Phase
2

Trade of Motor Mechanic

Module 2

Unit 4

Alternator/Circuit

Produced by

SOLAS

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CDX Global

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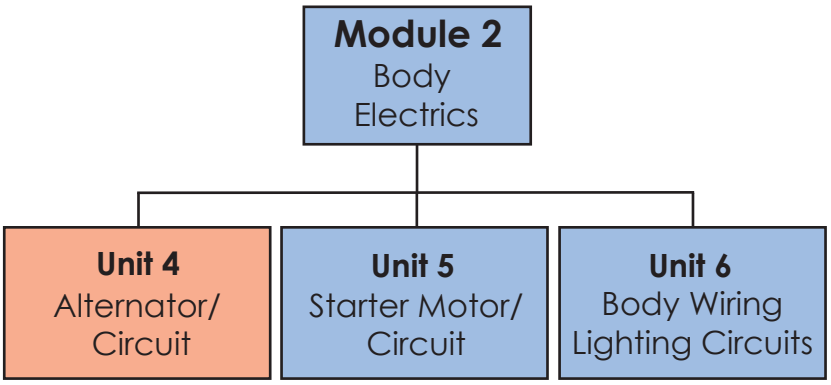
Table of Contents

Introduction

There are six Units in this Module. In Theory 1 we cover Units 1, 2 and 3 which focuses on the basics of electricity. In Theory 2 we cover Units 4, 5 and 6 which focuses on the fundamental electrical circuits in the vehicle.



In this Unit four it describes the basic function and operation of the alternator and related circuits. You will receive instruction on how Locate and calculate the total current load of the primary, constant, long time, short time consumers of a vehicle and compare these to the manufacturer's specifications. Draw a basic schematic block diagram of the charging system and describe the basic function of an alternator.

With the use of a voltmeter be able to carry out a basic charging system test underload and off load.

Carry out circuit continuity tests on the alternator wiring. Carry out a voltage drop test on the alternator output lead. Remove and examine for wear alternator brushes and check the voltage regulator assembly. Check and replace the alternator belt. Be made aware of the danger of working with running alternator pulleys, belts etc. and the damage to vehicle electronic circuit components by arcing/ voltage peaks. Health and safety issues related to this unit will also be covered.

Unit Objective

By the end of this unit each apprentice will be able to:

- State the primary, constant, long time and short time electrical loads in the petrol/diesel engined automobile
- Locate and calculate the total current load of the primary, constant, long time, short time consumers of a vehicle and compare to the manufacturer's alternator specification
- Draw a basic schematic block diagram of the charging system (no alternator internal details)
- Describe the basic function of an alternator
- Describe Faraday's conclusion on electromagnetic induction
- Use a Voltmeter across the battery to carry out a basic charging system 'voltage level underload/voltage level off load test'
- Carry out circuit continuity tests on the alternator wiring of an operational vehicle
- Carry out a voltage drop test on the alternator output lead of an operational vehicle
- Remove, examine for wear and replace alternator brushes and voltage regulator assembly
- Check/replace an alternator drive belt

1.0 Hazards when Working Charging Systems

Key Learning Points

- Danger of working with running alternator pulleys, belts etc. Damage to vehicle electronic circuit components by arcing/voltage peaks

1.1 Hazards when Working Charging Systems

It is important to be aware of the potential hazards when working an automotive charging system. Remember that the alternator is driven by a belt and the belt rotates very quickly when the engine is operating. Always ensure that you are aware of this when doing any work around the alternator when the engine is running (for instance when checking alternator output). If anything you are wearing (including long hair gets caught in the rotating belt and other components you could severely hurt yourself or even potentially be killed. There is also a danger of electronic components getting damaged from voltage peaks/arcing.

2.0 Electrical Loads

Key Learning Points

- Constant loads e.g. ignition and fuel systems; long time loads; lights etc.; short time, starter, glow plugs etc.

2.1 Alternator Loads

Current Demand and Flow

If you have an alternator that can produce 120 amps of current (max) and the total current demand from the electrical accessories (including the battery) is only 20 amps, the alternator will only produce the necessary current (20 amps) to maintain the target voltage (which is determined by the alternator's internal voltage regulator). Remember that the alternator monitors the electrical system's voltage. If the voltage starts to fall below the target voltage (approximately 13.8 volts depending on the alternator's design), the alternator produces more current to keep the voltage up. When the demand for current is low, the full current capacity of the alternator is not used/produced (a 120 amp alternator does not continuously produce 120 amps unless there is a sufficient current draw). See the following diagram for some of examples of current demand. Refer to automotive technical manuals for more vehicle specific data.

Short-term load		*Permanent load*	
Per interior lamp	5W	Ignition	20W
Per flasher lamp (indicator)	21W	Electric fuel pump	50–70W
2 stop lamps	42W	Electronic petrol injection	70–100W
Per reversing lamp	21W	*Long-term load*	
Horn	25–40 W	Car radio approx	10–100W
Fog lamp	21W	Per licence-plate lamp	10W
Rear-window wiper	30–65W	Side lamp	5W
Wipers.	80W	2 headlamp dip lights	110W
Cigarette lighter	100W	2 headlamp main beams	120W
Rear-window heater	120W	Per rear tail light	5W

For diesel cars	
Heater plugs for starting (per cylinder)	100W
Power windows	150W
Electric radiator fan	200W
Starter	800–3000w

Electrical Consumer Loads

Today, most systems in the average vehicle such as power windows, power seats and power door locks are electrically powered. Typical values for headlights would approx 10 amps and heater plugs would be in excess of 50 amps. Initial current draw from the starter on a diesel engine is approximately 120 amps. Refer to automotive technical manuals for more vehicle specific data

One constant and growing challenge is the average load of the automotive electrical system, which is increasing and is beginning to exceed the limits of the 14-volt alternator, which typically generates 150 amps to 180 amps. Increases the cable harness size, power distribution box complexity, the relay and switch rating also increases.

3.0 Current Load Manufacturers Data

Key Learning Points

- Source manufacturer's data for current quantity/load value of electrical systems
- Calculation of the total current requirement of S.I. /I.C. automotive Vehicle

Practical Task

This is a practical task. Please refer to your instructor for additional information, which is available from the automotive technical manuals.

4.0 Diagram of the Charging System

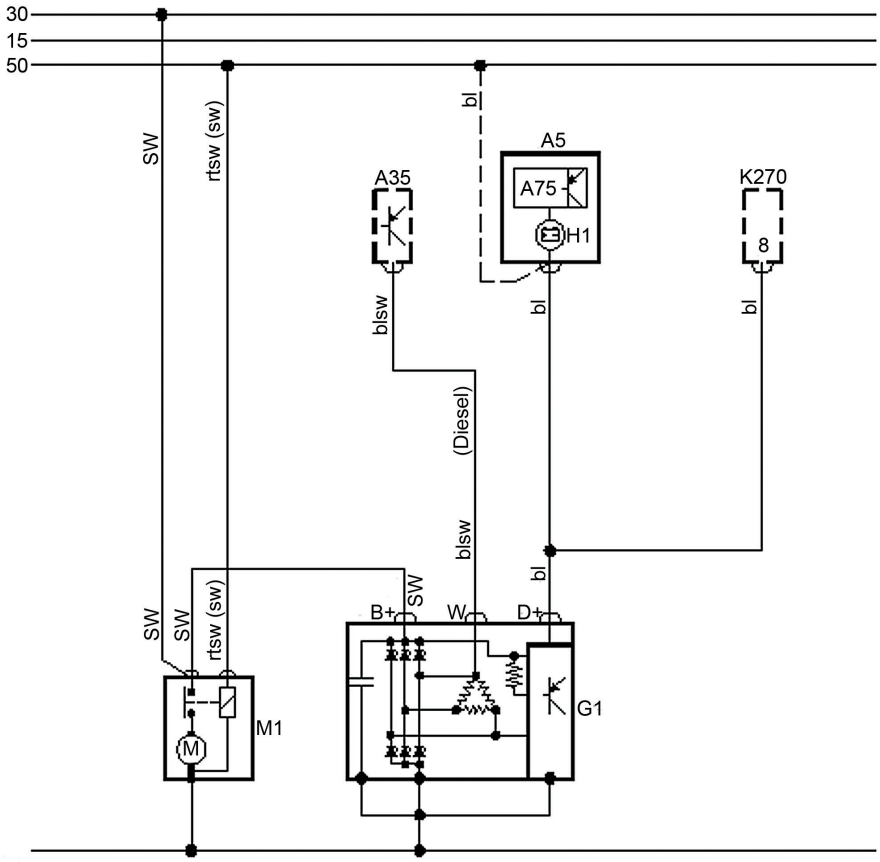
Key Learning Points

- Schematic block diagram drawn to industry standard i.e. correct terminal and component identification code/ number/symbols used.

4.1 Schematic Block Diagrams

See the following page.

Alternator/Starter Motor- Wiring Circuit



Manufacturer:
Volkswagen®
Engine code:
AFN
Tuned for:
Model: Passat (96-00) D TDI
Output: 81 (110) 4150
Year: 1996-00
Reproduced courtesy of Autodata® Limited, unit 5 priors way, maidenhead, England.

Component
G1 Alternator
H1 Alternator warning lamp
31 Battery -
30 Batter +
A35 Engine control module
K270 Engine running circuits relay
15 Ignition switch - ignition ON
50 Ignition switch - start signal
A35 Instrument panel
A75 Instrumentation control module
M1 Starter motor

Wiring colour Codes

bl	blue
gn	green
rs	pink
ws	white
x	braided cable
br	brown
gr	grey
rt	red
hbl	light blue
y	high tension
el	cream
nf	neutral
sw	black
hgn	light green
z	non-cable connection
ge	yellow
og	orange
vi	violet
rbr	maroon

Refer to Automotive technical manuals for these diagrams

5.0 Function of the Alternator

Key Learning Points

- Alternator converting mechanical energy into electrical energy Generating current to meet load demand

5.1 Charging System

The charging system provides electrical energy for all of the electrical components on the vehicle.

The main parts of the charging system include, the battery, the alternator; the voltage regulator, which is usually integral to the alternator; a charge warning, or indicator light; and wiring that completes the circuits.

The battery provides the electrical energy for starting. Then, once the engine is running, the alternator supplies all electrical components of the vehicle. It also charges the battery to replace the energy used to start the engine. The voltage regulator prevents over-charging.

Concepts

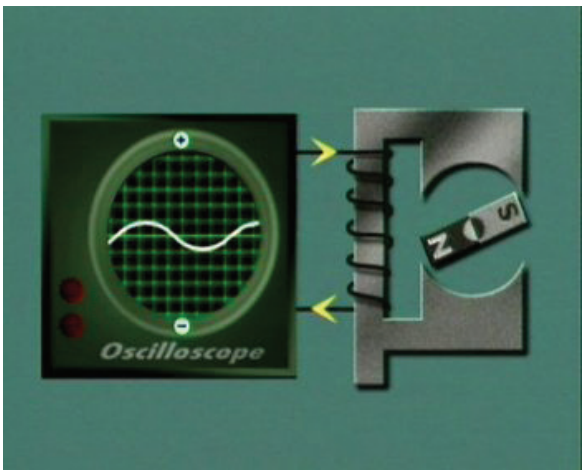
It is important to understand that the generator creates an electric current, but does not create electric charge, which is already present in the conductive wire of its windings. It is somewhat analogous to a water pump, which creates a flow of water but does not create the water itself.

Voltage regulation is the ability of a system to provide near constant voltage over a wide range of load conditions.

5.2 Alternator Principles

The alternator is universally used in automotive applications. It converts mechanical energy into electrical energy, by electro-magnetic induction.

In a simple version, a bar magnet rotates in an iron yoke which concentrates the magnetic field. A coil of wire is wound around the stem of the yoke. As the magnet turns, voltage is induced in the coil, producing a current flow. When the North Pole is up and South is down, voltage is induced in the coil, producing current flow in one direction.

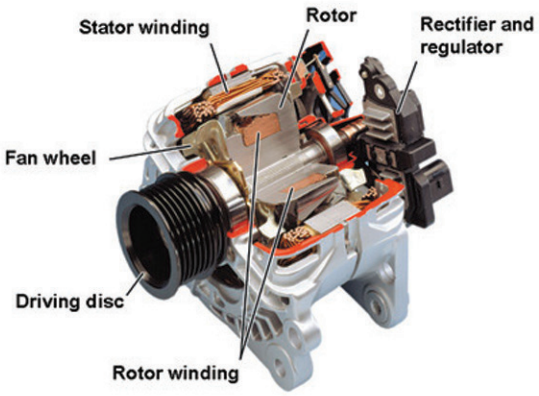


As the magnet rotates and the position of the poles reverses, the polarity of the voltage reverses too and as a result, so does the direction of current flow.

Current that changes direction in this way is called alternating current, or AC. The change in direction occurs once for every complete revolution of the magnet.

Theory of Operation

Alternators generate electricity by the same principle as DC generators. When magnetic field lines cut across a conductor, a current is induced in the conductor. In general, an alternator has a stationary part (stator) and a rotating part (rotor). The stator contains windings of conductors and the rotor contains a moving magnetic field. The field cuts across the conductors, generating an electrical current, as the mechanical input causes the rotor to turn.



Source: Volkswagen®

The rotor magnetic field may be produced by induction (in a "brushless" generator), by permanent magnets, or by a rotor winding energized with direct current through slip rings and brushes. Automotive alternators invariably use brushes and slip rings, which allows control of the alternator generated voltage by varying the current in the rotor field winding. Permanent magnet machines avoid the loss due to magnetizing current in the rotor but are restricted in size owing to the cost of the magnet material. Since the permanent magnet field is constant, the terminal voltage varies directly with the speed of the generator. Brushless AC generators are usually larger machines than those used in automotive applications.

6.0 Faraday's Conclusion on Electromagnetic Induction

Key Learning Points

- Faraday's conclusion of EMF induction
- Fleming's right-hand rule (dynamo rule)

6.1 Faraday's Laws and Fleming's Right Hand Rule

Faradays Law

Any change in the magnetic environment of a coil of wire will cause a voltage (emf - electro motive force) to be 'induced' in the coil. No matter how the change is produced, a voltage will be generated. The change could be produced by changing the magnetic field strength, moving a magnet toward or away from the coil, moving the coil into or out of the magnetic field, rotating the coil relative to the magnet, etc.

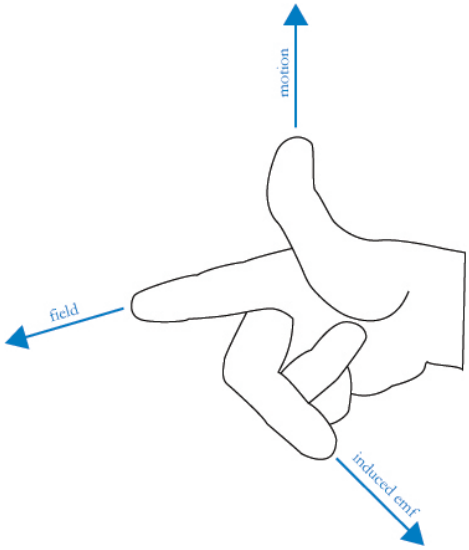
Electro Motive Force - EMF

The difference of potential produced by an electrical source to drive a current through an external electrical circuit. The SI unit of emf is the volt.

Fleming's Right Hand Rule

Also known as the Generator Rule this is a way of determining the direction of the induced emf of a conductor moving in a magnetic field.

The thumb, the first and the second fingers on the right hand are held so that they are at right angles to each other.



If the first finger points in the direction of the magnetic field and the thumb in the direction of the motion of the conductor then the second finger will point in the direction of the induced emf in the conductor.

7.0 Testing a Battery Using a Voltmeter

Key Learning Points

- Correct use of the multimeter
- Charging system basic test; appropriate current loading used, voltage levels compared to manufacturer's specifications

7.1 Checking a Charging System

Practical Task

This is a practical task. Please refer to your instructor for additional information, which is available from the automotive technical manuals.

Preparation and Safety

Objective

Check a charging system.

Safety Check

- Make sure the bonnet stay rod is secure.
- Always make sure that you wear the appropriate personal protection equipment before starting the work. It is very easy to hurt yourself even when the most exhaustive protection measures are taken.
- Always make sure that your work area/environment is as safe as you can make it. Do not use damaged, broken or worn out service department equipment.
- Always follow any manufacturer's personal safety instructions to prevent damage to the vehicle you are servicing.

- Make sure that you understand and observe all legislative and personal safety procedures when carrying out the following tasks. If you are unsure of what these are, ask your instructor.

Points to Note

- DVOM stands for Digital Volt Ohm Meter.
- DVOMs come in many forms. Always follow the manufacturer's instructions in the use of the meter, or you could seriously damage the meter or the electrical circuit.

Step-by-Step Instruction

1. *Set up the meter for a voltage check*: Prepare the Digital volt ohm meter or DVOM for testing for voltage by inserting the black probe lead into the "common" input port and the red probe lead into the "Volt/Ohms" input port.
2. *Check the meter function* Turn the rotary dial until you have selected the mode for "Volts DC". The reading on the meter should now be at Zero. Some meters will automatically sense the correct voltage range when a voltage is detected. On other meters you will have to set the voltage range before using the meter.
3. *Check the battery voltage* Place the Black probe onto the Negative terminal of the battery, which will be marked with a Minus sign and place the Red probe onto the Positive terminal of the battery. This is marked with a Plus sign. Note the voltage reading from the battery.
4. *Check the voltage after starting* Start the engine. The voltage now shown on the display should be within the 13.7 to 14.4 Volt range when the engine is running at approximately 2000RPM.
5. *Check the voltage with additional load* With the engine still running, turn the headlights of the vehicle ON and note any differences in the reading. The meter may "fluctuate" a little before settling down. Provided it retains a voltage reading within the original specifications, the voltage regulation side of the charging system is operating correctly.

7.2 Using a DVOM to Measure Voltages

Preparation and Safety

Objective

Use a DVOM to measure voltage.

Safety Check

- Make sure the bonnet stay rod is secure.
- Always make sure that you wear the appropriate personal protection equipment before starting the job. It is very easy to hurt yourself even when the most exhaustive protection measures are taken.
- Always make sure that your work area/environment is as safe as you can make it. Do not use damaged, broken or worn out workshop equipment.
- Always follow any manufacturer's personal safety instructions to prevent damage to the vehicle you are servicing.
- Make sure that you understand and observe all legislative and personal safety procedures when carrying out the following tasks. If you are unsure of what these are, ask your Instructor.

Points to Note

- DVOM stands for Digital Volt Ohm Meter.
- DVOMs come in many forms. Always follow the specific manufacturer's instructions in the use of the meter, or serious damage either to the meter and/or to the electrical circuit could result.

Step-by-Step Instruction

1. *Set up the meter for a voltage check*: Prepare the Digital Volt Ohm Meter or DVOM for testing voltage by inserting the black probe lead into the "common" input port and the red probe lead into the "Volt/Ohms" input port.

2. *Check the meter function*: Turn the rotary dial until you have selected the mode for "Volts DC". The reading on the meter should now be at Zero. Some meters will automatically sense the correct voltage range when a voltage is detected. On other meters you will have to set the voltage range before using the meter.

3. *Check the voltage of a battery*: Place the Black probe onto the Negative terminal of the battery, which will be marked with a Minus sign and place the Red probe onto the Positive terminal of the battery, which is marked with a Plus sign.

4. *Interpret the results*: Note the voltage reading from this 12-volt battery. If the battery is fully charged the meter will give a reading that is 12.6 volts or more. If it is NOT fully charged the reading will be less than 12.6 volts.

8.0 Circuit Continuity Testing on the Alternator Wiring

Key Learning Points

- Continuity test; cables removed correctly and secured free from shorts etc., voltage action/level compared to available system voltage

Practical Task

This is a practical task. Please refer to your instructor for additional information, which is available from the automotive technical manuals.

9.0 Voltage Drop Testing on the Alternator Output Lead

Key Learning Points

- Voltage drop test; voltmeter between either end of 'under load' connector, voltage drop compared and interpreted to manufacturer's recommended tolerances

Practical Task

This is a practical task. Please refer to your instructor for additional information, which is available from the automotive technical manuals.

9.1 Voltage Drop Test

A voltage drop test is the only effective way to find excessive resistance in high amperage circuits. It's a quick and easy test that doesn't require any disassembly and will quickly show you whether or not you've got a good connection or not.

To do a voltage drop test, you create a load in the circuit that's being tested i.e. output from alternator. Then you use a digital, volt and ohm meter (DVOM) to measure the voltage drop across the live connection while it is under the load. Voltage always follows the path of least resistance, so if the circuit or connection being tested has too much resistance some of the voltage will flow through the DVOM and create a voltage reading.

10.0 Alternator Brush and Voltage Regulator Examination

Key Learning Points

- Alternator brushes examined for wear/length/spring action etc., unit refitted/reassembled correctly, system tested for operation

Practical Task

This is a practical task. Please refer to your instructor for additional information, which is available from the automotive technical manuals.

11.0 Servicing an Alternator Drive Belt

Key Learning Points

- Alternator drive belt removed/examined for cracks etc., refitted/replaced as necessary, manual/automatic belt tension system examined/set to manufacturer's recommendations

Practical Task

This is a practical task. Please refer to your instructor for additional information, which is available from the automotive technical manuals.

11.1 Inspecting & Adjusting an Engine Drive Belt

Preparation and Safety

Objective

Inspect and manually adjust engine accessory drive belts.

Personal Safety

Whenever you perform a task in the workshop you must use personal protective clothing and equipment that is appropriate for the task and which conforms to your local safety regulations and policies. Among other items, this may include:

- Work clothing - such as coveralls and steel-capped footwear
- Eye protection - such as safety glasses and face masks
- Ear protection - such as earmuffs and earplugs
- Hand protection – such as rubber gloves and barrier cream
- Respiratory equipment – such as face masks etc.

Safety Check

- Never try to inspect belts with the engine running.
- Always make sure that you wear the appropriate personal protection equipment before starting the job. It is very easy to hurt yourself even when the most exhaustive protection measures are taken.
- Always make sure that your work area/environment is as safe as you can make it. Do not use damaged, broken or worn out workshop equipment.
- Always follow the manufacturer's personal safety instructions to prevent damage to the vehicle you are working on
- Make sure that you understand and observe all legislative and personal safety procedures when carrying out the following tasks. If you are unsure of what these are, ask your instructor.

Points to Note

There are two types of drive belts:

V-type: A V-type belt has a profile that looks like the photo below and sits inside a deep v-shaped groove in the pulley wheel. The sides of the V-belt contact the sides of the groove

Serpentine: Serpentine-type belts have a flat profile with a number of grooves running lengthwise along the belt. These grooves are the exact reverse of the grooves in the outer edge of the pulley wheels; they increase the contact surface area, as well as prevent the belt from slipping off the wheel as it rotates.

Conditions to Look for on a Drive Belt

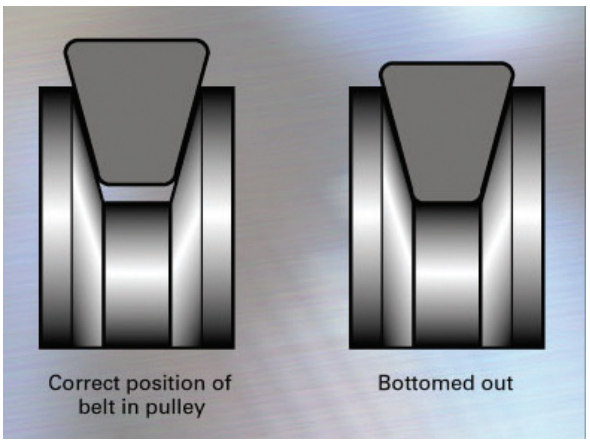
Cracked: Cracks in a belt indicate that it is getting ready to fail and should be replaced.

Oil-soaked: A belt that has been soaked in oil will not grip properly on the pulleys and will slip. If the oil contamination is severe enough for this to happen, replace the belt.

Glazed: Glazing is shininess on the surface of the belt, which comes in contact with the pulley. If the belt is worn, the glazing could be caused by the belt "bottoming-out" (see below) and it should be replaced. If it is not old and worn, glazing could simply indicate that the belt is not tight enough. Tightening the belt may be all that is necessary, depending on how bad the glazing is.

Torn: Torn or split belts are unserviceable and should be replaced immediately.

'Bottoming-out': When a V-type belt becomes worn, the bottom of the V-shape may contact the bottom of the groove in the pulley, preventing the sides of the belt from making good contact with the sides of the pulley groove. This reduced friction causes slippage; a belt worn enough to bottom-out should be replaced.



Manual Belt Tension versus Automatic Belt Tension

Many vehicles require the technician to manually adjust the tension on the belt. Other vehicles have an automatic spring tensioning system. Depending on the system used on the particular vehicle, you should always follow the manufacturer's service instructions.

There are a number of different types of tension gauges. Follow the operating instructions on the tool. If you don't have a tension gauge, you can estimate the tension by pushing the belt inwards with your hand. If it's correctly tensioned, you should be able to deflect the belt about 1.25 centimetres for each 30cm of belt (half an inch for each foot).

Step-by-Step Instruction

1. *Inspect and check belt condition*: Twist the belt so that you can see the underside of the 'V' shape or the ribs on a Serpentine belt. Look for signs of wear and damage. You may need a flashlight to see these clearly. A cracked or glazed or torn belt will need to be replaced.

2. *Check tension*: Check the belt tension by attaching the tension gauge to the longest belt span and pulling it to measure the tension. Compare your reading to the specifications in the vehicle workshop manual.

3. *Choose the correct tools*: Select the correct wrench to loosen the tension adjustment fastener. This is usually on the Alternator mounting or on a separate idler pulley wheel. You will also need a pry bar, which is a metal bar you can use as a lever to apply tension on the belt.

4. *Adjust belt tension*: Loosen the adjustment fastener, then wedge the pry bar between the alternator and a strong part of the engine and pull in the direction that will apply tension to the belt. Tighten the adjustment fastener.

5. *Check tension again and readjust if necessary*: Check the tension again with the gauge and if necessary loosen the fastener and adjust the belt again until it is at the correct tension for the vehicle.

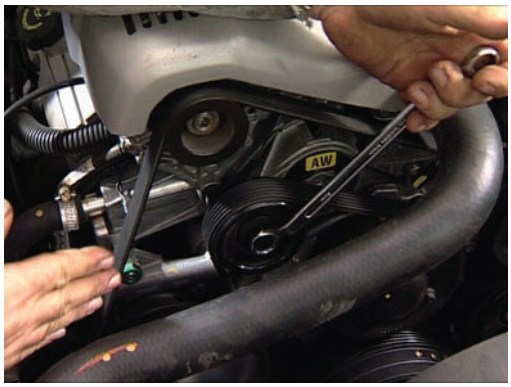
6. *Start the engine*: Start the engine and observe the belt to make sure it is properly seated and operating correctly. Stop the engine again and recheck the tension.

11.2 Replacing an Engine Drive Belt

Preparation and Safety

Objective

Remove and replace an engine accessory drive belt.



Personal Safety

Whenever you perform a task in the workshop you must use personal protective clothing and equipment that is appropriate for the task and which conforms to your local safety regulations and policies. Among other items, this may include:

- Work clothing - such as coveralls and steel-capped footwear
- Eye protection - such as safety glasses and face masks
- Ear protection - such as earmuffs and earplugs
- Hand protection – such as rubber gloves and barrier cream
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Safety Check

- Never try to inspect belts with the engine running.
- Always make sure that you wear the appropriate personal protection equipment before starting the job. It is very easy to hurt yourself even when the most exhaustive protection measures are taken.
- Always make sure that your work area/environment is as safe as you can make it. Do not use damaged, broken or worn out workshop equipment.
- Always follow any manufacturer's instructions in relation to personal safety and prevention of damage to the vehicle you are working on.
- Make sure that you understand and observe all legislative and personal safety procedures when carrying out the following tasks. If you are unsure of what these are, ask your instructor.

There are two types of drive belts:

V-type

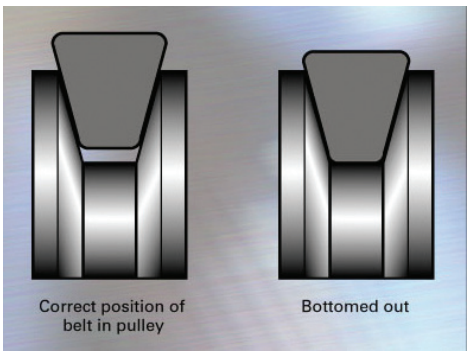
A V-type belt has a profile that looks like the photo below and sits inside a deep v-shaped groove in the pulley wheel. The sides of the V-belt contact the sides of the groove

Serpentine

Serpentine-type belts have a flat profile with a number of grooves running lengthwise along the belt. These grooves are the exact reverse of the grooves in the outer edge of the pulley wheels; they increase the contact surface area, as well as prevent the belt from slipping off the wheel as it rotates.

'Bottoming-out'

When a V-type belt becomes very worn, the bottom of the V-shape may contact the bottom of the groove in the pulley, preventing the sides of the belt from making good contact with the sides of the pulley groove. This reduced friction causes slippage; a belt worn enough to bottom-out should be replaced.



Many vehicles require the technician to manually adjust the tension on the belt. Other vehicles have an automatic spring tensioning system. Depending on the system used on the particular vehicle, you should always follow the manufacturer's service instructions.

There are a number of different types of tension gauges. Follow the operating instructions on the tool. If you don't have a tension gauge, you can estimate the tension by pushing the belt inwards with your hand. If it's correctly tensioned you should be able to deflect the belt about 1.25 centimetres for each 30cm of belt.

Step-by-Step Instruction

1. *Loosen tension and remove belt*: Locate the adjustment fastener and loosen it. This is usually on the alternator mounting or on a separate pulley wheel. Move the adjusting mechanism in far enough to allow you to remove the belt. Some vehicles use an automatic spring tension system. In that case, pull the tensioning device back so that you can remove the belt.

2. *Inspect drive & driven pulleys*: Check the drive and pulley wheels. Look for cracks and other forms of damage. Check that there is no sideways movement indicating worn bearings and spin the pulley wheels by hand to check that the bearings are rotating freely.

3. *Select correct replacement belt*: Obtain the correct size and type of replacement belt specified in the workshop manual and compare it with the belt you have just removed. They should be very similar, although the old belt may have stretched in use.

4. *Install V- belt*: Install the new belt, making sure that it is properly seated in the V-shape groove, or the multiple grooves in the pulley, depending on its construction.

5. *Install Serpentine belt*: If the belt is a Serpentine type, then make sure that it is the correct width and squarely aligned in the pulley grooves. If it is not correctly aligned, the belt will be thrown off the pulley wheels.

6. *Correctly tension new belt*: Tension the belt using a wrench and a pry bar and then check it with a tension gauge. With automatic tension systems, gently allow this to apply the tension to the belt.

7. *Start the engine*: Start the engine and observe the belt to make sure that it is properly seated and operating correctly. Stop the engine again and recheck the tension.

Self Assessment

Q1: How many phases does a typical automotive alternator have? (Tick one box only)

- ❑ 1. Three
- ❑ 2. Two
- ❑ 3. One
- ❑ 4. None

Q2: The main purpose of the rotor in an alternator is to: (Tick one box only)

- ❑ 1. Spin very fast
- ❑ 2. Support end bearings
- ❑ 3. Produce a rotating magnetic field
- ❑ 4. Complete the brush circuit

Q3: The stator in an alternator is made up of: (Tick one box only)

- ❑ 1. 3 phase windings and end frames
- ❑ 2. Laminated core and bearings
- ❑ 3. Laminated iron core and 3 phase windings
- ❑ 4. Laminated core and permanent magnets

Q4: On an alternator the main purpose of the end frames is to: (Tick one box only)

- ❑ 1. Support the bearings
- ❑ 2. Prevent dust intrusion
- ❑ 3. Stop vibration
- ❑ 4. Insulate the alternator

Q5: How many diodes does a basic automotive alternator rectifier have? (Tick one box only)

- ❑ 1. 6 positive and 6 negative
- ❑ 2. 1 positive and 1 negative
- ❑ 3. 3 positive and 3 negative
- ❑ 4. None

Q6: On an alternator the main purpose of the cooling fan is to: (Tick one box only)

- ❑ 1. Support the pulley
- ❑ 2. Provide a cooling air flow
- ❑ 3. Support the fan belt
- ❑ 4. Drive the alternator

Q7: The device that converts the AC stator output to DC at the B+ terminal on the alternator is? (Tick one box only)

- ❑ 1. Rectifier
- ❑ 2. Rotor
- ❑ 3. Stator
- ❑ 4. Regulator

Q8: What is the minimum number of diodes in the alternator 3 phase rectifier? (Tick one box only)

- ❑ 1. Nine
- ❑ 2. Three
- ❑ 3. Six
- ❑ 4. One

Q9: The main purpose of the regulator is to: (Tick one box only)

- ❑ 1. Regulate the rectifier diodes
- ❑ 2. Regulate alternator output by controlling field current
- ❑ 3. Regulate alternator speed
- ❑ 4. Regulate the field diodes

Q10: The maximum current output of an alternator is regulated by? (Tick one box only)

- ❑ 1. The rectifier diodes
- ❑ 2. The regulator
- ❑ 3. The field diodes
- ❑ 4. The design of the stator winding

Q11: When the engine is not running, current to operate electrical circuits is supplied by the: (Tick one box only)

- ❑ 1. Alternator
- ❑ 2. Battery
- ❑ 3. Starter
- ❑ 4. Light switch

Q12: The alternator converts: (Tick one box only)

- ❑ 1. Mechanical energy into electrical energy
- ❑ 2. Mechanical energy into chemical energy
- ❑ 3. Electrical energy into chemical energy
- ❑ 4. Electrical energy into mechanical energy

Q13: In a very simple alternator, what does the rotating magnet induce in the stationary windings? (Tick one box only)

- ❑ 1. A direct current flow
- ❑ 2. An alternating current flow
- ❑ 3. A variable current flow
- ❑ 4. A constant current flow

Task Sheets

Checking a Charging System

Preparation and Safety

Objective

Check a charging system.

Personal Safety

Whenever you perform a task in the workshop you must use personal protective clothing and equipment that is appropriate for the task and which conforms to your local safety regulations and policies. Among other items, this may include:

- Work clothing - such as coveralls and steel-capped footwear
- Eye protection - such as safety glasses and face masks
- Ear protection - such as earmuffs and earplugs
- Hand protection – such as rubber gloves and barrier cream
- Respiratory equipment – such as face masks etc.

Safety Check

- Make sure the bonnet rod is secure.
- Always make sure that you wear the appropriate personal protection equipment before starting the job. It is very easy to hurt yourself even when the most exhaustive protection measures are taken.
- Always make sure that your work area/environment is as safe as you can make it. Do not use damaged, broken or worn out service department equipment.
- Always follow any manufacturer's personal safety instructions to prevent damage to the vehicle you are servicing.
- Make sure that you understand and observe all legislative and personal safety procedures when carrying out the following tasks. If you are unsure of what these are, ask your instructor.

Points to Note

- DVOM stands for Digital Volt Ohm Meter.
- DVOMs come in many forms. Always follow the manufacturer's instructions in the use of the meter, or you could seriously damage the meter or the electrical circuit.

Step-by-step Instruction

1. *Set up the meter for a voltage check:* Prepare the Digital volt ohm meter or DVOM for testing for voltage by inserting the black probe lead into the "common" input port and the red probe lead into the "Volt/Ohms" input port.

2. *Check the meter function*: Turn the rotary dial until you have selected the mode for "Volts DC". The reading on the meter should now be at Zero. Some meters will automatically sense the correct voltage range when a voltage is detected. On other meters you will have to set the voltage range before using the meter.

3. *Check the battery voltage*: Place the Black probe onto the Negative terminal of the battery, which will be marked with a Minus sign and place the Red probe onto the Positive terminal of the battery. This is marked with a Plus sign. Note the voltage reading from the battery.

4. *Check the voltage after starting:* Start the engine. The voltage now shown on the display should be within the 13.7 to 14.4 Volt range when the engine is running at approximately 2000RPM.

5. *Check the voltage with additional load:* With the engine still running, turn the headlights of the vehicle ON and note any differences in the reading. The meter may "fluctuate" a little before settling down. Provided it retains a voltage reading within the original specifications, the voltage regulation side of the charging system is operating correctly.

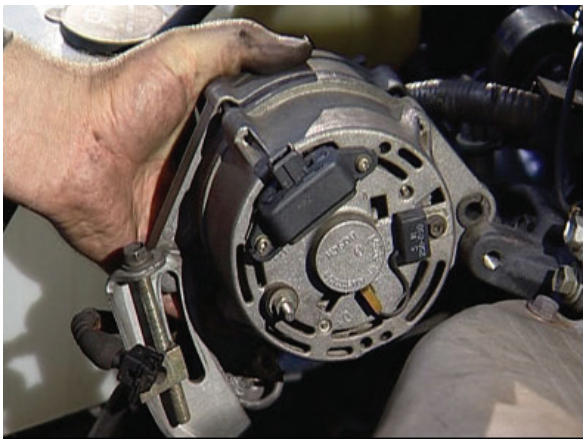
6. *Carry out load test:* Place an ammeter in series by clamping it over the cable, in accordance with equipment manufacturer's instructions, between the AC generator output terminal and the positive battery terminal and connect a carbon pile regulator across the battery terminals. Operate the engine at about 2500 RPM and adjust the carbon pile to obtain maximum current output. This reading should be compared against the alternator's rated output. Normally, readings more than 10 amperes out of specifications indicate a problem.

Removing & Replacing an Alternator

Preparation and Safety

Objective

Safely remove and replace a vehicle's alternator.



Personal Safety

Whenever you perform a task in the workshop you must use personal protective clothing and equipment that is appropriate for the task and which conforms to your local safety regulations and policies. Among other items, this may include:

- Work clothing - such as coveralls and steel-capped footwear
- Eye protection - such as safety glasses and face masks
- Ear protection - such as earmuffs and earplugs
- Hand protection – such as rubber gloves and barrier cream
- Respiratory equipment – such as face masks etc.

Safety Check

- When disconnecting a battery always disconnect the negative terminal first.
- When reattaching a battery always attach the negative terminal last.

- Do not wear jewellery that may cause a short circuit with an electrical connection.
- Alternators produce heat when operating. Make sure you test the temperature of the alternator before you handle it.
- Always wear protective clothing and the appropriate safety equipment.
- Make sure that you understand and observe all legislative and personal safety procedures when carrying out the following tasks. If you are unsure of what these are, ask your instructor.

Points to Note

- Vehicle alternators are designed for use only on a negative earth system.
- The alternator must not be operated with the battery disconnected or the terminals at the back of the alternator disconnected.
- Do not short circuit the alternator by connecting the battery connection directly to the engine or vehicle body.
- Even though most vehicle electrical systems are described as being 12 volt, they operate at between 13.8 to 14.2 volts. If the system is not operating at this value the alternator or the voltage regulator are faulty
- When removing electrical wires and connections make sure you refit the securing fastener to its thread so it doesn't get lost.

Step-by-step Instruction

1. *Disconnect the battery terminal:* Locate the battery and its negative terminal. Loosen the terminal clamp and remove the terminal from the battery post. Store the terminal so it cannot come in contact with the battery post while you are working on the vehicle.
2. *Loosen the drive belt:* Fit fender covers to the vehicle. Loosen the drive belt and remove it from the alternator pulley. Check the condition of the belt to see if it is still serviceable.

3. *Remove electrical connections: L*ocate the electrical connections at the rear of the alternator and note their positions. Loosen any securing fasteners or covers and remove terminals one at a time. In some cases the electrical terminals are encased in a plug.

4. *Remove the alternator:* Loosen the securing fasteners that hold the alternator to its mounting bracket making sure that the alternator is supported. Next remove the fasteners completely and then remove the alternator from the engine bay.

5. *Refit the alternator:* Locate the alternator in the mounting bracket and, while still supporting the alternator, loosely fit the securing fasteners that hold the alternator to its mounting bracket.

6. *Attach electrical connections*: Refit the electrical wires to their correct terminals referring to the manufacturers manual to check the connections are correct. Once all the wires are fitted check the security of any fastening device.

7. *Refit drive belt:* Fit the drive belt over the alternator drive pulley and using the correct tools, adjust the belt to the correct tension. The belt should not be over tightened to prevent damage in service.

8. *8. Refit the battery terminal:* Locate the battery terminal connection and re attach it to the negative post of the battery. Make sure that the fastener is tight. Replace any battery post covers.

9. *Test alternator output:* Turn the ignition switch to the ON position and make sure the charge light on the vehicle dash panel is illuminated. Start the engine and with a DVOM set to read DC voltage, place the positive probe onto the battery positive and the negative probe to the battery negative. Raise the engine speed to 2000 rpm and check that the DVOM is reading 13.8 to 14.2 volts.

10. *Clean up:* Remove the fender covers and return any tools used to their correct place.

Inspecting & Adjusting an Engine Drive Belt

Preparation and Safety

Objective

Inspect and manually adjust engine accessory drive belts.

Personal Safety

Whenever you perform a task in the workshop you must use personal protective clothing and equipment that is appropriate for the task and which conforms to your local safety regulations and policies. Among other items, this may include:

- Work clothing - such as coveralls and steel-capped footwear
- Eye protection - such as safety glasses and face masks
- Ear protection - such as earmuffs and earplugs
- Hand protection – such as rubber gloves and barrier cream
- Respiratory equipment – such as face masks etc.

Safety Check

- Never try to inspect belts with the engine running.
- Always make sure that you wear the appropriate personal protection equipment before starting the job. It is very easy to hurt yourself even when the most exhaustive protection measures are taken.
- Always make sure that your work area/environment is as safe as you can make it. Do not use damaged, broken or worn out workshop equipment.
- Always follow the manufacturer's personal safety instructions to prevent damage to the vehicle you are working on
- Make sure that you understand and observe all legislative and personal safety procedures when carrying out the following tasks. If you are unsure of what these are, ask your instructor.

Points to Note

There are two types of drive belts:

V-type: A V-type belt has a profile that looks like the photo below and sits inside a deep v-shaped groove in the pulley wheel. The sides of the V-belt contact the sides of the groove

Serpentine: Serpentine-type belts have a flat profile with a number of grooves running lengthwise along the belt. These grooves are the exact reverse of the grooves in the outer edge of the pulley wheels; they increase the contact surface area, as well as prevent the belt from slipping off the wheel as it rotates.

Conditions to Look for on a Drive Belt

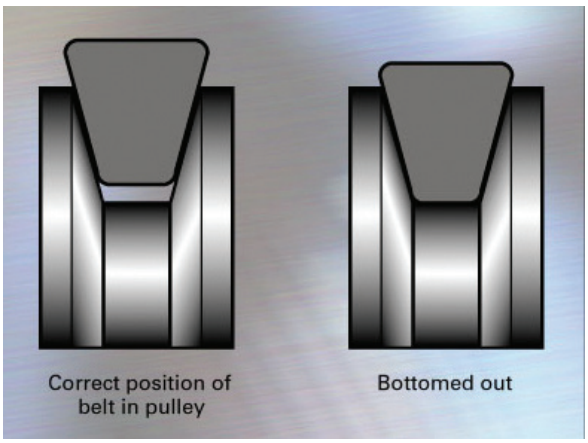
Cracked: Cracks in a belt indicate that it is getting ready to fail and should be replaced.

Oil-soaked: A belt that has been soaked in oil will not grip properly on the pulleys and will slip. If the oil contamination is severe enough for this to happen, replace the belt.

Glazed: Glazing is shininess on the surface of the belt, which comes in contact with the pulley. If the belt is worn, the glazing could be caused by the belt "bottoming-out" (see below) and it should be replaced. If it is not old and worn, glazing could simply indicate that the belt is not tight enough. Tightening the belt may be all that is necessary, depending on how bad the glazing is.

Torn: Torn or split belts are unserviceable and should be replaced immediately.

'Bottoming-out': When a V-type belt becomes worn, the bottom of the V-shape may contact the bottom of the groove in the pulley, preventing the sides of the belt from making good contact with the sides of the pulley groove. This reduced friction causes slippage; a belt worn enough to bottom-out should be replaced.



Manual Belt Tension versus Automatic Belt Tension

Many vehicles require the technician to manually adjust the tension on the belt. Other vehicles have an automatic spring tensioning system. Depending on the system used on the particular vehicle, you should always follow the manufacturer's service instructions.

There are a number of different types of tension gauges. Follow the operating instructions on the tool. If you don't have a tension gauge, you can estimate the tension by pushing the belt inwards with your hand. If it's correctly tensioned, you should be able to deflect the belt about 1.25 centimetres for each 30cm of belt (half an inch for each foot).

Step-by-Step Instruction

1. *Inspect and check belt condition*: Twist the belt so that you can see the underside of the 'V' shape or the ribs on a Serpentine belt. Look for signs of wear and damage. You may need a flashlight to see these clearly. A cracked or glazed or torn belt will need to be replaced.

2. *Check tension*: Check the belt tension by attaching the tension gauge to the longest belt span and pulling it to measure the tension. Compare your reading to the specifications in the vehicle workshop manual.

3. *Choose the correct tools*: Select the correct wrench to loosen the tension adjustment fastener. This is usually on the Alternator mounting or on a separate idler pulley wheel. You will also need a pry bar, which is a metal bar you can use as a lever to apply tension on the belt.

4. *Adjust belt tension*: Loosen the adjustment fastener, then wedge the pry bar between the alternator and a strong part of the engine and pull in the direction that will apply tension to the belt. Tighten the adjustment fastener.

5. *Check tension again and readjust if necessary*: Check the tension again with the gauge and if necessary loosen the fastener and adjust the belt again until it is at the correct tension for the vehicle.

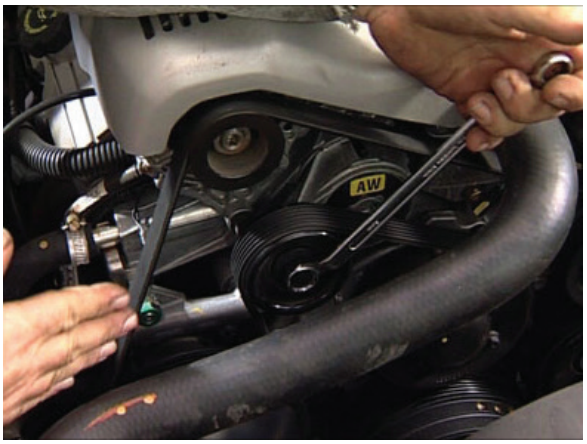
6. *Start the engine*: Start the engine and observe the belt to make sure it is properly seated and operating correctly. Stop the engine again and recheck the tension.

Replacing an Engine Drive Belt

Preparation and Safety

Objective

Remove and replace an engine accessory drive belt.



Personal Safety

Whenever you perform a task in the workshop you must use personal protective clothing and equipment that is appropriate for the task and which conforms to your local safety regulations and policies. Among other items, this may include:

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- Respiratory equipment – such as face masks etc.

Safety Check

- Never try to inspect belts with the engine running.
- Always make sure that you wear the appropriate personal protection equipment before starting the job. It is very easy to hurt yourself even when the most exhaustive protection measures are taken.
- Always make sure that your work area/environment is as safe as you can make it. Do not use damaged, broken or worn out workshop equipment.
- Always follow any manufacturer's instructions in relation to personal safety and prevention of damage to the vehicle you are working on.

- Make sure that you understand and observe all legislative and personal safety procedures when carrying out the following tasks. If you are unsure of what these are, ask your instructor.

There are two types of drive belts:

V-type

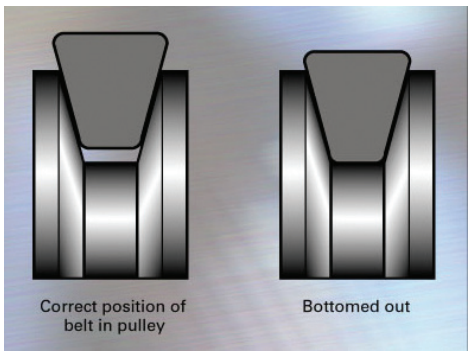
A V-type belt has a profile that looks like the photo below and sits inside a deep v-shaped groove in the pulley wheel. The sides of the V-belt contact the sides of the groove

Serpentine

Serpentine-type belts have a flat profile with a number of grooves running lengthwise along the belt. These grooves are the exact reverse of the grooves in the outer edge of the pulley wheels; they increase the contact surface area, as well as prevent the belt from slipping off the wheel as it rotates.

'Bottoming-out'

When a V-type belt becomes very worn, the bottom of the V-shape may contact the bottom of the groove in the pulley, preventing the sides of the belt from making good contact with the sides of the pulley groove. This reduced friction causes slippage; a belt worn enough to bottom-out should be replaced.



Many vehicles require the technician to manually adjust the tension on the belt. Other vehicles have an automatic spring tensioning system. Depending on the system used on the particular vehicle, you should always follow the manufacturer's service instructions.

There are a number of different types of tension gauges. Follow the operating instructions on the tool. If you don't have a tension gauge, you can estimate the tension by pushing the belt inwards with your hand. If it's correctly tensioned you should be able to deflect the belt about 1.25 centimetres for each 30cm of belt.

Step-by-Step Instruction

1. *Loosen tension and remove belt*: Locate the adjustment fastener and loosen it. This is usually on the alternator mounting or on a separate pulley wheel. Move the adjusting mechanism in far enough to allow you to remove the belt. Some vehicles use an automatic spring tension system. In that case, pull the tensioning device back so that you can remove the belt.

2. *Inspect drive & driven pulleys*: Check the drive and pulley wheels. Look for cracks and other forms of damage. Check that there is no sideways movement indicating worn bearings and spin the pulley wheels by hand to check that the bearings are rotating freely.

3. *Select correct replacement belt*: Obtain the correct size and type of replacement belt specified in the workshop manual and compare it with the belt you have just removed. They should be very similar, although the old belt may have stretched in use.

4. *Install V- belt*: Install the new belt, making sure that it is properly seated in the V-shape groove, or the multiple grooves in the pulley, depending on its construction.

5. *Install Serpentine belt*: If the belt is a Serpentine type, then make sure that it is the correct width and squarely aligned in the pulley grooves. If it is not correctly aligned, the belt will be thrown off the pulley wheels.

6. *Correctly tension new belt*: Tension the belt using a wrench and a pry bar and then check it with a tension gauge. With automatic tension systems, gently allow this to apply the tension to the belt.

7. *Start the engine*: Start the engine and observe the belt to make sure that it is properly seated and operating correctly. Stop the engine again and re check the tension.

Suggested Further Reading

- Advanced Automotive Diagnosis. Tom Denton. ISBN 0340741236
- Automobile Electrical and Electronic Systems (3rd Edition). Tom Denton. ISBN 0750662190
- Automotive Mechanics (10th Edition). William H. Crouse and Donald L. Anglin. ISBN 0028009436
- Bosch Automotive Electrics Automotive Electronics: Systems and Components (4th Edition). Robert Bosch. ISBN 0837610508
- Bosch Automotive Handbook (6th Edition). Robert Bosch. ISBN 1860584748
- Bosch Automotive Technology Technical Instruction booklet series (numerous titles)
- Hillier's Fundamentals of Motor Vehicle Technology: Book One (5th Edition). V.A.W. Hillier and Peter Coombes. ISBN 0748780823
- Hillier's Fundamentals of Motor Vehicle Technology: Book Two (5th Edition). V.A.W. Hillier and Peter Coombes. ISBN 0748780998
- Modern Automotive Technology. James E. Duffy. ISBN 1566376106
- Motor Vehicle Craft Studies - Principles. F.K. Sully. ISBN 040800133X
- National Car Test (NCT) Manual (Department of Transport, Vehicle Testers Manual - DoT VTM). Department of Transport
- Transmission, Chassis and Related Systems (Vehicle Maintenance and Repair Series: Level 3) (3rd Edition) John Whipp and Roy Brooks. ISBN 186152806X
- Vehicle and Engine Technology (2nd Edition). Heinz Heisler. ISBN 0340691867
- http://www.cdxglobal.com/
- http://auto.howstuffworks.com/
- http://www.autoshop101.com/
- http://www.cdxetextbook.com/
- Automotive Encyclopedia and Text Book Resource (CD version of e-textbook), Available from your instructor.

Notes

SOLAS

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