BY series

SERVICE MANUAL

4BY
6BY

P/N: 0BBY0-U00102

YAMAHA®

MARINE ENGINES

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1207

California
Proposition 65 Warning

Diesel engine exhaust and some of its constituents are known to the state of California to cause cancer, birth defects, and other reproductive harm.

California
Proposition 65 Warning

Battery posts, terminals, and related accessories contain lead and lead compounds, chemicals known to the state of California to cause cancer and reproductive harm.
Wash hands after handling.

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Section 1

INTRODUCTION

This manual gives specific instructions for the proper repair of Yanmar BY series marine engines.

Please follow the procedures carefully to ensure quality service.

Yanmar recommends that you read this *Service Manual* completely before starting repairs.

Along with standard tools, Yanmar recommends the use of special tools necessary to perform repairs correctly.

Yanmar products are continuously undergoing improvement. This *Service Manual* has been checked carefully in order to avoid errors. However Yanmar is not liable for any misrepresentations, errors of description or omissions. Contact an authorized Yanmar marine dealer or distributor for any questions you have regarding this *Service Manual.*

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REVISION HISTORY

This manual is a living document. Periodic manual revisions are published to document product improvements and changes. This practice ensures the manual has the most current information.

As manual revisions become necessary, individual pages are prepared and sent to those who need the information. If a page, or number of pages should be replaced, the replacement information is sent along with a revised Revision Control Table. Discard the older, obsolete information.

At times, the revision involves inserting additional pages in one or more sections. Replace the Revision Control Table and insert the new pages.

This method of revision control represents the most cost-effective solution to providing current, updated information as needed.

Revision Control Table

Revision Date Revision Number	New Page Numbers Involved	Remarks	Initiating Dept.
DEC 2006 Rev. 01	All	Re-release	YMU
NOV 2007 Rev. 02	3-2, 12-12 to 12-22	Table of Contents correction, pin identification information update	YMU
NOV 2007 Rev. 02	3-17, 3-18, 3-22, 4-3, 4-6, 4-10, 4-11, 5-54 and 12-11	Removed back pressure and negative intake pressure information, updated marine gear information, units of measure, periodic maintenance intervals, camshaft bearing cap marks, ECM legend	YMI

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PRINCIPAL ENGINE SPECIFICATIONS

Engine Model	4BY150 / 150Z	4BY180 / 180Z	6BY220 / 220Z	6BY260 / 260Z
Application Design	Models numbers with no suffix letter are used in marine gear applications. Models having a “Z” suffix are used with stern drive.			
Number of Cylinders	In-line 4		In-line 6	
Type	15° inclined, water-cooled, dual overhead camshaft, 4-cycle diesel			
Combustion System	Direct injection			
Aspiration	Turbocharged with charge air cooler			
Bore x Stroke	84 mm x 90 mm (3.307 in. x 3.543 in.)			
Displacement	1.995 L (121.7 cu in.)		2.993 L (182.6 cu in.)	
Firing Order*	1-3-4-2		1-5-3-6-2-4	
Compression Ratio	16.5:1		16.5:1	
Rated Power Output**	4BY150 / 4BY150Z	4BY180 / 4BY180Z	6BY220 / 6BY220Z	6BY260 / 6BY260Z
Continuous Output (at 3600 rpm)	85 kW (114 hp)	102 kW (137 hp)	124 kW (166 hp)	147 kW (197 hp)
Maximum Output (at 4000 rpm)	110 kW (150 hp)	132 kW (180 hp)	162 kW (220 hp)	191 kW (260 hp)
Mean Pressure	1.66 MPa (240.76 psi)	1.98 MPa (287.18 psi)	1.62 MPa (234.96 psi)	1.92 MPa (278.47 psi)
Low Idle Speed (Warm Engine @ 88°C [190°F])	750 rpm (ECU-controlled)		670 rpm (ECU-controlled)	
Cold Start Speed @ 20°C (68°F)	1200 rpm gradually decreasing to warm engine idle @ 88°C (190°F) (ECU-controlled)			
High Idle Speed	4600 rpm			
Rotation Direction	Counterclockwise (viewed from flywheel)			
No. of Valves per Cylinder	4			
Valve Adjustment	Hydraulic self-adjusting			
Turbocharger	MHI with pneumatic wastegate		HOLSET with pneumatic wastegate	
Charge Air Cooler	Seawater cooled			
Electrical System	12 V			
Starter	12 V / 2 kW (2.7 hp)			
Charging System	12 V / 150 A			
Battery Capacity - Recommended	12 V / 74 Ah / 680 CCA (cold cranking amps)			
Fuel Injection System	Common rail (ECU-controlled)			
Fuel Injection Pressure	Variable depending on rpm; 250 - 1600 bar (3626 - 23,206 psi)			
Injection Timing	Variable (ECU-controlled)			
ECU Threshold Voltage	7.8 V			
Cooling System	Closed cooling system with heat exchanger			
Coolant Capacity (Approximate)	10.0 L (10.6 qt)		13.5 L (14.3 qt)	

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Engine Model	4BY150 / 150Z	4BY180 / 180Z	6BY220 / 220Z	6BY260 / 260Z
Seawater Pump	Rubber impeller, belt driven			
Capacity	140 L / hour minimum (37 gal / hour minimum) at 4000 engine rpm			
Maximum Lift	2000 mm (78.75 in.)			
Hydraulic Oil Cooler	Seawater cooled			
Lubrication System	Totally enclosed, forced lube system			
Oil Cooler	Engine coolant system			
Lube Oil Pressure at 4000 rpm	3.5 - 6.0 bar (51 - 87 psi)			
Lube Oil Pressure at 1000 rpm	0.6 - 1.0 bar (8.7 - 14.5 psi)			
Lube System Capacity***	8.0 L (8.45 qt)****		11.0 L (11.5 qt)****	
Crankcase Ventilation	Closed, with filter			
Drive Options				
Stern Drive	Bravo-1, -2, -3			
Marine Gear	KMH40A or KMH50A		KMH40 or KMH50	
Installation Angles: Static Angle				
Front-to-Rear	± 4°			
Left-to-Right	± 0°			
Operational Angles: Front-to-Rear and Left-to-Right				
Continuous	10° maximum			
Peak	20° maximum			
Height	721 mm (28.4 in.)			
Length (without marine gear)				
Stern Drive (front-to-middle of engine mount)	760 mm (29.9 in.)		942 mm (37.1 in.)	
Marine Gear (front-to-marine gear mounting face)	644 mm (25.4 in.)		825.5 mm (32.5 in.)	
Overall Length	861 mm (33.9 in.)		1001 mm (39.4 in.)	
Width	670 mm (26.4 in.) (local exceeding)			
Weight (without marine gear)				
Dry (without mixing elbow)	250 kg (551 lb)		310 kg (683 lb)	
Wet (with mixing elbow)	270 kg (595 lb)		340 kg (750 lb)	

* *Cylinder numbering starts at the coolant pump end of the engine.*

** *Rating condition: ISO 8665. Temperature of fuel: 40°C (104°F) at fuel pump inlet.*
Fuel condition: Density at 15°C (59°F) = 0.827 g/cm^3.
Fuel temperature at the inlet of the fuel injection pump.
1 hp (metric horsepower) = 0.7355 kW

*** *The "Total Engine Lubricating Oil Capacity" includes oil in the oil pan, channels, coolers, and filter.*
The "Effective Engine Lubricating Capacity" indicates the difference in maximum scale of the dipstick and minimum scale.

**** *Capacity may vary depending on installation angle.*

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ABBREVIATIONS AND SYMBOLS

Abbreviations

A	ampere
AC	alternating current
ACEA	Association des Constructeurs Européens d'Automobilies
Ah	ampere-hour
API	American Petroleum Institute
ARB	Air Resources Board
ATDC	after top dead center
BDC	bottom dead center
BTDC	before top dead center
°C	degree Celsius
CARB	California Air Resources Board
CCA	cold cranking amp
cfm	cubic feet per minute
cm	centimeter
cm³	cubic centimeter
cm³/min	cubic centimeter per minute
cu in.	cubic inch
D	diameter
DC	direct current
DI	direct injection
DVA	direct volt adapter
EPA	Environmental Protection Agency
ESG	electronic speed governor
°F	degree Fahrenheit
fl oz	fluid ounce (U.S.)
fl oz/min	fluid ounce (U.S.) per minute
ft	foot
ft-lb	foot pound
ft-lbf/min	foot pound force per minute
g	gram
gal	gallon (U.S.)
gal/hr	gallon (U.S.) per hour
gal/min	gallon (U.S.) per minute
GL	gear lubricant
hp	horsepower (U.S.)
hr	hour
I.D.	inside diameter
ID	identification
IDI	indirect injection
in.	inch
in.Aq	inches Aqueous (water)
in.Hg	inches Mercury
in.-lb	inch pound
J	joule
JASO	Japanese Automobile Standards Organization
K	kelvin
kg	kilogram
kgf/cm²	kilogram force per square centimeter
kgf/m	kilogram force per meter
km	kilometers
kPa	kilopascal
kW	kilowatt
L	liter
L/hr	liter per hour
lb	pound
lbf	pound force
m	meter
mL	milliliter
mm	millimeter
mmAq	millimeter Aqueous (water)
MPa	megapascal
mV	millivolt
N	newton
N·m	newton meter
No.	number
O.D.	outside diameter
oz	ounce
Pa	pascal
PS	horsepower (metric)
psi	pound per square inch
qt	quart (U.S.)
R	radius
rpm	revolutions per minute
SAE	Society of Automotive Engineers
sec.	second
t	short ton 2000 lb
TBN	total base number
TDC	top dead center
V	volt
VAC	volt alternating current
VDC	volt direct current
W	watt

Symbols

°	degree
+	plus
-	minus
±	plus or minus
Ω	ohm
μ	micro
%	percent

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UNIT CONVERSIONS

Unit Prefixes

Prefix	Symbol	Power
mega	M	x 1,000,000
kilo	k	x 1,000
centi	c	x 0.01
milli	m	x 0.001
micro	μ	x 0.000001

Units of Length

mile	x	1.6090	= km
ft	x	0.3050	= m
in.	x	2.5400	= cm
in.	x	25.4000	= mm
km	x	0.6210	= mile
m	x	3.2810	= ft
cm	x	0.3940	= in.
mm	x	0.0394	= in.

Units of Volume

gal (U.S.)	x	3.78540	= L
qt (U.S.)	x	0.94635	= L
cu in.	x	0.01639	= L
cu in.	x	16.38700	= mL
fl oz (U.S.)	x	0.02957	= L
fl oz (U.S.)	x	29.57000	= mL
cm^3	x	1.00000	= mL
cm^3	x	0.03382	= fl oz (U.S.)

Units of Mass

lb	x	0.45360	= kg
oz	x	28.35000	= g
kg	x	2.20500	= lb
g	x	0.03527	= oz

Units of Force

lbf	x	4.4480	= N
lbf	x	0.4536	= kgf
N	x	0.2248	= lbf
N	x	0.1020	= kgf
kgf	x	2.2050	= lbf
kgf	x	9.8070	= N

Units of Torque

ft-lb	x	1.3558	= N·m
ft-lb	x	0.1383	= kgf/m
in.-lb	x	0.1130	= N·m
in.-lb	x	0.0115	= kgf/m
kgf/m	x	7.2330	= ft-lb
kgf/m	x	86.8000	= in.-lb
kgf/m	x	9.8070	= N·m
N·m	x	0.7376	= ft-lb
N·m	x	8.8510	= in.-lb
N·m	x	0.1020	= kgf/m

Units of Pressure

psi	x	0.0689	= bar
psi	x	6.8950	= kPa
psi	x	0.0703	= kgf/cm^2
bar	x	14.5030	= psi
bar	x	100.0000	= kPa
bar	x	29.5300	= inHg (60°F)
kPa	x	0.1450	= psi
kPa	x	0.0100	= bar
kPa	x	0.0102	= kgf/cm^2
kgf/cm^2	x	98.0700	= psi
kgf/cm^2	x	0.9807	= bar
kgf/cm^2	x	14.2200	= kPa
in.Hg (60°)	x	0.0333	= bar
in.Hg (60°)	x	3.3770	= kPa
in.Hg (60°)	x	0.0344	= kgf/cm^2
mmAq	x	0.0394	= in.Aq

Units of Power

hp (metric or PS)	x	0.9863201	= hp SAE
hp (metric or PS)	x	0.7354988	= kW
hp SAE	x	1.0138697	= hp (metric or PS)
hp SAE	x	0.7456999	= kW
kW	x	1.3596216	= hp (metric or PS)
kW	x	1.3410221	= hp SAE

Units of Temperature

°F = (1.8 x °C) + 32
°C = 0.556 x (°F - 32)

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INTRODUCTION

This section of the *Service Manual* describes the procedures for proper care and maintenance of the engine.

The Importance of Periodic Maintenance

Engine deterioration and wear occurs in proportion to length of time the engine has been in service and the conditions the engine is subject to during operation. Periodic maintenance prevents unexpected downtime, reduces the number of accidents due to poor machine performance and helps extend the life of the engine.

Performing Periodic Maintenance

Perform periodic maintenance procedures in an open, level area free from traffic. If possible, perform the procedures indoors to prevent environmental conditions such as rain, wind or snow from damaging the engine. **WARNING! *NEVER block windows, vents or other means of ventilation if the engine is operating in an enclosed area. All internal combustion engines create carbon monoxide gas during operation. Accumulation of this gas within an enclosure could cause illness or even death.***

Yanmar Replacement Parts

Yanmar recommends that you use genuine Yanmar parts when replacement parts are needed. Genuine replacement parts help ensure long engine life.

Required EPA Maintenance

To maintain optimum engine performance and compliance with the Environmental Protection Agency (EPA) Regulation Engines, it is essential that you follow the *Periodic Maintenance Schedule on page 4-5* and *Periodic Maintenance Procedures on page 4-9*.

EPA REQUIREMENTS

The EPA emission regulation is applicable only in USA.

Conditions to Ensure Compliance with EPA Emission Standards

This product is an EPA-approved engine.

The following are the conditions that must be met in order to ensure that the emissions during operation meet the EPA standards:

- Ambient temperature: -16° to +40°C (3° to 104°F)
- Relative humidity: 80% or lower

The fuel and lubricating oil used should be as follows:

- Diesel fuel: ASTM D975 No. 1-D or No. 2-D, or equivalent (minimum cetane No. 45)
- Lubricating oil: Type API, Class SM, SL, SJ, SH / CF and CF

Be sure to perform inspections as outlined in *Periodic Maintenance Procedures on page 4-9* and keep a record of the results.

Pay particular attention to these important points:

- Replacing the engine oil
- Replacing the lube oil filter
- Replacing the fuel filter
- Replacing the air filter

Note: Inspections are divided into two sections in accordance with who is responsible for performing the inspection: the user or the maker.

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Inspection and Maintenance

See Inspection and Maintenance of EPA Emission-Related Parts on page 4-8.

Inspection and maintenance procedures not shown in the *Inspection and Maintenance of EPA Emission-Related Parts* section are covered in *Periodic Maintenance Schedule on page 4-5*.

This maintenance must be performed to keep the emission values of your engine in the standard values during the warranty period. The warranty period is determined by the age of the engine or the number of hours of operation.

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PERIODIC MAINTENANCE SCHEDULE

Daily and periodic maintenance is important to keep the engine in good operating condition. The following is a summary of maintenance items by periodic maintenance intervals. Periodic maintenance intervals vary depending on engine application, loads, diesel fuel and engine oil used and are hard to establish definitively. The following should be treated only as a general guideline.

○: Check ◇: Replace

System	Item	Periodic Maintenance Interval					
		Daily	Every 50 hours or monthly whichever comes first	Every 250 hours or one year whichever comes first	Every 500 hours or 2 years whichever comes first	Every 1000 hours or 4 years whichever comes first	Every 2000 hours or 8 years whichever comes first
Whole	Visual inspection of engine exterior	○ Before starting					
Fuel System	Check for fuel leakage	○ Before starting					
	Check the fuel level and refill if necessary	○ Before starting					
	Drain water and sediment from fuel tank			○			
	Drain the fuel filter / water separator	○					
	Replace the fuel fine filter			◇			
	Replace fuel filter / water separator element			◇			
	Check the fuel pump and fuel lines				○		
Lubricating System	Check the engine oil level	○ Before starting					
	Change the engine oil and replace the oil filter element		◇ Initial 50	◇			
Cooling System - Engine Coolant	Visual inspection of cooling system	○ Before starting					
	Check coolant level and check for leaks	○ Before starting					
	Drain and refill closed cooling system (engine coolant)				◇		

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○: Check ◇: Replace

System	Item	Periodic Maintenance Interval					
		Daily	Every 50 hours or monthly whichever comes first	Every 250 hours or one year whichever comes first	Every 500 hours or 2 years whichever comes first	Every 1000 hours or 4 years whichever comes first	Every 2000 hours or 8 years whichever comes first
Cooling System - Seawater Circuit	Visual inspection of cooling system	○ Before starting					
	Check the seawater outlet	○ Before starting					
	Check seawater pump belt for wear, replace if necessary			◇			
	Check seawater filter (if equipped) and inlet		○				
	Replace the zinc anodes*			◇			
	Check or replace the seawater pump impeller			○		◇	
Air Intake and Exhaust System	Visual inspection	○ Before starting					
	Replace turbocharger heat shield			◇			
	Check the exhaust pipe	○					
	Check the air intake pipes		○				
	Check the exhaust / water mixing elbow			○			
	Replace the air filter element			○			
Electrical System	Check the electrolyte level in the battery (serviceable batteries only)		○				
	Check the wiring connectors	○ Before starting					
	Check alternator belt for wear or replace belt			○			◇

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PERIODIC MAINTENANCE PROCEDURES

After Initial 50 Hours of Operation

Perform the following maintenance after the initial 50 hours of operation.

- **Change the Engine Oil and Replace the Engine Oil Filter**
- **Check Shift Cable Adjustment**
- **Adjust the Propeller Shaft Alignment (If Equipped with Marine Gear)**

Every 50 Hours of Operation

After you complete the initial 50 hour maintenance procedures, perform the following procedures every 50 hours or monthly thereafter.

- **Check Seawater Filter (If Equipped) and Inlet**
- **Check the Air Intake Pipes**
- **Check Battery Electrolyte Level (Serviceable Batteries Only)**

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Every 250 Hours of Operation

Perform the following maintenance every 250 hours of operation or one year, whichever comes first.

- **Drain Water and Sediment from Fuel Tank**
- **Replace the Fuel Fine Filter**
- **Replace the Fuel Filter / Water Separator Element**
- **Change the Engine Oil and Replace the Engine Oil Filter Element**
- **Check / Replace the Seawater Pump Belt**
- **Replace the Zinc Anodes**
- **Check or Replace the Seawater Pump Impeller**
- **Replace the Turbocharger Heat Shield**
- **Check the Exhaust / Water Mixing Elbow**
- **Replace the Air Filter Element**
- **Check / Change the Alternator Belt**
- **Check / Change the Power Steering Fluid**
- **Check the Shift Cable Adjustment**
- **Adjust the Propeller Shaft Alignment**
- **Check the Hydraulic Oil Cooler**
- **Check or Replace Rubber Hoses**
- **Check Flexible Engine Mounts**

Every 500 Hours of Operation

Perform the following maintenance every 500 hours of operation or 2 years, whichever comes first.

- **Check Fuel Pump and Fuel Lines**
- **Drain and Refill Closed Cooling System (Engine Coolant)**

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Every 1000 Hours of Operation

Perform the following maintenance every 1000 hours of operation or 4 years, whichever comes first.

- **Check Flexible Engine Mounts**
- **Replace Seawater Pump Impeller**

Every 2000 Hours of Operation

Perform the following maintenance every 2000 hours of operation or 8 years, whichever comes first.

- **Replace Alternator Belt**

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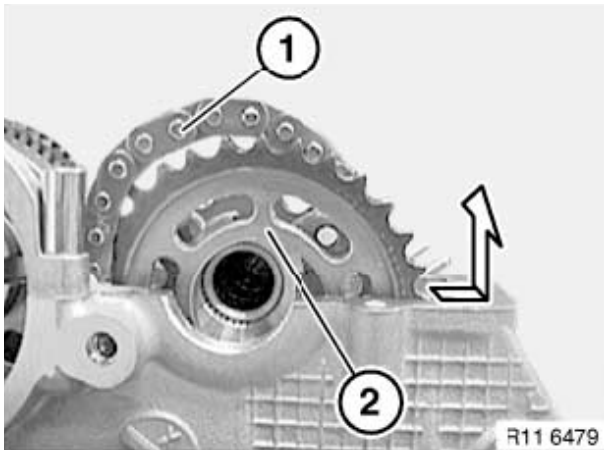


Figure 5-98

18. Remove camshaft sprocket **(Figure 5-98, (2))** from chain **(Figure 5-98, (1))** as shown by arrow.

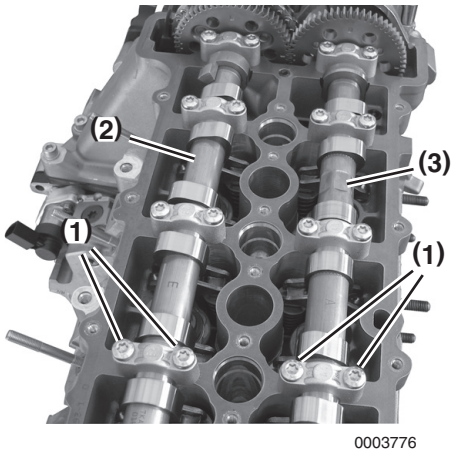


Figure 5-99

19. Evenly loosen all camshaft bearing cap bolts **(Figure 5-99, (1))** in 1/2-turn increments, working from each end towards the center.
20. Remove all bearing caps. *NOTICE: Camshaft bearing caps are numbered and must be installed in their original locations.*
21. Remove the intake **(Figure 5-99, (2))** and exhaust **(Figure 5-99, (3))** camshafts.

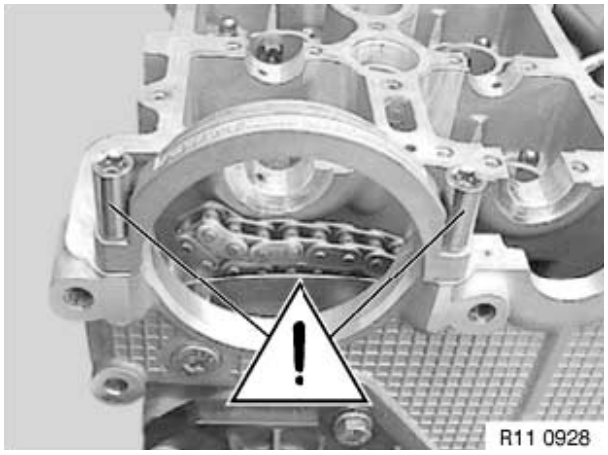


Figure 5-100

22. Do not remove loop casting bolts. *NOTICE: NEVER remove bolts retaining loop casting **(Figure 5-100)**.*

Install Camshafts

1. Lubricate all camshaft bearings, caps and journals with clean engine oil.

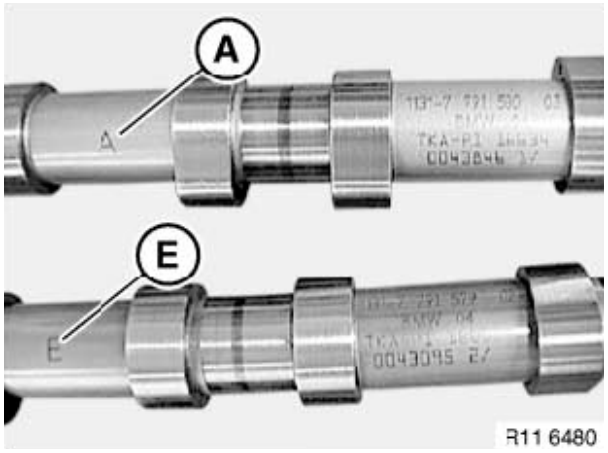


Figure 5-101

2. Identify the intake **(Figure 5-101, (E))** and exhaust **(Figure 5-101, (A))** camshafts.

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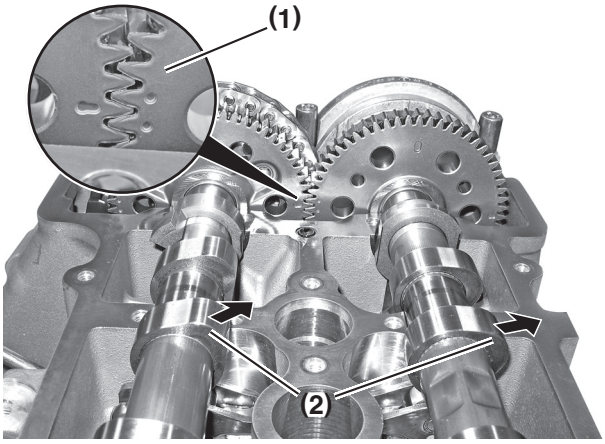


Figure 5-102

3. Install camshafts. Ensure the timing marks **(Figure 5-102, (1))** on the gears align as shown.

   When the timing marks are aligned, the lobes **(Figure 5-102, (2))** for cylinder No. 1 will face the exhaust side of the engine.

Note: The valves will hold the camshafts above the bearing seats until all bolts are tightened.

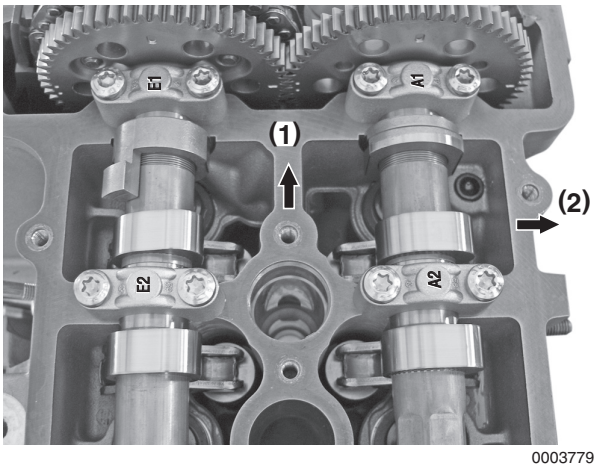


Figure 5-103

Note: Bearing caps are numbered beginning at the front **(Figure 5-103, (1))** of the engine. The numbered markings of all caps should face the exhaust side **(Figure 5-103, (2))**.

4. Install bearing caps in their proper locations.
   - Intake camshaft bearing caps are marked A1 - A7.
   - Exhaust camshaft bearing caps are marked E1 - E7.
5. Lightly oil the threads of all bolts and install finger-tight.
6. Tighten all bearing caps evenly in 1/2-turn increments, starting at the center and working toward each end, until all bearing caps are seated.
7. Tighten all bearing cap bolts to 10 N·m (89 in.-lb).
8. Install chain on sprocket and install sprocket on intake camshaft. Tighten bolts until snug.
9. Install guide rails.
10. Apply medium strength thread lock and sealer to the threads of the guide rail bearing pins. Install and tighten to 20 N·m (177 in.-lb).
11. Adjust camshaft timing. *See Adjust Camshaft Timing on page 5-45.*
12. Remove flywheel holding tool and install protective cap.
13. Remove chain tensioner locks.
14. Install alternator drive belt. *See Remove and Install Alternator on page 11-5.*
15. Fill engine with coolant. *See Drain and Fill Closed Cooling System on page 7-10*.
16. Install cylinder head cover. *See Remove and Install Cylinder Head Cover on page 5-17.*

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1 – Engine Control Unit (ECU)
2 – Internal ECU Sensors (operating voltage and ambient air pressure)
3 – Fuse (F2) 10 A[1] - Start
4 – Fuse (F1) 3 A - CAN Switched Power
5 – Fuse (F6) 10 A - Auxiliary Power
6 – Start Signal from Key Switch
7 – Fuse (F4) 30 A - ECU Switched Power
8 – Fuse (F3) 15 A - Fuel Supply Pump
9 – Fuse (F5) 20 A - Fuel Pressure Regulator, Water-in-Fuel, Camshaft Sensor, and Fuel Volume Regulator
10 – Circuit Breaker (Boatbuilder Installed)
11 – Power to Starter Solenoid Primary Terminal
12 – Starter Relay K1
13 – Main Power Relay K2
14 – Fuel Supply Pump Relay K3
15 – Power to Fuel Supply Pump
16 – B+ to Water-in-Fuel Sensor
17 – Not Used
18 – Check Engine Indicator Output
19 – Fuel Rail Pressure Control Valve
20 – Fuel Volume Control (high-pressure pump)
21 – Fuel Injector No. 4 (4BY) or No. 6 (6BY)
22 – Fuel Injector No. 2 (4BY) or No. 2 (6BY)
23 – Fuel Injector No. 3 (4BY) or No. 5 (6BY)
24 – Fuel Injector No. 1 (4BY) or No. 3 (6BY)
25 – Fuel Injector No. 1 (6BY)
26 – Fuel Injector No. 4 (6BY)
27 – CAN Signal - Low
28 – CAN Signal - High
29 – Panel, ECU, and CAN Ground
30 – K-Line
31 – Neutral Start Switch (NC in neutral)
32 – Jumper Fuse (F8) 3 A - CAN / Analog Throttle Selection, default is analog (fuse out). Insert 3 A fuse to configure for CAN.
33 – Jumper Fuse (F7) 3 A - Single / Port Selection, default is single / port (fuse in). Remove fuse for starboard configuration.
34 – Fuel Rail Pressure Sensor
35 – Fuel Temperature Sensor
36 – Subthrottle Sensor 2
37 – Subthrottle Sensor 1
38 – Oil Pressure Sensor
39 – Water-in-Fuel Sensor
40 – Camshaft Speed Sensor
41 – Crankshaft Speed Sensor
42 – Charge Air Pressure Sensor
43 – Charge Air Temperature Sensor
44 – Engine Coolant Temperature Sensor
45 – Ignition Power Input from Key Switch (terminal X1-D)
46 – Auxiliary Power Output (terminal X1-G)
47 – CAN+ to Warning Indicator (terminal X1-H)
48 – Battery Power to Key Switch (terminal X1-B)
49 – CAN Signal Blocking Diode
50 – High Bench 1
51 – High Bench 2

[1] *NEVER connect any additional devices to F2. F6 may be used however, it is not switched.*

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Figure 12-5 shows a general schematic diagram of all ECU input and output assignments.

The ECU is supplied by Bosch and has a hardware specification of EDC 16. The base ECU software is Bosch DDE 5. The engine control software is application specific version NSW 3.0, which is a torque-based software structure. It is NMEA 2000 implemented and provides diagnostics through OBD protocol.

The ECU monitors data from the various sensors and controls such functions as low-pressure fuel pump operation, fuel injection pressure, fuel injection system volume, and the timing and volume of fuel injected by the Bosch electronic fuel injectors. Throttle control is fly-by-wire, meaning it is controlled by electric signals from the helm. The throttle control is either analog or digital depending on the level of control options installed.

The ECU also uses sensor inputs to monitor engine condition and will generate a trouble code if a system or sensor indicates a problem. In most cases, a Check Engine light will be displayed. The engine may or may not run normally depending on the fault. If an engine coolant overheat is detected, for instance, the ECU will reduce the engine power output and the coolant overheat indicator will illuminate. If an audible alarm is installed, it too will sound.

Not all inputs are monitored by the ECU. Low oil pressure and water in fuel are two examples. Either of these conditions will result in a warning indicator and possible audible alarm. Low oil pressure will also be indicated by the oil gauge at the helm.

COMPONENT TESTS

NOTICE: When using a common automotive test lamp to test relays and their circuits, contact with terminal 85 ***(Figure 12-6, (2))*** *will cause the relay to engage. This will result in starter engagement or fuel pump operation.*

Relays

Relays control power to the starter, fuel feed pump and main system power.

The winding ground circuit (terminal 85) of all relays is controlled by the ECU.

Start Relay (K1)

12 V is supplied by fuse F5 to winding terminal 86. When the start signal from the key switch is seen at ECU terminal 224, the winding ground circuit (terminal 85) is completed at ECU terminal 234 (assuming neutral is sensed at ECU terminal 250) and current passes through terminals 87 and 30 to energize the starter motor.

Results of Failed Relay

Failure of the relay results in:

- Inability to start engine

If this relay is defective, no P-codes will be generated.

Note: Viewed from bottom of connector.

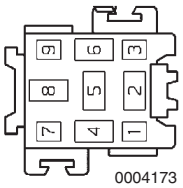


Figure 12-6

1 – Pin 2 - terminal 87 (not used)
2 – Pin 4 - terminal 85
3 – Pin 5 - terminal 87
4 – Pin 6 - terminal 30
5 – Pin 8 - terminal 86

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Main Relay (K2)

12 V is supplied directly to terminal 30 **(Figure 12-7, (4)**. An internal connection connects one end of the winding to terminal 30. When the key switch is turned ON, a 12 V signal is sent to ECU terminal 27. The ECU then completes the winding ground circuit (terminal 85) through ECU terminal 220.

Results of Failed Relay

Failure of the relay results in:

- Loss of power to all systems

If this relay is defective, the following P-codes may be generated.

- P0689 - short circuit to ground
- P0690 - short circuit to B+

Note: Viewed from bottom of connector.

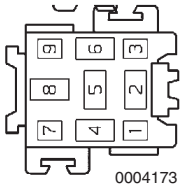


Figure 12-7

1 – Pin 2 - terminal 87
2 – Pin 4 - terminal 85
3 – Pin 5 - terminal 87
4 – Pin 6 - terminal 30

Fuel Pump Relay (K3)

12 V is supplied by fuse F3 to terminal 30 **(Figure 12-8, (4)**. An internal connection connects one end of the winding to terminal 30. When the key switch is turned ON, a 12 V signal is sent to ECU terminal 27. The ECU then completes the winding ground circuit (terminal 85) through ECU terminal 232.

Results of Failed Relay

Failure of the relay results in:

- Fuel supply pump will not operate

If this relay is defective, the following P-codes may be generated.

- P0230 - power interruption - defective fuse (F5) or relay or connections
- P0231 - regulation short circuit to B-
- P0232 - regulation short circuit to B+

Note: Viewed from bottom of connector.

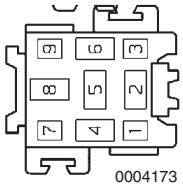


Figure 12-8

1 – Pin 2 - terminal 87
2 – Pin 4 - terminal 85
3 – Pin 5 - terminal 87 (not used)
4 – Pin 6 - terminal 30

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Oil Pressure Sensor

This sensor measures the engine oil pressure and sends the signal to the helm gauge. It is a pressure sensitive variable resistor. It is mounted in the front heat exchanger bracket and is connected to the engine block via a pressure line.

The sensor output is not used by the ECU.

Results of Failed Sensor

Failure of the sensor results in:

- Loss of engine oil pressure monitoring

If this sensor is defective, no P-codes will be generated.

Test Values

- Resistance at 0 bar (0 psi): 10 +3 -5 ohm
- Resistance at 2 bar (29 psi): 52 ±4 ohm
- Resistance at 4 bar (58 psi): 88 ±4 ohm
- Resistance at 6 bar (87 psi): 124 ±5 ohm

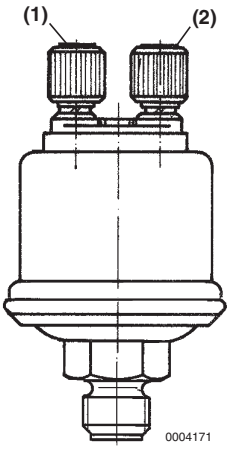


Figure 12-9

1 – Engine harness
2 – Engine harness

Note: Polarity of wire connections is not important. Either wire can be connected to either terminal.

Fuel Injector

The fuel injectors are continuously supplied with high-pressure fuel and are electronically triggered by the ECU. The ECU controls the frequency, duration and timing of injection.

Results of Failed Injector

If an injector-related failure occurs, the following P-codes may be generated:

- P2049 - Short circuit on high side to ground or B+
  - 4BY - engine will stop
  - 6BY - engine may continue to run
- P2052 - Short circuit on high side to ground or B+
  - Engine may continue to run
- P0261, P0264, P0267, P0270, P0273, P0276 - short circuit to B+
- P0201, P0202, P0203, P0204, P0205, P0206, - no connection / short to ground

Note: A minimum of two injectors must function for the 4BY to run. A minimum of three injectors must function for the 6BY to run.

Test Values

- Resistance at 20°C (68°F): 0.4 ohm

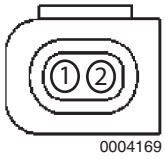


Figure 12-10

1 – Pin 1 - Low side
2 – Pin 2 - High side

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Engine Coolant Temperature Sensor

This sensor measures the temperature of the engine coolant. It is a NTC (negative temperature coefficient) type sensor. It is mounted in the cylinder head.

The sensor output is used by the ECU for:

- Calculation of the injection rate
- Regulating glow plug on-time
- Regulating engine low idle speed
- Regulating fuel rail pressure

Results of Failed Sensor

Failure of the sensor results in:

- Destruction of the sensor if short circuit to B+

If this sensor is defective, the following P-codes may be generated:

- P0117 - short circuit to B+
- P0118 - No connection / short to ground

Test Values

- Resistance at 20°C (68°F): 2.5 to 3.0 k-ohm
- Resistance at 50°C (122°F): 0.7 to 0.9 k-ohm
- Resistance at 100°C (212°F): 0.12 to 0.17 k-ohm

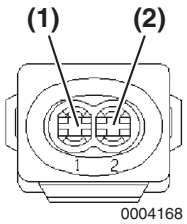


Figure 12-11

1 – Pin 1 - Out (ECU pin 182)
2 – Pin 2 - Ground (ECU pin 17)

Fuel Rail Pressure Control Valve

This valve controls the fuel pressure in the fuel rail. The ECU uses values supplied by several sensors and sends corresponding signals to control fuel pressure. It is mounted on the rear of the fuel rail.

Results of Failed Valve

Failure of the valve results in:

- Limitation of the injection rate (*See Engine Faults and Torque Limitations on page 13-3.*)
- Engine may fail to start

NOTICE: If a fault code is generated, check the fuel supply and delivery first.

If this valve is defective, the following P-codes may be generated:

- P0088 - fuel rail pressure out of range
- P0087 - fuel rail pressure out of range
- P0089 - fuel rail pressure out of range
- P0090 - not connected / valve failure
- P0091 - short circuit to ground / valve failure
- P0092 - short circuit to B+ / valve failure

Test Values

- Resistance at 20°C (68°F): 4.0 ohm
- At 1800 bar (26 107 psi) (relative): 4.5 V

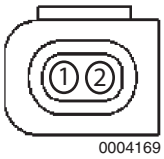


Figure 12-12

1 – Pin 1 - 12V (Fuse F5)
2 – Pin 2 - Out (ECU pin 172)

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Water-in-Fuel Sensor

This sensor monitors fuel for the presence of water and sends the signal to the helm display. If water is present, the resistance between the probes drops below the threshold of 47 k-ohms and results in a warning at the helm. It is mounted on the bottom of the fuel filter / water separator.

The sensor output is not used by the ECU.

Results of Failed Sensor

Failure of the sensor results in:

- Loss of water-in-fuel monitoring

If this sensor is defective, no P-codes will be generated.

Test Values

- No test values are available for this device

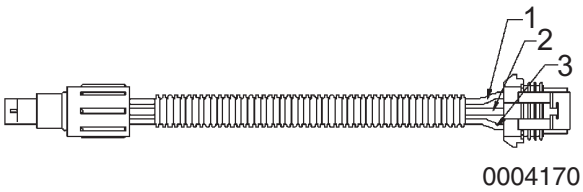


Figure 12-13

1 – Pin A - Black wire
2 – Pin B - Red wire
3 – Pin C - Yellow wire

Crankshaft Speed Sensor

This sensor measures the speed of the crankshaft. This value is compared with the camshaft speed by the ECU. It is mounted on the rear crankshaft seal housing at the rear of the engine. The ECU supplies 5V and ground.

The sensor signal is used by the ECU for:

- The calculation of the actual rotations of the engine
- The check of the starting conditions
- The calculation of the injection rate at the starting procedure
- The control of the injection start
- The calculation of the limitation of the injection rate
- The calculation if an external regulation of the injection rate is necessary
- The control of the glow plugs
- The control of the injection rate
- The control of the rail pressure
- The control at idle speed

Results of Failed Sensor

Failure of the sensor results in:

- Inability to start the engine. Engine can not run without this sensor.

If this sensor is defective, the following P-codes may be generated:

- P0344 - disagreement between camshaft speed sensor and crankshaft speed sensor
- P2617 - no connection / short circuit

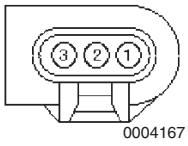


Figure 12-14

1 – Pin 1 - 5V (ECU pin 139)
2 – Pin 2 - F_out (ECU pin 187)
3 – Pin 3 - Ground (ECU pin 115)

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Glow Plug / Control Unit

The System

The glow plug control system consists of the following components:

- ECU
- Electronic glow plug control unit
- Glow plugs
- Bit-serial data (BSD) interface and electrical cables

The following information is important to understand the glow plug control:

- Glow plugs are designed for operating voltage between 5.3 and 7.8 volts
- Glow plugs are fast-start type
- Glow plug regulation is pulse-width modulated
- The electronic glow plug control unit replaces the more commonly used relay
- The implementation of a function for emergency cases
- Each circuit can be individually diagnosed

Function

The glow plug control unit communicates with the ECU via the bit-serial data interface. The heating output is calculated by the ECU according to the coolant temperature and the system voltage. Engine speed and injection rate effect the rate that the glow plugs are switched on and off.

Preheating

When the coolant temperature is above 25°C (77°F), the unit will operate for 0.5 seconds. As temperatures decrease below 25°C (77°F), the on-time will increase up to a maximum of 2.7 seconds, depending on temperature.

If the key switch is turned ON but the engine is not started immediately, the controller will continue to implement the glowing process for 10 seconds.

Post-Heating

Once the engine is started and the coolant temperature increases above 30°C (86°F), post heating will occur to improve idle and reduce emissions.

Results of Component Failure

Component failure results in:

- P0671 - cylinder 1 glow plug circuit - not connected / short circuit
- P0672 - cylinder 2 glow plug circuit - not connected / short circuit
- P0673 - cylinder 3 glow plug circuit - not connected / short circuit
- P0674 - cylinder 4 glow plug circuit - not connected / short circuit
- P0675 - cylinder 5 glow plug circuit - not connected / short circuit
- P0676 - cylinder 6 glow plug circuit - not connected / short circuit
- P0670 - Glow control unit - component failure / short circuit / over-current
- P0380 - Glow control relay actuator - not connected / short circuit

Test Values

- Glow plug resistance at 20°C (68°F): 0.5 ohm

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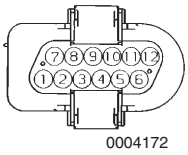


Figure 12-15

1 – Pin 1 - Glow plug No. 1
2 – Pin 2 - Glow plug No. 2
3 – Pin 3 - Glow plug No. 3
4 – Pin 4 - Glow plug No. 4
5 – Pin 5 - Glow plug No. 5
6 – Pin 6 - Glow plug No. 6
7 – Pin 12 - Signal of measured value (ECU pin 168)
8 – Pin 6 - Ground (ECU pin 170)
9 – Pin 5 - 12V (Fuse F5)

Connector X3

The control signals travel via connector X3. If the glow control unit is not installed, connector X3 must be protected by a cover.

Fuel Temperature Sensor

This sensor measures the temperature of the fuel being supplied to the high-pressure fuel pump. It is a NTC (negative temperature coefficient) type sensor. It is mounted in the fuel line just upstream from the high-pressure fuel pump.

The sensor output is used by the ECU for:

- Protecting the engine from overheating
- Calculation of the injection rate
- Calculation of the rate of the fuel pump

Results of Failed Sensor

Failure of the sensor results in:

- Limitation of the injection rate (*See Engine Faults and Torque Limitations on page 13-3.*)
- Destruction of the sensor if short circuit to B+

If this sensor is defective, the following P-codes may be generated:

- P0182 - short circuit to B+
- P0183 - No connection / short to ground

Test Values

- Resistance at -20°C (-4°F): 20 to 24 k-ohm
- Resistance at 0°C (32°F): 16.5 to 8 k-ohm
- Resistance at 20°C (68°F): 2.4 to 3.2 k-ohm
- Resistance at 120°C (248°F): 0.5 to 0.6 k-ohm

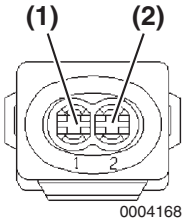


Figure 12-16

1 – Pin 1 - Ground (ECU pin 111)
2 – Pin 2 - Out (ECU pin 183)

Fuel Volume Regulator

This component controls fuel volume in the fuel injection system. The ECU uses values supplied by several sensors and sends corresponding signals to control fuel pressure. It is mounted on the rear of the high-pressure fuel pump.

Results of Failed Regulator

Failure of the regulator results in:

- Limitation of the injection rate (*See Engine Faults and Torque Limitations on page 13-3.*)
- All high-pressure fuel system control is provided by the fuel rail pressure control valve.

  NOTICE: If a fault code is generated, check the fuel supply and delivery first.

If this regulator is defective, the following P-codes may be generated:

- P0001 - not connected
- P0003 - short circuit to ground
- P0004 - short circuit to B+
- P0088 - fuel rail pressure out of range

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- P0087 - fuel rail pressure out of range
- P0089 - fuel rail pressure out of range
- P0090 - fuel rail pressure out of range

Test Values

- Resistance at 20°C (68°F): 3.0 ohm

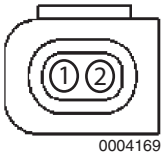


Figure 12-17

1 – Pin 1 - 12V (Fuse F5)
2 – Pin 2 - Out (ECU pin 171)

Charge Air Temperature Sensor

This sensor measures the temperature of the compressed air coming from the turbocharger. It is mounted on the charge air pipe.

Results of Failed Sensor

Failure of the sensor results in:

- Limitation of the injection rate (*See Engine Faults and Torque Limitations on page 13-3*.)
- Reduction in rated power
- Destruction of the sensor if short circuit to B+

If this sensor is defective, the following P-codes may be generated:

- P0112 - short circuit to B+
- P0113 - No connection / short to ground

Test Values

- Resistance at -20°C (-4°F): 40 to 48 k-ohm
- Resistance at 0°C (32°F): 14.5 to 16.5 k-ohm
- Resistance at 20°C (68°F): 6.0 to 6.5 k-ohm
- Resistance at 120°C (248°F): 0.18 to 0.22 k-ohm

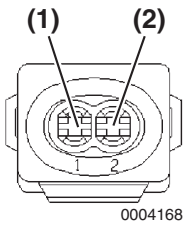


Figure 12-18

1 – Pin 1 - Out (ECU pin 157)
2 – Pin 2 - Ground (ECU pin 16)

Charge Air Pressure Sensor

This sensor measures the charge air pressure as absolute value (charge air pressure + atmospheric pressure). It is mounted on the charge air pipe and is sealed by an O-ring.

Results of Failed Sensor

Failure of the sensor results in:

- Limitation of the injection rate (*See Engine Faults and Torque Limitations on page 13-3*.)

If this sensor is defective, the following P-codes may be generated:

- P0238 - short circuit to B+
- P0237 - no connection / short circuit to ground
- P0236 - no plausibility

Test Values

Note: Pressure is kPa (absolute)

- Relation to supply voltage:
  Vout = (2/875 x pressure value - 1/70) x supply voltage

Examples:

- At 5V supply voltage and atmospheric pressure (98 kPa), Vout is approximately 1.04 V
- At 5V supply voltage and 200 kPa (absolute), Vout is approximately 2.21 V

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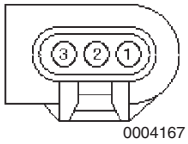


Figure 12-19

1 – Pin 1 - 5V (ECU pin 139)
2 – Pin 2 - Ground (ECU pin 180)
3 – Pin 3 - Out (ECU pin 154)

Fuel Rail Pressure Sensor

This sensor measures the fuel pressure in the fuel rail. The values are used by the ECU for fuel quantity regulation and fuel pressure regulation. It is mounted on the front of the fuel rail. The ECU supplies 5V and ground.

Results of Failed Sensor

Failure of the sensor results in:

- Default value in the ECU
- Limitation of the injection rate (*See Engine Faults and Torque Limitations on page 13-3.*)

NOTICE: If a fault code is generated, check the fuel supply and delivery first.

If this sensor is defective, the following P-codes may be generated:

- P0088 - fuel rail pressure out of range
- P0087 - fuel rail pressure out of range
- P0089 - fuel rail pressure out of range
- P0090 - fuel rail pressure out of range
- P0193 - no connection / short circuit B+
- P0192 - short circuit to ground

Test Values

- At 0 bar (0 psi) (relative): 0.5 V
- At 1800 bar (26, 107 psi) (relative): 4.5 V

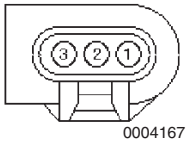


Figure 12-20

1 – Pin 1 - Ground (ECU pin 178)
2 – Pin 2 - Out (ECU pin 156)
3 – Pin 3 - 5V (ECU pin 130)

Camshaft Speed Sensor

This sensor measures the speed of the camshaft. This value is compared with the crankshaft speed by the ECU. It is mounted on the cylinder head cover near the front of the engine.

Results of Failed Sensor

Failure of the sensor results in:

- Difficulty starting and reduction in power (*See Engine Faults and Torque Limitations on page 13-3.*)

If this sensor is defective, the following P-codes may be generated:

- P0344 - disagreement between camshaft speed sensor and crankshaft speed sensor
- P2614 - no connection / short circuit

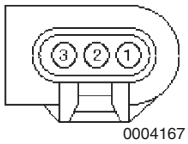


Figure 12-21

1 – Pin 1 - 12V (Fuse F5)
2 – Pin 2 - F_out (ECU pin 187)
3 – Pin 3 - Ground (ECU pin 115)

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Throttle Position Sensor

This sensor is located in the remote control head. It communicates with the ECU with varying signals based on throttle position. The ECU then calculates the position of the throttle lever in percent, and adjusts fuel injection to adjust engine speed. The ECU supplies 5V and ground connections.

Results of Failed Sensor

Failure of the sensor results in:

- One failed sensor - limitation of the injection rate (*See Engine Faults and Torque Limitations on page 13-3.*)
- Two failed sensors - engine low idle will increase

If this sensor is defective, the following P-codes may be generated:

- Sensor 1+2 (PWG):
  - P0122 - both throttle signals are missing / short circuit to ground
  - P0222 - both throttle signals are missing / short circuit to ground
- Sensor 1 only (PWG):
  - P0123 - throttle signal 1 short circuit to B+
  - P0122 - throttle signal 1 is missing / short circuit to ground
- Sensor 2 only (PGS):
  - P0223 - throttle signal 2 short circuit to B+
  - P0222 - throttle signal 2 is missing / short circuit to ground

Test Values

- At 0 bar (0 psi) (relative) - 0.5 V
- At 1800 bar (26 107 psi) (relative) - 4.5 V

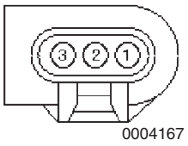


Figure 12-22

1 – Pin 1 - Ground (ECU pin 178)
2 – Pin 2 - Out (ECU pin 156)
3 – Pin 3 - 5V (ECU pin 130)

Voltage Set-Point Values

Sensor	Low Idle	High Idle
PWG 1	0.70 - 0.80	3.65 - 4.10
PWG 2	0.31 - 0.43	1.83 - 2.04

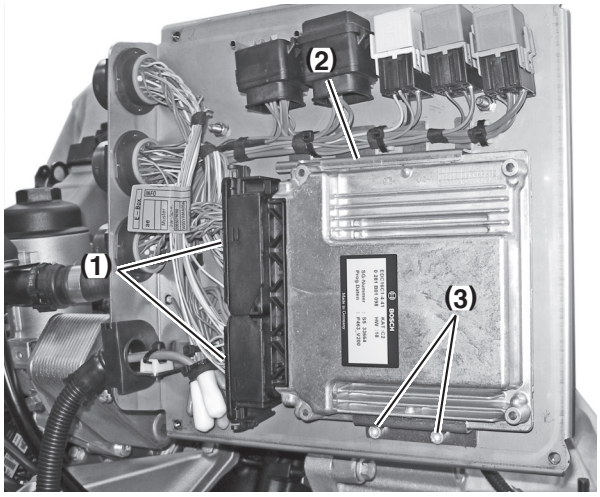
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REPAIR

Replace Engine Control Unit (ECU)

NOTICE: The ECU may be damaged if it is powered when you unplug it. Turn the key switch OFF and disconnect the battery before disconnecting the ECU from the electrical harness.

1. Disconnect the electrical panel power cables from the battery, negative (-) cable first.
2. Remove the electrical panel cover.



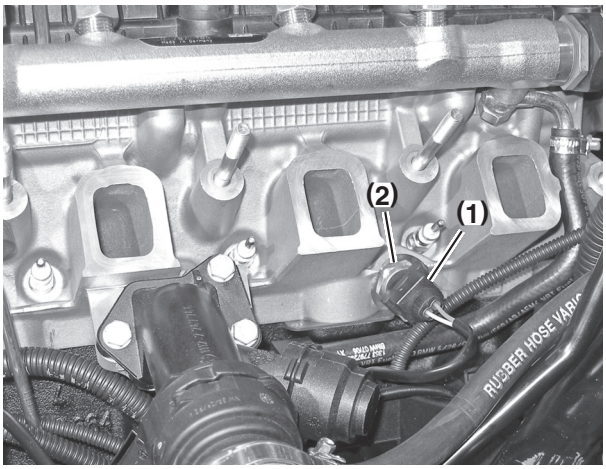
0003799

Figure 12-23

3. Disconnect two electrical connectors **(Figure 12-23, (1))** from ECU.
4. Remove screws securing the upper ECU retainer **(Figure 12-23, (2))**.
5. Loosen the lower attaching screws **(Figure 12-23, (3))** and remove the ECU.
6. Install the new control unit and tighten the screws.
7. Connect the electrical connectors to the ECU.
8. Connect the electrical panel power cables to the battery.
9. Check and delete any trouble codes that are registered in the ECU after the work has been completed.

Replace Coolant Temperature Sensor

1. Drain engine coolant. *See Drain and Fill Closed Cooling System on page 7-10*.
2. Remove intake manifold. *See Intake Manifold on page 5-66*.



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Figure 12-24

3. Remove electrical connector **(Figure 12-24, (1))** from sensor.
4. Remove sensor **(Figure 12-24, (2))** from cylinder head.
5. Installation is in reverse of removal.
6. Tighten sensor to 13.4 N·m (119 in.-lb)
7. Check and delete any trouble codes that are registered in the ECU after the work has been completed.

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