverse order.



SECTION 303-04C: Fuel Charging and Controls — 7.3L Diesel
REMOVAL AND INSTALLATION

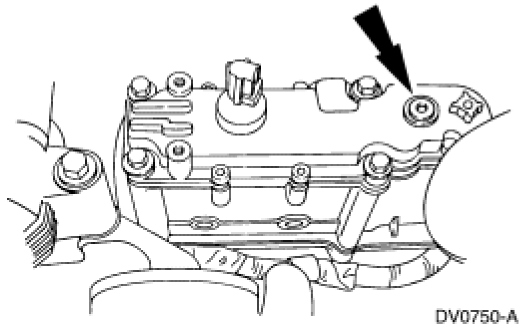
1999 F-Super Duty 250-550 Workshop Manual
Procedure revision date: 01/26/2000

Oil Pump Reservoir—High-Pressure

Special Tool(s)	
	Oil Suction Gun 303-D104 (D94T-9000-A) or Equivalent

Removal

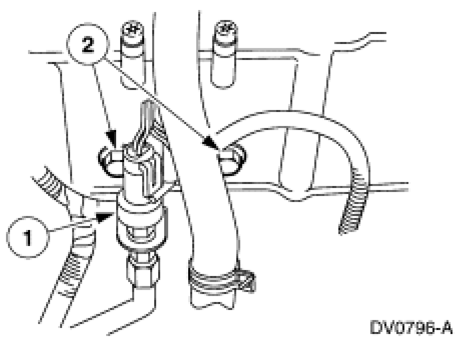
1. Remove the plug from the oil reservoir.



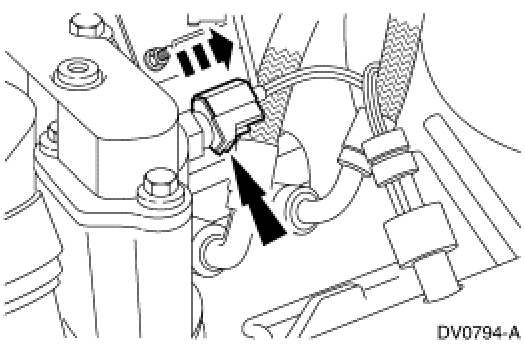
2. Using the Oil Suction Gun, drain the high-pressure oil pump reservoir.

3. Disconnect the fuel filter assembly from the engine front cover.
    1. Disconnect the electrical connector from the exhaust back pressure sensor.

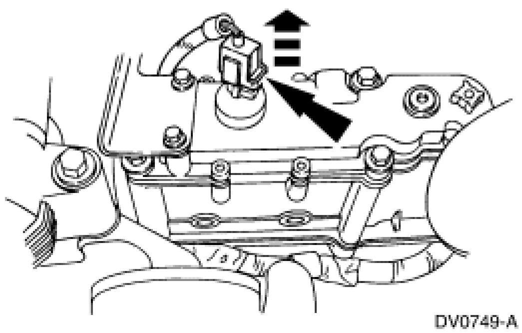
    2. Remove the fuel filter retaining bolts.



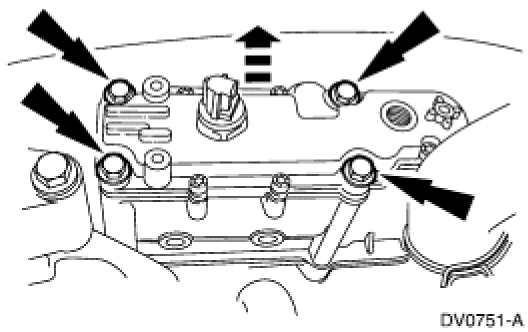
4. Disconnect the electrical connector from the oil temperature sensor.



5. Disconnect the electrical connector from the oil pressure switch.

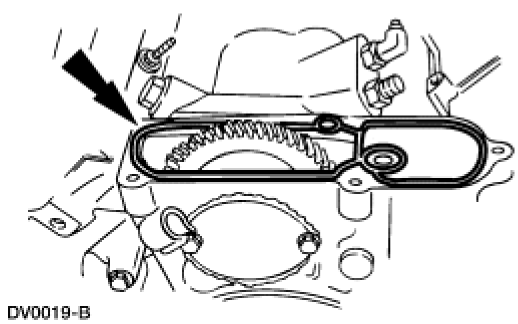


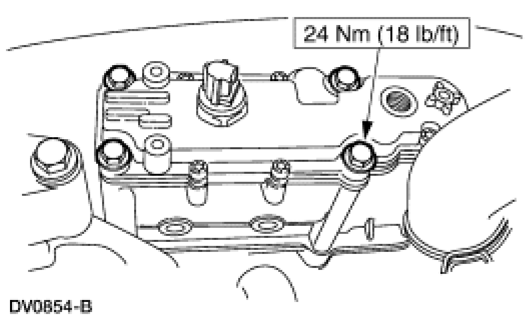
6. Remove the bolts, oil reservoir and seal from the engine front cover.

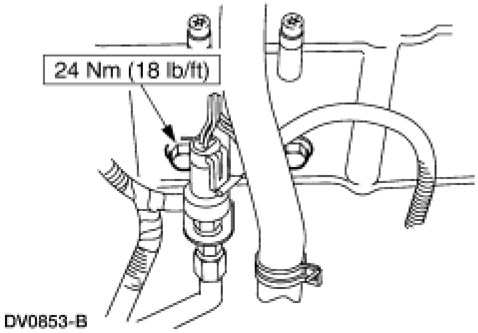


Installation

1. Position the seal on the engine front cover.







2. Follow the removal procedure in reverse order.

Fuel Heater

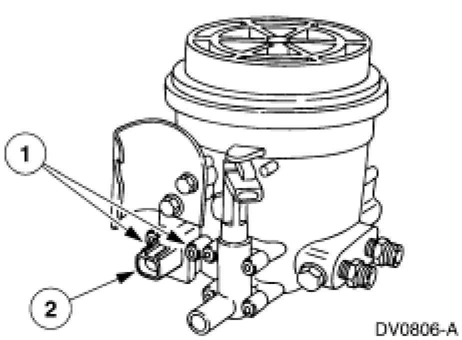
Removal

1. Remove the fuel filter/water separator assembly; for additional information, refer to Section 310-01.

2. Remove the fuel filter/water separator cap and element.

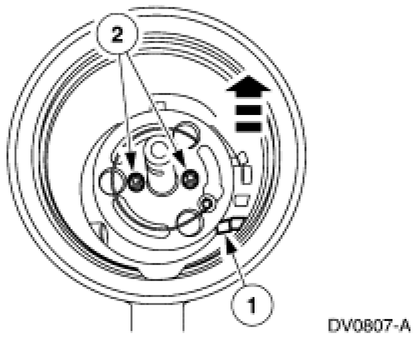
3. Remove the fuel filter heater thermostat.
    1. Remove the screws.

    2. Pull the thermostat out of the fuel filter/water separator housing.



4. Remove the fuel heater element.
    1. Disconnect the electrical connector.

2. Remove the screws and the fuel heater.



Installation

1. **WARNING: Clean all the fuel residue from the engine compartment. Failure to do so can cause personal injury or damage to the vehicle.**

   Follow the removal procedure in reverse order.

SECTION 303-04D:
Fuel Charging and Controls — Turbocharger

SPECIFICATIONS

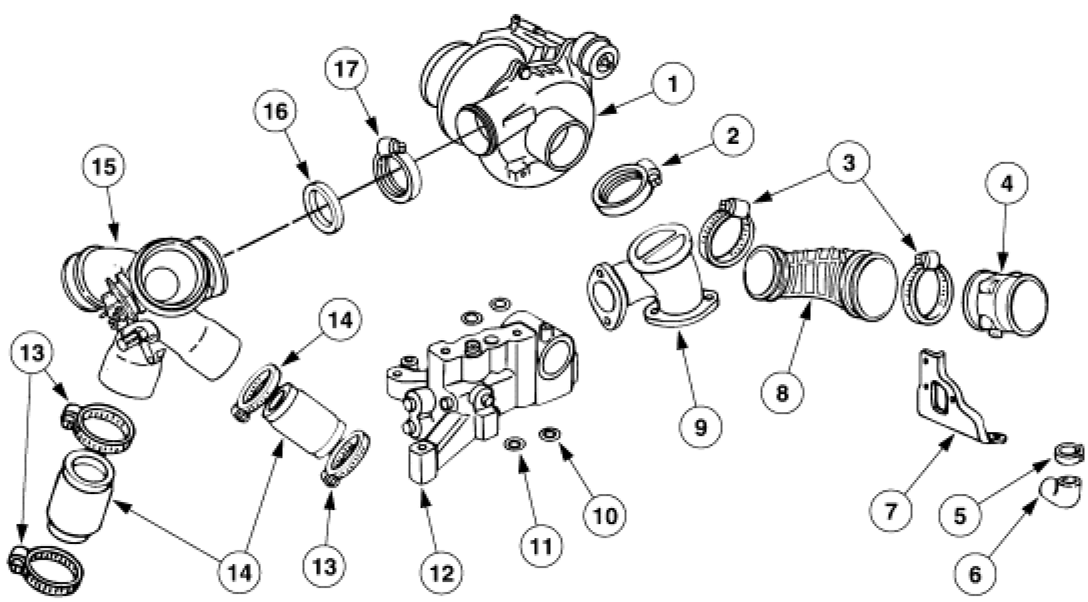
Procedure revision date: 01/26/2000

Torque Specifications

Description	Nm	Lb/Ft	Lb/In
Turbocharger Mounting Bolts	24	18	—
Turbocharger Pedestal Mounting Bolts	24	18	—
Exhaust Inlet Pipe to Turbocharger Marmon Clamp	7	—	62

Turbocharger

Component Location



DV0889-B

Item	Part Number	Description
1	6K682	Turbocharger
2	8287	Marmon Clamp
3	8287	Clamp
4	1820052C92	Air Inlet Duct
5	1813366C1	Breather Hose Elbow Clamp
6	181603022	Breather Hose Elbow
7	6K864	Air Inlet Bracket
8	9C681	Air Inlet Hose
9	6K854	Turbocharger Exhaust Inlet Manifold
10	6N653	Turbocharger Oil Supply O-Ring (2 Req'd)
11	6N653	Turbocharger Oil Drain O-Ring (2 Req'd)
12	6N639	Turbocharger Pedestal Assy
13	8287	Clamp

14	6C640	Intake Manifold Hose (2 Req'd)
15	6K889	Compressor Manifold
16	9E436	Turbocharger Compressor Outlet Seal
17	8287	Marmon Clamp

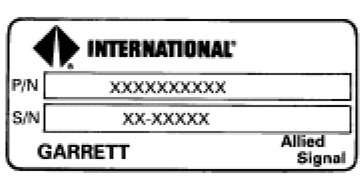
The 7.3L DIT Diesel Engine uses an electronically controlled wastegated GTP38 turbocharger to control the intake manifold pressure. An intake manifold pressure sensor provides readings to the PCM, the PCM compares this reading with the vehicle speed and engine load then sends a signal to the solenoid control valve. The solenoid control valve alters the pressure applied to the wastegate actuator to provide the proper position for the wastegate valve providing the proper boost pressure.

The wastegate turbocharger system components are:

- turbine housing
- compressor housing
- center housing
- compressor manifold
- turbocharger pedestal
- exhaust back pressure valve and control solenoid
- wastegate valve assembly
- wastegate actuator
- solenoid control valve
- intake manifold pressure sensor
- PCM (powertrain control module)

The turbocharger can be identified by the turbocharger I.D. plate.

Turbocharger I.D. Plate



A20421-A

The turbine and compressor wheels are mounted on opposite ends of a common shaft. The wheels are enclosed by two housings, and the common shaft is enclosed by the center housing.

High-velocity engine exhaust gases drive the turbine wheel, which turns the common shaft turning the compressor wheel at speeds up to 130,000 revolutions per minute. Air entering the compressor side of the turbocharger is compressed and delivered to the combustion chambers. This compressed air causes more engine power output, better fuel efficiency and better engine performance at higher altitudes.

The turbocharger is supplied with pressurized oil from the engine's main oil gallery through a passage in the turbocharger pedestal. Oil then drains back through another passage in the turbocharger pedestal into the oil pan. This eliminates the need for external lubrication supply and return lines.

Split ring seals are installed at each end of the common shaft between the shaft bearing and wheel assembly to prevent lubricating oil from entering the turbine or compressor area.

The pressurized oil entering the turbocharger also serves to actuate the exhaust back pressure warm-up system. This system consists of an actuator and a butterfly valve. This system operates only during the cold weather warm-up cycle.

Turbocharger

For additional information, refer to the Powertrain Control/Emissions Diagnosis (PC/ED) manual for testing procedures not covered in this section.

Inspection and Verification

1. Verify the customer concern.
2. Inspect the entire turbocharger system for obvious signs of damage, using the following chart.

Visual Inspection Chart
Mechanical
• Damaged intake hoses • Loose hose clamps • Loose exhaust clamps • Damaged turbocharger • Restricted intake or exhaust

3. If the concern(s) remains after the inspection, go to the symptom chart in this section.

Symptom Chart

SYMPTOM CHART		
Condition	**Possible Sources**	**Action**
• No Boost	• Wastegate actuator not functioning.	• For additional information, REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual.
	• Compressor air intake hose collapsed.	• REPAIR or REPLACE as required.
	• Compressor manifold hoses leaking.	• TIGHTEN hose clamps.
	• Turbocharger turbine or compressor wheel damage.	• REPLACE turbocharger.
	• Turbocharger bearings seized.	• REPLACE turbocharger.
	• Clogged air cleaner element or restriction upstream of compressor.	• REPAIR or REPLACE as required.
• Lack of Power	• Low compression.	• REPAIR as required.
	• Wastegate actuator not functioning.	• For additional information, REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual.
	• Clogged air cleaner element or restriction upstream of compressor.	• REPLACE the air cleaner element. REMOVE the restriction.

	• Insufficient fuel supply.	• REPAIR or REPLACE as required.
• Excessive Fuel Consumption (Black Exhaust Smoke)	• High fuel pressure. • Pressure regulator.	• REPAIR as required. For additional information, REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual.
	• Fuel return line plugged or kinked.	• CLEAN or REPLACE as required.
	• Injectors leaking.	• REPLACE the injectors.
	• Powertrain control module malfunctioning.	• For additional information, REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual.
• Excessive Oil Consumption (Blue, Gray, or White Exhaust Smoke)	• Incorrect type or grade of oil.	• DRAIN and FILL with specified oil.
	• Extended oil change intervals.	• CHANGE oil as recommended.
	• Clogged air cleaner element or restriction upstream of compressor.	• REPAIR as required.
	• Engine wear (piston rings, valve guides).	• REPAIR as required.
	• Turbocharger oil seals leaking.	• REFER to Turbocharger Internal Oil Leak Test in this section.
	• Injector or injector O-	• For additional information, REFER to

	ring leaking.	the Powertrain Control/Emissions Diagnosis (PC/ED) manual.
• Noise or Vibration	• Leaks at turbocharger inlet and outlet connections.	• REPAIR as required.
	• Foreign object damage to turbine or compressor blades.	• REPLACE turbocharger.
	• Turbine bearing failure.	• REPLACE turbocharger.
• High Boost	• Leak in exhaust system before muffler.	• REPAIR as required.
	• Malfunctioning wastegate.	• For additional information, REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual.

Component Tests

Turbocharger Leak Test

Check for loose connections or damage to air intake hoses and tubes.

Air leaks at the compressor manifold, intake manifold hoses or intake manifold covers can cause excessive smoke, loss of engine power or a noise condition.

Exhaust leaks at the exhaust manifolds or in the turbine housing will also cause loss of engine power and a noise condition.

Inspect turbocharger and components for loose connections or damage. Using a liquid soap on hose or tube connections will aid in leak detection.

Exhaust leaks can usually be detected audibly or visually by a discoloration caused by escaping hot exhaust gases.

Turbocharger Internal Oil Leak Test

NOTE: Some engine oil may be present in the turbocharger compressor inlet and in the air inlet components due to the crankcase breather system.

Check the turbocharger compressor inlet for evidence of oil. If excessive oil is present, this indicates that the failure is in the engine, not in the turbocharger; for additional information, refer to the Powertrain Control/Emissions Diagnosis (PC/ED) manual.

Check the turbocharger turbine outlet for evidence of oil. If oil is present in the outlet, remove the turbocharger from the engine and examine the oil supply and return passages in the turbocharger pedestal and engine block for restriction. If no restriction is found, replace the turbocharger.

Bearing Clearance Check

When bearing damage is suspected, verify using the following procedure.

Check for Free Rotation

NOTE: Turbine and compressor wheels must spin freely when turned by hand. No housing contact is permitted.

Press and rotate the radial shaft, then repeat from the opposite side. If either the compressor wheel or the turbine wheel contacts the housing, the bearings are bad, and the turbocharger must be replaced.

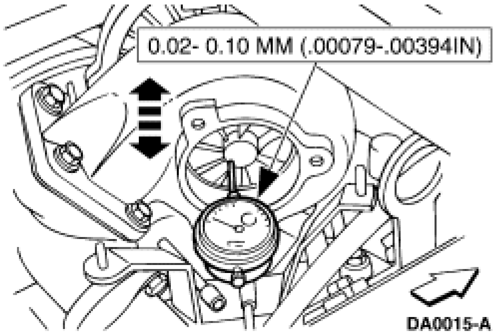
Check Axial End Play

1. **NOTE:** Radial shaft movement cannot readily be measured on this turbocharger.

   NOTE: Remove the exhaust back pressure valve from the turbocharger; for additional information, refer to Backpressure Valve in this section.

   Position the dial indicator on the turbine end of the radial shaft and zero the indicator.

2. Move the radial shaft back and forth by hand and record the reading.

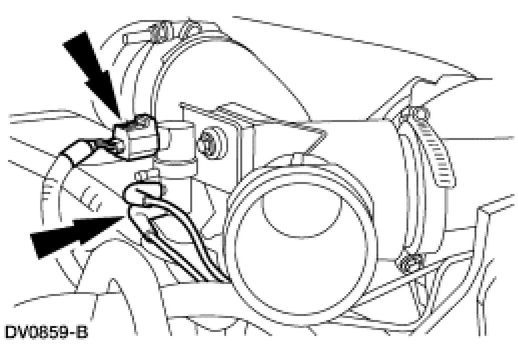


3. If readings exceed specifications, replace the turbocharger.

Turbocharger

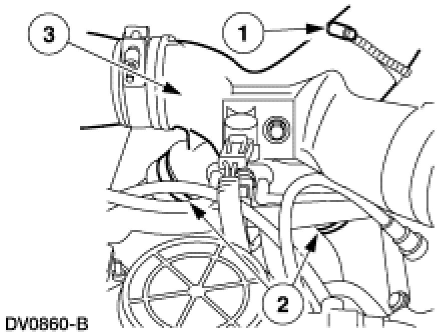
Removal

1. Open the hood.
2. Remove the charge air cooler inlet and outlet ducts from the compressor manifold; for additional information, refer to Section 303-12.
3. Disconnect the pressure lines and the pressure valve electrical connector.



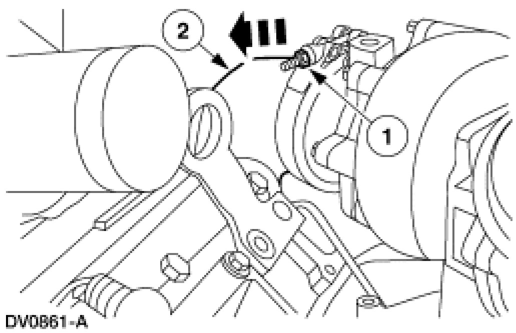
4. Remove the compressor manifold.
    1. Loosen the turbocharger to compressor manifold Marmon clamp.
    2. Loosen the clamps.

3. Remove the compressor manifold.



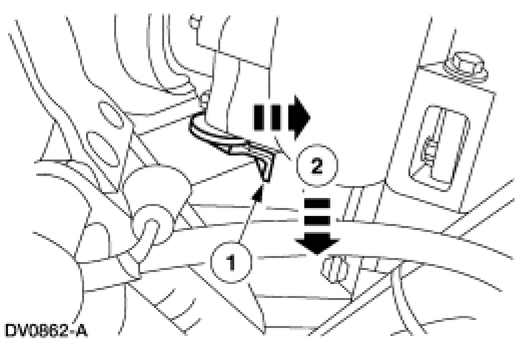
5. Remove the exhaust outlet pipe from the turbocharger.
    1. Loosen the Marmon clamp.

    2. Pull the exhaust outlet pipe away from the turbocharger.



6. Disconnect the exhaust back pressure valve.
    1. Slide the retaining clip away from the exhaust back pressure valve actuator lever.

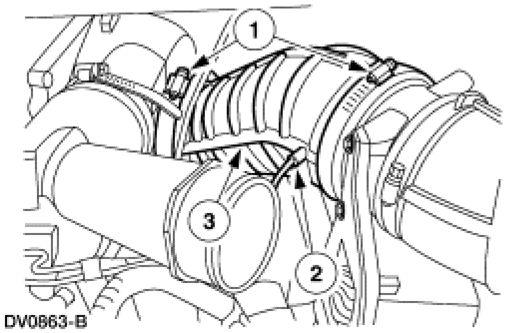
    2. Pull the actuator rod free of the exhaust back pressure valve actuator lever.



7. Remove the air inlet tube.
    1. Loosen the clamps.

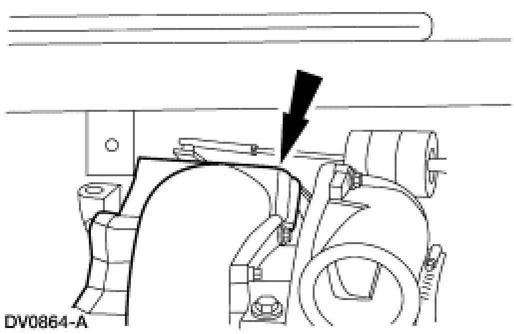
    2. Disconnect the pressure line.

    3. Remove the inlet tube.

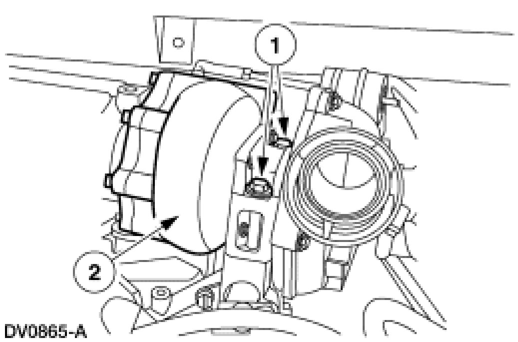


8. **NOTE:** The Marmon clamp cannot be removed with the turbocharger in place.

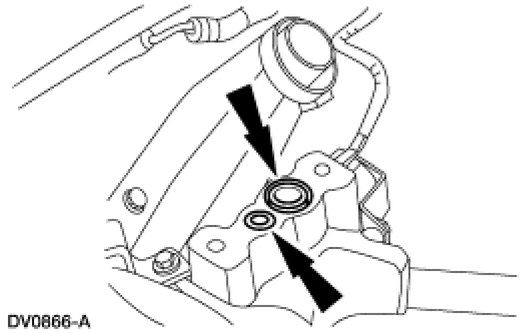
   Loosen the Marmon clamp.



9. Remove the turbocharger.
   1. Remove the bolts.
   2. Remove the turbocharger.

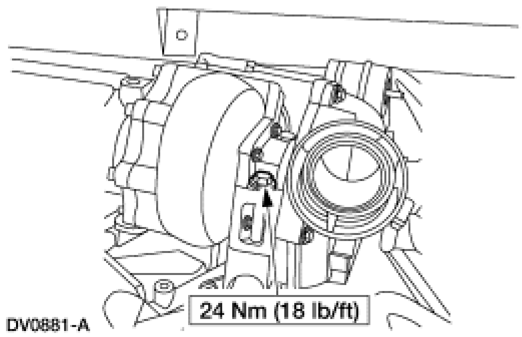


10. Remove the O-rings.



Installation

1. Follow the removal procedure in reverse order.

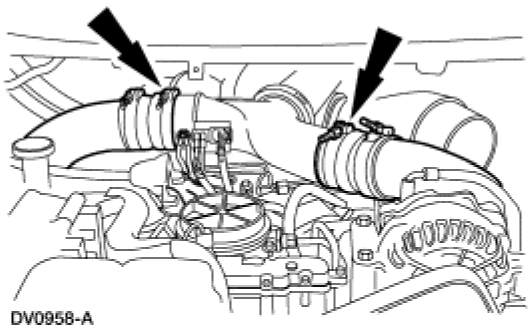


Turbocharger—Vehicles Built After 12/7/98

Removal

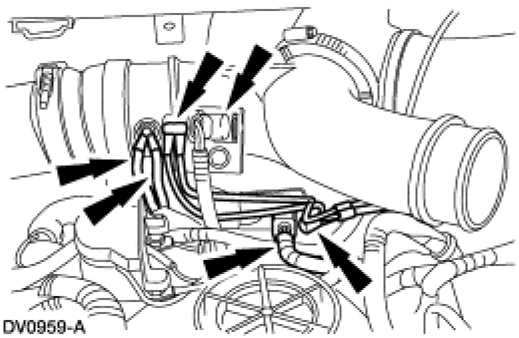
All vehicles

1. Open the hood.
2. Remove the engine cover.
3. Disconnect the charge air cooler inlet and outlet pipes.



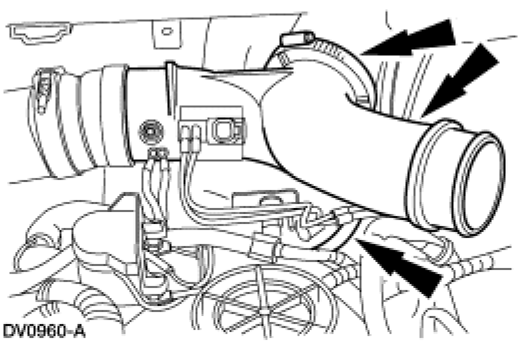
DV0958-A

4. Label and disconnect the intake air heater element electrical leads, intake air temperature (IAT) sensor electrical connector, manifold absolute temperature (MAP) sensor electrical connector and the pressure hoses.



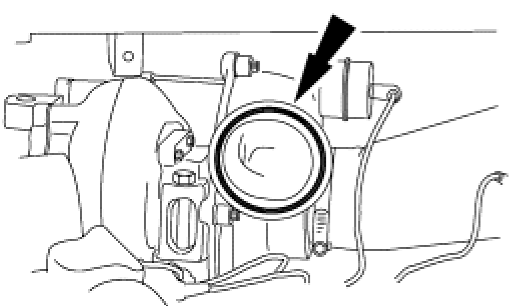
DV0959-A

5. Loosen the clamps. Remove the compressor manifold.



DV0960-A

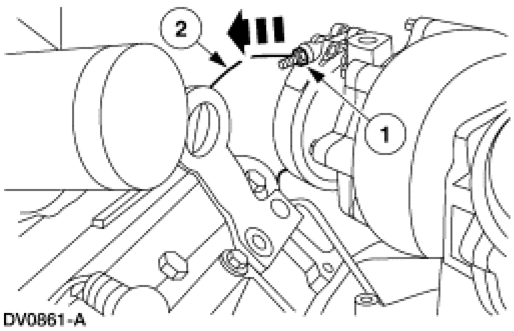
6. Remove and discard the compressor manifold O-ring seal.



DV0961-A

7. Disconnect the exhaust outlet pipe.
    1. Loosen the Marmon clamp.

    2. Disconnect the exhaust outlet pipe.

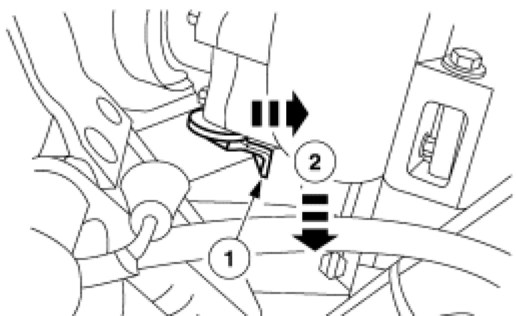


DV0861-A

Vehicle with exhaust back pressure system

8. Disconnect the exhaust back pressure valve.
    1. Slide the retaining clip away from the exhaust back pressure valve actuator lever.

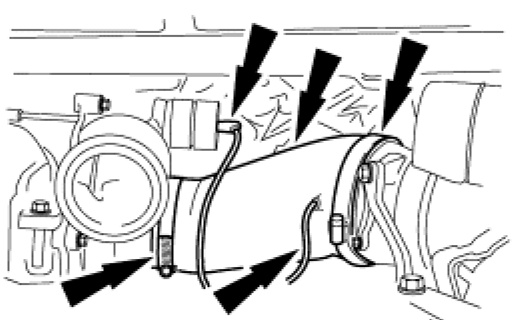
    2. Detach the exhaust back pressure valve actuator rod.



DV0862-A

All vehicles

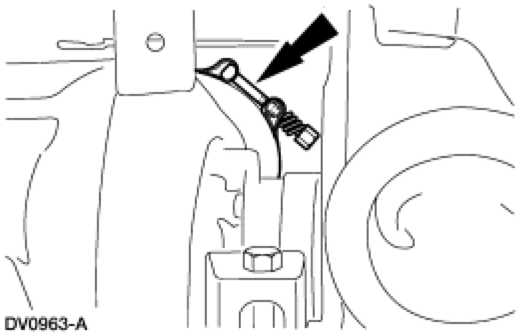
9. Label and disconnect the wastegate solenoid vacuum hose and the pressure hose. Loosen the clamps. Remove the air inlet tube.



DV0962-A

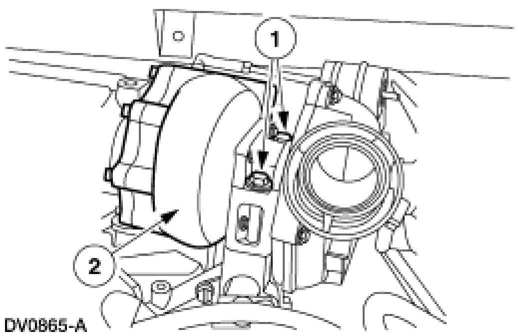
10. **NOTE:** The Marmon clamp cannot be removed with the turbocharger installed.

Loosen the Marmon clamp.

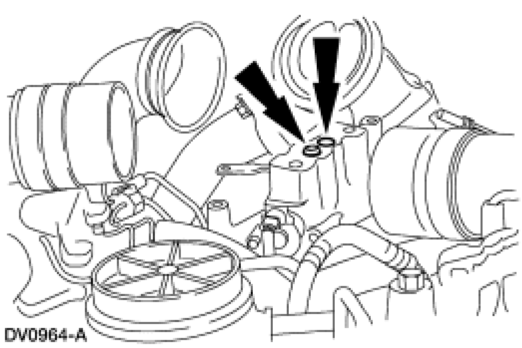


11. Remove the turbocharger.
    1. Remove the bolts.

    2. Remove the turbocharger.

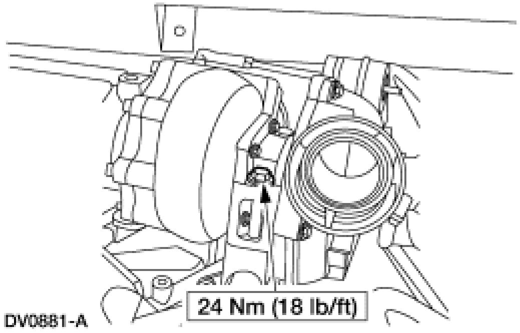


12. Remove and discard the O-ring seals.



Installation

1. To install, reverse the removal procedure.
    - The exhaust inlet Marmon clamp must be positioned on the exhaust inlet pipe before installing the turbocharger.



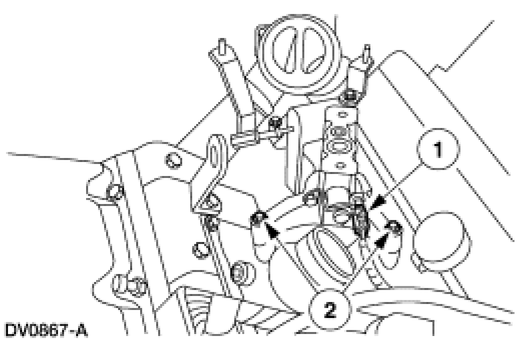
Pedestal—Turbocharger

Removal

1. Remove the turbocharger; for additional information, refer to Turbocharger in this section.

2. Remove the turbocharger pedestal.
   1. Disconnect the exhaust back pressure solenoid electrical connector.

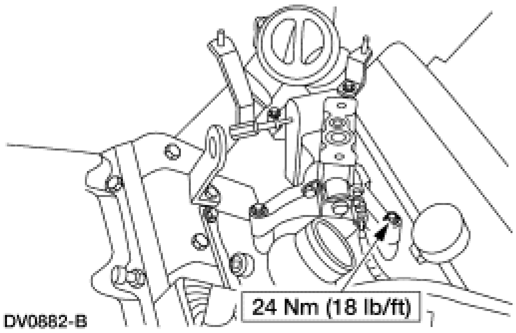
   2. Remove the four pedestal mounting bolts and the pedestal.



3. Remove and discard the two turbocharger pedestal to engine O-rings.

Installation

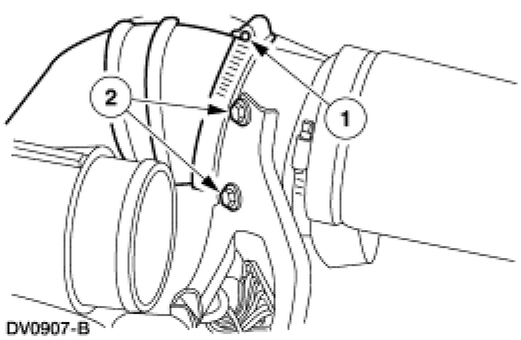
1. Follow the removal procedure in reverse order.



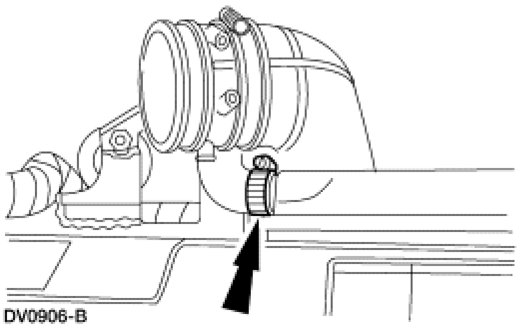
Turbocharger Intake Tube

Removal and Installation

1. Open the hood.
2. Remove the air cleaner to air inlet duct tube; for additional information, refer to Section 303-12.
3. Remove the air intake tube.
    1. Loosen the clamp.
    2. Remove the two mounting bolts and the duct.



4. Loosen the clamp and remove the hose from the crankcase breather assembly.



5. To install, reverse the removal procedure.

Backpressure Valve

Special Tool(s)	
	Spring Gauge 211-034 (T74P-3504-Y)

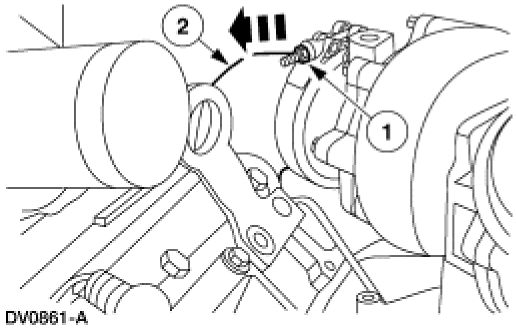
Removal

1. Open the hood.

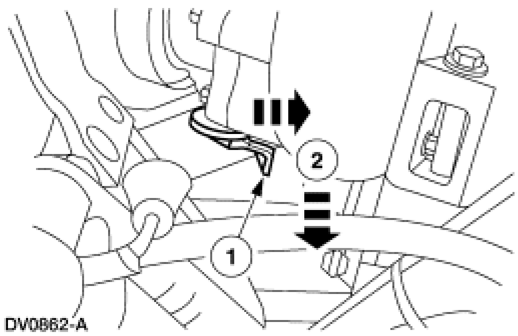
2. Remove the charge air cooler inlet and outlet ducts from the compressor manifold; for additional information, refer to Section 303-12.

3. Disconnect the exhaust outlet pipe from the turbocharger.
    1. Loosen the clamp.

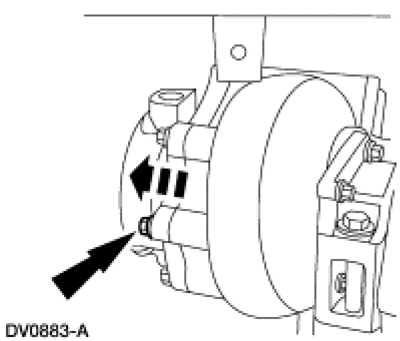
    2. Pull the exhaust pipe away from the exhaust back pressure valve.



4. Disconnect the exhaust back pressure valve.
    1. Slide the retaining clip toward the turbocharger housing.
    2. Disconnect the exhaust back pressure valve actuator rod from the exhaust back pressure valve.

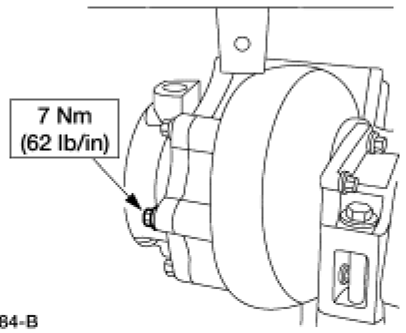


5. Remove the six bolts and the exhaust back pressure valve.



Installation

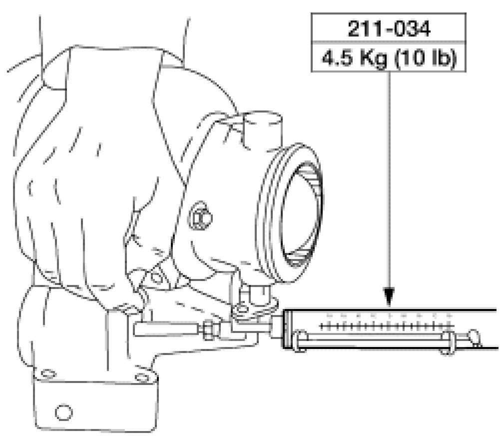
1. Follow the removal procedure in reverse order.



DV0884-B

2. **NOTE:** The butterfly valve should be fully closed when 4.5 kg (10 lb) of force is applied with the special tool.

   Using the Spring Gauge, adjust the actuator rod length to obtain the specified reading.



DV0939-A

SECTION 303-06B:
Starting System — Diesel Engine

Starter Specifications

Starter Motor	Max.	No	Starter Brushes

						Load	Load				
Motor Diameter		**Current Draw Under Normal Load**	**Normal Engine Cranking Speed**	**Min. Stall Torque @ 2.5 Volts**				**Mfg. Length**		**Spring Tension**	
mm	**Inches**	**Amps**	**rpm**	**—**	**Lb/Ft**	**Amps**	**Amps**	**mm**	**Inches**	**N**	**Oz**
85	3.4	230-630	150-200	37.3	27.5	2400	170 Max.	18	0.71	34	122

Maximum commutator runout is 0.12 mm (0.005 inch). Maximum starting circuit voltage drop (battery positive terminal to start terminal) at normal engine temperature is 0.5 volt.

Torque Specifications			
Description	**Nm**	**Lb/Ft**	**Lb/In**
Solenoid B-Terminal Nuts	9-14	—	80-124
Starter Mounting Bolts	22-28	17-21	—
Starter Relay Switch Screws	7-9	—	62-80
Starter Relay Switch Nuts	5-11	—	45-98
Starter Motor Ground Cable	17-23	13-17	—
Battery Cable Nut	10-14	7-11	—
Solenoid Wire Nut	4-6	1-3	—

SECTION 303-06B: Starting System — Diesel Engine | 1999 F-Super Duty 250-550 Workshop Manual

DESCRIPTION AND OPERATION | Procedure revision date: 01/26/2000

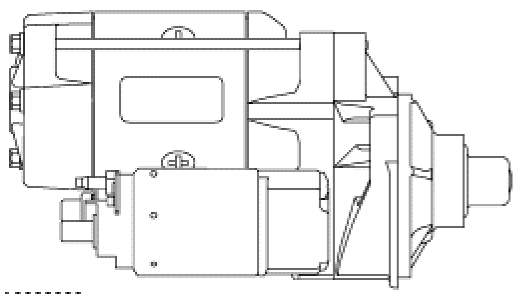
Starting System

The starting system consists of the following components:

- starter motor (11002)
- starter switch, part of the ignition switch (11572)
- digital transmission range (DTR) sensor (automatic transmission-equipped vehicles)
- starter motor solenoid relay switch (11450)
- starter solenoid (11390)

- starter drive (11350)

7.3L Diesel Engine Starter Motor



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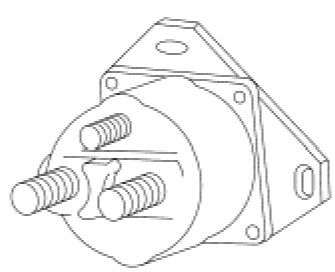
The starter motor:

- is a wound field, gear reduction, 12 VDC motor.
- has an integral starter solenoid.
- has an overrunning clutch in the starter drive.



J5903-A

The starter motor solenoid relay switch:

- controls current to the starter solenoid.
- is engaged by the ignition switch.
- connects the battery (10655) to the starter solenoid.

The digital transmission range (DTR) sensor on automatic transmission-equipped vehicles prevents starter motor engagement unless the transmission is in the NEUTRAL or PARK position. For additional information, refer to Section 307-01.

The starter drive:

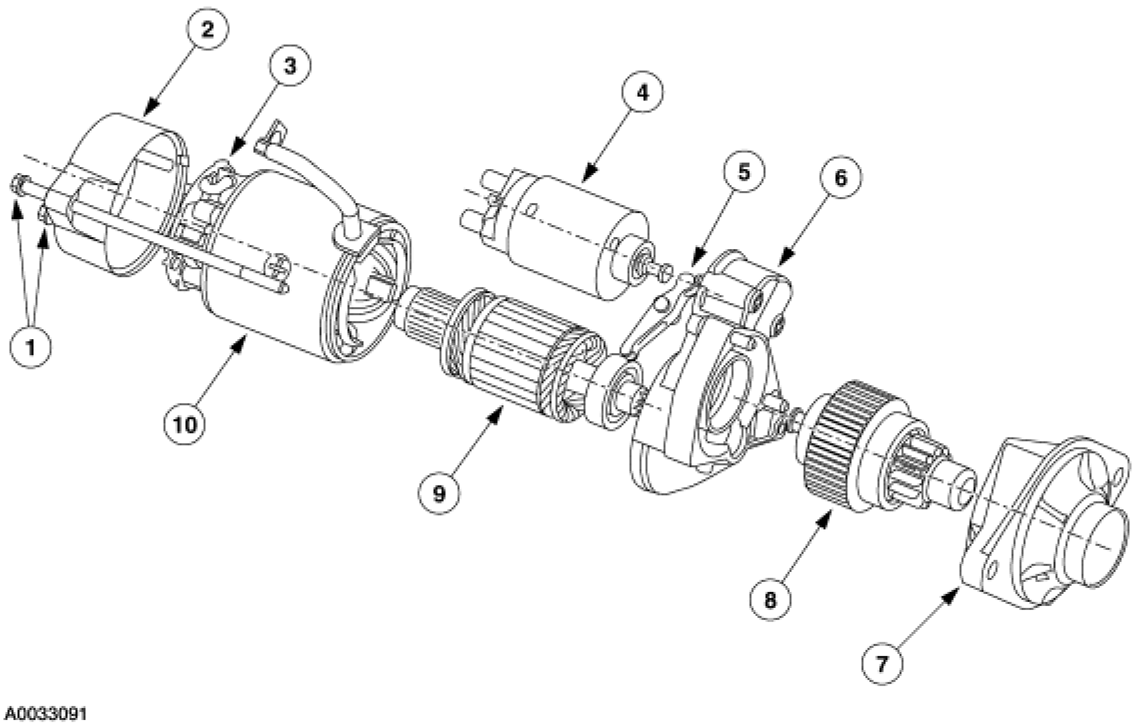
- is operated by the starter solenoid.
- engages the flywheel to turn the engine.
- has an internal overrunning clutch to disengage the starter motor when the engine starts.

The starter solenoid:

- is an electromagnet.

- engages the starter drive to the flywheel.
- when energized, contacts close, connecting the battery to the starter motor and causing the starter motor to turn the starter drive.
- is kept in the energized condition by a hold-in winding until the starter switch is released.

Starter Motor, Disassembled View



Item	Part Number	Description
1	—	Thru bolts
2	—	End plate
3	—	Brush assembly
4	—	Solenoid
5	—	Lever
6	—	Rear housing
7	—	Front housing
8	—	Drive assembly
9	—	Armature assembly
10	—	Frame assembly

Intake Air Heater Starting Aid System—Vehicles Built After 12/7/98

The intake air heater starting aid system improves cold weather starting and reduces white smoke and odor during cold weather starting and on extended idles.

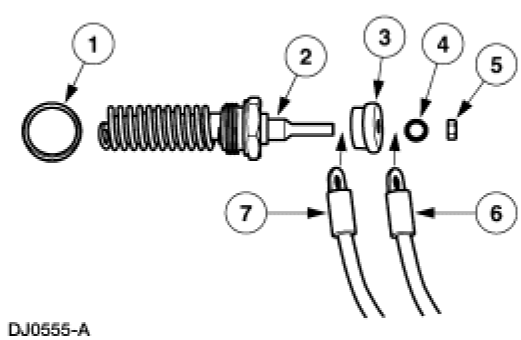
The intake air heater starting aid system consists of the following:

- engine oil temperature (EOT) sensor
- intake air heater relay switch
- intake air heater element
- intake air temperature (IAT) sensor
- powertrain control module (PCM)
- starter switch

Intake air heater starting aid system operation.

- The system is activated by the PCM when the ambient air temperature is below 0°C (32°F), the engine oil temperature is below 55°C (131°F) and the battery voltage is above 11.7 volts.
- The intake air heater will stay on for 30 minutes as long as the engine is idling and the above conditions are met.
- The intake air heating system will only activate once per "key on event". If the heater is activated and the vehicle is driven, the heater will not activate if the vehicle is taken back to idle.
- The intake air is heated by using a heating element mounted into the compressor manifold.
- The intake air heater relay switch, located next to the glow plug relay switch, supplies power to the intake air heater element.

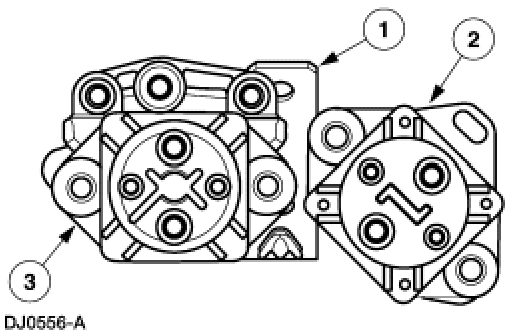
Air Intake Heater Element



Item	Description
1	Copper washer
2	Heating element
3	Insulator
4	Washer

5	Nut
6	B+ electrical lead
7	GND electrical lead

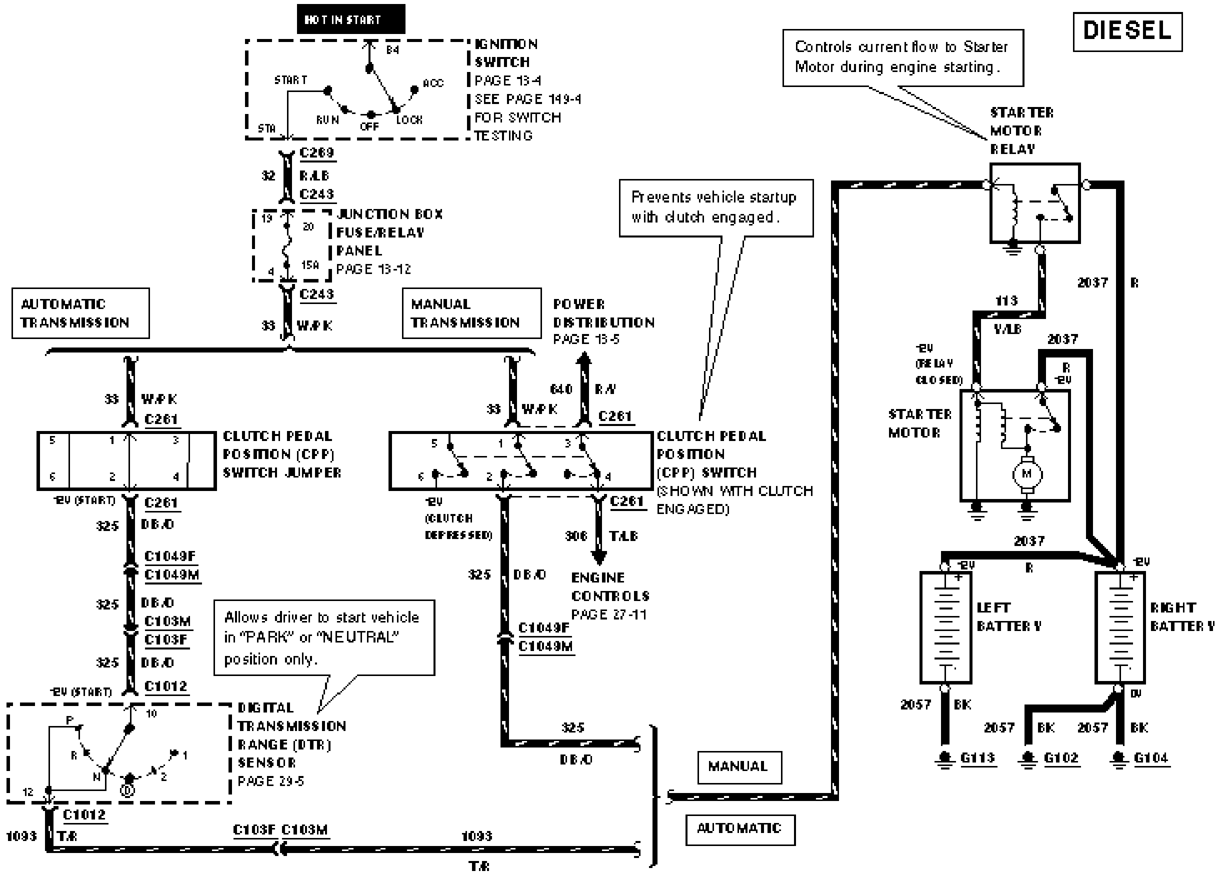
Air Intake Heater Relay Switch

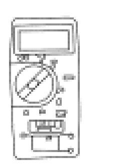
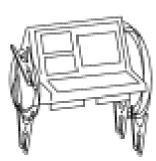


Item	Part Number	Description
1	—	Bracket
2	1825931	Glow plug relay
3	—	Intake air heater relay

Starting System

Refer to Wiring Diagrams Cell 20 (F-53 Motorhome Chassis, F-Super Duty 250-550), Starting for schematic and connector information.



Special Tool(s)	
 ST1137-A	73 Digital Multimeter 105-R0051 or Equivalent
 ST1179-A	Alternator, Regulator, Battery and Starter Tester (ARBST) 010-00725 or Equivalent

Inspection and Verification

1. ⚠ **WARNING: When servicing the starter motor or performing other underhood work in the vicinity of the starter motor, be aware that the heavy gauge battery input lead at the starter solenoid is electrically hot at all times.**

   Verify the vehicle owner's original concern by operating the system to duplicate the condition.

2. Inspect the system to determine if any of the following mechanical or electrical concerns apply.

Visual Inspection Chart	
Mechanical	**Electrical**
• Starter motor mounting • Starter relay mounting	• Battery condition • Electrical connections at the switches, relay and solenoid • Fuse 20

3. If the concern(s) remains after the inspection and verification, determine the symptoms and go to the symptom chart.

Symptom Chart

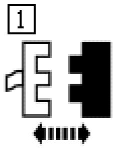
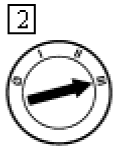
SYMPTOM CHART		
Condition	**Possible Sources**	**Action**
• The Engine Does Not Crank or the Relay Clicks	• Loose or corroded battery cable connections. • Undercharged battery. • Worn or damaged starter relay. • Faulty starter motor ground circuit. • Loose or corroded starter motor connections. • Worn or damaged starter motor.	• GO to Pinpoint Test A.
• Engine Cranks Slowly	• Loose or corroded battery cable connections. • Undercharged battery. • Loose or corroded starter motor connections. • Worn or damaged starter motor.	• GO to Pinpoint Test B.
• Unusual Starter Noise	• Starter motor improperly mounted. • Worn or damaged starter motor. • Improper starter drive	• GO to Pinpoint Test C.

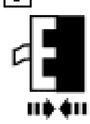
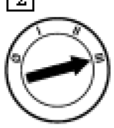
	engagement to flywheel.	
• The Starter Spins but the Engine Does Not Crank	• Worn or damaged starter motor. • Damaged flywheel ring gear.	• GO to Pinpoint Test D.

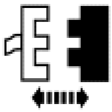
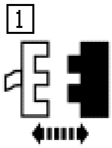
Pinpoint Tests

PINPOINT TEST A: THE ENGINE DOES NOT CRANK OR THE RELAY CLICKS

CONDITIONS	DETAILS/RESULTS/ACTIONS
A1 CHECK FUNCTION OF THE STARTER RELAY	
WARNING: The parking brake must be set and the transmission must be in neutral.	
	1 Connect a remote starter switch between the battery positive terminal at the starter relay and the starter relay S-terminal.
	2 Press the remote starter switch button.
	• **Did the starter crank the engine?** → **Yes** If equipped with an automatic transmission, GO to A5 . If equipped with a manual transmission, GO to A7 . → **No** If the relay did not close, GO to A2 . If the relay closed, GO to A3 .
A2 CHECK THE STARTER RELAY GROUND	
	1 Measure the resistance between the starter relay case and a clean chassis ground.
	• **Is the resistance less than 5 ohms?** → **Yes** INSTALL a new starter relay. TEST the system for normal operation. → **No** CLEAN the ground connection between the starter relay case and the body ground. TEST the system for normal operation.

A3 CHECK STARTER SOLENOID FUNCTION	
WARNING: The parking brake must be set and the transmission must be in neutral.	
	1 Connect a remote starter switch between the battery positive terminal at the starter motor and the starter motor S-terminal. On a manual transmission equipped vehicle, have a helper press the clutch pedal.
	2 Press the remote starter switch button.
	• **Did the starter crank the engine?** → **Yes** REPAIR open in the wire between the starter relay and starter solenoid. TEST the system for normal operation. → **No** GO to A4.
A4 CHECK THE STARTER SOLENOID	
	1 Label and disconnect the wiring at the starter solenoid.
	2 Test the starter solenoid. Refer to Component Tests in this section.
	• **Did the solenoid pass the test?** → **Yes** INSTALL a new starter motor. TEST the system for normal operation. → **No** INSTALL a new starter solenoid. TEST the system for normal operation.
A5 CHECK CIRCUIT 325 (DB/O) FOR AN OPEN — BATTERY FEED TO THE DIGITAL TRANSMISSION RANGE (DTR) SENSOR	
1  Digital Transmission Range (DTR) Sensor	
2 	

	3 Measure the voltage between the digital transmission range (DTR) sensor connector C1012 Pin 10, Circuit 325 (DB/O) and a clean chassis ground.
	• **Is the voltage greater than 10 volts?** → **Yes** GO to A6. → **No** REPAIR the open in Circuit 325 (DB/O). TEST the system for normal operation.
A6 CHECK FOR CONTINUITY AT THE DIGITAL TRANSMISSION RANGE (DTR) SENSOR	
1  Digital Transmission Range (DTR) Sensor	
2 	
	3 Measure the voltage between the digital transmission range (DTR) sensor connector C1012 Pin 12, Circuit 1093 (T/R) and a clean chassis ground.
	• **Is the voltage greater than 10 volts?** → **Yes** REPAIR the open in Circuit 32 (R/BL) between the digital transmission range (DTR) sensor and the starter relay. TEST the system for normal operation. → **No** CHECK the transmission linkage adjustment. If adjustment is OK, INSTALL a new digital transmission range (DTR) sensor. TEST the system for normal operation.
A7 CHECK CIRCUIT 33 (W/PK) FOR AN OPEN BATTERY FEED TO CLUTCH PEDAL POSITION (CPP) SWITCH	
1	

 Clutch Pedal Position Switch	
	2 Measure the voltage between the clutch pedal position (CPP) switch connector C261 Pin 1 and a clean chassis ground.
	• **Is the voltage greater than 10 volts?** → **Yes** GO to A8. → **No** REPAIR the open in Circuit 33 (W/PK). TEST the system for normal operation.
A8 CHECK FOR CONTINUITY AT THE CLUTCH PEDAL POSITION (CPP) SWITCH	
	1 Press the clutch pedal.
	2 Measure the resistance across clutch pedal position (CPP) switch Terminals 1 and 2.
	• **Is the resistance less than 5 ohms?** → **Yes** GO to A9. → **No** INSTALL a new clutch pedal position (CPP) switch. TEST the system for normal operation.
A9 CHECK CIRCUIT 1093 (T/R) — AUTOMATIC TRANSMISSION OR CIRCUIT 325 (DB/O) FOR AN OPEN	
1  Digital Transmission Range (DTR) Sensor (If equipped)	
	2 Measure the resistance at one of the following: ▪ Automatic Transmission — DTR sensor connector C1012, Pin

	12, Circuit 1093 (T/R) ▪ Manual Transmission — CPP switch connector C261, Pin 2, Circuit 325 (DB/O) and the starter relay
	• **Is the resistance less than 5 ohms?** → **Yes** REFER to Symptom Chart. → **Yes** REPAIR the open in Circuit 1093 (T/R) or Circuit 325 (DB/O). TEST the system for normal operation.

PINPOINT TEST B: THE ENGINE CRANKS SLOWLY

CONDITIONS	DETAILS/RESULTS/ACTIONS
B1 PERFORM THE STARTER LOAD TEST	
	1 Perform the starter load test. Refer to Component Tests in this section.
	• **Did the starter pass the load test?** → **Yes** GO to B2. → **No** TEST the batteries. For additional information, REFER to Section 414-01. If the batteries are OK, GO to B3 .
B2 CHECK THE STARTER CIRCUIT FOR EXCESSIVE RESISTANCE	
	1 Perform the voltage drop tests. Refer to Component Tests in this section.
	• **Did the starter circuit pass the voltage drop tests?** → **Yes** GO to B3. → **No** CLEAN the circuit connections as necessary. TEST the system for normal operation.
B3 PERFORM THE STARTER NO LOAD TEST	
	1 Perform the starter no load test. Refer to Component Tests in this section.

	• **Did the starter pass the no load test?** → **Yes** Slow cranking is caused by excessive engine drag. → **No** INSTALL a new starter motor.

PINPOINT TEST C: UNUSUAL STARTER NOISE

CONDITIONS	DETAILS/RESULTS/ACTIONS
C1 CHECK THE STARTER MOTOR MOUNTING	
	1 Check for loose starter motor mounting bolts.
	• **Are the starter motor mounting bolts tight?** → **Yes** GO to C2. → **No** TIGHTEN the mounting bolts. For additional information, REFER to Specifications in this section. TEST the system for normal operations.
C2 CHECK FOR PROPER ENGAGEMENT OF THE STARTER DRIVE	
	1 Remove the starter motor.
	2 Inspect the starter drive and flywheel for damage.
	• **Are the starter drive and flywheel OK?** → **Yes** INSTALL a new starter motor. TEST the system for normal operation. → **No** INSTALL a new starter motor and flywheel. TEST the system for normal operation.

PINPOINT TEST D: THE STARTER SPINS BUT THE ENGINE DOES NOT CRANK

CONDITIONS	DETAILS/RESULTS/ACTIONS
D1 CHECK THE FLYWHEEL	

	1 Remove the starter motor.
	2 Inspect the flywheel and the drive pinion for damage or excessive wear.
	• **Is the flywheel or the drive pinion worn or damaged?** → **Yes** INSTALL a new starter motor and flywheel. TEST the system for normal operation. → **No** GO to D2.
D2 CHECK THE OVERRUNNING CLUTCH	
	1 Check the operation of the overrunning clutch. Refer to Component Tests in this section.
	• **Does the overrunning clutch operate properly?** → **Yes** INSTALL a new starter motor. TEST the system for normal operation. → **No** INSTALL a new starter motor. TEST the system for normal operation.

Component Tests

Starter Motor — Load Test

NOTE: The batteries must be fully charged before performing a starter load test.

1. Set the parking brake and shift the transmission into the NEUTRAL position.
2. Remove Fuse 17 from the engine compartment fuse box.
3. Connect the Alternator, Regulator, Battery and Starter Tester (ARBST). Follow the manufacturer's supplied instructions.
4. Connect a remote starter switch across the starter relay S-terminal and the battery positive terminal post.
5. Turn the ignition switch to the RUN position.

6. Crank the engine and record the voltmeter reading.
7. Turn the carbon pile control knob until the voltmeter indicates the same reading recorded during cranking the engine. Record the ammeter reading.
8. Compare the ammeter reading with specifications.

Starter Motor — Drive Pinion Test

1. Rotate the pinion drive clockwise and counterclockwise.
2. The pinion drive should free-wheel in one direction and lock to the armature shaft in the other.
3. If the pinion drive free-wheels in both directions, Install a new starter motor.

Starter Motor — No-Load Test

1. Connect a fully charged battery to the starter.
2. Connect the Alternator, Regulator, Battery and Starter Tester (ARBST) as illustrated.
3. Connect a remote starter switch between the starter solenoid Terminal S and the positive battery terminal post.
4. Press the remote starter switch. The pinion should shift to the crank position and the motor should run smoothly.
5. While the starter motor is running, record the voltmeter and ammeter readings.
6. The voltage reading should be greater than 11.0 volts and the amperage should be no more than 170 amps.
7. If voltage is lower than specified or amperage is higher than specified, refer to the results chart below to determine possible cause and corrective action.

Starter Motor No-Load Test Results

Test Result	Probable Source	Action to Take
• Normal Current and Speed	• Cranking motor OK.	• RECHECK the battery, switches and wiring, including voltage drop tests, if cranking motor operation on the engine is slow

		or sluggish.
• Current Flow with Test Circuit Switch Open	• Solenoid contacts stuck closed.	• CARRY OUT the Starter Solenoid Component Test.
• Failure to Operate with Very Low or No Current	• Open solenoid winding. • Open field circuit. • Open armature coil(s) or high insulation between commutator bars. • Broken brush spring(s) or worn brushes.	• CARRY OUT the Starter Solenoid Component Test. • INSTALL a new starter motor. • INSTALL a new starter motor. • INSTALL a new starter motor.
• Failure to Operate with High Current	• Frozen bearing, or other damage to drivetrain. • Direct ground in terminals or fields.	• INSTALL a new starter motor. • INSTALL a new starter motor.
• Low Speed with High Current	• Excessive friction in bushings or gear reduction unit, bent armature shaft or loose pole shoe, bent driveshaft. • Shorted armature. • Grounded armature or fields.	• INSTALL a new starter motor. • INSTALL a new starter motor. • INSTALL a new starter motor.
• Low Speed with Normal (or Low) Current	• High internal electrical resistance caused by poor connections, defective leads or dirty commutator.	• INSTALL a new starter motor.

	• Open solenoid winding. • Open field circuit. • Open field circuit. • Broken brush spring(s) or worn brushes.	• CARRY OUT the Starter Solenoid Component Test. • INSTALL a new starter motor. • INSTALL a new starter motor. • INSTALL a new starter motor.
• High Speed with High Current	• Shorted fields.	• INSTALL a new starter motor.

Starter Motor — Motor Feed Circuit Voltage Drop Test

1. This test is performed to determine if slow cranking is caused by high resistance in the starter motor circuit wiring.
2. The voltage drop test can only be performed with the starter motor on the vehicle.
3. Disconnect the wiring from the fuel shutoff solenoid.
4. Connect the positive lead of the 73 Digital Multimeter to the battery positive (+) post, and the negative lead to the starter solenoid M-terminal.
5. Connect a remote starter switch between the starter solenoid S-terminal and the positive battery terminal post.
6. Press the remote starter switch and record the voltage reading.
7. The voltage reading should be 0.5 volt or less. A reading higher than 0.5 volt indicates high resistance.
8. Repeat the test on the starter solenoid B-terminal.
9. If the readings are higher than 0.5 volt, remove the wiring from the starter solenoid.
10. Clean and inspect each wire connector and the starter solenoid terminals.
11. Install the wires onto the starter solenoid and retest.
12. If the reading at the starter solenoid M-terminal is still higher than 0.5 volt or the reading at the B-terminal is lower, carry out the Starter Solenoid Component Test. If no change is noted, install a new positive battery cable lead.

Starter Motor — Motor Ground Circuit Voltage Drop Test

NOTE: A slow cranking condition can also be caused by high resistance in the ground circuit.

1. Disconnect the wiring from the fuel shutoff solenoid.
2. Connect the Digital Volt-Ohmmeter positive lead to the starter motor housing.
3. Connect the Digital Volt-Ohmmeter negative lead to the battery negative (-) terminal.
4. Connect a remote starter switch between the starter solenoid S-terminal and the positive battery terminal post.
5. Press the remote starter switch and record the voltage reading.
6. The voltage reading should be 0.2 volt or less. If the voltage reading is higher, remove and clean the negative cable connections at the battery, starter motor and the body.
7. Retest the system. If readings are still higher than 0.2 volt, test each individual negative cable.

Starter Solenoid

1. Disconnect the battery negative cable.
2. Using the Digital Multimeter, check the windings of the solenoid as follows:
   - Measure the resistance between the starter motor ground terminal and the solenoid case. The resistance reading should be approximately 0.95 ohms.
   - An extremely high resistance reading indicates a break or fault in winding continuity. A very low resistance reading indicates a short or ground in the winding circuit. Either condition is cause for installation of a new solenoid assembly.

SECTION 303-06B: Starting System — Diesel Engine | 1999 F-Super Duty 250-550 Workshop Manual

REMOVAL AND INSTALLATION | Procedure revision date: 01/26/2000

Starter Motor

Removal

WARNING: When performing maintenance on the starting system, be aware that heavy gauge leads are connected directly to the battery. Make sure protective caps are in place when maintenance is complete.

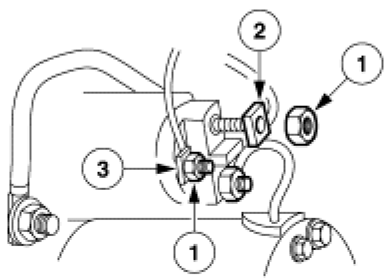
1. Disconnect the battery ground cable (14301). For additional information, refer to Section 414-01.

2. Raise and support the vehicle. For additional information, refer to Section 100-02.

3. Disconnect the starter motor electrical connections.
    1. Remove the nuts (B+ and S).

    2. Remove the battery cable.

    3. Remove the starter solenoid wire.



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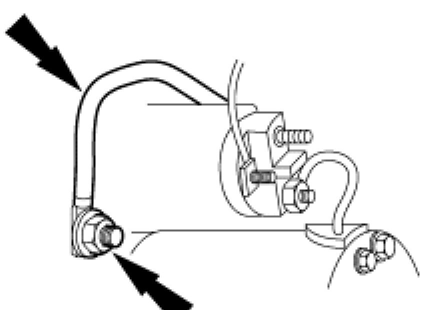
4. Remove the starter motor ground cable nut and the starter motor ground cable.



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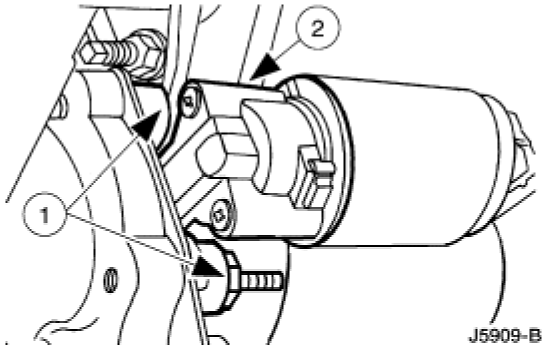
5. Remove the starter.
    1. Remove the two bolts.

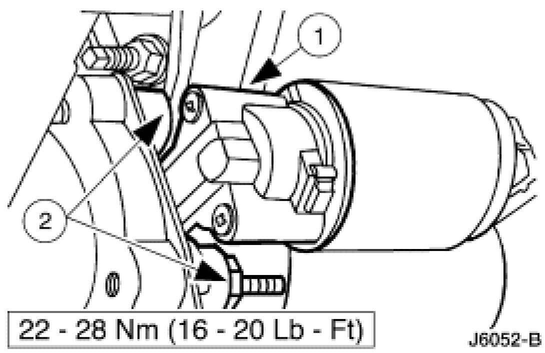
    2. Remove the starter.



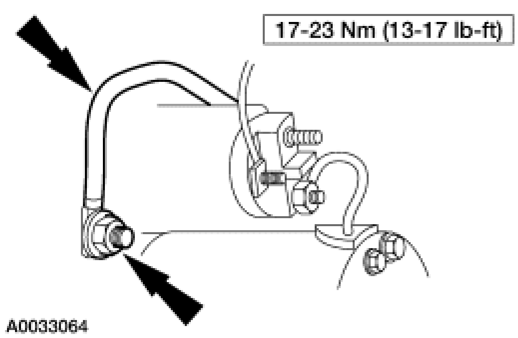
Installation

WARNING: When performing maintenance on the starting system, be aware that heavy gauge leads are connected directly to the battery. Make sure protective caps are in place when maintenance is complete.

1. Install the starter motor.
    1. Position the starter motor.
    2. Install the two bolts.

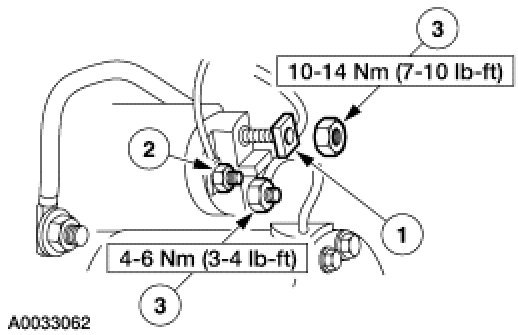


2. Connect the starter motor ground cable and install the starter motor ground cable nut.



3. Connect the starter motor electrical connections.
    1. Position the battery cable.
    2. Position the starter solenoid wire.

3. Install the nuts.



4. Lower the vehicle.

5. Reconnect the battery ground cable. For additional information, refer to Section 414-01.

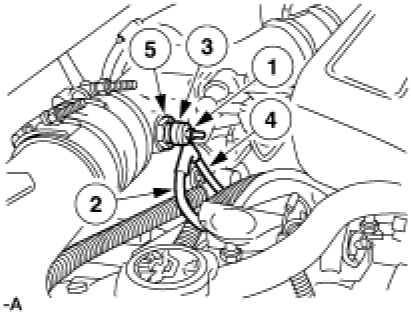
Intake Air Heater Element—Vehicles Built After 12/7/98

Removal

1. Open the hood.

2. Disconnect the battery ground cable (14301). For additional information, refer to Section 414-01.

3. Remove the intake air heater element.
    1. Remove the nut.
    2. Label and disconnect the electrical lead.
    3. Remove the insulator.
    4. Label and disconnect the electrical lead.
    5. Remove the intake air heater element and copper washer.



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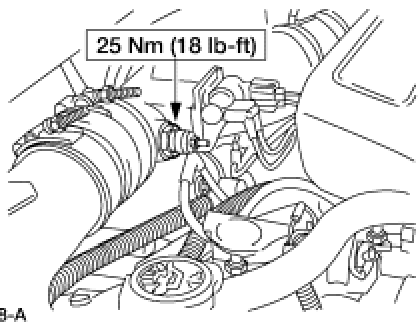
Installation

1. To install, reverse the removal procedure.



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SECTION 303-06B: Starting System — Diesel Engine	1999 F-Super Duty 250-550 Workshop Manual
REMOVAL AND INSTALLATION	Procedure revision date: 01/26/2000

Starter Relay

Removal

WARNING: When repairing the starter motor or performing other underhood work in the vicinity of the starter motor, be aware that the heavy gauge battery input lead at the starter solenoid is electrically hot at all times. The protective cap or boot provided over this terminal must be replaced after maintenance is complete. Make sure to disconnect the battery ground cable before working on the starter motor.

CAUTION: Do not disconnect the battery (10655) of the vehicle to be started. Disconnecting the battery could damage the vehicle electronic system.

1. Disconnect the battery ground cable (14301); for additional information, refer to Section 414-01.

2. Remove the relay cover.

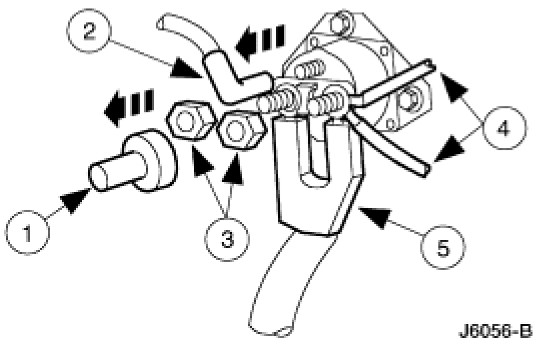
3. Disconnect the starter motor solenoid relay switch wires and cables.
    1. Remove the insulator.

    2. Disconnect the starter motor relay trigger terminal connector.

    3. Remove the starter motor solenoid relay switch terminal nuts.

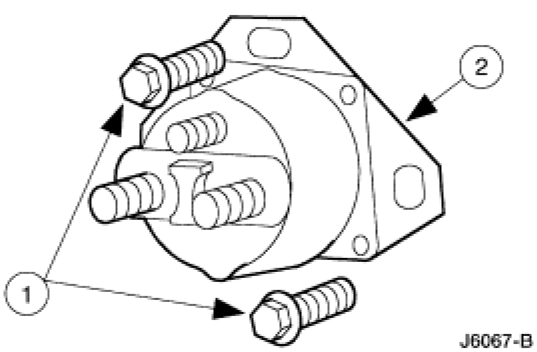
    4. Remove the engine control sensor wire and the generator wire.

    5. Remove the battery cables.



4. Remove the starter motor solenoid relay switch (11450).
    1. Remove the starter motor solenoid relay switch bolts.

    2. Remove the starter motor solenoid relay switch.

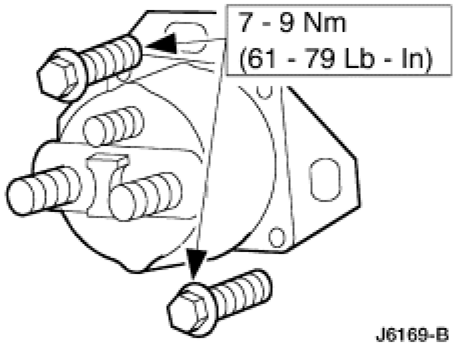


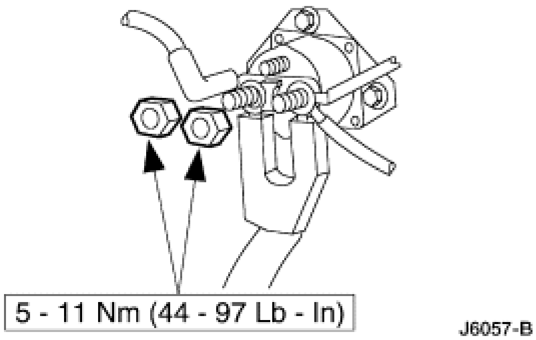
Installation

1. **WARNING: When performing maintenance on the starting system, be aware that heavy gauge leads are connected directly to the battery. Make sure protective caps are in place when maintenance is complete.**

   NOTE: Disconnect the battery ground cable; for additional information, refer to Section 414-01 for battery reconnect procedure.

Follow the removal procedure in reverse order.





SECTION 303-06B: Starting System — Diesel Engine	1999 F-Super Duty 250-550 Workshop Manual
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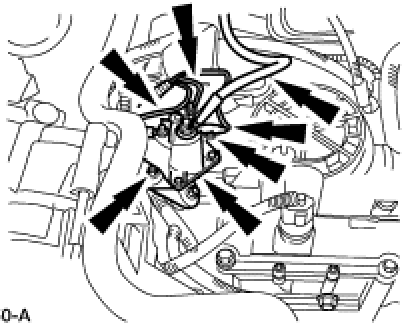
Intake Air Heater Relay Switch—Vehicles Built After 12/7/98

Removal

1. Open the hood.
2. Disconnect the battery ground cable (14301). For additional information, refer to Section 414-01.
3. Remove the engine cover.
4. Label and disconnect the intake heater relay switch leads. Remove the nuts and the relay.



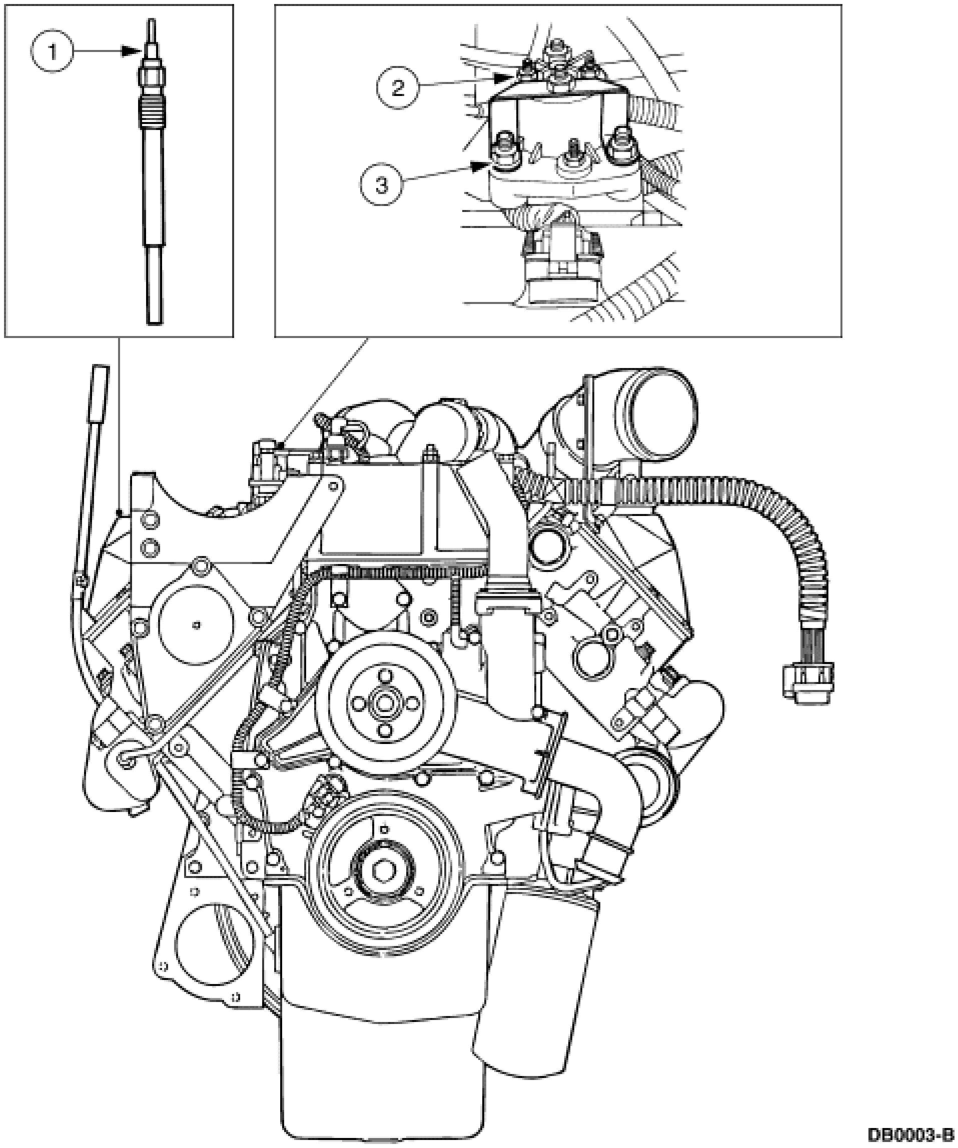
Installation

1. To install, reverse the removal procedure.

Torque Specifications			
Description	**Nm**	**lb-ft**	**lb-in**
Glow plug	19	15	—
Glow plug relay wire retaining nuts	8	—	71
Glow plug relay retaining nuts	11	8	—
Glow plug module retaining nuts	11	8	—

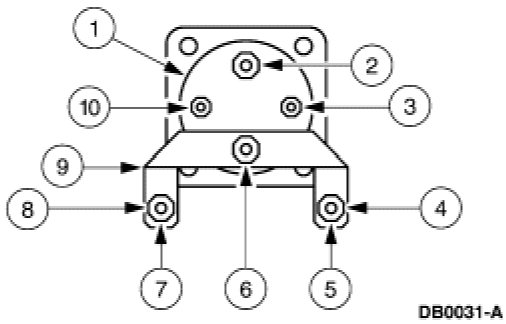
Glow Plug System

Glow Plug System Components



Item	Part Number	Description
1	12A342	Glow Plug
2	1825931	Glow Plug Relay
3	—	Mounting Bolt (2 Req'd) (Part of 12A343)

Glow Plug Relay



Item	Part Number	Description
1	1825931	Glow Plug Relay
2	—	Battery Feed Post (12 Volt) (Part of 1825931)
3	—	Glow Plug Control Post from PCM (Part of 1825931)
4	—	Left Bank Glow Plug Feed Post (Part of 1825931)
5	—	Left Bank Sensor Feed to PCM (Part of 1825931)
6	—	Center Post Sensor (Part of 1825931)
7	—	Right Bank Sensor Feed to PCM (Part of 1825931)
8	—	Right Bank Glow Plug Feed Post (Part of 1825931)
9	1825932	Shunt
10	—	Key Power Feed Post (Part of 1825931)

The 7.3L diesel engine uses a glow plug system that preheats air in the combustion chamber to improve cold engine starting.

The system consists of:

- intake manifold glow plugs (12A342).
- glow plug relay (12A343).
- powertrain control module (PCM) (12A650).
- engine oil temperature (EOT) sensor.
- barometric pressure sensor (BARO sensor) (12A644).

The glow plug system is electronically controlled by the powertrain control module. If the temperature is below 55°C (131°F) the powertrain control module will energize the glow plugs immediately after the key is placed in the ON position. Then, depending on the readings from the engine oil temperature (EOT) sensor and the barometric pressure (BARO) sensor, the powertrain control module determines how long the glow plugs will be on.

Glow Plugs — PCM-Controlled

The intake manifold glow plugs are located in the cylinder heads (6049), under the valve covers (6582).

The glow plugs are self-regulating. If the engine oil temperature is above 55°C (131°F), the powertrain control module will bulb-check the WAIT TO START lamp but not energize the glow plug relay.

The powertrain control module protects the glow plugs by energizing them for short durations if the battery voltage is abnormally high.

The glow plug ON time varies from 0-120 seconds depending on battery voltage, engine oil temperature and barometric pressure.

On California vehicles the glow plug monitor system is part of the On-Board Diagnostics II (OBD II) System.

The glow plug monitor (GPM) system is designed to find failed glow plugs or failed wiring in the glow plug system.

The GPM system uses a low resistance shunt to conduct current to the left and right bank glow plugs.

Three sensing wires measure the voltage drops across the shunt when the glow plugs are operating. A failure in the glow plug system will set a diagnostic trouble code (DTC).

Glow Plug System

Refer to the Powertrain Control/Emissions Diagnosis (PC/ED) manual.

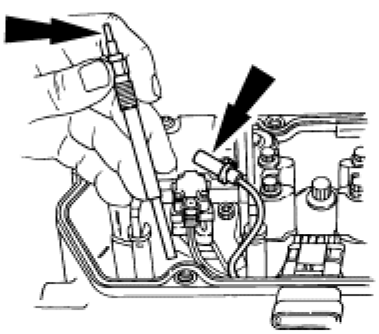
Glow Plug

Removal and Installation

1. **WARNING: The red-striped wiring harness carries 115 V DC. Severe electrical shock may be received. Do not pierce.**

   Remove the valve cover (6582). For additional information, refer to Section 303-01C.

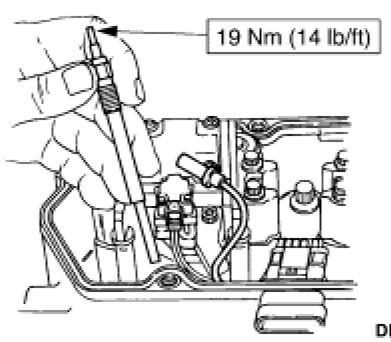
2. Disconnect the electrical connector and remove the glow plug (12A342) from the cylinder head (6049).



DB0005-A

3. Clean and inspect the glow plug tip for damage.

4. To install, reverse the removal procedure.



DB0006-A

Glow Plug Relay

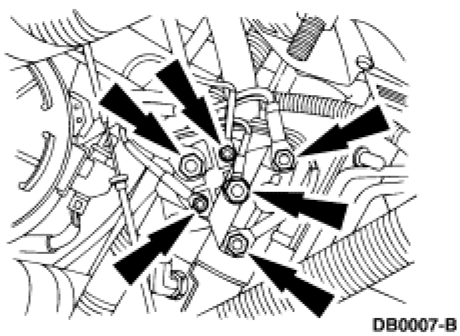
Removal

1. **WARNING: Do not use a screwdriver or similar tool to pry the terminal cover from the glow plug relay. Battery voltage is present at the terminals.**

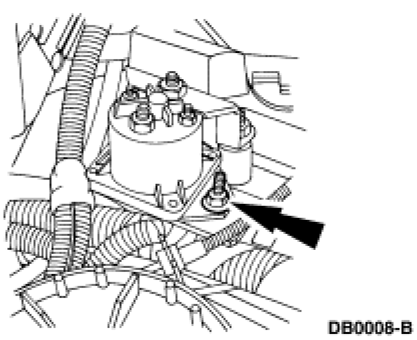
   Disconnect the battery ground cable (14301). On vehicles equipped with dual batteries, refer to Section 414-01.

2. Remove the glow plug relay terminal cover.

3. Remove the nuts and wiring from the glow plug relay (12A343).



4. Remove the two nuts and the glow plug relay.

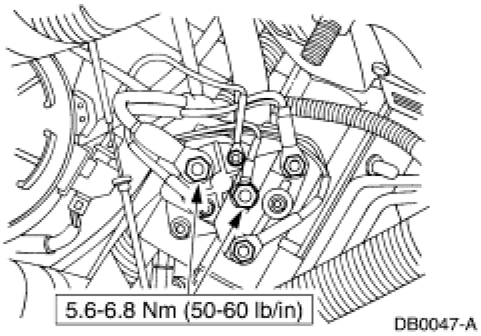


5. Inspect the plastic base and relay housing for cracks.

Installation

1. **NOTE:** On vehicles equipped with dual batteries, refer to Section 414-01 for battery reconnect procedure.

Follow the removal procedure in reverse order.



Torque Specifications

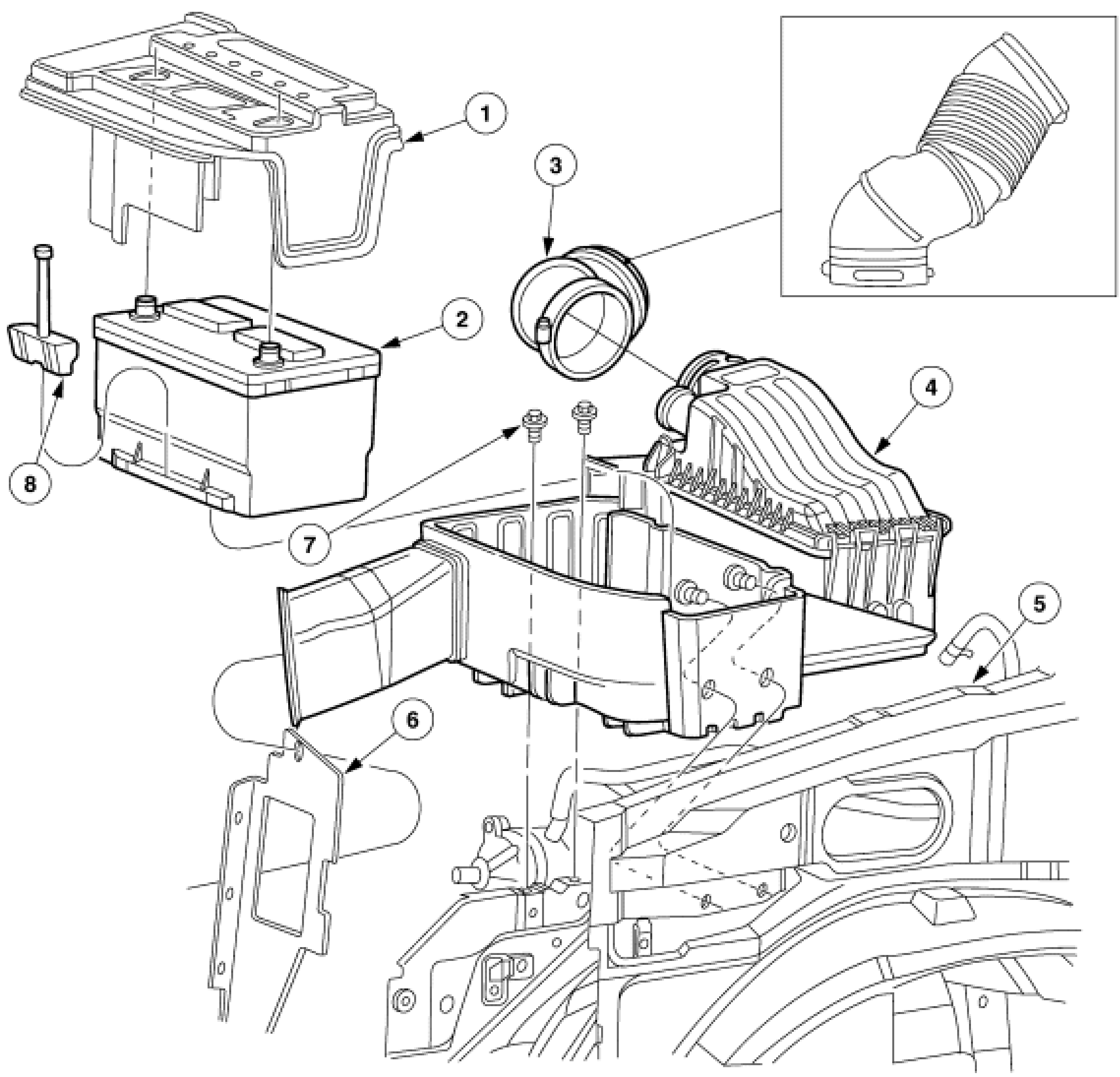
Description	Nm	Lb-Ft	Lb-In
Air cleaner bracket—pickup chassis	11-13	—	98-115
Battery tray/air cleaner assembly — 7.3L diesel, vehicles built after 12/7/98	16	—	12
Air cleaner outlet tube	3-4	—	31-35
Air cleaner outlet tube to throttle body-Motorhome	8	—	71
Air cleaner assembly mounting bolts	6	—	54
Charge air cooler mounting stud bolts	25	19	—
Charge air cooler inlet/outlet ducts retaining clamps	8	—	71

General Specifications

Item	Specification
Resin Hardener	CIBA CEICY ARADLITE AV 138M or equivalent. CIBA CEICY HV 998 or equivalent.
Alcan MIG Electrode Wire	1.20 mm (0.04 in) (3/16 inch) Diameter, 4043 Aluminum Alloy, Aluminum Wire or equivalent.

Intake Air Distribution and Filtering—7.3L Diesel, Vehicles Built After 12/7/98

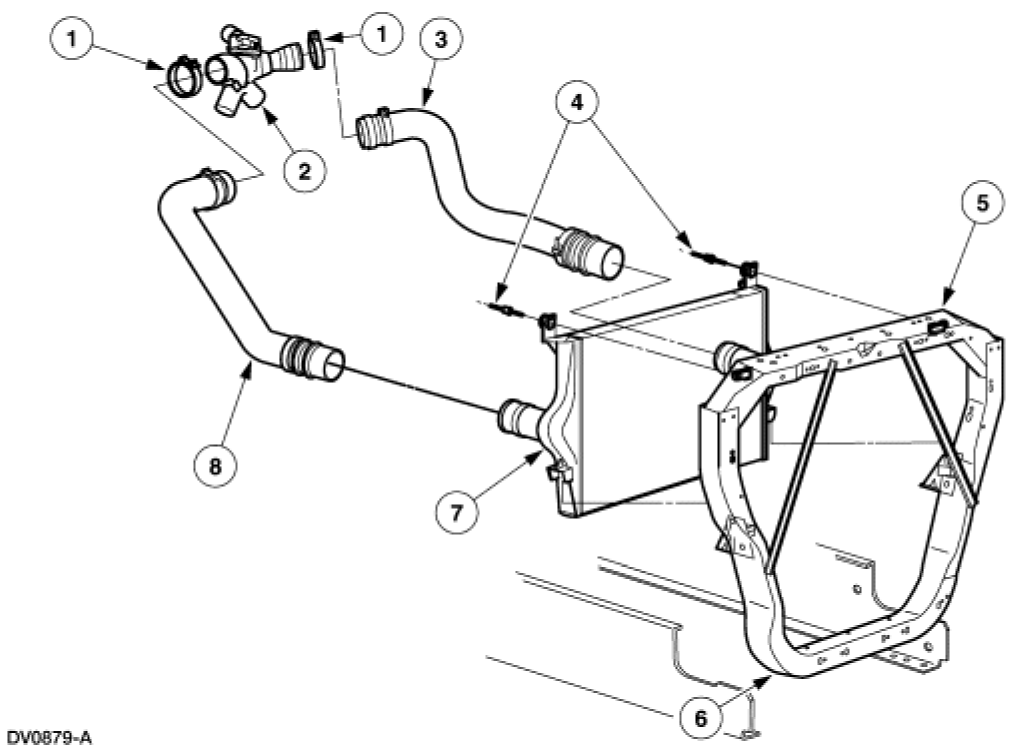
Air Intake Components — 7.3L Diesel Engine



Item	Part Number	Description
1	10B717	Battery cover
2	—	Battery

3	9B676	Air inlet tube
4	9C662	Battery tray/air cleaner assy
5	16K007	Inner fender (LH)
6	—	Air deflector
7	W503932-S426	Bolts (4 req'd)
8	10B648	Battery hold-down wedge

Charge Air Cooler and Components — 7.3L Diesel Engine



Item	Part Number	Description
1	6K786	Clamps (8 req'd)
2	6K889	Compressor manifold
3	6C646	Charge air cooler duct (outlet)
4	W705033-S301	Stud bolts
5	8A349	Radiator upper support
6	8A168	Radiator lower support
7	6K775	Charge air cooler
8	6C646	Charge air cooler duct (inlet)

Charge Air Cooler Repairs

1. Determine what type of damage has been done to the charge air cooler.
2. Refer to the Charge Air Cooler Cross-Reference Chart to determine if the damage is repairable and what types can be made.

Condition	Action To Take
• Tubes torn or cracked.	• Replace the charge air cooler. Refer to Charge Air Cooler in this section.
• Tubes dented, kinked or bent, resulting in a round edge (radius less than 1 mm (0.04 in) [1/32 inch]).	• Weld or epoxy. Refer to Welding Repairs—Tubes or Tube Header Joints or to Epoxy Repairs—Tubes or Headers in this section.
• Tubes dented, kinked or bent, resulting in a round edge (radius greater than 1 mm (0.04 in) [1/32 inch]).	• No repair required.
• Holes in tubes less than 1 mm (0.04 in) (1/32 inch) in all directions on tube surface.	• Weld or epoxy to fill. Refer to Welding Repairs—Tubes or Tube Header Joints or to Epoxy Repairs—Tubes or Headers in this section.
• External fins crushed or bent; no more than 1 mm (0.04 in) (1/32 inch) height reduction per fin row and the sidemember-to-sidemember dimension is within specification (687 mm [26-3/4 inch]).	• No repair required.
• External fins pushed in with no tearing.	• Straighten the fins.
• External fins pushed in with tearing less than 10 mm (0.4 in) (3/8 inch) deep from core face. Also tearing is less than 20 percent of a given fin row and less than 5 percent of the total fin rows.	• Remove loose fin material and straighten.
• External fins pushed in with tearing or more than 10 mm (0.4 in) (3/8 inch) from face core or more than 20 percent of a given row or more than 5 percent of the total fin row.	• Replace the charge air cooler. Refer to Charge Air Cooler in this section.
• Sidemembers bent or dented.	• Straighten the sidemember to original form. If the tubes are dented or the fins crushed, then straighten.
• Sidemember surfaces cracked or broken through.	• Weld the sidemember. Refer to Welding Repairs—Sidemembers in this section.
• Headers bent or dented, resulting in three or fewer tube or tube-to-header leaks, and cracks are less than 2 mm	•

(0.08 in)(1/16 inch).	**NOTE:** If the crack is less than 1 mm (0.04 in)(1/32 inch), repair can be made with epoxy. Weld the header. Refer to Welding Repairs—Tubes or Tube Header Joints in this section.
• Headers bent or dented, with more than three tube or tube-to-header leaks or a crack width greater than 2 mm (0.08 in)(1/16 inch).	• Replace the charge air cooler. Refer to Charge Air Cooler in this section.
• Headers cracked.	• Replace the charge air cooler. Refer to Charge Air Cooler in this section.
• Tank walls dented but not cracked or broken through, and fit and function of cooler is not affected.	• No repair required.
• Tanks cracked. Crack is no more than 2 mm (0.08 in)(1/16 inch) wide and 20 mm (0.8 in) (3/4 inch) long.	• Weld the tanks. Refer to Welding Repairs—Tanks in this section.
• Tanks cracked. Crack is no more than 2 mm (0.08 in)(1/16 inch) wide or 20 mm (0.8 in)(3/4 inch) long.	• Replace the charge air cooler. Refer to Charge Air Cooler in this section.
• Tanks punctured. Hole is no more than 5 mm (0.2 in)(3/16 inch) in all directions on tank surface.	• Weld the tanks. Refer to Welding Repairs—Tanks in this section.
• Tanks punctured. Hole is more than 5 mm (0.2 in)(3/16 inch) in any direction on tank surface.	• Replace the charge air cooler. Refer to Charge Air Cooler in this section.
• Tank-to-header welds cracked or porous.	• **CAUTION: Repair welds must not start or stop where a production weld ends.** Weld. Refer to Welding Repairs—Tubes or Tube Header Joints in this section.
• Threads stripped in tapped holes.	• Drill out stripped threads and tap to accept proper helicoil.
• Bosses and mounting brackets cracked or broken off, but crack or fractured surface does not go into tank wall.	• Weld. Refer to Welding Repairs—Mounting Brackets in this section.
• Bosses or mounting brackets cracked or broken off, and crack goes into tank wall.	• Replace the charge air cooler. Refer to Charge Air Cooler in this section.
• Mounting pins or other hardware cracked, broken or otherwise damaged, and repair will not affect fit, function or durability.	• Repair to original condition.
• Mounting pins or other hardware cracked, broken or otherwise damaged, and repair will not affect fit, function or durability.	• Replace the charge air cooler. Refer to Charge Air Cooler in this section.

Welding Repairs—Tanks

1. All surfaces to be welded must be free of all paint, oil, grease, water and other foreign matter in the area so the weld repair will adhere to the bare aluminum and will not be contaminated.

2. Heat the crack(s) to chase the ends until they stop.

3. Weld-fill the crack and continue the bead approximately 25 mm (1 in) past the ends of the crack.
   - Use a suitable MIG welder.

4. Wire brush and grind any excess weld material to blend the weld with the tank surface.

5. Clean the charge air cooler.

Welding Repairs—Sidemembers

1. All surfaces to be welded must be free of all paint, oil, grease, water and other foreign matter in the area so the weld repair will adhere to the bare aluminum and will not be contaminated.

2. Cut a V-shaped groove along the length of the crack to a depth equal to the member thickness.

3. Weld-fill the groove.
   - Use a suitable MIG welder.

4. Wire brush and grind any excess weld material to provide a flat surface.

5. Clean the charge air cooler.

Welding Repairs—Mounting Brackets

1. All surfaces to be welded must be free of all paint, oil, grease, water and other foreign matter in the area so the weld repair will adhere to the bare aluminum and will not be contaminated.

2. **CAUTION: Care must be taken not to melt the fins or the tube-to-header braze joint. If welding near the core, shield the core with a large steel plate. This will protect it from sparks and weld splatter and will act as a heat sink.**

   Tack weld the bracket in place.

   - This will retain the bracket in its correct orientation.
   - Use a suitable MIG welder.

3. Weld the bracket in place.
   - Use a suitable MIG welder.

4. Allow the bracket to air-cool.

5. Check the bracket alignment.

6. Clean the charge air cooler.

Welding Repairs—Tubes or Tube Header Joints

1. All surfaces to be welded must be free of all paint, oil, grease, water and other foreign matter in the area so the weld repair will adhere to the bare aluminum and will not be contaminated.

2. Weld the tube or tube header joint.
   - Use a suitable MIG welder.
   - Use Alcan MIG Electrode Wire, 1.20-mm (3/16-inch) diameter, 4043 aluminum alloy, aluminum wire or equivalent.

3. Clean the charge air cooler.

Epoxy Repairs—Tubes or Headers

1. All surfaces to be welded must be free of all paint, oil, grease, water and other foreign matter in the area so the epoxy will adhere to the bare aluminum.

2. Apply epoxy to the damaged tube or header.
   - Use only a high-temperature epoxy
     - Use resin CIBA GEIGY ARADLITE AV 138M and hardener CIBA GEIGY HV 998 or equivalents.
     - The mix and cure instructions on the products must be strictly adhered to.

3. Clean the charge air cooler.

Cleaning After Weld or Epoxy Repairs—Power Flushing

1. Orient the charge air cooler so that the tank containing the repair or closest to the repair point is at the bottom.

2. Power flush the charge air cooler from the opposite tank at the top.
   - Power flush with water at a rate of 0.06 in (1.5 mm) per second for 3 minutes.

3. Invert the charge air cooler.

4. Power flush the charge air cooler in the opposite direction.
   - Power flush with water at a rate of 1.5 mm (0.06 in) per second for 3 minutes.

5. Drain all of the water from the charge air cooler and allow it to air-dry.

6. **NOTE:** A leak test must be performed on all repairs prior to painting or installing the charge air cooler.

   Leak test the charge air cooler.

Cleaning After Weld or Epoxy Repairs—Alternate Method

1. Lay the charge air cooler flat with the inlet and outlet ports pointing up.
2. Fill the charge air cooler to 40 percent of its volume with water.
3. Agitate the charge air cooler by hand for at least 10 minutes.
4. Drain the water from the charge air cooler.
5. Repeat Steps 1 through 4 until no debris is found in the flushing water.
6. Allow the charge air cooler to air-dry.
7. **NOTE:** A leak test must be performed on all repairs prior to painting or installing the charge air cooler.

   Leak test the charge air cooler.

Leak Test—Charge Air Cooler

1. **NOTE:** To ensure proper performance, all repaired charge air coolers must be leak tested and pressure checked prior to painting or installing into the vehicle.

   Install an air pressure gauge in one port of the charge air cooler.
2. Install a stop/air supply in the other port.
3. Apply 50 psig of air pressure.
4. Reduce air pressure to 29 psig.
5. Let the charge air cooler stand for a few minutes and note any loss in pressure.
   - If the pressure loss exceeds 1.5 psig per minute, repair the leak.
6. Replace the charge air cooler if there is any permanent distortion.

Charge Air Cooler

Removal

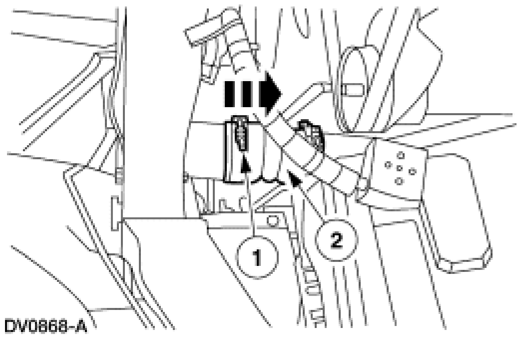
1. Remove the radiator; refer to Section 303-03.

2. **NOTE:** Both the inlet and the outlet ducts are removed the same way. Only the outlet duct is shown.

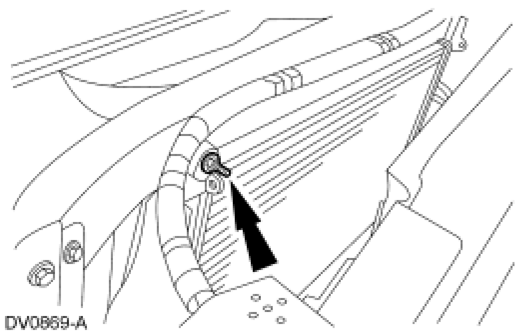
   Remove the inlet and outlet ducts from the charge air cooler.

   1. Loosen the clamp.

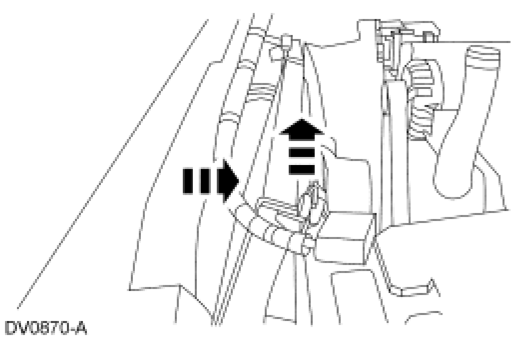
   2. Remove the ducts from the charge air cooler.



3. Remove the two stud bolts.

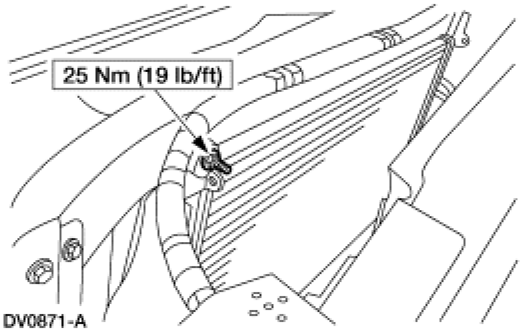


4. Remove the charge air cooler.



Installation

1. Follow the removal procedure in reverse order.


25 Nm (19 lb/ft)
DV0871-A

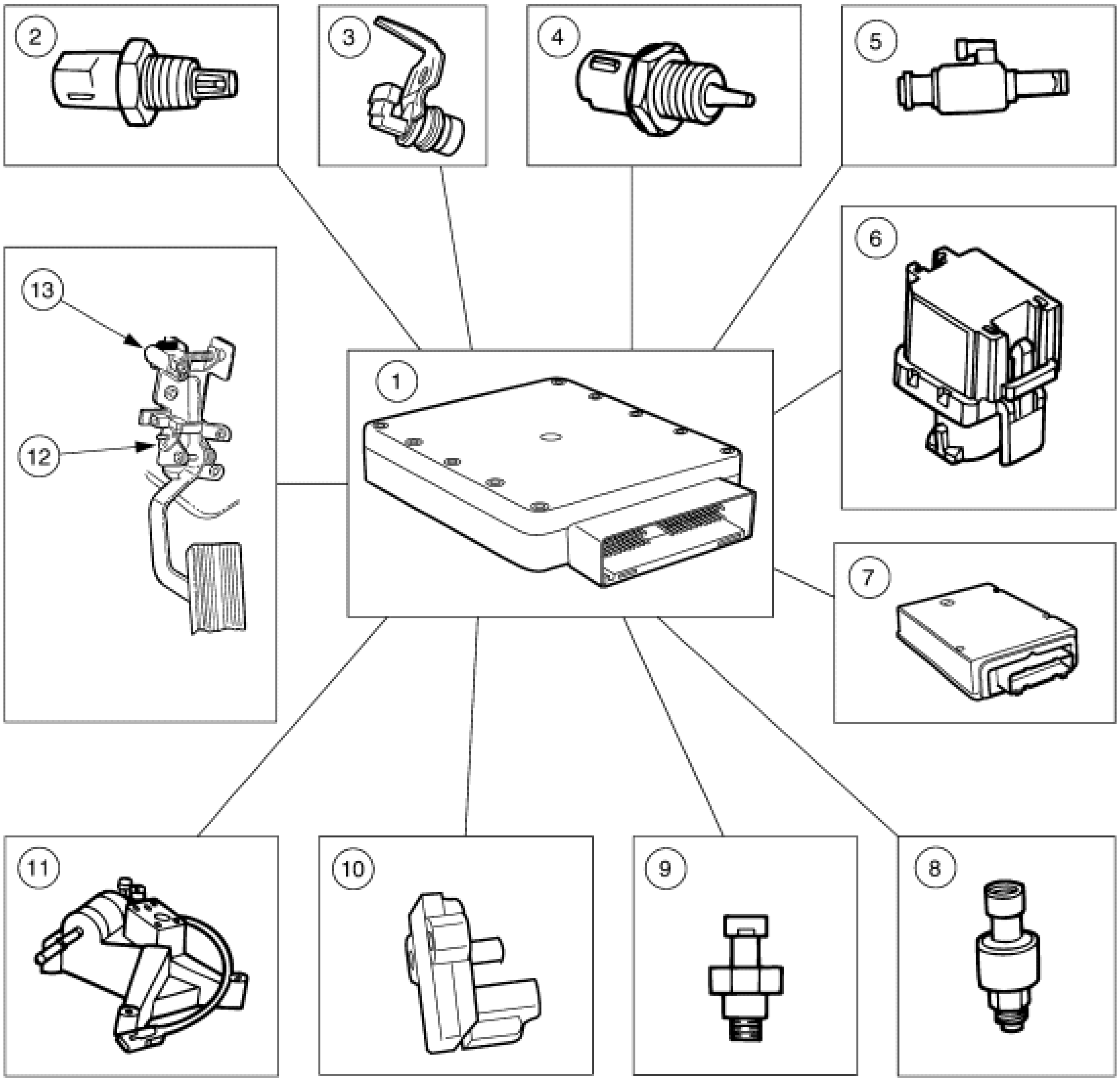
SECTION 303-14B: Electronic Engine Controls — Diesel Engine

Torque Specifications			
Description	**Nm**	**Lb/Ft**	**Lb/In**
Engine Coolant Temperature (ECT) Sensor 7.3L	16-24	12-18	—
Powertrain Control Module (PCM) Electrical Connector Bolt	7	—	62
Injector Driver Module (IDM) Mounting Bolts	5	—	45
Powertrain Control Module (PCM) Mounting Screws	8	—	71
Injector Driver Module Electrical Connector Retaining Bolt	6	—	54

Electronic Engine Controls

The electronic engine controls consist of the components shown in the following illustration. For further component description and operation, refer to the Powertrain Control/Emissions Diagnosis (PC/ED) manual.

Electronic Engine Controls — Diesel Engines



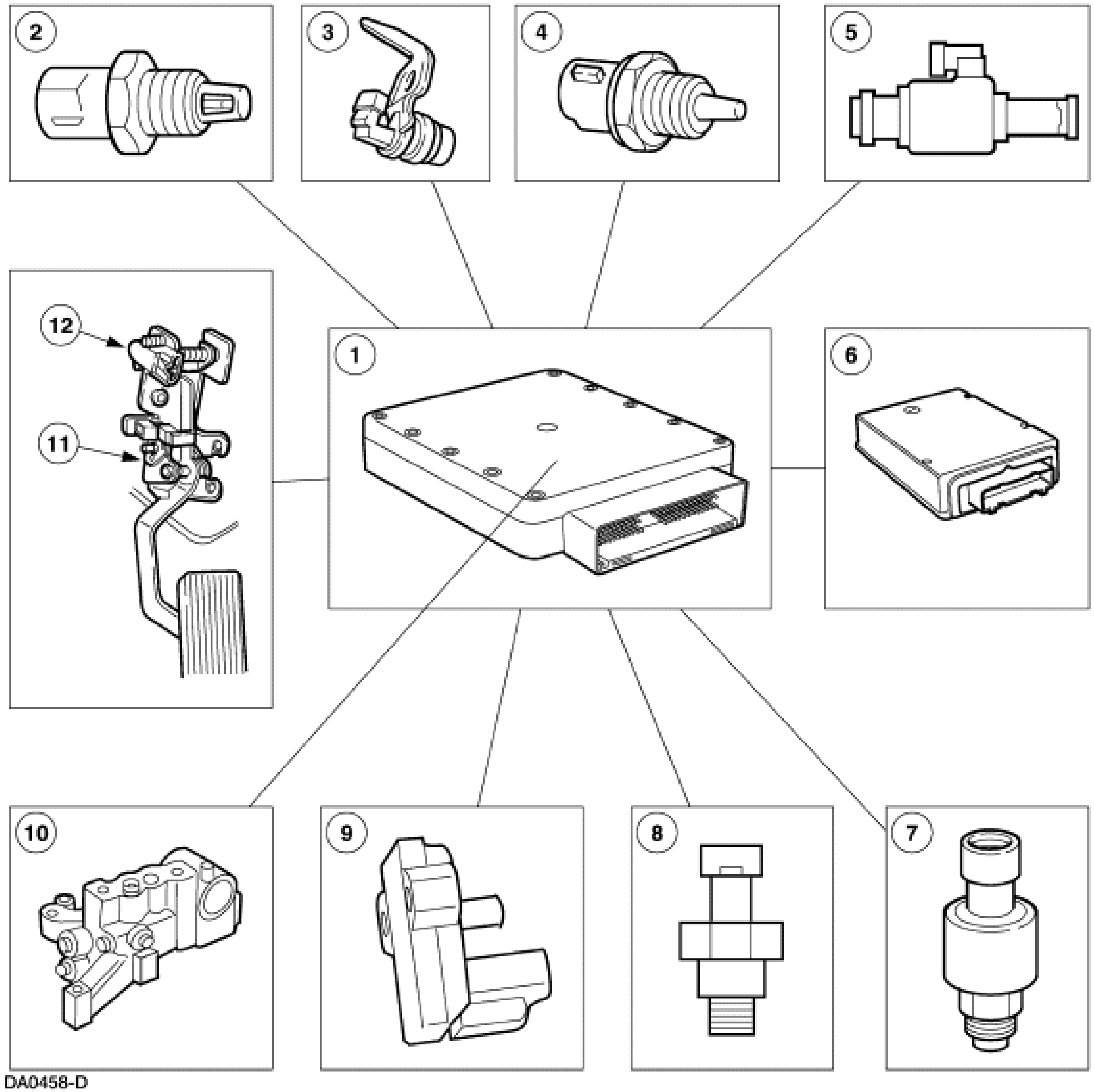
Item	Part Number	Description
1	12A650	Powertrain Control Module
2	12A697	Intake Air Temperature Sensor
3	6B288	Camshaft Position Sensor
4	12A648	Engine Coolant Temperature Sensor
5	9C968	Fuel Pressure Regulator
6	12A644	Barometric Pressure Sensor
7	12B599	Injector Driver Module
8	9F838	Injection Control Pressure Sensor
9	9J460	Exhaust Back Pressure Sensor
10	9F479	Manifold Absolute Pressure Sensor

11	—	Exhaust Back Pressure Regulator (EPR) (Part of 6N639)
12	—	Idle Validation Switch (Part of 9F836)
13	—	Accelerator Pedal Position Sensor (Part of 9F836)

Electronic Engine Controls—Vehicles Built After 12/7/98

The electronic engine controls consist of the components shown in the following illustration. For further component description and operation, refer to the Powertrain Control/Emissions Diagnosis (PC/ED) manual.

Electronic Engine Controls — Diesel Engines



Item	Part Number	Description
1	12A650	Powertrain control module (PCM)
2	12A697	Intake air temperature (IAT) sensor
3	6B288	Camshaft position (CMP) sensor
4	—	Engine oil temperature (EOT) sensor
5	9L968	Injection pressure regulator (IPR) valve
6	12B599	Injector driver module (IDM)
7	9F838	Injection control pressure (ICP) sensor
8	9J460	Exhaust back pressure sensor

9	9F479	Manifold absolute pressure (MAP) sensor
10	—	Exhaust back pressure regulator (EPR) (part of 6N639)
11	—	Idle validation switch (part of 9F836)
12	—	Accelerator pedal position (APP) sensor (part of 9F836)

Electronic Engine Controls

Refer to the Powertrain Control/Emissions Diagnosis (PC/ED) manual.

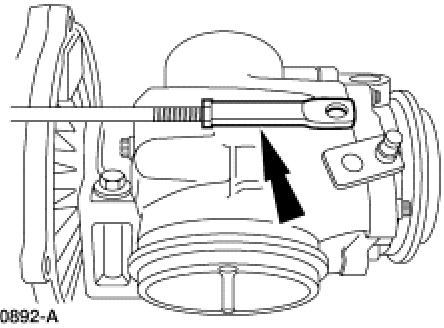
Wastegate Control Solenoid Adjustment

Adjustment

CAUTION: Failure to follow this procedure exactly as outlined can cause the turbocharger to overboost resulting in severe damage to the turbocharger or the engine.

NOTE: The adjustment procedure can be performed on-vehicle. This procedure is performed with the turbocharger removed from the vehicle for clarity purposes only.

1. Disconnect the pressure line from the wastegate control solenoid.
2. Install the adjustment rod end onto the wastegate control solenoid, if removed.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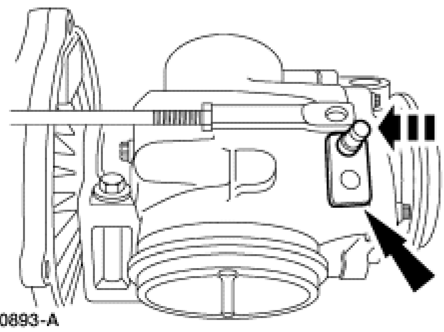
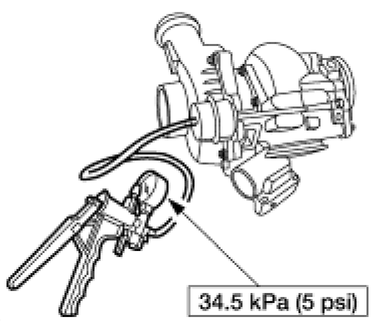
3. Press the wastegate crank toward the wastegate control solenoid.

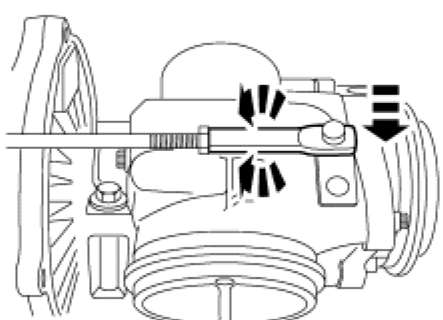

DV0893-A

4. Using the pressure pump apply 34.5 kPa (5 psi) of pressure to the actuator diaphragm.

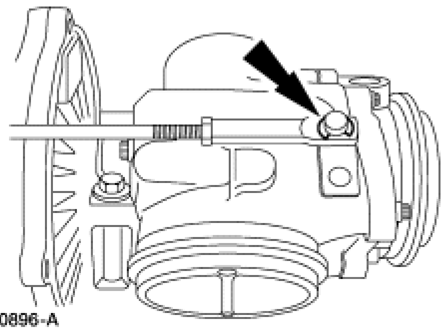


DV0894-A

5. Turn the adjustment rod until the adjustment eye slips over the wastegate crank pin with no resistance.


DV0895-A

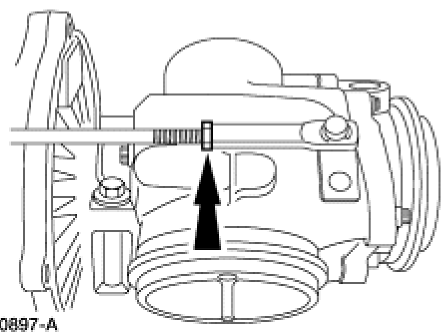
6. Install the clip.



DV0896-A

7. Release and reapply the 34.5 kPa (5 psi) of pressure to the control solenoid to verify wastegate operations.

8. Tighten the adjustment rod set nut to prevent the wastegate from loosing its adjustment.



DV0897-A

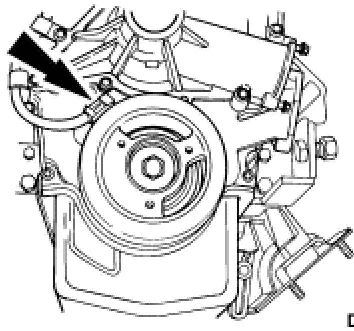
9. Disconnect the pressure pump and attach the pressure lines to the wastegate control solenoid.

Camshaft Position (CMP) Sensor

Removal

1. **CAUTION: Make sure the ignition switch is in the OFF position prior to working on the electronic engine controls.**

   Turn the ignition switch to the OFF position.



DA0469-A

2. Disconnect the wiring at the camshaft position sensor (CMP sensor) (6B288).
3. Remove the retaining bolt and the sensor.

Installation

1. **NOTE:** On vehicles equipped with dual batteries, for additional information, refer to Section 414-01 for battery reconnect procedure.

   Follow the removal procedure in reverse order.

SECTION 303-14B: Electronic Engine Controls — Diesel Engine	1999 F-Super Duty 250-550 Workshop Manual
REMOVAL AND INSTALLATION	Procedure revision date: 01/26/2000

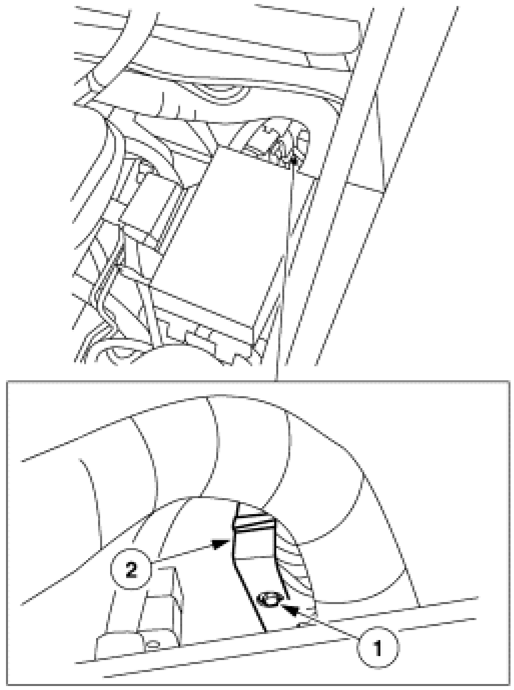
Powertrain Control Module (PCM)

Removal

1. **CAUTION: Always disconnect the battery ground cable (14301) prior to working on the electronic engine controls.**

   Disconnect the battery ground cable. On vehicles equipped with dual batteries, for additional information, refer to Section 414-01.

2. Disconnect the wiring harness.
   1. Loosen the bolt.
   2. Remove the wiring harness.

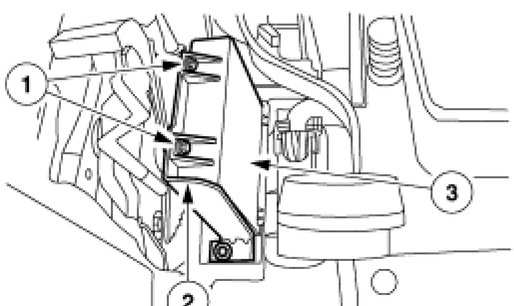


DA1736-A

3. Remove the powertrain control module (PCM) (12A650).
    1. Remove the screws.

    2. Remove the cover.

    3. Remove the powertrain control module.

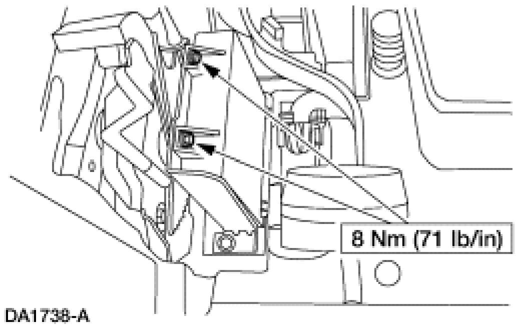


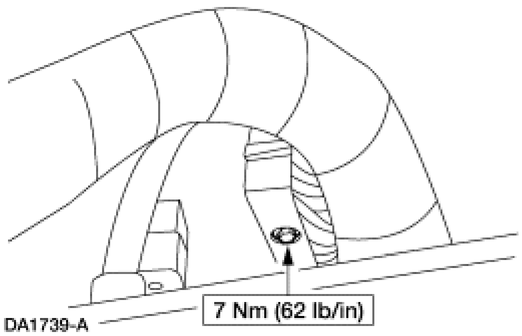
DA1737-A

Installation

1. **NOTE:** On vehicles equipped with dual batteries, for additional information, refer to Section 414-01 for battery reconnect procedure.

    Follow the removal procedure in reverse order.





SECTION 303-14B: Electronic Engine Controls — Diesel Engine | 1999 F-Super Duty 250-550 Workshop Manual

REMOVAL AND INSTALLATION | Procedure revision date: 01/26/2000

Injector Driver Module (IDM)

Removal

1. **WARNING: Electric shock. High voltage wires are inside the red-striped wire harness. You may receive a severe electrical shock if the wires are pierced. Do not pierce.**

   CAUTION: Do not pierce engine electrical wires or damage to the harness can occur.

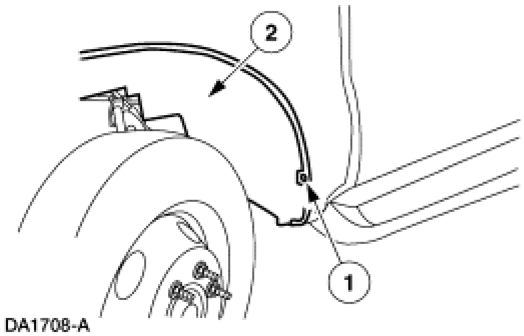
   CAUTION: Make sure the ignition switch is in the OFF position prior to working on the electronic engine controls.

   Turn the ignition switch to the OFF position.

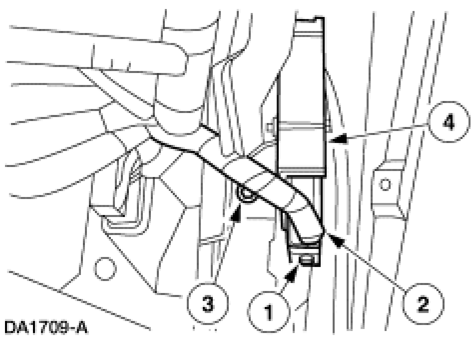
2. Raise and support the vehicle; for additional information, refer to Section 100-02.

3. Remove the driver side splash guard.

    1. Remove the screws.
    2. Remove the splash guard.

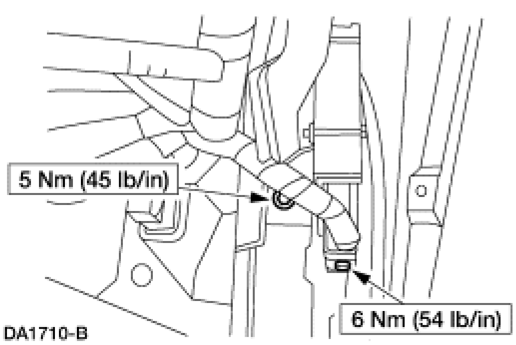


4. Remove the module.
    1. Loosen the connector bolt.
    2. Remove the wire connector.
    3. Remove the two retaining bolts.
    4. Remove the module.



Installation

1. Follow the removal procedure in reverse order.



Engine Coolant Temperature (ECT) Sensor

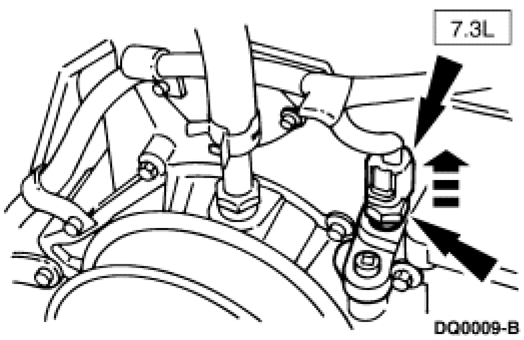
Removal

1. **CAUTION: Make sure the ignition switch is in the OFF position prior to working on the electronic engine controls.**

   Turn the ignition switch to the OFF position.

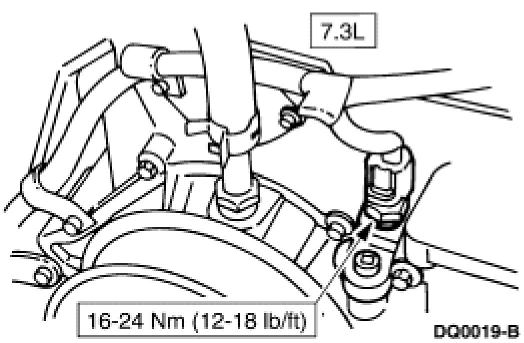
2. Partially drain the cooling system; for additional information, refer to Section 303-03.

3. Disconnect the electrical connector. Remove the water temperature indicator sender unit from the engine front cover.



Installation

1. Follow the removal procedure in reverse order.



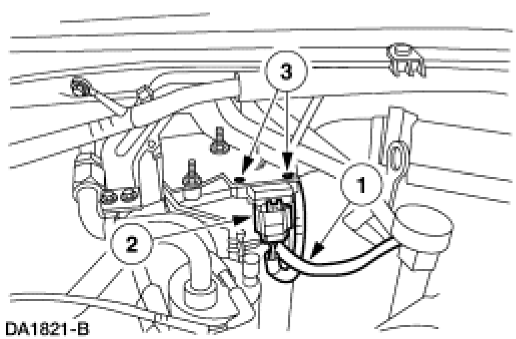
Manifold Absolute Pressure (MAP) Sensor

Removal

1. **CAUTION: Make sure the ignition switch is in the OFF position prior to working on the electronic engine controls.**

   Turn the ignition switch to the OFF position.

2. Remove the manifold absolute pressure (MAP) sensor.
   1. Disconnect the pressure line.
   2. Disconnect the electrical connector.
   3. Remove the two mounting screws.



Installation

1. Follow the removal procedure in reverse order.

SECTION 303-14B: Electronic Engine Controls — Diesel Engine
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1999 F-Super Duty 250-550 Workshop Manual
Procedure revision date: 01/26/2000

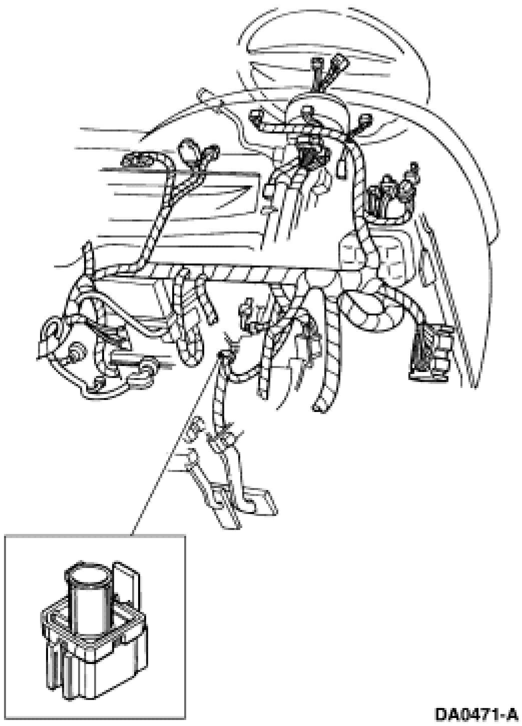
Barometric Pressure (BARO) Sensor—Vehicles Built Before 12/7/98

Removal

1. **CAUTION: Make sure the ignition switch is in the OFF position prior to working on the electronic engine controls.**

   Turn the ignition switch to the OFF position.

2. Disconnect the barometric pressure sensor electrical connector.



3. Remove the barometric pressure sensor (BARO sensor) (12A644).

Installation

1. Follow the removal procedure in reverse order.

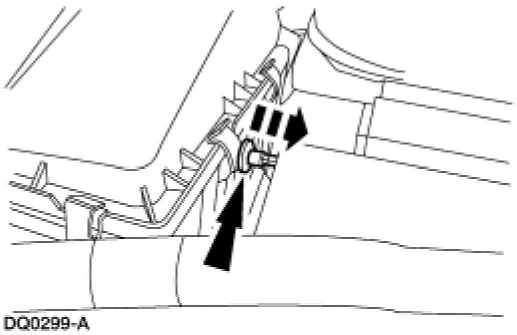
Intake Air Temperature (IAT) Sensor

Removal

1. **CAUTION: Make sure the ignition switch is in the OFF position prior to working on the electronic engine controls.**

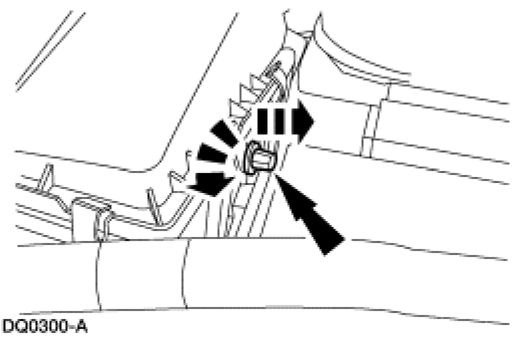
   Turn the ignition switch to the OFF position.

2. Disconnect the electrical connector from the intake air temperature sensor (IAT sensor) (12A697).



DQ0299-A

3. Rotate the intake air temperature sensor 1/4 turn counterclockwise and pull outward.



DQ0300-A

Installation

1. Follow the removal procedure in reverse order.

SECTION 303-14B: Electronic Engine Controls — Diesel Engine | 1999 F-Super Duty 250-550 Workshop Manual

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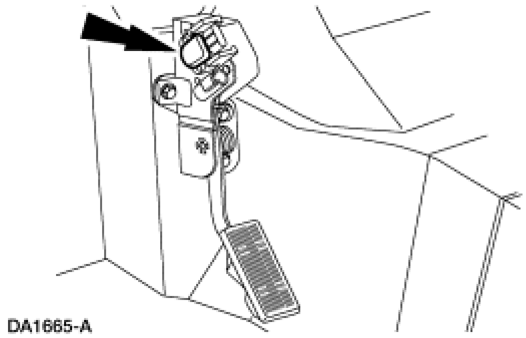
Accelerator Pedal Position (APP) Sensor

1. **NOTE:** The accelerator pedal (APP) position sensor is not serviced separately.

   Replace the accelerator pedal assembly if the APP position sensor requires service; for additional information, refer to Section 310-02.



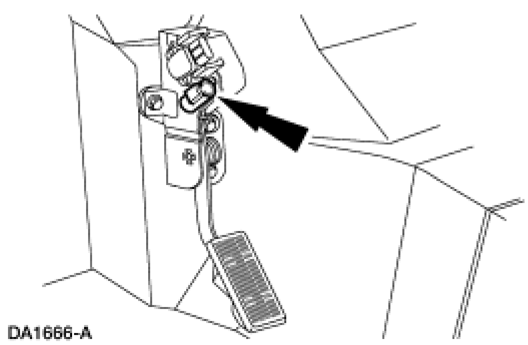
SECTION 303-14B: Electronic Engine Controls — Diesel Engine | 1999 F-Super Duty 250-550 Workshop Manual

REMOVAL AND INSTALLATION | Procedure revision date: 01/26/2000

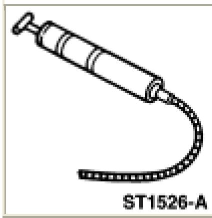
Idle Validation Switch

1. **NOTE:** The idle validation switch is not serviced separately.

   Replace the accelerator pedal assembly if the idle validation switch requires service; for additional information, refer to Section 310-02.



Oil Temperature Sensor

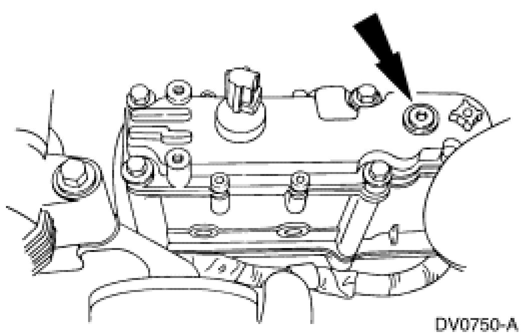
Special Tool(s)	
	Oil Suction Gun 303–D104 (D94T–9000–A) or Equivalent

Removal

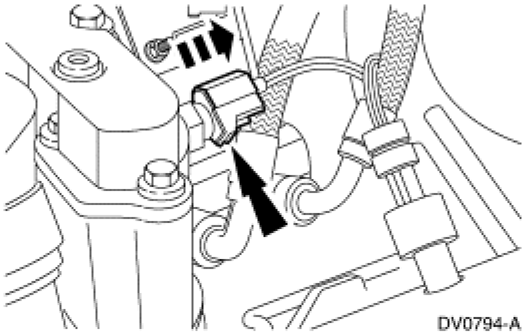
1.  **CAUTION: Make sure the ignition switch is in the OFF position prior to working on the electronic engine controls.**

   Turn the ignition switch to the OFF position.

2. Remove the plug. Using special tool 303–D104 (D94T-9000–A) draw the oil from the high-pressure oil pump reservoir.



3. Disconnect the engine oil temperature (EOT) sensor electrical connector. Remove the EOT sensor.



Installation

1. Follow the removal procedure in reverse order.
    - Fill the high pressure oil pump reservoir with clean engine oil before installing the plug.

SECTION 303-14B: Electronic Engine Controls — Diesel Engine	1999 F-Super Duty 250-550 Workshop Manual
REMOVAL AND INSTALLATION	Procedure revision date: 01/26/2000

Exhaust Back Pressure Sensor

Removal

1. **CAUTION: Make sure the ignition switch is in the OFF position prior to working on the electronic engine controls.**

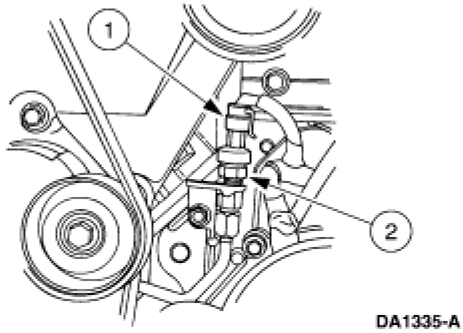
    Turn the ignition switch to the OFF position.

2. **NOTE:** The fan and fan clutch are removed for clarity.

    Remove the exhaust back pressure sensor.

    1. Disconnect the electrical connector.

    2. Loosen and remove the sensor from the mounting bracket.



Installation

1. Follow the removal procedure in reverse order.

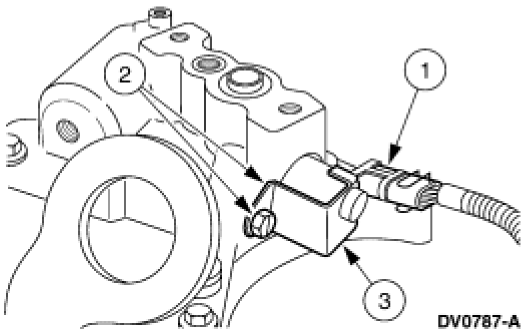
Exhaust Back Pressure Solenoid

Removal

1. Remove the turbocharger compressor manifold; for additional information, refer to Section 303-04D.
2. **NOTE:** The turbocharger is removed for clarity only.

   Remove the exhaust back pressure solenoid.

   1. Disconnect the electrical connector.
   2. Remove the bolt and the retaining bracket.
   3. Remove the exhaust back pressure solenoid.



Installation

1. Follow the removal procedure in reverse order.
   - Lubricate the O-ring seals with clean engine oil prior to installing the exhaust back pressure solenoid.

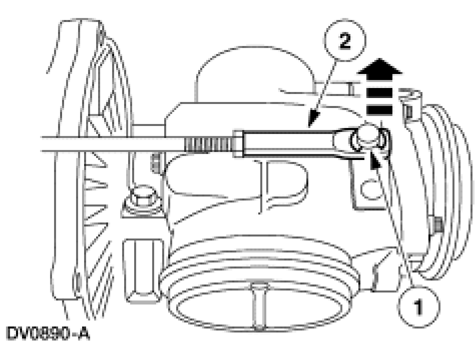
Wastegate Control Solenoid

Removal

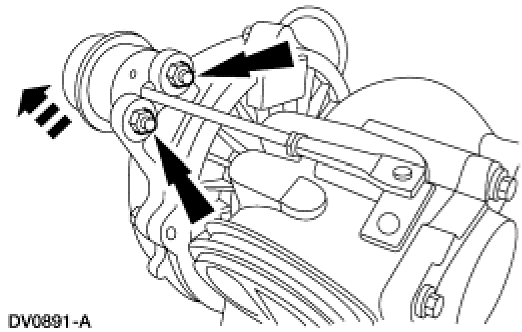
1. Remove the turbocharger; for additional information, refer to Section 303-04D.

2. Disconnect the adjustment rod from the wastegate crank.
   1. Remove the clip.

   2. Remove the adjustment rod.



3. Remove the two lock nuts and the wastegate control solenoid.



Installation

1. Follow the removal procedure in reverse order.

Powertrain Control/Emissions Diagnosis

1999

On Board Diagnostics II Diesel

Introduction

Note: The descriptions and specifications contained in this manual were in effect at the time this manual was approved for printing. Ford Motor Company reserves the right to discontinue models at any time, or change specifications or design without notice and without incurring obligation.

Important Safety Notice

Appropriate service methods and procedures are essential for the safe, reliable operation of all motor vehicles as well as the personal safety of the individual doing the work. This manual provides general directions for performing service with tested, effective techniques. Following them will help assure reliability.

There are numerous variations in procedures, techniques, tools, and parts for servicing vehicles, as well as in the skill of the individual doing the work. This manual cannot possibly anticipate all such variations and provide advice or cautions as to each. Accordingly, anyone who departs from the instructions provided in this manual must first establish that he compromises neither his personal safety nor the vehicle integrity by his choice of methods, tools or parts.

Notes, Cautions, and Warnings

As you read through the procedures, you will come across NOTES, CAUTIONS and WARNINGS. Each one is there for a specific purpose. NOTES give you added information that will help you to complete a particular procedure. CAUTIONS are given to prevent you from making an error that could damage the vehicle. WARNINGS remind you to be especially careful in those areas where carelessness can cause you personal injury. The following list contains some general WARNINGS that you should follow when you work on a vehicle.

- Always wear safety glasses for eye protection
- Use safety stands whenever a procedure requires you to be under the vehicle.
- Make sure that the ignition switch is always in the OFF position, unless otherwise required by the procedure.
- Set the parking brake when working on the vehicle. If you have an automatic transmission, set it in PARK unless instructed otherwise for a specific operation. If you have a manual transmission, it should be in REVERSE (engine OFF) or NEUTRAL (engine ON) unless

instructed otherwise for a specific operation. Place wood blocks (4" x 4" or larger) against the front and rear surfaces of the tires to help prevent the vehicle from moving.

- Operate the engine only in a well-ventilated area to avoid the danger of carbon monoxide poisoning.
- Keep yourself and your clothing away from moving parts when the engine is running, especially the drive belts.
- To prevent serious burns, avoid contact with hot metal parts such as the radiator, exhaust manifold, tail pipe, three-way catalytic converter and muffler.
- Do not smoke while working on a vehicle.
- To avoid injury, always remove rings, watches, loose hanging jewelry, and loose clothing before beginning to work on a vehicle.
- When it is necessary to work under the hood, keep hands and other objects clear of the radiator fan blades!

Where To Begin Diagnostics

To begin Diagnostics refer to Section 3 depending on the type of vehicle as listed below. This section contains the necessary information for establishing a systematic approach to diagnostics.

Vehicles Diagnosed:

Light Trucks

- 7.3L Diesel Econoline
- 1999 7.3L Diesel Super Duty Series F250, F350, F450, F550, Motor Home.

How To Use The Diagnostic Procedures

- Use the information about the vehicle drivability or emission concern (from the service write-up, Customer Information Worksheet, etc.) to attempt to verify/re-create the symptom. Look for any vehicle modifications or aftermarket items that may contribute to the symptom. A check of any applicable TSBs or OASIS messages may be useful, if this information is available.
- Refer to the Symptom Index (Section 3) and select the symptom that best describes the vehicle symptom. (For multiple symptoms, select the one that is most noticeable.)
- Go to the Symptom Chart indicated in the Symptom Index.
- Begin the Chart at step number "1."
- Follow the instructions in the step (including Preliminary Checks, etc.)
    - If the step contains a test procedure or question (without a reference outside the step), perform the test step/answer the question and continue as directed.
    - If the step sends you to a specific area for testing (for example Hard Start/No Start Procedures, a Pinpoint Test Step in this manual or a Workshop Manual group), go to the procedures. Follow the directions given in those procedures, including directions to other tests, sections. If a damaged part is found, repair/replace as directed. If no fault is found, and diagnosis in that area is complete, return to the Symptom Chart and continue as directed.
- During diagnosis, if directed to test a system/component that is not contained on that vehicle, proceed to the next step.

- If the Symptom Chart for the vehicle symptom is completed and no fault is found, return to the Symptom Index to address the next most prominent symptom.
- After service, verify that the vehicle is operating properly and the original complaint is eliminated.

Note: If a symptom is determined to be intermittent, careful visual and physical underhood inspection of connectors, wiring harnesses, vacuum lines, and components is required. The Customer Information Worksheet may contain more detailed symptom information. Before an in-depth diagnosis begins, start the engine and wiggle wires, tap on components, etc., while listening for an indication of a concern (such as rpm change or relay clicking).

Information about engine conditions is stored when a Diagnostic Trouble Code (DTC) that lights the Malfunction Indicator Lamp (MIL) is set.

Preface

This manual provides a step-by-step approach for diagnosing drivability, emission and powertrain control system symptoms. Before beginning diagnosis, it may be helpful to reference any Technical Service Bulletins (TSBs) or On-line Automotive Service Information System (OASIS) information when this is available.

This manual is used in conjunction with the Body, Chassis, Powertrain, Drivetrain Workshop Manuals and the Wiring Diagrams. The Service Manuals are used to provide additional diagnostics when directed by this manual. The Workshop Manuals are also used for component removal and replacement information. Refer to the Wiring Diagrams for vehicle-specific wiring information and component, connector and splice location.

All references to specific "Groups" refer to groups in the Body, Chassis, Powertrain, Drivetrain Workshop Manuals. The following is a description of the information contained in each section of this manual.

Section 1: Description and Operation

This section contains description and operation information on powertrain control systems and components. This section is designed to give the technician a general knowledge of the powertrain control system. It should be used when general information about the powertrain control system is desired, and is rarely referenced from other sections of the manual.

Section 2: Diagnostic Methods

The Diagnostic Methods section contains information on specific diagnostic tasks that are used during diagnosis. Descriptions of specific diagnostic methods are included, as well as detailed instructions on how to access or perform the tasks. This section provides the technician with step-by-step instructions for performing routine diagnostic tasks.

Section 3: Symptom Charts

All diagnosis begins in Section 3 with the Symptom Index. The Symptom Index contains the list of symptoms addressed in this manual. The Symptom Index will refer the technician to the appropriate Symptom chart, which guides the technician through diagnosis.

Section 4: Diagnostic Subroutines

Section 4 contains the Hard Start/No Start and Performance Diagnostic Procedures that are used to obtain quick diagnostic information. This section also contains the Powertrain Diagnostic Trouble Code (DTC) "Go To" Charts. Section 3 will direct the technician to these tests when required.

Section 5: Pinpoint Tests

All the pinpoint tests are included in Section 5. Never enter a Pinpoint Test unless directed there. When directed to a Pinpoint Test, always read the information and look at the schematic included at the beginning of the Pinpoint Test.

Section 6: Reference Values

Section 6 contains the Control System Diagnostic Sheet Reference Chart.

Diesel Vehicle Emission Control Information Decal

Each vehicle has a decal (Figure 1) and (Figure 2) containing emission control information that applies specifically to the vehicle and engine.

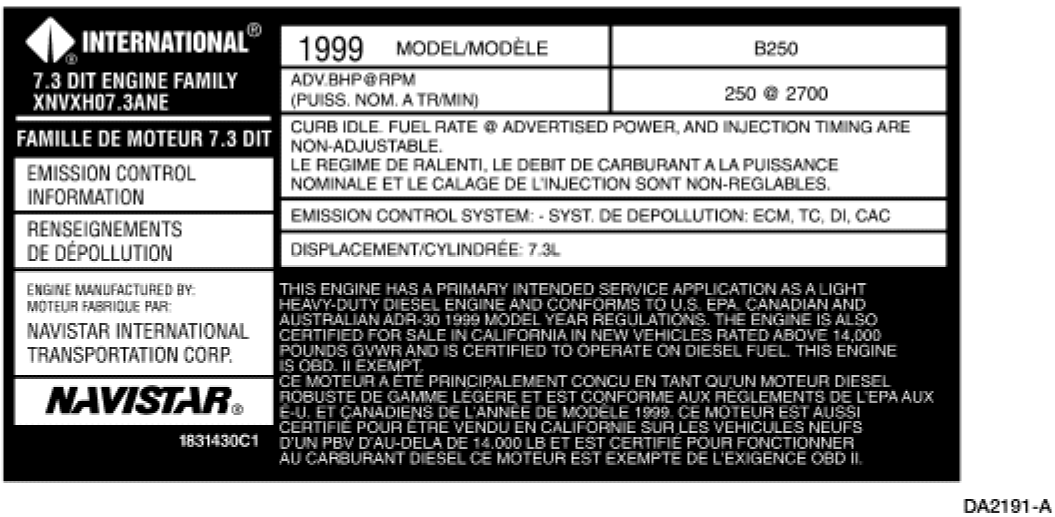


Figure 1: Typical Vehicle Emission Control Information Decal for 49-States Vehicles

Figure 2: Typical Vehicle Emission Control Information Decal for California Vehicles

The emission decal shows the model year, engine displacement, rated horsepower, fuel rate and idle speed.

Decal Location

Location of the decal will be on the RH valve cover.

Engine Calibration Identification

Use the NGS Tester to interpret the calibration code.

1. MODEL YEAR

   This number represents the model year in which the Calibration was first introduced (the model year 1999).

2. CALIBRATION DESIGN LEVEL

   Represents the design level assigned to the engine.

3. CALIBRATION REVISION LEVEL

   Represents the revision level of the calibration. These numbers will advance as revisions occur.

SECTION 1: Description and Operation

Diesel On Board Diagnostics II System

Overview

The California Air Resources Board (ARB) began regulation of On Board Diagnostic (OBD) for diesel vehicles sold in California beginning with the 1997 model year. OBD II requires monitoring of emission-related components. The Malfunction Indicator Lamp (MIL) was required to light and alert the driver of the malfunction and the need for service of the emission control system. The MIL must be labeled CHECK ENGINE. A fault code or Diagnostic Trouble Code (DTC) is associated with the MIL identifying the specific area of the fault.

The OBD II system meets government regulations by monitoring the emission control system. When a system or component exceeds emission thresholds or a component operates outside of tolerance, a Diagnostic Trouble Code (DTC) will be stored and the Malfunction Indicator Lamp (MIL) will be illuminated.

The OBD II Monitors detect system faults and initiate DTC setting and MIL activation. Fault detection strategy and MIL operation are associated with drive cycles. An OBD II pending DTC is stored in the PCM keep alive random access memory when a fault is first detected. The MIL is turned on after two consecutive drive cycles with the fault and the DTC is set. The DTC is cleared after 40 engine warm-up cycles without the fault being detected once the MIL is turned off. Once a Monitor turns on the MIL, it will require three consecutive drive cycles without a fault for the MIL to turn off. The operation of each of the OBD II Monitors is discussed in detail within this section.

The On Board diagnostic computer program in the Electronic EC Powertrain Control Module (PCM) coordinates the OBD II self-monitoring system. This program controls all the monitors and interactions, DTC and MIL operation, Freeze Frame data and scan tool interface.

Freeze Frame data describes stored engine conditions such as state of the engine rpm and load at the point the first fault is detected. This data is accessible with the scan tool to assist in repairing the vehicle.

OBD II Inspection Maintenance (IM) Readiness DTC P1000 indicates that not all of the OBD II monitors have been completed since the PCM's keep alive random access memory was last cleared. In certain states, it may be DTC P1000 cannot be present in order to purchase a vehicle license. To erase DTC P1000 from the PCM operate the vehicle until it is erased or use the manufacturer's specified drive cycle.

The On Board Diagnostic System is comprised of the Comprehensive Component Monitor, Glow Plug Monitor and Misfire Detection Monitor.

Diesel On Board Diagnostics II Monitors

This section provides a general description of each OBD II monitor. In these descriptions, the monitor strategy, hardware, testing requirements and methods are presented together to provide an overall understanding of each monitor operation. An illustration for each monitor is also provided to aid in the description. These illustrations should be used as typical examples and are not intended to represent all the possible configurations.

Each illustration depicts the Powertrain Control Module (PCM) as the main focus with the primary inputs and outputs for each monitor. The icons to the left of the PCM represent the inputs used by each of the monitor strategies to enable or activate the monitor. The components and subsystems to the right of the PCM represent the hardware and signals used while performing the tests and the systems being tested. The Comprehensive Component Monitor illustration has numerous components and signals involved and is shown generically. When referring to the illustrations, match the numbers to the corresponding numbers in the monitor descriptions for a better comprehension of the monitor and associated Diagnostic Trouble Codes (DTCs).

These monitor descriptions are intended as general information only.

Deviations From Standard Gasoline Implementation of OBD II

1. The Parameter IDs (PID) that are supported according to OBD II regulations are limited to: Calculated Load Value, MAP, VSS, IAT, and Engine Speed. Values for the other parameters are not accurate and are defaulted.

2. The Freeze Frame supports the following limited list of parameters: Freeze Frame Related Trouble Code, MAP, VSS and Engine Speed. Values for the other parameters are not representative and are defaulted.

3. Readiness (i.e.: all monitors complete) is based on diagnostics for the following 7.3L diesel engine systems:
   - Comprehensive Component Monitor (CCM)
   - Misfire Detection Monitor

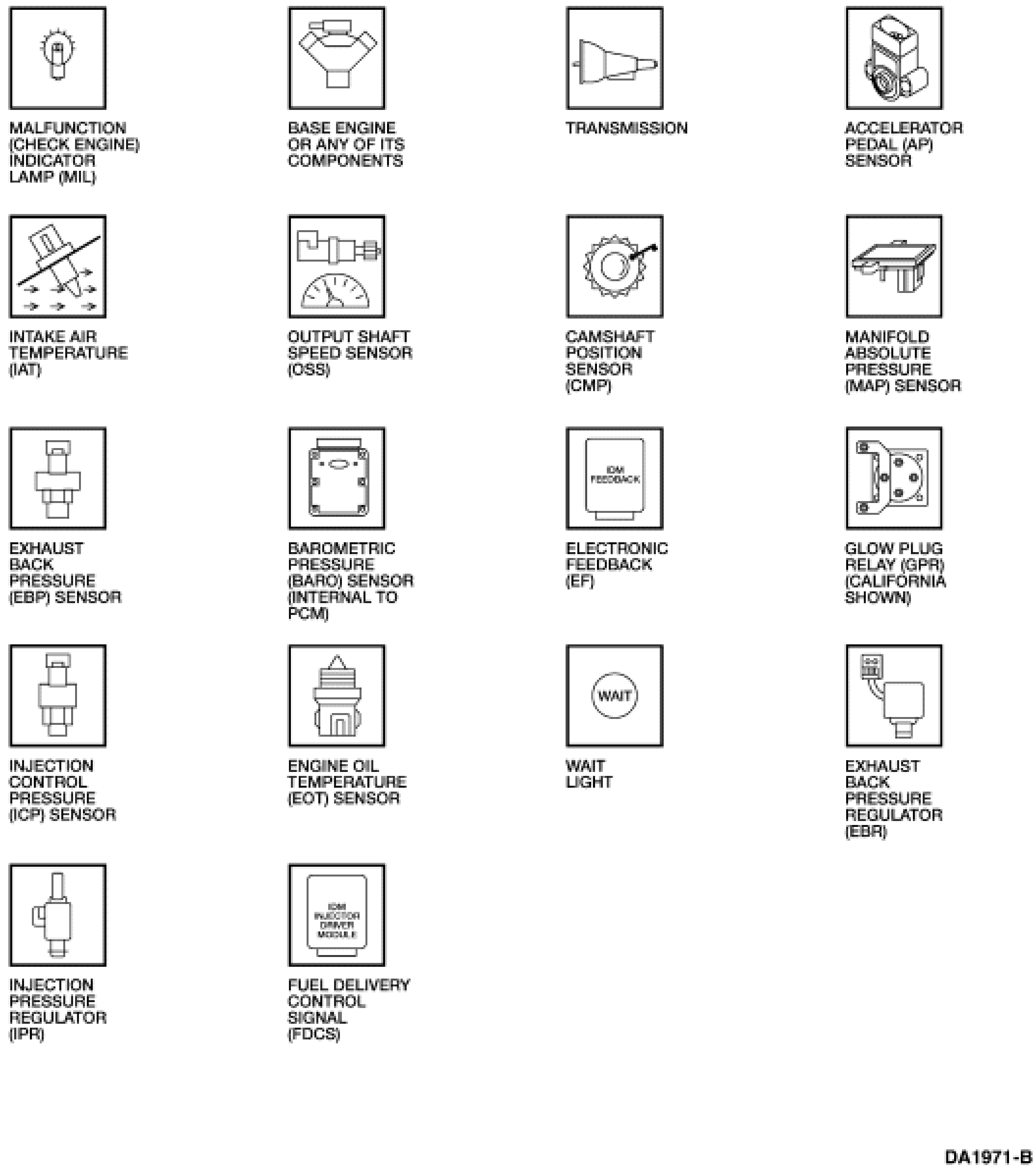
   The glow plug monitor is part of the comprehensive component monitor.

   Readiness is based on every OBD II code (component) having run sufficiently to have found a fault without regard to whether or not a fault exists.

4. The drive cycle provided in Section 2 is used to clear a P1000 code. Note that the diesel differs substantially from the gasoline system.

5. Unlike Ford gasoline vehicles, the OBD II command to Clear Codes will ONLY clear the OBD II system. Clearing codes from the vehicle specific menu will clear BOTH the manufacturer/vehicle specific codes and the OBD II codes. These icons are used in the

illustrations of the OBD II monitors and throughout this section.



Comprehensive Component Monitor

The Comprehensive Component Monitor (CCM) is an on-board strategy designed to monitor a fault in any electronic component or circuit that provides input or output signal to the Powertrain Control Module (PCM) and is not exclusively monitored by another monitor system. Inputs and outputs are considered inoperative when a failure exists due to a lack of circuit continuity, out-of-range value, or a failed rationality check.

The CCM covers many components and their circuits. The tests vary depending on the hardware, function, and type of signal. For example, analog inputs are typically checked for opens, shorts, out of range values and rationality. This type of monitoring is performed continuously. These tests may require the monitoring of several components and can only be performed under the appropriate test conditions. Outputs are checked for opens and shorts by monitoring the Output State Monitor (OSM) or circuit associated with the output driver when the output is energized or de-energized. Other outputs, such as relays, require additional OSM circuits to monitor the secondary side of the component. Some outputs are also monitored for the proper function by observing the reaction of the control system to a given change in the output command. An example of this would be the Injection Pressure Regulator (IPR) Valve.

In general, the CCM covers a broad range of individual component and circuit checks and testing is performed under various conditions. The CCM is enabled after the engine is started. Certain conditions are required before some components can be tested totally complete. A Diagnostic Trouble Code (DTC) is stored in continuous memory when a fault is determined, and the Malfunction Indicator Lamp (MIL) is activated if the fault detected affects emissions. Most of the CCM Monitor tests are also performed during on demand self-test.

The following is an example of some of the input and output components monitored by the CCM. The components monitored may belong to the engine, transmission or any other PCM supported subsystem.

1. Inputs:

   Engine Oil Temperature, Accelerator Position Sensor (AP), Camshaft Position (CMP),...

2. Outputs:

   Injection Pressure Regulator, Fuel Delivery Command Signal (FDCS), Shift Solenoid (SS), Torque Converter Clutch (TCC),...

3. The MIL is activated after a fault is detected on two consecutive drive cycles, if the fault detected affects emissions.

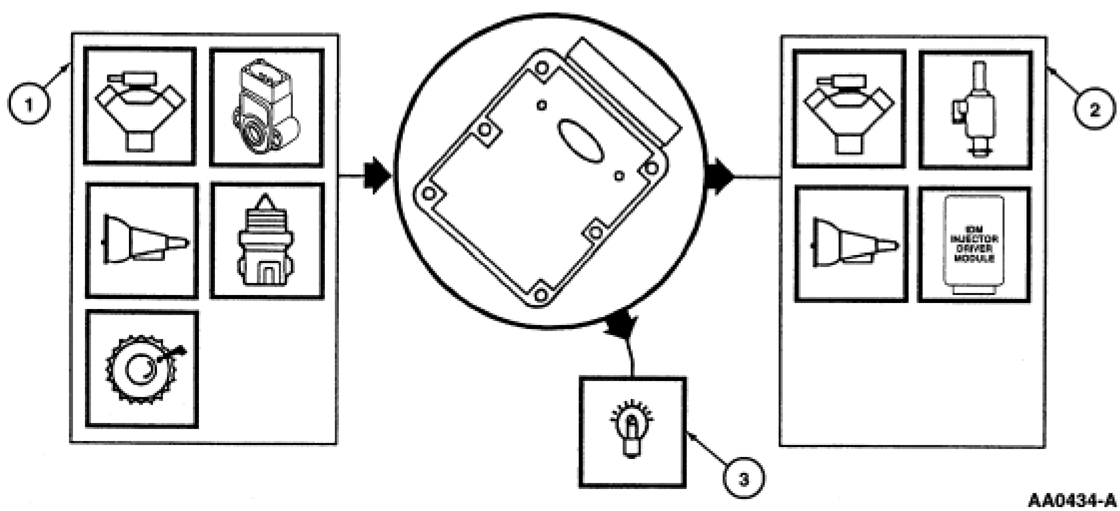
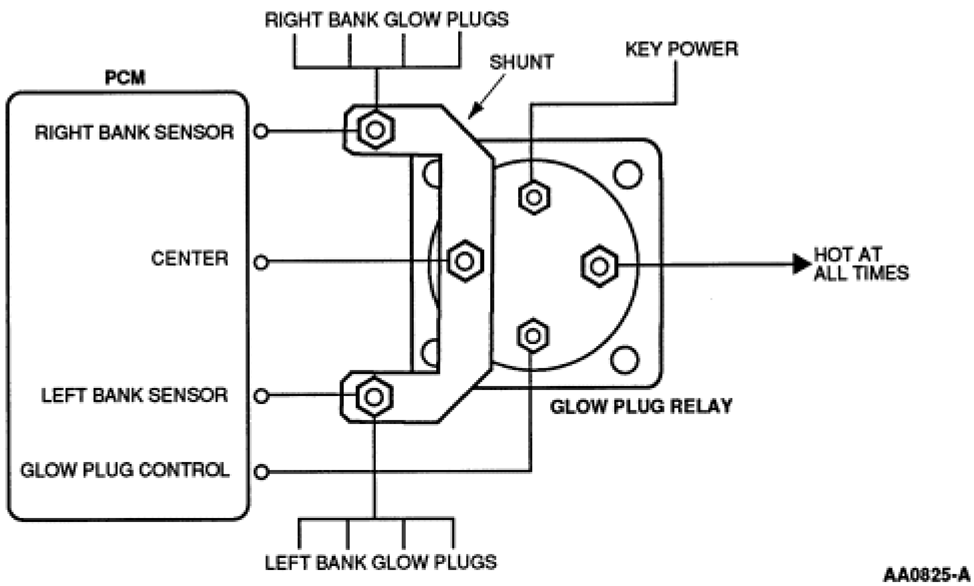


Figure 3: Comprehensive Component Monitor

Glow Plug Monitor

A diesel engine calibrated for California utilizes a Glow Plug Monitor (GPM) system designed to locate failed glow plugs or failed wiring in the glow plug system. Diagnostic Trouble Codes (DTCs) indicate which bank has failed glow plugs or failed glow plug wiring.

The GPM system uses a one piece conductor with two low resistance shunts. One shunt conducts current to the glow plugs in the left cylinder head and the other shunt conducts the current for the right cylinder head. Three sensing wires measure the voltage drops across the shunts when the glow plugs are operating (the voltage drops are proportional to the current in the shunt). The voltage drops are measured after the glow plug current stabilizes (approximately 30 seconds). Therefore, this system only checks glow plug operation when oil temperature and/or altitude conditions cause the glow plugs to stay on for 30 seconds or more and system voltage is between 11.5 and 14.0 volts.



During the KOER Glow Plug Monitor Test the glow plugs will be commanded on until the monitor is complete and will operate independent of oil temperature or altitude.

The GPM also checks the sensing wires for out of range readings. These checks indicate a shorted or open sensing wire, or a glow plug relay failure by setting DTCs. The DTCs are stored in continuous memory when a fault is determined, and the Malfunction Indicator Lamp (MIL) is illuminated on the second drive cycle if an OBD II fault is detected.

The glow plug relay coil is checked for opens or shorts as part of Comprehensive Component Monitoring.

The following is an example of some of the input and output components monitored by the GP monitor. The components monitored belong to the engine system.

1. Inputs:

   Engine Oil Temperature, Barometric Pressure Sensor (BARO), ...

2. Outputs:

   Glow Plug Relay (GPR), Glow Plugs

3. The MIL is activated after a fault is detected on two consecutive drive cycles, if the fault detected affects emissions.

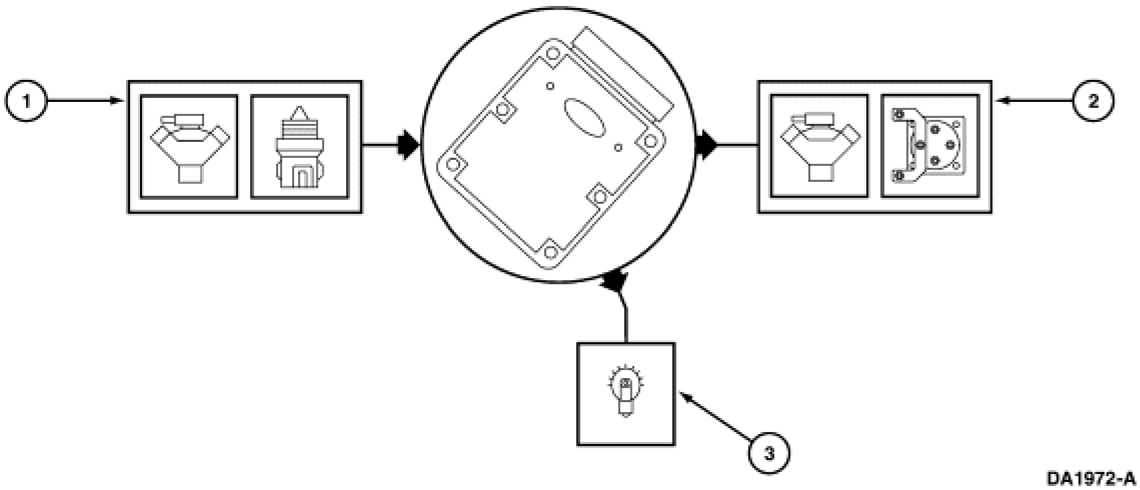


Figure 4: Glow Plug Monitor

1999 PCED On Board Diagnostics II Diesel SECTION 1: Description and Operation

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Malfunction Indicator Lamp (MIL)

The Malfunction Indicator Lamp (MIL) alerts the driver that the Powertrain Control Module (PCM) has detected an OBD II emission-related component or system fault. When this occurs, an OBD II Diagnostic Trouble Code (DTC) will be set.

- The MIL is located on the instrument panel and is labeled CHECK ENGINE.
- Power is supplied to the MIL whenever the ignition switch is in the RUN or START position.
- The MIL will remain on in the RUN/START mode as a bulb check until the CKP signal is detected.
- The light may also be on due to a short to ground of the MIL circuit.
- An engine, with federal calibration, operating in the Failure Mode Effects Management (FMEM) will cause the MIL to be on.
- To turn off the MIL after a repair, a clear code command from the Scan Tool must be sent.
- For any MIL concern, go to Section 3 , Symptom Charts.

Diesel Electronic EC System
Overview

The Electronic Engine Control (EC) system provides optimum control of the engine and transmission through the enhanced capability of the Powertrain Control Module (PCM). The Electronic EC also has an on-board diagnostics monitoring system (On Board Diagnostics II) with features and functions to meet federal regulations on exhaust emissions.

The Electronic EC system has two major divisions: hardware and software. The hardware includes the Powertrain Control Module (PCM), Injection Drive Module (IDM), sensors, switches, actuators, solenoids, and interconnecting terminals. The software in the PCM provides the strategy control for outputs (engine hardware) based on the values of the inputs to the PCM. Electronic EC hardware and software are discussed in this section.

The PCM receives information from a variety of sensor and switch inputs. Based on the strategy and calibration stored within the memory chip, the PCM generates the appropriate output. The system is designed to minimize emissions and optimize fuel economy and driveability. The software strategy controls the basic operation of the engine and transmission, provides the OBD II strategy, controls the Malfunction Indicator Lamp (MIL), communicates to the scan tool [New Generation Star (NGS), etc.] via the Data Link Connector (DLC), allows for Flash Electrically Erasable Programmable Read Only Memory (FEEPROM), fuel trim, and controls Failure Mode Effects Management (FMEM).

Modifications to OBD II Vehicles

Modifications or additions to the vehicle may cause incorrect operation of the OBD II system. Burglar alarms, cellular telephones and CB radios must be carefully installed. **Do not install these devices by tapping into or running wires close to powertrain control system wires or components.**

Diesel Powertrain Control Software

Multiplexing

The increased number of modules on the vehicle dictate a more efficient method of communication. Multiplexing is the process of communicating several messages over the same signal path. This process allows multiple modules to communicate with each other through the signal path (BUS+/BUS-). Modules communicate with the Powertrain Control Module using Standard Corporate Protocol (SCP) which determines the priority in which the signals are sent. (Refer to Standard Corporate Protocol for more information.)

Standard Corporate Protocol

The Standard Corporate Protocol (SCP) is a communication language used by Ford Motor Company for exchanging bi-directional messages (signals) between stand-alone modules and devices. Two or more signals can be sent over one circuit.

Included in these messages is diagnostic data that is output over the BUS + and BUS - lines to the Data Link Connector (DLC). This information is accessible with a scan tool. Information on this equipment is described in Section 2 , Diagnostic Methods.

Flash Electrically Erasable Programmable Read Only Memory

The Flash Electrically Erasable Programmable Read Only Memory (FEEPROM) is an Integrated Circuit (IC) within the PCM. This integrated circuit contains the software code required by the PCM to control the powertrain. One feature of the FEEPROM is that it can be electrically erased and then reprogrammed without removing the PCM from the vehicle. If a software change is required to the PCM, the module no longer needs to be replaced, but can be reprogrammed at the dealership through the Worldwide Diagnostic System (WDS) or New Generation Star (NGS) Tester. The reprogramming is done through the DLC.

Failure Mode Effects Management

Failure Mode Effects Management (FMEM) is an alternate system strategy in the PCM designed to maintain vehicle operation if one or more sensor inputs fail.

When a sensor input is perceived to be out-of-limits by the PCM, an alternative strategy is initiated. The PCM substitutes a fixed value and continues to monitor the incorrect sensor input. If the suspect sensor operates within limits, the PCM returns to the normal engine running strategy.

FMEM operation will result in Continuous Memory DTCs during normal engine operation and when performing Key On Engine Running Self-Test Mode.

Engine RPM Limiter

The Powertrain Control Module (PCM) limits engine rpm by cutting off fuel whenever an engine rpm overspeed (3500 rpm) condition is detected. The purpose of the engine rpm limiter is to prevent damage to the powertrain.

Vehicle Speed Limiter

In most applications, a diesel engine equipped vehicle is limited to a maximum speed of approximately 150 km/hr (95 mph). In certain applications (Ryder), the calibration is adjusted to limit maximum speed to 105-115 km/hr (65-70 mph).

Powertrain Control Module

The center of the Electronic EC system is a microprocessor called the Powertrain Control Module (PCM). The PCM has a 104-pin electrical connector. The PCM receives input from sensors and other electronic components (switches, relays, etc.) and places this information in RAM or Keep Alive RAM. Based on information programmed into its memory (ROM), the PCM generates output signals to control various relays, solenoids and actuators.

Keep Alive Random Access Memory (RAM)

The PCM stores information in Keep Alive RAM (a memory integrated circuit chip) about vehicle operating conditions, and then uses this information to compensate for component variability. Keep Alive RAM remains powered when the vehicle key is off so that this information is not lost.

Power and Ground Signals

Vehicle Power

When the key is turned to the start or run position, battery positive voltage (B+) is applied to the coil of the Electronic EC Power Relay. Since the other end of the coil is wired to ground, this energizes the coil and closes the contacts of the Electronic EC Power Relay. Vehicle power (VPWR) is now sent to the PCM and the Electronic EC System as VPWR.

Vehicle Reference Voltage

The Vehicle Reference Voltage (VREF) is a positive voltage (about 5.0 volts) that is output by the PCM. This is a consistent voltage that is used by the three-wire sensors.

Signal Return

The Signal Return (SIG RTN) is a dedicated ground circuit used by most Electronic EC sensors and some other inputs.

Power Ground

Power Ground (PWR GND) is an electric current path return for VPWR voltage circuit. The purpose of the PWR GND is to maintain sufficient voltage at the PCM.

Gold-Plated Pins

Some engine control hardware components have gold-plated pins on the connectors and mating harness connectors to improve electrical stability for low draw current circuits and to enhance corrosion resistance. The Electronic EC components equipped with gold terminals will vary by vehicle application.

Note: Damaged gold terminals should only be replaced with new gold terminals.

Diesel PCM Inputs

Air Conditioning Pressure Switch

The A/C Pressure Switch (ACPSW) (Figure 5) is used for additional A/C system pressure control. The ACPSW is either dual function for two speed electric fan applications or single function for all others. The ACPSW is also referred to as the Refrigerant Containment Switch (single function) or Refrigerant Containment/Fan Function Switch (dual function).

For refrigerant containment control, the normally closed high pressure contacts open at a predetermined A/C head pressure. This turns off the A/C by opening the A/C demand circuit, preventing the A/C pressure from rising to a level that would open the A/C High Pressure Relief Valve.

For fan function control, the normally open medium pressure contacts close at a predetermined A/C head pressure. This grounds the ACPSW circuit input to the PCM. The PCM will then turn on the high speed fan to help reduce the pressure.

For additional information, refer to the Service Manual Electrical Group, Ventilation/Climate Control Section.

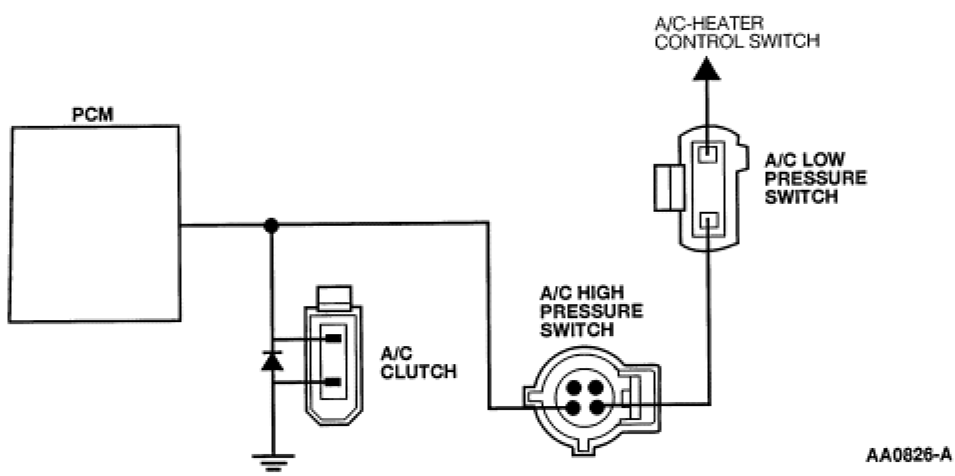


Figure 5: Air Conditioning Pressure Switch (ACPSW)

Brake Lamp Switch

The Brake Lamp Switch (Figure 6) signals the PCM with a battery positive voltage (B+) signal whenever the vehicle brake pedal is applied.

The signal informs the PCM to disengage the torque converter clutch and speed control.

If all the stoplamp bulbs are burned out (open), a high voltage is present at the PCM due to a pull-up resistor in the PCM. This provides fail-safe operation in the event the circuit to the Brake Lamp switch has failed.

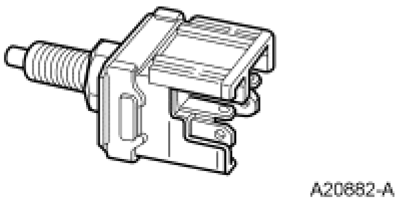


Figure 6: Brake Lamp Switch

Camshaft Position Sensor

The PCM receives engine rotational position information from the Camshaft Position (CMP) sensor (Figure 7). The CMP is a hall-effect device. It outputs 12 volts to the PCM whenever it detects the iron of a spoked target wheel in front of it, and it outputs 0 volts whenever it detects the space between the spokes. The target wheel spokes and spaces are each 15 crank degrees, except for narrow spoke which indicates cylinder No. 1 and a wide spoke which indicates cylinder No. 4 (fires 5th). The NGS PID RPM is generated by the PCM from the CMP signal.

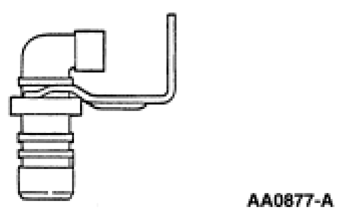


Figure 7: Camshaft Position (CMP) Sensor

Clutch Pedal Position Switch

The Clutch Pedal Position (CPP) switch (Figure 8) is an input to the PCM indicating the clutch pedal position. The CPP sends battery voltage to the PCM when the clutch is engaged (foot off of pedal) and zero voltage when the clutch is disengaged (pedal depressed).

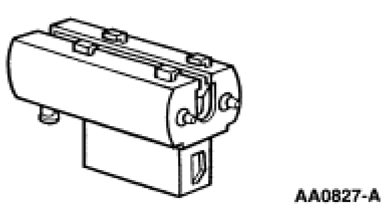


Figure 8: Clutch Pedal Position (CPP) Switch

Intake Air Temperature Sensor

The Intake Air Temperature (IAT) Sensors (Figure 9) are thermistor devices in which resistance changes with temperature. The electrical resistance of a thermistor decreases as the temperature increases, and increases as the temperature decreases. The varying resistance affects the voltage drop across the sensor terminals and provides electrical signals to the PCM corresponding to temperature.

Thermistor-type sensors are considered passive sensors. A passive sensor is connected to a voltage divider network so that varying the resistance of the passive sensor causes a variation in total current flow.

Voltage that is dropped across a fixed resistor in series with the sensor resistor determines the voltage signal at the PCM. This voltage signal is equal to the reference voltage minus the voltage drop across the fixed resistor.

The IAT signal provides air temperature information to the PCM. The PCM uses the air temperature information to operate the Exhaust Back Pressure (EBP) system and to determine the cold idle setpoint. During long idle periods at cold ambient temperatures, the setpoint will increase engine rpm.

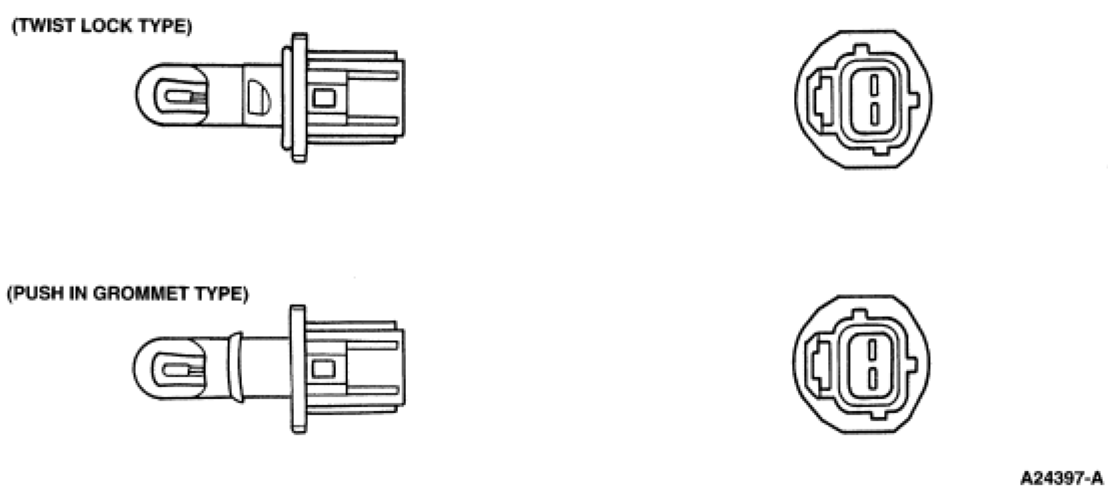


Figure 9: Intake Air Temperature (IAT) Sensor

Transmission Control Switch

The Transmission Control Switch (Figure 10) signals the PCM with key power whenever the transmission control switch is pressed. On vehicles with this feature, the Transmission Control Indicator Lamp (TCIL) (not shown) lights when the transmission control switch is cycled to disengage overdrive. The operator of the vehicle controls the position of the transmission control switch.

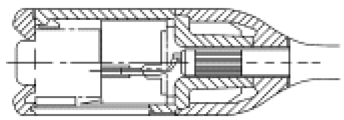


Figure 10: Column-Shift Transmission Control Switch

Vehicle Speed Sensor (Econoline Only)

For Econoline, the Vehicle Speed Sensor (VSS) (Figure 11) is a variable reluctance or Hall-effect type sensor that generates a waveform with a frequency that is proportional to the speed of the vehicle. If the vehicle is moving at a relatively low velocity, the sensor produces a signal with a low frequency. As the vehicle velocity increases, the sensor generates a signal with a higher frequency. The PCM uses the frequency signal generated by the VSS (and other inputs) to control such parameters as fuel injection, ignition control, transmission/transaxle shift scheduling and torque converter clutch scheduling.

For F-Series, the VSS signal is generated by the Programmable Speedometer/Odometer Module (PSOM). The PSOM generates VSS from a speed sensor on the rear axle.

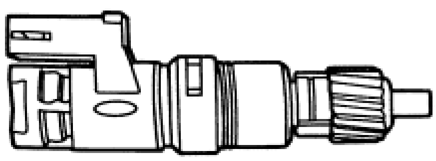


Figure 11: Vehicle Speed Sensor (VSS)

4x4 Low Switch

The 4x4 Low Switch sends a ground signal to the PCM when in 4x4L. This input is used to adjust the shift schedule.

Accelerator Pedal Sensor

The Accelerator Pedal (AP) sensor provides the PCM with the driver's demand for power. The AP sensor is a three-wire potentiometer that receives VREF from the PCM and returns a signal to the PCM directly proportional to the accelerator pedal position. The AP signal is used in calculating fuel quantity. Also, the AP input is used by the PCM to control the exhaust back-pressure regulator.

A PCM detected fault of the AP sensor will illuminate the Malfunction Indicator Lamp in the instrument cluster. An AP signal that is detected out of range, high or low, will cause the PCM to only allow the engine to operate at low idle.

Idle Validation Switch

The Idle Validation Switch verifies when the accelerator pedal is in the idle position. This switch protects against in-range failure of the AP sensor.

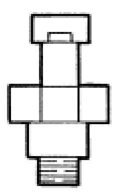
A PCM detected fault of the Idle Validation Switch will illuminate the Malfunction Indicator Lamp. An inoperative Idle Validation Switch detected by the PCM will only allow the engine to run at idle.

Exhaust Back-Pressure Sensor

The Exhaust Back-Pressure sensor is a variable capacitor sensor that is supplied a 5-volt reference signal by the PCM and returns a linear analog voltage signal that indicates pressure. The Exhaust Back-Pressure sensor measures the pressure in the RH exhaust manifold. This sensor is used in conjunction with the exhaust back-pressure regulator to form a closed loop exhaust back-pressure control system.

The exhaust back-pressure is controlled by the PCM to provide more heat to the coolant for cab heating when ambient air temperature is below 7° C (45°F) and engine oil temperature is below 75°C (167°F) during low load, low speed operating conditions.

An open or short in the Exhaust Back-Pressure sensor wiring will result in a low out of range voltage at the PCM, and the PCM will disable Exhaust Back-Pressure control.

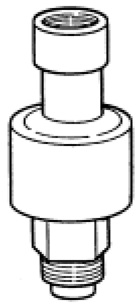


AA0828-A

Injection Control Pressure Sensor

The Injection Control Pressure sensor is a variable capacitor sensor that is supplied a 5-volt reference signal by the PCM and returns a linear analog voltage signal that indicates pressure. The sensor measures the oil pressure in the LH injection rail. PCM uses this information to determine injection control pressure. The Injection Control Pressure sensor along with the Injection Control Pressure Regulator form a closed loop fuel pressure control system.

If the PCM detects an inoperative Injection Control Pressure sensor, the PCM will control injection control pressure from a PCM-estimated injection control pressure.



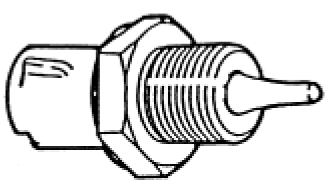
AA0829-A

Engine Oil Temperature Sensor

The Engine Oil Temperature sensor is a thermistor mounted to the oil reservoir whose resistance decreases as engine oil temperature increases. The Engine Oil Temperature signal is used by the PCM to calculate fuel quantity, injection timing, glow plug operation and exhaust back-pressure.

At oil temperatures below 50°C (122° F), low idle is increased to a maximum of 900 rpm to increase engine warm-up. Fuel quantity and timing is controlled throughout the total operating range to provide adequate torque and power.

An Engine Oil Temperature signal detected out of range, high or low, by the PCM will cause the PCM to assume an engine oil temperature of 20° C (68°F) for starting purposes and 100° C (212°F) for operating purposes. The Malfunction Indicator Lamp in the instrument cluster will be illuminated as long as the fault condition exists.

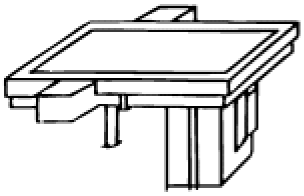


AA0830-A

Analog Manifold Absolute Pressure Sensor

The analog Manifold Absolute Pressure (MAP) sensor is a variable capacitor sensor that is supplied a 5-volt reference signal by the PCM and returns a voltage signal to the PCM relative to intake manifold pressure. The sensor voltage increases as pressure increases. The MAP sensor allows the PCM to determine engine load to calculate fuel quantity. In addition, the MAP signal is used to control smoke by limiting fuel quantity during acceleration until a specified boost pressure is obtained.

A MAP signal fault detected by the PCM will cause the PCM to calculate an estimated manifold pressure based on known engine conditions.



DA1453-A

Barometric Pressure Sensor

The Barometric Pressure (BARO) sensor is a variable capacitor sensor that processes a signal indicating atmospheric pressure. This allows the PCM to compensate for altitude. The PCM uses this information to calculate injection timing and glow plug control. With the 1999-1/2 model, the BARO sensor is no longer a stand alone component. It has been incorporated into the PCM.

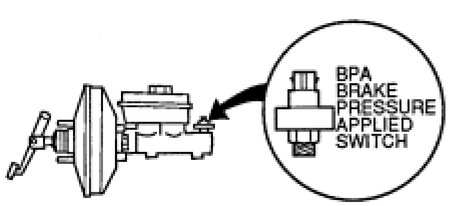
A BARO sensor fault will result in an out-of-range signal to the PCM. The PCM will assume a default value of 100 kPa (14.5 psi).

Parking Brake Signal Switch

The Parking Brake Signal switch indicates when the parking brake is applied. The Parking Brake Signal switch is located under the instrument panel. The Parking Brake Signal switch will deactivate speed control if the parking brake is applied during speed control operation.

Brake Pressure Applied

The Brake Pressure Applied switch is a hydraulically-actuated pressure switch that senses brake pressure and provides a back-up to the stoplight switch to deactivate speed control. The switch is totally independent (mechanically and electrically) from the brake lamp switch. The Brake Pressure Applied switch actuates after the Stoplight switch actuates. When the brake pedal is depressed, the switch is open. When the brake pedal is released, the switch is closed. The Brake Pressure Applied switch is located on the brake master cylinder.



AA0833-A

Speed Control Command Switches

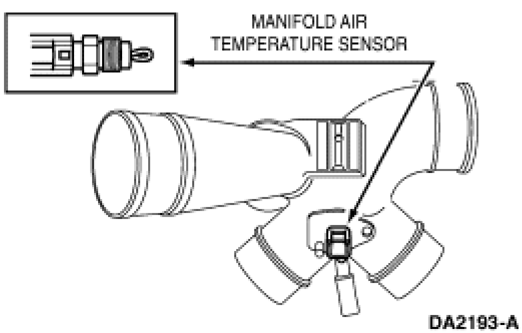
The Speed Control Command Switches are momentary switches which are located on the steering wheel. They consist of one ON-OFF switch and one SET/ACCEL-COAST-RESUME switch. These switches, when pressed, select one of several resistance values which is sent to the PCM to select speed control functions.

Injector Driver Module Feedback

The Injector Driver Module (IDM) provides an EF signal to the PCM which confirms that proper timing/duration of the PCM command was received by the IDM. The EF signal is also used to send diagnostic information about the IDM and fuel injector circuitry.

Manifold Air Temperature (MAT) Sensor

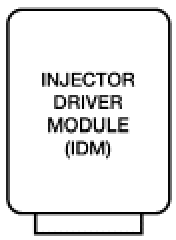
The PCM receives an intake air temperature from the manifold intake air (MAT) sensor. Based on this signal the PCM adjusts fuel and timing. The sensor is located in the compressor manifold downstream from the intercooler.



Diesel PCM Outputs

Injector Driver Module

The Injector Driver Module controls power to the fuel injectors based on information received from the PCM. The Injector Driver Module receives two digital control signals from the PCM: the Fuel Delivery Control Signal and the Camshaft Position signal. The Fuel Delivery Control Signal is used by the Injector Driver Module to control injection timing and injection duration. The CMP signal provides synchronization to the engine's first and the fifth injector (firing order, cylinders number one and four). The Injector Driver Module verifies that Fuel Delivery Control Signal and CMP occur at valid timing intervals for synchronization.

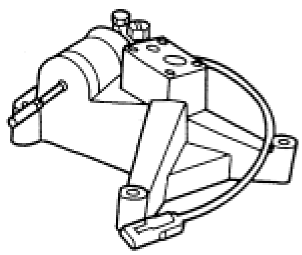


DA2194-A

Exhaust Back Pressure Regulator

Exhaust back pressure is controlled to provide more heat to the coolant for cab heating when ambient air temperature is below 5°C (40° F) and engine oil temperature is between -10° C (15°F) and 83°C (182°F) during low load. At high load, high speed conditions, the back pressure system is disabled.

The exhaust back pressure regulator solenoid and exhaust back pressure piston are contained in the turbocharger mounting pedestal. Turbocharger pressurized lube oil is routed to the exhaust back pressure solenoid. Oil regulated by the exhaust back pressure solenoid actuates the piston which operates the back pressure valve in the exhaust housing.

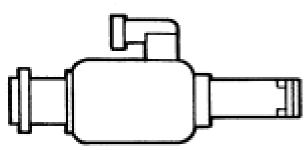


AA0835-A

Injection Pressure Regulator

The Injection Pressure Regulator controls injection oil pressure. An electrical signal to a solenoid creates a magnetic field which applies a variable force on a valve servo to control pressure. The quantity of fuel delivered to the combustion chamber is proportional to injection control pressure.

An open circuit will result in minimum oil pressure and a no-start situation. A short circuit results in maximum oil pressure, and is limited by a mechanical pop-off valve to 27,580 kPa (4000 psi).

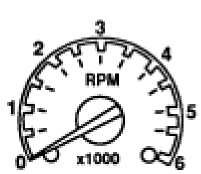


AA0836-A

Tachometer Output

The Tachometer Output provides a signal from the PCM to the instrumentation system. The signal is a buffered representation of the Camshaft Position Sensor (CMP). The tachometer is part of the instrument cluster.

An open or short circuit of the tachometer output wiring will result in an inoperative tachometer.

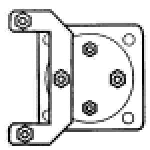


AA0837-A

Glow Plug Relay Control

The Glow Plug (GP) Relay Control is used to energize the glow plugs for assisting cold engine start-up. Engine Oil Temperature, battery positive voltage (B+), and Barometric Pressure (BARO) are used by the PCM to calculate glow plug on-time and the length of the duty cycle. On-time normally varies between 10 and 120 seconds. With colder oil temperatures and lower barometric pressures, the plugs are on longer. If battery voltage is abnormally high, the duty cycle is shortened to extend plug life. (The glow plug relay will only cycle on and off repeatedly when there is a system high voltage condition greater than 16 volts.)

An open in the glow plug relay circuit will render the glow plugs inoperative. A short circuit will result in a glow plug's always ON condition.



AA0838-A

Glow Plug Light Signal

The Glow Plug (GP) light signal controls the WAIT TO START indicator light located on the instrument panel. When the light goes off, the engine is ready to be started. As a bulb check, the light comes on every time a key on reset occurs, even though the glow plug system is not commanded on. On-time normally varies between 1 and 10 seconds. WAIT TO START light on-time is independent of glow plug relay on-time because the glow plugs may stay on to improve performance until engine reaches operating temperature.

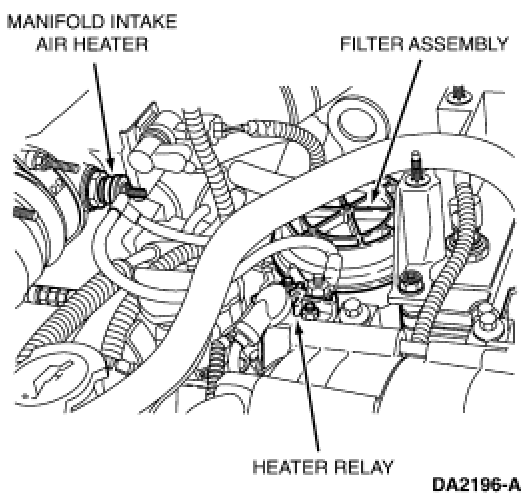
An open circuit in the glow plug light wiring will result in an inoperative glow plug light. A short circuit will result in a glow plug light always ON condition.

AA0839-A

Manifold Intake Air Heater

To reduce white smoke during long idle periods at low ambient temperatures, the ECM will activate the intake air heater. Specific conditions must be present before the heater is activated:

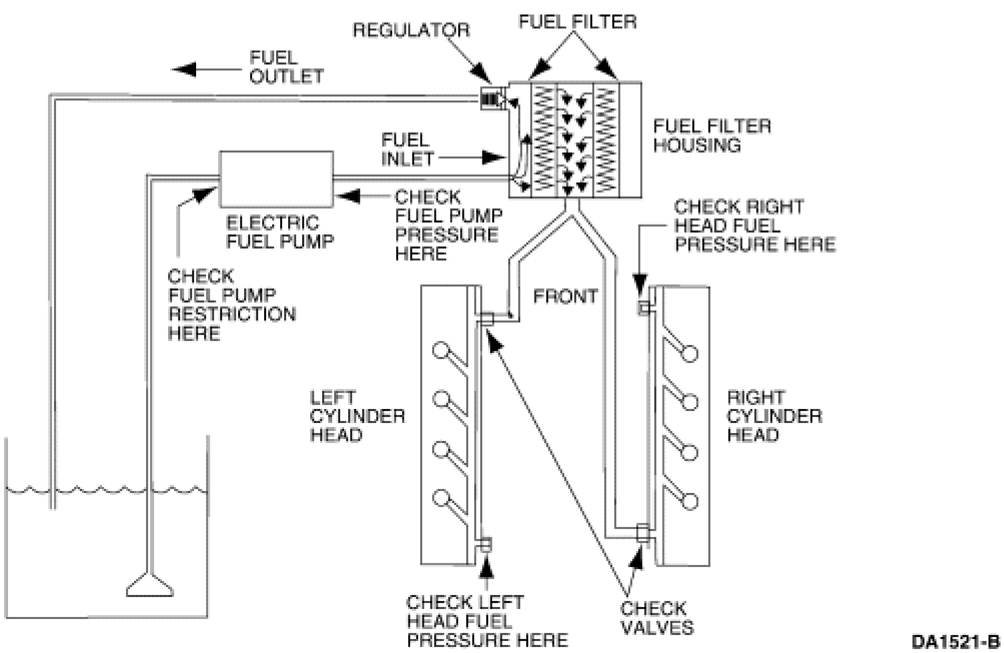
- ambient temperature must be below 0°C (32° F)
- engine oil temperature (EOT) must be below 55°C (131° F)
- vehicle power (IVPWR) must be between 11.8 and 15.0 volts


MANIFOLD INTAKE AIR HEATER
FILTER ASSEMBLY
HEATER RELAY
DA2196-A

Diesel Fuel System

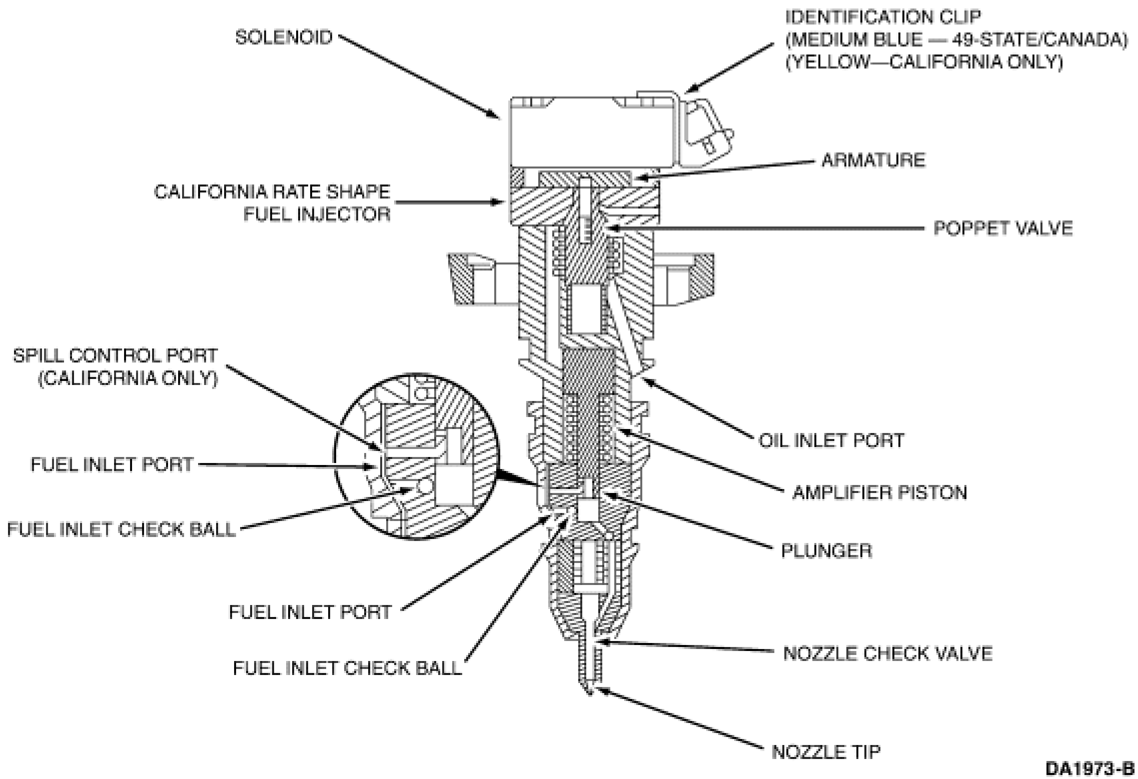
Fuel System

Fuel is drawn from the fuel tank through the primary filter (the screen on the fuel tank sending unit) by the electric fuel pump. Pressurized fuel (approximately 276-552 kPa [40-80 psi]) is supplied to the secondary filter (the fuel filter housing located in the V on top of the engine) by means of the electric pump and regulator valve. The regulator relieves the pressure, sending fuel back to the fuel tank. Only the filtered fuel going through the fuel filter will go to the heads. A check valve is located on both heads to prevent fuel pressure spikes in the fuel rail.



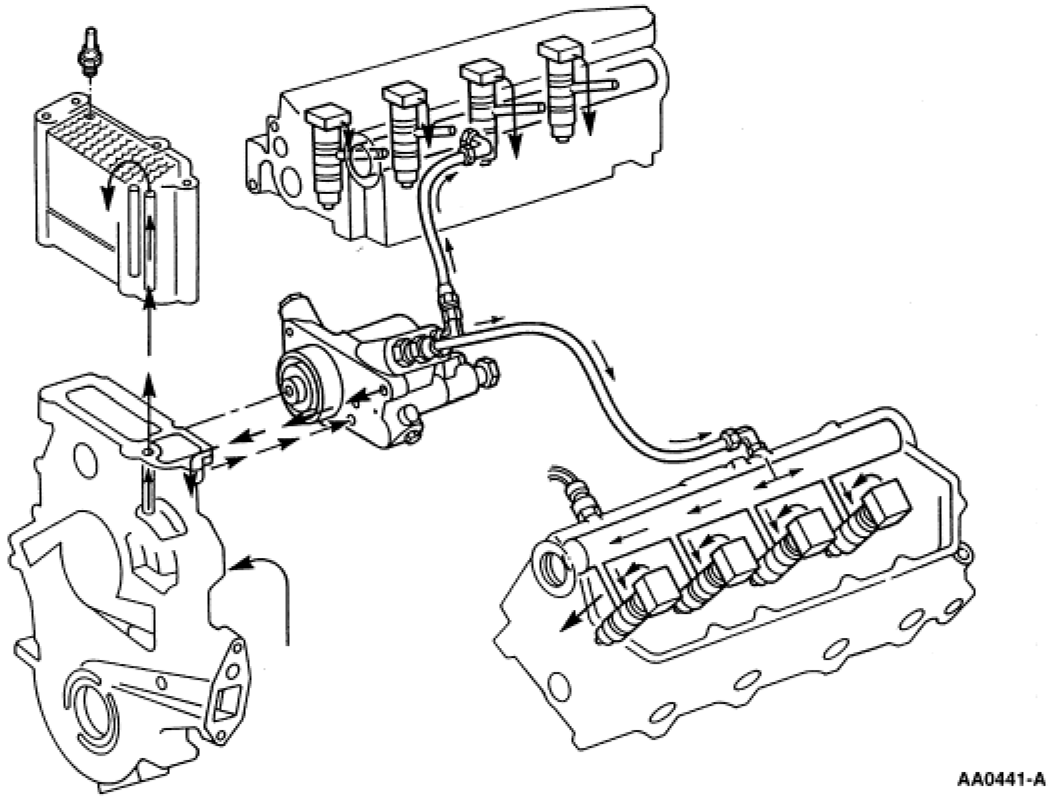
Unit Injector

The unit injector is composed of five major components: The electronic solenoid, the poppet valve, the amplifier piston, the fuel plunger and the nozzle assembly. Operation of the injector is included in the following description.



High Pressure Oil System

The 7.3L Powerstroke diesel injectors are powered by lubricating oil which is pressurized by a swashplate pump (Rexroth pump) in the engine valley. The pump output pressure ranges from 3,102 to 20,685 kPa (450 psi to 3,000 psi). Oil pressure is controlled by the Powertrain Control Module (PCM) through the Injector Pressure Regulator Valve. The PCM controls pressure in the oil rail by opening (relieving pressure) and closing (increasing pressure) the IPR valve. The high pressure oil is delivered to oil rails in the cylinder heads. An Injection Control Pressure sensor mounted on one of the oil rails sends an analog voltage signal (0.5V to 5.0V) to the PCM for feedback control of the oil pressure.



Unit Injector Amplifier Piston

The high pressure oil flows from the oil rails into an amplifier piston located in the injector. Oil entry and exit to and from the amplifier piston is controlled by a solenoid-operated poppet valve.

Unit Injector Fuel Plunger

The fuel plunger is located in the injector and is driven by the amplifier piston. The fuel plunger injects fuel into the combustion chamber at pressures of up to 144,795 kPa (21,000 psi) through the nozzle assembly. Fuel is supplied to the fuel at approximately 483 kPa (70 psi) through fuel rails in the cylinder heads.

Injection Driver Module

The solenoid-operated poppet valve requires 115 volts at up to 8 amps to operate, which is more power than the PCM can supply. Therefore, a high power device, the Injection Driver Module, is used to supply power to the solenoid on command from the PCM.

PCM Control of Fuel Injection

The command signal from the PCM to the Injection Driver Module is the Fuel Delivery Control Signal. The poppet requires 12 volts to command the poppet open and 0 volts to command the poppet closed. The PCM also supplies a synchronizing signal, CMP, to indicate cylinder No. 1 (going from 0 to 12 volts) and cylinder No. 4 (fires 5th) (going from 12 to 0 volts).

Engine Timing

The PCM controls both duration and timing of the injection event with the fuel delivery control signal. Signal duration, or fuel pulse width, is shown as Parameter ID (PID) "FUEL_PW" on the New Generation Star (NGS) Tester.

The PCM controls the fuel plunger injection pressure and fuel volume by varying the injection oil pressure with the Injection Pressure Regulator. The command to the Injection Pressure Regulator is a 12 volt, Pulse Width Modulated (PWM) signal (controlled on the ground side).

The injection oil pressure command is shown as NGS PID IPR which is the percentage ON of the pulse width modulated signal. Injection oil pressure is shown as NGS PID ICP.

The PCM receives engine rotational position information from the Camshaft Position sensor (CMP). The CMP is a hall-effect device. It outputs 12 volts to the PCM whenever it detects the iron of a spoked target wheel in front of it, and it outputs 0 volts whenever it detects the space between the spokes. The target wheel spokes and spaces are each 15 crank degrees, except for narrow spoke which indicates cylinder No. 1 and a wide spoke which indicates cylinder No. 4 (fires 5th). The NGS PID RPM is generated by the PCM from the CMP signal.

Fueling Corrections

The PCM adjusts injector output based on oil temperature information received from the Engine Oil Temperature sensor and turbo boost information received from the Manifold Absolute Pressure (MAP) Sensor, and the Barometric pressure (BARO) sensor. These corrections are necessary to meet emissions requirements and to optimize power. Outputs of these sensors are displayed on the NGS tester as EOT (temperature), MAP (boost pressure), BARO (pressure), and BARO V (volts). MGP shows boost.

Diesel Intake Air Systems

Intake Air System

This is similar to a gasoline system except it processes more air. It includes a filter minder to indicate when the air filter is clogging. The system feeds into the turbocharger compressor. Econoline systems include a resonator.

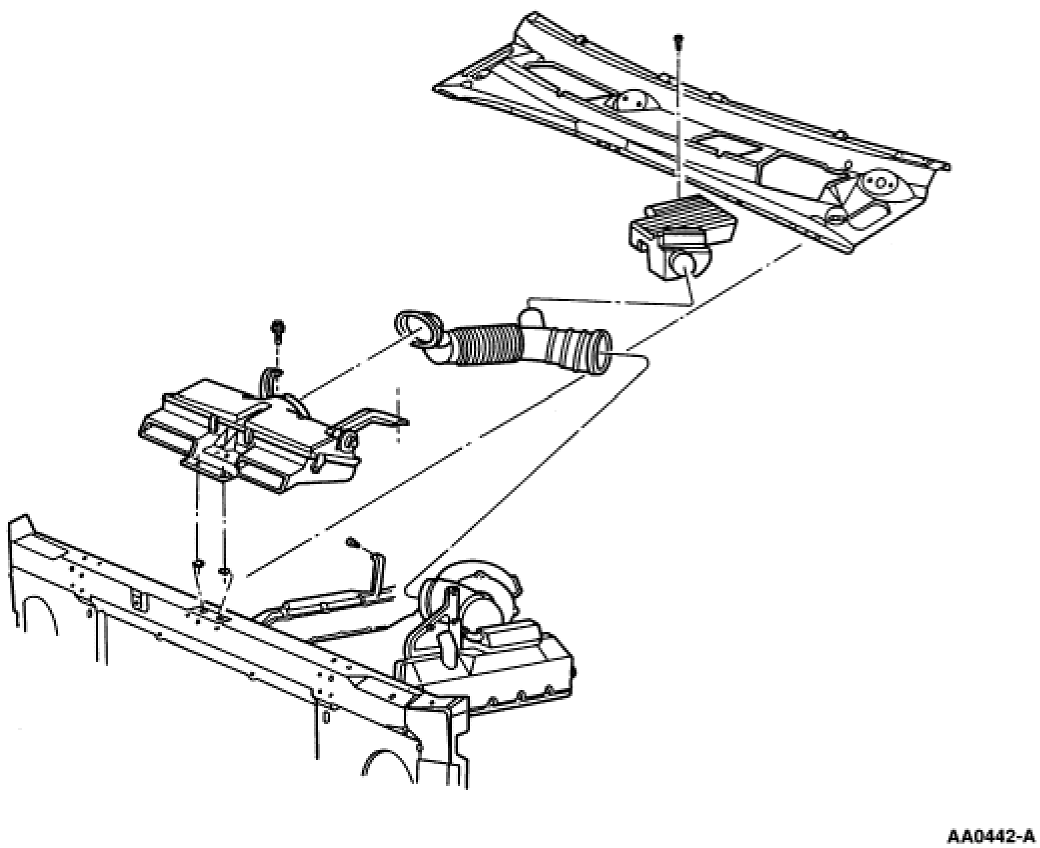


Figure 12: Engine Air Cleaner, 7.3L Diesel Engine—Econoline

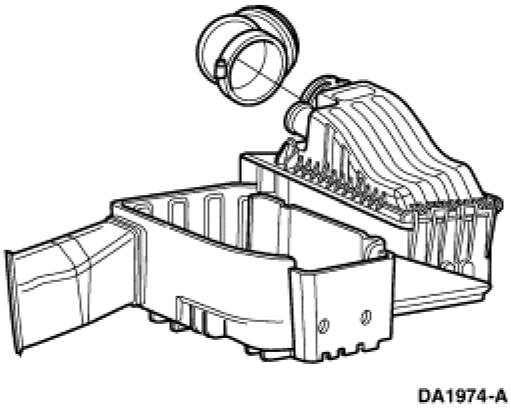


Figure 13: Engine Air Cleaner Installation, 7.3L Direct Injection Diesel Engine— F-Series

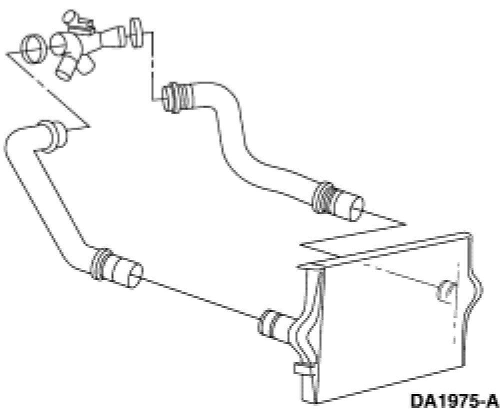


Figure 14: Turbocharger Intake Air Tube Assembly

Diesel Catalyst and Exhaust Systems

Catalytic Converter

Beginning with the 1999.5 model, the 7.3L diesel engine is no longer equipped with a catalytic converter.

Powertrain Control/Emissions Diagnosis

1999

On Board Diagnostics II Diesel

SECTION 2: Diagnostic Methods

SECTION 2: Diagnostic Methods

Diagnostic Methods

Overview

The Diagnostic Methods section provides detailed instructions on how to access or perform routine diagnostic tasks. This section can be referenced as many times as needed for step-by-step instructions for routine procedures.

When performing powertrain diagnostics, the system may be checked by an off board tester referred to as a scan tool. This section contains instructions for performing diagnostics with the New Generation Star (NGS) Tester.

Diagnostic Tools

Required Equipment

- New Generation Star (NGS) Tester 007-00500 or equivalent
- 104-Pin Breakout Box 014-00950 or equivalent
- 23 Multimeter 105-00050 or equivalent. Input impedance 10 megaohm minimum.
- 5/16-inch Fuel Line Disconnect Tool (Gray) 310-040 (T90T-9550-B) or equivalent.
- 3/8-inch Fuel Line Disconnect Tool (Blue) 310-041 (T90T-9550-C) or equivalent.
- Oil Pressure Leakage Test Adapters Set 303-5626.
- Fuel Pressure Adapter 310-D007 (D94T-6600-B) or equivalent.
- Fuel Pressure Adapter 310-D008 (D94T-6600-C) or equivalent.
- Crankcase Pressure Test Adapter 5631 or equivalent.
- Glow Plug Injector Adapter 134-00132 or equivalent.
- 7.3L Crankcase Test Adapter 014-0743 (D87T-6582-A) or equivalent.
- ICP/EBP Adapter Cable 418-D003 (D94T-50-A) or equivalent.
- Pressure Test Adapter Kit 014-00761 or equivalent.

Optional Equipment

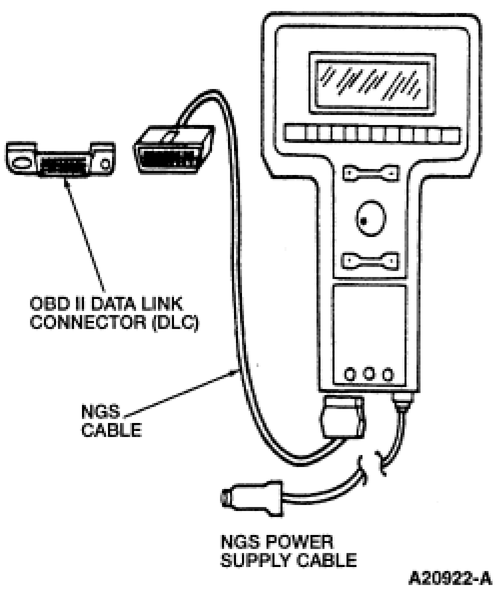
- R134A Manifold Gauge Set 176-R932A or equivalent.
- Non-powered test lamp.
- Service Bay Diagnostic System® (SBDS®) 001-00001.
- Vacuum/Pressure Tester 164-R0253 or equivalent. Range 101.3 kPa (0.30 in-Hg). Resolution 3.4 kPa (1 in-Hg).
- Fuel/Oil/Turbo Protector Cap Set T94T-9395-AH or equivalent.

SBDS® is a stand-alone system containing universal testers and meters, specialized diagnostic tools and guided diagnostics. OASIS, Electrical and Vacuum Troubleshooting Manuals (EVTMs), Powertrain Control/Emissions Diagnosis (PC/ED) manuals, and Technical Service Bulletins (TSBs) are also available on SBDS®.

Note: Refer to equipment user's manual for details on tool accessories and function.

Scan Tool Hookup

The NGS Tester or generic scan tool must be connected to the Data Link Connector (DLC) for communication with the vehicle.



Data Link Connector

The DLC is located in the passenger compartment. It is attached under the dash-board and accessible from the driver's seat.

The DLC is rectangular in design and capable of accommodating up to 16 terminals. The connector has keying features to allow easy connection. The vehicle connector and the test equipment connector have latching features that ensure the test equipment connector will remain mated when properly connected.

The NGS Tester is capable of many functions. Some of these are as follows.

- Monitor, Record and Playback of PIDS
- Diagnostic Test Modes/Clear Diagnostic DTCs (PCM Reset)
- Digital Measurement System (DVOM, Duty Cycle and Pulse Width Meter)

- Diagnostic Monitoring Test Results (for OBD II On-Board Monitoring)
- On-Board System Readiness (OBD II Monitor Completion Status)
- Clear and Retrieve 4WABS Codes

Some of these functions are described in this section.

Refer to the NGS Tester Instruction Manual or scan tool manufacturer's manual for specific information on scan tool setup and operation. Contact Rotunda for the latest version of the NGS Tester Instruction Manual at 1-800-ROTUNDA.

Note: You must recycle the key between each self test.

New Generation Star (NGS) Tester

- Key off.
- Verify that the proper memory (EPROM) card is inserted in the NGS Tester.
- Connect DLC adapter cable to the NGS Tester.
- Connect NGS Tester DLC adapter cable securely into the vehicle DLC.
- Connect the NGS Tester power supply cable to vehicle battery power supply through cigarette lighter, at the vehicle battery with alligator clip adapter, at the dashboard power point or into the pigtail power connector attached to the DLC adapter cable.
- Turn ignition key to the on position or start vehicle if necessary. The NGS Tester is ready to communicate with vehicle computers.

- Follow instructions on the NGS Tester or in the diagnostic manual.
- To disconnect NGS Tester, turn ignition key to the off position and disconnect NGS Tester from DLC and power supply.

Generic Scan Tool

- Refer to scan tool manufacturer's manual for specific cables and/or adapters required for scan tool hookup.

Communication Error

It is possible to get a communication error from a scan tool when initiating a test or viewing PIDs. The communication error could be caused by operator error, the vehicle wiring or connectors, or the powertrain control module (PCM) and other control modules connected to the DLC wiring. The PCM will respond to a scan tool whenever the scan tool requests a test. Some are normal responses to valid requests. The others are communication error responses. If the scan tool displays any of the communication error responses reinitialize the scan tool. If the error is still present, refer to Section 5, Pinpoint Test QA — Step QA1 , after checking scan tool connections, cable/adapters and entry of vehicle information. Verify auxiliary powertrain control (rpm control) is off when trying to perform self tests.

Quick Test Description

Quick Test is divided into eight specialized tests:

1. Retrieve/Clear Continuous DTCs
2. Key On Engine Off (KOEO) On-Demand Self Test
3. Key On Engine Off (KOEO) Injector Electrical Self Test
4. Key On Engine Off (KOEO) Output State Self Test
5. Key On Engine Running (KOER) On-Demand Self Test
6. Key On Engine Running (KOER) Switch Self Test
7. Key On Engine Running (KOER) Cylinder Contribution Self Test
8. Key On Engine Running (KOER) Glow Plug Monitoring Self Test

All eight are described below.

Quick Test checks the integrity and function of the EEC-V Powertrain Control system and outputs the test results upon demand. Quick Test also provides a quick end check of the powertrain control system and is usually performed at the start of each diagnostic procedure. It is also performed at the end of most pinpoint tests for verification of repair and to make sure no other faults were incurred while servicing a previous fault.

All self tests are completely menu driven in the New Generation Star (NGS) Tester.

Note: Retrieving continuous DTCs must be performed separately from KOEO Quick Tests.

Retrieve/Clear Continuous DTCs

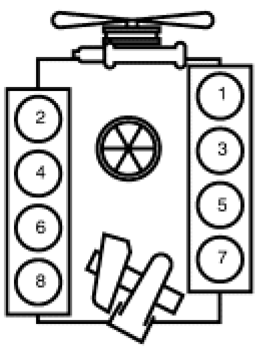
Retrieve/Clear Continuous DTCs is a functional test of the PCM. DTCs can be retrieved or cleared with the key on and the engine off or running. Unlike KOEO and KOER self tests, which can only be activated on demand, the Continuous monitor is always active in monitoring the system. When a fault is detected, a code will be stored in memory to be retrieved at a later date, making it possible to diagnose intermittent faults. For California vehicles, P1000 DTC may be the only code displayed, indicating an incomplete OBD II drive cycle (more drive time needed). The IDM stores both historical and hard IDM fault codes. To retrieve IDM fault codes, you must run KOEO On Demand Self Test or KOEO Injector Electrical Self Test. The only way to clear IDM DTCs is to Clear Continuous even though IDM codes do not show up on the Continuous display.

Key On Engine Off (KOEO) On-Demand Self Test

Key On Engine Off (KOEO) On-Demand Self Test is a functional test of the PCM performed on demand with the key on and the engine off. This test will check that all inputs and outputs (circuits, sensors, regulators, relays and solenoids) connected to the PCM are electrically operating without fault, with the exception of the Injector Driver Module DTCs. The IDM stores both historical and hard IDM fault codes; to ensure that IDM DTC is a hard fault, you must first clear continuous DTCs (be sure to record all fault codes before clearing). After clearing, rerun self test; a fault must be present at the time of testing for the KOEO On Demand Self Test to detect the fault. If a fault is detected, a Diagnostic Trouble Code (DTC) will be the output on the data link at the end of the test when requested by a scan tool. Only a hard fault code (DTC) will be displayed.

Key On Engine Off (KOEO) Injector Electrical Self Test

Key On Engine Off (KOEO) Injector Electrical Self Test is a functional test of the PCM performed on demand with the key on and the engine off. This test determines if the injector circuits and solenoids are electrically operating without fault. All injectors will first buzz (audible feedback of the injector solenoids energizing the injector valves) together for approximately 2 seconds, then each injector will buzz for approximately 1 second in numerical order (1 through 8). The IDM stores all historical IDM fault codes; to ensure that the DTC is a hard fault, you must first clear continuous DTCs (be sure to record all IDM fault codes before clearing). After clearing, rerun self test; a fault must be present at the time of testing for the KOEO Injector Electrical Self Test to detect the fault. If a fault is detected, a Diagnostic Trouble Code (DTC) will be the output on the data link at the end of the test when requested by a scan tool. Only a hard fault code (DTC) will be displayed.



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Key On Engine Off (KOEO) Output State Self Test

Key On Engine Off (KOEO) Output State Self Test is a functional test of the PCM performed on demand with the key on and the engine off. This test is designed to cycle outputs high and low. After pressing the trigger to start the test, you must then depress and release the accelerator pedal to cycle the outputs high: solenoids, wait to start lamp, IDM relay, TCIL, FDCS, CID and EF. The second time the accelerator pedal is depressed and released the outputs are cycled low, with the exception of the glow plug relay, which is cycled on for 5 seconds the first time only that the accelerator is pressed and released. This Self Test does not set any codes.

Key On Engine Running (KOER) Switch Self Test

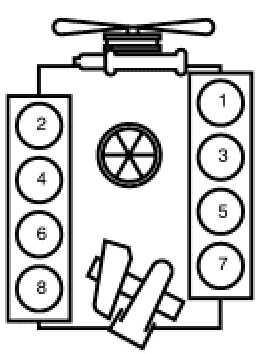
Key On Engine Running (KOER) Switch Self Test is a functional test of the PCM performed on demand with the engine running. This test is designed to set DTC(s) if the test does not detect a transition on one or more of the switches. After pressing the trigger to start the test, wait 5 seconds before running through the driver-operated controls to eliminate the chance of setting a false IVS code. The accelerator pedal must first be depressed and released to begin test, then the Parking Brake, Speed Control ON, OFF, SET, RESUME, COAST, Transmission Control or Clutch. The last to be depressed and released must be the brake pedal, which will test both the brake pressure applied (BPA) switch and the brake ON/OFF (BOO) switch.

Key On Engine Running (KOER) On-Demand Self Test

Key On Engine Running (KOER) On-Demand Self Test is a functional test of the PCM performed on demand with the engine running. Temperature is not a factor, but A/C must be turned off. A check is made on the injection control pressure (ICP) and exhaust back pressure (EBP) systems. During this test, engine rpm will increase; the PCM will first command ICP high and low, then command EBP high and low. A fault must be present at the time of testing for the KOER On Demand Self Test to detect a fault. If a fault is detected, a Diagnostic Trouble Code (DTC) will be the output on the data link at the end of the test when requested by a scan tool. Only a hard fault code (DTC) will be displayed.

Key On Engine Running (KOER) Cylinder Contribution Self Test

Key On Engine Running (KOER) Cylinder Contribution Self Test is a functional test of the PCM performed on-demand with the engine running, A/C off and engine oil temperature above 21°C (70° F). This test will determine if all cylinders are contributing equally to engine performance. The PCM will test all 8 cylinders continuously during the test; there is no change in engine speed or operation that can be detected by the technician. The test checks for cylinder-to-cylinder decrease in speed, and sets a code if the decrease is too high. The test consists of three portions. Each portion runs for 20 seconds. The first test checks for a badly missing injector or cylinder with no compression, and the second and third tests check for weak injectors or low compression cylinders. A fault must be present at the time of testing for the KOER Cylinder Contribution Self Test to detect a fault, so the engine operating condition at which the idle is the worst will produce the best test results. For automatic transmission vehicles, the best results are reached with the parking brake set and the transmission in DRIVE. If a fault is detected, a Diagnostic Trouble Code (DTC) will be output on the data link at the end of the test when requested by a scan tool. Only a hard fault code (DTC) will be displayed.



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Key On Engine Running (KOER) Glow Plug Monitor Self Test

Key On Engine Running (KOER) Glow Plug Monitor Self Test (California only) is a functional test of the PCM performed on demand with the engine running and the A/C off. The test will raise engine speed to 1200 rpm to maintain a system voltage of 11.5-14 volts. The PCM will activate the glow plug relay and monitor the glow plug circuits. A fault must be present at the time of testing for the test to detect a fault. If one bank is reading less than 32 amps or one bank is reading at least 8-1/2 amps lower than the other bank, a fault will be detected and a Diagnostic Trouble Code (DTC) will be output on the data link at the end of the test when requested by a scan tool. Only a hard fault code (DTC) will be displayed.

MIL DTCs

MIL DTCs are generated to alert the driver that there is a concern with the system or the vehicle is in Failure Management Effects Mode (FMEM). MIL DTCs are also used to indicate an emission concern for California vehicles. Non-MIL DTCs indicate a less serious or non-emission related concern with the system.

Quick Test Operation

Quick Test is performed by retrieving KOEO, KOER, and Continuous DTCs.

Special Notes

Before running Quick Test, always perform the necessary visual checks and safety precautions listed below.

Visual Check

- Inspect the air cleaner and inlet ducting.
- Check system wiring harness for proper connections, bent or broken pins, corrosion, loose wires, proper routing, etc.
- Check the PCM, sensors and actuators for physical damage.
- Check the engine coolant for proper level and mixture.
- Check the transmission fluid level and quality.
- Make all necessary repairs before continuing with Quick Test.

Vehicle Preparation

- Perform ALL safety steps required to start and run vehicle tests. Apply parking brake, place shift lever firmly into PARK position (NEUTRAL on manual transmission), block drive wheels, etc.
- Turn off ALL electrical loads-radios, lights, A/C, blower, fans, etc.
- Start engine and bring up to normal operating temperature before running Quick Test.

Quick Test Operation

For a Hard Start/No Start concern or a Performance concern, refer to Section 4 . For all other concerns, refer to the Symptom Charts in Section 3 . Quick Test is performed by retrieving KOEO, KOER and Continuous Memory DTC's. If a code is retrieved, you must then go to the appropriate Pinpoint Test. If unable to complete a self test, go to Pinpoint Test QA1 .

Key On Engine Off (KOEO) On-Demand Self Test
KOEO On-Demand Self Test

Connect the NGS Tester to the DLC under the dash. Turn off accessories. If vehicle is equipped with an auxiliary powertrain control (rpm control), it must be turned off to perform self tests.

- Perform the necessary vehicle preparation and visual inspection. Refer to Quick Test Operation .
- Select VEHICLE & ENGINE SELECTION menu.
- SELECT CORRECT VEHICLE, YEAR and MODEL.
- Select PCM — POWERTRAIN CONTROL MODULE.
- Select DIAGNOSTIC TEST MODE.
- Select KOEO ON DEMAND SELF TEST.
- Turn key on.
- Follow operating instructions from the menu.
- Record DTCs and follow appropriate pinpoint test.
- After test, cycle key to off before running other tests or driving vehicle.

If performing repeated self tests, it may be necessary to unplug glow plug relay to keep battery from going dead. Ignore any glow plug codes while glow plug relay is unplugged.

Key On Engine Running (KOER) On-Demand Self Test
KOER On-Demand Self Test

Connect the NGS Tester to the DLC under the dash. Turn off accessories. Turn A/C off. If vehicle is equipped with an auxiliary powertrain control (rpm control), it must be turned off to perform self tests.

Note: Engine will run rough during this test.

- Perform the necessary vehicle preparation and visual inspection. Refer to Quick Test Operation .
- Start engine.
- SELECT CORRECT VEHICLE, YEAR and MODEL.
- Select DIAGNOSTIC DATA LINK.
- Select PCM — POWERTRAIN CONTROL MODULE.
- Select DIAGNOSTIC TEST MODE.
- Select KOER ON DEMAND SELF TEST.
- Follow operating instructions from the menu.
- Record DTCs and follow appropriate pinpoint test.
- After test, cycle key to off before running other tests or driving vehicle.

Retrieve/Clear Continuous DTCs
Retrieve/Clear Continuous DTCs

Connect the NGS Tester to the DLC under the dash. Turn off accessories. If vehicle is equipped with an auxiliary powertrain control (rpm control), it must be turned off to perform self tests.

- Perform the necessary vehicle preparation and visual inspection. Refer to Quick Test Operation .
- SELECT CORRECT VEHICLE, YEAR and MODEL.
- Select DIAGNOSTIC DATA LINK.
- Select PCM — POWERTRAIN CONTROL MODULE.
- Select DIAGNOSTIC TEST MODE.
- Select RETRIEVE/CLEAR CONTINUOUS DTCs
- Turn key on.
- Follow operating instructions from the menu.
- Record DTCs and follow appropriate pinpoint test for continuous code diagnostics.
- After test, cycle key to off before running other tests or driving vehicle.
- Continuous DTCs must be cleared after repair is made.

KOEO Injector Electrical Self Test
KOEO Injector Electrical Self Test

Note: If no DTCs are present and the KOEO Injector Electrical Self Test aborts while trying to perform, go to Pinpoint Test NA — Step NA29 .

Connect the NGS Tester to the DLC under the dash. Turn off accessories. If vehicle is equipped with an auxiliary powertrain control (rpm control), it must be turned off to perform self tests.

- Perform the necessary vehicle preparation and visual inspection. Refer to Quick Test Operation .
- SELECT CORRECT VEHICLE, YEAR and MODEL.
- Select DIAGNOSTIC DATA LINK.
- Select PCM — POWERTRAIN CONTROL MODULE.
- Select DIAGNOSTIC TEST MODE.
- Select KOEO INJECTOR ELECTRICAL SELF TEST.
- Follow operating instructions from the menu.
- Record DTCs and follow appropriate pinpoint test.
- After test, cycle key to off before running other tests or driving vehicle.

KOEO Output State Self Test
KOEO Output State Self Test

Connect the NGS Tester to the DLC under the dash. Turn off accessories. If vehicle is equipped with an auxiliary powertrain control (rpm control), it must be turned off to perform self tests.

- Perform the necessary vehicle preparation and visual inspection. Refer to Quick Test Operation .
- SELECT CORRECT VEHICLE, YEAR and MODEL.
- Select DIAGNOSTIC DATA LINK.
- Select PCM — POWERTRAIN CONTROL MODULE.
- Select DIAGNOSTIC TEST MODE.
- Select KOEO output state self test.
- Follow special instructions on screen.
- Depress and release accelerator pedal to cycle output state on relays, solenoids, wait to start light, FDCS, EF, CID and TCIL. When the accelerator pedal is pressed for the first time, the glow plug relay will receive a 5 second on-command.
- After test, cycle key to off before running other tests or driving vehicle.

KOER Switch Self Test
KOER Switch Self Test

Connect the NGS Tester to the DLC under the dash. Turn off accessories. If vehicle is equipped with an auxiliary powertrain control (rpm control), it must be turned off to perform self tests.

- Perform the necessary vehicle preparation and visual inspection. Refer to Quick Test Operation .
- Start engine.
- SELECT CORRECT VEHICLE, YEAR and MODEL.
- Select DIAGNOSTIC DATA LINK.
- Select PCM — POWERTRAIN CONTROL MODULE.
- Select DIAGNOSTIC TEST MODE.
- Select KOER switch self test.
- Follow instructions on screen. After pressing the trigger to start the test, wait 5 seconds before running through the driver-operated controls. The test may also take up to 5 minutes to complete.
- After test, cycle key to off before running other tests or driving vehicle.

KOER Cylinder Contribution Self Test
KOER Cylinder Contribution Self Test

Connect the NGS Tester to the DLC under the dash. Turn off accessories. Turn A/C off. If vehicle is equipped with an auxiliary powertrain control (rpm control), it must be turned off to perform self tests.

- Perform the necessary vehicle preparation and visual inspection. Refer to Quick Test Operation .
- Start engine.
- SELECT CORRECT VEHICLE, YEAR and MODEL.
- Select DIAGNOSTIC DATA LINK.
- Select PCM — POWERTRAIN CONTROL MODULE.
- Select DIAGNOSTIC TEST MODE.
- Select KOER cylinder contribution self test.
- Follow instructions on screen.
- After test, cycle the key to off before running other tests or driving vehicle.

KOER Glow Plug Monitoring Self Test
KOER Glow Plug Monitoring Self Test
CALIFORNIA

Connect the NGS Tester to the DLC under the dash. Turn off accessories. Turn A/C off. If vehicle is equipped with an auxiliary powertrain control (rpm control), it must be turned off to perform self test.

Note: When running this self test, battery voltage must not drop below 11.5 volts or go above 14 volts. Make sure that batteries are OK and the charging system is working properly.

- Perform the necessary vehicle preparation and visual inspection. Refer to Quick Test Operation .
- Using a digital multimeter connected to the battery, monitor voltage. It may be necessary to raise rpm to maintain voltage.
- Start engine.
- Parking brake set, automatic transmission in PARK or manual transmission in NEUTRAL.
- SELECT CORRECT VEHICLE, YEAR and MODEL.
- Select DIAGNOSTIC DATA LINK.
- Select PCM — POWERTRAIN CONTROL MODULE.
- Select KOER GLOW PLUG MONITOR SELF TEST.
- Follow instructions on screen.
- Maintain system voltage until test is complete.
- Record DTCs and follow appropriate pinpoint test.

Parameter Identification (PID)

The Parameter Identification (PID) mode allows access to certain data values, analog and digital inputs and outputs, calculated values, and system status information. Throughout the manual, there will be references to PID values. PID Data Monitor and Record can be accessed from the Rotunda New Generation Star (NGS) Tester 007-00500 (or equivalent) through the Diagnostic Data Link menu.

Selecting Parameter Identification (PID)

Connect the NGS Tester to the DLC under the dash. Turn off accessories. If vehicle is equipped with an auxiliary powertrain control (rpm control), it must be turned off to perform self tests.

- Perform the necessary vehicle preparation and visual inspection. Refer to Quick Test Operation .
- SELECT CORRECT VEHICLE, YEAR and MODEL.
- Select DIAGNOSTIC DATA LINK.
- Select PCM — POWERTRAIN CONTROL MODULE.
- Select PID/DATA MONITOR AND RECORD.
- Turn key on or start vehicle.
- Follow operating instructions from the menu.
- Select the PIDs, press START to begin monitoring.

Parameter Identification (PID) List

Acronym	Description	Measurement Units
4x4L	4x4 Low Switch	ON/OFF
ACCS	Air Conditioning Clutch Status	ON/OFF
AP	Accel Pedal Position Sensor	Volts
ARPMDES	Ancillary Engine Speed Desired	RPM
BARO	Barometric Pressure Sensor	PSI
BARO V	Barometric Pressure Sensor Actual	Volts
BPP_BOO	Brake ON/OFF Switch	ON/OFF
BPA	Brake Pressure Applied	ON/OFF
CCS	Coast Clutch Solenoid	ON/OFF
CPP/TCS	Clutch Pedal Position/TCS	ON/OFF
CRUISE	Cruise Control Mode (Driving)	ON/STNDBY/TAPUP/TAPDN
CAS GND	Case Ground	Volts

DTC CNT	Diagnostic Trouble Code Count	DTC No.
EOT_V	Engine Oil Temperature Actual	Volts
EBP	Exhaust Back Pressure	PSI (Absolute)
EBP V	Exhaust Back Pressure Actual	Volts
EOT	Engine Oil Temperature	°F
EPC*	Electronic Pressure Control	PSI
EPC V	Electronic Pressure Control Actual	Volts
EPR	Exhaust Pressure Regulator	Percent
FLI	Fuel Level Input	Percent
FLI V	Fuel Level Input Actual (Voltage)	Volts
FP	Fuel Pump Control	Duty Cycle (100% = On)
FUEL PW	Fuel Pulse Width	Milliseconds
GEAR	Transmission Gear E4OD Only (Driving)	Trans. Gear
GPC	Glow Plug Control Duty Cycle	Percent
GPC TM	Glow Plug Control Time	Seconds
GPL TM	Glow Plug Lamp Time	Seconds
GPML	Glow Plug Monitoring Left Bank	Amp
GPMR	Glow Plug Monitoring Right Bank	Amp
IAT*	Intake Air Temperature	Degrees
IAT V	Intake Air Temperature Actual	Volts
ICP	Injector Control Pressure Sensor	PSI
ICP V	Injection Control Pressure Actual	Volts
IPR	Injector Control Pressure Regulator	Percent
IVS	Idle Validation Switch	ON/OFF
MAP	Manifold Absolute Pressure Sensor	PSI (Absolute)
MAP_V	Manifold Absolute Pressure Actual	Volts
MAT	Manifold Air Temperature	Degrees
MAT V	Manifold Air Temperature Actual (Voltage)	Volts
MFDES	Mass Fuel Desired	Milligrams
MGP	Manifold Gauge Pressure	PSI
PBA	Parking Brake Applied	ON/OFF
PERDEL 1	Percent Delta Cylinder #1 (Misfire Data)	Percent
PERDEL 2	Percent Delta Cylinder #2 (Misfire Data)	Percent

PERDEL 3	Percent Delta Cylinder #3 (Misfire Data)	Percent
PERDEL 4	Percent Delta Cylinder #4 (Misfire Data)	Percent
PERDEL 5	Percent Delta Cylinder #5 (Misfire Data)	Percent
PERDEL 6	Percent Delta Cylinder #6 (Misfire Data)	Percent
PERDEL 7	Percent Delta Cylinder #7 (Misfire Data)	Percent
RPM	Engine Speed	RPM
SCCS	Speed Control Command Switch	Volts
SCCS M	Speed Control Command Switch Mode	Mode
SS1	Shift Solenoid No. 1 — E4OD Only	ON/OFF
SS2	Shift Solenoid No. 2 — E4OD Only	ON/OFF
TCC	Torque Converter Clutch	ON/OFF/Percent
TCIL	Transmission Control Indicator Lamp	ON/OFF
TFT V*	Transmission Fluid Temperature Sensor Actual	Volts
TORQUE	Engine Torque	Lb/Ft
TPREL	Low Idle Throttle Position	V
TR	Transmission Range Sensor Position	PARK, REV, NTRL, OD, DRIVE, MAN2, MAN1
TR_D	Transmission Range Sensor Digital Signal	O's/1's
TR V	Transmission Ranger Sensor Actual	Volts
VFDES	Volume Fuel Desired	Cubic Millimeters
VPWR	Vehicle Power Supply	Volts
VREF	Vehicle Reference Voltage	Volts
VS SET	Vehicle Speed Setting	MPH
VSS	Vehicle Speed Sensor	MPH
WGC	Wastegate Control	Duty Cycle

* Designates PIDs that show PCM calculated values during fault.

NGS TESTER — DRIVER-OPERATED CONTROLS CHECK					
PID	**Operator's Setting**	**NGS Tester**	**EEC**	**Voltage**	**Pinpoint**

		Reading	Pin		Test
AP	Foot OFF of Accelerator Foot ON at WOT	Approx. 0.6V Approx. 3.8 V	89	Approx. 0.6V Approx. 3.8V	DO
IVS	Foot OFF of Accelerator Foot ON Accelerator	OFF ON	10	0V B+	FE
BOO	Foot ON Service Brake Foot OFF Service Brake	ON OFF	92	B+ 0V	FD
BPA	Foot ON Service Brake Foot OFF Service Brake	ON OFF	31	0V B+	FB
CPP/TCS	(M5OD) Clutch Depressed Foot OFF Clutch Pedal	 ON OFF	29	 0V B+	FC
PBA	Parking Brake ON Parking Brake OFF	ON OFF	5	0V B+	FF
CPP/TCS	(E4OD) Key On: Push CNCL (Latch) Push CNCL (VF Latch)	OFF ON OFF	29	0V B+ 0 V	*
TR	(E4OD) PRNDL in P PRNDL in R PRNDL in N PRNDL in OD PRNDL in OD with OD Cancel Light ON PRNDL in L2 PRNDL in L1	 PARK REV NTRL OD DRIVE MAN2 MAN1	64	 4.45V 3.64V 2.87V 2.87V 2.13V 1.40V 0.71V	*
TCIL	(E4OD) After Key ON Push OD Cancel (Latch) Push OD Cancel (Unlatch)	 OFF ON OFF	79	 0V B+ 0V	*
SCCS M	(Speed Control) After Key ON Speed Control OFF Speed Control ON SET/ACCEL COAST	 OPEN OFF ON SET AC COAST	61	 6.68V 0V B+ 2.74V 0.68V	FG

	RESUME	RESUME		4.66V	
CRUISE	(Speed Control/When Driving Only)		61		FG
OFF	OFF	OFF		0V	
	ON	STNDBY		B+	
	SET/ACCEL (After Pressing)	Tap Up (Active)		2.74V	
	COAST (After Pressing)	Tap Down (Active)		0.68V	
4x4L	(Transfer Case Shifter)		14		FH
	4x4H or 2H	OFF		B+	
4x4L (Cont'd)	4x4L	ON	0 V		
ACCS	(A/C Controls)		41		FA
	MAX/NORM AC or MIX/DEF with A/C Clutch ON	ON		B+	
	Floor or Vent or A/C Clutch OFF	OFF		0 V	

* Refer to the Powertrain Group in the Workshop Manual.

Accumulating PCM Data

Accumulating PCM data can be done in a number of ways. Gather as much data as possible when the malfunction is occurring to prevent misdiagnosis. Data should be accumulated in different operating conditions and based on the customer description of the intermittent fault. Acquisition of PCM PID data using a scan tool is one of the easiest ways to gather information. Listed below are instructions for gathering PID data using a Rotunda New Generation Star (NGS) Tester 007-00500.

Selecting and Viewing PIDs

1. Select VEHICLE & ENGINE SELECTION menu.
2. SELECT CORRECT VEHICLE, YEAR and MODEL.
3. Select DIAGNOSTIC DATA LINK.
4. Select PCM — POWERTRAIN CONTROL MODULE.
5. Select PID/DATA MONITOR AND RECORD.

6. Select the PIDs from the intermittent symptom chart or the PCM Pinpoint Test. The star symbol next to each PID on the screen indicates that PID has been selected. Scroll through the PID list using the menu dial and select PIDs using the trigger button.

7. Turn ignition key on or start vehicle.

8. Select the START key and access the PIDs.

Storing PIDs

1. When ready to capture and store the selected PIDs, press the trigger button.

2. Press trigger again when ready to save information.

3. Information saved is now located in the main recording area. Save to a viewing area before starting another recording or the data will be overwritten.

Recording Measurements Along with PIDs

1. Select DIGITAL MEASUREMENT SYSTEM.

2. Select a meter (i.e., VOLTMETER).

3. Select PIDs.

4. Select the PIDs and START recording.

5. Press REC to save DVOM function and PID data.

Playback of Stored PIDs

Look for abnormal behavior or values that are clearly incorrect. Inspect the signals for abrupt or unexpected changes. For example, during a steady cruise most of the sensor values should be relatively stable. Sensors such as accelerator pedal (AP), manifold absolute pressure (MAP) and rpm that change abruptly when the vehicle is traveling at a constant speed are clues to a possible fault area.

Look for agreement in related signals. For example, if accelerator pedal position is changed during acceleration, a corresponding change should occur in rpm.

Make sure the signals act in proper sequence. An increase in rpm after the accelerator pedal's position is increased is expected. However, if rpm increases without an accelerator pedal position change, then a problem may exist.

1. Select VIEW RECORDER AREAS.

2. Select a viewing area.

3. Select up to four PIDs to review in the table format or two PIDs to review in the graph mode.

4. Table Format: Scroll through the PID data while analyzing the information. Look for sudden drops or spikes in the values. (Refer to the following AP example or reference the EEC-V charts and graphs in this section.) Notice the major jump in the AP voltage while scrolling through the information.

5. Graph Format: Scroll through the PID data while analyzing the information. Look for sudden drops or spikes in the linear lines showing the transformation of values to the line graph. (Refer to the following TP example or reference the EEC-V charts and graphs in this section.) This example only applies to an analog signal.

Peripheral Inputs

Some signals may require certain peripherals or auxiliary tools. In some cases, these devices can be inserted into the measurement jacks of the scan tool or digital multimeter. The NGS Tester is capable of recording the value from the measurement jacks on the NGS Tester and storing the value with the other PIDs. For example, connecting an electronic fuel pressure gauge to monitor and record the fuel pressure would capture the data that would help find the fault. Listed are peripheral devices available.

Comparing PCM Data

After the PCM values have been acquired, it is necessary to determine the fault area. Typically, it will require the comparison of the actual values from the vehicle to the typical values. Refer to the pinpoint test procedures. Refer to the following example:

Circuit	Good PID Values	Actual Vehicle PID Values
AP	0.8V	0.9V
EOT	205°F--->	35°F<--Example of Fault
IAT	2.8V	2.7V
IPR	35%	50%

Analyzing PCM Data

Various Data Procedures

Once the fault area is identified, the circuit must be checked to determine if the wiring or component is at fault. Use any of the following methods to diagnose a suspected PCM wire circuit or device. Some methods are particular to a certain type of PCM device.

- Change Condition to Cause Response by Input
- Change Input and Verify Output Response
- Click Testing/Output Test Mode (Solenoids/Relays)
- Coil Resistance (Solenoids/Relays)
- Harness Opens
- Harness Shorts

Change Condition to Cause Response by Input

The purpose is to verify sensor receives and responds to changes.

1. Select, view and record the appropriate sensor PID(s).

2. Create condition or cause condition to change.

3. If reading changes appropriately, then it should be operating OK.

   Examples:
   - View EOT PID while engine warms up.
   - It should change from a higher voltage (2.6V) for a cold engine, to a lower voltage as the engine warms up (0.6V).
   - Move accelerator pedal, observe AP PID change.
   - Press brake pedal, watch BOO PID change states.

Change Input and Verify Output Response

The purpose is to verify how the PCM and actuator circuit responds to sensor input.

1. Select, view the appropriate sensor PID(s).

2. Create condition to cause input condition to change.

3. Observe change (response) in actuator PID or actuator signal circuit measured by a measuring device.

   Example:
   - Increase accelerator pedal position under load, observe RPM PID and circuit change.

Click Testing/Output Test Mode (Solenoids/Relays)

The purpose is to activate solenoid or relay from PCM by entering Output Test Mode.

1. Key on.

2. Enter Output Test Mode.

3. Turn outputs on and then off.

4. Listen for relays to click on and off. If a breakout box is connected to the PCM, measure the control circuit while turning the outputs on and off.

   Examples:
   - IDM relay and PCM power relay.
   - Glow plug relay receives on-command for 5 seconds.

Coil Resistance (Solenoids/Relays)

The purpose is to measure the correct resistance value of device.

1. Key off.

2. DLC disconnected.

3. Disconnect component from vehicle harness.

4. Using an ohmmeter and referencing the Static Resistance Value Chart in this section, measure across the component terminals in question.

Harness Opens

The purpose is to check harness for open circuits

1. Key off.

2. DLC disconnected from any diagnostic tools.

3. Disconnect component from vehicle harness.

4. Install breakout box.

5. Using an ohmmeter, isolate the circuit in question from the breakout box to the component connector signal pin.

6. Reading should be less than 5 ohms.

Harness Shorts

The purpose is to check harness for short circuits (to ground or power).

1. Key off only.
2. DLC disconnected from any diagnostic tools.
3. Disconnect component from vehicle harness.
4. Using an ohmmeter, measure between the signal circuit and signal return circuit or power ground circuit or vehicle power.
5. If reading is less than 10k ohms, then the two circuits are shorted.

On-Board System Readiness Test
Description

All OBD II scan tools should display the On-Board System Readiness (OSR) Test. The OSR will display the supported monitors on the vehicle, the status of all monitors (complete or not complete) and the MIL status. If a monitor is not complete, the scan tools will not identify the monitor that has not completed. None of the typical OBD II monitors such as catalyst, heated catalyst, evaporative system, secondary air, A/C, HO2S or the EGR monitors, apply to the 7.3L diesel. The values of the monitors are not used. Readiness is reported based on the completeness of the comprehensive component monitors (CCM) and the misfire monitor. Both monitors must be complete before readiness can be cleared. It is not possible to determine which individual monitors are complete/incomplete. Furthermore, the use of CCM to determine readiness for diesels is a relatively new feature and some scan tools may default to ALL OBD II MONITORS COMPLETE.

Accessing On-Board System Readiness Test
New Generation Star

- Perform the necessary vehicle preparation and visual inspection.
- Connect scan tool to DLC.
- SELECT CORRECT VEHICLE, YEAR and MODEL.
- Follow operating instructions from the menu.
- Select GENERIC OBD II FUNCTIONS.

  Note: If all the monitors are not complete, the OSR test will automatically be displayed along with a message.

  - Press TEST button to display OSR test.
- Select ON-BOARD SYSTEM READINESS.

Generic Scan Tool

Refer to the manufacturer's manual for specific instructions.

OBD II PID Data Monitor

The PID monitor for OBD II offers real time evaluation of several emissions-related parameters. Most of these are related to the HO2S and EGR, for which the diesel has no equivalent. The only parameters which apply to 7.3L diesel applications are CCNT, IAT, LOAD, MAP, MIL, RPM and VSS.

Accessing the PID Data Monitor
New Generation Star

- Perform the necessary vehicle preparation and visual inspection.
- Connect scan tool to DLC.
- SELECT CORRECT VEHICLE, YEAR and MODEL.
- Follow operating instructions from the menu.
- Select GENERIC OBD II FUNCTIONS.
- Select PID DATA MONITOR, choose only diesel-related PIDs.

Generic Scan Tool

- Refer to the manufacturer's manual for specific instructions.

OBD II Pending Codes

Pending codes are codes that have only set during one drive cycle and may not have set the MIL yet. While some codes can set the MIL during one drive cycle, they are not recorded as OBD II DTCs until failing during a second drive cycle. These DTCs may be identified using the Retrieve Pending Codes Feature. Additionally, they will be found in the vehicle-specific mode RETRIEVE/CLEAR CONTINUOUS DTCs from the instant that the code is set.

This function will only report pending failures that have occurred during the present drive cycle, but not indicate single failures that happened on any previous drive cycle.

Accessing the PID Data Monitor
New Generation Star

- Perform the necessary vehicle preparation and visual inspection.
- Connect scan tool to DLC.
- SELECT CORRECT VEHICLE, YEAR and MODEL.
- Select year, engine, model with the appropriate qualifier, if needed (for example, transmission, 49 States, California).
- Follow operating instructions from the menu.
- Select GENERIC OBD II FUNCTIONS.
- Select RETRIEVE PENDING CODES.

Generic Scan Tool

- Refer to the manufacturer's manual for specific instructions.

Misfire Monitoring Supported

This menu pick can be used to determine if the misfire monitoring system is supported on your particular application. All California emission-equipped 7.3L diesel vehicles under 10,000 lbs (OBD II) utilize misfire detection. When selecting this function, a message will be displayed on the screen: "test not supported by this module" or "test supported by this module."

Comprehensive Component Monitoring Supported

This menu pick can be used to determine if the comprehensive component monitoring system is supported on your particular application. All California emission-equipped 7.3L diesel vehicles under 10,000 lbs (OBD II) utilize comprehensive component monitoring. When selecting this function, a message will be displayed on the screen: "test not supported by this module" or "test supported by this module."

Misfire Monitoring Status

This menu pick can be used to determine the status of the misfire monitoring system on your particular application. All California emission-equipped 7.3L diesel vehicles under 10,000 lbs (OBD II) utilize misfire detection. When selecting this function, a message will be displayed on the screen: "test complete, or not applicable" or "test not complete."

Comprehensive Component Monitoring Status

This menu pick can be used to determine the status of the comprehensive component monitoring system on your particular application. All California emission-equipped 7.3L diesel vehicles under 10,000 lbs (OBD II) utilize comprehensive component monitoring. When selecting this function, a message will be displayed on the screen: "test complete, or not applicable" or "test not complete."

PTO Status

This menu pick can be used to determine the status of the PTO system on your particular application. Some transmission OBD II monitors are disabled during PTO and split shaft operation. Vehicle must be out of PTO mode to clear P1000. When selecting this function, a message will be displayed on the screen: "PTO active" or "PTO non active."

Freeze Frame Data
Description

Freeze Frame Data allows access to emission related values from specific generic PIDs. These values are stored the instant an emission related DTC is stored in Continuous Memory. This provides a snapshot of the conditions that were present when the DTC was stored. Once one set of freeze frame data is stored, this data will remain in memory even if another emission related DTC is stored. There are no fuel system DTCs for the 7.3L diesel. When a DTC associated with the freeze frame is erased or a PCM memory reset is performed, new freeze frame data can be stored again. In the event of multiple emission related DTCs in memory, always note the DTC for the freeze frame data. Load, RPM and VSS are the only parameters used for the 7.3L Diesel; all other parameters are to be ignored.

FREEZE FRAME DATA TABLE			
PID#	**Acronym**	**Description**	**Measurement Units**
0004	LOAD	Calculated Load Value	PERCENT
000C	RPM	Engine RPM	R/MIN
000D	VSS	Vehicle Speed	MPH-KMH

Accessing Freeze Frame PID Data
New Generation Star

- Perform the necessary vehicle preparation and visual inspection.
- Connect scan tool to DLC.
- SELECT CORRECT VEHICLE, YEAR and MODEL.
- Select year, engine, model with the appropriate qualifier, if needed (i.e., transmission, 49 States, California).
- Follow operating instructions from the menu.
- Select GENERIC OBD II FUNCTIONS.
    - Press CONT button if all OBD II monitors are not complete.
- Turn key on.
- Select FREEZE FRAME PID REQUEST.

Generic Scan Tool

Refer to the manufacturer's manual for specific instructions.

Resetting Vehicle Specific Codes
New Generation Star

- Perform the necessary vehicle preparation and visual inspection.
- SELECT CORRECT VEHICLE YEAR and MODEL.
- Follow operating instructions from the menu.
- Select DIAGNOSTIC DATA LINK.
- Select PCM.
- Select DIAGNOSTIC TEST MODES.
- Select RETRIEVE/CLEAR CONTINUOUS DTCs.
- Select CLEAR.
- Generic Scan Tool.
- Refer to the manufacturer's manual for specific instructions.

OBD II PID Data Monitor

The PID monitor for OBD II offers real time evaluation of several emissions-related parameters. Most of these are related to the HO2S and EGR, for which the diesel has no equivalent. The only parameters which apply to 7.3L diesel applications are CCNT, IAT, LOAD, MAP, MIL, RPM and VSS.

Powertrain Control Module (PCM) Reset
Description

The Powertrain Control Module (PCM) Reset allows the scan tool to command the PCM to clear all emission-related diagnostic information. When resetting the PCM, a DTC P1000 will be stored in the PCM until all the OBD II system monitors or components have been tested to satisfy a drive cycle, without any other faults occurring. For more information about a drive cycle, refer to Drive Cycles in this section. Clearing codes from the vehicle-specific RETRIEVE/CLEAR CONTINUOUS DTCs will clear all systems, including the OBD II systems. Clearing codes from the OBD II generic menu will only clear OBD II features for the 7.3L diesel.

The following events occur when a PCM reset is performed:

- Clears the number of Diagnostic Trouble Codes (DTC).
- Clears the DTCs.
- Clears the freeze frame data.
- Resets status of the OBD II system monitors.
- Sets DTC P1000 as a vehicle-specific DTC. P1000 will not appear as an OBD II code.

Resetting OBD II Codes
New Generation Star

- Turn key off.
- Perform the necessary vehicle preparation and visual inspection.
- SELECT CORRECT VEHICLE YEAR and MODEL.
- Follow operating instructions from the menu.
- Select GENERIC OBD II FUNCTIONS.
  - Press CONT button if all OBD II monitors are not complete.
- Turn key on.
- Select CLEAR DIAGNOSTIC CODES.
- Press START Key.

Generic Scan Tool

Refer to the manufacturer's manual for specific instructions.

Resetting KAM

Disconnect the negative lead from the battery for a minimum of 5 minutes.

After KAM has been reset, DTCs P1000 and P0603 will be stored in the PCM.

Drive Cycles
OBD II Drive Cycle
Description

The primary intention of the OBD II Drive Cycle is to clear the DTC P1000 and to satisfy the specifications for SAE specification J1979. Each OBD II monitor must run during the drive cycle.

If the drive cycle is completed and P1000 is not cleared, repeat the entire drive cycle. If a particular step is interrupted, simply repeat the drive mode. If the drive cycle is interrupted with a key-off, only drive modes that were incomplete must be run.

CAUTION: Strict observance of posted speed limits and attention to driving conditions are mandatory when proceeding through the drive cycle.

Rough road conditions may prevent certain steady state conditions and steady accelerations from validating the transmission- and load-related monitors.

Vehicles equipped with Power Take-Off (PTO) must have that system disengaged before the OBD II drive cycle is initiated.

Drive Cycle Procedure:

1. Key on. Do not crank until the WAIT TO START light extinguishes, or at least 10 seconds, whichever is greater.

2. Start the engine. Idle in PARK or NEUTRAL for 40 seconds.

3. The following outlines the appropriate conditions for running certain OBD II monitors that require the engine to be under load:
    a. For vehicles with automatic transmission, select OVERDRIVE CANCEL to run the test in third gear. Turn on accessories such as headlamps, A/C compressor, blower fan, etc. Do not use hazards or PTO. Select an uphill or level road. Driving downhill will unload the engine, thereby defeating the test.

    b. Accelerate steadily to third gear (M/T use fourth gear) and hold at 1500 rpm for 3 seconds. Accelerate steadily from 35 mph to 65 mph over approximately 15 seconds (M/T 11 seconds minimum).

    c. Repeat Step 3b three times while maintaining the conditions in Step 3a.

    d. Before proceeding, turn all accessories off and disengage overdrive cancel.

4. Automatic transmission only:
    a. Drive in fourth gear continuously for 60 seconds.

    b. Accelerate steadily from a full stop to fourth gear and then return to a full stop. Repeat 10 times.

5. Before continuing, EOT must exceed 60°C (140° F).

6. Idle the vehicle for 20 seconds in PARK or NEUTRAL.

7. Key off.

8. Start the engine. Idle in PARK or NEUTRAL for 40 seconds.

9. Rerun Quick Test.

Note: If P1000 is present after running the drive cycle:

- Rerun Step 3b, being certain to maintain a minimum MFDES of 37 mg/stroke above 1500 rpm for 11 seconds. Also, maintain a minimum MFDES of 37 mg/stroke above 2300 rpm for at least 6 seconds.
- Rerun Step 6. MFDES must remain below 12 mg/stroke for 11 consecutive seconds.

OBD II PID Data Monitor

The PID monitor for OBD II offers real time evaluation of several emission-related parameters. Most of these are related to the HO2S and EGR, for which the diesel has no equivalent. The only parameters that apply to 7.3L diesel applications are CCNT, IAT, LOAD, MAP, MIL, RPM and VSS.

Accessing the PID Data Monitor
New Generation Star

- Perform the necessary vehicle preparation and visual inspection.
- Connect scan tool to DLC.
- SELECT CORRECT VEHICLE, YEAR and MODEL.
- Select year, engine, model with the appropriate qualifier, if needed (for example, transmission, 49 States, California).
- Follow operating instructions from the menu.
- Select GENERIC OBD II FUNCTIONS.
- Select PID Data Monitor, choose only diesel-related PIDs.

Generic Scan Tool

Refer to the manufacturer's manual for specific instructions.

OBD II Pending Codes

Pending codes are codes that have only set during one drive cycle and may not have set the MIL yet. While some codes can set the MIL during one drive cycle, they are not recorded as OBD II DTCs until failing during a second drive cycle. These DTCs can be identified using the Retrieve Pending Codes feature. Additionally, they will be found in the vehicle-specific mode RETRIEVE/CLEAR CONTINUOUS DTCs from the instant the code is set.

This function will only report pending failures that have occurred during the present drive cycle, but will not indicate single failures that happened on any previous drive cycle.

Accessing the PID Data Monitor
New Generation Star

- Perform the necessary vehicle preparation and visual inspection.
- Connect scan tool to DLC.
- SELECT CORRECT VEHICLE, YEAR and MODEL.
- Select year, engine, model with the appropriate qualifier, if needed (for example, transmission, 49 States, California).
- Follow operating instructions from the menu.
- Select GENERIC OBD II FUNCTIONS.
- Select RETRIEVE PENDING CODES.

Generic Scan Tool

Refer to the manufacturer's manual for specific instructions.

Intermittent Diagnostic Techniques

Intermittent diagnostic techniques help find and isolate the root cause of intermittent faults associated with the EEC-V system. The material is organized to help find the fault and perform the repair. There are examples that illustrate the diagnostic techniques. The process of finding and isolating an intermittent, starts with recreating a fault symptom, accumulating PCM data and comparing that data to typical values and analyzing the results.

Before proceeding, be sure that:

- Customary mechanical system tests and inspections do not reveal a problem. (Remember, mechanical component problems can make a PCM system react abnormally.)
- Review Technical Service Bulletins (TSBs) and OASIS messages, if available.
- Quick Test and associated Pinpoint diagnosis have been completed without finding a fault, and the symptom is still occurring.

Recreating the Fault

Recreating the fault is the first step in isolating the cause of the intermittent symptom. A thorough investigation should start with the customer information worksheet located in the Introduction. If Freeze Frame Data is available, it may help in recreating the conditions at the time of a Malfunction Indicator Lamp Diagnostic Trouble Code (MIL-type DTC). Listed below are some of the conditions for recreating the fault.

CONDITIONS TO RECREATE FAULT	
Engine Type Conditions	**Non-Engine Type Conditions**
Engine Temperature	Ambient Temperature
Engine RPM	Moisture Conditions
Engine Load Engine idle/accel/decel	Road Conditions (smooth-bumpy)

Accumulating PCM Data

PCM data can be accumulated in a number of ways. Gather as much data as possible when the malfunction is occurring to prevent misdiagnosis. Data should be accumulated during different operating conditions and based on the customer description of the intermittent fault. Reference the known good data values located in Section 6, Reference Values. This will require recording data in four conditions for comparison: 1) KOEO, 2) HOT IDLE, 3) 30 mph and 4) 55 mph. Acquisition of PCM PID data using a scan tool is one of the easiest ways to gather information. Listed below are instructions for gathering PID data using a New Generation Star (NGS) scan tool.

Selecting and Viewing PIDs

1. Select Vehicle and Engine Selection and enter the proper year, vehicle and engine package from the menu.
2. Select DIAGNOSTIC DATA LINK.
3. Select POWERTRAIN CONTROL MODULE (PCM).
4. Select PID/DATA MONITOR AND RECORD.
5. Select the PIDs from the intermittent symptom chart or the PCM Pinpoint test. The star symbol next to each PID on the screen indicates that PID has been selected.
6. Turn ignition key on or start vehicle.
7. Select the START key and access the PIDs.

Storing PIDs

1. When ready to capture and store the selected PIDs, press the trigger button.

2. Press trigger again when ready to save information.

3. The information is now located in the main recording area. Store to a viewing area before starting another recording or the data will be overwritten.

Recording DVOM Measurements Along with PIDs

1. Select DIGITAL MEASUREMENT SYSTEM.

2. Select one of the meters (i.e., VOLTMETER).

3. Select PIDS.

4. Select PID/DATA MONITOR.

5. Select PCM.

6. Select the PIDs and START to record.

7. Press REC to save digital multimeter function and PID data.

8. Press TRIGGER to save, store and view.

Playback of Stored PIDs

Look for abnormal behavior or values that are clearly incorrect. Inspect the signals for abrupt or unexpected changes. For example, during a steady cruise most of the sensor values should be relatively stable. Sensors such as AP, MAP and RPM that change abruptly when the vehicle is traveling at a constant speed are clues to a possible fault area.

Look for agreement in related signals. For example, if AP is changed during acceleration, a corresponding change should occur in RPM PIDS.

Make sure the signals act in proper sequence. An increase in RPM after the AP is increased is expected. However, if RPM increases without an AP change, then a problem may exist. An RPM increase is normal during extended idle at colder ambient temperatures and during PTO operation.

1. Select VIEW RECORDER AREAS.

2. Select a viewing area.

3. Select up to four PIDs to review in the table format or two PIDs to review in the graph mode.

4. Table Format: Scroll through the PID data while analyzing the information. Look for sudden drops or spikes in the values. (Refer to the following AP example or reference the EEC-V charts and graphs in this section.) Notice the major jump in the AP voltage while scrolling through the information. This example would require a smooth and progressive throttle pedal travel during a key ON and engine OFF mode.

5. Graph Format: Scroll through the PID data while analyzing the information. Look for sudden drops or spikes in the linear lines showing the transformation of values to the line graph.

Peripheral Inputs

Some signals may require certain peripherals or auxiliary tools to aid in diagnostics. In some cases, these devices can be inserted into the measurement jacks of the scan tool or digital multimeter. The NGS is capable of recording the value from the measurement jacks on the NGS while storing the value from other PIDs.

Comparing PCM Data

After the PCM values have been acquired, it is necessary to determine the fault area. Typically, it will require the comparison of the actual values from the vehicle to the typical values from Reference Value Charts in Section 6.

Analyzing PCM Data

Once the fault area is identified, the circuit must be checked to determine if the wiring or component is at fault. When making circuit and component measurements, make sure all accessories and dome and hood lights are off. Use any of the following methods to diagnose a suspected PCM wire circuit or device. Some methods are particular to a certain type of PCM device.

- Change Condition to Cause Response by Input
- Change Input and Verify Output Response
- Click Testing/Output Test Mode (Solenoids/Relays)
- Coil Resistance (Solenoids/Relays)
- Harness Opens
- Harness Shorts

Change Conditions to Cause Response by Input

The purpose is to verify the sensor receives and responds to changes.

1. Select, view and record the appropriate sensor PID(s).

2. Create condition or cause condition to change.

3. If reading changes appropriately, then it should be operating OK.

   Examples:
   - EOT should change from a higher voltage (2.6V) for a cold engine, to a lower voltage as the engine warms up (0.6V).
   - Move AP, observe AP PID change.
   - Press brake pedal, watch BOO PID change states.

Change Input and Verify Output Response

The purpose is to verify how the PCM and actuator circuit responds to sensor input.

1. Select, view and record the appropriate sensor PID(s).
2. Create condition to cause input condition to change.
3. Observe change (response) in actuator PID or actuator signal circuit measured by a measuring device.

Click Testing (Solenoids/Relays)

The purpose is to activate a solenoid or relay from the PCM by entering Output Self Test Mode.

1. Key on.
2. Enter Output Self Test Mode.
3. Turn outputs on and then off. The state of the output can be changed by cycling the accelerator pedal.
4. Listen for relays to click on and off. If a breakout box is connected to the PCM, measure the control circuit while turning the outputs on and off. A voltage change of greater than 4 volts should occur during the ON and OFF transition. (NOTE: The glow plug relay will only cycle on for 5 seconds the first time the accelerator pedal is pressed.)

Coil Resistance (Solenoids/Relays)

The purpose is to measure the correct resistance value of a device.

1. Key off.
2. Data Link Connector (DLC) disconnected from any diagnostic tools.
3. Disconnect component from vehicle harness.
4. Using an ohmmeter and referencing the Static Resistance Value Chart in the EEC-V graphs and charts at the end of this section, measure across the component terminals.

Harness Opens

The purpose is to check harness for open circuits.

1. Key off.
2. DLC disconnected from any diagnostic tools.
3. Disconnect component from vehicle harness.
4. Install breakout box.

5. Using an ohmmeter, isolate the circuit in question from the breakout box to the component connector pin.

6. Reading should be less than 5 ohms.

Harness Shorts

The purpose is to check the harness for short circuits (to ground or power).

1. Key off only.

2. DLC disconnected from any diagnostic tools.

3. Disconnect component from vehicle harness.

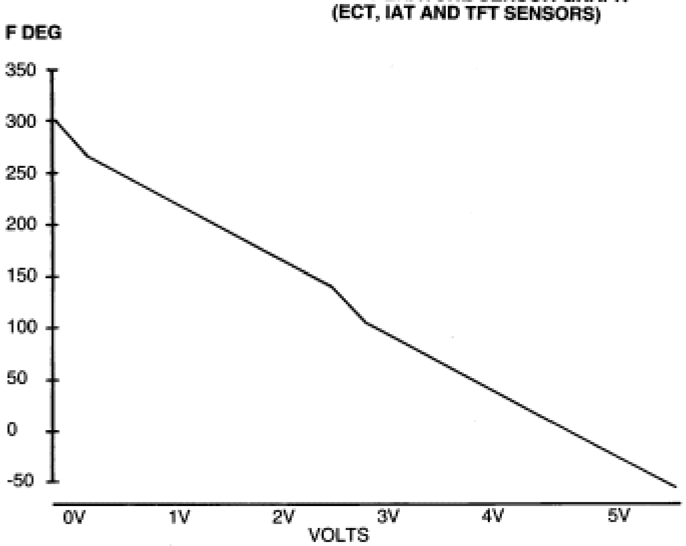
4. Using a digital multimeter, measure between the signal circuit and signal return circuit or power ground circuit or vehicle power.

5. If reading is less than 10 kohms, then the two circuits may be shorted.

EEC-V Graphs and Charts
Static Resistance Values

Component	Ohm Value
EPC	3 to 5.1 ohms
SS 1	15 to 25 ohms
SS 2	15 to 25 ohms
TCC	0.9 to 1.9 ohms

TEMPERATURE SENSOR GRAPH
(ECT, IAT AND TFT SENSORS)



TRANSFORMATION TABLE

TEMPERATURE F DEG	TEMPERATURE C DEG	VOLTAGE VOLTS	RESISTANCE K OHMS
302	160	0.12	0.54
267	131	0.2	0.8
248	120	0.28	1.18
230	110	0.36	1.55
212	100	0.47	2.07
194	90	0.61	2.8
176	80	0.8	3.84
158	70	1.04	5.37
140	60	1.35	7.6
104	40	2.16	16.15
86	30	2.62	24.27
68	20	3.06	37.3
50	10	3.52	58.75
32	0	3.97	65.849
14	−10	4.422	78.194
−4	−20	4.874	90.539
−22	−30	4.89	102.884
−40	−40	4.91	115.229
−58	−50	5	127.574

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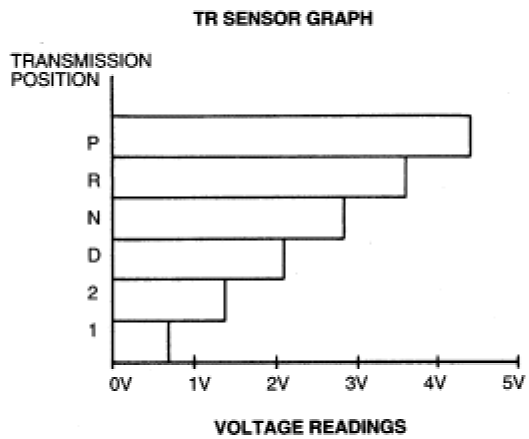

TRANSFORMATION TABLE

TRANSMISSION RANGE POSITION	VOLTAGE VALUE	RESISTANCE OHMS
P	4.41	4.16K
R	3.60	1.44K
N	2.83	733
D	2.09	401
2	1.37	211
1	0.68	81

TR SENSOR DATA:
VOLTAGE VALUES CALCULATED FOR VREF = 5.0V AND MAY VARY +/- 5%.

A21128-B

Note: The above illustrations are examples of generic NGS data and are not 7.3L diesel-specific.

Basic Circuit Checks
Description

Basic circuit checks help to minimize pinpoint test steps by providing a procedure to diagnose harness faults associated with the Electronic Engine Control (EC) System. The following techniques provide helpful reminders for diagnosing open circuits (continuity), shorts to ground and shorts to power.

Note:

- The suspect circuit must be isolated before testing.
- When disconnecting any harness connector, always inspect for damaged or pushed-out pins, corrosion and loose wires. Repair as necessary.
- The digital multimeter must be set to the correct scale. AUTO scale is used for NGS with the data link connector (DLC) disconnected.
- The techniques do no apply in all situations; therefore, it is necessary to perform each pinpoint test step accurately and completely.
- General resistance and voltage values are specified below. Always use the pinpoint test values if they differ.
- Always turn the key to the OFF position unless directed otherwise by the pinpoint test.

Each of the following procedures will require the powertrain control module (PCM) and component to be disconnected to isolate the harness.

Open Circuit (Continuity)

Install PCM breakout box and leave PCM disconnected. Measure the harness resistance between the suspect circuit at the harness connector and the appropriate PCM breakout box test pin. The resistance must be less than 5.0 ohms.

Shorts to Ground

Measure the harness resistance between the suspect circuit at the harness connector and a reliable ground (B-, chassis and or PWR and at the PCM breakout box). The resistance must be greater than 10,000 ohms.

Shorts to Power

Key ON to power up circuit. Measure voltage between the suspect circuit at the harness connector and a reliable ground. The voltage must be less than 1.0 volt.

Powertrain Control/Emissions Diagnosis

1999

On Board Diagnostics II Diesel

SECTION 3: Symptom Charts

SECTION 3: Symptom Charts

Symptom Chart Index

Driveability			
System/Symptom		**Oasis Number**	**Chart Number**
Starting Concerns	No Crank/Slow Crank	601300	1
	Hard Start/Long Crank/Erratic Start/Erratic Crank	602300	3
	Hard Start/No Start — Dry Reservoir	—	17
	Stall After Start	—	3
	No Start/Normal Crank	603300	3
Unique Idle Concerns	Slow Return to Idle	617400	5
	Rolling Idle	608400	6
	Stalls When Engaging Clutch	—	6
	Fast Idle	619400	7

Driveability — Performance While Driving Concerns			
System/Symptom		**Oasis Number**	**Chart Number**
Stalls/Quits	Idle	607400	2
	Acceleration	607500	2
	Cruise	607600	2
	Deceleration	607700	2
Runs Rough	Idle	608400	6
	Acceleration	608500	8
	Cruise	608600	8
Misses	Idle	609400	8
	Acceleration	609500	8
	Cruise	609600	8
Buck/Jerk	Acceleration	610500	8
	Cruise	610600	8
	Deceleration	610700	8
Hesitation/Stumble	Acceleration	611500	8
Surge	Acceleration	612500	9
	Cruise	612600	9

Lack/Loss of Power	Acceleration	614500	10
	Cruise	614600	10

Additional Driveability Concerns		
System/Symptom	**Oasis Number**	**Chart Number**
Engine Will Only Idle	—	4
Poor Fuel Economy	622000	10
CHECK ENGINE Light Concern	698298	11
Speed Control	205200	13

Electrical			
System/Symptom		**Oasis Number**	**Chart Number**
Warning Indicators	CHECK ENGINE Light	206000	11
	TCIL	698298	14

Driveline			
System/Symptom		**Oasis Number**	**Chart Number**
Automatic Transmission Shift Concerns	A/T Upshift Concern	501000	15
	A/T Downshift Concern	502000	15
	Engagement Concern	503000	15

Engine			
System/Symptom		**Oasis Number**	**Chart Number**
Oil System Concerns	High Oil Consumption	401100	16
	Leaks	401800	16
Exhaust System Concerns	Visible Smoke	403400	12

1-: Symptom Chart 1
Introduction

1-: Pinpoint Tests

Symptom	OASIS Number
Starting Concerns ▪ No Crank/Slow Crank	601300

1-: Pinpoint Tests

1999 PCED On Board Diagnostics II Diesel SECTION 3: Symptom Charts

1-: Symptom Chart 1

1-: Introduction

1-1 PRELIMINARY CHECKS

- Perform the following preliminary checks:
  - Automatic transmission in PARK or NEUTRAL
  - Clutch fully depressed
  - Battery connections
  - Starter relay connections
  - Battery load test
  - Alarm anti-theft devices
  - Fuse links
  - Ignition switch

Are all checks OK?

Yes	No
GO to 1-2 .	REPAIR as necessary.

1-2 CHECK STARTER RELAY

- Cycle ignition key.

Is a "clicking" sound heard from the starter relay when the ignition key is turned to start?

Yes	No
GO to 1-4 .	GO to 1-3 .

1-3 CHECK ELECTRICAL ACCESSORIES

Do any other electrical accessories operate (headlights, radio, etc.)?

Yes	No
GO to 1-4 .	GO to the Electrical Group in the Workshop Manual to check the battery and charging systems.

1-4 CHECK STARTING SYSTEM SECONDARY CIRCUITS

- Go to the Powertrain Group in the Workshop Manual to check starter ground and starter relay cable to starter.

Is a fault indicated?

Yes	No
REPAIR as required according to Workshop Manual direction.	GO to 1-5 .

1-5 CHECK STARTING SYSTEM COMPONENTS

- Go to the Powertrain Group in the Workshop Manual to check starter, starter relay, clutch pedal position sensor and manual lever position sensor.

Is a fault indicated?

Yes	No
REPAIR as required according to Workshop Manual direction.	GO to the Powertrain Group in the Workshop Manual to check for base engine concerns (seized/hydro-locked engine or damaged flywheel). REPAIR as required according to Workshop Manual direction.

2-: Symptom Chart 2
Introduction

2-: Pinpoint Tests

Symptom	OASIS Number
Stalls/Quits	607000
▪ Idle	607400
▪ Acceleration	607500
▪ Cruise	607600
▪ Deceleration	607700

2-: Pinpoint Tests

2-: Introduction

2-1 PRELIMINARY CHECKS

- Perform the following preliminary checks:
  - Engine overheating
  - Electrical connections
  - Engine oil level/quality
  - MAP sensor vacuum hose leak
  - Automatic transmission TCC
  - ATF level

Are all checks OK?

Yes	No
GO to 2-2 .	REPAIR as necessary. VERIFY a symptom no longer exists.

2-2 CHECK FOR COLD WEATHER STALL

Does stall occur with cold oil (below 0°C [32°F]) after several minutes of operation?

Yes	No
Oil return to oil pan may be too slow. CONFIRM proper grade of oil for frigid conditions. GO to 2-3 .	GO to 2-3 .

2-3 CHECK PERFORMANCE DIAGNOSTICS

- GO to Section 4 , Diagnostic Subroutines. Perform Performance Diagnostic Procedures.

Is a fault indicated?

Yes	No
FOLLOW Performance Diagnostic Procedures direction.	GO to the Powertrain Group in the Workshop Manual to perform automatic transmission diagnosis.

3-: Symptom Chart 3 Introduction

3-: Pinpoint Tests

Symptom	OASIS Number
Starting Concerns	
▪ Hard Start/Long Crank/Erratic Start/Erratic Crank	602300
▪ Stall After Start	
▪ No Start/Normal Crank	603300
Stalls/Quits	607000
▪ Idle	607400

3-: Pinpoint Tests

3-1 PRELIMINARY CHECKS

Note: Refer to Section 4 , Diagnostic Subroutines, Performance Diagnostic Procedures or the 11 x 17-inch Diagnostics Guide for the following preliminary checks.

- Perform the following preliminary checks:
  - Check engine oil level
  - Confirm proper dipstick part number
  - Check for sufficient clean fuel
  - Check for an intake restriction

Are all checks OK?

Yes	No
GO to 3-2 .	REPAIR as necessary. VERIFY a symptom no longer exists.

3-2 CHECK HIGH PRESSURE PUMP OIL LEVEL

- Check engine oil level in high pressure pump reservoir.

Is oil level within 25.4 mm (1 inch) of inspection plug?

Yes	No
GO to 3-4 .	GO to 3-3 .

3-3 ATTEMPT TO START ENGINE

- Refill high pressure pump reservoir.
- Attempt to start engine.

Does engine start and then stall after about 15 seconds?

Yes	No
Reservoir is not supplying enough oil to the high-pressure oil pump. GO to Symptom Chart 17 .	GO to 3-4 . If no other faults are indicated, GO to Symptom Chart 17 .

3-4 PERFORM KOEO ON-DEMAND SELF TEST

Note: NGS will reset below 9.5 volts. Charge batteries as necessary.

- Go to Section 4 , Diagnostic Subroutines, Performance Diagnostic Procedures. Perform KOEO On-Demand Self Test.

Is a fault indicated?

Yes	No
GO to appropriate pinpoint test.	GO to 3-5 .

3-5 PERFORM KOEO INJECTOR ELECTRICAL SELF TEST

Is a fault indicated?

Yes	No
GO to appropriate pinpoint test.	If test does not run, GO to 3-6 . If no codes are present, Go to 3-7 .

3-6 REPEAT KOEO INJECTOR ELECTRICAL SELF TEST

- Repeat KOEO Injector Electrical Self Test for each injector connector with one connector disconnected at a time.

Does the KOEO Injector Electrical Self Test run?

Yes	No
REMOVE valve cover and INSPECT the disconnected valve cover wiring harness for a pinched or grounded injector wire.	GO to Pinpoint Test NC to check IDM power and ground. GO to Pinpoint Test NA29 to locate short to ground at IDM or in injector circuits.

3-7 CHECK PARAMETER IDENTIFICATIONS (PIDS)

- Go to Section 4 , Diagnostic Subroutines, Hard Start/No Start Diagnostics. Perform Steps 9a, 9b, 9c and 9d.

Is a fault indicated?

Yes	No
GO to appropriate pinpoint test.	GO to 3-8 .

3-8 CHECK GLOW PLUGS

Note: Run these checks if starting difficulty is in cold temperatures and/or if excessive white smoke is generated after starting in warmer temperatures.

Note: Refer to Pinpoint Test KC for circuit diagrams.

- Disconnect all glow plug/injector connectors on both valve cover gaskets.
- Check resistance between ground and each glow plug connector using a digital multimeter and special tool.

Is resistance between 0.1 and 2.0 ohms?

Yes	No
GO to 3-9 .	REMOVE valve cover and INSPECT harness for opens and shorts. If harness is OK, REPLACE indicated glow plug.

3-9 CHECK GLOW PLUG CONNECTORS

- Check resistance between each glow plug contact in the engine harness and the two brown wires on the glow plug relay.

Is resistance between 0 and 2.0 ohms?

Yes	No
GO to 3-10 .	REPLACE engine wiring harness.

3-10 CHECK GLOW PLUG RELAY CIRCUIT

- Check voltage between glow plug relay Circuit 38 (BK/O) and chassis ground.

Is battery voltage present?

Yes	No
GO to 3-11 .	**CAUTION: Confirm resistance to ground is above 10,000 ohms before attaching to starter relay.** REPLACE relay feeder wire fusible links 299 (DB).

3-11 CHECK GLOW PLUG RELAY

- Connect all glow plug connectors.
- Connect glow plug control connector on side of relay.
- Disconnect EOT.
- Connect voltmeter between relay terminal with two brown wires and chassis ground.
- Measure voltage with key off and key on while wiggling wires connected to relay (relay will remain closed for two minutes with key on).

Does voltage change from 0 to battery voltage and stay at battery voltage for approximately 2 minutes?

Yes	No
GO to 3-12 .	REPLACE glow plug relay.

3-12 CHECK FUEL PUMP PRESSURE

- Connect EOT.
- Go to Section 4 , Diagnostic Subroutines, Performance Diagnostic Procedures. Perform Fuel Pump Pressure test.

Is fuel pressure less than 138 kPa (30 psi) at key on?

Yes	No
GO to Section 4 , Diagnostic Subroutines, Performance Diagnostics, Step 7.	REPAIR as necessary.

4-: Symptom Chart 4 Introduction

4-: Pinpoint Tests

Symptom	OASIS Number
Additional Driveability Concerns ▪ Engine Will Only Idle	

4-: Pinpoint Tests

4-: Symptom Chart 4

4-: Introduction

4-1 PRELIMINARY CHECKS

- Perform the following preliminary checks:
  - IVS and AP sensor connector attachment
  - Interference from floor mats
  - Accelerator pedal damage

Are all checks OK?

Yes	No

GO to Pinpoint Test FE	REPAIR as necessary. VERIFY a symptom no longer exists.

5-: Symptom Chart 5
Introduction

5-: Pinpoint Tests

Symptom	OASIS Number
Unique Idle Concerns ▪ Slow Return to Idle	617400

5-: Pinpoint Tests

5-: Introduction

5-1 PRELIMINARY CHECKS

- Perform the following preliminary checks:
  - Accelerator pedal for binding, broken return spring, stuck (floor mats)
  - External fuel source

Are all checks OK?

Yes	No
GO to 5-2 .	REPAIR as necessary. VERIFY a symptom no longer exists.

5-2 PERFORM QUICK TEST OPERATION

- Go to Section 2 , Diagnostic Methods. Perform Quick Test Operation.

Is a fault indicated?

Yes	No
GO to appropriate pinpoint test.	GO to 5-3 .

5-3 CHECK ACCELERATOR PEDAL

- Check for floor mat interference.
- Check bushing for damage.
- Check return spring.

Is a fault indicated?

Yes	No
REPAIR as required according to Workshop Manual direction.	GO to 5-4 .

5-4 CHECK CRANKCASE

- Check for overfilled crankcase.

Is crankcase overfilled?

Yes	No
DRAIN crankcase to correct level.	GO to 5-5 .

5-5 CHECK ENGINE OIL

- Check for coolant in engine oil.

Is there coolant in engine oil?

Yes	No
REPAIR as required according to Workshop Manual direction.	GO to 5-6 .

5-6 CHECK FOR FUEL CONTAMINATION

- Check crankcase for fuel contamination.

Does the crankcase have fuel contamination?

Yes	No
GO to Section 4 , Diagnostic Subroutines. PERFORM Performance Diagnostic Procedures.	GO to 5-7 .

5-7 CHECK EOT SENSOR

- Warm engine to between 15°C and 70°C (59°F and 158°F).
- Remove fill/check plug from high-pressure oil pump reservoir.
- Measure reservoir oil temperature with an A/C thermometer.
- Measure EOT using NGS tester or DVOM.

Do readings between EOT and thermometer agree within ± 3°C (± 5.4° F)?

Yes	No
GO to Symptom Chart 10 .	GO to Pinpoint Test DB . CONFIRM wiring is OK. If OK, REPLACE EOT according to Workshop Manual direction.

6-: Symptom Chart 6 Introduction

6-: Pinpoint Tests

Symptom	OASIS Number
Unique Idle Concerns ▪ Rolling Idle ▪ Stalls When Engaging Clutch	608400
Runs Rough ▪ Idle	608000 608400

6-: Pinpoint Tests

6-1 PRELIMINARY CHECKS

- Perform the following preliminary checks:
  - Check engine oil level
  - Confirm oil change within 8046.5 km (5000 miles) (5632.6 km [3500 miles] if severe duty)
  - Check Filter Minder
  - Check MAP sensor hose for holes, blockage, or disconnection. Confirm correct MAP sensor
  - Check intake manifold system for leaks with soapy water with engine running. Include orange seals, gaskets and fittings
  - Confirm acceptable SAE oil viscosity:
    - 15W-40: preferred -1°C to 49°C (30° F to 120°F)
    - 10W-30: preferred -23°C to -34°C (-10° F to -30°F)
    - 5W-30: preferred below -28°C to -40°C (-20°F to -40°F)
  - Check fuel quality by opening filter drain and cranking engine.
  - Confirm proper dipstick part number.

Are all checks OK?

Yes	No
GO to 6-2 .	REPAIR as necessary. VERIFY a symptom no longer exists.

6-2 PERFORM KOEO ON-DEMAND SELF TEST

- Go to Section 4 , Diagnostic Subroutines, Performance Diagnostic Procedures. Perform KOEO On-Demand Self Test.

Is a fault indicated?

Yes	No
GO to appropriate pinpoint test.	GO to 6-3 .

6-3 PERFORM KOEO INJECTOR ELECTRICAL SELF TEST

- Go to Section 4 , Diagnostic Subroutines, Performance Diagnostic Procedures. Perform KOEO Injector Electrical Self Test.

Is a fault indicated?

Yes	No
GO to appropriate pinpoint test.	GO to 6-4 .

6-4 CHECK FOR AERATED OIL

⚠ **CAUTION: Before running oil aeration tests, make sure the high-pressure oil passages are free of air from recent repairs by running vehicle hard for 32 kilometers (20 miles) after repair.**

⚠ **CAUTION: Engine must be warmed up to normal operating temperature.**

- Go to Section 4 , Diagnostic Subroutines, Performance Diagnostic Procedures. Perform Injection Control Pressure Test.
- Run engine at 3400 rpm for 30 seconds.

Does ICP read greater than 11032 kPa (1600 psi) or 2.15 volts in 30 seconds or less?

Yes	No
GO to 6-5	GO to 6-6 .

6-5 CHECK FOR AIR LEAKS

- Confirm proper oil change interval.
- Confirm proper oil level and type.
- Overfill engine by 1.9 liters (2 quarts).
- Raise and support rear of vehicle 254 mm (10 inches).
- Run engine at 3400 rpm for 3 minutes.

Does ICP read greater than 11032 kPa (1600 psi [2.15 volts])?

Yes	No
LOWER vehicle. RETURN oil level to normal. GO to 6-6 .	Aeration is caused by O-ring leak or a hole in the oil pickup tube. REPAIR as required according to Workshop Manual direction.

6-6 OIL AERATION TEST

- Go to Section 4 , Diagnostic Subroutines, Performance Diagnostic Procedures. Perform Injection Control Pressure Tests.
- Warm engine to normal operating temperature.
- Run engine at 3400 rpm for 3 minutes.

Does ICP read greater than 8756 kPa (1270 psi) or 1.75 volts?

Yes	No
Oil is aerating due to lack of defoaming agents. CHANGE to oil that meets CG4/SH specifications, and CONFIRM oil quantity is 13.2 liters (14 quarts).	GO to 6-7 .

6-7 LOW IDLE STABILITY TEST

- Go to Section 4 , Diagnostic Subroutines, Performance Diagnostic Procedures. Perform Low Idle Stability Test.

Does idle immediately smooth out?

Yes	No
GO to Pinpoint Test DC . CONFIRM wiring is OK. If OK, REPLACE ICP according to Workshop Manual direction.	GO to 6-8 .

6-8 CHECK FUEL PUMP PRESSURE

- Go to Section 4 , Diagnostic Subroutines, Performance Diagnostic Procedures. Perform Fuel Pump Pressure Test.

Is fuel pressure less than 206 kPa (30 psi)?

Yes	No
FOLLOW Performance Diagnostic Procedures direction.	GO to 6-9 .

6-9 CHECK HIGH-PRESSURE OIL SYSTEM

- Confirm engine oil level in high-pressure pump reservoir is within 25.4 mm (1 inch) of inspection plug.
- Attach 689 kPa (100 psi) oil pressure gauge on gauge bar (14-00761) to reservoir.
- Warm engine to normal operating temperature.

Is oil pressure 69 kPa (10 psig) or greater at idle (650 rpm)?

Yes	No
GO to 6-10 .	GO to the Powertrain Group in the Workshop Manual to check for cause of low oil pressure.

6-10 CHECK FOR BIASED ICP SENSOR

- Turn off engine for one minute.

Does ICP PID read greater than 0 kPa (0 psi) or ICP V PID read greater than 0.30 volt?

Yes	No
GO to Pinpoint Test DC . CONFIRM wiring is OK. If OK, REPLACE ICP sensor according to Workshop Manual direction.	GO to 6-11 .

6-11 KOER ON-DEMAND SELF TEST

CAUTION: Before running KOER On-Demand Self Test, make sure that the high-pressure oil passages are free of air from recent repairs by running vehicle hard for 32 kilometers (20 miles) after repair.

- Warm engine to normal operating temperature.
- Clear codes.
- Go to Section 4 , Diagnostic Subroutines, Performance Diagnostic Procedures. Perform KOER On-Demand Self Test.

Was DTC 1211 received?

Yes	No
GO to 6-12 .	GO to 6-17 .

6-12 CHECK PRESSURE BALANCE

- Plug off high-pressure hose for right cylinder head using special tool.
- Check IPR at 3000 rpm.
- Plug off high-pressure hose for left cylinder head using special tool, and reattach high-pressure hose on right cylinder head.
- Check IPR at 3000 rpm.

Is IPR duty cycle difference greater than 2%?

Yes	No
GO to 6-13 .	REPLACE IPR according to Workshop Manual direction.

6-13 CHECK ROUGH IDLE

Was rough idle present when vehicle was new?

Yes	No
GO to 6-14 .	GO to 6-15 .

6-14 CHECK HIGH-PRESSURE OIL PUMP

- Attach right hose to left head and plug left hose.
- Check IPR at idle.
- Compare this reading to reading for left head in Step 6-12.

Is difference in readings greater than 0.2 volt or 2%?

Yes	No
Imbalance caused by high-pressure oil pump.	GO to 6-15 .

CONFIRM high-pressure hoses are clear, and REPLACE high-pressure oil pump according to Workshop Manual direction.	

6-15 KOER CYLINDER CONTRIBUTION TEST

- Go to Section 4 , Diagnostic Subroutines, Performance Diagnostic Procedures. Perform KOER Cylinder Contribution Test.

Is a cylinder identified?

Yes	No
REPLACE identified injector according to Workshop Manual direction.	GO to 6-16 .

6-16 CHECK FOR LEAK SOURCE

- Remove valve cover on cylinder(s) with higher IPR reading.
- With engine idling, look for bubbling around injector bores or oil gallery drain plugs.
- Or, with engine off, attach approximately 689 kPa (100 psi) air pressure to high-pressure oil gallery.
- Look/listen for leaks.

Is a leak present?

Yes	No
REPLACE seals on injectors or RESEAL oil galleries as required according to Workshop Manual direction.	REPLACE seals on all injectors on the indicated bank according to Workshop Manual direction.

6-17 CHECK FOR WEAK CYLINDER

- Go to Section 4 , Diagnostic Subroutines, Performance Diagnostic Procedures. Perform KOER Cylinder Contribution Test.

Is a cylinder identified?

Yes	No
GO to 6-18 .	GO to 6-19 .

6-18 CHECK FOR ENGINE WEAR

- Go to Section 4 , Diagnostic Subroutines, Performance Diagnostic Procedures. Perform Crankcase Pressure Test.

Is crankcase pressure higher than 4 inches of H_2O?

Yes	No
REPAIR engine for rings or valves as required according to Workshop Manual direction.	REPLACE injector in identified cylinder according to Workshop Manual direction.

6-19 CHECK TRANSMISSION TYPE

Is vehicle equipped with a manual transmission?

Yes	No
GO to 6-20 .	GO to 6-23 .

6-20 CHECK FLYWHEEL

- Go to Section 4 , Diagnostic Subroutines, Performance Diagnostic Procedures. Perform KOER On-Demand Self Test.

During KOER On-Demand Self Test, or normal idling does flywheel make a rattling noise?

Yes	No
GO to 6-21 .	GO to 6-23 .

6-21 CHECK CLUTCH

- Press on clutch pedal.

Does rattling noise remain?

Yes	No
GO to 6-22 .	GO to 6-23 .

6-22 CHECK RATTLING NOISE

- With noise present in normal running mode, slowly increase engine rpm to 850.

Is rattling noise and rough idle eliminated?

Yes	No
REPLACE dual mass flywheel according to Workshop Manual direction.	GO to 6-23 .

6-23 CHECK FOR INCORRECT INJECTOR APPLICATION

- Remove engine valve covers.

- Check part number stamped on top of each injector.

Are the correct injectors installed?

Yes	No
Cause of rough idle cannot be determined. COMPARE idle performance with other vehicles.	REPLACE injectors according to Workshop Manual direction.

7-: Symptom Chart 7
Introduction

7-: Pinpoint Tests ➡

Symptom	OASIS Number
Unique Idle Concerns ▪ Fast idle	619400

7-: Pinpoint Tests ➡

⬅ 7-: Introduction

7-1 PRELIMINARY CHECKS

- Perform the following preliminary checks:
  - PCM system check
  - Accelerator pedal for binding, broken return spring, stuck (floor mats)
  - External fuel source
  - Engine not reaching normal operating temperature
  - PTO and charge protect devices disengaged

Are all checks OK?

Yes	No

GO to 7-2 .	REPAIR as necessary. VERIFY a symptom no longer exists.

7-2 PERFORM QUICK TEST OPERATION

- Go to Section 2 , Diagnostic Methods. Perform Quick Test Operation.

Is a fault indicated?

Yes	No
GO to appropriate pinpoint test.	GO to 7-3 .

7-3 CHECK PARAMETER IDENTIFICATIONS (PIDS)

- Go to Section 2 , Diagnostic Methods, Parameter Identification (PID), Selecting Parameter Identification (PID).
- Warm engine to normal operating temperature.
- Select PID EOT.

Is EOT value below 38°C (100°F)?

Yes	No
REPLACE EOT sensor according to Workshop Manual direction.	GO to 7-4 .

7-4 CHECK ACCELERATOR PEDAL

- Check for floor mat interference.
- Check bushing for damage.
- Check return spring.

Is a fault indicated?

Yes	No
REPAIR as required according to Workshop Manual direction.	GO to 7-5 .

7-5 CHECK ENGINE OIL

- Check for coolant in engine oil.

Is there coolant in engine oil?

Yes	No
REPAIR as required according to Workshop Manual direction.	GO to 7-6 .

7-6 CHECK FOR FUEL CONTAMINATION

- Check crankcase for fuel contamination.

Does the crankcase have fuel contamination?

Yes	No
CHECK injectors for leakage.	GO to Symptom Chart 10 .

8-: Symptom Chart 8 Introduction

8-: Pinpoint Tests

Symptom	OASIS Number
Runs Rough	608000
▪ Acceleration	608500
▪ Cruise	608600
Misses	609000
▪ Idle	609400
▪ Acceleration	609500
▪ Cruise	609600
Buck/Jerk	610000
▪ Acceleration	610500
▪ Cruise	610600
▪ Deceleration	610700
Hesitation/Stumble	611000
▪ Acceleration	611500

8-: Pinpoint Tests

8-1 PRELIMINARY CHECKS

- Perform the following preliminary checks:
  - Engine overheating
  - Electrical connections
  - Engine oil level/quality
  - MAP sensor vacuum hose leak
  - PCM automatically limits RPM at top engine speed
  - Automatic transmission TCC
  - ATF level

Are all checks OK?

Yes	No
GO to 8-2 .	REPAIR as necessary. VERIFY a symptom no longer exists.

8-2 CHECK PERFORMANCE DIAGNOSTICS

- Go to Symptom Chart 10 .

Is a fault indicated?

Yes	No
FOLLOW Symptom Chart direction.	GO to the Powertrain Group in the Workshop Manual to perform automatic transmission diagnosis.

9-: Symptom Chart 9 Introduction

9-: Pinpoint Tests

Symptom	OASIS Number
Surge	612000
▪ Acceleration	612500

▪ Cruise	612600

9-: Pinpoint Tests

9-1 PRELIMINARY CHECKS

- Perform the following preliminary checks:
  - Engine oil level/quality
  - Electrical wiring

Are all checks OK?

Yes	No
GO to 9-2 .	REPAIR as necessary. VERIFY a symptom no longer exists.

9-2 CHECK PERFORMANCE DIAGNOSTICS

Note: Surges at rpm limiter or top end speed limiter are normal functions of the PCM.

- Go to Symptom Chart 10 .

Is a fault indicated?

Yes	No
FOLLOW Symptom Chart direction.	GO to the Powertrain Group in the Workshop Manual to perform automatic transmission diagnosis.

10-: Symptom Chart 10 Introduction

10-: Pinpoint Tests

Symptom	OASIS Number
Lack/Loss of Power ▪ Acceleration ▪ Cruise	614000 614500 614600
Additional Driveability Concerns ▪ Poor Fuel Economy	 622000

10-: Pinpoint Tests

10-1 PRELIMINARY CHECKS

- Perform the following preliminary checks:
  - Confirm brakes are not dragging
  - Confirm transmission and axle fluid levels
  - Confirm transmission and axle tube are not "cooked"
  - Check for engine overheating
  - Check for oil in coolant
  - Check engine oil level
  - Confirm oil change within 8046.5 km (5000 miles), (5632.6 km [3500 miles] if severe duty)
  - Check Filter Minder
  - Check MAP sensor hose for holes, blockage, or disconnection. Confirm correct MAP sensor.
  - Check intake manifold system for leaks with soapy water with engine running. Include orange seals, gaskets and fittings
  - Confirm acceptable SAE oil viscosity:
    - 15W-40: preferred -1°C to 49°C (30° F to 120°F)
    - 10W-30: preferred -23°C to -34°C (-10° F to -30°F)
    - 5W-30: preferred below -28°C to -40°C (-20°F to -40°F)
  - Check fuel quality by opening filter drain and cranking engine
  - Confirm proper dipstick part number.

- Check for sufficient clean fuel
- Check for an intake restriction
- Check MAP sensor hose

Are all checks OK?

Yes	No
GO to 10-2 .	REPAIR as necessary. VERIFY a symptom no longer exists.

10-2 PERFORM KOEO ON-DEMAND SELF TEST

- GO to Section 4 , Diagnostic Subroutines, Performance Diagnostic Procedures. Perform KOEO On-Demand Self Test.

Is a fault indicated?

Yes	No
GO to appropriate pinpoint test.	GO to 10-3 .

10-3 PERFORM KOEO INJECTOR ELECTRICAL SELF TEST

- GO to Section 4 , Diagnostic Subroutines, Performance Diagnostic Procedures. Perform KOEO Injector Electrical Self Test.

Is a fault indicated?

Yes	No
GO to appropriate pinpoint test.	GO to 10-4 .

10-4 RETRIEVE/CLEAR CONTINUOUS DTCS

- GO to Section 4 , Diagnostic Subroutines, Performance Diagnostic Procedures. Retrieve/Clear Continuous DTCs.
- Record any codes retrieved.
- Clear Continuous DTCs.
- Check camshaft timing.
    - Rotate engine by hand until crankshaft timing mark for cylinder No. 1 is aligned with CMP sensor pointer.
    - Remove CMP sensor.
    - View spoked timing disk through hole for CMP sensor. If narrow spoke is not visible, rotate engine an additional 360 degrees.

Is narrow sync spoke aligned with the middle of the hole?

Yes	No
GO to 10-5 .	Cam gear is misindexed with crank gear.

	REPAIR as required according to Workshop Manual direction.

10-5 CHECK COLD CMP CLEARANCE

Did engine fail to reach rated speed only when engine oil was cold?

Yes	No
GO to 10-6 .	GO to 10-7 .

10-6 CHECK CMP CLEARANCE TO TIMING DISK

- Remove and inspect CMP for evidence of contact with the timing disk (scratches or unplugged holes on working surface).

Is there evidence of contact?

Yes	No
REPLACE CMP according to Workshop Manual direction and add shim F6TZ-12J027-M to create approximately 0.5 mm (0.020 inch) clearance to timing disk.	GO to 10-7 .

10-7 CHECK FOR BIASED ICP SENSOR

- Warm up engine.
- Turn off engine for one minute.
- KOEO.
- GO to Section 2 , Diagnostic Methods, Parameter Identification (PID), selecting Parameter Identification (PID).
- Select PIDs ICP and ICP V.

Does ICP PID read greater than 0 kPa (0 psi) or ICP V PID read greater than 0.30 volt?

Yes	No
GO to Pinpoint Test DC . CONFIRM wiring is OK. If OK, REPLACE ICP sensor according to Workshop Manual direction.	GO to 10-8 .

10-8 CHECK FOR LOW IDM POWER

- Run engine at WOT, unloaded.

Does engine reach 3300 rpm?

Yes	No

GO to 10-12 .	GO to 10-9 .

10-9 VERIFY GOVERNED IDLE

Does engine stay at governed idle (650 rpm)?

Yes	No
GO to Symptom Chart 4 .	GO to 10-10 .

10-10 CONFIRM INJECTION CONTROL PRESSURE

- Go to Section 2 , Diagnostic Methods, Parameter Identification (PID), selecting Parameter Identification (PID).
- Select PIDs ICP and ICP V.

Does ICP PID read at least 6895 kPa (1000 psi [1.46 volts]) at maximum rpm reached?

Yes	No
GO to 10-11 .	GO to 10-20 .

10-11 CHECK FUEL PUMP PRESSURE

- Go to Section 4 , Diagnostic Subroutines, Performance Diagnostic Procedures. Perform Fuel Pump Pressure Test.
- Check both tanks.

Is fuel pressure at least 172 kPa (25 psi) at maximum rpm?

Yes	No
GO to Pinpoint Test NA Step NA29 . CONFIRM injector wiring circuits are OK. If OK, REPLACE IDM according to Workshop Manual direction.	GO to 10-15 .

10-12 CHECK FOR AERATED OIL

CAUTION: Before running oil aeration tests, make sure the high-pressure oil passages are free of air from recent repairs by running vehicle hard for 32 kilometers (20 miles) after repair.

CAUTION: Engine must be warmed up to normal operating temperature.

- Go to Section 4 , Diagnostic Subroutines, Performance Diagnostic Procedures. Perform Injection Control Pressure Test.

- Run engine at WOT for 30 seconds.

Does ICP read greater than 11032 kPa (1600 psi) or 2.15 volts in 30 seconds or less?

Yes	No
GO to 10-13 .	GO to 10-14 .

10-13 CHECK FOR OIL PUMP INTAKE LEAKS

- Confirm proper oil change interval.
- Confirm proper oil level and type.
- Overfill engine by 1.9 liters (2 quarts).
- Raise and support rear of vehicle 254 mm (10 inches).
- Run engine at WOT for 30 seconds.

Does ICP read greater than 11032 kPa (1600 psi [2.15 volts])?

Yes	No
LOWER vehicle. RETURN oil level to normal. GO to 10-14 .	Aeration is caused by O-ring leak or a hole in the oil pickup tube. REPAIR as required according to Workshop Manual direction.

10-14 INJECTION CONTROL PRESSURE TEST

- Go to Section 4 , Diagnostic Subroutines, Performance Diagnostic Procedures. Perform Injection Control Pressure Test.
- Warm engine to normal operating temperature.
- Run engine at WOT for 3 minutes.

Does ICP read greater than 8756 kPa (1270 psi) or 1.75 volts?

Yes	No
Oil is aerating due to lack of defoaming agents. CHANGE to oil that meets CG4/SH specifications and CONFIRM oil quantity is 13.2 liters (14 quarts). GO to 10-15 .	GO to 10-15 .

10-15 FUEL SYSTEM CHECK

- Go to Section 4 , Diagnostic Subroutines, Performance Diagnostic Procedures. Perform Fuel Pump Pressure Test.

Is fuel pressure less than 206 kPa (30 psi) at 3300 rpm?

Yes	No
REMOVE filter cover and filter. DETACH pressure regulator from filter housing and	GO to 10-16 .

CHECK for clogged return screen. CHANGE fuel filter, and RERUN pressure check. If fuel pressure is still less than 206 kPa (30 psi) at 3300 rpm, GO to 10-16 .	

10-16 CHECK FUEL REGULATOR

- Detach pressure regulator from filter housing, and check for clogged return screen or clogged orifices.
- Check regulator valve for evidence of sticking or debris.

Is regulator valve faulty?

Yes	No
REPLACE regulator valve according to Workshop Manual direction.	GO to 10-17 .

10-17 CHECK PUMP INLET RESTRICTION

- Go to Section 4 , Diagnostic Subroutines, Performance Diagnostic Procedures. Perform Pump Inlet Pressure Test.

Is vacuum greater than 20 kPa (6 in-Hg)?

Yes	No
CHECK inlet lines between tank(s) and fuel line fitting for blockage.	GO to 10-18 .

10-18 CHECK FUEL REGULATOR FOR BLOCKAGE

- Remove fuel regulator and check for blockage.

If there blockage?

Yes	No
REPLACE fuel regulator according to Workshop Manual direction.	GO to 10-19 .

10-19 CHECK FUEL INLET LINE FOR BLOCKAGE

- Check fuel inlet line for blockage between quick connect fitting and fuel pump.

Is there blockage?

Yes	No
REPLACE fuel inlet line according to	REPLACE fuel pump according to

Workshop Manual direction.	Workshop Manual direction.

10-20 CHECK HIGH-PRESSURE OIL SYSTEM

- Confirm engine oil level in high-pressure pump reservoir is within 25.4 mm (1 inch) of inspection plug.
- Attach 689 kPa (100 psi) oil pressure gauge on gauge bar (14-00761) to reservoir.
- Warm engine to normal operating temperature.

Is oil pressure 69 kPa (10 psig) or higher at idle (650 rpm)?

Yes	No
GO to 10-21 .	GO to the Powertrain Group in the Workshop Manual to check for cause of low oil pressure.

10-21 KOER ON-DEMAND SELF TEST

CAUTION: Before running KOER On-Demand Self Test, make sure the high-pressure oil passages are free of air from recent repairs by running vehicle hard for 32 kilometers (20 miles) after repair.

- Go to Section 4 , Diagnostic Subroutines, Performance Diagnostic Procedures. Perform KOER On-Demand Self Test.

Was DTC P1211 received?

Yes	No
GO to 10-23 .	GO to 10-22 .

10-22 CHECK FOR DTC P0476

Referring to Step 10-21, was DTC P0476 received?

Yes	No
GO to 10-26 .	GO to 10-30 .

10-23 CHECK PRESSURE BALANCE

- Plug off high-pressure hose for right cylinder head using special tool.
- Record IPR at 3300 rpm.
- Plug off high-pressure hose for left cylinder head using special tool, and reattach high-pressure hose on right cylinder head.
- Record IPR at 3000 rpm.

Is IPR duty cycle difference greater than 2%?

Yes	No
GO to 10-24 .	REPLACE IPR according to Workshop Manual direction.

10-24 KOER CYLINDER CONTRIBUTION TEST

- Go to Section 4 , Diagnostic Subroutines, Performance Diagnostic Procedures. Perform KOER Cylinder Contribution Test.

Is a cylinder identified?

Yes	No
REPLACE identified injector according to Workshop Manual direction.	GO to 10-25 .

10-25 CHECK FOR LEAK SOURCE

- Remove valve cover on cylinder head with higher IPR reading.
- With engine idling, look for bubbling around injector bores or oil gallery drain plugs.
- Or, with engine off, attach approximately 689 kPa (100 psi) air pressure to high-pressure oil gallery.
- Look/listen for leaks.

Is a leak present?

Yes	No
REPLACE seals on injectors or RESEAL oil galleries as required according to Workshop Manual direction.	REPLACE seals on all injectors on the indicated bank according to Workshop Manual direction.

10-26 EXHAUST RESTRICTION TEST

- Inspect exhaust system for damage.
- Remove engine cover (lid).
- Observe EBP valve operation while rerunning KOER On-Demand Self Test.

Does EBP valve cycle and then open completely (tang against stop)?

Yes	No
GO to 10-28 .	GO to 10-27 .

10-27 CHECK ELECTRICAL SYSTEM

- Go to Section 5, Pinpoint Test KB , and confirm that EPR and wiring are working.

Is electrical system OK?

Yes	No
REPAIR EBP system.	REPAIR electrical system.

10-28 CHECK FOR BIASED EBP SENSOR

- KOEO.
- Use NGS tester to read EBP, MAP and BARO PIDs.

Is the difference between EBP, MAP and BARO PIDs greater than 20 kPa (3 psi)?

Yes	No
GO to Pinpoint Test DE. CONFIRM wiring and PCM are OK. If OK, REPLACE EBP according to Workshop Manual direction.	GO to 10-29 .

10-29 CHECK FOR EXHAUST RESTRICTION

- Unplug EOT to cause EBP valve to stay open.
- Run engine at WOT.
- Read EBP on NGS or DVOM.

Is EBP greater than 172 kPa [25 psia (2 volts)]?

Yes	No
LOCATE and REPAIR exhaust restriction according to Workshop Manual direction.	GO to Pinpoint Test C.

10-30 CHECK FOR WEAK CYLINDER

- Go to Section 4 , Diagnostic Subroutines, Performance Diagnostic Procedures. Perform KOER Cylinder Contribution Test.

Is a cylinder identified?

Yes	No
GO to 10-31 .	GO to 10-32 .

10-31 CHECK FOR ENGINE WEAR

- Go to Section 4 , Diagnostic Subroutines, Performance Diagnostic Procedures. Perform Crankcase Pressure Test.

Is crankcase pressure higher than 4 inches of H_2

Yes	No

REPAIR engine for rings or valves as required according to Workshop Manual direction.	GO to 10-32 .

10-32 BOOST PRESSURE TEST

- Go to Section 4 , Diagnostic Subroutines, Performance Diagnostic Procedures. Perform Boost Pressure Test.
- Display PID MGP on NGS.
- Road test to determine turbo boost.
- Accelerate hard between 1500 and 3000 rpm.

Is boost OK?

Yes	No
GO to 10-34 .	GO to 10-33 .

10-33 CHECK MAP SENSOR

- Go to Section 5. Perform Pinpoint Test DH .

Does MAP system check OK?

Yes	No
REPLACE MAP sensor according to Workshop Manual direction.	INSPECT turbocharger. REPAIR as necessary according to Workshop Manual direction.

10-34 CHECK FOR BIASED EOT SENSOR

- Soak vehicle overnight.
- Do not start engine.
- Read EOT and IAT using NGS Tester with KOEO.

Do readings agree within 6°C (11°F)?

Yes	No
GO to 10-35 .	GO to Pinpoint Test DB . CONFIRM wiring is OK. If OK, REPLACE EOT according to Workshop Manual direction.

10-35 CHECK EOT SENSOR

- Warm engine to between 15°C and 70°C (59°F and 158°F).
- Remove fill/check plug from high-pressure oil pump reservoir.
- Measure reservoir oil temperature with an A/C thermometer.

- Measure EOT using NGS Tester or DVOM.

Do readings between EOT and thermometer agree within ± 3°C (± 5.4° F)?

Yes	No
With transmission in fourth gear (M/T) or OD locked out (E4OD), RECORD time to accelerate hard between 48 and 97 km/h (30 and 60 mph). COMPARE time to another power stroke vehicle with same weight, transmission and axle.	GO to Pinpoint Test DB . CONFIRM wiring is OK. If OK, REPLACE EOT according Workshop Manual direction.

11-: Symptom Chart 11 Introduction

11-: Pinpoint Tests

Symptom	OASIS Number
Additional Driveability Concerns ▪ CHECK ENGINE Light Concern	698298
Warning Indicators ▪ CHECK ENGINE Light	206000

11-: Pinpoint Tests

11-: Symptom Chart 11

11-: Introduction

11-1 OBSERVE CHECK ENGINE LIGHT

Is CHECK ENGINE light continuously illuminated?

Yes	No

GO to 11-2 .	GO to 11-3 .

11-2 PERFORM KOEO ON-DEMAND SELF TEST AND RETRIEVE/CLEAR CONTINUOUS DTCS

- Go to Section 2 , Diagnostic Methods. Perform KOEO On-Demand Self Test, and Retrieve/Clear Continuous DTCs.

Is fault indicated?

Yes	No
GO to appropriate pinpoint test.	GO to 11-3 .

11-3 RUN BULB CHECK

- Cycle ignition switch.

Does CHECK ENGINE light flash?

Yes	No
CHECK ENGINE light is OK.	GO to Pinpoint Test NB .

12-: Symptom Chart 12 Introduction

12-: Pinpoint Tests

Symptom	OASIS Number
Exhaust System Concerns	403000
▪ Visible Smoke	403400

12-: Pinpoint Tests

12-1 PRELIMINARY CHECKS

- Perform the following preliminary checks:
  - Check Filter Minder
  - Check MAP sensor hose for holes, blockage, or disconnection. Confirm correct MAP sensor.
  - Check intake manifold system for leaks with soapy water with engine running. Include orange seals, gaskets and fittings
  - Confirm acceptable SAE oil viscosity:
    - 15W-40: preferred -1°C to 49°C (30° F to 120°F)
    - 10W-30: preferred -23°C to -34°C (-10° F to -30°F)
    - 5W-30: preferred below -28°C to -40°C (-20°F to -40°F)
  - Check fuel quality by opening filter drain and cranking engine.

Are all checks OK?

Yes	No
GO to 12-2 .	REPAIR as required according to Workshop Manual direction. VERIFY a symptom no longer exists.

12-2 ATMOSPHERIC PRESSURE RATIONALITY CHECK

- Go to Section 2 , Diagnostic Methods, Parameter Identification (PID), Selecting Parameter Identification (PID).
- Select PIDs EBP, MAP and BARO.
- Key on, engine off.

Do all readings agree within 21 kPa (3.0 psi)?

Yes	No
GO to the appropriate pinpoint test for the sensor that disagrees with the other two sensors.	GO to 12-3 .

12-3 CHECK TAILPIPE EXHAUST SMOKE

Is exhaust smoke coming from the tailpipe?

Yes	No
If exhaust smoke is white, GO to 12-4 . If exhaust smoke is black, GO to 12-6 .	VERIFY a symptom no longer exists.

12-4 CHECK WHITE TAILPIPE EXHAUST SMOKE

Note: White tailpipe exhaust smoke is a normal condition at start-up with temperatures below 10°C (50°F) or with an extended idle in a cool climate.

- Go to Section 4 , Diagnostic Subroutines, Hard Start/No Start Diagnostic Procedures. Perform Glow Plug System Operation check.
- Go to Section 4 , Diagnostic Subroutines. Perform Performance Diagnostic Procedures.

Is a fault indicated?

Yes	No
FOLLOW Diagnostic Procedures direction.	GO to 12-5 .

12-5 CHECK ENGINE COOLING

- Go to the Powertrain Group in the Workshop Manual to check thermostat operation.

Is thermostat operating properly?

Yes	No
REPAIR as necessary according to Workshop Manual direction.	PERFORM cooling system leak tests. CHECK for internal engine leaks according to Workshop Manual direction.

12-6 MAP SENSOR VACUUM CHECK

- Apply vacuum to MAP sensor.

Does MAP sensor hold vacuum?

Yes	No
Unable to verify concern at this time. RETURN to Symptom Index.	REPLACE MAP sensor according to Workshop Manual direction.

13-: Symptom Chart 13 Introduction

13-: Pinpoint Tests

Symptom	OASIS Number
Additional Driveability Concerns	

▪ Speed Control	205200

13-: Pinpoint Tests ➡

13-: Symptom Chart 13

⬅ 13-: Introduction

13-1 CHECK ABS LIGHT

Is ABS light on?

Yes	No
REPAIR as necessary according to Workshop Manual direction.	GO to 13-2 .

13-2 CHECK BRAKE WARNING LIGHT

Is brake warning light on?

Yes	No
GO to Pinpoint Test FF .	GO to 13-3 .

13-3 PERFORM KOEO ON-DEMAND SELF TEST AND RETRIEVE/CLEAR CONTINUOUS DTCS

- Go to Section 2 , Diagnostic Methods. Perform KOEO On-Demand Self Test, and Retrieve/Clear Continuous DTCs.

Is a fault indicated?

Yes	No
GO to appropriate pinpoint test.	GO to 13-4 .

13-4 PERFORM KOER SWITCH SELF TEST

- Go to Section 2 , Diagnostic Methods. Perform KOER switch self test.

Is a fault indicated?

Yes	No
GO to appropriate pinpoint test.	GO to 13-5 .

13-5 ROAD TEST

- Go to Section 2 , Diagnostic Methods, Parameter Identification (PID), Selecting Parameter Identification (PID).
- Select PIDs PBA, BPA, CPP, BOO, SCCS__ M, VSS, and VS SET.
- Drive vehicle and function speed control system.
- Compare VSS to Speedometer.

Does NGS display proper values for each PID selected?

Yes	No
GO to 13-6 .	GO to appropriate pinpoint test.

13-6 CHECK SPEED CONTROL

Does speed control drop out when climbing hills?

Yes	No
Engine power is not adequate to hold hill. GO to 13-7 .	GO to Symptom Chart 10 .

13-7 CHECK VEHICLE LOAD

- Check vehicle for heavy loads.

Is vehicle load too heavy to hold hills?

Yes	No
Vehicle speed dropped 10 mph below speed control set mph, causing speed control disengagement. CONFIRM condition with NGS PIDS VSS and VS SET.	GO to Symptom Chart 10 .

14-: Symptom Chart 14 Introduction

14-: Pinpoint Tests

Symptom	OASIS Number
Warning Indicators ▪ TCIL	698298

14-: Pinpoint Tests

1999 PCED On Board Diagnostics II Diesel SECTION 3: Symptom Charts

14-: Symptom Chart 14

14-: Introduction

14-1 CHECK TCIL

Is TCIL flashing?

Yes	No
GO to 14-3 .	GO to 14-2 .

14-2 TOGGLE TCIL

- Toggle TCIL by pushing TCS switch several times.

Does TCIL toggle on and off?

Yes	No
TCIL is OK.	GO to Pinpoint Test H .

14-3 OBSERVE CHECK ENGINE LIGHT

Is Check Engine Light on?

Yes	No

GO to Symptom Chart 11 .	GO to 14-4 .

14-4 RUN QUICK TEST

- Go to Section 2 , Diagnostic Methods. Perform Quick Test Operation.

Is a fault indicated?

Yes	No
GO to appropriate pinpoint test.	GO to Pinpoint Test H .

15-: Symptom Chart 15 Introduction

15-: Pinpoint Tests

Symptom	OASIS Number
Automatic Transmission Shift Concerns	
▪ A/T Upshift Concern	501000
▪ A/T Downshift Concern	502000
▪ Engagement Concern	503000

15-: Pinpoint Tests

15-1 CHECK AUTOMATIC TRANSMISSION FLUID

- Check automatic transmission fluid level and quality.

Are fluid level and quality OK?

Yes	No

GO to 15-2 .	REPAIR as necessary according to Workshop Manual direction. VERIFY a symptom no longer exists.

15-2 CHECK PARAMETER IDENTIFICATIONS (PIDS)

Note: Refer to NGS Tester — Driver Operated Controls Check for PID values.

- Go to Section 2 , Diagnostic Methods, Parameter Identification (PID), Selecting Parameter Identification (PID).
- Display PIDs TR, SCCS M, 4x4L and VSS.

Does the scan tool display proper values for each PID?

Yes	No
GO to 15-3 .	GO to appropriate pinpoint test.

15-3 CHECK PERFORMANCE DIAGNOSTICS

- Go to Symptom Chart 10.

Is a fault indicated?

Yes	No
REPAIR engine faults first, then REPAIR automatic transmission faults.	GO to the Powertrain Group in the Workshop Manual to perform automatic transmission diagnosis.

16-: Symptom Chart 16 Introduction

16-: Pinpoint Tests

Symptom	OASIS Number
Oil System Concerns	401000
▪ High Oil Consumption	401100
▪ Leaks	401800

16-: Pinpoint Tests

16-1 PRELIMINARY CHECKS

- Perform the following preliminary checks:
  - External leaks (rocker cover gasket, crankshaft seals, etc.)
  - Proper dipstick
  - Proper oil viscosity

Are all checks OK?

Yes	No
GO to 16-2 .	REPAIR as required according to Workshop Manual direction. VERIFY a symptom no longer exists.

16-2 CHECK PERFORMANCE DIAGNOSTICS

- Go to Symptom Chart 10.

Is a fault indicated?

Yes	No
FOLLOW Diagnostic Procedures direction.	GO to the Powertrain Group in the Workshop Manual to CHECK valves, valve guides, valve stem seals, intake manifold gaskets, cylinder head drain passages (blue smoke on startup), and piston rings. REPAIR as required according to Workshop Manual direction.

17-: Symptom Chart 17 Introduction

17-: Pinpoint Tests

Symptom	OASIS Number
Starting Concerns ▪ Hard Start/No Start — Dry Reservoir	

17-: Pinpoint Tests ➡

17-1 PERFORM OIL PUMP PRESSURE TEST

Note: Low oil pressure from the engine oil pump can also cause low oil levels in the reservoir.

- Go to the Powertrain Group in the Workshop Manual. Perform Oil Pump Pressure Test.

Is a fault indicated?

Yes	No
REPAIR as required according to Workshop Manual direction.	GO to 17-2 .

17-2 CHECK OIL RESERVOIR

- Remove oil reservoir fill plug and refill reservoir.
- Start engine and test drive vehicle for 16 kilometers (10 miles).
- Remove oil reservoir fill plug and check reservoir oil level.

Is oil reservoir full?

Yes	No
GO to 17-3 .	INSPECT oil reservoir and engine front cover for evidence of oil leakage. If leakage is detected, REPAIR or REPLACE as required according to Workshop Manual direction.

17-3 RECHECK OIL RESERVOIR

Note: Perform the following step before starting engine.

- Allow vehicle to sit overnight.
- Remove oil reservoir fill plug and check reservoir oil level.

Is oil reservoir full?

Yes	No
VERIFY a symptom no longer exists.	REMOVE high-pressure oil pump. INSPECT for internal leak pass across high-pressure oil pump gasket beads. REMOVE oil reservoir cover. INSPECT oil reservoir for casting porosity. If necessary, REPLACE high-pressure oil pump or oil reservoir according to Workshop Manual direction.