

# Automotive Engines Theory and Servicing

Ninth Edition

## Automotive Engines Theory and Servicing

Ninth Edition  
James D. Halderman



## Chapter 33

Balancing and  
Blueprinting

ALWAYS LEARNING

Copyright © 2016, 2015, 2011 Pearson Education, Inc. All Rights Reserved

PEARSON

---

---

---

---

---

---

---

---

## OBJECTIVES (1 OF 2)

**33.1** Explain the purpose of balancing an engine.

**33.2** Describe the blueprinting process.

**33.3** Discuss the importance of combustion chamber volume.

**33.4** Discuss the purpose of flow testing cylinder heads.

Copyright © 2016, 2015, 2011 Pearson Education, Inc. All Rights Reserved

PEARSON

---

---

---

---

---

---

---

---

## OBJECTIVES (2 OF 2)

**33.5** Discuss the purpose of degreasing the camshaft.

**33.6** Explain the procedure of determining proper push rod length.

**33.7** Discuss short block blueprinting.

Copyright © 2016, 2015, 2011 Pearson Education, Inc. All Rights Reserved

PEARSON

---

---

---

---

---

---

---

---

### BALANCING AN ENGINE (1 OF 5)

- For any engine to operate with a minimum amount of vibration, all of the reciprocating parts must be close to the same weight.
  - Production engines use parts that are usually within 3 grams of each other and result in a relatively smooth operating engine.

Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

---

---

### BALANCING AN ENGINE (2 OF 5)

- Whenever all rotating and reciprocating parts of an engine are to be balanced, the following components are needed to balance inline engines.
  - Crankshaft
  - Vibration damper (harmonic balancer)
  - Flywheel or flexplate
  - Pressure plate

Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

---

---

### BALANCING AN ENGINE (3 OF 5)

- All bolts, lock washers, keys, and spacers needed to assemble the above parts on the crankshaft
  - Connecting rods
  - Pistons
  - Wrist pins
- STEP 1 Equalize the reciprocating weight, which includes the pistons and rods.

Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

---

---

## BALANCING AN ENGINE (4 OF 5)

- STEP 2 Connecting rods have a big end and a small end.
  - The big end of the rod is considered to be part of the rotating weight and the small end part of the reciprocating weight after the rod has been reconditioned.
  - The two ends should be weighed and matched separately.

Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

---

---

**FIGURE 33-1** Weighing the big end of a connecting rod on a scale that keeps it perfectly horizontal so that each end can be weighed separately.



Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

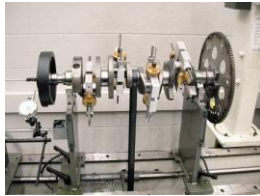
---

---

---

## BALANCING AN ENGINE (5 OF 5)

- Bob Weights
- Balancing Factor
- Balancing Machines



**FIGURE 33-3** A crankshaft with bob weights attached as well as the flexplate and the harmonic balancer.

Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

---

---

## BLUEPRINTING PROCESS (1 OF 2)

- General Use Questions
  - Blueprinting is the process used to custom fit and select variables to best match a predetermined level of performance.
- Specific Requirement Needs
  - Block
  - Rotating assembly
  - Breathing system

Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

---

---

## BLUEPRINTING PROCESS (2 OF 2)

- Size Matters
  - Boring the block
  - Stroking the engine
- Parts Manufacturer Help
- Follow Parts Manufacturer's Recommendations

Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

---

---

## COMBUSTION CHAMBER VOLUME

- All cylinders should have the same compression.
- The technician or engine builder needs to know the combustion chamber volume to accurately calculate the compression ratio.
- To accurately measure the volume of the combustion chamber, a graduated burette is used with mineral spirits.

Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

---

---

**FIGURE 33-7** Setup needed to measure the combustion chamber volume in cubic centimeters (cc).



Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved

PEARSON

---

---

---

---

---

---

---

---

## FLOW TESTING CYLINDER HEADS

- Purpose
  - Used to measure the amount of air in cubic feet per minute that can flow through the valves at various valve openings
- Flow Rate and Horsepower



**FIGURE 33-8** Cylinder head setup for flow testing. Note the weak valve springs that are strong enough to keep the valves shut, yet weak enough to permit the flow bench operator to vary the intake valve opening amount.

Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved

PEARSON

---

---

---

---

---

---

---

---

**FIGURE 33-9** Modeling clay is installed around the port to duplicate the flow improvement characteristics of an intake manifold.



Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved

PEARSON

---

---

---

---

---

---

---

---

## DEGREEING THE CAMSHAFT

- Purpose
  - To locate the valve action exactly as the camshaft manufacturers intended
- Procedure
- Advanced Cam Timing
- Retarded Cam Timing

Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

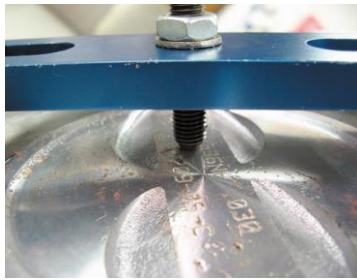
---

---

---

---

FIGURE 33–11 A piston stop is used to help determine top dead center.



Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

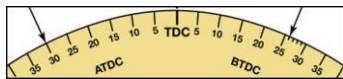
---

---

---

---

FIGURE 33–12 The degree wheel indicates where the piston stopped near top dead center. By splitting the difference between the two readings, the true TDC (28 degrees) can be located on the degree wheel.



Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

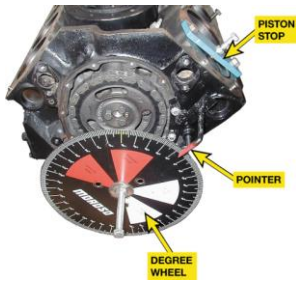
---

---

---

---

**FIGURE 33-13** Note the setup required to degree a camshaft. The pointer, the degree wheel, and the piston stop are used to find exact top dead center.



Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved

PEARSON

---

---

---

---

---

---

---

---

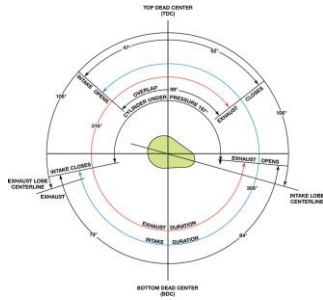
---

---

---

---

**FIGURE 33-14** Typical valve timing diagram showing the intake lobe centerline at 106 degrees ATDC.



Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved

PEARSON

---

---

---

---

---

---

---

---

---

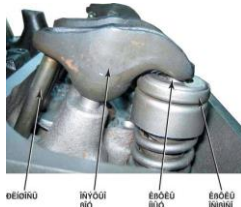
---

---

---

## DETERMINING PROPER PUSHROD LENGTH

- Purpose
  - The length of the pushrod is determined by the geometry of the engine when it was originally built
- When Needed
- Procedure



**FIGURE 33-15** A side view of a small block Chevrolet engine showing that the rocker arm is contacting the top of the valve stem. A roller-tipped rocker arm will show a more definite line of contact than a stamped steel rocker.

Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved

PEARSON

---

---

---

---

---

---

---

---

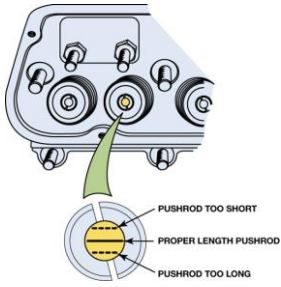
---

---

---

---

**FIGURE 33-16** Checking where on the valve stem the marker has been worn off by the rocker arm, is the method to use to check for proper pushrod length.



Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

---

---

---

---

**FIGURE 33-17** An adjustable pushrod is adjustable for length compared to a conventional stock pushrod.



Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

---

---

---

---

## SHORT BLOCK BLUEPRINTING

- Determine Engine Use
- Trial Assembly
  - Before the engine is assembled it should be partially assembled to double check all clearances

Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

---

---

---

---



FIGURE 33-2 Removing material from the balancing pad on the small end of the rod to match it to the weight of the small end of the lightest rod being used in the engine.



Copyright © 2010, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

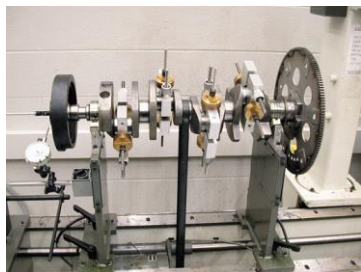
---

---

---

---

FIGURE 33-3 A crankshaft with bob weights attached as well as the flexplate and the harmonic balancer.



Copyright © 2010, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

---

---

---

---

FIGURE 33-4 The display of a crankshaft balancer showing where weight needs to be removed to achieve a balanced assembly.



Copyright © 2010, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

---

---

---

---

**FIGURE 33-5** A drill is often used to remove weight from the crankshaft to achieve proper balance.



Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

---

---

**FIGURE 33-6** Heavy metal installed and welded in place.



Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

---

---

**FIGURE 33-8** Cylinder head setup for flow testing. Note the weak valve springs that are strong enough to keep the valves shut, yet weak enough to permit the flow bench operator to vary the intake valve opening amount.



Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

---

---

**FIGURE 33-10** A flow bench that can measure and record the airflow through the intake and exhaust ports of each cylinder.



Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

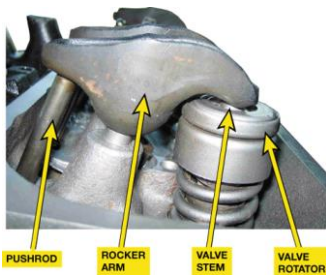
---

---

---

---

**FIGURE 33-15** A side view of a small block Chevrolet engine showing that the rocker arm is contacting the top of the valve stem. A roller-tipped rocker arm will show a more definite line of contact than a stamped steel rocker.



Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

---

---

**1** The crankshaft should always be balanced with the flywheel (or flexplate) and harmonic balancer installed.



Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

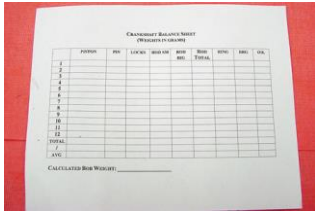
---

---

---

---

2 Use a worksheet so that all weights can be measured and recorded.



Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

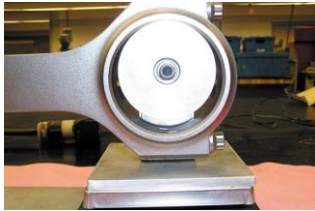
---

---

---

---

3 Using a fixture to hold the connecting rod horizontally, measure and record the weight of the big end of the rod.



Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

---

---

---

---

4 Using a fixture to hold the connecting rod horizontally, measure and record the weight of the small end of the rod.



Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

---

---

---

---

5 Weigh each piston. Remove some metal from the heaviest pistons to match their weight with the lightest.



Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

---

---

6 Weigh and record the weight of each piston pin.



Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

---

---

7 Weigh and record the weight of each piston pin locks if used.



Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

---

---

8 Weigh and record the weight of the piston rings for each piston.



Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

---

---

9 Weigh and record the weight of the rod bearings for each connecting rod.



Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

---

---

10 Using the worksheet and plugging the measured values into the balancer, adjust the BOB weight to the desired weight.



Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

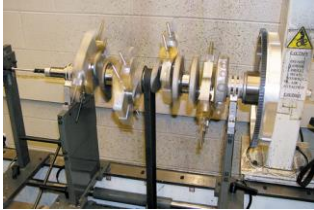
---

---

---

---

11 Install the BOB weights and operate the balancer according to the instructions for the balancer being used.



Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

---

---

12 Use a drill and drill the counterweight in the designated location as indicated on the balancer.



Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

---

---

## SUMMARY (1 OF 2)

- Proper balancing of the engine is important for smooth operation.
- Both rotating weight and reciprocating weight are considered during the balancing procedure.
- Blueprinting means following the exact procedures and specifications for the parts used.

Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

---

---

## SUMMARY (2 OF 2)

- Checking combustion chamber volume is used to ensure that all cylinders have the exact same compression ratio.
- Degreasing a camshaft is done to ensure that the valve events occur at the correct time.
- Checking for proper pushrod length is important after the machining operations have changed the height of the cylinder head(s).

Copyright © 2018, 2015, 2011 Pearson Education, Inc. All Rights Reserved.

PEARSON

---

---

---

---

---

---

---

---