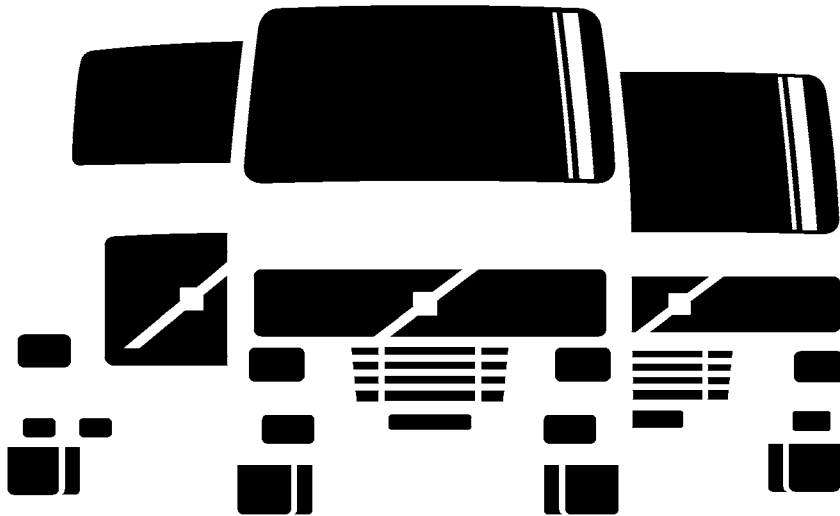


Service Manual Trucks

Group **330–500**

Starting and Charging
VN, VHD



Foreword

The descriptions and service procedures contained in this manual are based on designs and methods studies carried out up to March 2001.

The products are under continuous development. Vehicles and components produced after the above date may therefore have different specifications and repair methods. When this is believed to have a significant bearing on this manual, supplementary service bulletins will be issued to cover the changes.

The new edition of this manual will update the changes.

In service procedures where the title incorporates an operation number, this is a reference to an S.R.T. (Standard Repair Time).

Service procedures which do not include an operation number in the title are for general information and no reference is made to an S.R.T.

The following levels of observations, cautions and warnings are used in this Service Documentation:

Note: Indicates a procedure, practice, or condition that must be followed in order to have the vehicle or component function in the manner intended.

Caution: Indicates an unsafe practice where damage to the product could occur.

Warning: Indicates an unsafe practice where personal injury or severe damage to the product could occur.

Danger: Indicates an unsafe practice where serious personal injury or death could occur.

Volvo Trucks North America, Inc.
Greensboro, NC USA

Order number: PV776-TSP146025

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Feedback

Operation Numbers

General

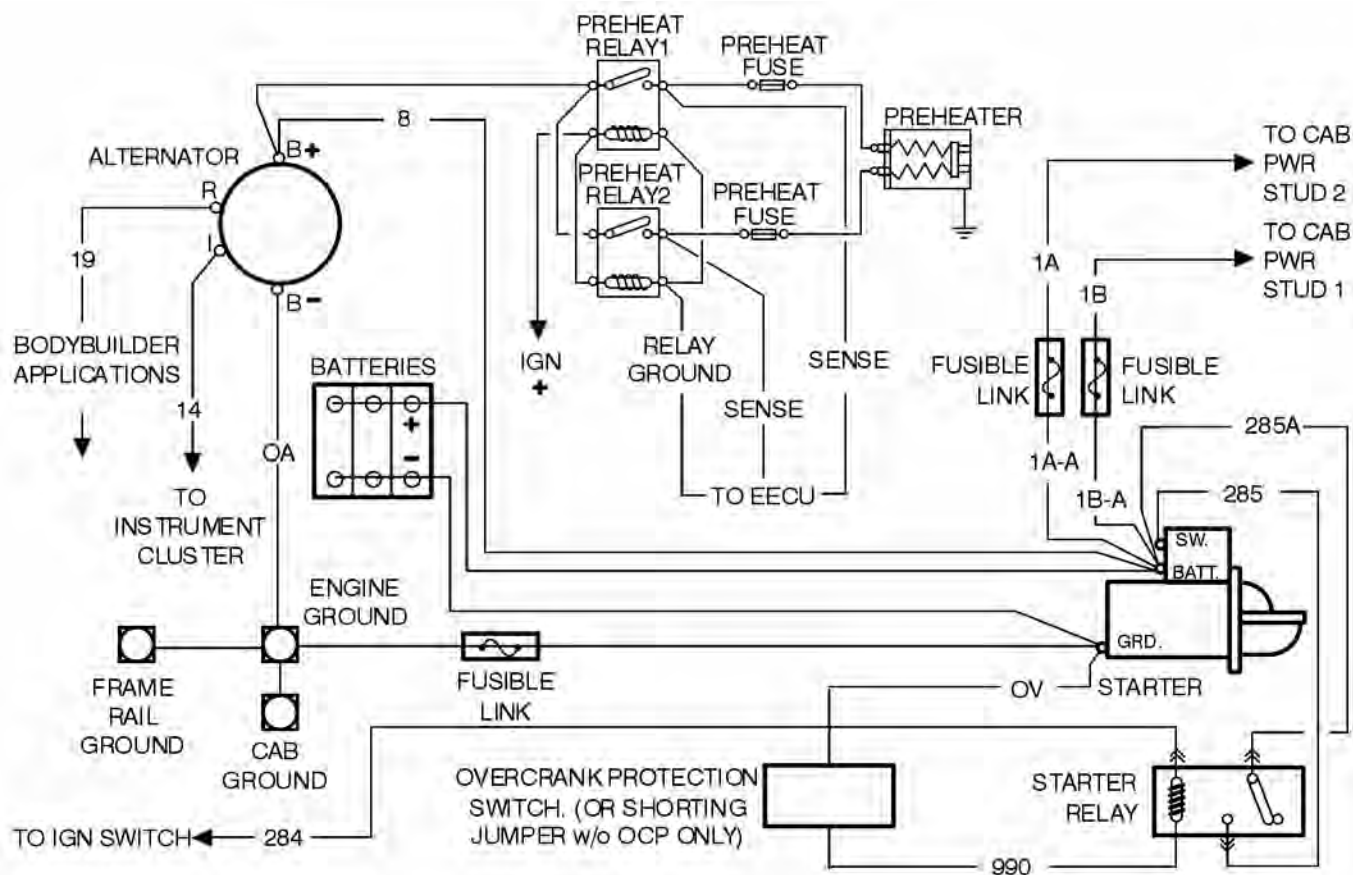
Starting and Charging

The starting and charging system on the VN/VHD series vehicles is comprised of batteries, the starter, alternator and all the connecting wiring, cables and switches. Vehicles equipped with Volvo engines may also have preheaters installed in the intake manifold to assist starting. For maximum efficiency, all parts of the system must function properly.

Note: The information in this manual pertains specifically to the Volvo VN/VHD series vehicles. For more general information on the starting and charging system, including test, refer to:

Vendor Information Diagnostic Procedures For Heavy Duty Electrical Systems

Delco Remy DRA/DP1029



W3004734

Starting and Charging Circuit, Simplified Schematic.

This simplified schematic should only be used to clarify the design features of the VN/VHD starting and charging circuit. For detailed vehicle-specific schematics, refer to:

Service Manual Electrical Schematics VN, VHD

IMPACT Function Group: 370
Information Type: Schematics

Tools

Special Tools

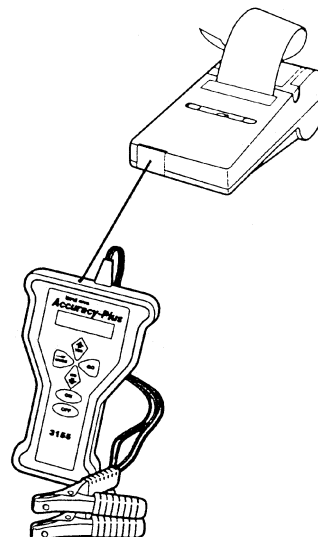
The tools referenced in this manual are listed below. They can be obtained by contacting your local Volvo Trucks parts dealer, Kent-Moore at 1-800-328-6657, or you may call a local listed tool vendor.

Note: For VCADS Pro tooling refer to:

Service Manual VCADS Pro User's Manual
Group Number 030-600

Battery tester kit. Includes: Tester J-44700 and Printer 238598, available from Kent-Moore (telephone: 800-328-6657).

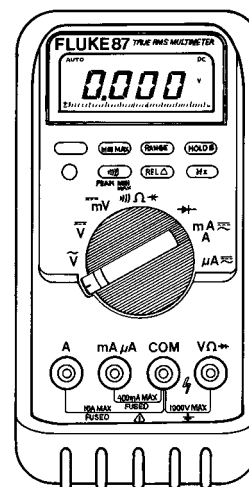
J-44701



W0001836

Fluke 87 digital multimeter, available from Volvo or Kent-Moore (telephone: 800-328-6657).

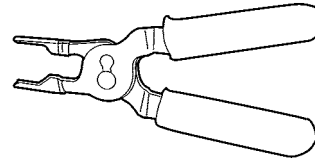
J-39200



W2001014

Relay puller tool, available from Kent-Moore (telephone: 800-328-6657).

J-43244



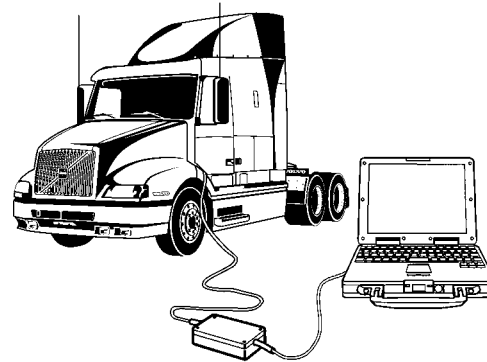
W0001917

VCADS Pro

For VCADS Pro tooling refer to:

Service Manual

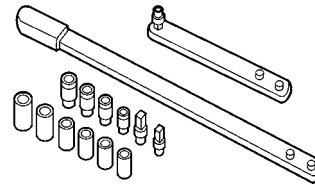
VCADS Pro User's Manual
Group Number 030-600



W0001632

Fan Belt Tensioner Tool, available from Volvo or Kent-Moore (telephone: 800-328-6657).

J-44392



W0001817

(BT-33-73F) Belt Tension Gauge, available from Kent-Moore (telephone: 800-328-6657).

J-23600-B



W0001844

BVA-34 System Analyzer

The BVA-34 System Analyzer is a digital, carbon pile, battery load tester and starting/charging system analyzer. It is portable and designed for use in the heavy truck market. Optional tester stand, part number ES-2, is also available. For more information contact AutoMeter® (telephone: 435-283-4142) or visit their web site at www.autometer.com.



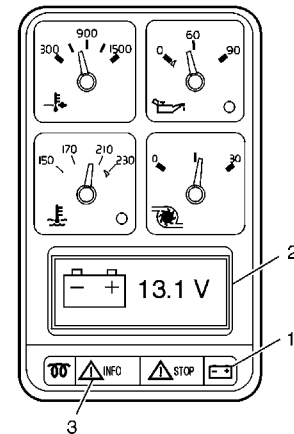
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Design and Function

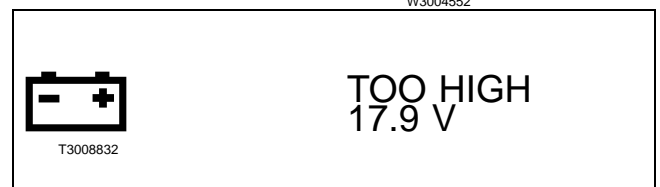
Starting and Charging System Indicator Lights

When the ignition key is turned "ON," the Charging Indicator (telltale) lamp (1) will momentarily illuminate for a bulb test. The lamp will remain on until the engine is started. With the engine running and the alternator properly charging, the Charging telltale light should go off.

The instrument cluster left module is equipped with a graphics display (2) that includes a voltmeter function. With the voltmeter function active, the display will show a battery icon and display the battery/charging voltage.



If the battery/charging voltage exceeds 17 volts, the yellow "INFO" lamp (3) will illuminate and the graphic display will show the voltage reading with the text message "TOO HIGH."

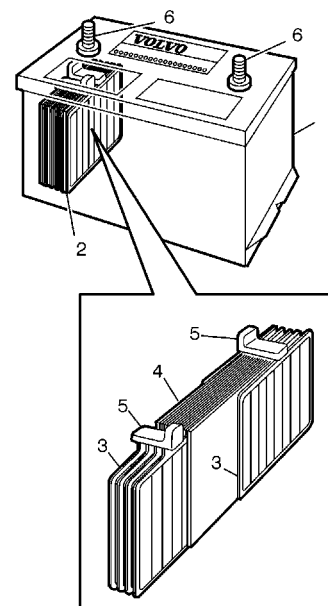


Battery

The battery is an electrochemical device for converting chemical energy into electrical energy. The battery, or battery pack, performs four basic functions:

- 1 It supplies energy for starting the engine.
- 2 It supplies energy to operate all the vehicles electrical systems and accessories.
- 3 It acts as a voltage stabilizer for the electrical system.
- 4 It supplies additional energy to operate the electrical system during peak demands, for instance, when the alternator is already at maximum output.

The battery case (1) is made of a strong, lightweight material, commonly polypropylene, to withstand shock and vibration. The cover is vented to allow chemical gases to escape. Each battery cell (2) is constructed of positive and negative plates (3) that are insulated from each other by a porous separator (4). Plate straps (5) connect the positive and negative plates and provide a means of interconnecting the cells. The cell is immersed in an electrolyte solution of sulfuric acid and water. The electrical energy is produced in the battery by the chemical reaction of the active materials that comprise the positive and negative plates and the electrolyte. Each cell will produce approximately 2.1 volts. The six cells that comprise the battery are connected in series to deliver approximately 12.6 volts at the battery post (6).



W3004553

Cold Cranking Amps

The “Cold Cranking Amps” rating is the amount of amperage load that can be maintained at -18°C (0°F) without the post voltage falling below 7.2 volts. This rating is useful in determining the battery’s ability to start an engine in cold weather conditions. The cold cranking amp rating is determined by the amount of plate surface area in each cell.

Reserve Capacity

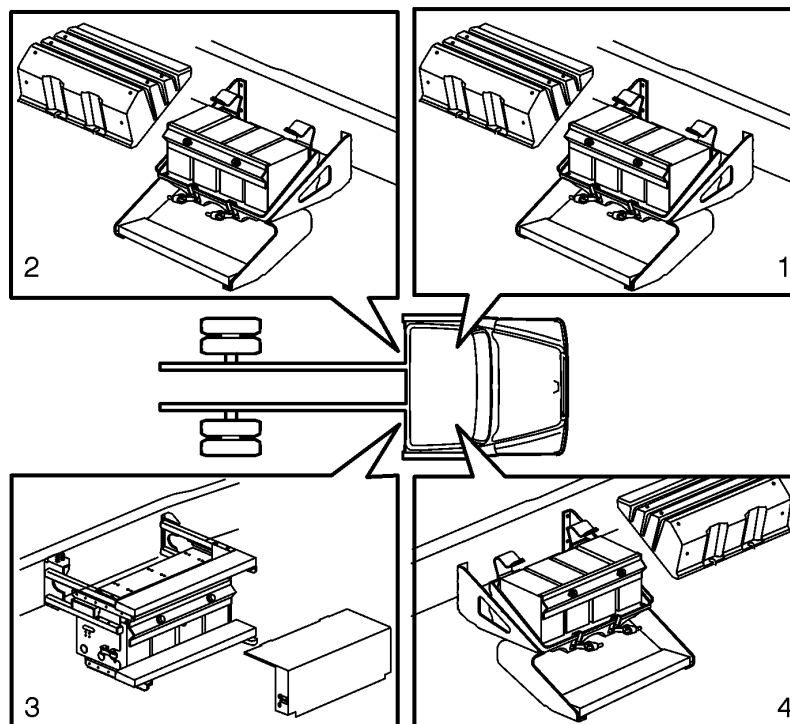
The “Reserve Capacity” is the number of minutes that a battery can sustain a 25 Amp load at 27°C (80°F) until the post voltage drops to 10.5 volts. This rating is useful in determining the battery’s ability to supply operating power in the event of a vehicle charging system failure. The reserve capacity is determined by the amount of active plate material in each cell.

Open Circuit Voltage

The “Open Circuit Voltage” is the voltage at the battery post with no loads applied.

Battery Locations

Battery box locations vary per application. The standard mounting location (1) is on the left frame rail under the cab steps. This is the mounting location for all VN and some VHD vehicles. Depending on the equipment ordered, there are three optional battery box mounting locations for the VHD vehicle. See illustration for locations: (2), (3) and (4).

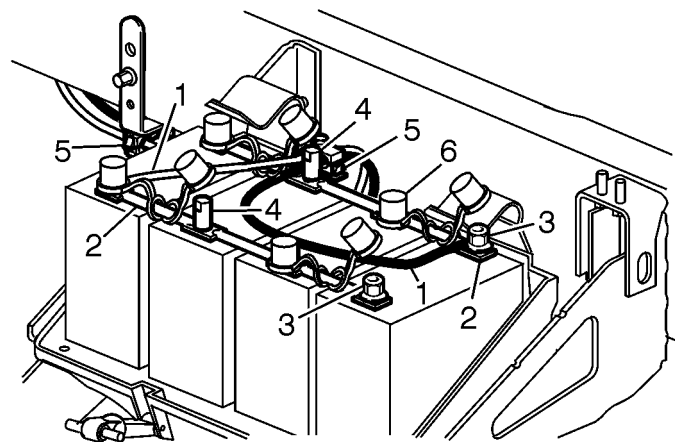


Battery Cables

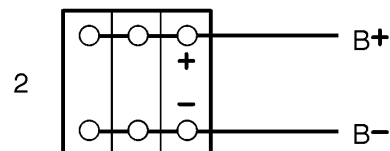
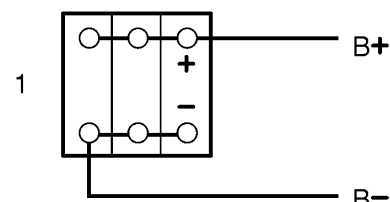
All copper, 3/0 battery cables (1) are used on VN/VHD vehicles. Single cables are used if the batteries are mounted in the standard location. If the batteries are mounted in optional locations, dual cables are used to prevent excessive voltage drop due to cable length. Battery inter-connection cables (2) are 2/0 size. Some applications may use interconnection bars instead of cables. All battery cables are sealed with polyvinyl chloride (PVC) insulation to resist abrasion and the elements.

The battery cable terminals are secured to the batteries with either stainless steel terminal nuts (3) or brass jumper studs (4). Some applications may be equipped with insulated terminal nuts that are made of plastic with a brass insert. Protective covers (6) are installed on all uninsulated battery cable terminal nuts/studs. Mounting brackets (5) support and secure the battery cables at approximately 300 mm (12 in.) to 600 mm (24 in.) intervals to avoid damage from abrasion, vibration, heat and strain.

Ideally, battery sets should be connected to the battery/starter cables in a diagonal pattern (1) rather than both cables being connected to one battery at the end of the set (2). The diagonal connection will help assure that all batteries in the set are cycled at the same rate, extending service life.



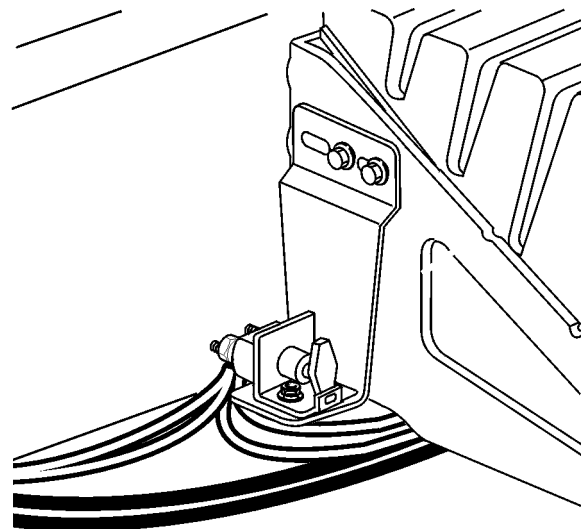
W3004556



W3004557

Battery Disconnect Switch

As an option, some vehicles may have a master battery disconnect switch (main switch). The switch will be mounted on or near the battery box in all applications. The battery disconnect switch should not be used as a substitute for removing battery cables to prevent damage to the vehicle when welding.



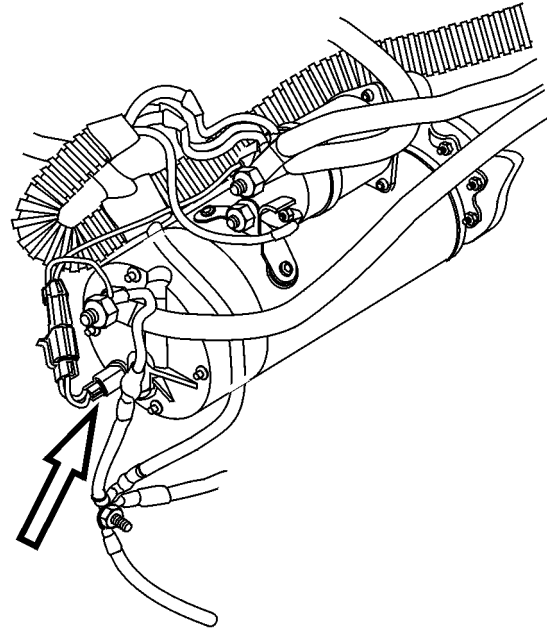
W3004404

Starting System

Starting Circuit

When the ignition switch is turned to the "START" position, power to energize the starter relay coil is supplied on wire number 284. The starter relay coil is grounded through the overcrank protection switch (OCP) or a shorting jumper.

The OCP switch is located inside the starter. This switch is optional. Where the OCP switch is not used, a shorting jumper is used to complete the starter relay coil ground circuit.



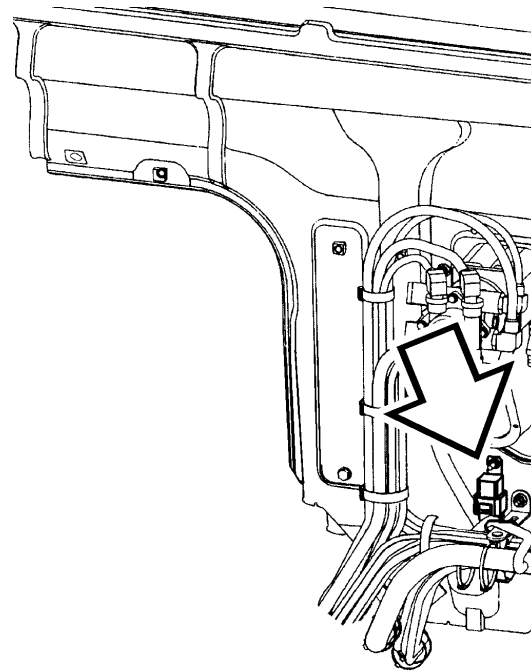
W3004339

overcrank protection (OCP) input switch.

When the starter relay is energized, a connection is made from the starter solenoid BATT terminal (wire 285A) to the starter solenoid SW terminal (wire 285).

When the solenoid pulls in, a connection is made internally in the solenoid, which connects the battery terminal to the motor terminal, then the starter begins to crank the engine.

For more details see schematic in "Starting and Charging" page 3.

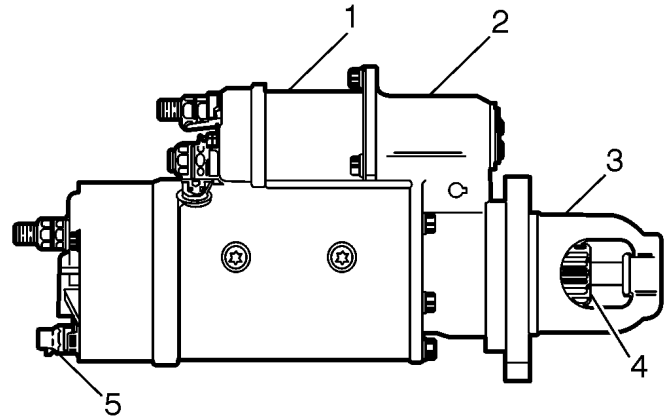


W3003757

Starter Relay.

Starter

Volvo VN/VHD vehicles are equipped with Delco Remy-42MT starters for most applications. If the vehicle is equipped with a Volvo D7 engine, it will be equipped with a Delco-Remy 37MT starter. These starters, sometimes referred to as starting motors, have a shift lever and solenoid housing that is totally enclosed to protect them from the elements. The nose housing can be rotated to “clock” the solenoid to accommodate various engine mounting locations. A positive engagement shift mechanism moves the pinion into mesh with the engine flywheel ring gear prior to cranking to minimize gear tooth damage. An optional overcrank protection (OCP) switch protects the starter in adverse starting conditions, such as cold weather starting or operator misuse. The OCP switch is a temperature sensitive circuit breaker that prevents overcrank heat damage by opening the starter relay ground, then automatically resetting when the starter has cooled sufficiently.



W3004558

- 1 Solenoid
- 2 Shift Lever Housing
- 3 Nose Housing
- 4 Pinion
- 5 Overcrank Protection Input Switch

Preheat System

Preheat Circuit

Vehicles equipped with Volvo engines may be equipped with intake air preheaters to assist in cold weather starting.

Preheating is standard on the D7 engine with one preheat relay/element, and optional on the D12 engine with two preheat relays/elements.

In normal operation, the ignition switch is turned to the “preheat” position then released back to the “On” position. The Vehicle Electronic Control Unit (VECU) recognizes the preheat request and sends the request to the Engine Electronic Control Unit (EECU), via the J-1939 Control Data Link. The EECU will supply a ground to the preheat relay(s), and the preheater will begin to operate.

Based on engine temperature, the EECU will time the interval for preheater operation. The operator may also hold the ignition switch in the “preheat” position if additional preheat is desired after the timed preheat period.

The preheat relay(s) coil is supplied ignition power via a fuse in the Truck Electrical Center (TEC) panel. The relay(s) is energized when a ground is supplied by the EECU. When the relay(s) is energized, an internal connection is made that connects the preheater element power supply from the alternator cable to the fuse that connects to the preheat element(s). The preheat element(s) are case grounded.

A “sense” circuit(s) provides information to the EECU to confirm that the preheat circuit is intact. If the EECU determines that the circuit is not intact, a fault code(s) will be generated.

For simplified schematic see: “Starting and Charging”

page 3.

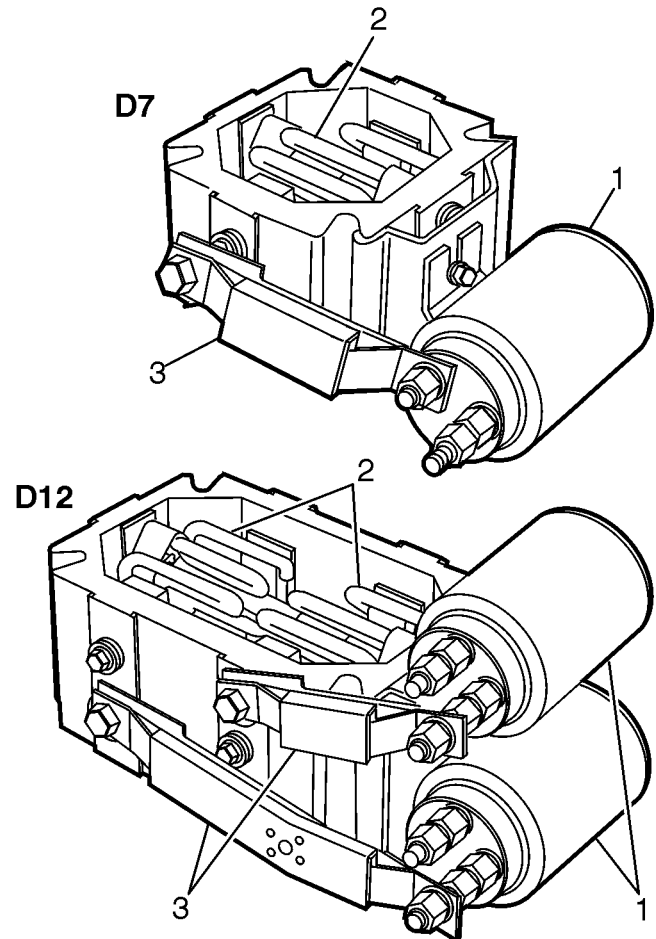
Preheater Assembly



WARNING

Use caution when working around the preheat elements. When active, the elements will heat to approximately 705°C (1300°F). Allow sufficient time for the elements to cool to avoid severe burns.

The preheater assembly on a D7 engine is standard with one relay element and fuse. The preheater assembly on a D12 engine is optional with two relays, elements and fuses.



W3004559

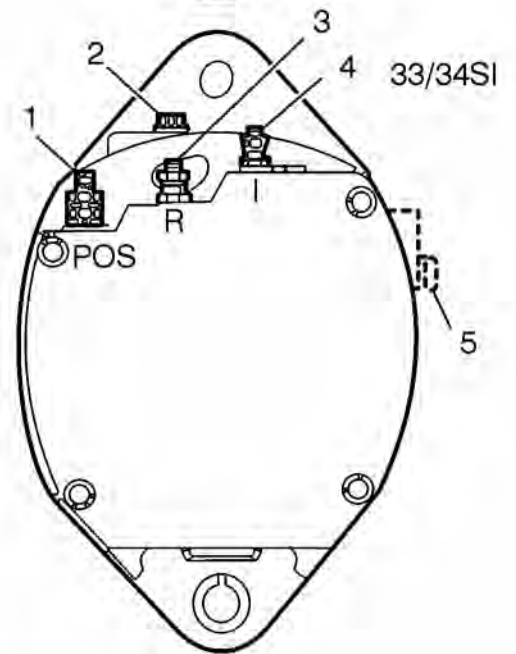
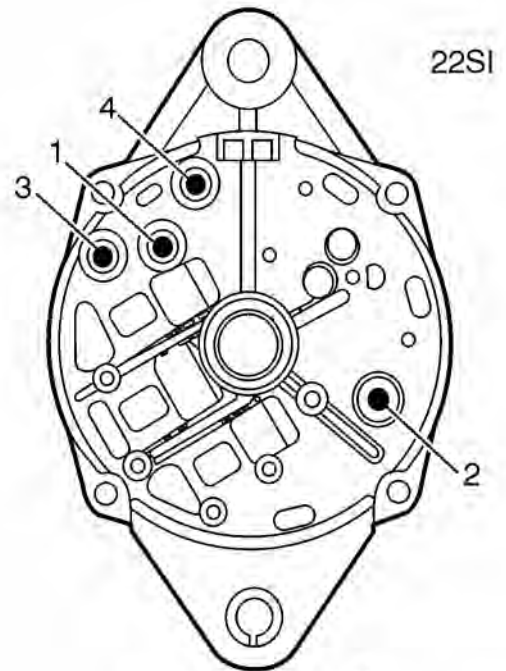
- 1 Relay
- 2 Element
- 3 Fuse Assembly

Charging System

Charging Circuit

With the engine running, DC voltage is generated at the alternator output (B+) terminal and supplied to the vehicles electrical system through wire no. 8. The alternator is grounded by a wire from the ground terminal (B-) on the alternator case to the engine ground terminal. A fusible link in the ground circuit is designed to protect the vehicle electrical system if a short in the alternator, alternator cable or battery cable occurs.

A wire from the alternator indicator light terminal to the instrument cluster sends a signal to indicate that the alternator is not charging. Vehicles with body builder applications may also have a wire from the alternator relay terminal to provide engine speed information for PTO operation. Also see Starting and Charging Simplified Schematic in "Starting and Charging" page 3.



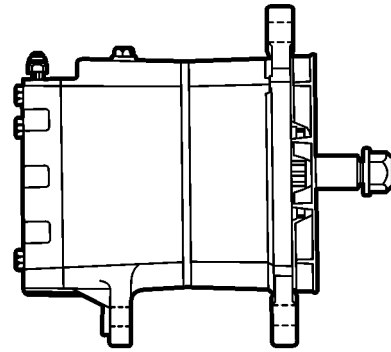
- 1 Output Terminal (B+)
- 2 Ground Terminal (B-)
- 3 Relay Terminal
- 4 Indicator Light Terminal
- 5 Ground Terminal (B-) 34SI only

W3004731

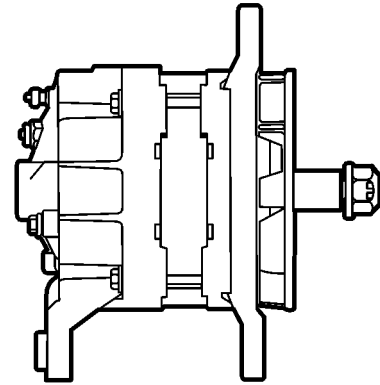
Alternator

The alternator converts the mechanical energy supplied by the engine via drive belts into electrical energy that is used to recharge the batteries and operate the electrical devices on the vehicle. The alternator produces alternating current (AC), which is converted to direct current (DC) by the diodes in the rectifier bridge. The rectifier bridge also has design features to “clamp” voltage spikes that may damage vehicle electronics. An internal voltage regulator limits the charging voltage from 13.8 to 14.2 volts. Volvo VN/VHD vehicles currently are equipped with one of three different Delco Remy alternators:

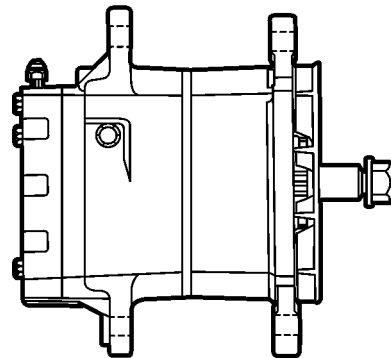
- 33SI — The 33SI alternator is a brushless design for longer operating life. It is the standard alternator used in most applications. It is available with 110 and 135 amp output ratings.
- 22SI — The 22SI alternator is a smaller, standard brush type alternator. It is available with 100, 130 and 145 amp output ratings.
- 34SI — The 34SI alternator is internally identical to the 33SI. The major difference is that the housing has a fourth mounting lug to withstand higher vibration applications. The 34SI is currently only used in VN vehicles equipped with Detroit Diesel engines.



33 SI



22 SI



34 SI

W3004561

Troubleshooting

Battery Troubleshooting

DANGER

Before working on a vehicle, set the parking brakes, place the transmission in neutral, and block the wheels. Failure to do so can result in unexpected vehicle movement and can cause serious personal injury or death.

WARNING

Always wear eye protection when working around batteries to prevent the risk of injury due to contact with sulfuric acid or an explosion. (Important: If contacted with sulfuric acid, flush immediately with water and get medical attention).

WARNING

Batteries may contain explosive gases. To help minimize the risks of explosion, avoid sparks or open flames near batteries. Do not smoke when servicing batteries.

CAUTION

If there are other ground cables connected to the battery (such as engine ECU's, satellite system, etc.), disconnect those grounds first, then remove the main battery ground cable. Electronic modules may be damaged when additional grounds are connected/disconnected without the main battery ground connected. Disconnect the main battery ground last.

CAUTION

In vehicles with a Supplemental Restraint System (SRS), turn the ignition switch ON before connecting the battery. Failure to do so may result in permanent damage to the instrument cluster or other electronic circuits within the vehicle. (This applies only to vehicles with SRS and a Cummins or Detroit Diesel engine.) Always check for fault codes after repairs are completed.

CAUTION

Possible damage to electronic components. Turn the vehicle ignition switch OFF before disconnecting or connecting any electronic components. Failure to de-energize circuits may result in permanent damage to electronic components.

Battery State of Charge

The battery state of charge must be determined before battery testing. Battery hydrometers that measured battery acid specific gravity were used to determine the state of charge in earlier battery designs with removable filler caps. In current "maintenance free" design batteries the state of charge is determined by a built-in hydrometer or an open circuit voltage test.

The battery may have a special temperature compensated hydrometer built into the cover to show at a glance the battery's state-of-charge. The hydrometer has a green ball within a cage which is attached to a clear, plastic rod. The green ball will float at a predetermined specific gravity of the electrolyte that represents about 65% state-of-charge. When the green ball floats, it rises within the cage and positions itself under the rod. Visually a green dot then shows in the center of the hydrometer. The built-in hydrometer provides a guide for battery testing and charging.

In testing, the green dot means the battery is charged enough for testing. If the green dot is not visible, it means the battery must be charged before the test procedure is performed.

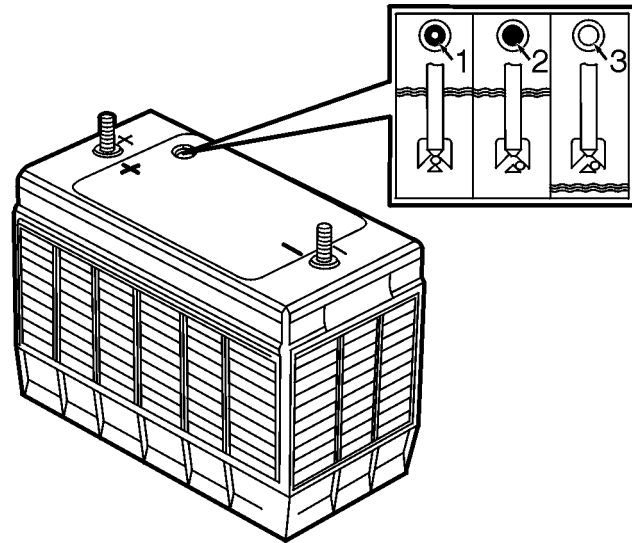
In charging, the appearance of the green dot means that the battery is sufficiently charged.

The hydrometer on some batteries may be clear or light yellow. This means the fluid level is below the bottom of the rod and attached cage. This may have been caused by excessive or prolonged charging, a broken case, excessive tipping or normal battery wear out.

If a battery displays a clear eye, it must be replaced. Do not attempt to charge, test or jump start the battery.

Note: The built-in hydrometer only monitors one battery cell. Low state of charge in other cells will not be indicated by the built-in hydrometer.

The battery state of charge may also be checked by reading the open circuit voltage. To check, connect a voltmeter to the positive and negative battery post. If the reading is below 12.40 volts, the battery is too low for proper testing and must be recharged. If the reading is above 12.66 volts, the surface charge must be removed before testing. See: "Battery Surface Charge Removal" page 19.



1. State of charge 65% or above
2. Below 65% state of charge
3. Low electrolyte level

W3004562

Battery Surface Charge Removal

When a battery is charged, very small hydrogen gas bubbles form on the surface of the battery plates, causing what is known as “surface charge.” When a voltmeter is connected to the battery post, it may give a false reading if the surface charge is not removed.

Before testing a battery, the surface charge must be removed by one of the following methods:

- Turn on the headlights for 2–3 minutes. Then allow the battery to stabilize for 1 minute before testing.
- Remove the Engine ECU fuse in the battery box to prevent the engine from starting. Start the engine for 5–10 seconds. Then allow the battery to stabilize for 1 minute before testing.
- Use BVA-34 System Analyzer or equivalent tool to load the battery to 300 amps for 5–10 seconds. Then allow the battery to stabilize for 1 minute before testing.

Note: The open circuit voltage must be at least 12.4 volts after the surface charge has been removed to continue battery testing.

Load Testing Batteries

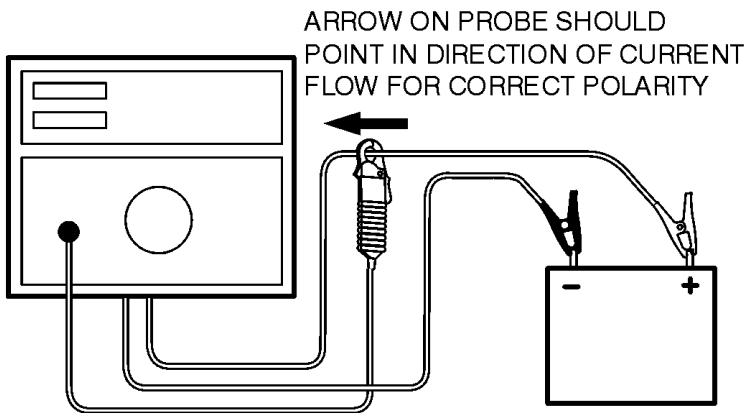
7

The BVA-34 System Analyzer is a digital, carbon pile, battery load tester and starting/charging system analyzer. It is portable and designed for use in the heavy truck market. The test that follows may be performed with the BVA-34 System Analyzer, or equivalent carbon pile type tester, and should be used as a general guide for performing a battery load test. Read and follow the test instructions supplied with the tester used to perform battery testing.

- 1 Batteries must be tested individually. Remove battery cables as described in "Battery Cables, Removal and Installation" page 41.
- 2 Visually inspect the battery for corroded terminals, damage or a clear built-in hydrometer eye, if equipped. Clean the terminals if needed. Replace damaged batteries or batteries with clear hydrometer eyes (indicates electrolyte loss).
- 3 Screw the brass "jumper studs" onto the positive and negative terminal before connecting the tester. Do not connect the tester leads directly to the battery terminal post.
- 4

ESTIMATED ELECTROLYTE TEMPERATURE	MINIMUM REQUIRED VOLTAGE UNDER 15 SECOND LOAD
70°F (21°C) and above	9.6
60°F (16°C)	9.5
50°F (10°C)	9.4
40°F (4°C)	9.3
30°F (-1°C)	9.1
20°F (-7°C)	8.9
10°F (-12°C)	8.7
0°F (-18°C)	8.5

Compare the voltage reading obtained to the temperature compensated chart above. If the battery does not meet or exceed the minimum voltage required, replace the battery.



W3004563

Connect the BVA-34 System Analyzer (or equivalent tool) to the battery as shown. Set the voltmeter to the "INTERNAL" setting. Zero the ammeter.

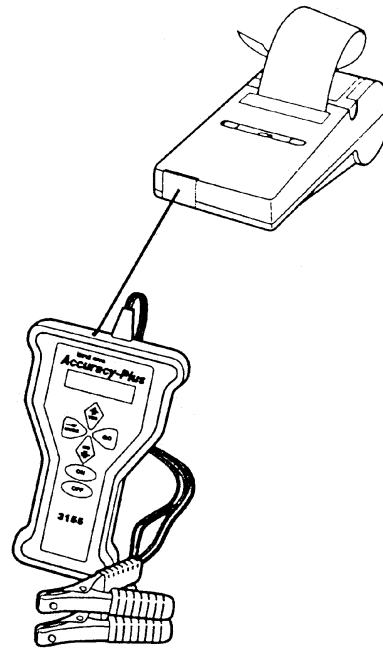
- 5 Check the battery open circuit voltage. The reading must be between 12.40 and 12.66 volts to proceed. If not, see "Battery State of Charge" page 18.
- 6 Adjust the load control knob to equal one half the battery's Cold Cranking Amp (CCA) rating. The battery CCA specification can be found on the battery label. Maintain the load for 15 seconds then note the battery voltage (with load applied).

Electronic Battery Testing

The J-44700 Accuracy Plus HD Battery Tester is a hand held electronic battery diagnostic tester. The tester applies variable loads to the battery and measures the battery's response. Results are then displayed and may be printed if desired with the optional printer number 238598. Both the J-4477 Accuracy Plus tester and the 238598 printer are available in kit part number J-44701.

The test that follows may be performed with the J-44770 Accuracy Plus HD Battery Tester, or equivalent electronic testers, and should be used as a general guide for performing electronic battery testing. Read and follow the test instructions supplied with the electronic test equipment used to perform battery testing.

- 1 Batteries must be tested individually. Remove battery cables as described in "Battery Cables, Removal and Installation" page 41.
- 2 Visually inspect the battery for corroded terminals, damage, or a clear built-in hydrometer eye if equipped. Clean the terminals if needed. Replace damaged batteries or batteries with clear hydrometer eyes (indicates electrolyte loss).
- 3 To operate the Accuracy Plus tester, connect the positive and negative tester leads to the battery stud posts. Select the "Battery Test" and follow the on screen prompts until the test is complete. Test results will appear on screen.



W0001836

J-44700 Accuracy Plus HD Battery Tester.

Starting System Troubleshooting

DANGER

Before working on a vehicle, set the parking brakes, place the transmission in neutral, and block the wheels. Failure to do so can result in unexpected vehicle movement and can cause serious personal injury or death.

WARNING

Always wear eye protection when working around batteries to prevent the risk of injury due to contact with sulfuric acid or an explosion. (Important: If contacted with sulfuric acid, flush immediately with water and get medical attention).

WARNING

Batteries may contain explosive gases. To help minimize the risks of explosion, avoid sparks or open flames near batteries. Do not smoke when servicing batteries.

WARNING

HOT ENGINE! Keep clear of all moving parts or hot engine parts and/or fluids. A hot engine and/or fluids can cause burns.

CAUTION

Possible damage to electronic components. Turn the vehicle ignition switch OFF before disconnecting or connecting any electronic components. Failure to de-energize circuits may result in permanent damage to electronic components.

CAUTION

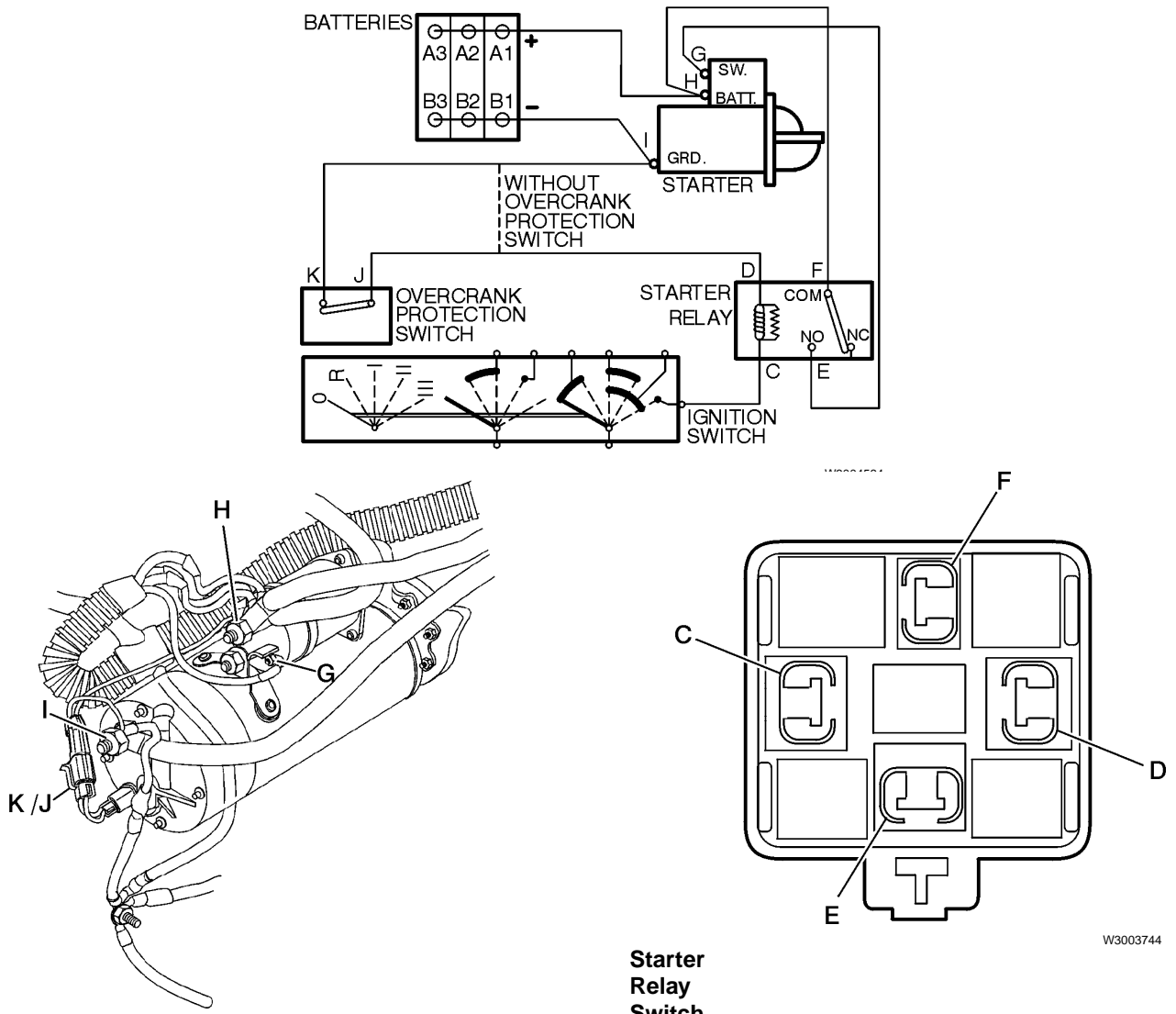
Never use the ohmmeter mode of the DMM in a powered circuit, or as a substitute for a voltmeter or ammeter, since this will result in damage to the instrument. Use the ohmmeter mode only when power is removed from the circuit.

Troubleshooting Simplified Schematic, Starting System

The simplified schematic and illustration below should be used to clarify the troubleshooting procedures in "Troubleshooting Battery/Starter Cables With Digital Multimeter" page 25 , "Troubleshooting Ignition Switch/Starter Relay Circuit With Digital Multimeter" page 26 and "Troubleshooting Starter with Digital Multimeter" page 27. For detailed, vehicle-specific schematics refer to:

Service Manual Electrical Schematics VN, VHD

IMPACT Function Group: 370
Information Type: Schematics



Starter Motor

H, I, J and K are measuring points. For details see "Troubleshooting Battery/Starter Cables With Digital Multimeter" page 25.

Starter Relay Switch

The connector is illustrated from the relay insertion side.

- C=86** 12V from Ignition Switch
- D=85** Coil Ground
- E=87** 12V to Starter Solenoid
- F=30** 12V Supply

Troubleshooting Ignition Switch with VCADS Pro Tool

The VCADS Pro Tool is a Windows 95 based PC tool that can be used to perform some ignition switch testing. The following is a brief description of tests that are currently available.

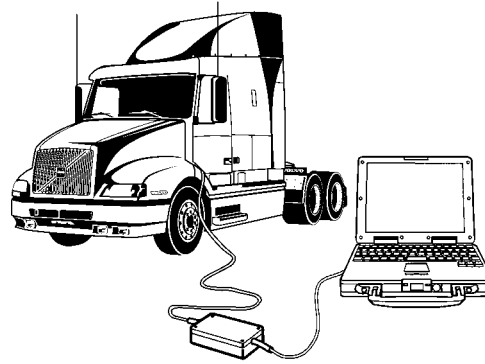
Test number 3340-08-02-01, "Ignition Switch, test"

Indicators on the VCADS Pro Screen will illuminate green when the ignition key is turned to the "Start" position.

For detailed information about the VCADS Pro Tool operation see refer to:

Service Manual VCADS Pro User's Manual
Group Number 030-600

Note: This test only applies to vehicles with a Vehicle ECU (Volvo engines).



W0001632

Troubleshooting Battery/Starter Cables With Digital Multimeter

The starter is supplied power and ground through cables connected directly to the batteries. Excessive resistance in the cables or connectors will cause decreased current flow to the starter.

Due to the high current flow demands of the starting circuit, voltage drop tests are more effective than ohm-meter tests in determining if excessive resistance exists in the cable assemblies.

- 1 Check for 12.4V at the battery cable terminals (A1 & B1) to the starter motor. If 12.4 V is not present or if a weak battery(s) is suspected, see: "Battery Troubleshooting" page 17 for battery testing information.
- 2 Test complies with SAE J541 (10/96) or 0.1 volts per 100 amps current draw. Specification assumes a typical 700 amps starting current draw.

- 3 Confirm that the cables between batteries are clean, tight and in proper working order.
- 4 Remove engine ECU fuses, located in the battery box, to prevent the engine from running during the tests.

Use the digital multimeter J-39200 or equivalent tool to perform the test in the table below. The measuring points referenced in the tables as A,B,C etc. correspond to measuring points that are illustrated in the simplified schematics and drawing. See: "Troubleshooting Simplified Schematic, Starting System" page 23.

Note: Due to battery mounting locations some vehicles will have dual positive and negative cables. This test assumes that both cables are connected.

Note: Test complies with SAE J541 (10/96) of 0.1 volts per 100 amp current draw. Specification assumes a maximum of 700 amps starting current draw and normal circuit temperature of 20°C (68° F).

Function	Key Position	Measuring Point	Approximate Value	Note	Possible Cause (if expected value not correct)
Positive Cable	Start	Battery positive-post (A1)/Starter "BATT" post (H)	<0.7 V drop. See Note 2 above.	Starter cranking engine	Positive battery cable or connectors
Negative cable	Start	Battery negative post (B1)/Ground post at starter (I)	<0.7 V drop. See Note 2 above.	Starter cranking engine	Negative battery cable or connectors
Positive Inter-Connect Cables	Start	Individual Battery Positive Post A1/A2; A2/A3; etc.	<0.1 V drop between any terminals	Starter cranking engine	Positive battery interconnect cable or connections
Negative Inter-Connect Cables	Start	Individual Battery Negative Post B1/B2;B2/B3; etc.	<0.1 V drop between any terminals	Starter cranking engine	Negative battery interconnect cable or connections

Troubleshooting Ignition Switch/Starter Relay Circuit With Digital Multimeter

When the “start” position is selected at the ignition switch, 12 volts are supplied to the starter relay coil. If the starter relay coil is properly grounded, either directly or through the overcrank protection switch, the starter relay will energize and close the contacts between the “common” and “normally open” terminals.

This creates a connection between the battery that connects to the “common” terminal, and the starter solenoid switch feed, that connects to the “normally open” terminal. With this connection made, 12 volts are supplied to the starter solenoid, which engages, and the starter motor begins to crank the engine.

The overcrank protection switch is designed to open and prevent the starter from turning if the starter becomes excessively hot. It should reset when the starter cools sufficiently.

- 1 Check for 12.4V at the battery cable terminals (A1 & B1) to the starter motor. If 12.4 V is not present or if a weak battery(s) is suspected, see: “Battery Troubleshooting” page 17 for battery testing information.
- 2 Confirm that the cables between batteries are clean, tight and in proper working order.
- 3 Remove the engine ECU fuses located in the battery box to prevent the engine from running during the tests.
- 4 Unplug the starter relay from the connector.

Use digital multimeter J-39200 or equivalent tool to perform the test in the table below. The measuring points referenced in the tables as A,B,C, etc. correspond to measuring points that are illustrated in the starting system simplified schematics and drawing. See “Troubleshooting Simplified Schematic, Starting System” page 23.

Function	Key Position	Measuring Point	Expected Value	Note	Possible Cause (if expected value not correct)
Start signal to starter relay	Start	Ignition switch terminal at the starter relay (C)/alternate ground	12V		<ol style="list-style-type: none"> 1 Power supply to ignition switch 2 Connectors/ wiring fault in circuit from ignition switch to starter relay 3 Ignition switch
Ground to starter relay	Off	Ground terminal at starter relay (D)/alternate ground	<1 Ω		<ol style="list-style-type: none"> 1 Connectors/ wiring fault in ground circuit from starter relay 2 Overcrank protection switch open (if equipped)
Battery signal to starter relay	Off	Battery terminal at starter relay (F)/alternate ground	12V		<ol style="list-style-type: none"> 1 Power supply to starter "batt" post 2 Connectors/ wiring fault in circuit from starter "batt" post to starter relay
Start signal to starter solenoid	Start	SW terminal at starter solenoid (G)/alternate ground	12V	Reinstall relay to connector. Starter relay should "click" when energized.	<ol style="list-style-type: none"> 1 Connectors or wiring faults in starter relay/starter solenoid circuit 2 If values in previous test OK, probably starter relay failure
Overcrank Protection (OCP) Switch	Off	OCP Switch connector (K/J)	<1 Ω	Not equipped on all engines	<ol style="list-style-type: none"> 1 Starter overheated 2 OCP Switch failure

Troubleshooting Starter with Digital Multimeter

The starter motor/solenoid is supplied power and ground through cables connected directly to the batteries. The starter solenoid is engaged when a 12 volt signal is delivered to the "SW" terminal via the starter relay. When the starter solenoid engages, a connection is made internally in the solenoid that connects the battery and motor terminals and the starter cranks the engine.

- 1 Check for 12.4V at the battery cable terminals (A1 & B1) to the starter motor. If 12.4 V is not present or if a weak battery(s) is suspected, see: "Battery Troubleshooting" page 17 for battery testing information.

- 2 Confirm that the cables between batteries are clean tight and in proper working order.
- 3 Remove the engine ECU fuses located in the battery box to prevent the engine from running during tests.

Use a digital multimeter J-39200 or equivalent tool to perform the test in the table below. The measuring points referenced in the tables as A, B, C etc. correspond to measuring points that are illustrated in the starting system simplified schematics and drawing. See: "Troubleshooting Simplified Schematic, Starting System" page 23.

Function	Key Position	Measuring Point	Expected Value	Note	Possible Cause (if expected value not correct)
Power supply from batteries	Off	Starter "Batt" post (H) / alternate ground	12V		1 Positive battery cable or connectors. See: "Troubleshooting Battery/Starter Cables With Digital Multimeter" page 25.
Ground from batteries	Off	Ground post at starter (I) / alternate ground	<1Ω		1 Negative battery cable or connectors. See: "Troubleshooting Battery/Starter Cables With Digital Multimeter" page 25.
Start signal from starter relay.	Start	Starter "SW" terminal (G) /alternate ground	12V	Starter should crank with terminal energized	1 Starter relay. 2 Connectors or wiring faults in starter relay/ignition switch circuit. See: "Troubleshooting Ignition Switch/Starter Relay Circuit With Digital Multimeter" page 26.

- If all the measurements are correct and the starter will not engage, the starter is probably defective.
- If all the measurements are correct and the starter engages, but will not crank or the engine cranks slowly, perform the following checks before replacing starter:
 - 1 Check that the engine can be manually turned with a reasonable amount of effort to eliminate the possibility of a mechanical engine fault.
 - 2 Check the starting system with the engine at operating temperature. Extreme cold will make the engine more difficult to turn and will reduce the batteries output.
 - 3 Perform the test "Troubleshooting Battery/Starter Cables With Digital Multimeter" page 25.

Preheat System Troubleshooting

DANGER

Before working on a vehicle, set the parking brakes, place the transmission in neutral, and block the wheels. Failure to do so can result in unexpected vehicle movement and can cause serious personal injury or death.

CAUTION

Use caution when working around the preheat elements. When active, the elements will heat to approximately 705°C (1300°F). Allow sufficient time for the elements to cool to avoid severe burns.

CAUTION

Do not keep the ignition key in the preheating position longer than approx. 15 seconds. Allow the starting heater to cool between each activation or damage to the preheater can occur.

CAUTION

Possible damage to electronic components. Turn the vehicle ignition switch OFF before disconnecting or connecting any electronic components. Failure to de-energize circuits may result in permanent damage to electronic components.

CAUTION

Never use the ohmmeter mode of the DMM in a powered circuit, or as a substitute for a voltmeter or ammeter, since damage to the instrument will result. Use the ohmmeter mode only when power is removed from the circuit.

Troubleshooting Preheater with VCADS Pro Tool

Group Number 030–600

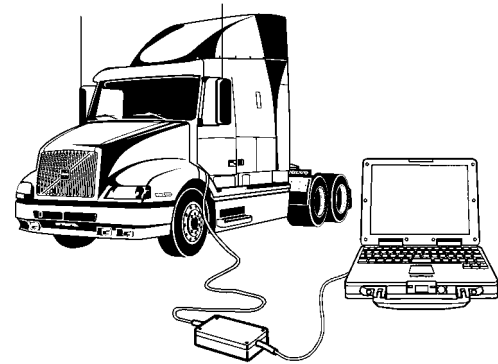
The VCADS Pro tool is a Windows 95 based PC tool that can be used to perform some preheater testing. The following is a brief description of tests that are currently available.

Test number — 3330–08–02–01, preheat test.

Indicators on the VCADS Pro screen will illuminate green when the ignition key is turned to the preheat position and when the preheat relay 1 and/or 2 is activated. The VCADS Pro Tool also displays the engine coolant temperature.

For detailed information about the VCADS Pro Tool operation, refer to:

Service Manual VCADS Pro User's Manual



W0001632

Troubleshooting Preheater with Fault Codes

Check for stored fault codes when beginning troubleshooting procedures for preheating. If any of the following fault codes is present, refer to:

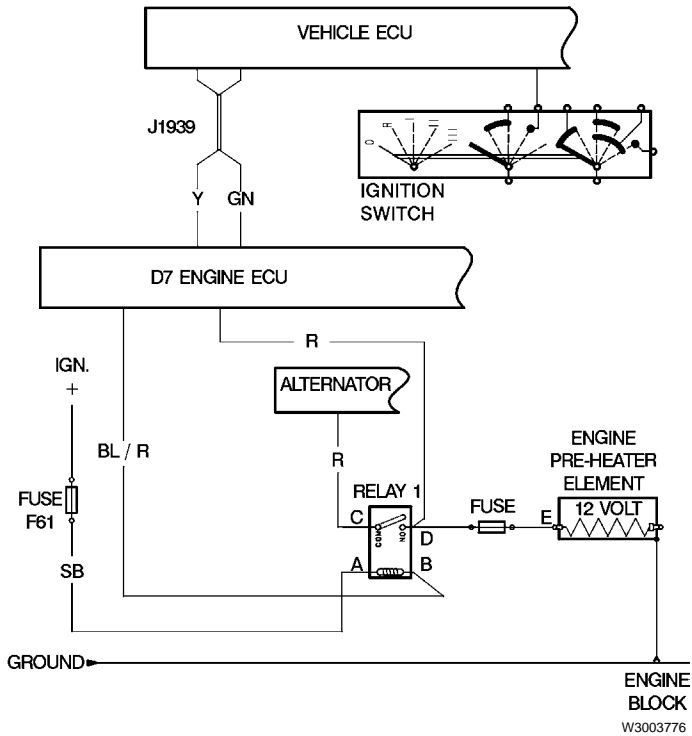
Service Information Fault Tracing Information
Diagnostics Binder

IMPACT Function Group: 0
Information Type: Diagnostics

- MID 128 — PID 45, preheating
- MID 128 — SID 70, preheating element 1
- MID 128 — SID 71, preheating element 2

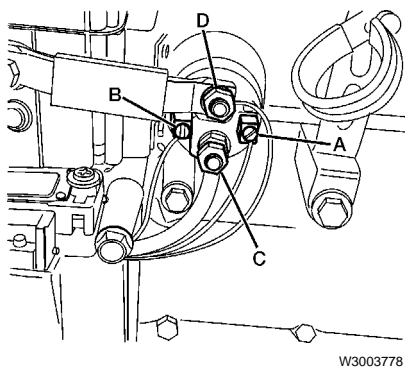
Troubleshooting Simplified Schematic, D7 Preheater

The simplified schematic and Illustration below should clarify the procedures in “Troubleshooting Preheater with Digital Multimeter” page 32. For detailed, vehicle-specific schematics refer to Function Group 370, Service Manual: Electrical Schematics VN, VHD. Information Type: Schematics.



Wire color codes in schematic:

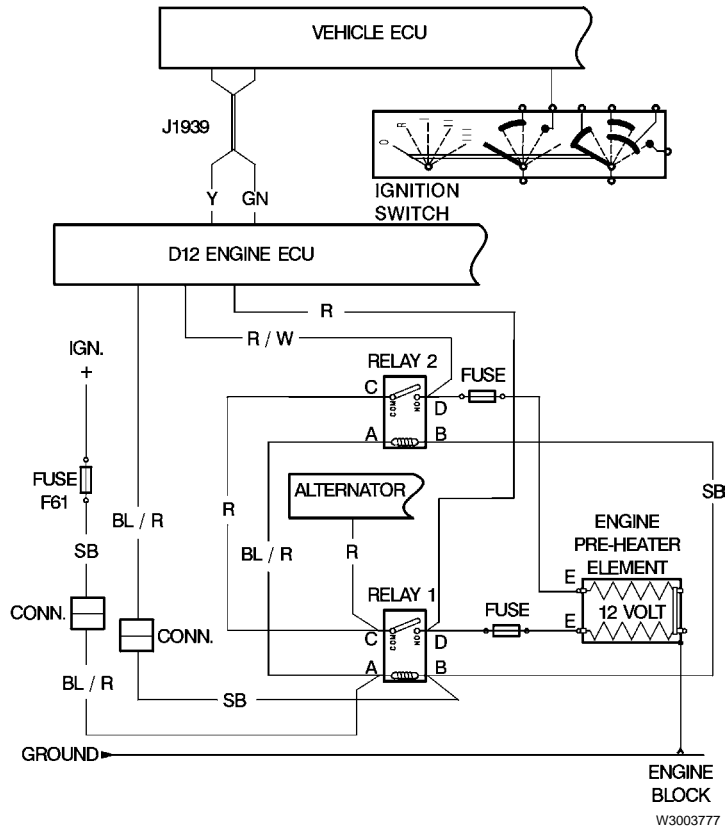
- SB** Solid Black
- BL/R** Blue/Red
- R** Red
- R/W** Red/White
- Y** Yellow
- GN** Green



A, B, C and D are measuring points. See: “Troubleshooting Preheater with Digital Multimeter” page 32 for more information.

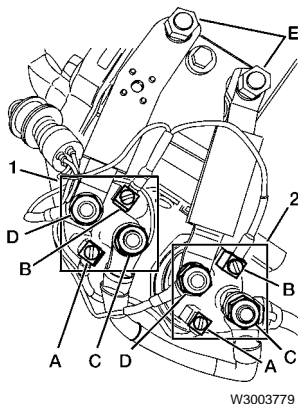
Troubleshooting Simplified Schematic, D12 Preheater

The simplified schematic and Illustration below should clarify the procedures in “Troubleshooting Preheater with Digital Multimeter” page 32. For detailed, vehicle-specific schematics refer to Function Group 370, Service Manual: Electrical Schematics VN, VHD. Information Type: Schematics.



Wire color codes in Schematic:

- SB** Solid Black
- BL/R** Blue/Red
- R/W** Red/White
- Y** Yellow
- GN** Green



A, B, C and D are measuring points. See: “Troubleshooting Preheater with Digital Multimeter” page 32 for more information. **1:** Relay 1, **2:** Relay 2.

Troubleshooting Preheater with Digital Multimeter

Use digital Multimeter J-39200 or equivalent tool to perform the test in the table below. The measuring points referenced in the table as A, B, C, etc. correspond to measuring points that are illustrated in the preheat simplified schematics and drawings in "Troubleshooting Simplified Schematic, D7 Preheater" page 30 and "Troubleshooting Simplified Schematic, D12 Preheater" page 31.

These measuring points should not be confused with the wire color codes that are listed beside each schematic.

Each preheat relay, fuse and element must be checked independently on D12 engines.

Function	Key Position	Measuring Points	Expected Value	Note	Possible Cause (if expected value not correct)
Power Supply to Relay Coil	On	Relay coil positive connector (A) to alternate ground.	12V		Fuse, connectors or wiring fault in power supply circuit.
Ground to Relay Coil	Off	Control Wire (B) to alternate ground	180 k Ω \pm 20%	Disconnect control wire at relay	Connectors or wiring fault in ground circuit through EECU.
Control Signal	Preheat	Control Wire (B) to alternate ground	<1V	Relay(s) click in	1 Connectors or wiring fault in ground circuit through EECU 2 Preheat relay(s).
Relay Coil Function Test	On	Control Wire (B) to alternate ground	Relay(s) click in		If values above are correct probably relay fault.
Power Supply for Pre-heater Elements	Off	Relay "Common" (C) terminal to alternate ground	12V		Connectors or wiring fault in power supply circuit from alternator.
Ground through Preheater Elements	Off	Relay "NO" (D) terminal to alternate ground	<1 Ω		1 Preheater fuse. 2 Preheater element.
Relay Function Test	Preheat	Relay "NO" (D) terminal to alternate ground	9V - 12V	Relay(s) click in	If power supply for pre-heater elements correct, probable relay fault.
Preheat Fuses	Preheat	Preheat element connection (E) to alternate ground	9V - 12V	Relay(s) click in	If relay function correct, probable pre-heat fuse fault
Preheater Elements	Preheat	Preheat element connection (E) to alternate ground	9V - 12V	With relay(s) clicked in elements should produce heat	If values above correct, probable pre-heater element fault

Charging System Troubleshooting



DANGER

Before working on a vehicle, set the parking brakes, place the transmission in neutral, and block the wheels. Failure to do so can result in unexpected vehicle movement and can cause serious personal injury or death.



CAUTION

Possible damage to electronic components. Turn the vehicle ignition switch OFF before disconnecting or connecting any electronic components. Failure to de-energize circuits may result in permanent damage to electronic components.



CAUTION

Never use the ohmmeter mode of the DMM in a powered circuit or as a substitute for a voltmeter or ammeter, since this will damage the instrument. Use the ohmmeter mode only when power is removed from the circuit. (If contacted with sulfuric acid, flush immediately with water and get medical attention).



WARNING

Always wear eye protection when working around batteries to prevent the risk of injury due to contact with sulfuric acid or an explosion. (Important: If contacted with sulfuric acid, flush immediately with water and get medical attention).



WARNING

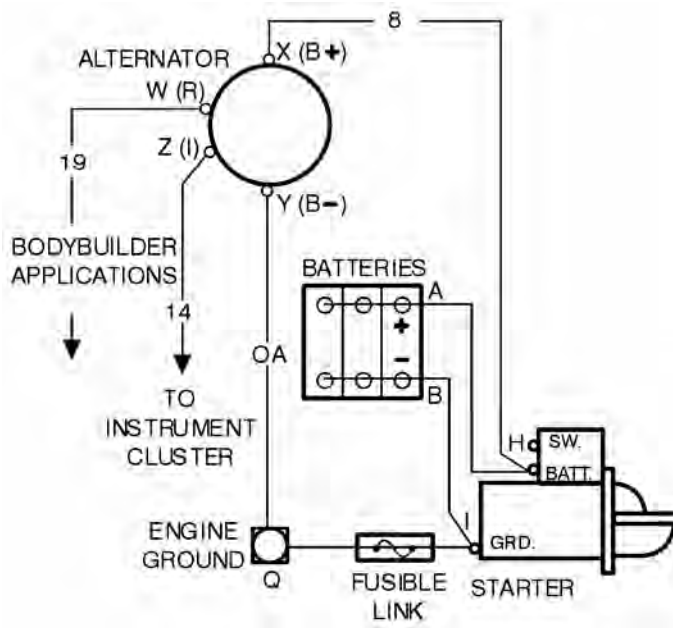
HOT ENGINE! Keep clear of all moving parts or hot engine parts and/or fluids. A hot engine and/or fluids can cause burns.

Troubleshooting Simplified Schematics, Charging System

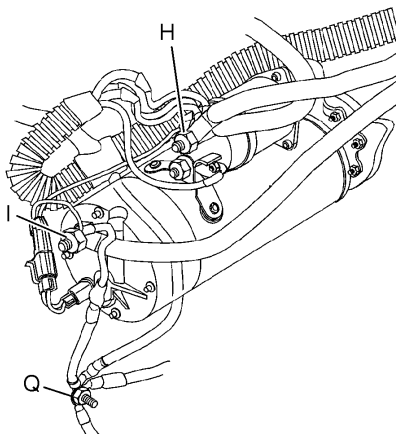
The simplified schematic and illustration below should be used to clarify the procedures in "Troubleshooting Charging System with Digital Multimeter" page 35. For detailed, vehicle-specific schematics refer to:

Service Manual Electrical Schematics VN/VHD

IMPACT Function Group: 370
Information Type: Schematics.

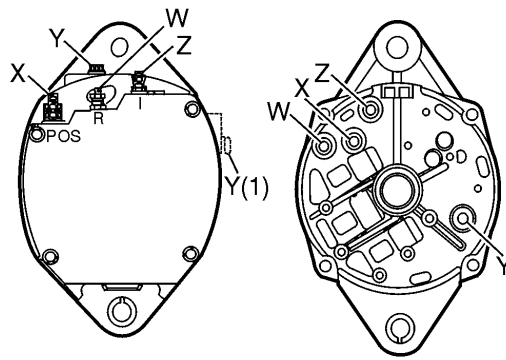


W3004720



W3004567

H, I and Q are measuring points, for more information see page 37.



W3004566

- X** Output Terminal (B+)
- Y** Ground Terminal (B-)
- W** Relay Terminal
- Z** Indicator Light Terminal
- Y(1)** Ground Terminal (B-) 34SI only

Troubleshooting Charging System with Digital Multimeter

One or more of the following conditions will generally indicate charging systems problems:

- Undercharged or overcharged batteries.
- Charging indicator telltale lamp “on” with the engine running.
- Charging indicator telltale lamp “off” with the ignition switch on and the engine not running.
- The voltmeter in the graphic display showing a charging rate outside the normal range.
- Incorrect or no operation of accessories connected to the “Relay” terminal.

- Short life of light bulbs or other electrical components due to unusually high system voltage.

Prior to troubleshooting, visually check the cables and connections for obvious problems. Check the drive belt tension and adjust if necessary.

Use the digital multimeter J-39200 or equivalent tool to perform the test in the following table. The measuring points referenced in the table as X, Y, Z, etc. correspond to measuring points that are illustrated in the charging system simplified schematics and drawings. See: “Troubleshooting Simplified Schematics, Charging System” page 34.

Funtion	Key Position	Measuring Point	Expected Value	Note	Possible Cause (if expected valve not correct)
Alternator Charging Voltage	ON/ Engine Running	Output Terminal (X)/ Ground Terminal Y or Ground Terminal Y(1)	13.8 - 14.2 V	Accessories Off	<ol style="list-style-type: none"> 1 Power circuit from battery 2 Ground circuit from battery 3 Alternator belt loose/missing 4 Alternator failure
Charging Voltage at Batteries	ON/ Engine Running	Batt (+) Terminal (A)/ Batt (-) Terminal (B)	13.8 - 14.2 V	Accessories Off. Reading may be slightly less than at alternator.	If alternator charging voltage OK, probable power or ground cable fault.
Relay Terminal Signal	ON/ Engine Running	Relay Terminal (W)/ Ground Terminal (Y)	Approx. 1/2 Charging Voltage	Accessories Off.	<ol style="list-style-type: none"> 1 Probable alternator failure. 2 Check for broken or loose no. 19 ire at the alternator terminal.
Ins. Cluster Indicator Lamp Operation	ON/ Engine Running	Ind. Light Terminal (Z)/ Terminal (Y)	Approx. Charging Voltage	Accessories Off. Indicator Lamp Off.	See: "Troubleshooting Charging Indicator (Telltale) Lamp" page 37.
Positive Cables	ON/ Engine Running	Output Terminal (X)/ Batt + Terminal (A)	<0.5 total voltage drop = positive and negative voltage drops combined	A/C On, Blower Motor on High, Headlamps on Bright	Excessive resistance in positive cables. Check measuring points X/H and A/H to help isolate problem cable/ connectors.
Ground Cables	ON/ Engine Running	Ground Terminal (Y) Batt - Terminal (B)	<0.5 total voltage drop = positive and negative voltage drops combined	A/C On, Blower Motor on High, Headlamps on Bright	Excessive resistance in negative cables. Check measuring points Y/Q, Y1/Q, Q/I and I/B to help isolate problem cable/ connectors.

Troubleshooting Charging Indicator (Telltale) Lamp

When the ignition key is turned "ON", the Charging Indicator (telltale) lamp will momentarily illuminate for a bulb test. The lamp will remain on until the engine is started. With the engine running and the alternator properly charging, the wire at the indicator light terminal from the instrument cluster and the indicator light terminal on the alternator (Z) should be at approximately the same voltage. With the voltages equal, the Charging telltale light should go out.

To clarify the procedures below refer to: "Troubleshooting Simplified Schematics, Charging System" page 34.

- Instrument cluster and bulb check: Test the Charging Indicator (telltale) lamps ability to function by running the "Bulb Test" from the instrument cluster self test menu. Use the graphic display control buttons to access the "System Diagnostics" menu, select "Cluster Self Test," then "Bulb Test." With the bulb test active, all the telltale and LED indicator lamps, including the Charging telltale, will illuminate for approximately 5 seconds. With the bulb test active, the charging indicator wiring is ignored and the test is operated by the instrument cluster internal electronics. If the indicator does not illuminate properly, refer to:

Service Manual Instrumentation, VN from 3/99, VHD

IMPACT Function Group: 381
Information Type: Diagnostics
"Instrument Cluster Tests"

- Wiring check — grounded circuit: With the ignition key "ON" and the engine not running, the Charging

telltale should be illuminated. Disconnect the wire at the indicator light terminal (Z). The Charging telltale should go off. If not, check for a grounded circuit between the alternator and instrument cluster. If a grounded circuit is indicated, refer to manual below for detailed vehicle-specific schematics:

Service Manual Electrical Schematics VN, VHD

IMPACT Function Group: 370
Information Type: Schematics

- Wiring check — open circuit: With the ignition key "ON" and the engine not running, the Charging telltale should be illuminated. Disconnect the wire at the indicator light terminal (Z). Use a jumper wire to ground the removed indicator light wire. The Charging telltale should illuminate. If not, check for an open circuit between the alternator and the instrument cluster. If an open circuit is indicated, refer to:

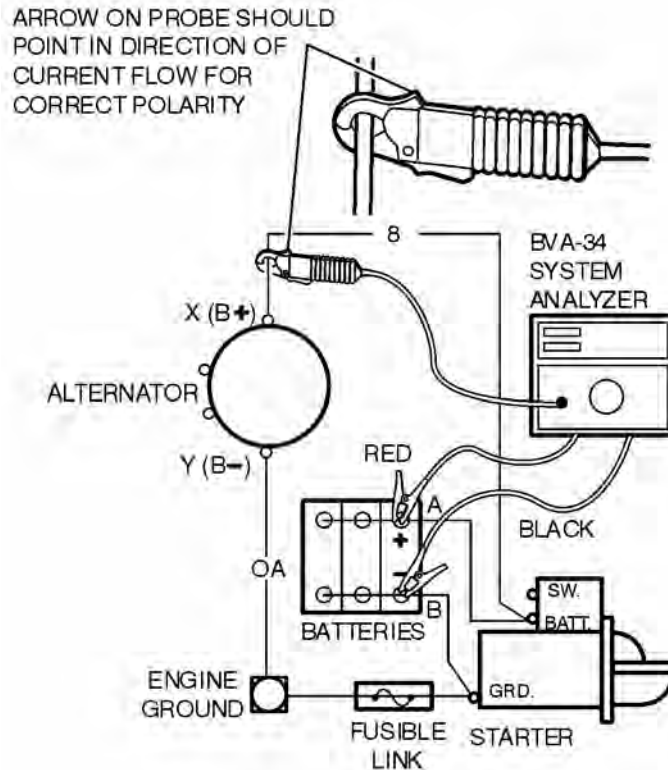
Service Manual Electrical Schematics VN, VHD

IMPACT Function Group: 370
Information Type: Schematics

- Alternator check: With the engine running and the alternator properly charging, remove the wire at the indicator light terminal. The indicator light terminal on the alternator (Z) should be at approximately charging voltage. If not, the alternator is probably defective.

Troubleshooting — Alternator Output Test with BVA-34 Tester

Before beginning the alternator output test, visually check the cables and connections for obvious problems. Check the drive belt tension and adjust if necessary.



Use BVA-34 System Analyzer or equivalent tool to perform the test below. Read and follow the directions with the test equipment used. The test outlines below should be used as a general guide for performing an alternator output test. The measuring points referenced in the text as A, B, X etc. correspond to measuring points that are illustrated in the alternator output test simplified schematics above.

- 1 Set the volt switch to the "INTERNAL VOLTS" position. Connect the clamps from the tester to the positive and negative (A & B) battery jumper stud posts.
- 2 "Zero" the ammeter if necessary.
- 3 Clamp the inductive amp probe around the output cable from the B+ post (X) at the alternator. Be sure that the inductive amp probe is pointing the proper direction.
- 4 Turn the ignition key to "ON" and note the amps draw.

- 5 Start the engine and run at high idle.

Note: Engine speed must be above approximately 1700 RPM to achieve maximum alternator output.

- 6 While observing the volt and amp gauges on the meter, adjust the load knob to obtain maximum alternator output. Use caution not to go below 12 volts when applying the load. Also note the red "STATOR DIODE" LED. If the LED glows steady red, it indicates that a diode or the stator is faulty.
- 7 Note the maximum alternator output (observe in step 6). Add the current draw obtained in step 4. This is the total alternator output, which should be a minimum of 85 percent of the rated alternator output.

Note: The rated alternator output can be found on the alternator identification tag.

Troubleshooting Starting and Charging System with The Accuracy Plus Tester

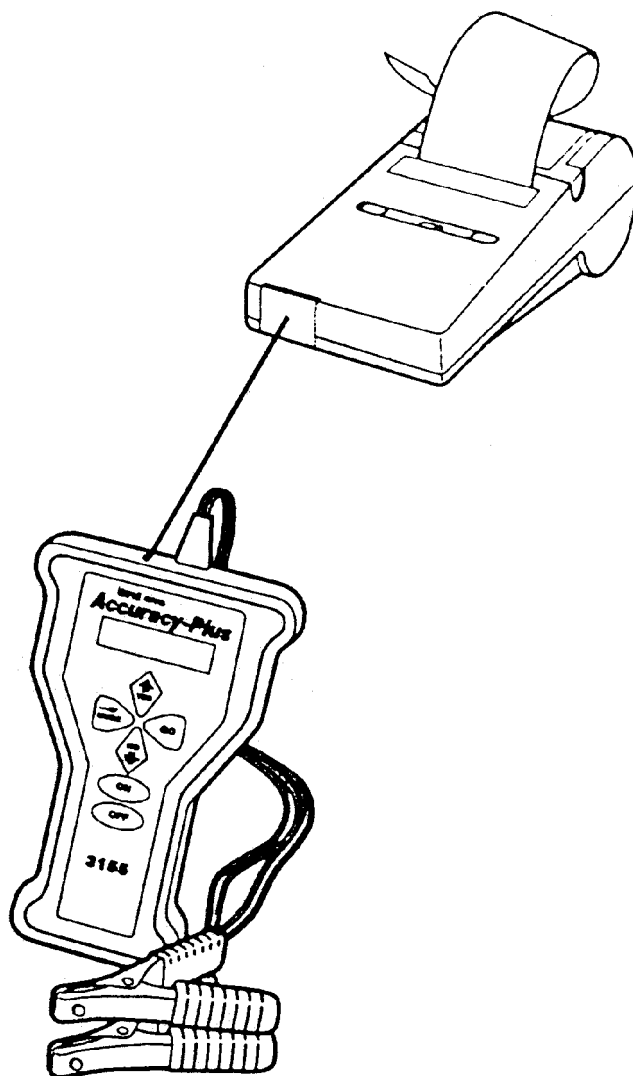
The J-44700 Accuracy Plus Tester will test the starting and charging system for the following:

- Battery open circuit voltage
- Cranking voltage
- Charging voltage
- Regulator voltage
- Diode condition

To operate the Accuracy Plus tester, connect the positive and negative tester leads to the battery jumper stud posts. Select the "System Test" and follow the on screen prompts until the tests are complete. The test results may be printed if desired with the optional printer number 238598. Both the J-44700 Accuracy Plus tester and the 238598 printer are available in kit part number J-44701. See the tools section of this manual for more information.

Note: Enter the combined CCA rating of all batteries when prompted.

Note: If the results of this test indicate a faulty battery, the batteries must be disconnected and tested individually. See section: "Battery Troubleshooting" page 17.



J-44700 Accuracy Plus HD Battery Tester.

W0001836

Service Procedures

3714-19-03-01 Battery Cables, Removal and Installation

DANGER

Before working on a vehicle, set the parking brakes, place the transmission in neutral, and block the wheels. Failure to do so can result in unexpected vehicle movement and can cause serious personal injury or death.

WARNING

Always wear eye protection when working around batteries to prevent the risk of injury due to contact with sulfuric acid or an explosion (If contacted with sulfuric acid, flush immediately with water).

WARNING

Batteries may contain explosive gases. To help minimize the risks of explosion, avoid sparks or open flames near batteries. Do not smoke when servicing batteries.

CAUTION

If there are other ground cables connected to the battery (such as engine ECU's, satellite system, etc.), disconnect those grounds first, then remove the main battery ground cable. Electronic modules may be damaged when additional grounds are connected/disconnected without the main battery ground connected. Disconnect the main battery ground last.

CAUTION

In vehicles with a Supplemental Restraint System (SRS), turn the ignition switch ON before connecting the battery. Failure to do so may result in permanent damage to the instrument cluster or other electronic circuits within the vehicle. (This applies only to vehicles with SRS and Cummins or Detroit Diesel engine.) Always check for fault codes after repairs are completed.

CAUTION

Possible damage to electronic components. Turn the vehicle ignition switch OFF before disconnecting or connecting any electronic components. Failure to de-energize circuits may result in permanent damage to electronic components.

All Cables

Volvo VN/VHD vehicles are equipped with 2, 3 or 4 batteries depending on the engine and options ordered. The batteries are connected together, in parallel, with battery interconnecting cables. The batteries cannot be tested or serviced as a set, but must be tested or serviced individually.

To test or service the batteries, all battery cables and wiring connected directly to the batteries must be removed. If the battery cables and wiring are not removed and installed in the proper order, damage to sensitive electronic equipment may occur. To properly remove and install the battery cables, proceed as follows:

Removal

- 1 Turn the ignition key to the "OFF" position.
- 2 Disconnect the ground wiring from electrical equipment connected directly to the batteries, such as ECU's, satellite systems, etc.
- 3 Disconnect the main ground cable(s).
- 4 Disconnect the positive wiring from the electrical equipment connected directly to the batteries.
- 5 Disconnect the main positive cables(s).
- 6 Disconnect the battery interconnecting cables.
- 7 Perform battery test or service as needed.

Installation

8

Connect the battery interconnection cables.

9

Connect the main positive cable(s).

10

Connect the positive wiring from the electrical equipment connected directly to the batteries.

11

If the vehicle is equipped with a Supplemental Restraint System (SRS) and a Cummins or Detroit Diesel engine, turn the ignition switch to the "ON" position. If not, leave the ignition switch in the "OFF" position.

12

Connect the main ground cable(s). Turn the ignition switch back to "OFF" if necessary.

13

Connect ground wiring from the electrical equipment connected directly to the batteries.

14

Secure all battery terminal nuts. Battery terminal torque = 3.7 ± 5.7 Nm (10 –15 ft-lb)
 3.7 ± 5.7 Nm
 (10 –15 ft-lb)

Ground Cables

Many service operations require the removal of the battery ground (negative) cables as a safety measure. If the battery ground cable(s) and wiring are not removed and installed in the proper order, damage to sensitive electronic equipment may occur. To properly remove and install the battery ground cables and wiring, proceed as follows:

Removal

1

Turn the ignition key to the "OFF" position.

2

Disconnect the ground wiring from electrical equipment connected directly to the batteries, such as ECU's, satellite systems, etc.

3

Disconnect the main ground cable(s).

4

Perform service operations as needed.

Installation

5

If the vehicle is equipped with a Supplemental Restraint System (SRS) and a Cummins or Detroit Diesel engine, turn the ignition switch to the "ON" position. If not, leave the ignition switch in the "OFF" position.

6

Connect the main ground cable(s). Turn the ignition switch back to "OFF" if necessary.

7

Connect ground wiring from the electrical equipment connected directly to the batteries.

8

Secure all battery terminal nuts. Battery terminal torque = 13 ± 20 Nm (10 –15 ft-lb)
 13 ± 20 Nm
 (10 –15 ft-lb)

Battery Jump Starting

DANGER

Before working on a vehicle, set the parking brakes, place the transmission in neutral, and block the wheels. Failure to do so can result in unexpected vehicle movement and can cause serious personal injury or death.

CAUTION

Do not use a "Hot Shot" type starting cart, as most use extremely high voltages. Use of "Hot Shot" device to jump start the vehicle will seriously damage the ECU's and other electrical equipment.

CAUTION

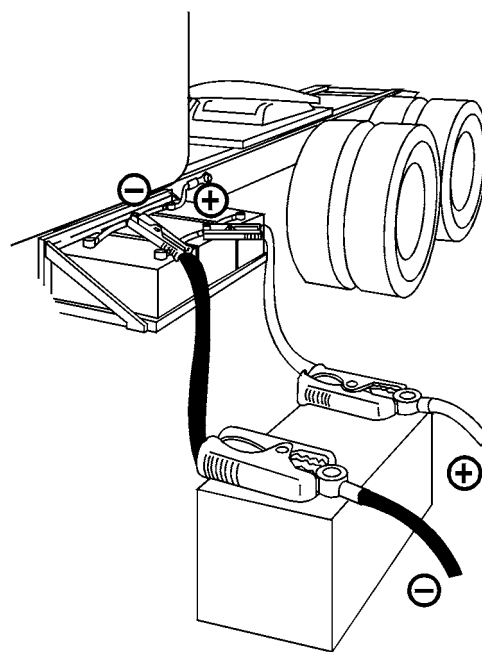
Do not attempt to jump-start a vehicle equipped with Delco Maintenance Free batteries, if the test indicator light is yellow. Replace the battery instead.

WARNING

Always wear eye protection when working around batteries to prevent the risk of injury due to contact with sulfuric acid or an explosion (If contacted with sulfuric acid, flush immediately with water and get medical attention).

WARNING

Batteries may contain explosive gases. To help minimize the risks of explosion, avoid sparks or open flames near batteries. Do not smoke when servicing batteries.



W3002432

If the vehicle needs to be jump started, use starting batteries. DO NOT use battery chargers with "boosting" capability. These utilize a high voltage that will cause damage to the vehicle electrical and electronic components.

When jumping batteries to start an engine, it is important that the jumper cables are connected directly from one set of batteries in one vehicle to the other set of batteries in the other vehicle. This is so the cranking current is carried through the proper starter wiring.

To access the batteries on a vehicle equipped with side fairings, open the fairing access cover. "Jumper Studs", which are longer and made of brass, are factory installed on one battery positive and negative post. These jumper studs are designed to accept the jumper cable claws.

Connect the jumper cables to the positive, or "hot" terminal first and the ground terminal last. When disconnecting the cables, disconnect the ground terminal first. Connect the jumper cable clamps to the discharged battery first and to the booster battery last. Avoid creating sparks by making all connections quickly and firmly. Do not permit the vehicles to touch each other when jump starting.

3111-03-02-02 Battery, Replacement (One or Two)

DANGER

Before working on a vehicle, set the parking brakes, place the transmission in neutral, and block the wheels. Failure to do so can result in unexpected vehicle movement and can cause serious personal injury or death.

WARNING

Always wear eye protection when working around batteries to prevent the risk of injury due to contact with sulfuric acid or an explosion (If contacted with sulfuric acid, flush immediately with water and get medical attention).

WARNING

Batteries may contain explosive gases. To help minimize the risks of explosion, avoid sparks or open flames near batteries. Do not smoke when servicing batteries.

CAUTION

If there are other ground cables connected to the battery (such as engine ECU's, satellite system, etc.), disconnect those grounds first, then remove the main battery ground cable. Electronic modules may be damaged when additional grounds are connected/disconnected without the main battery ground connected. Disconnect the main battery ground last.

CAUTION

In vehicles with a Supplemental Restraint System (SRS), turn the ignition switch ON before connecting the battery. Failure to do so may result in permanent damage to the instrument cluster or other electronic circuits in the vehicle. This applies only to vehicles with SRS and Cummins or Detroit Diesel engines. Check for fault codes after repairs are complete.

CAUTION

Possible damage to electronic components. Turn the vehicle ignition switch OFF before disconnecting or connecting any electronic components. Failure to de-energize circuits may result in permanent damage to electronic components.

Note: Some applications will require the removal of air fairings, battery box covers, or other components to access the batteries.

Removal

- 1 Turn the ignition key to the "OFF" position.
- 2 Disconnect ground wiring from electrical equipment connected directly to the batteries, such as ECU's, satellite systems, etc.
- 3 Disconnect the main ground cable(s) at the batteries.
- 4 Disconnect the positive cable(s) at the batteries.
- 5 Remove the battery nuts on all battery connections and remove all cables and wiring.
- 6 Loosen the battery hold down clamp nuts enough to allow removal of the hold down clamp assembly.
- 7 Remove the defective battery(s).
- 8 Clean any battery post or cable terminals as necessary.

Installation

- 9 Install the replacement battery(s). Observe that the battery positive and negative posts are oriented properly when installed.

10

Install the battery hold down clamp.
Torque =
24 ± 4 Nm
(18 ± 3 ft-lb)

24 ± 4 Nm
(18 ± 3 ft-lb)

11

Install all battery cables and wiring connections removed in steps 5. Install the battery nuts (hand tighten) securing those cables/wiring.

12

Connect the positive cables(s) and any positive wiring from electrical equipment connected directly to the batteries.

13

If the vehicle is equipped with a Supplemental Restraint System (SRS) and a Cummins or Detroit Diesel engine, turn the ignition switch to "ON" position. If not, leave the ignition switch in the "OFF" position.

14

Connect the main ground cable(s). Turn ignition switch back to "OFF" if necessary.

15

Connect ground wiring from electrical equipment connected directly to the batteries.

16

Tighten all battery cable connections.
Torque =
13 ± 20 Nm
(10 –15 ft-lb)

13 ± 20 Nm
(10 –15 ft-lb)

3714-03-02-03**Battery Cables to Starter, Replacement** **DANGER**

Before working on a vehicle, set the parking brakes, place the transmission in neutral, and block the wheels. Failure to do so can result in unexpected vehicle movement and can cause serious personal injury or death.

 **WARNING**

Always wear eye protection when working around batteries to prevent the risk of injury due to contact with sulfuric acid or an explosion (If contacted with sulfuric acid, flush immediately with water and get medical attention).

 **WARNING**

Batteries may contain explosive gases. To help minimize the risks of explosion, avoid sparks or open flames near batteries. Do not smoke when servicing batteries.

 **CAUTION**

If there are other ground cables connected to the battery (such as engine ECU's, satellite system, etc.), disconnect those grounds first, then remove the main battery ground cable. Electronic modules may be damaged when additional grounds are connected/disconnected without the main battery ground connected. Disconnect the main battery ground last.

 **CAUTION**

In vehicles with a Supplemental Restraint System (SRS), turn the ignition switch ON before connecting the battery. Failure to do so may result in permanent damage to the instrument cluster or other electronic circuits in the vehicle. This applies only to vehicles with SRS and Cummins or Detroit Diesel engines. Check for fault codes after repairs are complete.

**CAUTION**

Possible damage to electronic components. Turn the vehicle ignition switch OFF before disconnecting or connecting any electronic components. Failure to de-energize circuits may result in permanent damage to electronic components.

Before you start the replacement of the battery to starter cable(s), visually inspect the existing cables. Note the location of all routing, support clips (brackets), and cable ties. If any area is visibly distressed take appropriate corrective actions to prevent damage to the replacement cable(s). The following installation points should be observed always when replacing battery to starter cables.

- Cables should be supported at no less than 600 mm (24 in.) intervals with non-conductive compression clips.
- Cables must be supported as close as possible to all cable bends.
- Cable ties may be used as needed to prevent relative movement between cables.
- Strain relief should be provided at terminals to prevent terminal breakage.
- Route cables to avoid sharp edges or abrasive areas.
- Edges that cables pass through must be bushed with suitable grommets.
- Cables must not be routed within 130 mm (5 in.) of engine exhaust components or other sources of intense heat.
- Cables should not be located in areas that experience routine exposure to diesel fuel, hydraulic fluid, or oil.

Note: Some applications will require removal of air fairings, battery box covers, or other components to access the battery cables.

Removal

1
Turn the ignition key to the "OFF" position.

2
Disconnect ground wiring from the electrical equipment connected directly to the batteries, such as ECU's, satellite systems, etc.

3
Disconnect the main ground cable(s) at the batteries.

4
Disconnect the positive cable(s) at the batteries.

5
Remove all support clips (brackets) and cut cable ties.

6
Disconnect the battery cables at the starter. Note the wire positions to aid in installation.

7
Remove the defective cable(s).

Installation

8
Position the replacement cable(s) in the proper routing position. Be sure the cable will connect to the starter and batteries when all the support clips are secure.

9
Install the battery cables and wiring at the starter. Torque = 30.5 ± 3.5 Nm
(22.5 ± 2.5 ft-lb)

10
Install the cables into the support clips and secure beginning at the starter and working toward the battery. Observe the installation points as noted above. Support Clip Torque = 18 ± 2 Nm
(13 ± 1.5 ft-lb)
Secure with cable ties as needed.

11
Connect the positive cable(s) and any positive wiring from electrical equipment connected directly to the batteries.

12
If the vehicle is equipped with a Supplemental Restraint System (SRS) and a Cummins or Detroit Diesel engine, turn the ignition switch to the "ON" position. If not, leave the ignition switch in the "OFF" position.

13

Connect the main ground cable(s).
Turn ignition switch back to "OFF" if necessary.

14

Connect ground wiring from the electrical equipment connected directly to the batteries.

15

Tighten all battery cable connections.
Torque =
13 ± 20 Nm
(10 –15 ft-lb)

13 ± 20Nm
(10 –15 ft-lb)

3714-03-02-04**Battery Inter-connection Cables, Replacement**
 **DANGER**

Before working on a vehicle, set the parking brakes, place the transmission in neutral, and block the wheels. Failure to do so can result in unexpected vehicle movement and can cause serious personal injury or death.

 **WARNING**

Always wear eye protection when working around batteries to prevent the risk of injury due to contact with sulfuric acid or an explosion (If contacted with sulfuric acid, flush immediately with water and get medical attention).

 **WARNING**

Batteries may contain explosive gases. To help minimize the risks of explosion, avoid sparks or open flames near batteries. Do not smoke when servicing batteries.

 **CAUTION**

If there are other ground cables connected to the battery (such as engine ECU's, satellite system, etc.), disconnect those grounds first, then remove the main battery ground cable. Electronic modules may be damaged when additional grounds are connected/disconnected without the main battery ground connected. Disconnect the main battery ground last.

 **CAUTION**

In vehicles with a Supplemental Restraint System (SRS), turn the ignition switch ON before connecting the battery. Failure to do so may result in permanent damage to the instrument cluster or other electronic circuits in the vehicle. This applies only to vehicles with SRS and Cummins or Detroit Diesel engines. Check for fault codes after repairs are complete.

**CAUTION**

Possible damage to electronic components. Turn the vehicle ignition switch OFF before disconnecting or connecting any electronic components. Failure to de-energize circuits may result in permanent damage to electronic components.

Removal

- 1**
Turn the ignition key to the "OFF" position.
- 2**
Disconnect ground wiring from the electrical equipment connected directly to the batteries, such as the ECU's, satellite systems, etc.
- 3**
Disconnect the main ground cable(s) at the batteries.
- 4**
Disconnect the positive cable(s) at the batteries.
- 5**
Remove the battery nuts on all battery connections and remove all cables and wiring.
- 6**
Clean any battery post or cable terminals as necessary.

Installation

- 7**
Replace the defective battery inter-connecting cable(s).
- 8**
Install all battery cables and wiring connections removed in step five (5). Install the battery nuts (hand tighten) securing the cables/wiring.
- 9**
Connect the positive cable(s) and positive wiring from the electrical equipment connected directly to the batteries.

10

If the vehicle is equipped with a Supplemental Restraint System (SRS) and a Cummins or Detroit Diesel engine, turn the ignition switch to the "ON" position. If not, leave the ignition switch in the "OFF" position.

11

Connect the main ground cable(s). Turn the ignition switch back to "OFF" if necessary.

12

Connect ground wiring from the electrical equipment connected directly to the batteries.

13

Tighten all battery cable connections.
Torque =
13 ± 20 Nm
(10 –15 ft-lb)

13 ± 20 Nm
(10 –15 ft-lb)

3311-03-02-01 Starter Motor, Replacement Volvo D12B or D12C Engine

DANGER

Before working on a vehicle, set the parking brakes, place the transmission in neutral, and block the wheels. Failure to do so can result in unexpected vehicle movement and can cause serious personal injury or death.

WARNING

Always wear eye protection when working around batteries to prevent the risk of injury due to contact with sulfuric acid or an explosion (If contacted with sulfuric acid, flush immediately with water and get medical attention).

WARNING

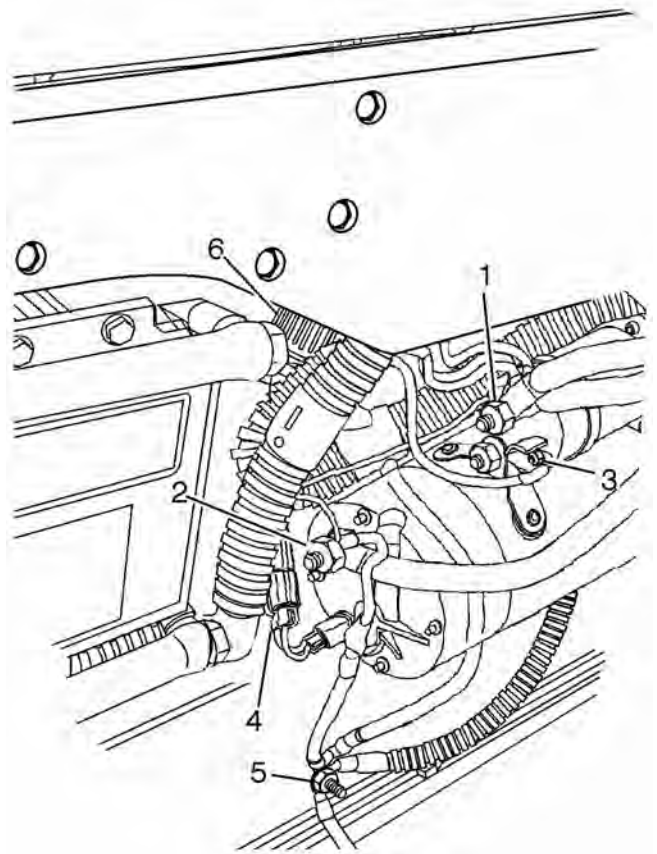
Batteries may contain explosive gases. To help minimize the risks of explosion, avoid sparks or open flames near batteries. Do not smoke when servicing batteries.

CAUTION

If there are other ground cables connected to the battery (such as engine ECU's, satellite system, etc.), disconnect those grounds first, then remove the main battery ground cable. Electronic modules may be damaged when additional grounds are connected/disconnected without the main battery ground connected. Disconnect the main battery ground last.

CAUTION

Possible damage to electronic components. Turn the vehicle ignition switch OFF before disconnecting or connecting any electronic components. Failure to de-energize circuits may result in permanent damage to electronic components.



W3004732

See removal and installation procedures following this illustration, for explanation of numbers 1 to 6 shown in above illustration.

Note: In some installations, the replacement of the starter may be aided by the removal of additional components or wiring not referenced in this manual, or affected by alternate battery cable routing due to alternate battery mounting locations.

Removal

- 1 Turn the ignition key to the "OFF" position.
- 2 Disconnect ground wiring from the electrical equipment connected directly to the batteries, such as the ECU's, satellite systems, etc.
- 3 Disconnect the main battery ground cable(s).
- 4 Remove the splash shield.
- 5 Remove the inner fender assembly.

6

Loosen or remove the battery cable mounting support brackets, if needed to allow enough slack for removal of the battery cable terminals at the starter.

7

Remove the positive (1) and negative (2) cables/wiring and "switch" terminal (3) wire from the starter. Disconnect the overcrank protection switch (4) (if equipped). Note the cable/wiring position for installation.

8

Remove the engine ground terminal connector (5).

9

Disconnect the engine wiring harness connector (6). Remove the engine wiring harness support clamp and pull the harness away from the starter area.

10

Remove the starter mounting bolts and remove the starter from the vehicle.

Installation**11**

Compare the orientation of the nose housing on the old starter to the replacement starter. If necessary, remove the nose housing on the replacement starter and "clock" it to the position of the old starter.

Nose housing bolt torque =

10 ± 13 Nm
(13 – 17 ft-lb)

10 ± 13 Nm
(13 – 17 ft-lb)

12

Install the replacement starter and secure the mounting bolts.

Torque =

85 ± 9 Nm
(63 ± 6.5 ft-lb)

85 ± 9 Nm
(63 ± 6.5 ft-lb)

13

Position the engine wiring harness and engage the connector (6). Install the engine wiring harness support clamp.

14

Install the engine ground cables (5) and secure.

Torque =

48 ± 8 Nm
(35 ± 6 ft-lb)

48 ± 8 Nm
(35 ± 6 ft-lb)

15

Install all starter wiring and cables. (Battery cable terminals (1 & 2)

torque =

30.5 ± 3.5 Nm
(22.5 ± 2.5 ft-lb)

Switch terminal (3) torque =

2.6 ± 0.8 Nm
(23 ± 7 in-lb)

30.5 ± 3.5 Nm
(22.5 ± 2.5 ft-lb)
2.6 ± 0.8 Nm.
(23 ± 7 in-lb)

16

Secure the battery cables in the mounting support brackets.

17

Install the inner fender assembly.

18

Install the splash shield.

19

Install the main ground cable(s).

20

Install ground wiring from the electrical equipment connected directly to the batteries.

21

Secure with the battery terminal nut(s).

Torque =

3.7 ± 5.7 Nm
(10 – 15 ft-lb)

3.7 ± 5.7 Nm
(10 – 15 ft-lb)

3311-03-02-01 Starter Motor, Replacement

Volvo D7C Engine

DANGER

Before working on a vehicle, set the parking brakes, place the transmission in neutral, and block the wheels. Failure to do so can result in unexpected vehicle movement and can cause serious personal injury or death.

WARNING

Always wear eye protection when working around batteries to prevent the risk of injury due to contact with sulfuric acid or an explosion. (If contacted with sulfuric acid, flush immediately with water and get medical attention).

WARNING

Never disconnect an air system component unless all system pressure has been depleted. Failure to deplete system pressure before disconnecting hoses or components may result in them separating violently, causing serious eye and/or body injury.

WARNING

HOT ENGINE! Keep clear of all moving parts or hot engine parts and/or fluids. A hot engine and/or fluids can cause burns.

WARNING

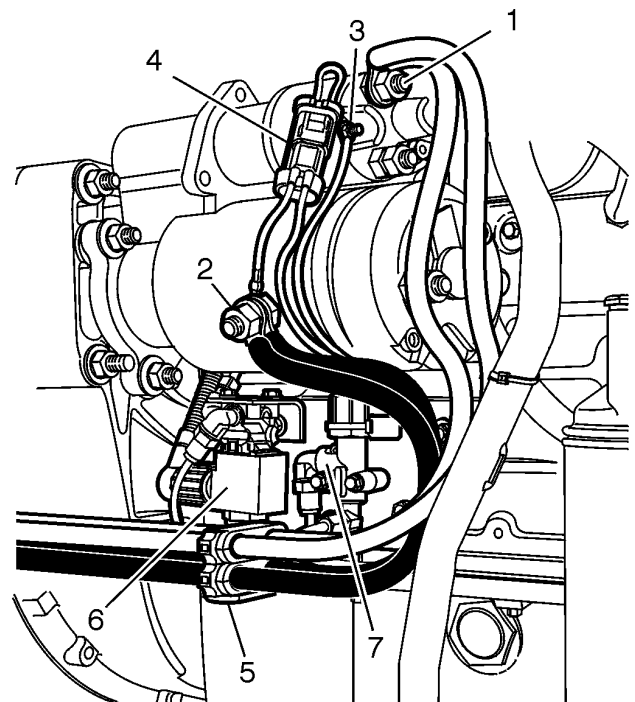
Batteries may contain explosive gases. To help minimize the risks of explosion, avoid sparks or open flames near batteries. Do not smoke when servicing batteries.

CAUTION

If there are other ground cables connected to the battery (such as engine ECU's, satellite system, etc.), disconnect those grounds first, then remove the main battery ground cable. Electronic modules may be damaged when additional grounds are connected/disconnected without the main battery ground connected. Disconnect the main battery ground last.

CAUTION

Possible damage to electronic components. Turn the vehicle ignition switch OFF before disconnecting or connecting any electronic components. Failure to de-energize circuits may result in permanent damage to electronic components.



W3004733

Starter D7C Engine
Dual Battery Cables shown.

- 1 Positive cables
- 2 Negative cables
- 3 Switch terminal
- 4 overcrank protection connector (with jumper)
- 5 Cable support bracket
- 6 EPG solenoid
- 7 EPG regulator

Note: In some installations, replacement of the starter may be aided by removal of additional components or wiring not referenced in this manual, or affected by alternate battery cable routing due to alternate battery mounting locations.

Removal

1
Turn the ignition key to the "OFF" position.

2
Disconnect ground wiring from electrical equipment connected directly to the batteries, such as ECU's, satellite systems, etc.

3
Disconnect the main battery ground cable(s).

4
Remove the right inner fender assembly.

5
Remove the positive and negative cables and "switch" terminal wire from the starter. Disconnect the overcrank protection switch (if equipped). Note the cable/wiring position for installation.

6
Remove the battery cable support bracket which is below the starter and pull the cables away from the starter area (cables under starter routing).

7
Bleed all pressure from the vehicle air system. Disconnect the Exhaust Pressure Governor (EPG) solenoid connector. Note their position for installation, then disconnect the EPG solenoid and regulator air lines. Remove the EPG solenoid/regulator assembly for the engine.

8
Remove the starter mounting nuts and remove the starter from the vehicle.

Installation

9
Compare the orientation of the nose housing on the old starter to the replacement starter. If necessary, remove the nose housing on the replacement starter and "clock" it to the position of the old starter.
Nose housing bolt torque =
18 ± 23 Nm (13 – 17 ft-lb)

10
Install the replacement starter and secure the mounting nuts.
Torque = 85 ± 15 Nm
(63 ± 6.5 ft-lb)

11
Install the EPG solenoid/regulator assembly. Install the EPG solenoid and regulator air lines. Engage the EPG solenoid connector.

12
Install the battery cable support bracket below the starter.

13
Install all starter wiring and cables.
Battery cable terminals torque =
30.5 ± 3.5 Nm
(22.5 ± 2.5 ft-lb);
switch terminal torque =
2.6 ± 0.8 Nm
(23 ± 7 in-lb) Secure wiring with cable ties as needed.

14
Install the right inner fender assembly.

15
Install the main ground cable(s) onto the battery ground terminal.

16
Install ground wiring from the electrical equipment connected directly to the batteries onto the battery ground terminal.

17
Tighten all battery cable connections.
Torque =
13 ± 20 Nm
(10 –15 ft-lb)

3311-03-02-01 Starter Motor, Replacement

Cummins or Detroit Diesel Engine

DANGER

Before working on a vehicle, set the parking brakes, place the transmission in neutral, and block the wheels. Failure to do so can result in unexpected vehicle movement and can cause serious personal injury or death.

WARNING

Always wear eye protection when working around batteries to prevent the risk of injury due to contact with sulfuric acid or an explosion (If contacted with sulfuric acid, flush immediately with water and get medical attention).

WARNING

HOT ENGINE! Keep clear of all moving parts or hot engine parts and/or fluids. A hot engine and/or fluids can cause burns.

CAUTION

In vehicles with a Supplemental Restraint System (SRS), turn the ignition switch ON before connecting the battery. Failure to do so may result in permanent damage to the instrument cluster or other electronic circuits within the vehicle. (This applies only to vehicles with SRS and a Cummins or Detroit Diesel engine.) Always check for fault codes after repairs are completed.

CAUTION

If there are other ground cables connected to the battery (such as engine ECU, satellite system, etc.), disconnect those grounds first, then remove the main battery ground cable. Electronic modules may be damaged when additional grounds are connected/disconnected without the main battery ground connected. Disconnect the main battery ground last.

CAUTION

Possible damage to electronic components. Turn the vehicle ignition switch OFF before disconnecting or connecting any electronic components. Failure to de-energize circuits may result in permanent damage to electronic components.

Note: In some installations, the replacement of the starter may be aided by the removal of additional components or wiring not referenced in this manual, or affected by alternate battery cable routing due to alternate battery mounting locations.

Removal

- 1**
Turn the ignition key to the "OFF" position.
- 2**
Disconnect ground wiring from the electrical equipment connected directly to the batteries, such as ECU's, satellite systems, etc.
- 3**
Disconnect the main battery ground cable(s).
- 4**
Remove the left splash shield.
- 5**
Remove the left inner fender assembly.
- 6**
Loosen or remove the battery cable mounting support brackets and cable dividers (if equipped) as needed to allow enough slack for removal of the battery cable terminals at the starter. Cut any cable ties as needed.
- 7**
Remove the positive and negative cables and "switch" terminal wire from the starter. Disconnect the overcrank protection switch (if equipped). Note the cable/wiring position for installation.
- 8**
Remove any wiring harness support clamps and brackets as needed to access the starter mounting bolts and allow removal of the starter.

9

Remove the starter mounting bolts and remove the starter and spacer (if equipped) from the vehicle.

Installation**10**

Compare the orientation of the nose housing on the old starter to the replacement starter. If necessary, remove the nose housing on the replacement starter and "clock" it to the position of the old starter.

Nose housing bolt torque =
 $9.5 \pm 12.5 \text{ Nm}$
 (13 –17 ft-lb)

$9.5 \pm 12.5 \text{ Nm}$
 (13 –17 ft-lb)

11

Install the replacement starter and spacer (if equipped) and secure the mounting bolts. Torque =

$176 \pm 25 \text{ Nm}$
 (130 ± 18 ft-lb)

$176 \pm 25 \text{ Nm}$
 (130 ± 18 ft-lb)

12

Install any wiring harness support clamps and brackets removed to access the starter mounting bolts.

13

Install all starter wiring and cables. (Battery cable terminals torque =

$30.5 \pm 3.5 \text{ Nm}$
 (22.5 ± 2.5 ft-lb);

switch terminal torque =
 $2.6 \pm 0.8 \text{ Nm}$
 (23 ± 7 in-lb)

$30.5 \pm 3.5 \text{ Nm}$
 (22.5 ± 2.5 ft-lb)
 $2.6 \pm 0.8 \text{ Nm}$
 (23 ± 7 in-lb)

14

Secure the battery cables in the mounting support brackets and cable dividers. Secure with cable ties as needed.

15

Install the inner fender assembly.

16

Install the splash shield.

17

If the vehicle is equipped with a Supplemental Restraint System (SRS), turn the ignition switch to the "ON" position. If not, leave the ignition switch in the "OFF" position.

18

Install the main ground cable(s). Turn ignition switch back to "OFF" if necessary.

19

Install ground wiring from electrical equipment connected directly to the batteries.

20

Secure with the battery terminal nuts. Torque =

$3.7 \pm 5.7 \text{ Nm}$
 (10 –15 ft-lb)

$3.7 \pm 5.7 \text{ Nm}$
 (10 –15 ft-lb)

3331-03-02-02 Preheater Fuse, Replacement

DANGER

Before working on a vehicle, set the parking brakes, place the transmission in neutral, and block the wheels. Failure to do so can result in unexpected vehicle movement and can cause serious personal injury or death.

WARNING

HOT ENGINE! Keep clear of all moving parts or hot engine parts and/or fluids. A hot engine and/or fluids can cause burns.

WARNING

Batteries may contain explosive gases. To help minimize the risks of explosion, avoid sparks or open flames near batteries. Do not smoke when servicing batteries.

CAUTION

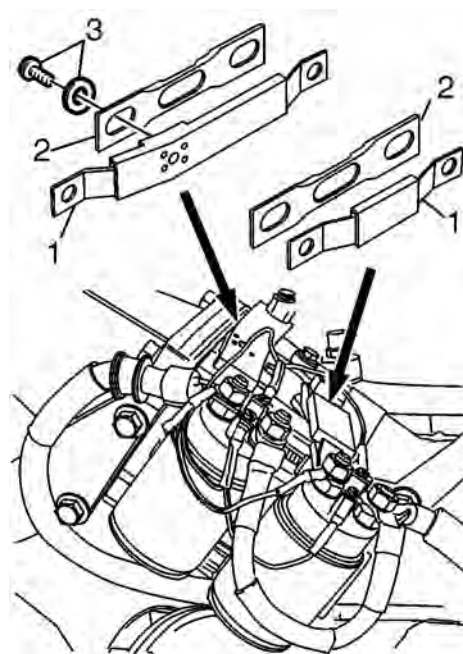
If there are other ground cables connected to the battery (such as engine ECU, satellite system, etc.), disconnect those grounds first, then remove the main battery ground cable. Electronic modules may be damaged when additional grounds are connected/disconnected without the main battery ground connected. Disconnect the main battery ground last.

CAUTION

Possible damage to electronic components. Turn the vehicle ignition switch OFF before disconnecting or connecting any electronic components. Failure to de-energize circuits may result in permanent damage to electronic components.

CAUTION

Use caution when working around the preheat elements. When active, the elements will heat to approximately (705°C) 1300°F. Allow sufficient time for the elements to cool to avoid severe burns.



W3004715

The preheat fuse assembly includes a support (1) designed to protect the fuse (2) from physical damage. The support is also used as a path for current flow and a connection point (3) for the fuse on the long fuse assembly used in the D12 engines.

Removal

1
Turn the ignition key to the "OFF" position.

2
Disconnect ground wiring from the electrical equipment connected directly to the batteries, such as ECU's, satellite systems, etc.

3
Disconnect the battery main ground cable(s).

4
Remove the nuts securing the defective fuse assembly(s).

5
Remove the wiring, support and fuse.

Installation

6
If the defective fuse assembly is the long fuse assembly on the D12 engine, remove the screw securing the fuse to the support. Install the replacement fuse onto the support and secure with the screw.

7
Install the replacement fuse, with support and wiring, onto the mounting terminals and secure.

8
Install the main ground cable(s).

9
Install ground wiring from the electrical equipment directly to the batteries.

10
Secure with the battery terminal nut(s).
Torque = 3.7 ± 5.7 Nm
(10 – 15 ft-lb)

3331-03-02-03 Preheater Relay, Replacement Volvo D12B or D12C Engine

DANGER

Before working on a vehicle, set the parking brakes, place the transmission in neutral, and block the wheels. Failure to do so can result in unexpected vehicle movement and can cause serious personal injury or death.

WARNING

HOT ENGINE! Keep clear of all moving parts or hot engine parts and/or fluids. A hot engine and/or fluids can cause burns.

CAUTION

If there are other ground cables connected to the battery (such as engine ECU's, satellite system, etc.), disconnect those grounds first, then remove the main battery ground cable. Electronic modules may be damaged when additional grounds are connected/disconnected without the main battery ground connected. Disconnect the main battery ground last.

CAUTION

Possible damage to electronic components. Turn the vehicle ignition switch OFF before disconnecting or connecting any electronic components. Failure to de-energize circuits may result in permanent damage to electronic components.

CAUTION

Use caution when working around the preheat elements. When active, the elements will heat to approximately (705°C) 1300°F. Allow sufficient time for the elements to cool to avoid severe burns.

Removal

1
Turn the ignition key to the "OFF" position.

2
Disconnect ground wiring from electrical equipment connected directly to the batteries, such as ECU's, satellite systems, etc.

3
Disconnect the battery main ground cable(s).

4
Remove the power cable, fuse, and wiring from relays. Note position for re-assembly.

5
Remove the support bracket/wiring harness clamp bolts (VN) or fan ring support bracket (VHD).

6
Remove the charge air pipe hose clamp.

7
Remove the charge air piping/preheater mounting bolts and remove the charge air piping from the vehicle.

8
Remove the preheater element block from the intake manifold. Tap the relay mounting bracket off the element block.

9
Remove the relay(s) from the mounting bracket.

Installation

10
Install the replacement relay(s) onto the bracket and secure.

11
Clean the gasket surfaces.

12
Tap the relay mounting bracket onto the element block.

13
Install the preheater element block, with new gaskets, and the charge air piping to the intake manifold.

14
Secure with mounting bolts. Torque = 24 ± 4 Nm (18 ± 3 ft-lb)

15
Install and secure the charge air pipe hose clamp.

16
Install the support bracket/wiring harness clamp bolts (VN) or fan ring support bracket (VHD) and secure.

17
Install the power cable, fuse, and wiring to the relays and secure.

18
Install the main ground cable(s).

19
Install ground wiring from the electrical equipment connected directly to the batteries.

20
Secure with the battery terminal nut(s). Torque = 3.7 ± 5.7 Nm ($10 -15$ ft-lb)

3331-03-02-03 Preheater Relay, Replacement

D7C Engine



Before working on a vehicle, set the parking brakes, place the transmission in neutral, and block the wheels. Failure to do so can result in unexpected vehicle movement and can cause serious personal injury or death.



HOT ENGINE! Keep clear of all moving parts or hot engine parts and/or fluids. A hot engine and /or fluids can cause burns.



If there are other ground cables connected to the battery (such as engine ECU's, satellite system, etc.), disconnect those grounds first, then remove the main battery ground cable. Electronic modules may be damaged when additional grounds are connected/disconnected without the main battery ground connected. Disconnect the main battery ground last.



Possible damage to electronic components. Turn the vehicle ignition switch OFF before disconnecting or connecting any electronic components. Failure to de-energize circuits may result in permanent damage to electronic components.



Use caution when working around the preheat elements. When active, the elements will heat to approximately (705°C) 1300°F. Allow sufficient time for the elements to cool to avoid severe burns.

Removal

1
Turn the ignition key to the "OFF" position.

2
Disconnect ground wiring from the electrical equipment connected directly to the batteries, such as ECU's, satellite systems, etc.

3
Disconnect the battery main ground cable(s).

4
Remove the power cable, fuse, and wiring from relay. Note position for re-assembly.

5
Remove the relay from its mounting and remove from the vehicle.

Installation

6
Install the replacement relay and secure.

7
Install the power cable, fuse and wiring to the relay and secure.

8
Install the main ground cable(s).

9
Install ground wiring from the electrical equipment connected directly to the batteries.

10
Secure with the battery terminal nut(s) 3.7 ± 5.7 Nm
(10 –15 ft-lb)
Torque =
3.7 ± 5.7 Nm
(10 –15 ft-lb)

3331-03-02-01 Preheater Element, Replacement

D12B or D12C Engine

DANGER

Before working on a vehicle, set the parking brakes, place the transmission in neutral, and block the wheels. Failure to do so can result in unexpected vehicle movement and can cause serious personal injury or death.

WARNING

HOT ENGINE! Keep clear of all moving parts or hot engine parts and/or fluids. A hot engine and /or fluids can cause burns.

CAUTION

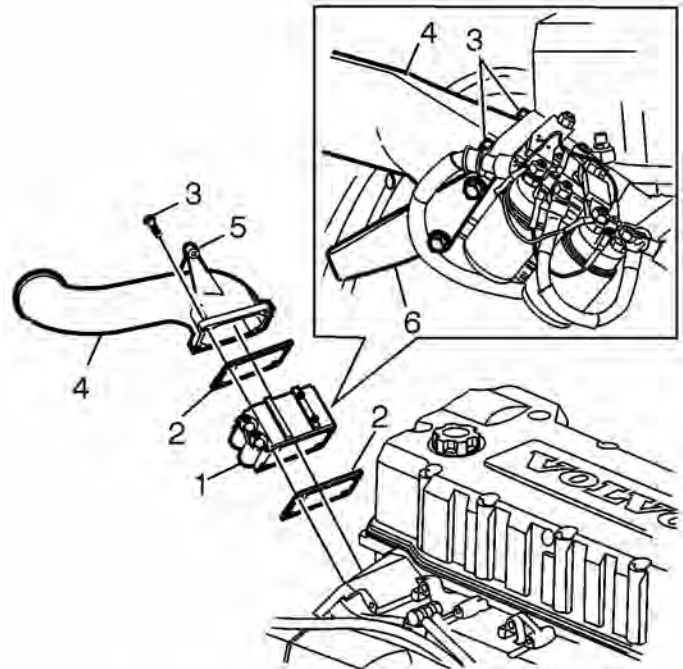
If there are other ground cables connected to the battery (such as engine ECU's, satellite system, etc.), disconnect those grounds first, then remove the main battery ground cable. Electronic modules may be damaged when additional grounds are connected/disconnected without the main battery ground connected. Disconnect the main battery ground last.

CAUTION

Possible damage to electronic components. Turn the vehicle ignition switch OFF before disconnecting or connecting any electronic components. Failure to de-energize circuits may result in permanent damage to electronic components.

CAUTION

Use caution when working around the preheat elements. When active, the elements will heat to approximately 705°C (1300°F). Allow sufficient time for the elements to cool to avoid severe burns.



W3004730

Removal

- 1**
Turn the ignition key to the "OFF" position.
- 2**
Disconnect ground wiring from electrical equipment connected directly to the batteries, such as ECU's, satellite systems, etc.
- 3**
Disconnect the battery main ground cable(s).
- 4**
Remove the power cable, fuses, and wiring from relays. Note position for re-assembly.
- 5**
Remove the support bracket/wiring harness clamp bolts (6, VN only) or fan ring support bracket (5, VHD only).

6
Remove the charge air pipe hose clamp.

7
Remove the charge air piping / preheater mounting bolts (3) and remove the charge air piping (4) from the vehicle.

8
Remove the preheater element block (1) from the intake manifold. Tap the relay mounting bracket off the element block.

9
Clean the gasket surfaces.

Installation

10
Tap the relay mounting bracket onto the replacement element block.

11
Install the preheater element block, with new gaskets (2), and the charge air piping to the intake manifold. Secure with mounting bolts.
Torque =
 $24 \pm 4 \text{ Nm}$
($18 \pm 3 \text{ ft-lb}$)

12
Install and secure the charge air pipe hose clamp.

13
Install the support bracket/wiring harness clamp bolts (VN) or fan ring support bracket (VHD) and secure.

14
Install the power cable, fuse and wiring to the relays and secure.

15
Install the main ground cable(s).

16
Install ground wiring from the electrical equipment connected directly to the batteries.

17
Secure with the battery terminal nut(s). $3.7 \pm 5.7 \text{ Nm}$
Torque = $3.7 \pm 5.7 \text{ Nm}$
($10 - 15 \text{ ft-lb}$)

3331-03-02-01 Preheater Element, Replacement

D7C Engine



DANGER

Before working on a vehicle, set the parking brakes, place the transmission in neutral, and block the wheels. Failure to do so can result in unexpected vehicle movement and can cause serious personal injury or death.



WARNING

HOT ENGINE! Keep clear of all moving parts or hot engine parts and/or fluids. A hot engine and /or fluids can cause burns.



CAUTION

If there are other ground cables connected to the battery (such as engine ECU's, satellite system, etc.), disconnect those grounds first, then remove the main battery ground cable. Electronic modules may be damaged when additional grounds are connected/disconnected without the main battery ground connected. Disconnect the main battery ground last.



CAUTION

Possible damage to electronic components. Turn the vehicle ignition switch OFF before disconnecting or connecting any electronic components. Failure to de-energize circuits may result in permanent damage to electronic components.



CAUTION

Use caution when working around the preheat elements. When active, the elements will heat to approximately 705°C (1300°F). Allow sufficient time for the elements to cool to avoid severe burns.

Removal

1
Turn the ignition key to the "OFF" position.

2
Disconnect ground wiring from the electrical equipment connected directly to the batteries, such as ECU's, satellite systems etc.

3
Disconnect the battery main ground cable(s).

4
Remove the power cable, fuse and wiring from relay. Note position for re-assembly.

5
Remove the relay from its mounting and remove from the vehicle.

6
Remove the charge air pipe hose clamp.

7
Remove the charge air piping mounting bolts at the fan ring and preheater and remove the vehicle.

8
Remove the ground wire from the preheater element book.

9
Remove the preheater element block from the intake manifold.

10
Clean the gasket surfaces.

Installation

11
Install new gasket between intake manifold and replacement preheater element block. Install the preheater element block. Install new gasket on the intake side of the preheater element block.

12
Install the ground wire from the preheater element block.

13
Install the charge air piping. Secure the mounting bolts at the preheat element block. 24 ± 4 Nm
(18 ± 3 ft-lb)
Torque =
24 ± 4 Nm
(18 ± 3 ft-lb)
secure the mounting bolts at the fan ring.

14
Install and secure the charge air pipe hose clamp.

15
Install the relay and secure.

16
Install the power cable, fuse and wiring to the relay and secure.

17
Install the main ground cable(s).

18
Install ground wiring from electrical equipment connected directly to the batteries.

19
Secure with the battery terminal nut(s). 3.7 ± 5.7 Nm
(10 –15 ft-lb)
Torque =
3.7 ± 5.7 Nm
(10 –15 ft-lb)

3211-03-02-03 Alternator, Replacement (Ad- justable Mount)

DANGER

Before working on a vehicle, set the parking brakes, place the transmission in neutral, and block the wheels. Failure to do so can result in unexpected vehicle movement and can cause serious personal injury or death.

WARNING

HOT ENGINE! Keep clear of all moving parts or hot engine parts and/or fluids. A hot engine and /or fluids can cause burns.

CAUTION

If there are other ground cables connected to the battery (such as engine ECU's, satellite system, etc.), disconnect those grounds first, then remove the main battery ground cable. Electronic modules may be damaged when additional grounds are connected/disconnected without the main battery ground connected. Disconnect the main battery ground last.

CAUTION

In vehicles with a Supplemental Restraint System (SRS), turn the ignition switch ON before connecting the battery. Failure to do so may result in permanent damage to the instrument cluster or other electronic circuits in the vehicle. This applies only to vehicles with SRS and Cummins or Detroit Diesel engines. Check for fault codes after repairs are complete.

CAUTION

Possible damage to electronic components. Turn the vehicle ignition switch OFF before disconnecting or connecting any electronic components. Failure to de-energize circuits may result in permanent damage to electronic components.

Note: In some installations, the replacement of the alternator may be aided by the removal of splash shields.

Removal

- 1 Turn the ignition key to the "OFF" position.
- 2 Disconnect ground wiring from the electrical equipment connected directly to the batteries, such as ECU's, satellite systems, etc.
- 3 Disconnect the main ground cable(s).
- 4 Disconnect all alternator wiring. Note wire positions to aid in installation.
- 5 Loosen the alternator mounting bolts.
- 6 Loosen the tensioner bolt as needed and remove the belt from the pulley.
- 7 Remove the alternator mounting bolts and remove the alternator from the vehicle.

Installation

- 8 If necessary, remove the pulley from the alternator and install it on the replacement alternator. Torque = 109 ± 11 Nm (80 ± 8 ft-lb)
 109 ± 11 Nm
(80 ± 8 ft-lb)
- 9 Install the replacement alternator and tensioner. Leave bolts loose enough to adjust belt tension.

10

Adjust the tensioner as needed to achieve a belt tension of 111 Nm (150 ft-lb) for a new belt or 73 Nm (100 ft-lb) for a used belt. Use Belt Tension Gauge J-23600-B, or equivalent tool, to check tension.

11

Tighten the alternator adjustment mounting bolt. 48 ± 8 Nm
(34 ± 6 ft-lb)
Torque =
48 ± 8 Nm
(34 ± 6 ft-lb)

12

Tighten the alternator pivot mounting bolt. 88 ± 7 Nm
(65 ± 5 ft-lb)
Torque =
88 ± 7 Nm
(65 ± 5 ft-lb)

13

Connect all alternator wiring. Torque =

BATTERY TERMINAL	6.5 ± 0.5 Nm (58 ± 5 in-lb)
GROUND TERMINAL	6.2 ± 0.5 Nm (55 ± 5 in-lb)
"I" TERMINAL	2.3 ± 0.5 Nm (20 ± 5 in-lb)
"R" TERMINAL	2.3 ± 0.5 Nm (20 ± 5 in-lb)

14

If the vehicle is equipped with a Supplemental Restraint System (SRS) and a Cummins or Detroit Diesel engine, turn the ignition switch to the "ON" position. If not, leave the ignition switch in the "OFF" position.

15

Connect the main ground cable(s). Turn ignition switch back to "OFF" if necessary.

16

Connect ground wiring from the electrical equipment connected directly to the batteries

17

Tighten all battery cable connections. 13 ± 20 Nm
(10 –15 ft-lb)
Torque =
13 ± 20 Nm
(10 –15 ft-lb)

3211-03-02-04**Alternator, Replacement (Fixed Mount)****DANGER**

Before working on a vehicle, set the parking brakes, place the transmission in neutral, and block the wheels. Failure to do so can result in unexpected vehicle movement and can cause serious personal injury or death.

**WARNING**

HOT ENGINE! Keep clear of all moving parts or hot engine parts and/or fluids. A hot engine and /or fluids can cause burns.

**CAUTION**

If there are other ground cables connected to the battery (such as engine ECU's, satellite system, etc.), disconnect those grounds first, then remove the main battery ground cable. Electronic modules may be damaged when additional grounds are connected/disconnected without the main battery ground connected. Disconnect the main battery ground last.

**CAUTION**

In vehicles with a Supplemental Restraint System (SRS), turn the ignition switch ON before connecting the battery. Failure to do so may result in permanent damage to the instrument cluster or other electronic circuits in the vehicle. This applies only to vehicles with SRS and Cummins or Detroit Diesel engines. Check for fault codes after repairs are complete.



CAUTION

Possible damage to electronic components. Turn the vehicle ignition switch OFF before disconnecting or connecting any electronic components. Failure to de-energize circuits may result in permanent damage to electronic components.

Note: In some installations, the replacement of the alternator may be aided by the removal of splash shields.

Removal

1
Turn the ignition key to the "OFF" position.

2
Disconnect the ground wiring electrical equipment connected directly to the batteries, such as ECU's, satellite systems, etc.

3
Disconnect the main ground cable(s).

4
Disconnect all alternator wiring. Note wire positions to aid in installation.

5
Use fan belt tensioner tool J-44392, or equivalent tool, to release the pressure from the automatic belt tensioner and remove the belt from the alternator pulley.

6
Remove the alternator mounting bolts and remove the alternator from the vehicle.

Installation

7
If necessary, remove the pulley from the alternator and install it on the replacement alternator. Torque = 109 ± 11 Nm (80 ± 8 ft-lb)
 109 ± 11 Nm
(80 ± 8 ft-lb)

8
Install the replacement alternator and tighten the mounting bolts. Torque = 88 ± 7 Nm (65 ± 5 ft-lb)
 88 ± 7 Nm
(65 ± 5 ft-lb)

9
Use fan belt tensioner tool J-44392, or equivalent tool, to release the pressure from the automatic belt tensioner and install the belt onto the alternator pulley.

10
Connect all alternator wiring. Torque =

BATTERY TERMINAL	6.5 ± 0.5 Nm (58 ± 5 in-lb)
GROUND TERMINAL	6.2 ± 0.5 Nm (55 ± 5 in-lb)
"I" TERMINAL	2.3 ± 0.5 Nm (20 ± 5 in-lb)
"R" TERMINAL	2.3 ± 0.5 Nm (20 ± 5 in-lb)

11
If the vehicle is equipped with a Supplemental Restraint System (SRS) and a Cummins or Detroit Diesel engine, turn the ignition switch to the "ON" position. If not, leave the ignition in the "OFF" position.

12
Connect the main ground cable(s). Turn ignition switch back to "OFF" if necessary.

13
Connect ground wiring from the electrical equipment connected directly to the batteries.

14
Tighten all battery cable connections. Torque = 3.7 ± 5.7 Nm ($10 - 15$ ft-lb)
 3.7 ± 5.7 Nm
($10 - 15$ ft-lb)

Feedback

One of our objectives is that workshop personnel should have access to correct and appropriate service manuals where it concerns fault tracing, repairs and maintenance of Volvo trucks.
In order to maintain the high standards of our literature, your opinions and experience when using this manual would be greatly appreciated.
If you have any comments or suggestions, make a copy of this page, write down your comments and send them to us, either via telefax or mailing directly to the address listed below.

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From

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Comments/proposals

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Concerns Service Manual:

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