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SERVICE
INFORMATION

MOTORSERVICE

Secondary-air system
Design, components, trouble-shooting

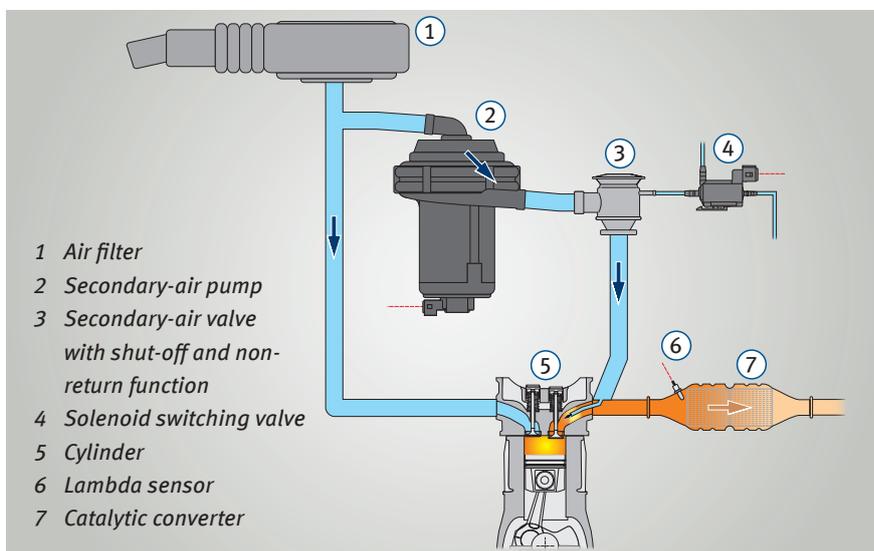| Vehicle	Product
All vehicles with spark-ignition engine and secondary-air system	Secondary-air valve, secondary-air pump, solenoid switching valve

With spark-ignition engines, the greatest pollution occurs on cold starting. Secondary-air systems have been successfully employed to reduce such cold starting emissions.

A "rich mixture" ($\lambda < 1$), i.e. a mixture with excess fuel, is required for starting a cold spark-ignition engine.
Until the catalytic converter reaches operating temperature and Lambda control action starts to take effect, large quantities of carbon monoxide and unburnt hydrocarbons are produced.
To reduce the level of these pollutants, ambient air with a high oxygen content ("secondary-air") is injected into the exhaust manifold directly downstream of the exhaust valves during the cold starting phase. This results in post-oxidation ("afterburning") of the pollutants to form carbon dioxide and water.
The heat generated in this process additionally warms the catalytic converter and speeds up the onset of Lambda control action.

1 Air filter
2 Secondary-air pump
3 Secondary-air valve with shut-off and non-return function
4 Solenoid switching valve
5 Cylinder
6 Lambda sensor
7 Catalytic converter

Block diagram of secondary-air system (pneumatically actuated)

Secondary-air valve and secondary-air pump in BMW E46 (highlighted)

The right of changes and deviating pictures is reserved. For assignment and replacement parts, refer to the current catalogues, TecDoc CD or respective systems based on TecDoc.

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Secondary-air system components

The secondary-air pump draws in ambient air and injects it into the exhaust manifold downstream of the exhaust valves.
There is a separate integrated air filter if the air is not drawn in from the intake system but rather directly from the engine compartment.

Secondary-air valves are fitted between the secondary-air pump and the exhaust manifold.
Use is made of different versions.
The secondary-air non-return valve stops exhaust gas, condensate or pressure peaks in the exhaust system (e.g. misfiring) causing damage to the secondary-air pump.
The secondary-air shut-off valve ensures that secondary-air is only routed to the exhaust manifold in the cold starting phase.
Secondary-air valves are either actuated by a vacuum controlled by a solenoid switching valve or open in response to the pressure of the secondary-air pump.

With more recent generations, the shut-off and non-return functions are combined in one single "secondary-air valve".

The latest development is the solenoid secondary-air valve, featuring shorter opening and closing times than pneumatically actuated valves.
Thanks to higher actuating forces, this type of valve is less susceptible to clogging by soot or dirt.

Solenoid secondary-air valves may be equipped with an integrated pressure sensor for on-board diagnosis (OBD) monitoring.

Various 1st and 2nd generation secondary-air pumps

Vacuum-controlled valve with shut-off and non-return function (since approx. 1995) and solenoid switching valve

Pressure-controlled valve with shut-off and non-return function (since approx. 1998)

Solenoid Secondary-air valve (since approx. 2007)

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Secondary-air system and OBD

European EOBD only checks the electrical connection of the secondary-air system, but not its action.

The electrical connection is monitored for short to earth, short to power supply and open circuit.

The American on-board diagnosis version OBD II monitors the action of the secondary-air system:

As a check, the secondary-air pump is switched on once per driving cycle with the engine warm.

The Lambda sensor thus registers excess oxygen. The probe signal is compared to the set values in the control unit.

Possible OBD fault codes:
• P0410 Malfunction
• P0411 Insufficient quantity

An open secondary-air valve can lead to biasing of the Lambda probe signal as being "too lean".

This may result in the following fault message:
• Lambda sensor – Control limit reached

Trouble-shooting advice

The most common problems relating to secondary-air systems are:
• Noisy secondary-air pump
• No secondary-air pump operation

In most of these cases, a defective non-return valve or incorrect actuation of the secondary-air valve has led to exhaust gas condensate ingressing into and damaging the secondary-air pump.

The standard remedy is then just to replace the secondary-air pump, which often leads to the same problem occurring again in a short space of time.

The malfunctioning of just one component in the secondary-air system can result in damage to other components.

If problems arise it is therefore essential to check all the components.

Checking: Secondary-air pump

With a cold engine, the secondary-air pump must be heard to start up for max. 90 seconds after starting.

For component checking with a warm engine, the secondary-air pump connector can be unplugged and supplied with vehicle electrical system voltage.

Note:
The secondary-air pump is not designed for continuous operation, i.e. it should not be allowed to run for more than 90 seconds.

• The secondary-air pump must be replaced if it does not run or makes a scraping, whistling or scratching noise during operation.
• In such cases, the other secondary-air system components should also be checked.
• Check for contamination of the engine air filter.
  If the secondary-air is drawn in directly from the engine compartment rather than from the intake system, the separate air filter fitted upstream of the secondary-air pump may be clogged.

Corrosive exhaust gas condensate in the drive motor of a secondary-air pump

View of the corroded inlet of a secondary-air pump

Liquid exhaust gas condensate from a secondary-air pump

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Checking: Secondary-air valve

Following removal, operation of a vacuum-controlled secondary-air valve can be checked using a vacuum hand pump:

- The secondary-air valve must be replaced if it does not open on applying vacuum.
- If the secondary-air valve opens on applying vacuum, the solenoid actuation valve (solenoid switching valve) and the vacuum hoses must be checked.
- The secondary-air valve diaphragm is leaking if the vacuum applied with the vacuum hand pump decreases.
- Deposits on the side facing the secondary-air pump (check with finger, refer to adjacent illustration) are an indication of non-return valve leakage.
- To check, unfasten the connecting hose between the secondary-air pump and secondary-air valve.

In this case, the secondary-air pump may already have suffered damage: Check and if necessary replace the secondary-air pump.

Checking: Solenoid switching valve

- The solenoid switching valve is energised for the duration of secondary-air injection (cold starting phase).
  The solenoid switching valve is open when energised and closed when de-energised.
- A vacuum hand pump can be used to check for opening and leakage.
- During secondary-air injection, electrical system voltage must be applied to the connector of the solenoid switching valve. If not, an electrical fault has occurred which must be localised with the help of a circuit diagram.

Checking: Vacuum system

- The control vacuum may not be attained in the event of leakage.
- A manometer, e.g. on the vacuum hand pump, can be used to check the control vacuum at the solenoid switching valve and on vacuum-controlled secondary-air valves.
- If a minimum control vacuum of 390 mbar (corresponding to an absolute pressure of 610 mbar) is not attained, the entire vacuum system must be examined for leaks and the damaged component replaced.

Possible sources of trouble:

- Defective hoses (porous, rodent attack)
- Leaking connections at pneumatic valves
- Leaking non-return valves/vacuum accumulator
- Defective/porous diaphragms or seals at pneumatic actuators
- Leakage in intake manifold
- Defective vacuum pump

Checking: Connection to exhaust manifold

Exhaust gas may be heard to escape at the connecting flange if a seal is defective.

- Check the connection for leaks and re-seal if necessary.
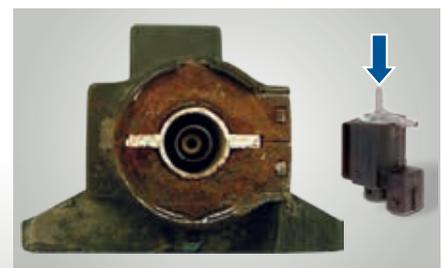

*Open secondary-air valve
left: damage caused by exhaust gas condensate, right: as-new condition*

Checking a secondary-air valve with a vacuum hand pump

*Finger check at secondary-air valve in BMW 520i (highlighted)
If deposits are found on this end, the non-return valve is leaking and must be replaced.*

Corroded solenoid switching valve (open)

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