FACTORY MANUALS

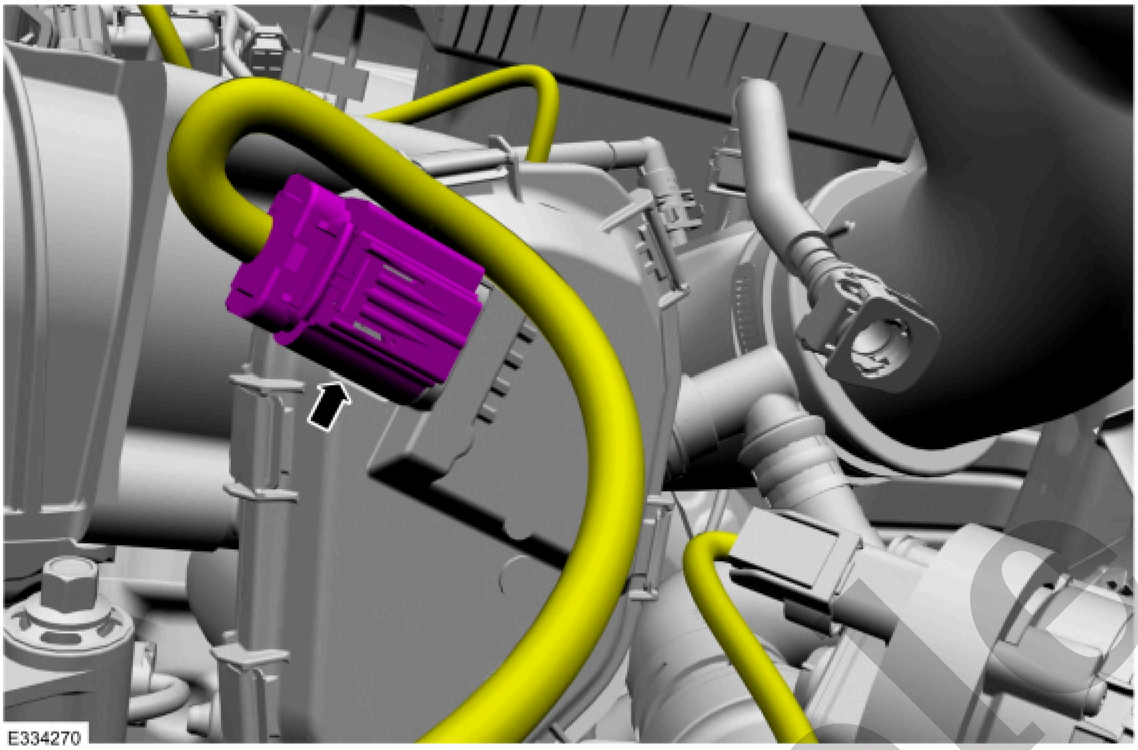
https://factorymanuals.net/

Your Ultimate Source for OEM Repair Manuals

FactoryManuals.net is a great resource for anyone who wants to save money on repairs by doing their own work. The manuals provide detailed instructions and diagrams that make it easy to understand how to fix a vehicle.

2022 Ford E-350 Super Duty Service and Repair Manual

Go to manual page



Click here to learn about symbols, color coding, and icons used in this manual.

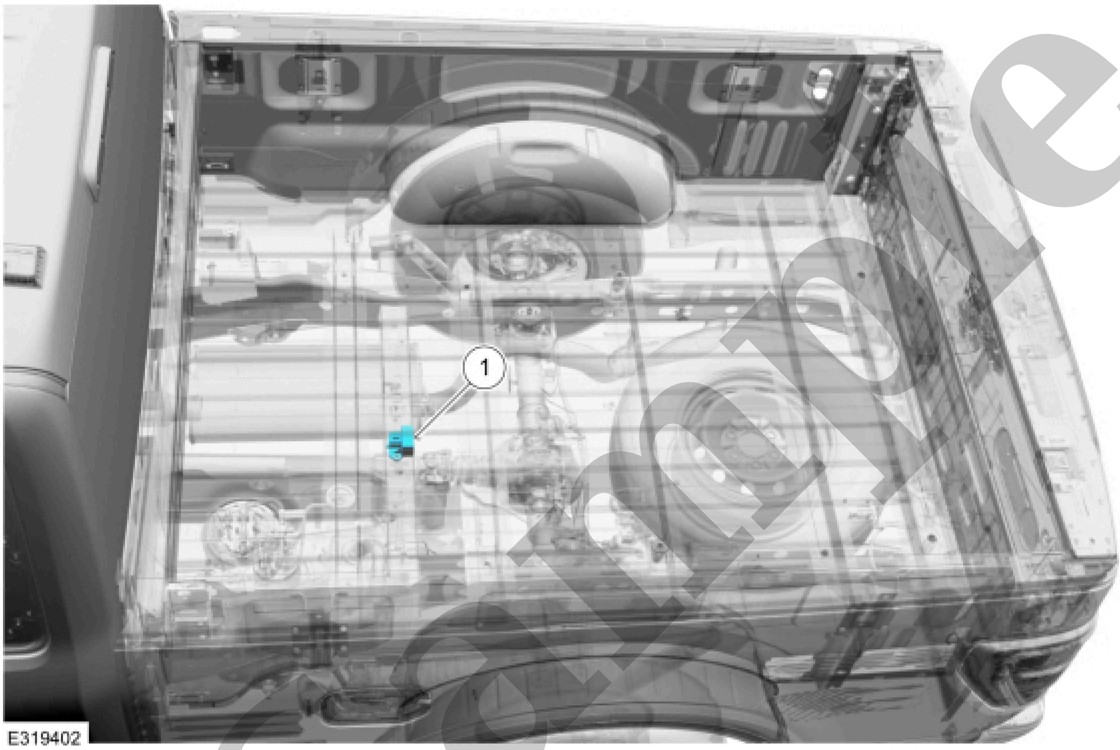
5. Install the charge air cooler outlet pipe.

   Refer to: Charge Air Cooler (CAC) Outlet Pipe(303-12A Intake Air Distribution and Filtering - 2.7L EcoBoost (238kW/324PS), Removal and Installation).

6. If a new throttle body was installed, road test the vehicle.

3	High-pressure fuel pump
4	Port fuel injector
5	Direct injection fuel rail
6	Direct fuel injector

Fuel Pump Driver Module



Item	Description
1	Fuel pump driver module

levels of cylinder to cylinder air fuel ratio imbalance. The monitor uses the CKP (crankshaft position) to calculate an acceleration term during each cylinder firing event. The calculated acceleration value is proportional to engine torque during the firing event. The monitor will modulate each cylinder to generate an air fuel ratio deviation relative to stoichiometric operation. The monitor generates five total torque values for each cylinder. Two torque values richer than stoichiometric, two torque values leaner than stoichiometric and one torque value at stoichiometric. The monitor uses a calibrated torque curve defined by the five generated values compared to an ideal torque curve to estimate each cylinder air fuel ratio deviation. The monitor estimates each cylinder air fuel ratio deviation compared to the other cylinders to determine if a concern exists.

The MIL (malfunction indicator lamp) is activated after a concern is detected during a drive cycle.

Deceleration Fuel Shut Off (DFSO)

During a DFSO event the PCM (powertrain control module) disables the fuel injectors. A DFSO event occurs during closed throttle, deceleration; similar to exiting a freeway. This strategy improves fuel economy, allows for increased rear HO2S (heated oxygen sensor) concern detection, and allows for misfire profile correction learning. On vehicles with direct fuel injection, the PCM (powertrain control module) may also disable the ignition coils. This strategy extends spark plug life during the fuel shutoff events.

Flex Fuel

Flex fuel vehicles are designed to be compatible with any combination of ethanol and gasoline up to 85% ethanol (E85). The percentage of ethanol content in the fuel is inferred by the PCM (powertrain control module) flex fuel strategy.

The fuel level input (FLI) determines if a refueling event has occurred after an ignition ON or while the engine is running. If a refueling event is detected, the PCM (powertrain control module) saves the current inferred ethanol value. The PCM (powertrain control module) flex fuel strategy recognizes a refueling event as gasoline or E85, and enables the flex fuel learn procedure. The flex fuel strategy will infer the correct air to fuel ratio, based on the oxygen sensor input, to maintain stoichiometry after the vehicle refueling event occurs.

The new fuel is calculated to reach the engine after a calibrated amount of fuel has been consumed from the fuel lines and fuel rails. Normal long term fuel trim learning and EVAP (evaporative emission) purge control are temporarily disabled to allow the new ethanol content to gasoline percentage to be inferred. Ethanol content learning continues until the inference is stabilized within the engine operating conditions.

Typical flex fuel vehicle operation:

- The initial air to fuel ratio and flex fuel percentage is calculated for gasoline after a KAM (keep alive memory) reset. Vehicles that have E85 in the fuel tank after having a KAM (keep alive memory) reset may result in a hard start when cold, or a cold engine acceleration lack of power, until the PCM (powertrain control module) flex fuel strategy calculates the correct percentage of ethanol content in the fuel.

(adaptive limit) and LAMBSE to exceed a calibrated limit. The fuel system monitor stores the appropriate DTC when a concern is detected as described below.

- The universal HO2S (heated oxygen sensor) detects the presence of oxygen in the exhaust and provides the PCM (powertrain control module) with feedback indicating air to fuel ratio.
- A correction factor is added to the fuel injector pulse width calculation and the mass airflow calculation, according to the long and short term fuel trims as needed to compensate for variations in the fuel system.
- When deviation in the LAMBSE parameter increases, air to fuel control suffers and emissions increase. When LAMBSE exceeds a calibrated limit and the fuel trim table has clipped, the fuel system monitor sets a DTC. The DTCs associated with the monitor detecting a lean shift in fuel system operation are P0171 (Bank 1) and P0174 (Bank 2). The DTCs associated with the monitor detecting a rich shift in fuel system operation are P0172 (Bank 1) and P0175 (Bank 2).
- The MIL (malfunction indicator lamp) is activated after a concern is detected on 2 consecutive drive cycles.

Typical fuel system monitor entry conditions:

- Air mass range greater than 5.67 g/sec (0.75 lb/min)
- Purge duty cycle of 0%
- Engine coolant temperature is between 65.5° C to 110° C (150° F to 230° F)
- Engine load greater than 12%
- Intake air temperature -34° C to 65° C (-30° F to 150° F)

Typical fuel monitor thresholds:

- Lean Condition Concern: LONGFT greater than 25%, SHRTFT greater than 5%
- Rich Condition Concern: LONGFT less than 25%, SHRTFT less than 10%

Fuel Trim

Short Term Fuel Trim

If the oxygen sensors are warmed up and the PCM (powertrain control module) determines the engine can operate near the 14.7 to 1 (9 to 1 E100) stoichiometric air to fuel ratio, the PCM (powertrain control module) enters closed loop fuel control mode. Since an oxygen sensor can only indicate rich or lean, the fuel control strategy continuously adjusts the desired air to fuel ratio between rich and lean causing the oxygen sensor to switch around the stoichiometric point. If the time between rich and lean switches is the same, then the system is actually operating at stoichiometric. The desired air to fuel control parameter is called short term

The fuel volume regulator controls the volume of low pressure fuel that enters the inlet check valve and the pump piston inside the fuel injection pump. The PCM (powertrain control module) regulates fuel pressure by controlling the timing of the fuel volume regulator solenoid.

High pressure fuel exits the fuel injection pump and is delivered to the fuel rails through the fuel supply line. The fuel rails distribute and channel high pressure fuel to the fuel injectors.

The FRP (fuel rail pressure) sensor provides a feedback signal to indicate the fuel rail pressure so the PCM (powertrain control module) can command the correct injector timing and pulse width for correct fuel delivery at all speed and load conditions.

The fuel injectors meter fuel flow to the engine. A given cylinder fuel injector can deliver single or multiple injections for each cylinder event. The amount of fuel is controlled by the length of time the fuel injectors are held open.

Heated Oxygen Sensor (HO2S) Monitor

The HO2S (heated oxygen sensor) monitor is an on board strategy designed to monitor the heated oxygen sensors for concerns or deterioration which can affect emissions. The fuel control or stream 1 HO2S (heated oxygen sensor) are checked for correct output voltage and response rate. Response rate is the time it takes to switch from lean to rich or rich to lean. The rear or stream 2 HO2S (heated oxygen sensor) is monitored for correct output voltage and is used for catalyst monitoring and fore aft oxygen sensor (FAOS) control. Input is required from the CMP (camshaft position) sensor, the CKP (crankshaft position) sensor, the ECT (engine coolant temperature) sensor or the CHT (cylinder head temperature) sensor, the fuel rail pressure temperature (FRPT) sensor, the fuel tank pressure (FTP) sensor, the IAT (intake air temperature) sensor, the MAF (mass air flow) sensor (if equipped), the MAP (manifold absolute pressure) sensor, the TP (throttle position) sensor and vehicle speed to activate the HO2S (heated oxygen sensor) monitor. The fuel system monitor and misfire detection monitor must also have completed successfully before the HO2S (heated oxygen sensor) monitor is enabled.

The HO2S (heated oxygen sensor) senses the oxygen content in the exhaust flow. Lean of stoichiometric, air to fuel ratio of approximately 14.7 to 1 (9 to 1 E100), the HO2S (heated oxygen sensor) generates a voltage less than 0.45 volt. Rich of stoichiometric, the HO2S (heated oxygen sensor) generates a voltage greater than 0.45 volt. The current required to maintain the universal HO2S (heated oxygen sensor) at 0.45 volt is used by the PCM (powertrain control module) to calculate the air to fuel ratio. The HO2S (heated oxygen sensor) monitor evaluates the HO2S (heated oxygen sensor) for correct function.

The time between HO2S (heated oxygen sensor) switches is monitored after vehicle startup and during closed loop fuel conditions. Excessive time between switches or no switches since startup indicates a concern. Since lack of switching concerns can be caused by HO2S (heated oxygen sensor) concerns or by shifts in the fuel system, DTCs are stored that provide additional information for the lack of switching concern. Different DTCs indicate whether the sensor always indicates lean, rich, or disconnected. The HO2S (heated oxygen sensor) signal is also monitored for high voltage. An over voltage condition is caused by a HO2S (heated oxygen sensor) heater or battery power short to the HO2S (heated oxygen sensor) signal line.

Torque Based Electronic Throttle Control (ETC)

The torque based ETC is a hardware and software strategy that delivers an engine output torque (via throttle angle) based on driver demand (pedal position). It uses an electronic throttle body throttle actuator control (TAC), the PCM (powertrain control module) , and an accelerator pedal assembly to control the throttle opening and engine torque.

Torque based ETC enables aggressive automatic transmission shift schedules (earlier upshifts and later downshifts). This is possible by adjusting the throttle angle to achieve the same wheel torque during shifts, and by calculating this desired torque, the system prevents engine lugging (low RPM (revolutions per minute) and low manifold vacuum) while still delivering the performance and torque requested by the driver. It also enables many fuel economy/emission improvement technologies such as VCT (variable camshaft timing) , which delivers same torque during transitions.

The torque based ETC system illuminates a powertrain malfunction indicator (wrench) on the instrument panel cluster (IPC) when a concern is present. Concerns are accompanied by diagnostic trouble codes (DTCs) and may also illuminate the MIL (malfunction indicator lamp) .

Electronic Throttle Control (ETC) System Strategy

The ETC strategy was developed to improve fuel economy and to accommodate variable camshaft timing. This is possible by not coupling the throttle angle to the driver pedal position. Uncoupling the throttle angle (produce engine torque) from the pedal position (driver demand) allows the powertrain control strategy to optimize fuel control and transmission shift schedules while delivering the requested wheel torque.

The ETC monitor system is distributed across 2 processors within the PCM (powertrain control module) : the main powertrain control processor unit (CPU) and a separate monitoring processor. The primary monitoring function is carried out by the independent plausibility checker software, which resides on the main processor. It is responsible for determining the driver demanded torque and comparing it to an estimate of the actual torque delivered. If the generated torque exceeds driver demand by a specified amount, appropriate corrective action is taken.

ETC System Failure Mode and Effects Management:

Effect	Failure Mode
No Effect On Driveability	A loss of redundancy or loss of a non critical input could result in a concern that does not affect driveability. The powertrain malfunction indicator (wrench) illuminates, but the MIL (malfunction indicator lamp) does not illuminate in this mode. However, cruise control and PTO (power take-off) may be disabled. A DTC (diagnostic trouble code) sets to indicate the component or circuit with the concern.
Delayed APP (accelerator pedal position)	This mode is caused by the loss of one APP (accelerator pedal position) sensor input due to sensor, wiring, or PCM (powertrain control module) concerns. The system is unable to verify the APP (accelerator pedal position) sensor input and driver demand. The throttle

	related component sets. The EGR (exhaust gas recirculation) and VCT (variable camshaft timing) outputs are set to default values and cruise control is disabled.

Component Description

Electronic Throttle Body Throttle Actuator Control (TAC)

The electronic throttle body TAC is a DC motor controlled by the PCM (powertrain control module) . An internal spring returns the throttle plate to a default position. The default position is typically a throttle angle of 7 to 8 degrees from the hard stop angle. The closed throttle plate hard stop prevents the throttle from binding in the bore. This hard stop setting is not adjustable and is set to result in less airflow than the minimum engine airflow required at idle.

Electronic Throttle Body Throttle Position Sensor (ETBTPS)

The ETBTPS has one digital signal output from the sensor. There is one reference voltage circuit (ETCREF) and one signal return circuit (ETCRTN) for the sensor dedicated to the ETBTPS.

Fuel Injection Pump

NOTE

Do not apply battery positive (B+) voltage directly to the fuel volume regulator solenoid electrical connector pins. Internal damage to the solenoid may occur in a matter of seconds.

The engine driven fuel injection pump increases fuel rail pressure to the desired level to support fuel injection requirements. Unlike conventional port fuel injection systems, with direct injection the desired fuel rail pressure ranges widely over operating conditions. The pump receives fuel from the fuel pump (FP) assembly, increases the fuel pressure from approximately 448 kPa (65 psi) to a variable pressure up to 20 MPa (2900 psi), and delivers it to the fuel rails. The fuel injection pump is driven by a dedicated intake camshaft lobe and is located on top of the engine.

The fuel volume regulator is a solenoid valve permanently mounted to the pump assembly. The PCM (powertrain control module) commands the fuel volume regulator to meter in a specified fuel volume with each pump stroke. The PCM (powertrain control module) regulates the fuel volume entering the rail to achieve the desired fuel rail pressure.

The fuel volume regulator control is synchronous to the cam position on which the pump is mounted. The fuel volume regulator control takes into account that camshaft phasing varies during engine operation for purposes of valve control.

Fuel Injectors

NOTICE

assembly pressure due to the pressure drop across the fuel injection pump. Thus, if the fuel pump (FP) assembly pressure is 448 kPa (65 psi), then the fuel rail pressure would be approximately 379 kPa (55 psi) if the injectors are active.

Fuel Rail Pressure Temperature (FRPT) Sensor

The temperature component of the fuel rail pressure temperature (FRPT) sensor is a thermistor device in which resistance changes with temperature. The electrical resistance of a thermistor decreases as the temperature increases, and resistance increases as the temperature decreases. The varying resistance affects the voltage drop across the sensor terminals and provides electrical voltage signals to the PCM (powertrain control module) corresponding to temperature.

The pressure component of the fuel rail pressure temperature (FRPT) sensor provides a signal to the PCM (powertrain control module) indicating fuel rail pressure. The PCM (powertrain control module) supplies a 5 volt reference (VREF) signal, as well as supplying 5 volts on the fuel rail pressure (FRP) circuit. As pressure increases, the sensor signal voltage decreases.

The fuel rail pressure temperature (FRPT) sensor measures the pressure and temperature of the fuel in the fuel rail and sends these signals to the PCM (powertrain control module) . The PCM (powertrain control module) uses the fuel pressure and temperature sensor inputs to command the correct fuel pump speed. The relationship between the fuel pressure and the fuel temperature is also used to determine the possible presence of fuel vapor in the fuel rail.

Heated Oxygen Sensor (HO2S)

The HO2S (heated oxygen sensor) detects the presence of oxygen in the exhaust and produces a variable voltage according to the amount of oxygen detected. A high concentration of oxygen (lean air to fuel ratio) in the exhaust produces a voltage signal less than 0.4 volt. A low concentration of oxygen (rich air to fuel ratio) produces a voltage signal greater than 0.6 volt. The HO2S (heated oxygen sensor) provides feedback to the PCM (powertrain control module) indicating air to fuel ratio in order to achieve a near stoichiometric air to fuel ratio of 14.7 to 1 (9 to 1 E100) during closed loop engine operation.

When the oxygen sensor is cold, disconnected or on initial start up, the voltage may read between 1.5 to 1.7 volts. The oxygen sensor voltage will decrease to the normal operating range of 0.0 to 1.1 volts during warm, stabilized engine running conditions.

The HO2S (heated oxygen sensor) heater is embedded with the sensing element. The heating element heats the sensor to a temperature of 800°C (1,472°F). At approximately 300°C (572°F) the engine enters closed loop operation. The VPWR circuit supplies voltage to the heater. The PCM (powertrain control module) turns the heater ON by providing the ground when the correct conditions occur. The heater allows the engine to enter closed loop operation sooner. The use of this heater requires the HO2S (heated oxygen sensor) heater control to be duty cycled, to prevent damage to the heater.

Universal Heated Oxygen Sensor (HO2S)

Air/Fuel Ratio

303-04B Fuel Charging and Controls - 3.3L Duratec-V6	*2022 F-150*
Diagnosis and Testing	***Procedure revision date: 10/2/2020***

Air/Fuel Ratio

Diagnostic Trouble Code (DTC) 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).

Diagnostic Trouble Code Chart

Module	DTC (diagnostic trouble code)	Description	Action
PCM (powertrain control module)	P0030:00	HO2S Heater Control Circuit (Bank 1 Sensor 1): No Sub Type Information	GO to Pinpoint Test DZ
PCM (powertrain control module)	P0036:00	HO2S Heater Control Circuit (Bank 1 Sensor 2): No Sub Type Information	GO to Pinpoint Test DW
PCM (powertrain control module)	P0037:00	HO2S Heater Control Circuit Low (Bank 1 Sensor 2): No Sub Type Information	GO to Pinpoint Test DW
PCM (powertrain control module)	P0038:00	HO2S Heater Control Circuit High (Bank 1 Sensor 2): No Sub Type Information	GO to Pinpoint Test DW