DIAGNOSTIC MANUAL

N13 Engine with SCR

Navistar, Inc.

2701 Navistar Drive, Lisle, IL 60532 USA

000002161
Revision 10
October 2014

TABLE OF CONTENTS

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.

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

This manual includes necessary information and specifications for technicians to maintain Navistar® diesel engines. See vehicle manuals and Technical Service Information (TSI) bulletins for additional information.

Technical Service Literature

Navistar® N13 with SCR *Engine Operation and Maintenance Manual*

Navistar® N13 with SCR *Engine Service Manual*

Navistar® N13 with SCR Engine and Aftertreatment Wiring Schematic Form

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

NOTE: To order technical service literature, contact your International dealer.

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 and diagnostic test equipment
- 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
- Engine Wiring Schematic Form
- Service Bulletins

Safety Information

This manual provides general and specific maintenance 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

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 safety glasses and shoes.
- Wear correct hearing protection.
- Wear cotton work clothing.
- Wear sleeved heat protective gloves.
- Do not wear rings, watches or other jewelry.
- Restrain long hair.

Vehicle

- Make sure the vehicle is in neutral, the parking brake is set, and the wheels are blocked before servicing engine.

- Clear the area before starting the engine.

Engine

- The engine should be operated or serviced only by qualified individuals.
- Provide necessary ventilation when operating engine in a closed area.
- Keep combustible material away from engine exhaust system and exhaust manifolds.
- Install all shields, guards, and access covers before operating engine.
- Do not run engine with unprotected air inlets or exhaust openings. If unavoidable for service reasons, put protective screens over all openings before servicing engine.
- Shut engine off and relieve all pressure in the system before removing panels, housing covers, and caps.
- If an engine is not safe to operate, tag the engine and ignition key.

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

- 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

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

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

SCR Component Locator

SCR Switchback Assembly

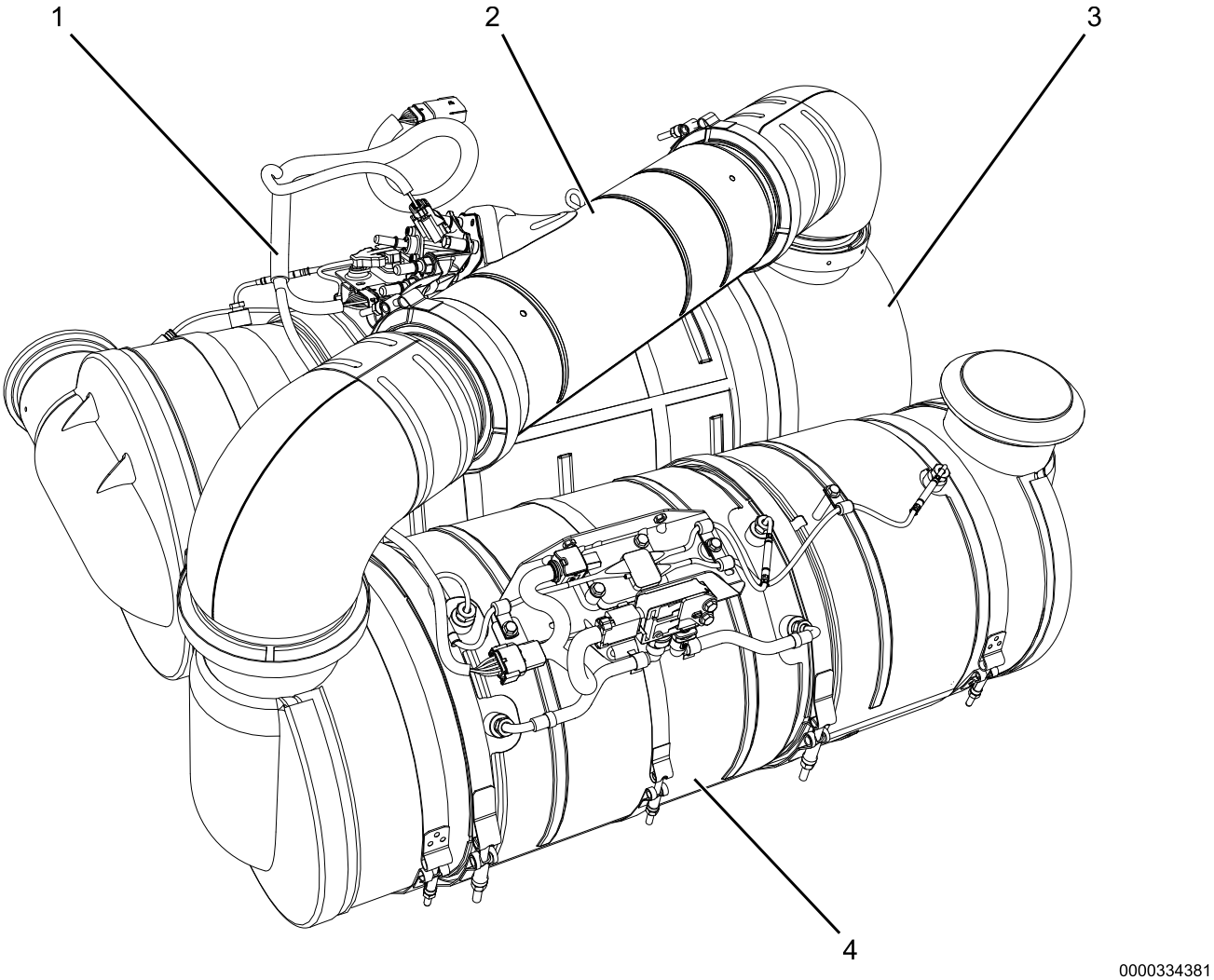

Figure 1 SCR Switchback Assembly

1. Exhaust Jumper Harness
2. Decomposition Reactor Tube
3. Selective Catalyst Reduction (SCR) assembly
4. Diesel Particular Filter (DPF) assembly

DPF Components

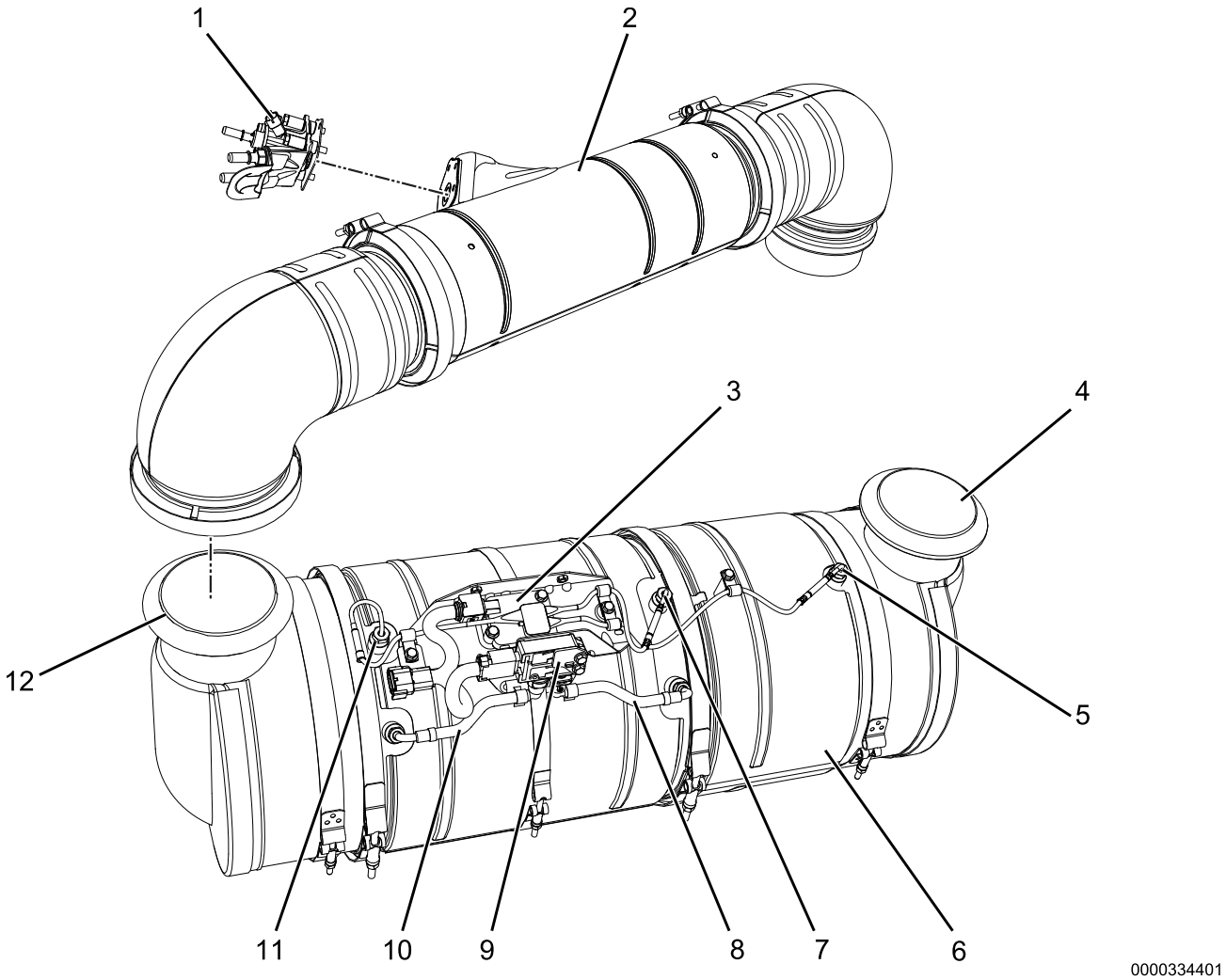

Figure 2 DPF Components

1. Diesel Exhaust Fluid Doser Valve (DEFDV)
2. Decomposition Reactor Tube
3. Diesel Oxidation Catalyst (DOC) / DPF Diesel Particulate Filter (DPF) Temperature sensor module
4. DOC Intake
5. Diesel Oxidation Catalyst Intake Temperature (DOCIT) sensor
6. Diesel Particulate Filter (DPF) assembly
7. Diesel Particulate Filter Inlet Temperature (DPFIT) sensor
8. High Pressure Tube
9. Diesel Particulate Filter Differential Pressure (DPFDP) / outlet pressure sensor module
10. Low Pressure Tube
11. Diesel Particulate Filter Outlet Temperature (DPFOT) sensor
12. DPF Outlet

SCR Components

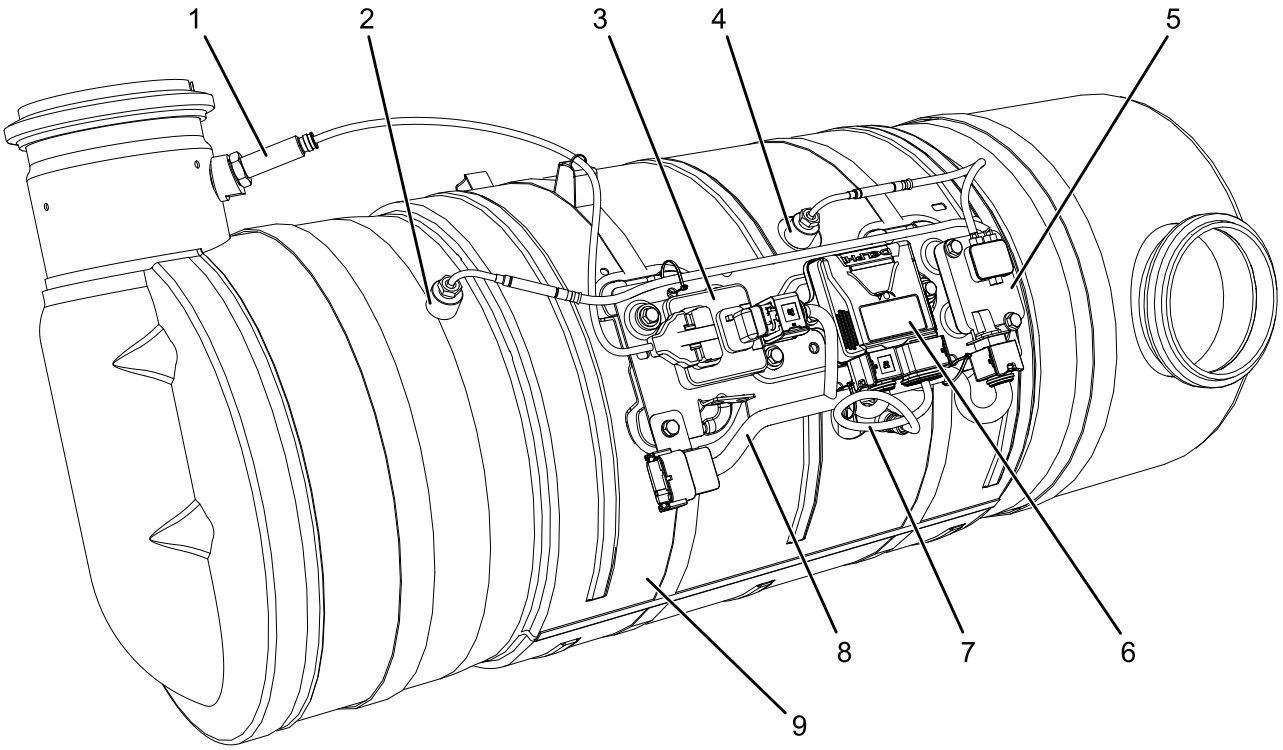

Figure 3 SCR Components

1. NOx Out sensor
2. Selective Catalyst Reduction Outlet Temperature (SCROT) sensor
3. NOx Sensor Module
4. Selective Catalyst Reduction Inlet Temperature (SCRIT) sensor
5. Selective Catalyst Reduction (SCR) temperature sensor module
6. Ammonia (NH3) sensor module
7. Ammonia (NH3) sensor
8. SCR sensor jumper harness
9. Selective Catalyst Reduction (SCR) assembly

Table of Contents

Engine Identification

Engine Serial Number

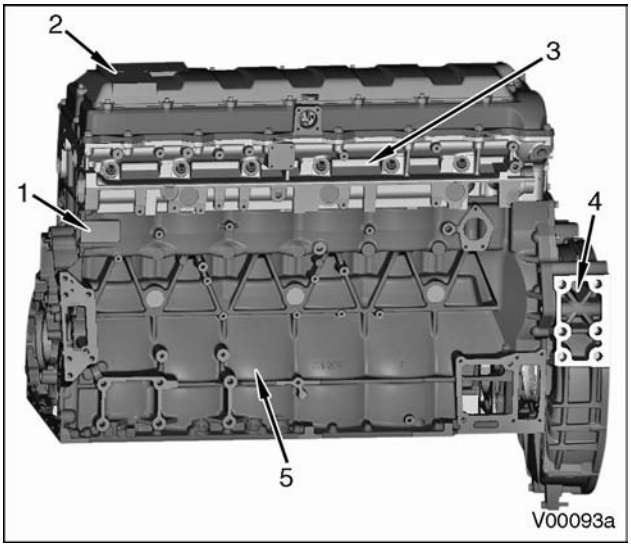

Figure 4 Engine serial number

1. Engine Serial Number (ESN) location
2. Engine emission label
3. Cylinder head
4. Flywheel housing
5. Crankcase

The Engine Serial Number (ESN) is located on the front of the crankcase (left side), below the cylinder head.

Engine Serial Number Examples

Navistar® N13: 126HM2YXXXXXXX

Engine Serial Number Codes

126 – N13 with SCR engines
H – Diesel, turbocharged, Charge Air Cooler (CAC), and electronically controlled
M2 – Motor truck
Y – Huntsville, Alabama
7 digit suffix – Engine serial number sequence

Engine Emission Label

Figure 5 2010 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 valve cover (front left side). The EPA label typically includes the following:

- Model year
- Engine family, model, and displacement
- Advertised brake horsepower and torque rating
- Emission family and control systems
- Valve lash specifications
- Engine Serial Number (ESN)
- EPA, Onboard Diagnostics (OBD), EURO, and reserved fields for specific applications

Engine Accessory Labels and Identification Plates

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

- Aftertreatment Control Module (ACM)
- Aftertreatment Purge Air Valve (AFTPAV)
- Air compressor
- Air conditioning compressor
- Alternator
- Cooling fan clutch
- Diesel Oxidation Catalyst (DOC)
- Diesel Particulate Filter (DPF)
- Engine Control Module (ECM)
- High Pressure (HP) fuel pump
- Power steering pump
- Selective Catalyst Reduction (SCR) catalyst
- Starter motor
- Turbochargers

Engine Specifications

Navistar® N13 Diesel Engine	
Engine Configuration	4 stroke, inline six cylinder diesel
Advertised brake horsepower @ rpm	
• Navistar® N13	See EPA exhaust emission label
Peak torque @ rpm	
• Navistar® N13	See EPA exhaust emission label
Displacement	
• Navistar® N13	12.4 L (758 in³)
Compression ratio	
• Navistar® N13	17.0:1
Stroke	
• Navistar® N13	166 mm (6.54 in)
Bore (sleeve diameter)	
• Navistar® N13	126 mm (4.96 in)
Total engine weight (dry weight without trim or accessories)	
• Navistar® N13	1087 kgs (2392 lbs)

Firing order	1-5-3-6-2-4
Engine rotation direction (facing flywheel)	Counterclockwise
Aspiration	Dual turbocharged and charge air cooled
Combustion system	Direct injection turbocharged
Fuel system	High-pressure common rail
Lube system capacity (including filter)	40 L (42 qts)
• Navistar® N13	
Lube system capacity (overhaul only, with filter)	44 L (46 qts)
• Navistar® N13	
Engine oil pressure at operating temperature with SAE 15W-40 oil	
• Low idle	69 kPa (10 psi) min.
• High idle	276 - 483 kPa (40 - 70 psi)
Idle speed (no load)	600 rpm, nominal
Thermostat operating temperature	
• Primary	83°C - 95°C (181°F - 203°F)
• Secondary	87°C - 102°C (189°F - 216°F)

Heavy Duty On Board Diagnostics (HD-OBD)

The EPA has added new regulations for 2010 to reduce heavy duty vehicle emissions. The HD-OBD system is designed specifically for electronically controlled heavy duty engines. The goal for HD-OBD regulation is to keep engine emissions in specification for as long as a given vehicle is in use.

HD-OBD is legislated to be implemented in three phases:

- 2010: First engine for each Original Equipment Manufacture (OEM) becomes fully certified.
  - The lead engine is determined by a legislated equation based on projected sales volume & useful life of the engine.
  - For Navistar®, this is the EPA 2010® N13 engine.
- 2013: One engine in each engine family becomes fully certified.
  - This will be the largest step of the three phases.
- 2016: All engines must be fully HD-OBD certified.

The HD-OBD system continuously monitors for proper engine operation, and will alert the vehicle operator to emission-related faults using the Malfunction Indicator Lamp (MIL).

The MIL is installed in the Electronic Instrument Cluster. When a detected emissions fault occurs, the MIL will be illuminated. Diagnostic information is also stored in the Engine Control Module (ECM), and may be accessed by the technician for diagnosis and repair of the malfunction. Diagnostic information is accessed by connecting the Electronic Service Tool (EST) to the in-cab Diagnostic Connector.

Engine Description

The Navistar® N13 diesel engine is designed for increased durability, reliability, and ease of maintenance.

The cylinder head has four valves per cylinder for increased airflow. The overhead valve train includes rocker arms and valve bridges to operate the four valves. The fuel injector is centrally located between the four valves, directing fuel over the piston for improved performance and reduced emissions.

The overhead camshaft is supported by seven bearings in the cylinder head. The camshaft gear is driven from the rear of the engine. The overhead valve train includes roller rocker arms and dual valves that open, using a valve bridge.

Navistar® N13 engines use one-piece steel pistons. All pistons use an offset piston axis and centered combustion bowls. Crown markings show correct piston orientation in the crankcase.

The one-piece crankcase uses replaceable wet cylinder liners that are sealed by dual crevice seals.

The crankshaft has seven main bearings with fore and aft thrust controlled at the sixth bearing. One fractured cap connecting rod is attached at each crankshaft journal. The piston pin moves freely inside the connecting rod and piston. Piston pin retaining rings secure the piston pin in the piston. The rear oil seal carrier is part of the flywheel housing.

A gerotor lube oil pump is mounted behind the front cover and is driven by the crankshaft. Pressurized oil is supplied to various engine components. All Navistar® N13 engines also use an engine oil cooler and a cartridge-style engine oil filter, which are installed in the engine lube oil module.

The low-pressure fuel pump draws fuel from the fuel tank(s) through a chassis mounted filter/water separator. The low-pressure fuel pump provides fuel for the engine mounted fuel module. Conditioned low-pressure fuel is supplied from the engine mounted fuel module to the high-pressure fuel pump, Inlet Air Heater fuel solenoid, and the AFT fuel doser module.

The high-pressure fuel system is a direct fuel injected common-rail system. The common-rail includes a high-pressure fuel pump, two fuel rail supply lines, fuel rail, six fuel injectors, and pressure relief valve.

The fuel injectors are installed in the cylinder head under the valve cover and are electronically actuated by the ECM.

Navistar® N13 engines use a dual stage, fixed geometry turbocharger assembly. Each stage includes a Charge Air Cooler (CAC). The High Pressure (HP) turbocharger includes a pneumatically operated wastegate. The Low Pressure Charge Air Cooler (LPCAC) is mounted on the lower right side of the engine, and uses the engine cooling system to regulate charge air temperatures. The High Pressure Charge Air Cooler (HPCAC) is mounted in front of the engine cooling package. The HPCAC is an air-to-air type cooler, and requires no connections to the engine's cooling system.

The Exhaust Gas Recirculation (EGR) system circulates cooled exhaust into the air inlet duct. The dual stage EGR cooler provides regulated cooling of the EGR gases before entering the air inlet duct. This cools the combustion process, and reduces Nitrogen Oxides (NO_x) emissions.

The open crankcase breather system uses a centrifugal Crankcase Oil Separator (CCOS) to return oil mist to the crankcase, and vent the cleaned crankcase gasses to the atmosphere. The CCOS is part of the oil module. The breather system has been redesigned, and uses no crankcase breather filter or external piping. Blowby gases enter the CCOS through the side of the crankcase.

The Inlet Air Heater system warms the incoming air supply during engine cranking and several minutes after cold engine start up to help reduce emissions.

The Navistar® Engine Brake by Jacobs® is optional for Navistar® N13 engine displacements. The engine brake is a compression release system that provides additional vehicle braking performance. The operator can control the engine brake for different operating conditions.

Optional Equipment

Optional cold climate features available are an oil pan heater and a coolant heater. Both heaters use an electric element to warm engine fluids in cold weather.

The oil pan heater warms engine oil to ensure optimum oil flow to engine components.

The coolant heater warms the engine coolant surrounding the cylinders. Warmed engine coolant increases fuel economy and aids start-up in cold weather.

Chassis Mounted Equipment

- The chassis mounted fuel filter/water separator removes a majority of the water and foreign particles that may enter the fuel system from the supply tank(s). This filter works with the engine mounted fuel module to eliminate foreign matter and moisture from the fuel before entering the fuel injection system.
- The Low Temperature Radiator (LTR) regulates the temperature of the LPCAC and the low-temperature stage of the EGR cooler. The LTR is mounted in front of the radiator cooling package, and requires connections to the engine cooling system.
- The HPCAC lowers temperature after the air is compressed by the turbochargers, and has no connections to the engine cooling system. The HPCAC is an air-to-air cooler. The HPCAC is mounted in front of the radiator cooling package.

- The Diesel Oxidation Catalyst (DOC) oxidizes hydrocarbons and carbon monoxide, provides heat for exhaust system warm-up, aids in temperature management for the Diesel Particulate Filter (DPF), and oxidizes NO into NO_2 for passive DPF regeneration. The DOC is monitored by the Aftertreatment Control Module (ACM) using one Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor positioned at the DOC inlet, and one Diesel Particulate Filter Inlet Temperature (DPFIT) sensor positioned at the DPF inlet.
- The DPF temporarily stores carbon-based particulates, oxidizes stored particulates, stores non-combustible ash, and provides required exhaust back pressure for proper engine performance. The DPF is monitored by the ACM using the DOC / DPF temperature sensor module installed on the DPF, and the Diesel Particulate Filter Differential Pressure (DPFDP) / outlet pressure sensor installed on or near the DPF.
- The Selective Catalyst Reduction (SCR) catalyst oxidizes Nitrogen Oxides (NOx) into Nitrogen gas and water. The SCR catalyst is monitored by the ACM using a NOx IN sensor module installed after the HP turbocharger outlet pipe, and a NOx OUT sensor module installed after the outlet of the SCR catalyst. An ammonia (NH_3) sensor provides feedback to the ACM related to Diesel Exhaust Fluid (DEF) injection into the SCR catalyst.

Air Management System

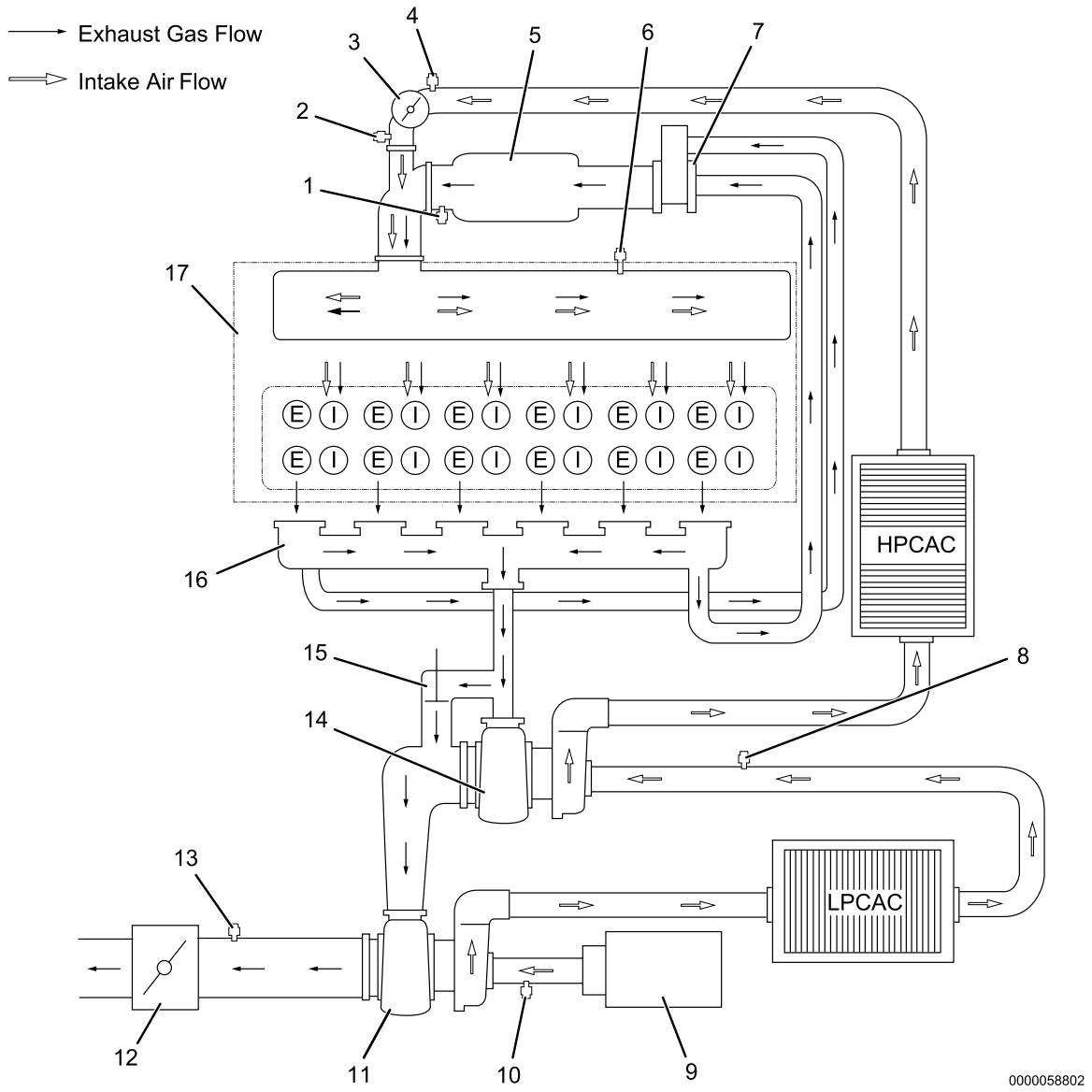

Figure 6 Air Management System

1. Exhaust Gas Recirculation Temperature (EGRT) sensor
2. Intake Manifold Pressure (IMP) sensor
3. Engine Throttle Valve (ETV)
4. Charge Air Cooler Outlet Temperature (CACOT) Sensor
5. EGR cooler
6. Intake Manifold Temperature (IMT) sensor
7. EGR valve
8. Turbocharger 2 Compressor Inlet Sensor (TC2IS)
9. Air filter housing
10. Humidity Sensor (HS) / Inlet Air Temperature (IAT) sensor
11. Low Pressure (LP) turbocharger
12. Exhaust Back Pressure Valve (EBPV)
13. Oxygen Sensor (O_2S)
14. High Pressure (HP) turbocharger
15. HP turbocharger wastegate
16. Exhaust manifold
17. Cylinder head

Airflow

Air flows through the air filter assembly and enters the Low-Pressure (LP) turbocharger. The LP turbocharger increases air pressure and temperature before entering the Low Pressure Charge Air Cooler (LPCAC). Cooled and compressed air then flows from the LPCAC into the High Pressure (HP) turbocharger (compressor inlet). Hot and highly compressed air flows from the HP turbocharger (compressor outlet) into the High Pressure Charge Air Cooler (HPCAC) where it is cooled, and into the intake throttle duct, and continues through the Engine Throttle Valve (ETV). The HP and LP turbochargers can increase pressures up to 345 kPa (50 psi).

If the Exhaust Gas Recirculation Valve (EGRV) is open, exhaust gases pass through the EGR cooler and into the intake throttle duct where it is mixed with filtered air. This mixture flows into the intake manifold, and then the cylinder head. The intake manifold is an integral part of the cylinder head casting.

During cold weather, the Inlet Air Heater system activates the heater element, vaporizing and igniting small quantities of fuel into the air inlet duct.

After combustion, exhaust gases exit through the cylinder head exhaust valves and ports. The exhaust gas is forced through the exhaust manifold where, depending on EGRV position, it is split between the EGR system and the exit path through the HP turbocharger, LP turbocharger, and Exhaust Back Pressure Valve (EBPV).

The EBPV is operated by the Air Control Valve (ACV), a pneumatic actuator. When the ACV is applied, the EBPV restricts flow and increases exhaust back pressure. Operation of the EBPV is controlled by the ECM using the ACV and the Turbocharger 1 Turbine Outlet Pressure (TC1TOP) sensor. When the EBPV is opened, exhaust back pressure is released.

Exhaust gases exiting the engine flow through the EBPV, then through the vehicle Aftertreatment (AFT) system, and out the exhaust tail pipe.