


**Automotive Engines Theory and Servicing**  
Ninth Edition

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Theory and Servicing  
Ninth Edition  
James D. Halderman

**Chapter 21**  
Turbocharging and Supercharging



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**OBJECTIVES (1 OF 2)**

**21.1** Discuss airflow requirements and volumetric efficiency of engines.

**21.2** Explain forced induction principles.

**21.3** Discuss superchargers.

**21.4** Discuss turbochargers and turbocharger failures.

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**OBJECTIVES (2 OF 2)**

**21.5** Explain boost control.

**21.6** Describe the purpose of a nitrous oxide system.

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## INTRODUCTION (1 OF 2)

- A four-stroke engine can take in only so much air
  - How much fuel it needs for proper combustion depends on how much air it takes in.
- Engineers calculate engine airflow requirements using three factors.
  - Engine displacement
  - Engine revolutions per minute (RPM)
  - Volumetric efficiency

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## INTRODUCTION (2 OF 2)

- Volumetric efficiency is a measure of how well an engine breathes.
  - It is a comparison of the actual volume of air-fuel mixture drawn into an engine to the theoretical maximum volume that could be drawn in.
  - Volumetric efficiency is expressed as a percentage.

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FIGURE 21-1 A supercharger on a Ford V-8.



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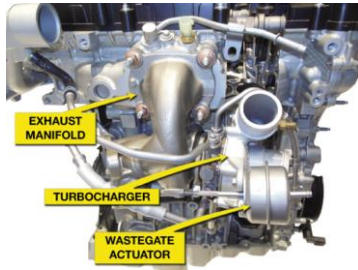
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FIGURE 21-2 A turbocharged Ford three-cylinder 1.0 liter Eco Boost engine.



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## FORCED INDUCTION PRINCIPLES (1 OF 2)

- The amount of force an air-fuel charge produces when it is ignited is largely a function of the charge density.
  - Charge density is a term used to define the amount of the air-fuel charge introduced into the cylinders.
  - Density is the mass of a substance in a given amount of space.

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## FORCED INDUCTION PRINCIPLES (2 OF 2)

- Forced induction systems use an air pump to pack a denser air-fuel charge into the cylinders.
- Because the density of the air-fuel charge is greater, the following occurs.
  - The weight of the air-fuel charge is higher.
  - Power is increased because it is directly related to the weight of an air-fuel charge consumed within a given time period.

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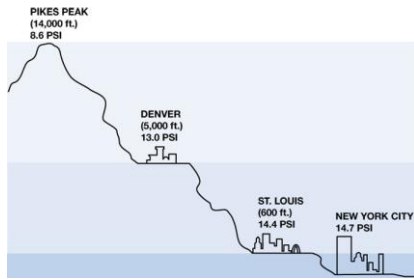
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**FIGURE 21-4 Atmospheric pressure decreases with increases in altitude.**



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## SUPERCHARGERS (1 OF 2)

- A supercharger is an engine-driven air pump that supplies more than the normal amount of air into the intake manifold and boosts engine torque and power.
  - A supercharger provides an instantaneous increase in power without any delay.
  - A supercharger, because it is driven by the engine, requires horsepower to operate and is not as efficient as a turbocharger.

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## SUPERCHARGERS (2 OF 2)

- Types of Superchargers
  - Roots type
  - Centrifugal supercharger
- Supercharger Boost Control
- Supercharger Service

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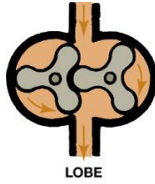
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FIGURE 21-5 A roots-type supercharger uses two lobes to force the air around the outside of the housing and into the intake manifold.



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## TURBOCHARGERS (1 OF 2)

- A turbocharger uses the heat of the exhaust to power a turbine wheel and therefore does not directly reduce engine power.
  - In a naturally aspirated engine, about half of the heat energy contained in the fuel goes out the exhaust system.

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## TURBOCHARGERS (2 OF 2)

- Operation
- Turbocharger Operation
- Turbocharger Size and Response Time

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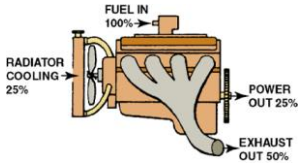
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FIGURE 21-8 A turbocharger uses some of the heat energy that would normally be wasted.



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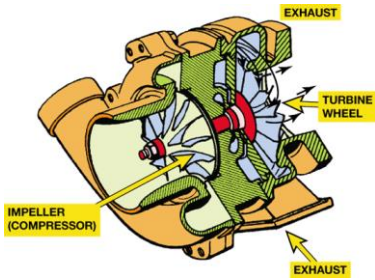
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FIGURE 21-9 A turbine wheel is turned by the expanding exhaust gases.



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## BOOST CONTROL

- Boost Control Factors
- Wastegate
- Relief Valves
  - Compressor bypass valve (CBV)
  - Blow-off valve (BOV)

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**FIGURE 21–12** The unit on top of this Subaru that looks like a radiator is the intercooler, which cools the air after it has been compressed by the turbocharger.



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## TURBOCHARGER FAILURES

- Symptoms of Failure
  - When turbochargers fail to function correctly, a noticeable drop in power occurs
- Preventing Turbocharger Failures

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## NITROUS OXIDE (1 OF 2)

- Nitrous oxide is used for racing or high-performance only, and is not used from the factory on any vehicle.
- This is a relatively inexpensive way to get additional power from an engine.
  - But can cause serious engine damage if not used correctly or in excess amounts, or without proper precautions.

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## NITROUS OXIDE (2 OF 2)

- Principles
- Engine Power Adder
- Pressure and Temperature
- Wet And Dry System
- Engine Changes Needed For N<sub>2</sub>O
- System Installation And Calibration

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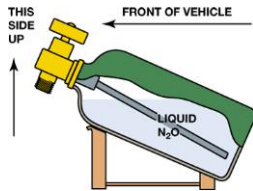
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**FIGURE 21-16** Nitrous bottles have to be mounted at an angle to ensure that the pickup tube is in the liquid N<sub>2</sub>O.



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**FIGURE 21-17** An electrical heating mat is installed on the bottle of nitrous oxide to increase the pressure of the gas inside.



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### SUMMARY (1 OF 4)

- Volumetric efficiency is a comparison of the actual volume of air-fuel mixture drawn into the engine to the theoretical maximum volume that can be drawn into the cylinder.
- A supercharger operates from the engine by a drive belt and it forces a greater amount of air into the cylinders for even more power.

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### SUMMARY (2 OF 4)

- There are two types of superchargers: roots-type and centrifugal.
- A turbocharger uses the normally wasted heat energy of the exhaust to turn an impeller at high speed.
- A bypass valve is used to control the boost pressure on most factory installed superchargers.

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### SUMMARY (3 OF 4)

- An intercooler is used on many turbocharged and some supercharged engines to reduce the temperature of air entering the engine for increased power.
- Nitrous oxide injection can be used as a power adder, but only with extreme caution.

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## SUMMARY (4 OF 4)

- A wastegate is used on most turbocharger systems to limit and control boost pressures, as well as a relief valve, to keep the speed of the turbine wheel from slowing down during engine deceleration.

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