Sub:Automotive Engineering
Sub code:10me844
8th sem

Introduction to IC Engine Components

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Objectives

- Explain the principles of internal combustion engine operation
- Identify internal combustion engine parts by name
- Describe the function of engine parts

Introduction

- First chapter of this gave a basic description of engine operation
- This chapter covers more in-depth information
- Later chapters cover firing orders, valve adjustment, oil pressure testing, etc.

Basic Engine Operation

- Simple reciprocating engine parts
  - Cylinder and piston
  - Connecting rod and crankshaft
- Spark-ignited internal combustion engine
  - Fuel must be an easily vaporized liquid or flammable gas
  - When air-fuel mixture compressed and burned it pushes the piston down in a cylinder
    - Turns a crankshaft that powers the vehicle

Basic Engine Operation (cont'd.)

- Flywheel
  - Bolted to rear of crankshaft
  - Weight blends power pulses into one continuous crankshaft output
- Cylinder head
  - Has intake valve port for each cylinder
    - Allows air and fuel into the cylinder
  - Exhaust valve port allows burned gases to flow out and is sealed by a poppet valve
  - Valve is opening controlled by the camshaft

Four-Stroke Engine Operation

- Piston travel
  - Upper limit is top dead center
  - Lower limit is bottom dead center
- Piston strokes
  - Intake
  - Compression
  - Power
  - Exhaust

Intake Stroke

- Characteristics
  - Gasoline will not burn unless mixed with air
    - Crankshaft turns and pulls the rod and piston down into the cylinder
    - Creates a low-pressure suction
    - Atmospheric pressure pushes air-fuel mixture
  - Stoichiometric mixture: 15:1 air to fuel ratio
  - Air volume: measured at standard temperature and pressure of 25˚ C at sea level
  - Individual cylinder volume
    - Engine displacement divided by cylinders

Intake Stroke (cont'd.)

- One mole of air is one ounce
  - One mole of nitrogen is 28 grams
  - One mole of oxygen is 32 grams
- One pound of air takes up 98 gallons
  - Slightly less than two 55-gallon drums
- Engine displacement measured in cubic centimeters or liters
  - Convert cubic centimeters to inches: divide by 16.4 and then divide the result by 1728

Compression Stroke

- Begins at BDC after intake stroke completes
  - Intake valve closes during compression stroke as the piston moves up in the cylinder
    - Compresses air-fuel mixture
  - Compressing the air-fuel mixture heats it
    - Makes it easier to burn

Power Stroke

- Air-fuel mixture becomes flammable as the piston approaches TDC
  - Ignition system produces a spark at the spark plug and ignites the air-fuel mixture
- Air-fuel mixture expands as it burns
  - Forces the piston down until it reaches BDC
  - Action of the piston turns the crankshaft
- Blowby causes pressure around the crankshaft

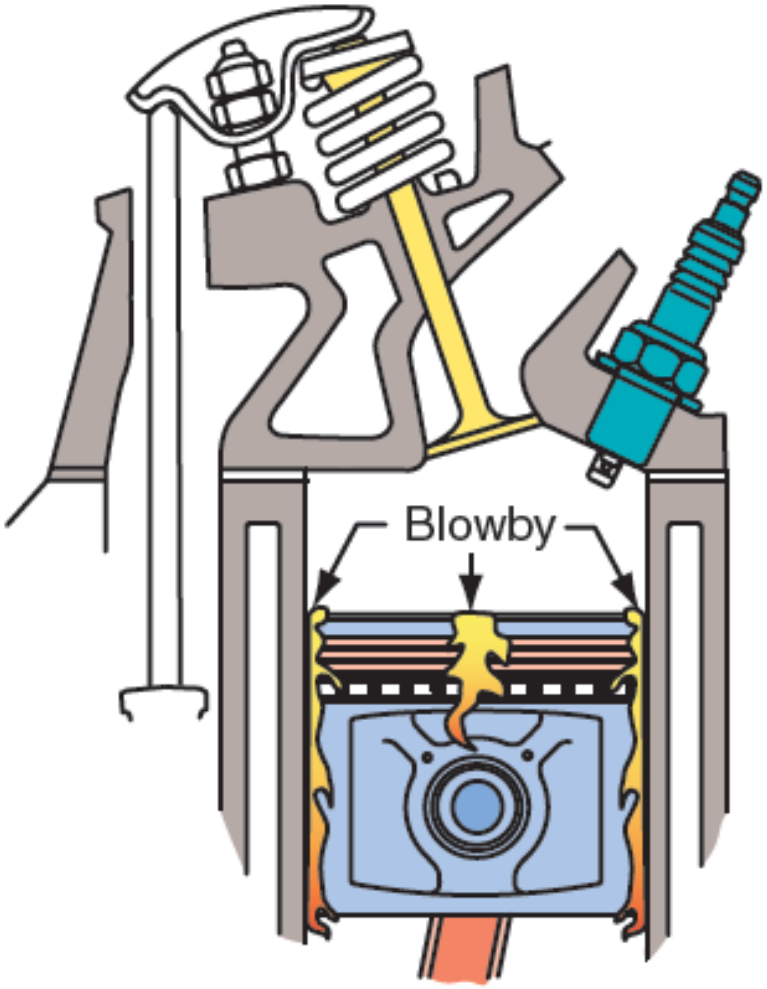


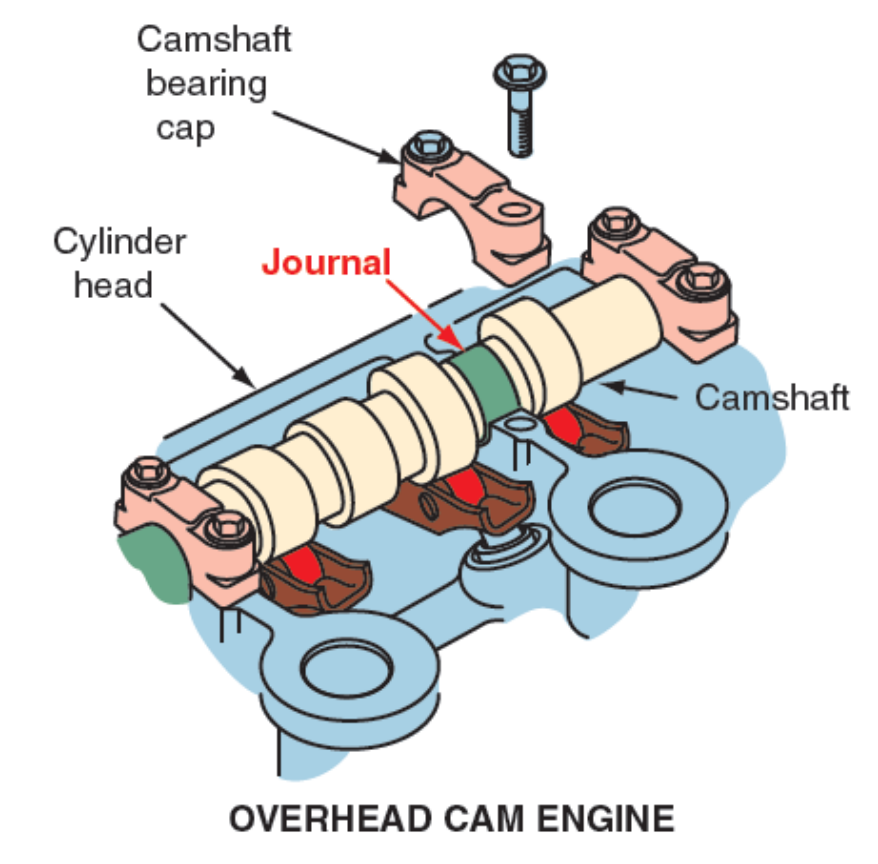
Figure 15.4 Leakage of gases past the rings is known as blowby.

Exhaust Stroke

- Exhaust valve opens and allows burned gases to escape
  - Expanding gases are forced through open valve
- Piston moves up in the cylinder
  - Forces remaining gases out
- Exhaust valve closes a few degrees past TDC
- One four-stroke cycle takes two 360-degree crankshaft revolutions
  - Intake and exhaust valves open once
  - Ignition occurs once

Engine Upper End

- Parts of the upper end of the engine
  - Cylinder head(s) and valve train
- Valve train
  - Includes parts that open and close the valves
  - Cam: located either in block or cylinder head
  - Rocker arms: mounted on top of cylinder head
  - Pushrod engines: cam bearings are pressed into bores in the block
  - Overhead cam: cam journals ride in bores in the cylinder head



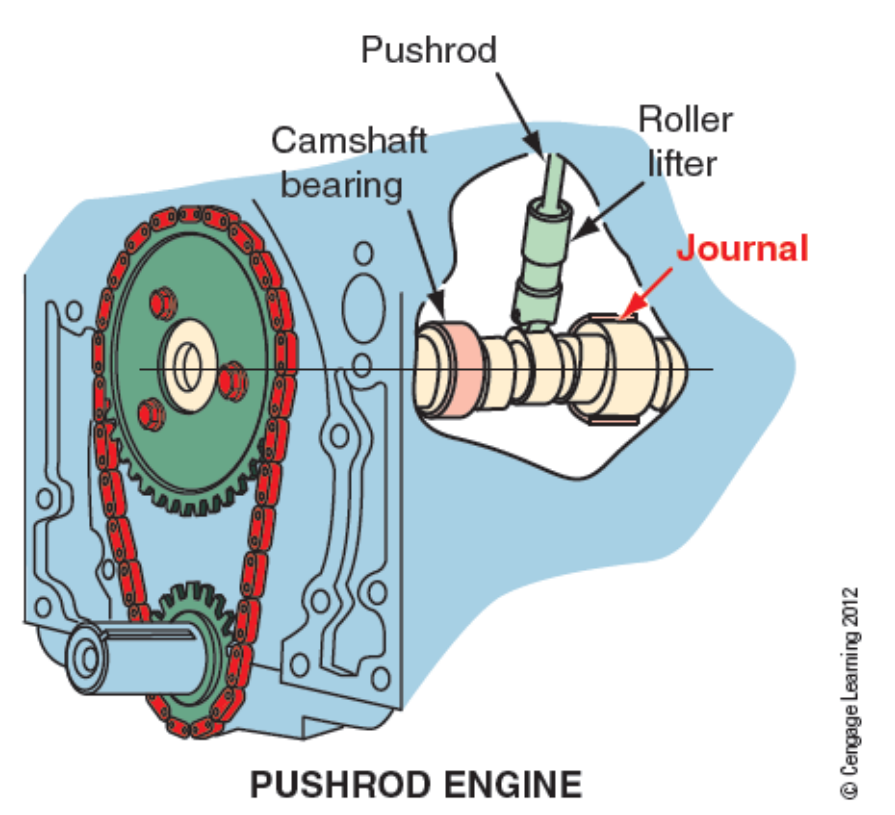


Figure 15.7 Cam journals ride inside of cam bearings to support the camshaft.

Cylinder Head

- Cylinder head: bolts to the top of the engine block, sealing off the cylinders
- Valve parts
  - Two valves per cylinder in combustion chambers
    - Intake valve is the larger
  - Several other valve parts
- Intake manifold: bolted to side of a head or between cylinder heads
- Exhaust manifold: bolted to cylinder head

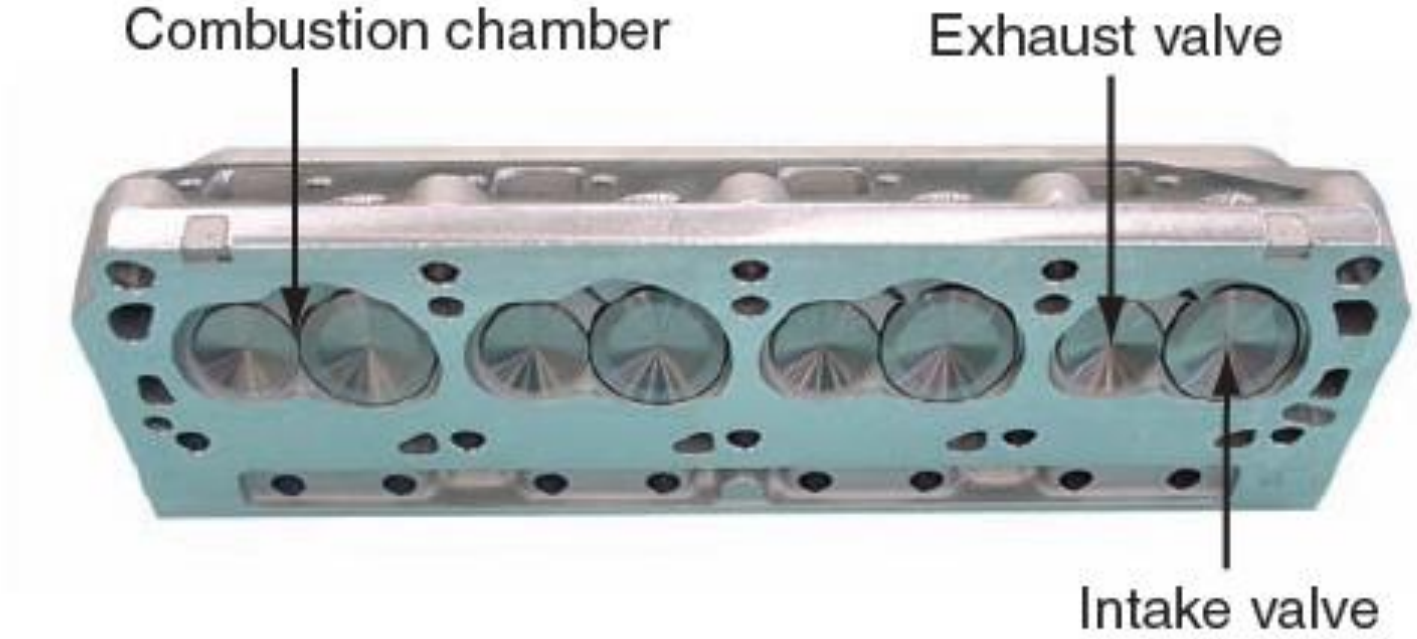


Figure 15.8 Combustion chambers on the bottom side of a cylinder head.

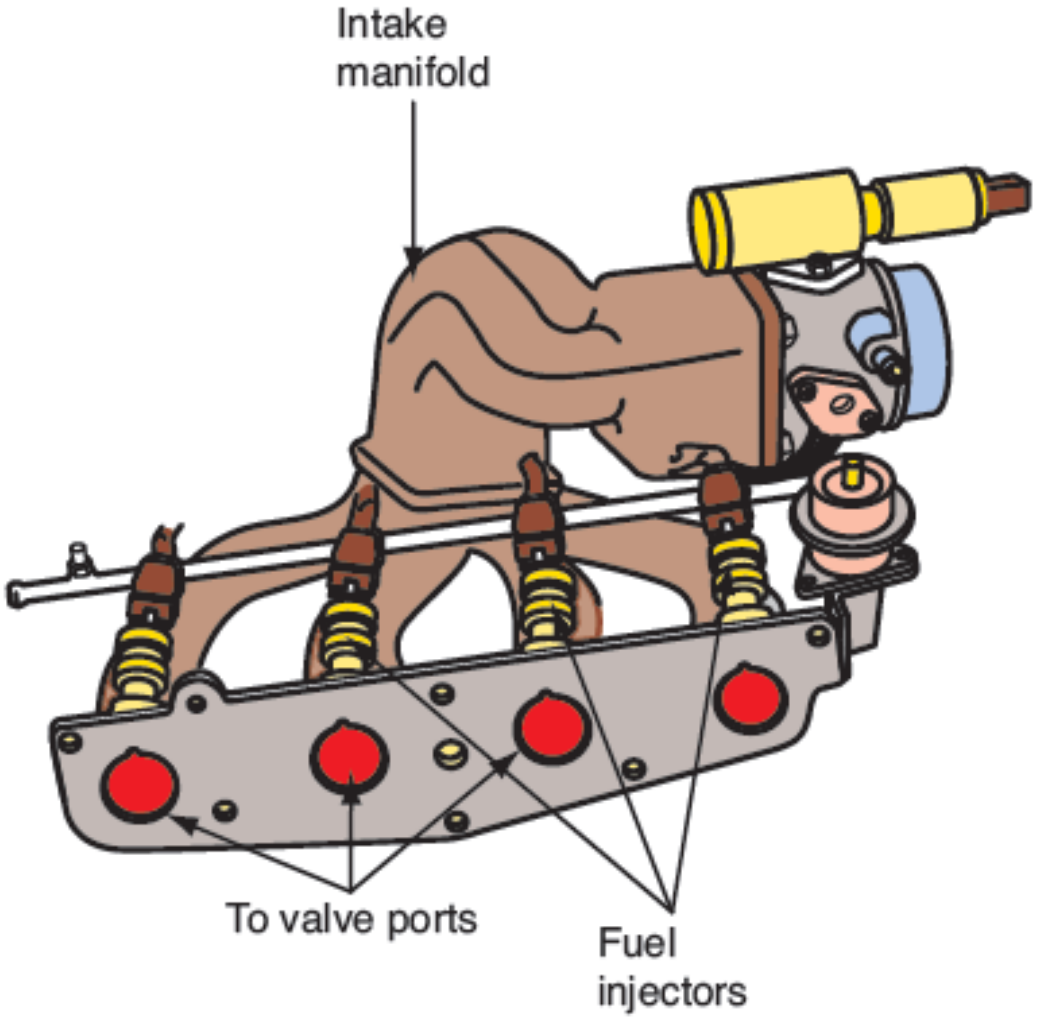
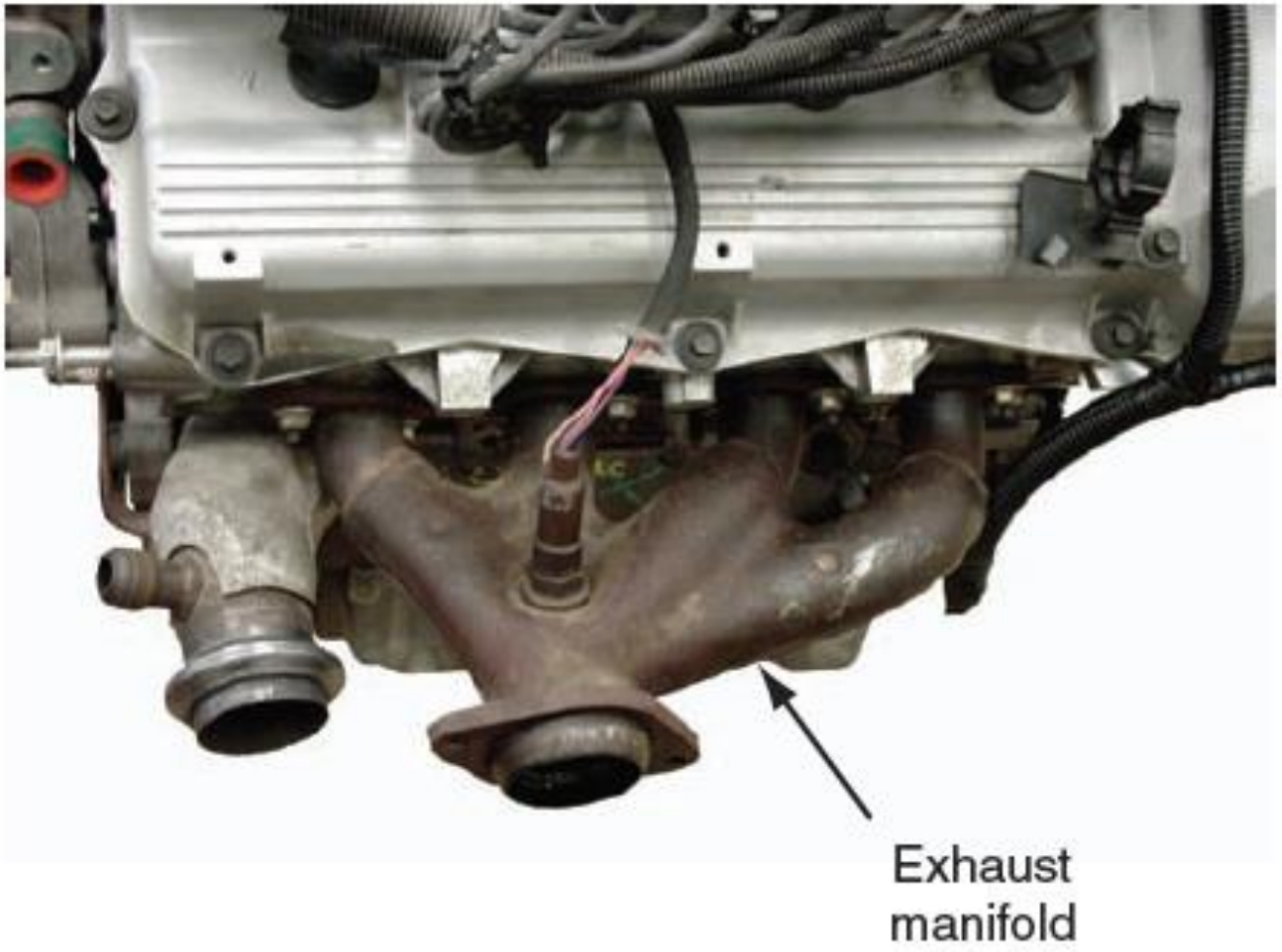


Figure 15.11 An intake manifold provides a passage to the intake valve ports in the head.



Tim Gilles

Figure 15.12 An exhaust manifold.

Engine Front

- Camshaft: driven by timing gears or sprockets
  - Used with a timing chain or belt
- Timing cover: seals against oil leakage
  - Keeps elements out of engines with a timing belt
- Vibration damper: minimizes vibrations in the crankshaft and prevents damage
  - Outer and inner ring are separated by thin rubber strip
    - Also called harmonic balancer

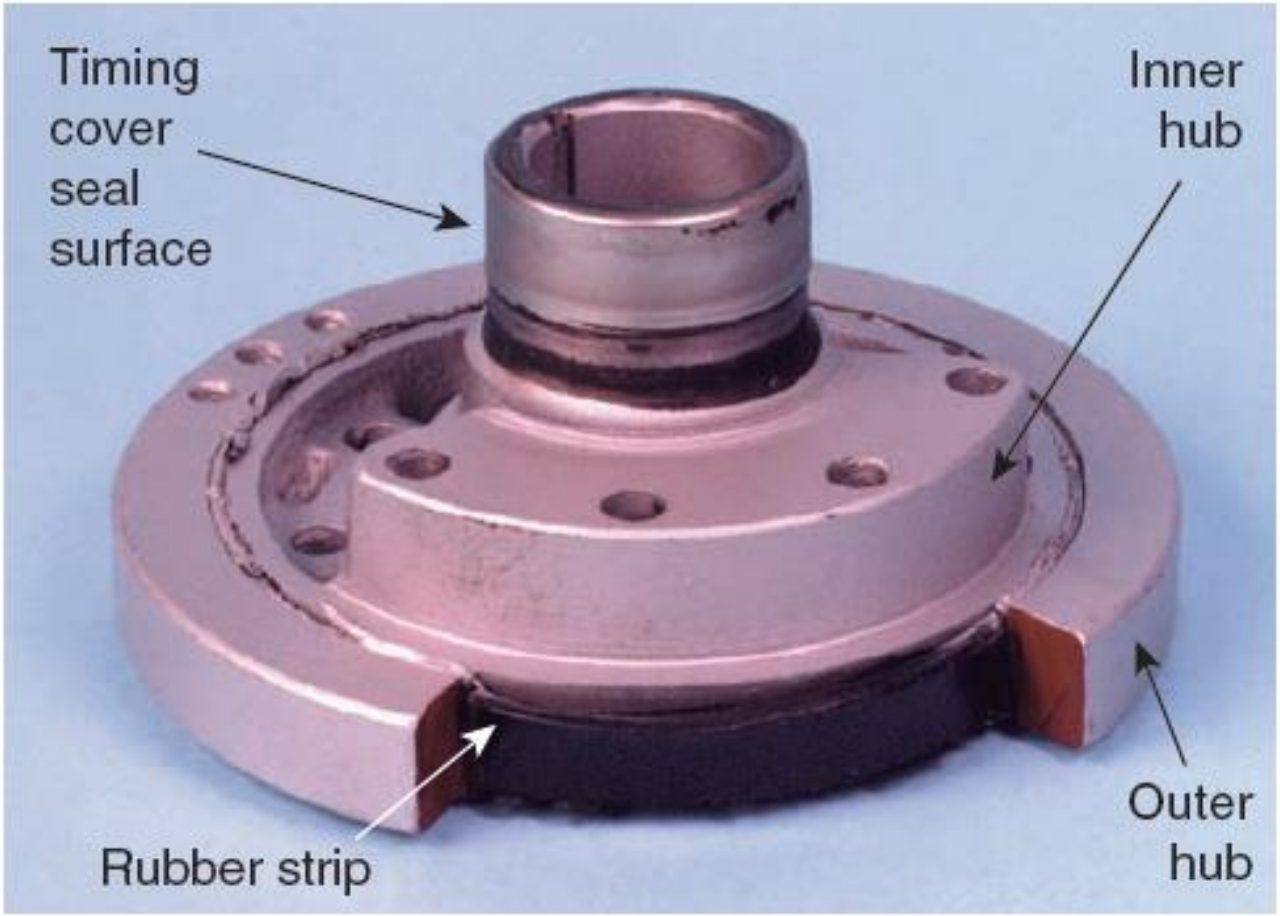
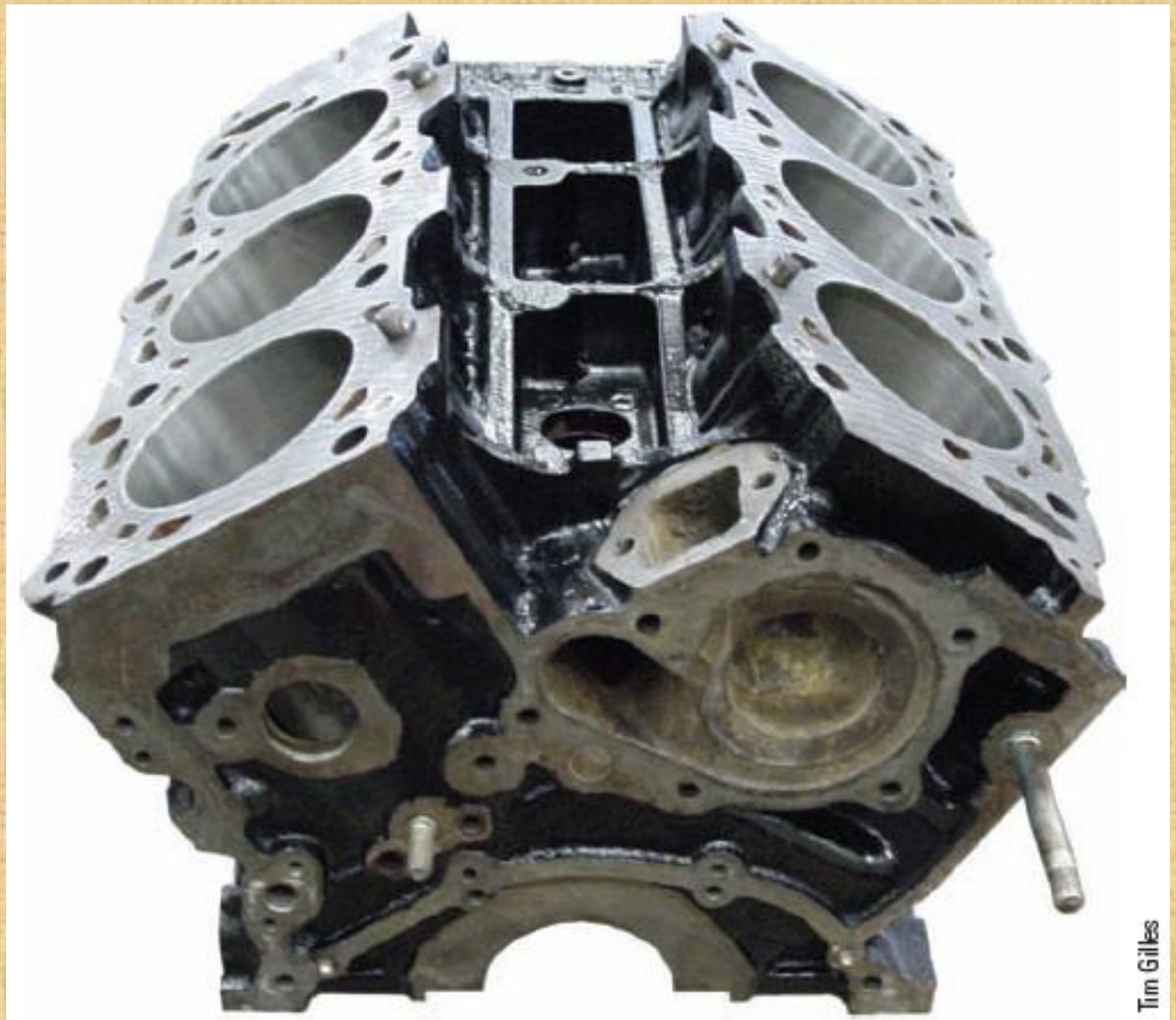


Figure 15.15 This cutaway shows the three pieces of a damper—the inner and outer hubs separated by a rubber strip—along with the timing cover seal surface.

Cylinder Block Assembly (Lower End)

- Cylinder block
  - Cast from iron or aluminum
  - Crankshaft and bearings are in the crankcase
  - Main bearing bores accommodate the crankshaft
  - Main bearing caps allow for installation and removal of the crankshaft
  - Cylinder head gasket fits between the head and the deck



Tim Gilles

Figure 15.16 A cylinder block casting.

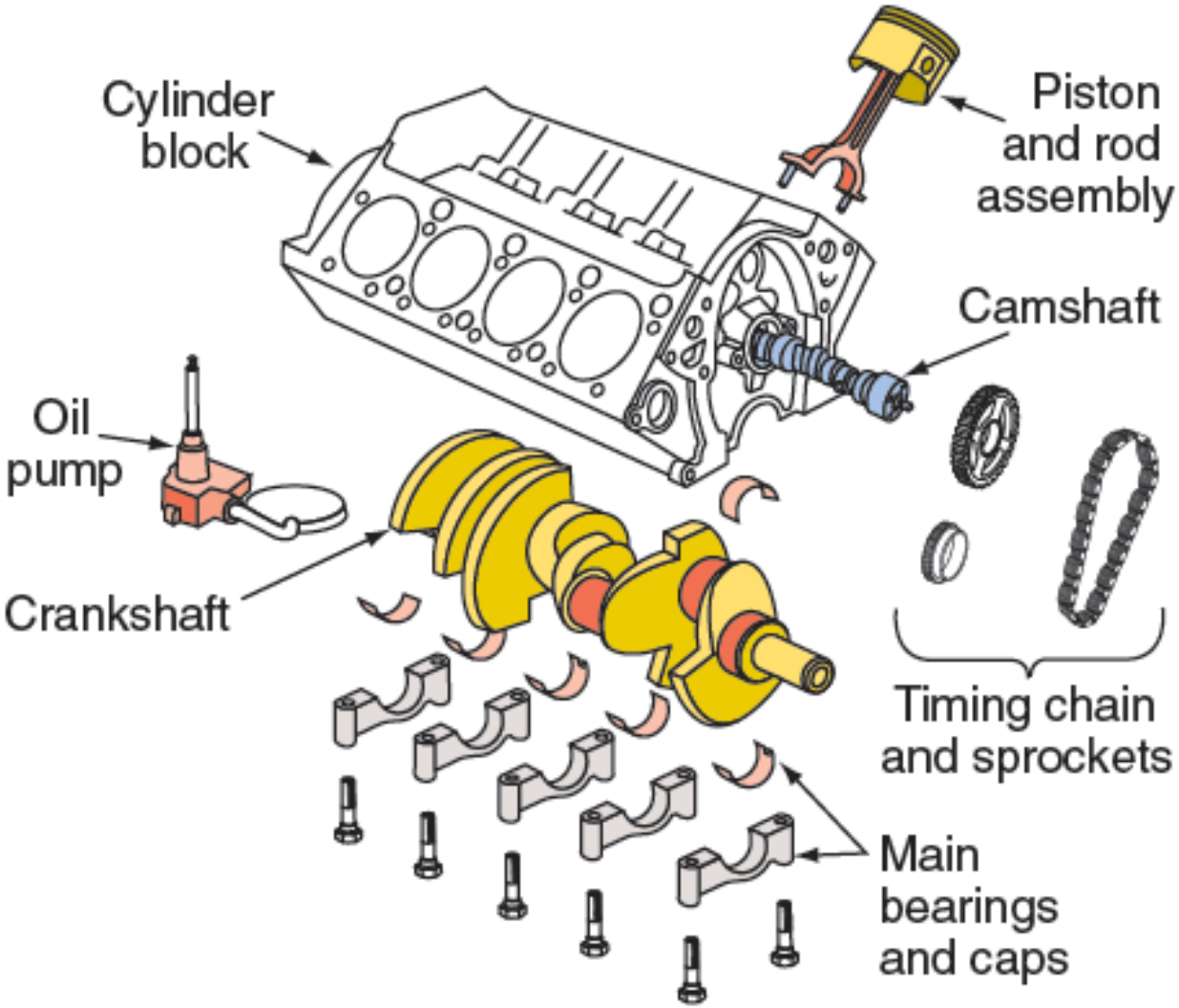


Figure 15.17 Lower end parts.

Short Block and Long Block

- Long block: complete block assembly with entire valve train
- Short block: cylinder block assembly without heads installed
- Crankshaft: converts reciprocating motion to rotating motion
- Connecting rod: shaped like an I-beam
  - Large bore connects rod journal
  - Rod cap is attached to bottom of the rod

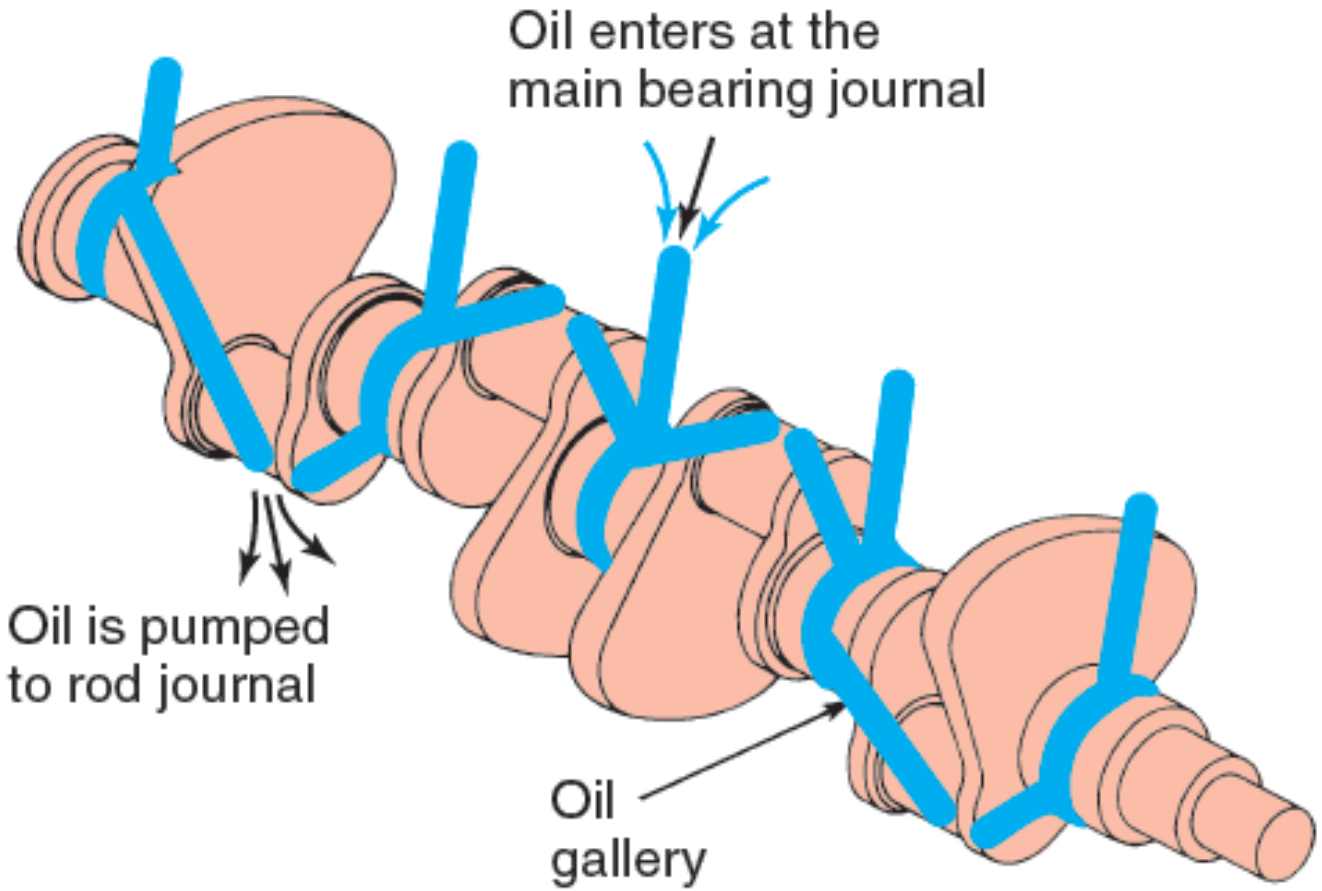


Figure 15.20 Crankshaft parts.

Short Block and Long Block (cont'd.)

- Piston skirt: fits to cylinder bore
  - Typical piston has three ring grooves above
    - Two on top for compression rings
    - Bottom for oil control
- Piston pin: installed on connecting rod small end
  - Pin bores provide a pivot point for the piston pin
- Piston rings: seal between piston ring grooves and cylinder wall
  - Keeps combustion pressure from entering crankcase

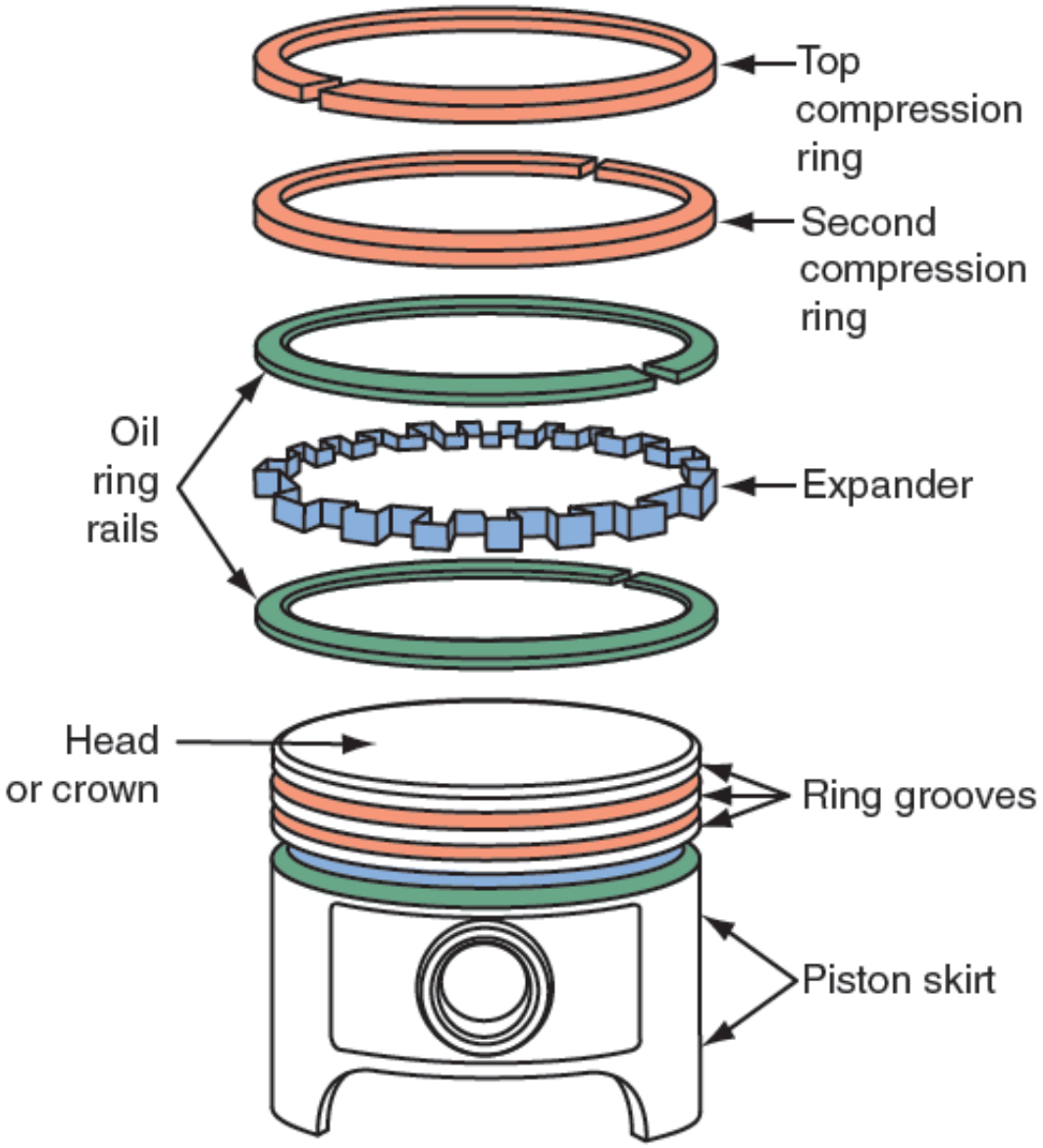


Figure 15.24 Piston and rings.

Short Block and Long Block (cont'd.)

- Oil seals: installed on the front and rear of crankshaft
- Oil pan: stamped sheet metal or plastic that encloses the crankcase
- Flywheel: used with manual transmission
  - Weight carries crankshaft beyond BDC
  - Ring gear provides a gear drive for the starter
  - Provides a surface for the clutch to work upon
- Torque converter and flexplate: replace flywheel in automatic transmissions

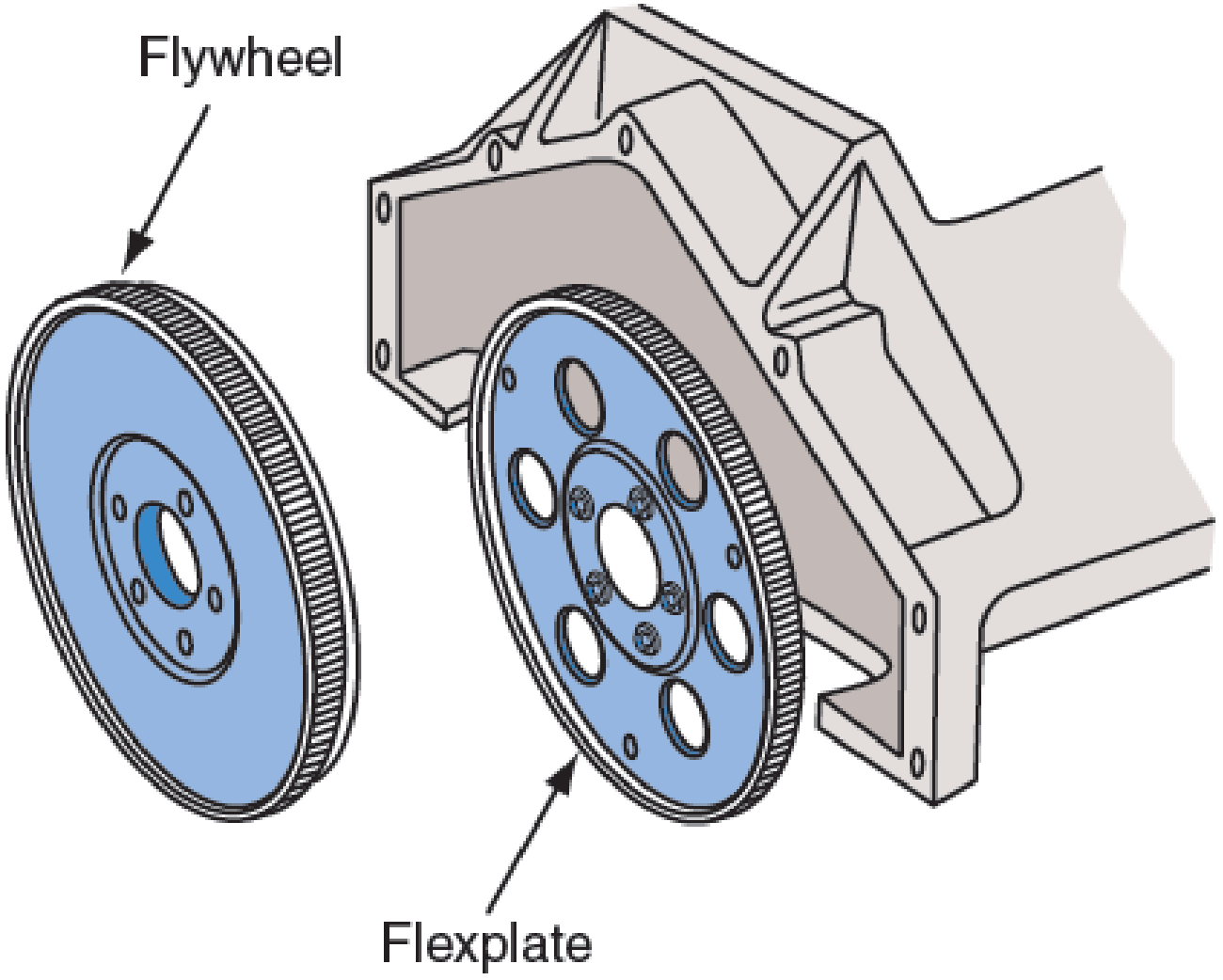


Figure 15.28 A flywheel and flexplate.

Summary

- One four-stroke cycle completes the intake, compression, power, and exhaust strokes
  - Camshaft turns once and crankshaft turns twice during one four-stroke cycle
- Piston motion is changed to rotary motion by the connecting rod and crankshaft
- Flywheel gives momentum to the crankshaft and smoothes impulses between power strokes
- Camshaft and valve train control the engine's intake and exhaust flow

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Emission Control System Fundamentals

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Objectives

- Describe the different types of air pollution caused by motor vehicles
- Explain the fundamentals of the major emission control systems
- Label the parts of emission control systems
- Explain the operation of electronically controlled emission systems

Introduction

- Emission controls
  - Began to be included on cars in the 1960s
  - Complicated specialty area
  - Most states: emission specialists are required to be licensed to perform repairs

Air Pollution

- Photochemical smog
  - Hydrocarbons and oxides of nitrogen react with sunlight
  - Warm air inversion layer traps smog
- Pollution laws
  - Administered by the EPA
  - Vehicles manufactured today produce less than 5% of the air pollution of 1960s models

Automotive Emissions

- Sources of emissions
  - Exhaust pipe, crank-case, and vapors
- Hydrocarbon sources
  - Blowby gases
  - Skin effect
  - Raw gas in exhaust
  - Insufficient compression
  - Inadequate ignition spark

Automotive Emissions (cont'd.)

- Carbon monoxide emissions
  - Result when gasoline not completely burned
- Oxides of nitrogen
  - Produced when combustion temperatures are too high
- Particulates
  - Are airborne microscopic particles
- Carbon dioxide and oxygen
  - Used to diagnose combustion problems
  - Carbon dioxide is a greenhouse gas

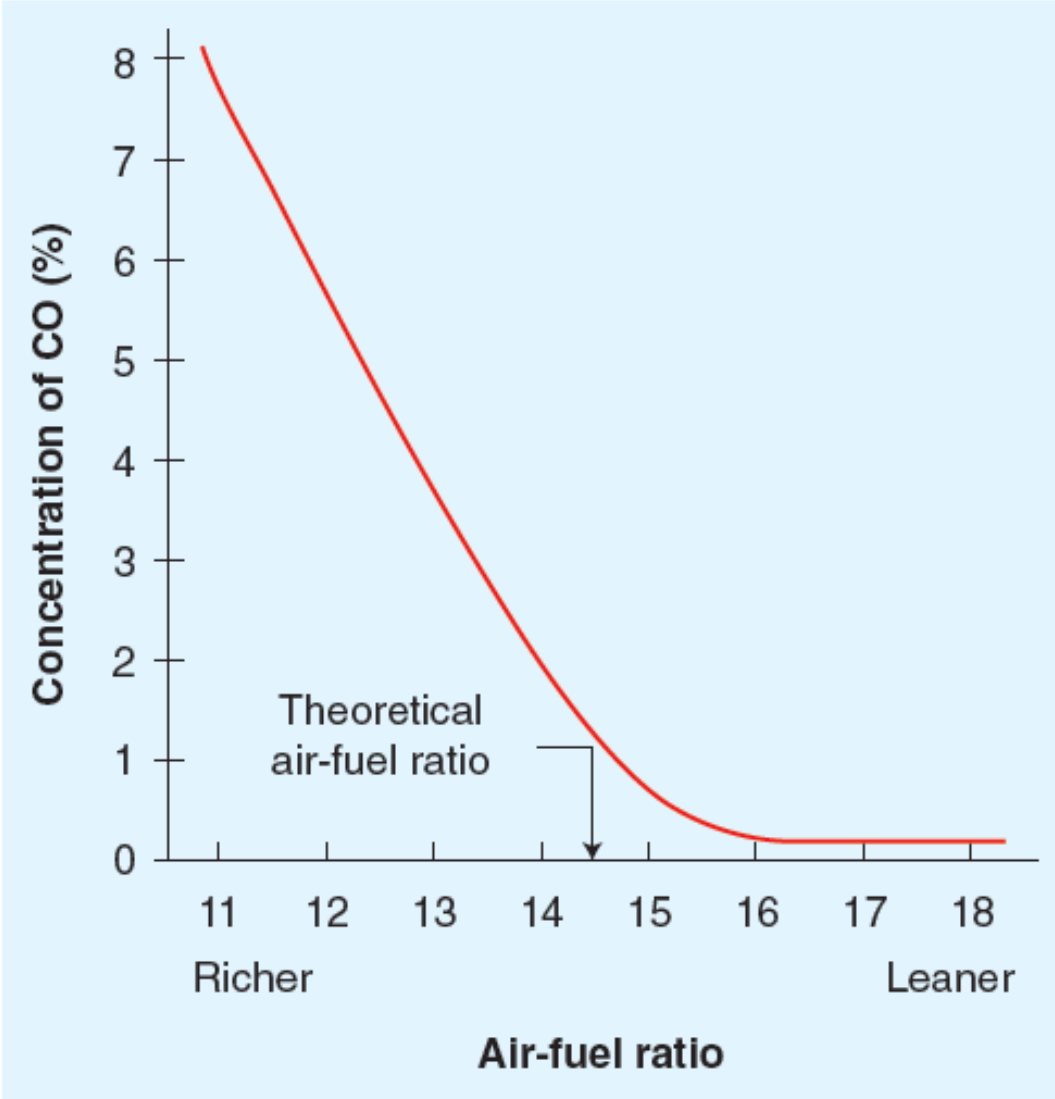

Figure 43.4 The amount of carbon monoxide (CO) in the exhaust varies with the air-fuel ratio.

Pollution Control

- Early 1960s: California led emission control legislation
  - 1961: crankcase emission system required on all new cars in California
- 1963: crankcase emission system required on all new cars in U.S.
- 1966: exhaust emission systems required on new cars in California
- 1970: U.S. Congress passed Clean Air Act

Automobile Emission Control Systems

- Lower exhaust emissions
  - Engine design
  - Fuel and ignition system controls
  - Devices designed to control emissions
- Computers manage emission devices
  - Engine load
  - Engine temperature
  - O_2 sensor

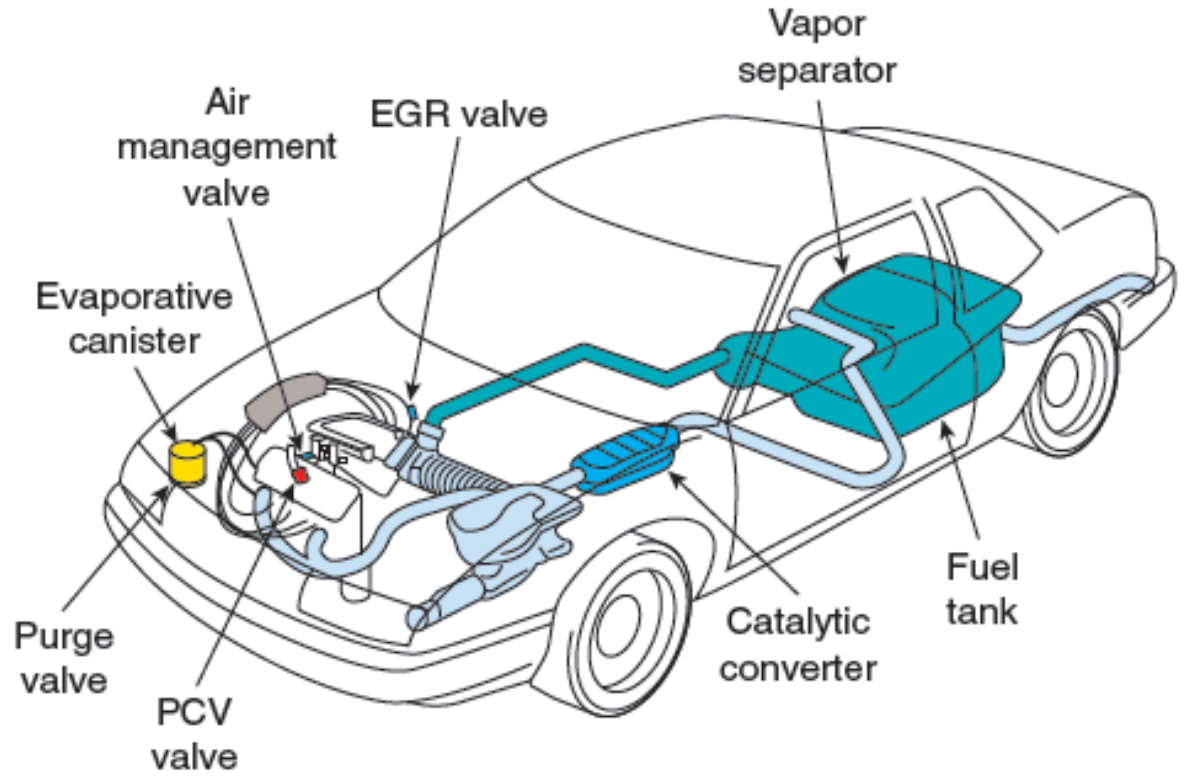

Figure 43.5 Typical emission control system.

Crankcase Ventilation

- PCV system
  - Reintroduces blowby gases into combustion chambers
- Benefits of PCV system
  - Prevents emissions of HCs
  - Reduces sludge
  - Reduces oil leakage
- Closed ventilation system
  - Filtered intake air is supplied through hose from air cleaner

Air Injection System

- Feeds hot gases to keep them burning
  - Air is provided by belt-driven air pump, electric motor-driven pump, or non-pump pulse air system
- Functions
  - Provides low-pressure air supply
  - Provides air to catalytic converter
- Air injection system uses an air pump, control valves, and lines to manifolds
  - Some vehicles have electric air pumps

Aspirator Valve or Pulse Air System

- Momentary low-pressure condition (pulse) occurs at end of exhaust stroke
  - Aspirator valve or pulse air system uses pulses to blow fresh air into exhaust
    - Not efficient at high speeds
  - One-way check valve (i.e., aspirator valve) allows fresh air from cleaner
    - Flows when vacuum created by exhaust pulse
    - Closes when exhaust pressure builds

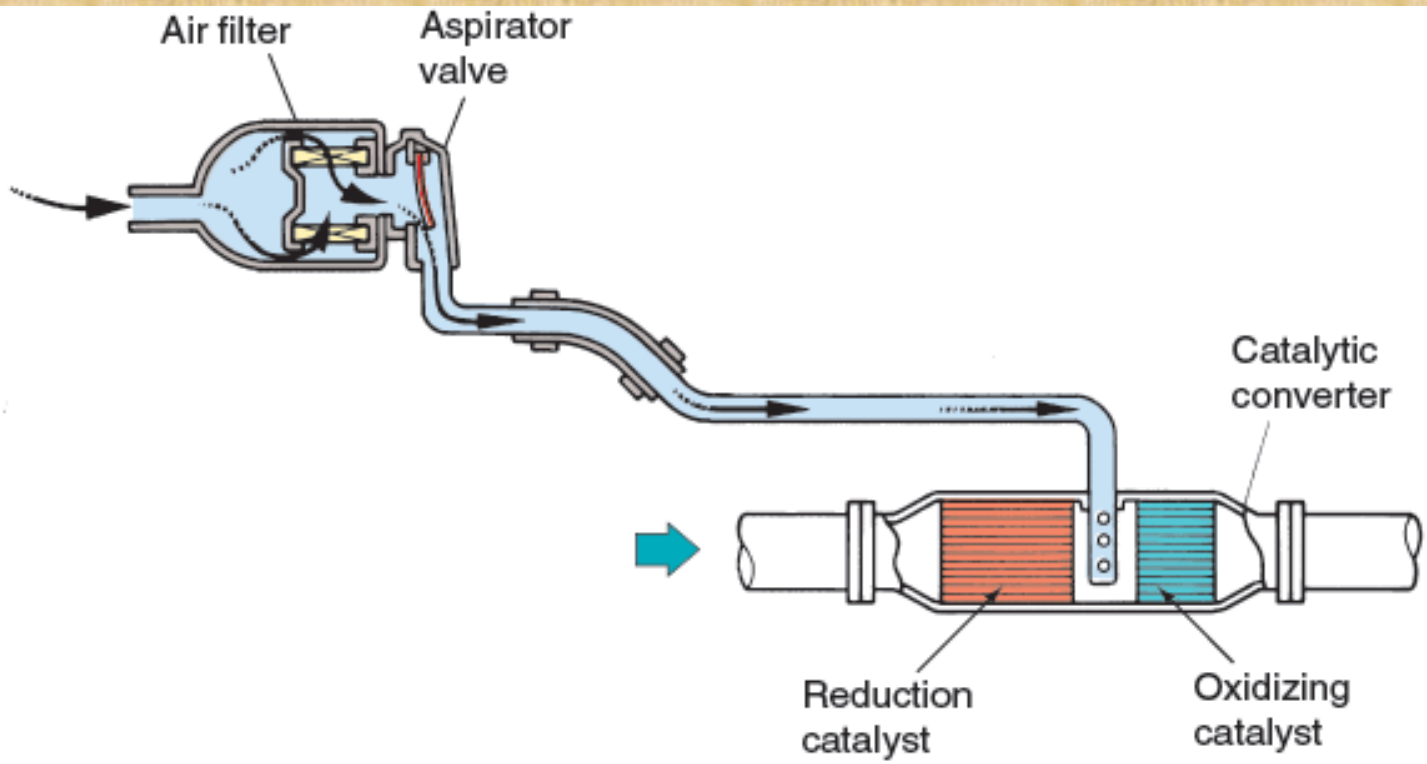

Figure 43.14 An aspirator valve system providing air to a catalytic converter.

Exhaust Gas Recirculation

- Lean air-fuel mixtures and higher operating temperatures raise NO_X
  - Exhaust gas recirculation (EGR) system allows exhaust gas into air-fuel mixture
    - Diluting air-fuel mixture with exhaust gas lowers combustion temperature by 300° F
  - EGR improves fuel economy
    - Early EGR systems were often disabled to improve fuel economy

EGR System Operation

- Simple EGR system has an EGR valve operated by engine vacuum
  - Located on intake manifold
- Little NOX is formed at idle
  - EGR valve is closed at these times
- Exhaust backpressure is a good indicator of engine load
  - More EGR flow needed under load
- Thermal vacuum valve (TVV)
  - Prevents vacuum operation before engine is warm

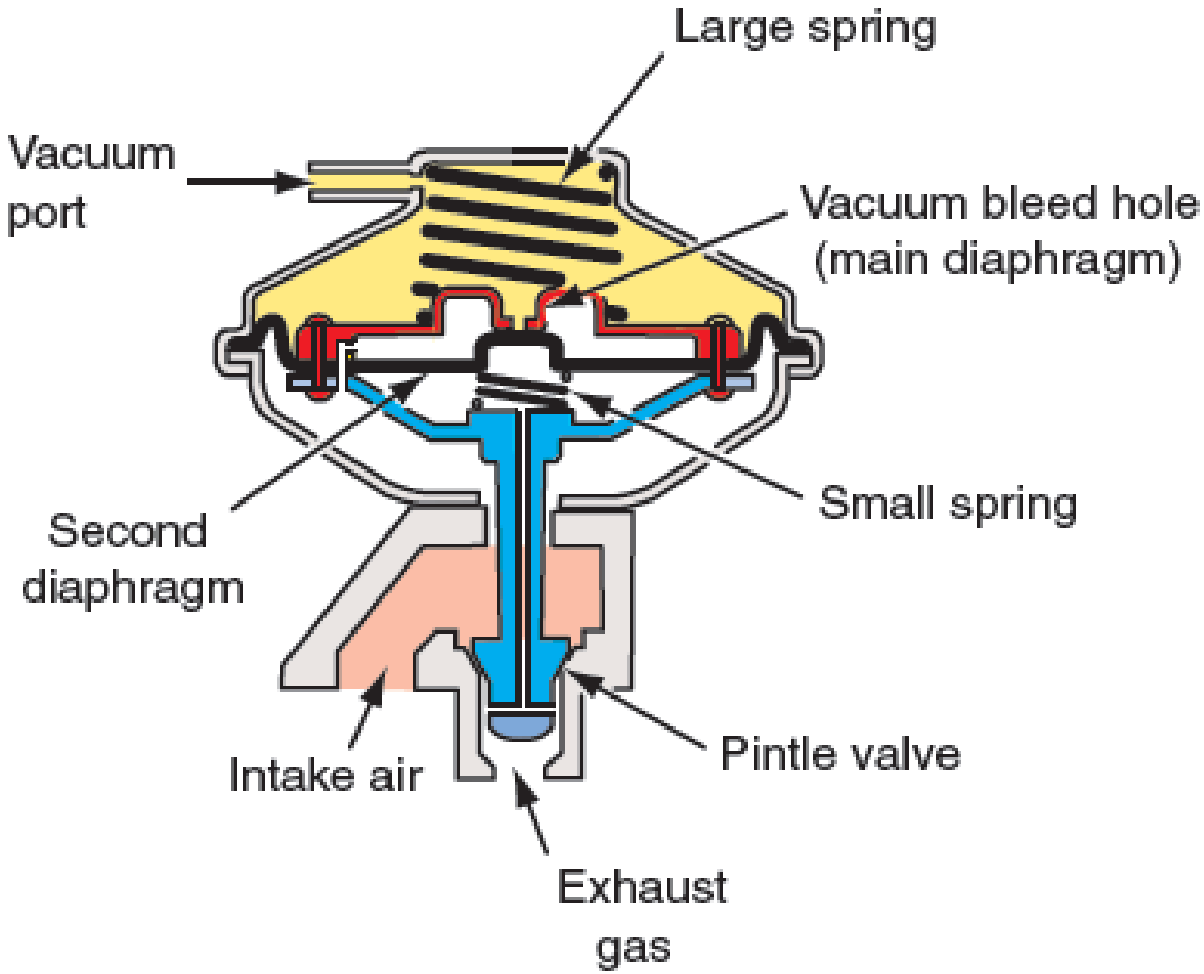

Figure 43.16 A mechanical EGR valve allows a small amount of exhaust gas to leak into the intake stream. This EGR valve is in the *closed* position.

Computer-Controlled EGR Systems

- Today's cars have computer-controlled EGR systems
  - EGR valve is controlled by input signals of engine temperature and load
    - Vehicle speed signal or PRNDL switch
  - Position sensors on EGR valves: included in late-model engines
  - Digital EGR valves: EGR flow regulated by computer using a series of solenoids
  - Linear EGR valves: include a stepper motor

Catalytic Converter

- Catalyst
  - Causes chemical reaction without changing itself
    - Chemical reaction only occurs in presence of catalyst or occurs faster because of one
- Catalytic converters
  - Must be hot to operate
  - Monolithic catalyst has thing coating of platinum applied to ceramic coated with alumina
  - Late-model vehicles have pre-catalysis which begin operating earlier

Types of Catalytic Converters

- Two-way catalyst; changes HC and CO into CO_2 and H_2O
- Three-way catalytic converter: used with oxygen sensor
  - Reduces NO_X and oxidizes HC and CO
  - Single or dual bed design
    - Dual bed catalytic converters include air switching valve and diverter
  - Use rhodium as a catalyst
  - Needs heat and regulated air-fuel mixture

Evaporative Controls

- Control emission of gasoline vapors from tank
  - Activated charcoal store gasoline vapors until they are drawn into the engine and burned
  - Emission of fuel vapors is controlled by sealing the fuel system
- Gasoline tanks allow for fuel expansion of 10%
  - Expansion dome and liquid/vapor separator
  - Expansion tank
  - Filler neck design
- Gas caps sealed or have pressure vacuum valve

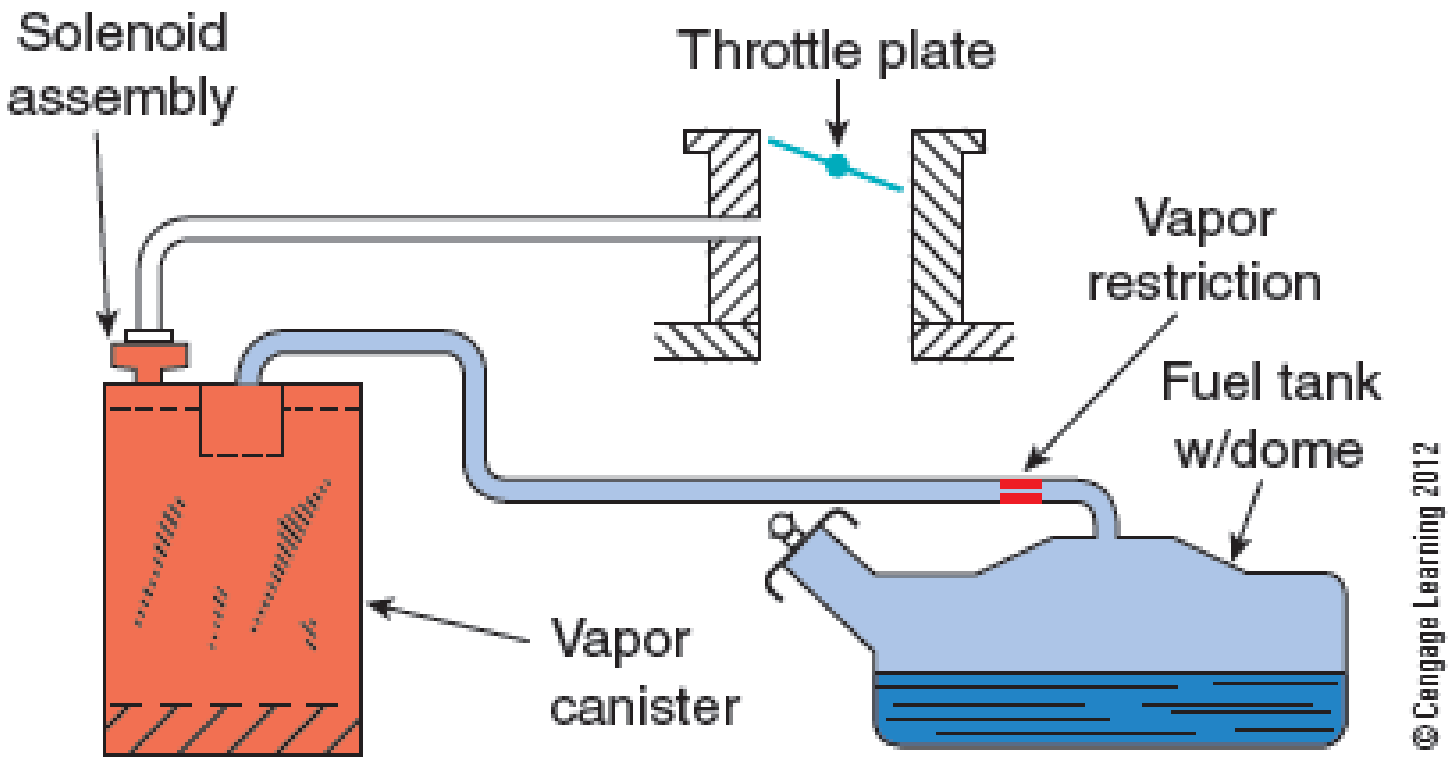

Figure 43.31 A simplified evaporative emission control system.

Other Parts of the Fuel Tank System

- Include:
  - Liquid vapor separator keeps liquid fuel from being drawn into charcoal canister
  - Charcoal canister stores vapors from fuel tank
  - Thermostatic air cleaner (TAC) maintain consistent air-fuel mixture
  - Manifold heat control valves were used to reduce exhaust emissions and improve drivability during engine warmup

On-Board Diagnostics

- 1988: on-board diagnostics regulations became law
  - Require computer to monitor engine's O2 sensor, EGR valve, and charcoal canister purge solenoid
  - Malfunction indicator light was also required
- Names of emission parts and connections for test equipment were standardized
  - Part of the OBD II regulations

Engine Emission Modifications

- Common modifications
  - As little as possible exposed surface area on the combustion chamber and top of piston
  - Engines run with higher cooling system temperatures
  - Advancing ignition timing can increase fuel economy
  - Changing cam design specifications results in different emissions
  - Domestic diesel light trucks and vans are now using urea selective catalyst reduction

Subject: Automotive Engineering

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Refer the following link for further information regarding the I C Engine and Its components

S.N	URL	S.N	URL
1	Engine basics parts and their functions_ a)https://youtu.be/saPGX-1qC4M b) https://youtu.be/zA_19bHxEYg	7	7. ignition systems_ https://youtu.be/W94iksaQwUo
2	2.engine cooling system_ https://youtu.be/y5p31F_dVJU	8	8.transmission systems_ a) https://youtu.be/wCu9W9xNwtI b) https://youtu.be/QPaUJfA1KsY c) https://youtu.be/devo3kdSPQY
3	3.engine lubrication system_ https://youtu.be/mmmcj53TNic	9	9.Drive to wheels_ a) propeller shaft https://youtu.be/lbXb_s7UomU b) universal joint_ https://youtu.be/LCMZz6YhbOQ c) https://youtu.be/OezhCX4WBLs
4	4.fuel supply system in SI and CI engines a)(CI engine) https://youtu.be/Z5_vfZhMWOg b) (SI engine) https://youtu.be/m6-KZS19HDU	10	10.suspension system_ a) https://youtu.be/nMQxqsyuJKE b) https://youtu.be/DKql4Is8Pas
5	5.function of superchargers_ a)https://youtu.be/_vaw5zwnhrA b) https://youtu.be/fHRX3Uzppv4	11	11.braking system_ a) https://youtu.be/bMg_j5_AGMg b)springs and suspensions_ https://youtu.be/9nIaVjWeXsI
6	6.function of turbochargers _ a) https://youtu.be/RVnlRKnMjhk b) https://youtu.be/DXNH3FD_Qa8	12	12.automotive emission control system_ a) https://youtu.be/qBD2XjejCEI b) https://youtu.be/W6dIsC_eGBI