

---

## TABLE OF CONTENTS

Foreword.....	1
Service Diagnosis.....	2
Safety Information.....	3
Engine Systems.....	5
Mounting Engine on Engine Stand.....	45
Engine Electrical.....	53
Exhaust Gas Recirculation (EGR) System.....	113
Dual Turbocharger, Exhaust Manifolds, and Piping.....	141
Air Compressor and Power Steering Pump.....	185
Fuel System.....	207
Front Cover, Cooling System, and Related Components.....	263
Oil Cooler, Oil Pump, Oil Filter, and Oil Pan.....	285
Cylinder Heads, Valve Covers, and Valve Train.....	309
Flywheel Assembly and Flywheel Housing.....	367
Power Cylinders.....	395
Crankcase, Crankshaft, and Camshaft.....	417
Abbreviations and Acronyms.....	443
Terminology.....	449
Appendix A – Specifications.....	461
Appendix B – Torques.....	469
Appendix C – Special Service Tools.....	479

---



## Foreword

Navistar, Inc. is committed to continuous research and development to improve products and introduce technological advances. Procedures, specifications, and parts defined in published technical service literature may be altered.

This *Engine Service Manual* provides a general sequence of procedures for out-of-chassis engine overhaul (removal, inspection, and installation). For in-chassis service of parts and assemblies, the sequence may vary.

**NOTE: Photo illustrations identify specific parts or assemblies that support text and procedures; other areas in a photo illustration may not be exact.**

See vehicle manuals and Technical Service Information (TSI) bulletins for additional information.

## Technical Service Literature

1171971R1	<i>MaxxForce® 7 Engine Operation and Maintenance Manual</i>
0000002383	<i>MaxxForce® 7 (EPA 10) with HD-OBD Engine Service Manual</i>
0000001681	<i>MaxxForce® 7 (EPA 10) with HD-OBD Engine Diagnostic Manual</i>
0000003382	<i>MaxxForce® 7 (EPA 10) with HD-OBD Hard Start and No Start Diagnostic Form</i>
0000003381	<i>MaxxForce® 7 (EPA 10) with HD-OBD Performance Diagnostic Form</i>
0000003201	<i>MaxxForce® 7 (EPA 10) with HD-OBD Engine Wiring Schematic Form</i>

Technical Service Literature is revised periodically. If a technical publication is ordered, the latest revision will be supplied.

To order technical service literature, contact your International® dealer.

All marks are trademarks of their respective owners.

## Service Diagnosis

Service diagnosis is an investigative procedure that must be followed to find and correct an engine application problem or an engine problem.

If the problem is engine application, see specific vehicle manuals for further diagnostic information.

If the problem is the engine, see specific *Engine Diagnostic Manual* for further diagnostic information.

### Prerequisites for Effective Diagnosis

- Availability of gauges, diagnostic test equipment, and diagnostic software.
- Availability of current information for engine application and engine systems
- Knowledge of the principles of operation for engine application and engine systems
- Knowledge to understand and do procedures in diagnostic and service publications

### Technical Service Literature required for Effective Diagnosis

- *Engine Service Manual*
  - *Engine Diagnostic Manual*
  - Diagnostics Forms
  - Electronic Control Systems Diagnostics Forms
  - Service Bulletins
-

## Safety Information

This manual provides general and specific service procedures essential for reliable engine operation and your safety. Since many variations in procedures, tools, and service parts are involved, advice for all possible safety conditions and hazards cannot be stated.

Read safety instructions before doing any service and test procedures for the engine or vehicle. See related application manuals for more information.

Disregard for Safety Instructions, Warnings, Cautions, and Notes in this manual can lead to injury, death or damage to the engine or vehicle.

### SAFETY TERMINOLOGY

Three terms are used to stress your safety and safe operation of the engine: Warning, Caution, and Note

**Warning:** A warning describes actions necessary to prevent or eliminate conditions, hazards, and unsafe practices that can cause personal injury or death.

**Caution:** A caution describes actions necessary to prevent or eliminate conditions that can cause damage to the engine or vehicle.

**Note:** A note describes actions necessary for correct, efficient engine operation.

### SAFETY INSTRUCTIONS

#### Vehicle

- Make sure the vehicle is in neutral, the parking brake is set, and the wheels are blocked before doing any work or diagnostic procedures on the engine or vehicle.

#### Work area

- Keep work area clean, dry, and organized.
- Keep tools and parts off the floor.
- Make sure the work area is ventilated and well lit.
- Make sure a First Aid Kit is available.

#### Safety equipment

- Use correct lifting devices.
- Use safety blocks and stands.

#### Protective measures

- Wear protective glasses and safety shoes.

- Wear appropriate hearing protection.
- Wear correct work clothing.
- Do not wear rings, watches, or other jewelry.
- Restrain long hair.

#### Fire prevention

- Make sure charged fire extinguishers are in the work area.

**NOTE: Check the classification of each fire extinguisher to ensure that the following fire types can be extinguished.**

1. Type A — Wood, paper, textiles, and rubbish
2. Type B — Flammable liquids
3. Type C — Electrical equipment

#### Batteries

Batteries produce highly flammable gas during and after charging.

- Always disconnect the main negative battery cable first.
- Always connect the main negative battery cable last.
- Avoid leaning over batteries.
- Protect your eyes.
- Do not expose batteries to open flames or sparks.
- Do not smoke in workplace.

#### Compressed air

- Limit shop air pressure for blow gun to 207 kPa (30 psi).
- Use approved equipment.
- Do not direct air at body or clothing.
- Wear safety glasses or goggles.
- Wear hearing protection.
- Use shielding to protect others in the work area.

#### Tools

- Make sure all tools are in good condition.
- Make sure all standard electrical tools are grounded.

- Check for frayed power cords before using power tools.

**Fluids under pressure**

- Use extreme caution when working on systems under pressure.
- Follow approved procedures only.

**Fuel**

- Do not over fill the fuel tank. Over fill creates a fire hazard.

- Do not smoke in the work area.
- Do not refuel the tank when the engine is running.

**Removal of tools, parts, and equipment**

- Reinstall all safety guards, shields, and covers after servicing the engine.
  - Make sure all tools, parts, and service equipment are removed from the engine and vehicle after all work is done.
-

---

## Table of Contents

Engine Identification.....	7
Engine Serial Number.....	7
Emission Label.....	7
Engine Accessories.....	7
Engine Description.....	8
Standard Features.....	9
Optional Features.....	10
Thermal Management Valve (TMV).....	10
Chassis-mounted Features.....	10
Engine Components.....	11
Air Management System.....	16
Air Management Components and Air Flow.....	16
Air Flow.....	17
Charge Air Cooler (CAC).....	17
Charge Air Cooler Outlet Temperature (CACOT) Sensor.....	17
Dual Turbocharger Assembly.....	19
High-pressure Turbocharger.....	20
Turbocharger 1 Compressor Outlet Temperature (TC1COT) Sensor.....	20
Thermal Management Valve (TMV) (optional).....	20
Low-pressure Turbocharger.....	20
Turbocharger 1 Wastegate Control (TC1WC) Solenoid.....	20
Exhaust Gas Recirculation (EGR) System.....	21
EGR Flow.....	21
EGR Control Valve and Position Sensor.....	22
Engine Throttle Valve (ETV) and Position Sensor.....	23
Aftertreatment (AFT) System.....	24
AFT Control System.....	24
Sensors.....	24
Diesel Oxidation Catalyst (DOC).....	24
Diesel Particulate Filter (DPF).....	24
AFT Conditions and Responses.....	24
Fuel System.....	25
Fuel System Components.....	25
High-pressure Fuel System.....	26
High-pressure Fuel Pump (HPFP) Assembly.....	26
Internal Transfer Pump (ITP).....	26
Fuel Pressure Control Valve (FPCV).....	26
Fuel Volume Control Valve (FVCV).....	27
Fuel Rail Pressure (FRP) Sensor.....	27
High-pressure Piezo Common Rail (HPCR) System.....	27
Return Fuel System.....	27
Low-pressure Fuel System.....	29
Fuel Pump.....	29
Primary Fuel Filter.....	29

---

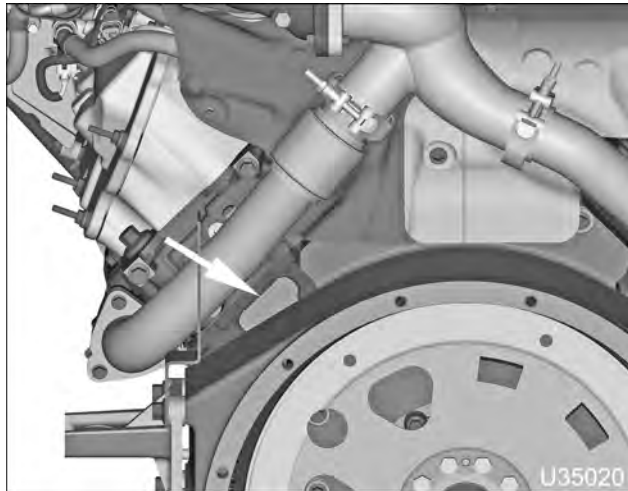
Secondary Fuel Filter.....	29
Fuel Cooler.....	29
Fault Detection/Management.....	29
Engine Lubrication System.....	30
Lubrication System Components and Oil Flow.....	30
Cooling System.....	32
Cooling System Components and Flow.....	32
Water Pump.....	32
Front Crankcase Cover Flow.....	33
Thermostats.....	33
Deaeration Tank.....	33
Radiator Shutters (220 Horsepower only).....	33
Fuel Coolant Valve (FCV).....	33
Engine Speed Position System.....	34
Electronic Control System.....	35
Electronic Control System Components.....	35
Operation and Function.....	37
Reference Voltage (VREF).....	37
Signal Conditioner.....	37
Microprocessor.....	37
Microprocessor Memory.....	37
Flash Memory.....	37
RAM.....	37
Engine Fan Control (EFC).....	38
Inlet Air Heater (IAH).....	38
Actuator Control.....	38
Actuators.....	38
H-Bridge Circuit.....	38
Exhaust Gas Recirculation (EGR) Valve and Control.....	38
ETV and Engine Throttle Position Sensor.....	39
Engine and Vehicle Sensors.....	39
Thermistor Sensors.....	39
Variable Capacitance Sensors.....	40
Micro Strain Gauge (MSG) Sensor.....	40
Magnetic Pickup Sensors.....	41
Potentiometer.....	41
Switches.....	42
Inlet Air Heater (IAH) System.....	43

---



## Engine Identification

### Engine Serial Number



**Figure 1 Engine Serial Number**

The engine serial number is stamped on the crankcase pad, on the rear left side below the cylinder head.

### Engine Serial Number Example

6.5HM2YXXXXXX

**6.5** – Engine family code

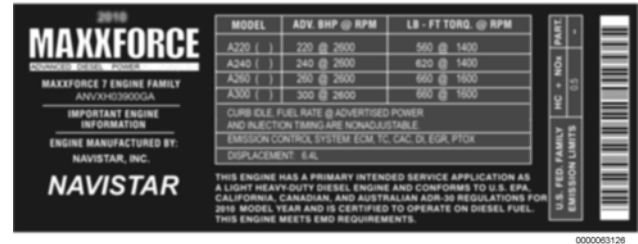
**H** – Diesel, turbocharged, air-intercooled and electronically controlled

**M2** – Motor truck

**Y** – United States, Huntsville

**7 digit suffix** – Sequence number

### Emission Label



**Figure 2 U.S. Environmental Protection Agency (EPA) Exhaust Emission Label (example)**

The U.S. Environmental Protection Agency (EPA) exhaust emission label is on top of the EGR manifold mixer on the front of the engine. The label includes the following:

- Advertised brake horsepower ratings
- Engine model code
- Service applications
- Emission family and control systems
- Year the engine was certified to meet EPA emission standards

### Engine Accessories

The following engine accessories may have manufacturers' labels or identification plates:

- Air compressor
- Air conditioning compressor
- Alternator
- Cooling fan clutch
- Power steering pump
- Starter motor

Labels or identification plates include information and specifications helpful to vehicle operators and technicians.

**Engine Description****MaxxForce® 7 Features and Specifications**

---

Engine configuration	4 stroke, V8 diesel
Displacement	6.4 liters (389 in <sup>3</sup> )
Bore (sleeve diameter)	98.2 mm (3.87 in)
Stroke	105 mm (4.134 in)
Compression ratio	16.5:1
Aspiration	Dual Turbocharger and Charge Air Cooled (CAC)
Rated power @ rpm	See EPA exhaust emission label
Peak torque @ rpm	See EPA exhaust emission label
Engine rotation (facing flywheel)	Counterclockwise
Combustion system	Direct injection, turbocharged advanced EGR
Fuel system	Direct injection, common rail
Cooling system capacity (engine only)	10.23 liters (10.8 quarts US)
Lube system capacity (including filter)	18.9 liters (20 quarts US)
Lube system capacity (overhaul only, with filter)	19.9 liters (21 quarts US)
Firing order	1-2-7-3-4-5-6-8

---

---

### Standard Features

The MaxxForce® 7 is a V8 engine with a displacement of 6.4 liters (389 cubic inches).

The electronic governor controls the engine rpm within a safe and stable operating range for ideal performance. A low-idle governor prevents the engine rpm from dropping below a stable speed to prevent stalling when various loads are demanded on the engine. A high-idle governor prevents the engine rpm from going above a safe speed that would cause internal damage to the engine.

The cylinder heads have four valves per cylinder. Each fuel injector is centrally located between the four valves and directs fuel over the piston bowl for improved performance and reduced emissions.

The camshaft is supported by five bushings pressed into the crankcase. The camshaft is crankshaft-driven and thrust is controlled by a plate mounted behind the rear bulkhead.

The overhead valve train includes hydraulic roller cam followers, push rods, rocker arms, and valve bridges to open the dual intake and exhaust valves.

The crankcase is composed of two major matching components. The upper crankcase houses the cylinders, main bearing saddles, and oil and coolant passages. Cast or machined. The lower crankcase consists of a structural plate with the main bearing caps machined into it for improved load retention and alignment.

The crankshaft is supported by five main bearings, with fore and aft thrust controlled at the upper half of the fourth main bearing. Two connecting rods are attached to each crankshaft rod journal and are offset to minimize vibration. Piston pins are free-floating, allowing the pins free, lateral movement within the connecting rod as well as the piston. Piston pins are held in place with retaining rings.

One-piece aluminum-alloy pistons are fitted with one keystone ring, one rectangular intermediate compression ring, and a two-piece oil control ring. The combustion bowl is located in the piston crown to reduce emissions. All pistons are mated to fractured cap joint connecting rods.

The Crankshaft Position (CKP) sensor and Camshaft Position (CMP) sensor are used by the Engine Control Module (ECM) to calculate rpm, fuel timing, fuel quantity, and duration of fuel injection.

The Exhaust Gas Recirculation (EGR) system includes an EGR valve, Intake Air Heater (IAH), and Engine Throttle Valve (ETV). The EGR valve assembly is mounted on the manifold mixer on the front top of the engine. The ETV is installed on the Intake Air Heater (IAH) mounted on the manifold mixer.

A gerotor lube oil pump, mounted on the front crankcase bulkhead, is driven by the crankshaft to supply pressurized oil to engine components. All MaxxForce® 7 engines use an engine oil cooler and spin-on oil filter. The oil filter is located at the lower driver-side corner of the engine where there is an integrated filter header to the cast-aluminum oil pan.

An open crankcase breather system draws crankcase vapors through a breather element. The breather element coalesces (separates) and oil migrates towards the low point in the housing which then gets returned back to crankcase. Clean blow-by gas (vapors) exit the breather cover and vents out to atmosphere.

The high-pressure fuel system includes a High-pressure Fuel Pump (HPFP), high-pressure common rails, and fuel injectors. The ECM electronically controls the injectors, which allows multiple injections and more precise fuel delivery to improve combustion, emissions, and cold-start performance.

The low-pressure fuel system uses an electric fuel lift pump to draw fuel from the fuel tank(s) to the engine. This eliminates the need for a hand primer. The pump is located in the primary and secondary fuel module mounted over the left valve cover. The primary fuel filter assembly includes a Water in Fuel (WIF) sensor and an optional fuel heater. Water and solids are separated from the fuel and the water is collected in the water separator bowl. The instrument panel WIF lamp illuminates and 'Water in Fuel' message is displayed when water needs to be drained. A manual drain valve is provided in the water separator bowl to drain water out. Fuel is discharged to the secondary fuel filter. The secondary fuel filter assembly is pressure-regulated and incorporates an air bleed orifice to automatically purge air introduced into the system.

A two-stage turbocharger provides boost air pressure to the engine for various speed and load conditions. An electronically controlled solenoid modulates boost air to a wastegate actuator.

---

The EGR system circulates cooled exhaust into the intake air stream in the intake manifold. This cools the combustion process and reduces the formation of NO<sub>x</sub> engine emissions.

Diamond Logic<sup>®</sup> engine control is a single electronic control unit that monitors and controls the engine and chassis components.

A relay-controlled grid heater is used to aid cold, ambient starting.

A coolant heater raises the temperature of the coolant surrounding the cylinders for improved performance during cold weather startups.

### **Optional Features**

An air compressor is available for applications that require air brakes or air suspension.

An optional fuel heater is available and installed in the primary fuel filter assembly. It warms the supply fuel to prevent waxing during cold conditions where the fuel filter module's internal fuel passages between the

primary and secondary filter do not provide sufficient warming.

### **Thermal Management Valve (TMV)**

A TMV is available to enable engine braking and to reduce the amount of time needed to bring the engine to operating temperature.

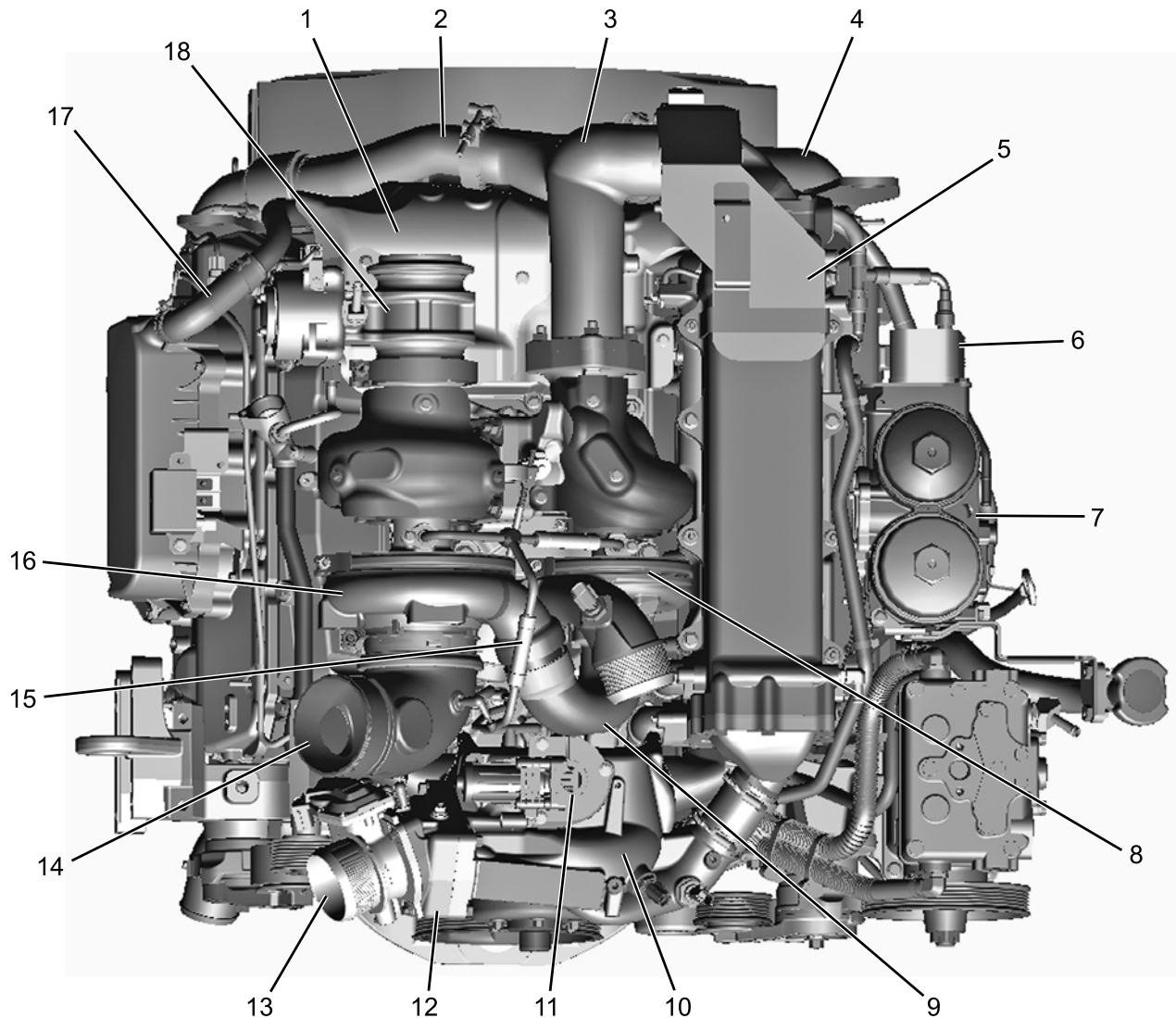
### **Chassis-mounted Features**

A Charge Air Cooler (CAC) is an air-to-air heat exchanger which increases the density of the air charge.

The Aftertreatment System processes engine exhaust so that it meets emission requirements at the tailpipe.

- The oxidation catalyst removes oxygen and hydrocarbons in the exhaust stream.
  - The Diesel Particulate Filter (DPF) captures and removes particulates in the exhaust stream.
-

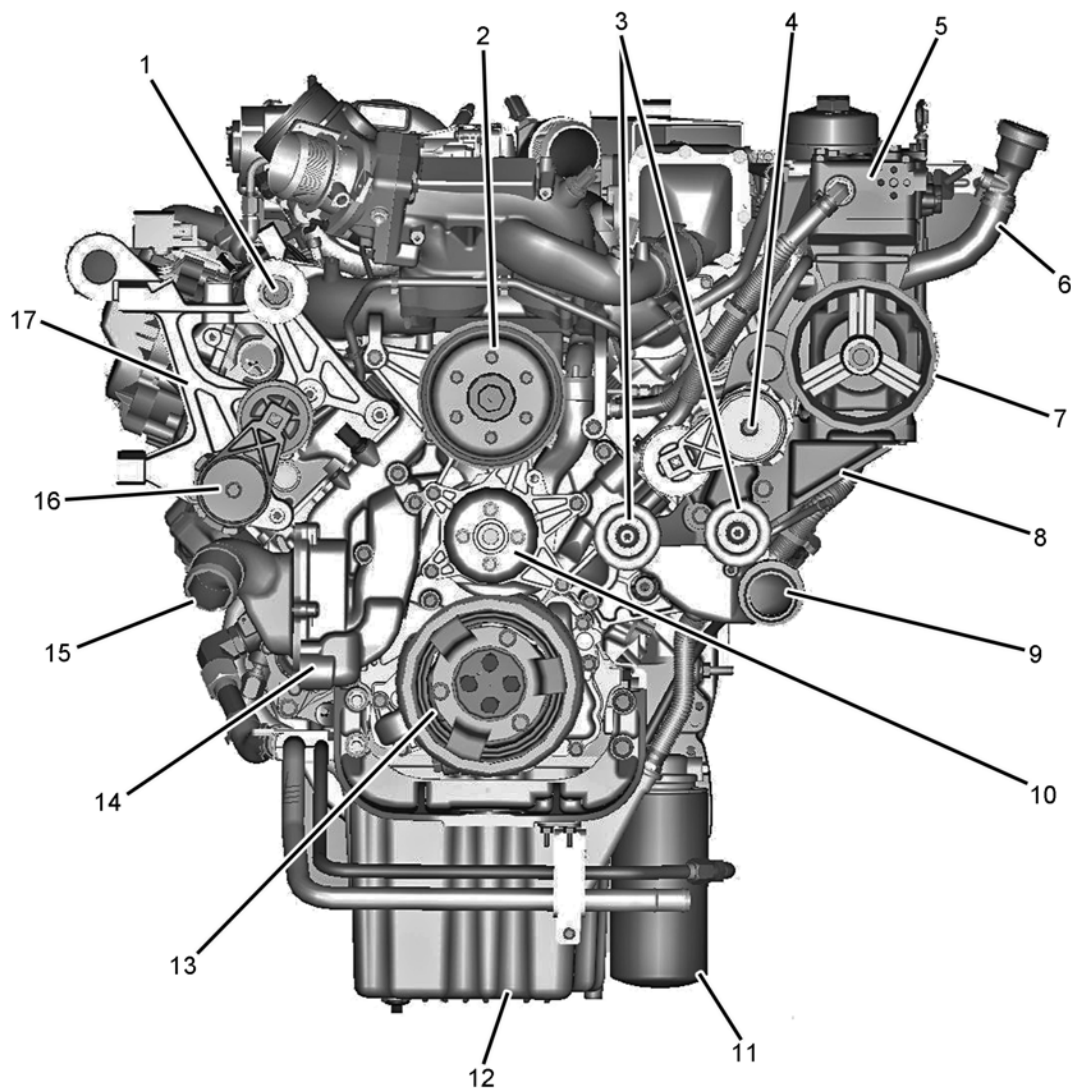
## Engine Components



0000063431

**Figure 3 Top**

- |  |  |   |
|--|--|---|
| 1. Pump cover heat shield (right)      | 9. Crossover tube                      | 17. Draft tube                                |
| 2. Right exhaust tube assembly         | 10. Manifold mixer                     | 18. Thermal Management Valve (TMV) (optional) |
| 3. Exhaust turbocharger inlet manifold | 11. EGR valve                          |   |
| 4. Left exhaust tube assembly          | 12. Inlet Air Heater (IAH)             |   |
| 5. EGR cooler                          | 13. Engine Throttle Valve (ETV)        |   |
| 6. Fuel cooler                         | 14. Turbocharger inlet duct assembly   |   |
| 7. Fuel filter module housing          | 15. Turbocharger oil supply tube       |   |
| 8. High-pressure turbocharger assembly | 16. Low-pressure turbocharger assembly |   |



0000061234

**Figure 4 Front**

- |   |                                     |   |
|---|-------------------------------------|---|
| 1. Grooved idler pulley                             | 7. Air compressor pulley            | 14. Front crankcase cover (heater return) |
| 2. Fan pulley                                       | 8. Air compressor bracket           | 15. Thermostat housing (coolant outlet)   |
| 3. Flat idler pulley (2)                            | 9. Coolant inlet                    | 16. Belt tensioner                        |
| 4. Belt tensioner (if equipped with air compressor) | 10. Water pump pulley               | 17. Alternator bracket                    |
| 5. Air compressor                                   | 11. Oil filter assembly             |   |
| 6. Oil fill tube assembly                           | 12. Oil pan                         |   |
|   | 13. PTO air compressor front pulley |   |