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2017 Ford E-350 Super Duty Service and Repair Manual

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Exhaust System - System Operation and Component Description

309-00D Exhaust System - 3.5L V6 PowerBoost (CN)	***2022 F-150***
Description and Operation	***Procedure revision date: 10/8/2020***

Sample

Exhaust System - System Operation and Component Description

System Operation

Catalyst And Exhaust Systems

The catalytic converter and exhaust systems work together to control the release of harmful engine exhaust emissions into the atmosphere. The engine exhaust gas consists mainly of nitrogen (N), carbon dioxide (CO_2) and water (H_2O). However, it also contains carbon monoxide (CO), nitrogen oxides (NO_x), hydrogen (H), and various unburned hydrocarbons (HCs). The major air pollutants of CO, NO_x, and HCs, and their emission into the atmosphere must be controlled.

The exhaust system generally consists of an exhaust manifold, a front exhaust pipe, a universal HO2S (heated oxygen sensor) , a rear exhaust pipe, a catalyst HO2S (heated oxygen sensor) , a muffler, and an exhaust tailpipe. The catalytic converter is typically installed between the front and rear exhaust pipes. Catalytic converter efficiency is monitored by the OBD (on-board diagnostic) system strategy in the PCM (powertrain control module) .

Only 2 heated oxygen sensors are used in an exhaust stream. The universal HO2S (heated oxygen sensor) is before the catalyst (universal HO2S11 or universal HO2S21) and used for primary fuel control while the rear HO2S (heated oxygen sensor) is after the catalyst (HO2S12 or HO2S22) and used to monitor catalyst efficiency.

Catalytic Converter

A catalyst is a material that remains unchanged when it initiates and increases the speed of a chemical reaction. A catalyst also enables a chemical reaction to occur at a lower temperature. The catalytic converter assists in controlling the concentration of exhaust gas products released to the atmosphere. It contains a catalyst in the form of a specially treated ceramic honeycomb structure saturated with catalytically active precious metals. As the exhaust gases come in contact with the catalyst, they are changed into mostly

conditions, high efficiency catalysts have significant oxygen storage. This makes the switching frequency of the rear HO2S (heated oxygen sensor) very slow and reduces the amplitude, which provides for a shorter signal length. As the catalyst efficiency deteriorates due to thermal and chemical deterioration, the catalyst ability to store oxygen declines. The post catalyst or downstream HO2S (heated oxygen sensor) signal begins to switch more rapidly with increasing amplitude and signal length. The predominant failure mode for high mileage catalysts is chemical deterioration (phosphorus deposits on the front brick of the catalyst) and thermal deterioration.

The catalyst monitor calculates the rear HO2S (heated oxygen sensor) signal lengths for 10 to 20 seconds during part throttle, closed loop fuel conditions after the engine is warmed up, the inferred catalyst temperature is within limits, and fuel tank vapor purge is disabled. The catalyst monitor is enabled for 10 to 20 seconds per drive cycle. When the catalyst monitor is active, the PCM (powertrain control module) commands a fixed fuel control routine. During monitor operation the rear HO2S (heated oxygen sensor) signal lengths are continually calculated. The calculated rear HO2S (heated oxygen sensor) signal length is then divided by a calibrated signal length, which has compensation for mass airflow. The calibrated signal length is based on the signal length of an HO2S (heated oxygen sensor) placed after a catalyst without a washcoat. An index ratio near 0.0 indicates high oxygen storage capacity and high HC (hydrocarbon) efficiency. An index ratio near 1.0 indicates low oxygen storage capacity and low HC (hydrocarbon) efficiency. If the actual index ratio exceeds the threshold index ratio, the catalyst is considered failed.

Inputs from the ECT (engine coolant temperature) sensor or the CHT (cylinder head temperature) sensor, the IAT (intake air temperature) sensor, MAF (mass air flow) sensor (if equipped), the CKP (crankshaft position) sensor, the TP (throttle position) sensor, and the vehicle speed sensors are required to enable the catalyst efficiency monitor.

Typical Monitor Entry Conditions:

- Minimum 330 seconds since start up at 21°C (70°F)
- Engine coolant temperature is between 76.6°C - 110°C (170°F - 230°F)
- Intake air temperature is between -7°C - 82°C (20°F - 180°F)
- Time since entering closed loop is 30 seconds
- Inferred rear HO2S (heated oxygen sensor) temperature of 482°C (900°F)
- EGR (exhaust gas recirculation) is between 1% and 12%
- Part throttle, maximum rate of change is 0.2 volts/0.050 sec
- Vehicle speed is between 8 and 112 km/h (5 and 70 MPH)
- Fuel level is greater than 15%
- First Airflow Cell

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threshold of 0.5 may be used at E10 (10% ethanol) and 0.9 may be used at E85 (85% ethanol). The thresholds are adjusted based on the percentage of alcohol in the fuel. Standard fuel may contain up to 10% ethanol.

The PCM (powertrain control module) calibration prevents the catalyst monitor from running on a new vehicle until 60 minutes of time has accumulated with the catalyst temperature greater than 426°C (800°F) or 483 km (300 miles) have accumulated. A replacement PCM (powertrain control module) or updated calibration does not prevent the catalyst monitor from running.

The MIL (malfunction indicator lamp) is activated after the first concern is detected. When a concern is detected after a KAM (keep alive memory) reset, the MIL (malfunction indicator lamp) is activated after 2 concecutive key cycles.

Integrated Air Fuel Catalyst Monitor

The integrated air fuel catalyst monitor is an on board strategy designed to monitor the oxygen storage capacity of the catalyst after a deceleration fuel shut off (DFSO) event. The monitor determines the amount of fuel needed to drive the catalyst to a rich condition when starting from an oxygen saturated, lean condition. The monitor is a measure of how much fuel is required to force the catalyst from a lean to a rich condition. The monitor runs during catalyst reactivation following a DFSO event. The monitor completes after approximately 3 DFSO monitoring events have occurred.

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Customer Symptom	Action
Start/Run/Move > Running > Failed Emissions Testing > Catalyst	GO to Pinpoint Test EM
Start/Run/Move > Odor > Chemical > Always	GO to Pinpoint Test HF

Pinpoint Tests

PINPOINT TEST EM : EMISSION COMPLIANCE

NOTE

Canada and some states or metropolitan areas in the United States require periodic emission, or inspection/maintenance tests. All Ford products are designed to pass these tests. If a Ford product fails the test, the most likely causes are:

- The engine or catalyst temperature are not warm and stabilized before the test.
- Excessive idling by the vehicle before the test.

Normal Operation and Fault Conditions

If any new emission components are installed, carry out the following steps before repeating the inspection/maintenance test procedure:

- Reset the KAM (keep alive memory) . Refer to Resetting The KAM (keep alive memory) .
- To relearn some basic adaptive learning (trim) values, run the engine at 2,500 RPM (revolutions per minute) for 1 minute and idle the engine for 2 minutes.

Sample

from the verification trip must be at least half of the baseline reading, or an average of 220 ppm or less.

- This method only gives a general idea of how much the ppm reading needs to be reduced in order for the vehicle to pass an inspection/maintenance test that calculates gpm. This test is not exact. Experience still has to be used to determine if the emission readings are reduced enough for the vehicle to pass the inspection/maintenance test.

Possible Sources

- Intake air system concern
- Exhaust system concern
- Fuel system concern
- Ignition system concern

Pinpoint Test Steps available in the on-line Workshop Manual.

PINPOINT TEST HF : CATALYST EFFICIENCY MONITOR AND EXHAUST SYSTEMS

Normal Operation and Fault Conditions

Refer to the DTC (diagnostic trouble code) Fault Trigger Conditions.

DTC Fault Trigger Conditions

DTC (diagnostic trouble code)	Description	Fault Trigger Condition
PCM (powertrain control module) P0420:00	Catalyst System Efficiency Below Threshold (Bank 1): No Sub Type Information	Sets when PCM (powertrain control module) detects the bank 1 catalyst system efficiency is below the acceptable threshold. Under normal closed loop fuel conditions, high efficiency catalysts have oxygen storage capability. As catalyst efficiency deteriorates, its ability to store oxygen declines. Refer to the Catalyst Efficiency Monitor description for additional information. Diagnose any base engine concerns. Refer to the appropriate 303-00 section, Engine System.
PCM (powertrain control module) P0430:00	Catalyst System Efficiency Below Threshold (Bank 2): No Sub Type Information	Sets when PCM (powertrain control module) detects the bank 2 catalyst system efficiency is below the acceptable threshold. Under normal closed loop fuel conditions, high efficiency catalysts have oxygen storage capability. As catalyst efficiency deteriorates, its ability to store oxygen declines. Refer to the Catalyst Efficiency Monitor description for additional information. Diagnose any base engine concerns. Refer to the appropriate 303-00 section, Engine System.

Sample

Exhaust System

309-00D Exhaust System - 3.5L V6 PowerBoost (CN)	***2022 F-150***
Diagnosis and Testing	***Procedure revision date: 10/12/2020***

Exhaust System

Global Customer Symptom Code (GCSC) Chart

Diagnostics in this manual assume a certain skill level and knowledge of Ford-specific diagnostic practices.

REFER to: Diagnostic Methods

(100-00 General Information, Description and Operation).

Global Customer Symptom Code Chart

Customer Symptom	Action
Fit/Finish/Body > Paint/Finish > Exhaust > Corrosion/Rust	GO to Pinpoint Test C
Start/Run/Move > Noise > Exhaust > Always	GO to Pinpoint Test D
Driving Performance > Lack/Loss of Power > Acceleration > Always	GO to Pinpoint Test A
Safe & Secure > Smoke/Odor > Exhaust > Hot	GO to Pinpoint Test B

Symptom Chart(s)

Symptom Chart - Exhaust System

NOTE

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- Restricted exhaust (possible frozen condensate in mufflers or exhaust actuator valves)

Visual Inspection and Pre-checks

- Inspect for loose, damaged, contaminated or incorrect components.

A1 CHECK THE EXHAUST SYSTEM FOR SIGNS OF DAMAGE

- Inspect the exhausts system aftertreatment components and associated sensors for damage.

Is damage to the aftertreatment components and associated sensors found?

Yes	INSTALL new components as necessary.

No	GO to A2

A2 CHECK THE EXHAUST SYSTEM FOR OBSTRUCTIONS OR RESTRICTED FLOW

- Inspect the exhausts system pipework for pinched or crushed components.

Is any flow restricting damage to the exhaust components seen?

Yes	INSTALL new components as necessary.

No	The condition may be intermittent. Advise the customer no repair is required.

PINPOINT TEST B : ODOUR FROM VEHICLE

NOTE

Aftertreatment components consist of some or all of the following: Catalytic Converters, Gasoline Particulate Filters, Diesel Particulate Filters, Selective Catalytic Reduction Catalysts.

Normal Operation and Fault Conditions

REFER to: Exhaust System - Overview(309-00B Exhaust System - 3.3L Duratec-V6, Description and Operation).

Possible Sources

- Damaged or contaminated aftertreatment components
- Incorrect fuel or fuel with excessive sulfur content in fuel

Sample

PINPOINT TEST C : SURFACE RUST OR DEGRADATION OF SURFACE TREATMENT

NOTE

Surface rust is a characteristic of materials used on exhaust systems. Exposure to heat or road salt may result in surface rust.

Normal Operation and Fault Conditions

REFER to: Exhaust System - Overview(309-00B Exhaust System - 3.3L Duratec-V6, Description and Operation).

Possible Sources

- Perforated catalytic converter/exhaust system

Visual Inspection and Pre-checks

- Inspect for loose, damaged, contaminated or incorrect components.

C1 CHECK THE EXHAUST SYSTEM FOR PERFORATIONS, RUST OR DAMAGE

- Visually inspect the exhaust system, paying specific attention to joints, bends, low points and check for rust, perforations or surface degradation.

Are perforations, rust or damage present?

Yes	INSTALL new components as necessary.
No	GO to C2

C2 CHECK FOR CORRECT PCM (POWERTRAIN CONTROL MODULE) OPERATION

- Using a diagnostic scan tool, perform the PCM self-test.

Are the powertrain controls operating correctly?

Yes	The condition may be intermittent. Advise the customer no repair is required.
No	Correct and fix any powertrain control issues. Using a diagnostic scan tool, perform the PCM self-test. Test and confirm the issue has been resolved.

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Were exhaust system isolators and hanger brackets found to be in correct alginment and in good condition?

Yes	GO to D3

No	INSTALL new components as necessary.

D3 CHECK FOR MISSING OR DAMAGED EXHAUST HEAT SHIELDS

- Check for noise originating from missing or damaged exhaust heat shields.

Were the exhaust heat shields found to be present and in correct alignment?

Yes	GO to D4

No	INSTALL new components as necessary.

D4 CHECK THE EXHAUST SYSTEM FOR ALIGNMENT

- Manually move the exhaust system to simulate the bouncing action of the vehicle, checking for exhaust-to-body contact whilst the exhaust system is moving.

Was the exhaust noise seen to originate from contact between the exhaust system and the surrounding components/vehicle body?

Yes	Ensure the exhaust system is installed correctly on the exhaust hangers and isolators. INSTALL new components as necessary.

No	GO to D5

D5 CHECK THE EXHAUST SYSTEM FOR INTERNAL DAMAGE

- Using a soft hammer or rubber mallet, lightly tap the resonators, mufflers, aftertreatment components and exhaust pipework, listening for loose internal baffling or internal damage.

Was noise such as rattling, clanging or twanging heard within the exhaust components?

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