


**Automotive Engines Theory and Servicing**  
Ninth Edition

**Automotive Engines**  
Theory and Servicing

Ninth Edition  
James D. Halderman



**Chapter 19**  
Emission Control  
Devices Operation and  
Diagnosis

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**OBJECTIVES (1 OF 4)**

**19.1** Explain exhaust gas recirculation systems.

**19.2** Discuss OBD-II EGR monitoring strategies, diagnosing a defective EGR system, and EGR trouble codes.

**19.3** Discuss crankcase ventilation, PCV system diagnosis, and PCV-related trouble codes.

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**OBJECTIVES (2 OF 4)**

**19.4** Explain the secondary air-injection system and its diagnosis.

**19.5** Explain the purpose and function of catalytic converters, their diagnosis, and guidelines to replace them.

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### OBJECTIVES (3 OF 4)

**19.6** Explain evaporative emission control system, and compare enhanced evaporative control systems and nonenhanced evaporative control systems.

**19.7** Discuss the leak detection pump system and onboard refueling vapor recovery.

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### OBJECTIVES (4 OF 4)

**19.8** Discuss the diagnosis of the EVAP system and state inspection EVAP tests.

**19.9** Describe evaporative system monitors and typical EVAP monitors.

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### SMOG

- What is smog?
- What are the emissions that are controlled?

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**FIGURE 19–1** Notice the red-brown haze which is often over many major cities. This haze is the result of oxides or nitrogen in the atmosphere.



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## EXHAUST GAS RECIRCULATION SYSTEMS (1 OF 2)

- Exhaust gas recirculation (EGR) is an emission control system that lowers the amount of nitrogen oxides (NOx) formed during combustion.
  - In the presence of sunlight, NOx reacts with hydrocarbons in the atmosphere to form ozone (O3) or photochemical smog, an air pollutant.
- NOx Formation
- Controlling NOx

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## EXHAUST GAS RECIRCULATION SYSTEMS (2 OF 2)

- EGR System Operation
- EGR Benefits
- Positive and Negative Backpressure EGR Valves
- Computer-controlled EGR Systems
- EGR Valve Position Sensors
- Digital EGR Valves
- Linear EGR

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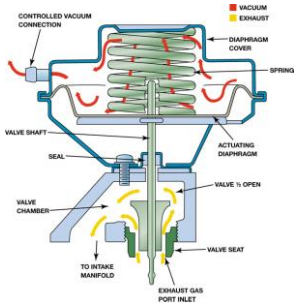
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**FIGURE 19-2** When the EGR valve opens, the exhaust gases flow through the valve and into passages in the intake manifold.



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## OBD-II EGR MONITORING STRATEGIES (1 OF 2)

- U.S. EPA began requiring OBD-II systems in all passenger cars and most light-duty trucks.
  - These systems include emissions system monitors that alert the driver and the technician if an emissions system is malfunctioning.
  - The OBD-II system performs this test by opening and closing the EGR valve.

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## OBD-II EGR MONITORING STRATEGIES (2 OF 2)

- The PCM monitors an EGR function sensor for a change in signal voltage.
- If the EGR system fails, a diagnostic trouble code (DTC) is set.
- If the system fails two consecutive times, the malfunction indicator light (MIL) is lit.

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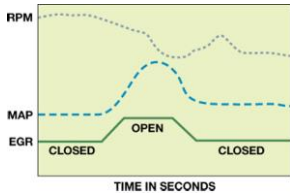
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**FIGURE 19-9** An OBD-II active test. The PCM opens the EGR valve and then monitors the MAP sensor and/or engine speed (RPM) to verify that it meets acceptable values.



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### DIAGNOSING A DEFECTIVE EGR (1 OF 3)

- If the EGR valve is not opening or the flow of the exhaust gas is restricted, then the following symptoms are likely.
  - Detonation (spark knock or ping) during acceleration or during cruise (steady-speed driving)
  - Excessive oxides of nitrogen (NOx) exhaust emissions

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### DIAGNOSING A DEFECTIVE EGR (2 OF 3)

- If the EGR valve is stuck open or partially open, then the following symptoms are likely.
  - Rough idle or frequent stalling
  - Poor performance/low power, especially at low engine speed
- The first step in almost any diagnosis is to perform a thorough visual inspection.

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### DIAGNOSING A DEFECTIVE EGR (3 OF 3)

- To check for proper operation of a vacuum-operated EGR valve, follow these steps.
  - STEP 1 Check the vacuum diaphragm of the EGR valve to see if it can hold vacuum.
  - STEP 2 Apply vacuum from a hand-operated vacuum pump and check for proper operation.
  - STEP 3 Monitor engine vacuum drop.

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### EGR-RELATED OBD-II DIAGNOSTIC TROUBLE CODES

- P0400
- P0401
- P0402
- What are they and what are the possible causes?

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### CRANKCASE VENTILATION (1 OF 2)

- The problem of crankcase ventilation has existed since the beginning of the automobile, because no piston ring, new or old, can provide a perfect seal between the piston and the cylinder wall.
  - When an engine is running, the pressure of combustion forces the piston downward.

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## CRANKCASE VENTILATION (2 OF 2)

- This same pressure also forces gases and unburned fuel from the combustion chamber, past the piston rings, and into the crankcase.
- Blowby is the term used to describe when combustion gases are forced past the piston rings and into the crankcase.

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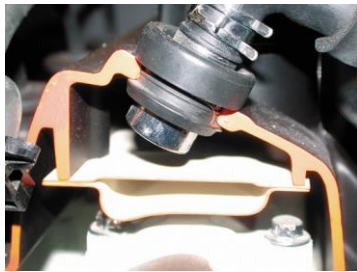
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FIGURE 19–11 A PCV valve in a cutaway valve cover, showing the baffles that prevent liquid oil from being drawn into the intake manifold.



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## PCV SYSTEM DIAGNOSIS

- Symptoms
- PCV System Performance Check
- Rattle Test
- The 3 x 5 Card Test
- Snap-back Test
- Crankcase Vacuum Test
- PCV Monitor

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FIGURE 19-16 Using a gauge that measures vacuum in units of inches of water to test the vacuum at the dipstick tube, being sure that the PCV system is capable of drawing a vacuum on the crankcase. Note that 28 inch of water equals 1 PSI, or about 2 inch of mercury (inch Hg) of vacuum.



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### PCV-RELATED DIAGNOSTIC TROUBLE CODE

- P0101
- P0505
- What are they and what are the possible causes?

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### SECONDARY AIR-INJECTION SYSTEM (1 OF 2)

- The secondary air-injection (SAI) system provides the air necessary for the oxidizing process either at the exhaust manifold or inside the catalytic converter.
  - Parts and Operation
  - Air Distribution Manifolds and Nozzles
  - Exhaust Check Valves

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## SECONDARY AIR-INJECTION SYSTEM (2 OF 2)

- Belt-driven Air Pumps
- Electric Motor-driven Air Pumps
- Symptoms
- Visual Inspection
- Four-gas Exhaust Analysis

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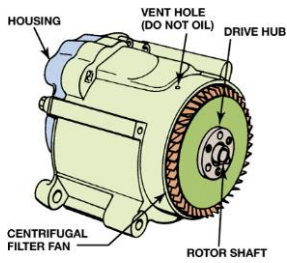
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**FIGURE 19-18** A typical belt-driven AIR pump. Air enters through the revolving fins behind the drive pulley. The fins act as an air filter because dirt is heavier than air and therefore the dirt is deflected off of the fins at the same time air is being drawn into the pump.



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## SECONDARY AIR-INJECTION SYSTEM DIAGNOSIS

- Symptoms
- Visual inspection
- Four-gas exhaust analysis
  - What are the four steps?

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## SAI-RELATED DIAGNOSTIC TROUBLE CODE

- P0410
- What is it and what are the possible causes?

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## CATALYTIC CONVERTERS (1 OF 3)

- A catalytic converter is an aftertreatment device used to reduce exhaust emissions outside of the engine.
- The catalytic converter uses a catalyst, which is a chemical that helps start a chemical reaction but does not enter into the chemical reaction.
  - The catalyst materials on the surface of the material inside the converter help create a chemical reaction.

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## CATALYTIC CONVERTERS (2 OF 3)

- The chemical reaction changes harmful exhaust emissions into nonharmful exhaust emissions.
- The converter converts harmful exhaust gases into water vapor (H<sub>2</sub>O) and carbon dioxide (CO<sub>2</sub>).
- Catalytic Converter Construction
- Catalytic Converter Operation
- Converter Light-off Temperature

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## CATALYTIC CONVERTERS (3 OF 3)

- Converter Usage
- OBD-II Catalytic Converter Performance
- Converter-damaging Conditions
  - Contamination
  - Excessive temperatures
  - Improper air-fuel mixtures

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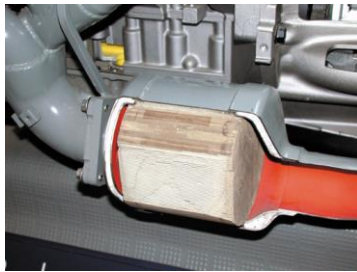
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**FIGURE 19–22** Most catalytic converters are located as close to the exhaust manifold as possible, as seen in this display of a Chevrolet Corvette.



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## DIAGNOSING CATALYTIC CONVERTERS

- The Tap Test
- Testing Backpressure With a Pressure Gauge
- Testing For Backpressure Using a Vacuum Gauge
- Testing a Catalytic Converter For Temperature Rise
- Catalytic Converter Efficiency Tests

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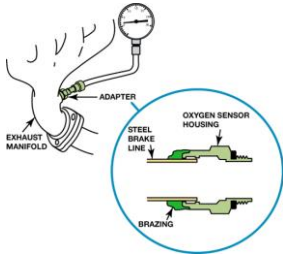
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**FIGURE 19–26** A back pressure tool can be made by using an oxygen sensor housing and epoxy or braze to hold the tube to the housing.



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### CATALYTIC CONVERTER REPLACEMENT GUIDELINES (1 OF 2)

- Because a catalytic converter is a major exhaust gas emission control device, the Environmental Protection Agency (EPA) has strict guidelines for its replacement, including:
  - If a converter is replaced on a vehicle with less than 80,000 miles or eight years, depending on the year of the vehicle, an original equipment catalytic converter must be used as a replacement.

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### CATALYTIC CONVERTER REPLACEMENT GUIDELINES (2 OF 2)

- The replacement converter must be of the same design as the original. If the original had an air pump fitting, so must the replacement.
- The old converter must be kept for possible inspection by the authorities for 60 days.
- A form must be completed and signed by both the vehicle owner and a representative from the service facility.

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## CATALYTIC CONVERTER-RELATED DIAGNOSTIC TROUBLE CODE

- P0420
- What is it and what are the possible causes?

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## EVAPORATIVE EMISSION CONTROL SYSTEM

- The purpose of the evaporative (EVAP) emission control system is to trap and hold gasoline vapors, also called volatile organic compounds, or VOCs.
  - The evaporative control system includes the charcoal canister, hoses, and valves.
  - These vapors are routed into a charcoal canister, then into the intake airflow where they are burned in the engine instead of being released into the atmosphere.

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**FIGURE 19–29** A capless system from a Ford Flex does not use a replaceable cap; instead, it has a spring-loaded closure.



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## NONENHANCED EVAPORATIVE CONTROL SYSTEMS

- What is a nonenhanced evaporative control system?
- Is it different than enhanced evaporative control systems?

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## ENHANCED AND NONENHANCED EVAPORATIVE CONTROL SYSTEM

- Prior to 1996, evaporative systems were referred to as nonenhanced evaporative (EVAP) control systems
  - Evaporative systems that had limited diagnostic capabilities
- Background
- Canister Vent Valve
- Canister Purge Valve

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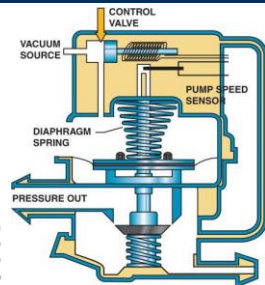
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## LEAK DETECTION PUMP SYSTEM

- Many vehicles use a leak detection pump (LDP) as part of the evaporative control system diagnosis equipment.

– Operation

FIGURE 19-33 A leak detection pump (LDP) used on some Chrysler vehicles to pressurize (slightly) the fuel system to check for leaks.



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## ONBOARD REFUELING VAPOR RECOVERY

- Purpose and Function
- Operation
  - The fuel tank is vented to the charcoal canister with air flowing into the filler tube, no vapors can escape to the atmosphere



FIGURE 19-34 A restricted fuel fill pipe shown on a vehicle with the interior removed.

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## STATE INSPECTION EVAP TESTS

- In some states, a periodic inspection and test of the fuel system are mandated along with a dynamometer test.
- How can the fuel tank, cap, fuel lines, canister, and other fuel system components be tested?

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## DIAGNOSING THE EVAP SYSTEM

- Symptoms
  - Poor fuel economy
  - Poor performance
- Locating leaks in the system
  - Smoke machine testing
  - Nitrogen gas pressurization

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FIGURE 19–35 Some vehicles will display a message if an evaporative control system leak is detected that could be the result of a loose gas cap.



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## EVAPORATIVE SYSTEM MONITOR

- OBD-II Requirements
  - Serious faults cause a blinking malfunction indicator lamp (MIL) or even an engine shutdown.
  - Less serious faults may simply store a code but not illuminate the MIL.
- Engine-off natural vacuum

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FIGURE 19–39 The fuel tank pressure sensor (black unit with three wires) looks like a MAP sensor and is usually located on top of the fuel pump module (white unit).



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### TYPICAL EVAP MONITOR (1 OF 3)

- The PCM will run the EVAP monitor when the following enable criteria are met.
  - Cold start
  - Barometric pressure (BARO) greater than 70 kPa (20.7 in. Hg or 10.2 PSI)
  - Intake air temperature (IAT) between 39°F and 86°F at engine start-up

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### TYPICAL EVAP MONITOR (2 OF 3)

- Engine coolant temperature (ECT) between 39°F and 86°F at engine start-up
- ECT and IAT within 39°F of each other at engine start-up
- Fuel level within 15% to 85%
- Throttle position (TP) sensor between 9% and 35%

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### TYPICAL EVAP MONITOR (3 OF 3)

- Running the Evap Monitor
  - Weak vacuum test (P0440—large leak)
  - Small leak test (P0442—small leak)
  - Excess vacuum test (P0446)

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## EVAP SYSTEM-RELATED DIAGNOSTIC TROUBLE CODES

- P0440
- P0442
- P0446
- What are they and what are the possible causes?

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## SUMMARY (1 OF 4)

- Recirculating 6% to 10% inert exhaust gases back into the intake system by the EGR system reduces peak temperature inside the combustion chamber and reduces NOx exhaust emissions.
  - OBD-II requires flow rate be tested and achieved by opening EGR valve and observing the reaction of the MAP sensor.

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## SUMMARY (2 OF 4)

- Positive crankcase ventilation systems use a valve or a fixed orifice to control and direct the fumes from the crankcase back into the intake system.
- The secondary air-injection (SAI) system forces air at low pressure into the exhaust to reduce CO and HC exhaust emissions.

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### SUMMARY (3 OF 4)

- A catalytic converter is an after treatment device that reduces exhaust emissions outside of the engine.
- The purpose of the evaporative emission control system is to reduce the release of volatile organic compounds into the atmosphere.

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### SUMMARY (4 OF 4)

- A carbon canister is used to trap and hold gasoline vapors until they can be purged and run into the engine to be burned.
- OBD-II regulation requires that the evaporative emission control system be checked for leakage and proper purge flow rates.
- External leaks can best be located by pressurizing the fuel system with low-pressure smoke.

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