2008 MY OBD System Operation Summary for 6.4L Diesel Engine

April 28, 2008 Running Change (R42)

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Introduction – OBD-I, OBD-II and EMD

OBD-I Systems

OBD-I vehicles use that same PCM, J1850/CAN serial data communication link, J1962 Data Link Connector, and PCM software as the corresponding OBD-II vehicle. The only difference is a different PCM calibration. Starting in the 2006 MY, all Federal vehicles from 8,500 to 14,000 lbs. GVWR will have been phased into OBD-II and OBD-I systems will no longer be utilized in vehicles up to 14,000 lbs GVWR.

OBD-II Systems

California OBD-II applies to all California and "California State" gasoline engine vehicles up to 14,000 lbs. Gross Vehicle Weight Rating (GVWR) starting in the 1996 MY and all diesel engine vehicles up to 14,000 lbs. GVWR starting in the 1997 MY.

"California States" are ones that have adopted California emission regulations, starting in the 1998 MY. At this time, Massachusetts, New York, Vermont and Maine have adopted California's regulations. These States receive California-certified vehicles for passenger cars and light trucks, and medium-duty vehicles, up to 14,000 lbs. GVWR."

Federal OBD-II applies to all gasoline engine vehicles up to 8,500 lbs. GVWR starting in the 1996 MY and all diesel engine vehicles up to 8,500 lbs. GVWR starting in the 1997 MY.

Starting in the 2004 MY, Federal vehicle over 8,500 lbs. are required to phase in OBD-II. Starting in 2004 MY, gasoline-fueled Medium Duty Passenger Vehicles (MDPVs) are required to have OBD-II. By the 2006 MY, all Federal vehicles from 8,500 to 14,000 lbs. GVWR will have been phased into OBD-II.

OBD-II system implementation and operation is described in the remainder of this document.

EMD Systems

Engine Manufacturer Diagnostics (EMD) applies to all 2007 MY and beyond California gasoline-fueled and diesel fueled on-road heavy duty engines used in vehicles over 14,000 lbs Gross Vehicle Weight Rating (GVWR). EMD systems are required to functionally monitor the fuel delivery system, exhaust gas recirculation system, particulate matter trap, as well as emission related ECM input inputs for circuit continuity and rationality, and emission-related outputs for circuit continuity and functionality. EMD requirements are very similar to current OBD-I system requirements. As such, OBD-I system philosophy will be employed, the only change being the addition of some comprehensive component monitor (CCM) rationality and functionality checks.

EMD vehicles use the same PCM, CAN serial data communication link, J1962 Data Link Connector, and PCM software as the corresponding OBD-II vehicle. The only difference is a different PCM calibration.

The following list indicates what monitors and functions have been altered from OBD-II for EMD calibrations:

Monitor / Feature	Calibration
Misfire Monitor	Same as OBD-II but does not set the MIL.
EGR Cooler Monitor	Same as OBD-II but does not set the MIL.
Glow Plug Monitor	Same as OBD-II but does not set the MIL.
DOC Monitor	Same as OBD-II but does not set the MIL.
Comprehensive Component Monitor	All circuit checks for components supporting other EMD monitors, as well as those for some of the other components, are the same as OBD-II.
Communication Protocol and DLC	Utilizes CAN communication, same as OBD-II, all generic and enhanced scan tool modes work the same as OBD-II but reflect the EMD calibration that contains fewer supported monitors. "OBD Supported" PID indicates EMD.
MIL Control	Same as OBD-II

General Description 6.4 DIT V8

The 6.4L is a V8 engine designed to meet customer expectations of high horsepower and torque with exceptional fuel economy and low NVH. It must do this while meeting the tough emissions standards set by the EPA and CARB.

Some of the technologies employed to meet these diverse criteria include a two stage Variable Geometry Turbocharger (VGT) with Electronic Variable Response Turbocharger (EVRT) control of the high pressure stage, common rail fuel injection system, four valves per cylinder, electronically controlled, cooled EGR, a diesel oxidation catalyst (DOC) and a diesel particulate filter (DPF).

The system schematic on the next page shows the path of the air as it is compressed by the turbocharger, cooled by the air-to-air intercooler, and mixed with the cooled EGR gases. The state of this compressed and heated air is sensed by the MAT (manifold air temperature) and MAP (manifold absolute pressure) sensors just before it enters the cylinders. The exhaust gas pressure is measured by the exhaust backpressure gauge (EP) sensor before it exits through the turbocharger. The exhaust after treatment system consists of a DOC, a DPF and a muffler.

The high pressure stage EVRT is electronically controlled and actuated to achieve a desired backpressure. This backpressure is used to control manifold boost pressure, EGR rates and after treatment regeneration.

An electronic, proportional valve controls EGR rates with an integral position sensor (EGRP). Flows are determined by valve position and the amount that backpressure exceeds boost pressure. An EGR throttle (EGRTP) is used for regeneration control as well as to optimize the boost pressure vs. backpressure levels.

Fuel injection pressure is measured by the high-pressure fuel rail sensor (FRP). Injection pressure is controlled by the high pressure pump and two regulating valves, a Pressure Control Valve (PCV), and a Volume Control Valve (VCV).

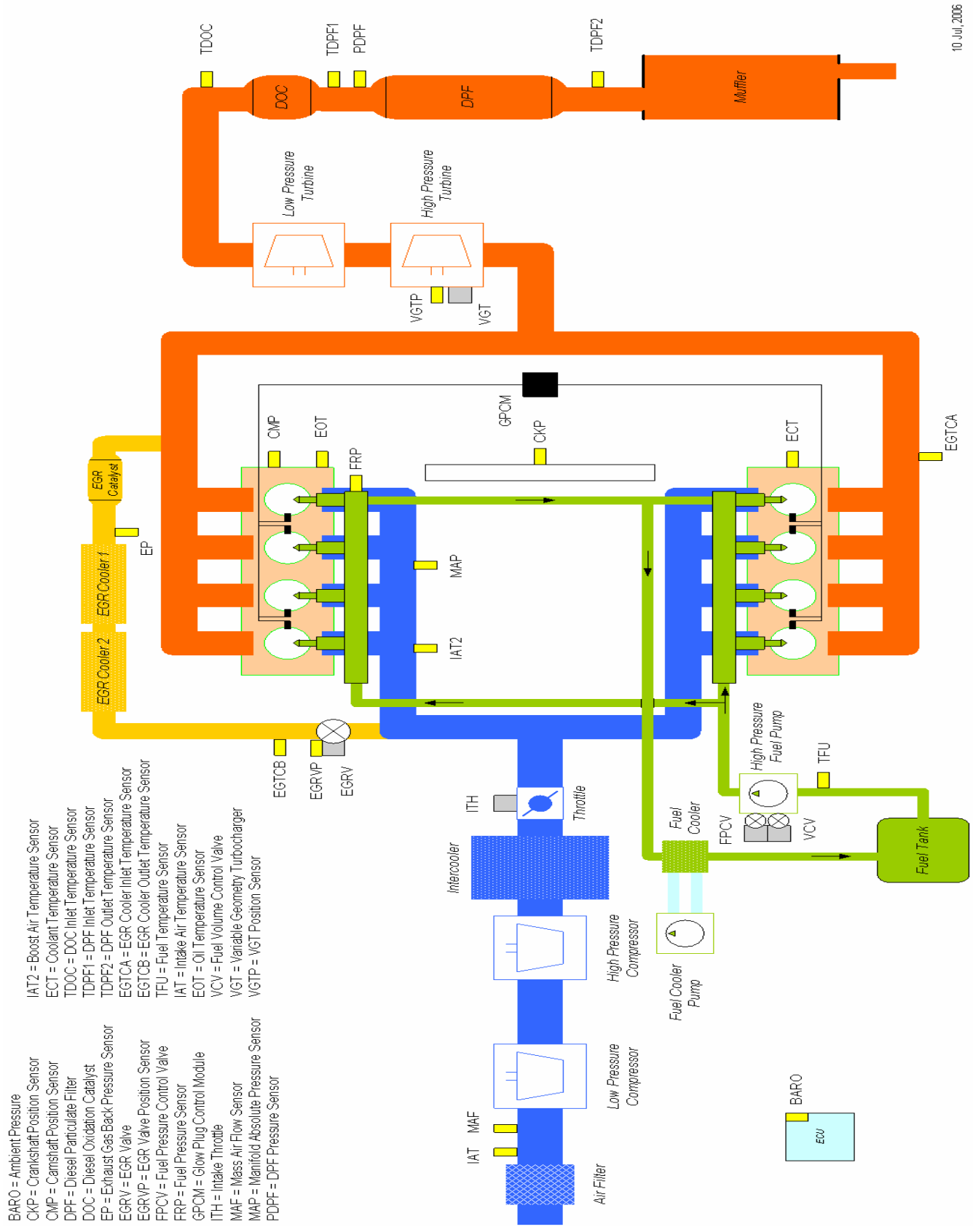
Engine speed (N) and crankshaft position are determined by the crankshaft position sensor (CKP) which senses a 60 minus 2 tooth target wheel. Camshaft position is determined by the camshaft position sensor (CMP), which senses a peg located on the camshaft.

Atmospheric pressure is determined by the Barometric pressure sensor (BP, formerly BARO).

During engine operation, the Powertrain Control Module (PCM) calculates engine speed from the crankshaft position sensor. The PCM controls engine operation by controlling the piezo injector opening and closing times as well as the pressure at which the fuel is injected, thereby controlling fuel quantity and timing. Simultaneously, airflow is modulated by controlling the turbocharger vane position.

Fuel quantity is controlled by injector “on time” (pulse width) and the fuel rail pressure. Desired engine speed is determined from the position of the accelerator pedal.

System Schematic 6.4 DIT V8



Misfire Monitor

System Overview

The 6.4L Diesel engine utilizes a variable reluctance sensor (CKP) that processes the edges of a 60-2 tooth stamped target wheel mounted on the crankshaft. The software gets an edge every 3 degrees and these edges are used for fuel injection timing, fuel quantity control, and the calculation of engine speed. The 6.4L utilizes a second variable reluctance sensor (CMP) that processes a peg mounted on the camshaft for cylinder identification. The CMP signal and the window of 2 missing teeth on the crankshaft target wheel indicate proper camshaft to crankshaft position for correct cylinder timing. The CKP and CMP signals are hardware buffered.

A cylinder balancing strategy is used to detect cylinders that are contributing either too much or too little torque relative to the other cylinders. The crankshaft rotation is divided into 8 segments, with each segment corresponding to a cylinder. The average time of the previous 8 segments is continually updated and used with the current and previous engine speeds to calculate a speed gradient value. The speed gradient is integrated and corrected so that there is no fueling bias, and the corrections are applied to the desired fuel mass for the main injection events. As engine speed increases, the time between each segment decreases. To insure accurate calculations, the cylinder balancing algorithm is only active below a calibratible engine speed limit.

Misfire Algorithm Processing

The Misfire Monitor uses both the instantaneous and the integrated speed gradient values. These values are filtered and compared to thresholds to determine if a misfire condition exists. The threshold levels depend upon whether the vehicle is in drive or park/neutral.

The misfire algorithm is active only when the cylinder balancing algorithm is active. In addition, other engine operating parameters are monitored to ensure misfire operates in a region that yields accurate misfire results. The table below outlines the entry conditions required for executing the misfire monitor algorithm.

Misfire Monitor Operation:	
DTCs	P0300 – Random Misfire Detected P0301 – Cylinder 1 Misfire Detected P0302 – Cylinder 2 Misfire Detected P0303 – Cylinder 3 Misfire Detected P0304 – Cylinder 4 Misfire Detected P0305 – Cylinder 5 Misfire Detected P0306 – Cylinder 6 Misfire Detected P0307 – Cylinder 7 Misfire Detected P0308 – Cylinder 8 Misfire Detected
Monitor execution	Continuous
Monitor Sequence	None
Sensors OK	Exhaust Gas Recirculation Position (EGRP), Exhaust Pressure (EP), Intake Air Temperature (IAT), Engine Coolant Temperature (ECT), Fuel Temperature, Engine Oil Temperature (EOT), Vehicle Speed (VSS), Fuel Rail Pressure (FRP), Crankshaft Position Sensor (CKP)
Monitoring Duration	1 minute

Typical Misfire Monitor Entry Conditions:		
No Exhaust Gas Recirculation (EGR) valve actuator errors		
No EGR position sensor minimum stop performance errors		
No EGR flow monitor errors		
No EGR valve position plausibility errors		
No exhaust pressure control errors		
No fuel pressure control valve (PCV) controller errors		
No low fuel pressure at engine start errors		
No fuel volume control valve (VCV) adaptation error		
No piezo power stage errors		
No battery voltage errors		
No brake switch errors		
Entry condition	Minimum	Maximum
Engine Speed (Low Idle)	500rpm	950 rpm
Engine Coolant Temperature (ECT)	> -40 deg C	< 120 deg C
Fuel Temperature	> -50 deg C	
Engine Oil Temperature (EOT)	> -20 deg C	
Vehicle Speed (VSS)	>= 0 km/hr	<= 10 km/hr
Intake Air Temperature (IAT)	> -40 deg C	< 100 deg C
Intake Manifold Pressure (MAP)	< 1200 hPa	
Battery Voltage (IVPWR)	> 9.0 V	
Total fuel mass	>= 5.0 mg/stroke	<= 35.0 mg/stroke

Typical Misfire Monitor Malfunction Thresholds:

P0300:

Transmission in park/neutral:

Filtered instantaneous cylinder balancing speed difference > 0.75 AUTO or 0.35 MANUAL

AND Filtered integrated cylinder balancing speed difference > 1.50

Transmission in gear:

Filtered instantaneous cylinder balancing speed difference > 1.50 AUTO or n/a MANUAL

AND Filtered integrated cylinder balancing speed difference > 1.50

Every engine cycle, a counter is incremented by 2 if the above conditions are met for ANY cylinder, or decremented by 1 if they are not. If the counter exceeds **4000**, a fault is set.

P0301 - P0308:

Transmission in park/neutral:

Filtered instantaneous cylinder balancing speed difference > 0.75 AUTO or 0.35 MANUAL)

AND Filtered integrated cylinder balancing speed difference > 1.50

Transmission in gear:

Filtered instantaneous cylinder balancing speed difference > 1.50 AUTO or n/a MANUAL

AND Filtered integrated cylinder balancing speed difference > 1.50

Every engine cycle for EACH cylinder, a counter is incremented by 2 if the above conditions are met, or decremented by 1 if they are not met. If the counter exceeds **600**, a fault is set.

Exhaust Gas Recirculation Monitor

EGR System and Comprehensive Component Monitors:

The Delta Pressure Exhaust Gas Recirculation (EGR) System is a closed loop EGR Valve Position control system. It utilizes an exhaust manifold pressure sensor, an intake manifold pressure sensor and a speed density estimate of total mass flow and derives a desired EGR Valve position based on a desired EGR flow percentage.

The EGR Monitor is a series of electrical tests and functional tests that monitor various aspects of EGR system operation.

EGR Flow Tests:

An intrusive test is used to detect low EGR flow rates (P0401) and high EGR flow rates (P0402). The EGR valve is closed and engine volumetric efficiency is estimated using intake air flow (MAF), manifold pressure (MAP), manifold temperature (IAT2). Airflow through the engine is then calculated using the estimated volumetric efficiency, MAP and engine rpm. At this point, the EGR valve is commanded to open and the change in MAF is observed. The EGR flow rate can now be determined by looking at the difference between the speed density engine flow rate and MAF flow rate. EGR flow rate is divided by the engine flow rate to estimate EGR fraction, i.e. % EGR.

Exhaust Gas Recirculation (EGR) Low Flow Monitor Operation:	
DTCs	P0401 - Exhaust Gas Recirculation Flow Insufficient Detected
Monitor execution	Multiple times per driving cycle
Monitor Sequence	None
Sensors OK	MAP (P0106, P0107, P0108, P0069,P006B), MAF (P0100, P0101, P0102, P0103, P0104, P1102, P1103), IAT2 (P0096, P0097, P0098, P2199), Exhaust Gas Recirculation Position Sensor (EGRP) (P0405, P0406, P0404, P1335, P042E, P042F), CKP (P0337, P0336, P1336) EGRTA (P041B), EVRT (P2263)
Monitoring Duration	The test will run 5 times per trip. Two of the 5 test runs must indicate low flow failures to set the fault. It takes 12 seconds to run each test, which consists of 5 steps to estimate EGR flow rate. The time breakdown for each step is as follows, and there a slight lag between steps that account for another second: Open EGR valve and wait for a settling time: 4 sec Estimate flow rate with open EGR valve: 2 sec Close EGR valve and wait for a settling time: 4 sec Estimate volumetric efficiency: 1 sec Delay before EGR monitor can run again: 60 sec

Typical Exhaust Gas Recirculation (EGR) Monitor Low Flow Entry Conditions:		
Entry condition	Minimum	Maximum
DPF regeneration not requested		
Pressure ratio (MAP) / exhaust pressure (EP) across the EGR valve		< 0.99
Rate of change of engine speed (N)		< 0.05 rpm/s
Rate of change of indicated torque setpoint (TQI_SP)		< 0.05 Nm/s
Engine speed (N)	600 rpm	800 rpm
Indicated torque setpoint (TQI_SP)	45 Nm	174 Nm
PTO not active		

Typical EGR Monitor Low Flow Malfunction Thresholds:
Delivered EGR is -28 %.(less) than expected for the operating conditions. EGR rates are specified as a function of engine speed (N) and indicated torque setpoint..

Exhaust Gas Recirculation (EGR) High Flow Monitor Operation:	
DTCs	P0402 – Exhaust Gas Recirculation Flow Excessive Detected
Monitor execution	Continuous
Monitor Sequence	None
Sensors OK	BAP (P2228, P2229, P2230, P0069, P0106) ECT (P0117, P118) MAF (P0100, P0101, P0102, P0103, P0104, P1102, P1103), Exhaust Gas Recirculation Position Sensor (EGRP) (P0405, P0406, P0404, P1335, P042E, P042F),
Monitoring Duration	Continuous

Typical Exhaust Gas Recirculation (EGR) High Flow Monitor Entry Conditions:		
Entry condition	Minimum	Maximum
Engine speed (N)	TBD rpm	800 TBD rpm
Indicated torque setpoint (TQI_SP)	45 TBD Nm	174 TBD Nm
ECT above minimum threshold	TBD C	TBD C
Minimum high resolution engine speed gradient)	TBD rpm/sec	N/A
Intrusive EGR monitor not active		

Typical EGR High Flow Monitor Malfunction Thresholds:
If the difference between the expected and measured mass air flow is greater than the error threshold of TBD Kg/H, determination is made that EGR high-flow condition exists.

Exhaust Gas Recirculation Position Sensor (EGRP):	
DTCs	P0405 - Exhaust Gas Recirculation Sensor A Circuit Low P0406 - Exhaust Gas Recirculation Sensor A Circuit High
Monitor execution	Continuous
Monitor Sequence	None
Sensors OK	Not Applicable
Typical Monitoring Duration	3 sec.

Typical Exhaust Gas Recirculation Position Sensor Entry Conditions:
No reference voltage errors (P2505, P2507, P2508)

Typical Exhaust Gas Recirculation Position Sensor Check Malfunction Thresholds:
Voltage < 0.24 volts or voltage > 4.50 volts

Exhaust Gas Recirculation Valve Actuator (EGRAM) Monitor Operation:	
DTCs	P0403 – Exhaust Gas Recirculation Control Circuit
Monitor Execution	Continuous
Monitor Sequence	None
Sensors OK	Not Applicable
Monitoring Duration	1 sec.

Typical Exhaust Gas Recirculation Valve Actuator Monitor Entry Conditions:		
Entry condition	Minimum	Maximum
Battery voltage	7 V	
Ignition voltage	7 V	

Typical Exhaust Gas Recirculation Valve Actuator Monitor Malfunction Thresholds:
Actuator smart driver status indicates open/short

EGR Valve Monitors

The EGR functional monitor checks if the closed-loop EGR valve position deviation is within a specified limit (P0404), whether the EGR valve stuck closed (P042F) or whether the EGR valve is stuck open (P042E). There is also a check to see if the voltage adaptation at the bottom limit stays within the expected tolerance.

Exhaust Gas Recirculation (EGR) Valve:	
DTCs	P0404 – Exhaust Gas Recirculation Control Circuit Range/ Performance P042E – EGR Control Stuck Open P042F – EGR Control Stuck Closed P1335 – EGR Position Sensor Minimum Stop Performance
Monitor Execution	Continuous
Monitor Sequence	None
Sensors OK	P0404, P042E, P042F – EGR (P042E, P042F), EGRP (P0405, P0406, P1335) P1335 – None
Typical Monitoring Duration	P0404 – 5 sec. P042E – 4 sec. P042F – 4 sec. P1335 – 2.5 sec.

Typical Exhaust Gas Recirculation (EGR) Valve Entry Conditions:		
Entry condition	Minimum	Maximum
Engine run time	4 sec.	
EGR monitor not active		

Typical Exhaust Gas Recirculation (EGR) Valve Thresholds:
P0404 – absolute value of the error between the commanded EGR Valve Position (EGRVP) and actual EGRVP is > 10%
P042E – Commanded EGR Valve Position (EGRVP) is < 15% AND actual EGRVP is > 30%
P042F – Commanded EGR Valve Position (EGRVP) is > 30% AND actual EGRVP is < 15%
P1335 – Actual EGRVP closed position sensor voltage < 0.4 volts or > 1.5 Volts

EGR Cooler Efficiency Monitor

The EGR cooler is monitored to determine if the EGR cooler efficiency is low. The EGR cooler monitor utilizes an EGR cooler outlet temperature sensor to determine whether or not the EGR gases are being cooled effectively by the EGR cooler. If the temperature indicated by the EGR cooler outlet temperature sensor is above a maximum limit for a long enough period of time, the P2457 fault is set.

The EGR cooler outlet temperature sensor is monitored for circuit high, circuit low, intermittents and rationality.

Exhaust Gas Recirculation (EGR) Cooler Efficiency Monitor:	
DTCs	P2457 – Exhaust Gas Recirculation Cooler System Performance
Monitor execution	Continuous
Monitor Sequence	None
Sensors/Actuators OK	EGRP (P0405, P0406), TEGR_OUT (P041B, P041C, P041D), EGR (P0401,), EGR Valve (P0404, P042E, P042F, P1335)
Monitoring Duration	20 sec.

Typical Exhaust Gas Recirculation (EGR) Cooler Efficiency Monitor Entry Conditions:		
Entry condition	Minimum	Maximum
Time with EGR Valve Position (EGRVP) >= 0	10 seconds	
Engine speed (N)	600 rpm	1300 rpm
Indicated torque setpoint (TQI_SP)	50 Nm	400 Nm
No DPF regeneration requested		
Engine off time	2 hours	

Typical Exhaust Gas Recirculation (EGR) Cooler Efficiency Monitor Thresholds:

EGR Cooler Outlet Temperature (TEGR_OUT) > 165 deg C, multiplied by the following function of ECT:

ECT (degrees C):	50	60	70
Multiplier:	1.0	1.1	1.2

EGR Cooler Outlet Temperature (TEGR_OUT) Sensor Circuit Check:	
DTCs	P041C - Exhaust Gas Recirculation Temperature Sensor "B" Circuit Low P041D - Exhaust Gas Recirculation Temperature Sensor "B" Circuit High
Monitor execution	Continuous
Monitor Sequence	None
Sensors OK	Not applicable
Typical Monitoring Duration	5 sec.

Typical EGR Cooler Outlet Temperature Sensor Circuit Check Entry Conditions:		
Entry condition for P041C, P041D	Minimum	Maximum
Entry condition for P041C – none		
Entry condition for P041D:		
Engine Speed (N)	650 rpm	
Engine indicated torque setpoint (TQI_SP)	53 Nm	
Engine Coolant Temperature	80 deg C	

Typical EGR Cooler Outlet Temperature Sensor Circuit Check Malfunction Thresholds:
Voltage < 0.15 volts or voltage > 4.95 volts

EGR Cooler Inlet Temperature (TEGR_OUT) Sensor Circuit Check:	
DTCs	P040C - Exhaust Gas Recirculation Temperature Sensor "A" Circuit Low P040D - Exhaust Gas Recirculation Temperature Sensor "A" Circuit High
Monitor execution	Continuous
Monitor Sequence	None
Sensors OK	Not applicable
Typical Monitoring Duration	5 sec.

Typical EGR Cooler Inlet Temperature Sensor Circuit Check Entry Conditions:		
	Minimum	Maximum
Entry condition for P040C – none		
Entry condition for P040D:		
Engine Speed (N)	650 rpm	
Engine indicated torque setpoint (TQI_SP)	53 Nm	
Engine Coolant Temperature	60 deg C	

Typical EGR Cooler Inlet Temperature Sensor Circuit Check Malfunction Thresholds:
Voltage < 0.07 volts or voltage > 4.65 volts

EGR Cooler Outlet Temperature (TEGR_OUT) Rationality Check:	
DTCs	P041B - Exhaust Gas Recirculation Temperature Sensor "B" Circuit Range/Performance
Monitor Execution	Continuous
Monitor Sequence	None.
Sensors OK	TEGR_OUT (P041C, P041D), ECT (P0117, P0118)
Typical Monitoring Duration	2 drive cycles

EGR Cooler Outlet Temperature Rationality Check Entry Conditions:		
Entry condition	Minimum	Maximum
Initial Engine Coolant Temperature (ECT)		30 deg C
Engine Coolant Temperature (ECT) increase	80 deg C	
ECM on	3 seconds	

Typical EGR Cooler Outlet Temperature Rationality Check Malfunction Thresholds:
Increase in EGR Cooler Outlet Temperature (TEGR_OUT) is < 6 deg C

Fuel System Monitor

The fuel rail pressure is controlled either with the Pressure Control Valve or with the Volume Control Valve, depending upon whether the engine operating condition demands low fuel flow, or high fuel flow, respectively. Feedback is provided by the Fuel Rail Pressure Sensor (FRP). Fuel system monitors include those for the FRP, PCV, VCV, and for fuel pressure control.

Fuel Rail Pressure (FRP) Sensor Circuit Check:	
DTCs	P0192 - Fuel Rail Pressure Sensor A Circuit Low Input P0193 - Fuel Rail Pressure Sensor A Circuit High Input P0194 - Fuel Rail Pressure Sensor A Circuit Intermittent/Erratic
Monitor Execution	Continuous
Monitor Sequence	None
Sensors OK	P0191 – VCV (P0642, P0643)
Typical Monitoring Duration	P0192, P0193 - 0.5 sec P0194 - 0.1 sec

Typical Fuel Rail Pressure Sensor Circuit Check Entry Conditions:
None

Typical Fuel Rail Pressure Sensor Circuit Check Malfunction Thresholds:
P0192, P0193 - Voltage < 0.2 volts or voltage > 4.8 volts
P0194 - Absolute value of rate of change of pressure greater than 40 MPa / 10 ms

The fuel delivery monitor (P0148) detects if there is an injection commanded when there is no torque request from the driver.

Fuel Delivery Monitor Operation:	
DTCs	P0148 – Fuel Delivery Error
Monitor Execution	Continuous
Monitor Sequence	None
Sensors OK	P0201 to P0208, P062D, P062E, P1551 to P1558
Typical Monitoring Duration	3 seconds

Typical Fuel Delivery Monitor Entry Conditions:		
Entry condition	Minimum	Maximum
Pedal Position	= 0	
Engine Speed	1600 rpm	

Typical Fuel Delivery Monitor Malfunction Thresholds:
Any of the commands to the injectors (as detected on the injection command line from the ECU) meet criteria for a 'commanded injection'

Fuel Rail Pressure Monitors:

The fuel rail pressure is controlled either with the Pressure Control Valve or with the Volume Control Valve, depending upon whether the engine operating condition demands low fuel flow, or high fuel flow, respectively. The high and low Fuel Rail Pressure Monitors detect when there is an excessive deviation from the desired fuel pressure when the controller has reached a control limit.

Fuel Rail Pressure (FRP) Monitor Operation:	
DTCs	P0088 - Fuel Rail/System Pressure - Too High P0087 - Fuel Rail/System Pressure - Too Low
Monitor Execution	P0088 - Continuous P0087 - Continuous
Monitor Sequence	None
Sensors OK	P0088 - FRP (P0191, P0192, P0193, P0194,P2289), PCV, P0090 P0091 P0092), VCV (P0001 P0002 P0003, P0642, P0643) P0087- PCV (P0090 P0091 P0092), VCV, (P0001, P0002, P0003, P0642, P0643), FRP (P0191, P0192, P0193, P0194, P2289)
Typical Monitoring Duration	P0088 - 5sec P0087 - 5sec

Typical Fuel Rail Pressure Monitor Entry Conditions:		
Entry condition	Minimum	Maximum
P0088, P0087 -		
Engine running		
Rate of change of FRP setpoint	-180 MPa/s, 5sec	120 MPa/s, 5sec

Typical Fuel Rail Pressure Monitor Malfunction Thresholds:
P0088: If the relative error in Fuel Rail Pressure (FRP) (absolute value of error divided by FRP setpoint) is greater than or equal to 3% AND (the Pressure Control Valve is operating closed-loop AND the controller has reached its minimum output OR the Volume Control Valve is operating closed-loop AND the controller has reached its minimum output) AND these conditions are fulfilled for more than 0.2 seconds the fault is set. P0087: If the relative error in Fuel Rail Pressure (FRP) (absolute value of error divided by FRP setpoint) is greater than or equal to 5% AND (the Pressure Control Valve is operating closed-loop AND the controller has reached its maximum output OR the Volume Control Valve is operating closed-loop AND the controller has reached its maximum output) AND these conditions are fulfilled for more than 0.2 seconds the fault is set.

Fuel Rail Pressure (FRP) Functional Check Operation:	
DTCs	P0191 - Fuel Rail Pressure Sensor A Circuit Range/Performance
Monitor Execution	P0191 - Continuous
Monitor Sequence	None
Sensors OK	P0191 – VCV (P0642, P0643)
Typical Monitoring Duration	P0191 – 1sec

Typical Fuel Rail Pressure Functional Check Entry Conditions:		
Entry condition	Minimum	Maximum
Engine running in part load		
FRP	10 MPa	
Injections enabled		

Typical Fuel Rail Pressure Functional Malfunction Thresholds:
P0191 – Minimum and maximum Fuel Rail Pressure (FRP) sensor voltages over 0.4 seconds are found. The fault is set if the difference between the maximum and the minimum voltages is less than 0.01 V.

Fuel Rail Pressure (FRP) Functional Check Operation:	
DTCs	P2289 - Injector Control Pressure Too High – Engine Off
Monitor Execution	P2289 - Continuous
Monitor Sequence	None
Sensors OK	P2289 - VCV (P0642, P0643), FRP (P0192, P0193)
Typical Monitoring Duration	P2289 - 0.4 sec

Typical Fuel Rail Pressure Functional Check Entry Conditions:		
Entry condition	Minimum	Maximum
Engine has just been switched off and key is in off-position		
Time after engine switch-off and key-off	0.4 sec	

Typical Fuel Rail Pressure Functional Malfunction Thresholds:
Fuel Rail Pressure (FRP) is greater than 10 MPa.

Volume Control Valve (VCV) Monitor Operation:	
DTCs	P0001 - Fuel Volume Regulator Control Circuit / Open P0003 - Fuel Volume Regulator Control Circuit Low P0004 - Fuel Volume Regulator Control Circuit High
Monitor Execution	P0001 - Continuous P0003 (test 1) - Continuous P0003 (test 2) - Continuous P0004 - Continuous
Monitor Sequence	None
Sensors OK	Serial Communication (P0600)
Typical Monitoring Duration	P0001 – 0.5sec. P0003 (test 1) - 0.5sec. P0003 (test 2) - 0.5sec. P0004 - 0.5sec.

Typical Volume Control Valve Monitor Entry Conditions:		
Entry condition	Minimum	Maximum
Battery Voltage	7 V	
Engine is running		
P0003 (test 2) – Key- on		

Typical Volume Control Valve Monitor Malfunction Thresholds:
P0001 - The period of the fuel pressure control valve (VCV) command signal is greater than or equal to 400 microseconds OR circuit resistance is greater than 500 Ohm
P0003 (test 1) - The period of the fuel pressure control valve (VPCV) command signal is greater than or equal to 250 microseconds OR measured circuit voltage = 0 V.
P0003 (test 2) – Valve current (VCV) is greater than 3 A.
P0004 - The period of the fuel pressure control valve (VCV) command signal is greater than or equal to 50 microseconds OR circuit voltage = 12 V.

Fuel Pressure Control Valve (PCV) Monitor Operation:	
DTCs	P0090 - Fuel Pressure Regulator Control Circuit P0091 - Fuel Pressure Regulator Control Circuit Low P0092 - Fuel Pressure Regulator Control Circuit High
Monitor Execution	P0090 - Continuous P0091 (test 1) - Continuous P0091 (test 2) - Continuous P0092 (test 1) - Continuous
Monitor Sequence	None
Sensors OK	Serial Communication (P0600)
Typical Monitoring Duration	P0090 – 0.5sec. P0091 (test 1) - 0.5sec. P0091 (test 2) - 0.5sec. P0092 (test 1) - 0.5sec.

Typical Fuel Pressure Control Valve Monitor Entry Conditions:		
Entry condition	Minimum	Maximum
P0090,P0091(test 1), P0092 (test 1):		
Battery Voltage	7 V	
Engine is running		
P0091 (test 2):		
Engine is running		

Typical Fuel Pressure Control Valve Monitor Malfunction Thresholds:
P0090 - The period of the fuel pressure control valve (PCV) command signal is greater than or equal to 400 microseconds OR circuit resistance is greater than 500 Ohm P0091 (test 1) - The period of the fuel pressure control valve (PCV) command signal is greater than or equal to 250 microseconds OR measured circuit voltage = 0 V. P0091 (test 2) – Valve current (PCV) is greater than 3 A. P0092 - The period of the fuel pressure control valve (PCV) command signal is greater than or equal to 50 microseconds OR circuit voltage = 12 V.

Fuel Injector Driver Circuits Monitor Operation:	
DTCs	P062D - Fuel Injector Driver Circuit Performance Bank 1 P062E - Fuel Injector Driver Circuit Performance Bank 2
Monitor Execution	P062D (test 1 & 4), P062E (test 1 & 4) – Once per drive cycle P062D (test 2 & 3), P062E (test 2 & 3) – Continuous
Monitor Sequence	None
Sensors OK	PPS (P062E, P062D)
Typical Monitoring Duration	P062D (test 1) – 1sec. P062D (test 2) – 5sec. P062D (test 3) – 5sec. P062D (test 4) –1 sec. P062E (test 1) – 1 sec. P062E (test 2) – 5sec. P062E (test 3) – 5sec. P062E (test 4) – 1 sec.

Typical Fuel Injector Driver Circuits Entry Conditions:		
Entry condition	Minimum	Maximum
P062D (test 1 & 4), P062E (test 1 & 4):		
Key-on		
P062D (test 2), P062E (test 2):		
Engine is cranking or running		
P062D (test 3), P062E (test 3):		
Engine is cranking or running		
Battery Voltage	7 V	

Typical Fuel Injector Driver Circuits Malfunction Thresholds:
P062D (test 1), P062E (test 1) – Fuel injector driver circuit indicates initialization error
P062D (test 2), P062E (test 2) – Fuel injector driver circuit indicates plausibility error
P062D (test 3), P062E (test 3) – (Main 1 injection event sum voltage greater than 229 V OR Main 1 injection event sum voltage less than 93 V) OR
(Main 2 injection event present AND (Main 2 injection event sum voltage greater than 229 V OR Main 2 injection event sum voltage less than 93 V)) OR
(Post 1 injection event present AND (Post 1 injection event sum voltage greater than 229 V OR Post 1 injection event sum voltage less than 93 V)) OR
(Post 2 injection event present AND (Post 2 injection event sum voltage greater than 229 V OR Post 2 injection event sum voltage less than 93 V))
P062D (test 4), P062E (test 4) – Fuel injector driver circuit indicates initialization voltage error.

Injection Circuits Monitor Operation:	
DTCs	P0201 - Injector Circuit / Open - Cylinder 1 P0202 - Injector Circuit / Open - Cylinder 2 P0203 - Injector Circuit / Open - Cylinder 3 P0204 - Injector Circuit / Open - Cylinder 4 P0205 - Injector Circuit / Open - Cylinder 5 P0206 - Injector Circuit / Open - Cylinder 6 P0207 - Injector Circuit / Open - Cylinder 7 P0208 - Injector Circuit / Open - Cylinder 8 P1551 - Injector Circuit Range/Performance - Cylinder 1 P1552 - Injector Circuit Range/Performance - Cylinder 2 P1553 - Injector Circuit Range/Performance - Cylinder 3 P1554 - Injector Circuit Range/Performance - Cylinder 4 P1555 - Injector Circuit Range/Performance - Cylinder 5 P1556 - Injector Circuit Range/Performance - Cylinder 6 P1557 - Injector Circuit Range/Performance - Cylinder 7 P1558 - Injector Circuit Range/Performance - Cylinder 8
Monitor Execution	Continuous
Monitor Sequence	None
Sensors OK	PPS (P062E, P062D)
Typical Monitoring Duration	P0201 – P208 (test 1) – 3 seconds. P0201 – P208 (test 2) – 1 second. P1551 – P1558 – 3 seconds.

Typical Injection Circuits Entry Conditions:		
Entry condition	Minimum	Maximum
Engine running or cranking		
Battery Voltage	7 V	
Injections are active on specified injector		

Typical Injection Circuits Malfunction Thresholds:
P0201 – P0208 (test 1) – (The MAIN1, MAIN2, POST1, or POST2 injection event is present AND (The injector charge during the specified injection event is greater than 1320 µAs) OR (The injector charge during the specified injection event is less than 76 µAs)) P0201 – P0208 (test 2) – The injection event is present AND (the charging time for any injection is less than 0.0144 ms OR the discharging time for any injection is less than 0.0144 ms OR the charging time for any injection is greater than 3.0 ms OR the discharging time for any injection is greater than 3.0 ms) P1551 – P1558 – Current error reported by fuel injector driver circuit OR Injector capacity for Main 1 injection greater than 32 µF OR Injector capacity for Main 1 injection less than 0.0 µF OR (Main 1 injection present AND (Main 1 injection voltage greater than 210 V OR Main 1 injection voltage less than 62 V)) OR (Main 2 injection present AND (Main 2 injection voltage greater than 210 V OR Main 2 injection voltage less than 62 V)) OR (Post 1 injection present AND (Post 1 injection voltage greater than 210 V OR Post 1 injection voltage less than 62 V)) OR (Post 2 injection present AND (Post 2 injection voltage greater than 210 V OR Post 2 injection voltage less than 62 V))

The injector/injection timing control circuit monitor (P0216) detects if the commanded post injection is erroneously producing torque.

Injector/Injection Timing Circuit Monitor Operation:	
DTCs	P0216 – Injector/Injection Timing Circuit Error
Monitor Execution	Continuous
Monitor Sequence	None
Sensors OK	P0201 to P0208, P062D, P062E, P1551 to P1558
Typical Monitoring Duration	0.44 seconds

Typical Injector/Injection Timing Circuit Monitor Entry Conditions:		
Entry condition	Minimum	Maximum
Pedal Position	= 0	
Engine Speed	1600 rpm	

Typical Injector/Injection Timing Circuit Monitor Malfunction Thresholds:
Start of post injection is before 20 deg ATDC or other injections beside post injection are detected.

Catalyst and Aftertreatment Monitors (DOC and DPF)

Aftertreatment System Overview

The 6.4L Diesel engine utilizes a Diesel Oxidation Catalyst (DOC) and Diesel Particulate Filter (DPF) for aftertreatment emission control. The DOC and DPF work in harmony to reduce tailpipe emissions of HC, CO, NOx and Diesel Particulates. Diesel particulates are captured and reduced periodically by performing the necessary aftertreatment regeneration cycle.

Comprehensive tests are performed on the analog pressure and temperature sensors. Circuit continuity checks are performed continuously. Rationality checks are performed on the temperature sensors after an 8-hour soak by comparing the sensor readings to ambient, and also observing temperature rise behavior immediately after start. Rationality checks are performed on the pressure sensor at every key-on. The pressure sensor is also checked for a stuck sensor reading during continuous operation.

DOC Functional Monitor

The DOC is monitored during the regeneration events to ensure that a sufficient exothermic temperature increase is achieved to support a thorough and efficient reduction of soot to ash. The exotherm is defined as the DOC outlet temperature (EGT12) minus the DOC inlet temperature (EGT11). No other preconditioning is required.

After a short time delay after the start of regeneration (to ensure that the DOC has achieved light-off), the monitor will continuously monitor the exotherm. It will compare the measured exotherm against a maximum expected value. If the exotherm drops below a certain fraction of the expected value, a filtering routine will begin. A fault will be indicated if the net accumulated time below the threshold during the regeneration event exceeds a certain limit.

DOC Aftertreatment Monitor:	
DTCs	P0420 – Diesel Catalyst System Efficiency Below Threshold
Monitor execution	Once Per Trip in which an active DPF regeneration occurs
Monitor Sequence	None
Sensors OK	EGT11, EGT12
Monitoring Duration	4 minutes

Typical DOC Aftertreatment Entry Conditions:		
Entry condition	Minimum	Maximum
Monitor is activated during aftertreatment regeneration events		
Engine speed	600	3000
Torque setpoint	100 Nm	900 Nm
Engine coolant temperature during aftertreatment regeneration events	-40 deg C	

Typical DOC Aftertreatment Malfunction Thresholds:
Output of Fault Filtering exceeds a value correlating to approximately two minutes. Fault filtering is a counter that counts up when the exotherm is below 25% of the maximum expected value and counts down when the exotherm is above that value. (Minimum value of this filter is 0.) The maximum expected exotherm is a function of post-injection quantity, and is between 120 and 180C.

DOC Aftertreatment Sensor Monitors

The temperature sensors associated with the DOC – EGT11, EGT12, and EGT13 – are monitored for circuit failure, range/performance, and functionality.

Functionality is checked by measuring the sensor output at key-on. This measurement is compared to the output of an ambient temperature model.

Range/Performance is checked by measuring the output of the sensor at key on and comparing this with the output of the sensor after the engine has run a certain amount of time.

DOC Aftertreatment Sensor Monitors	
DTCs	P0545 – EGT11 Sensor Circuit Low P0546 – EGT11 Sensor Circuit High P2080 – EGT11 Sensor Circuit Range/Performance P0544 – EGT11 Sensor Circuit Functional P2032 – EGT12 Sensor Circuit Low P2033 – EGT12 Sensor Circuit High P2084 – EGT12 Sensor Circuit Range/Performance P2031 – EGT12 Sensor Circuit Functional P242C – EGT13 Sensor Circuit Low P242D – EGT13 Sensor Circuit High P242B – EGT13 Sensor Circuit Range/Performance P242A – EGT13 Sensor Circuit Functional
Monitor execution	P0545, P0546, P2032, P2033, P242C, P242D: Continuous. P2080, P0544, P2084, P2031, P242B, P242A: Once per trip
Monitor Sequence	None
Sensors OK	Engine Off Timer, IAT (P0112, P0113)
Monitoring Duration	P0545, P0546, P2032, P2033, P242C, P242D -5 seconds P2080, P2084, P242B - 5 minutes of engine running P0544, P2031, P242A - 10 minutes of driving

Typical Aftertreatment Sensor Entry Conditions:		
Entry condition	Minimum	Maximum
P0545, P0546, P2032, P2033, P242C, P242D:		
None		
P2080, P0544, P2084, P2031, P242B, P242A		
Engine soak	8 hours	
Engine speed (for ambient model update)	25 mph	
Difference between ambient model mature value and ambient model at start		25 deg C

Typical Aftertreatment Sensor Malfunction Thresholds:
Exhaust Gas Temperature Bank 1 Sensor 1/2/3 Circuit Low/High Test: P0545, P2032, P242C, Voltage < 0.20 volts P0546, P2033, P242D Voltage > 4.75 volts in initial release, updated to 2.5 volts by running change
Temperature Sensor Range/Performance Test: (sensor comparisons to ambient model after full soak) P2080, P2084, P242B | ambient - actual sensor reading at key-on | > 40 deg C ("ambient" is determined from the ambient temperature model, which updates after 5 minutes of vehicle driving.)
Temperature Sensor Circuit Functional Test: (sensor dynamic response test after start) P0544: | actual reading 10 minutes of engine running – reading at key-on | > 40 deg C for EGT1 P2031: | actual reading 10 minutes of engine running – reading at key-on | > 30 deg C for EGT2 P242A: | actual reading 10 minutes of engine running – reading at key-on | > 15 deg C for EGT3 (This test also completes after the ambient model updates.)

DPF Functional Monitors

The DPF is monitored to ensure no leaks have developed in the substrate. Preconditioning is required for DPF monitoring such that the distance traveled is greater than 5000 km, which allows the DPF to cycle through several regeneration events before the monitor becomes active.

An efficiency monitor compares the restriction of the DPF to restriction values that are a function of engine volumetric flow. A differential pressure monitor compares the measured differential pressure across the DPF to threshold values that are a function of engine volumetric flow. Both of the monitors use a filtering routine that consist of a counter that counts up when the measured value is below the threshold and counts up when it above the threshold. When a certain count is reached the fault is stored.

DPF Aftertreatment Monitor:	
DTCs	P2002 – Diesel Particulate Trap Efficiency Below Threshold P244A – Diesel Particulate Filter Differential Pressure Too Low P200E – Catalyst System Over Temperature
Monitor execution	Continuous while meeting entry conditions
Monitor Sequence	None
Sensors OK	EGT, DPFP, CKP, ECT (P0117, P0118), INJ(P0201-P0208)
Monitoring Duration	3 minutes for P2002, 5 minutes for P244A. 5 seconds for P200E.

Typical DPF Aftertreatment Entry Conditions:		
Entry condition	Minimum	Maximum
P200E - none		
P2002, P244A:		
Distance preconditioning	5000 km	
At least one active regeneration has been performed		
Exhaust volumetric flow	400 m3/hour	2400 m3/hour
Not a regeneration event		
Time after completion of an active regeneration	200 seconds	
Intake air temperature	-20 degrees C	
Coolant temperature	50 degrees C	

Typical DPF Aftertreatment Malfunction Thresholds:
For P2002 and P244A, a fault is stored when the filtering results in an accumulated count correlating to approximately two minutes. A counter counts up when the threshold is exceeded (restriction or differential pressure lower than the threshold), and counts down (to a minimum of 0) when the threshold is not exceeded. DPF Efficiency Test: (P2002) Normalized measured restriction (based primarily on pressure measurement) is below restriction threshold, which is a function of engine exhaust volumetric flow. (2 trip MIL) DPF Differential Pressure Test: (P244A) Measured differential pressure is less than a threshold that is a function of engine exhaust volumetric flow. (2 trip MIL) Catalyst Over Temperature Test: (P200E) The DTC sets and the engine FMEM actions will activate if EGT2 exceeds 830 deg C OR if EGT3 exceeds 950 deg C. The MIL lights immediately upon fault detection. (Immediate MIL)

DPF Aftertreatment Monitor:	
DTC	P2463 – Diesel Particulate Trap Overloaded
Monitor execution	Continuous while meeting entry conditions
Monitor Sequence	None
Sensors OK	None
Monitoring Duration	300 seconds

Typical DPF Aftertreatment Entry Conditions:		
Entry condition	Minimum	Maximum
Engine Speed	625 rpm	

Typical DPF Aftertreatment Malfunction Thresholds:
Calculated normalized restriction > 7.0 (Immediate MIL)

DPF Aftertreatment Sensor Monitors

The DPF pressure sensor (DPFP) is monitored for circuit continuity and for range/performance. Range/performance comprised two tests. One measures the sensor output at key-on, and identifies a fault if the output is not near zero. The other measures the sensor output while the engine is running and verifies that the output changes appropriately.

DPF Sensor Monitors	
DTCs	P2452 – DPFP Sensor Rationality
Monitor execution	Continuous when entry conditions met
Monitor Sequence	None
Sensors OK	None
Monitoring Duration	Test 1: > 10 seconds Test 2: < 25 seconds

Typical DPF Sensor Entry Conditions:		
Entry condition	Minimum	Maximum
Test 1 – Idle:		
Engine Speed	625 rpm	
Exhaust Flow		175 cubic meters/hr
Dist. since regen	50 km	
TIA	0 deg C	
TCO	0 deg C	
Test 2 – Part Load:		
Engine Speed	1200 rpm	
Exhaust Flow	400	2800 cubic meters/hr
Dist. since regen	50 km	
TIA	0 deg C	
TCO	50 deg C	

Typical DPF Sensor Malfunction Thresholds:
Test 1: 1.5 < DPFP < 38.5 Test 2: Function of exhaust flow.

DPF Sensor Monitors	
DTCs	P2454 – DPFP Sensor Circuit Low P2455 – DPFP Sensor Circuit High P2453 – DPFP Sensor Circuit Range/Performance
Monitor execution	P2454, P2455, P2453 (Test 2): Continuous P2453 (Test 1): Once per trip at key-on
Monitor Sequence	None
Sensors OK	Engine Off Timer, IAT (P0112, P0113)
Monitoring Duration	P2453: 5 minutes P2454, p2455: 15 seconds

Typical DPF Sensor Entry Conditions:		
Entry condition	Minimum	Maximum
P2453:		
(Test 1) Engine State	Key on	
(Test 2) Engine Speed	?	
(Test 2) Torque setpoint	?	
P2454, P2455: None		

Typical DPF Sensor Malfunction Thresholds:
P2454 – DPFP Sensor Circuit Low Voltage < 0.10 volts P2455 – DPFP Sensor Circuit High Voltage > 4.90 volts P2453 – DPFP Sensor Circuit Range/Performance : Test 1 - Key-on Pressure Sensor Rationality Test : pressure > 25 hPa Test 2 - Continuous Pressure Sensor Rationality Test: absolute value of change in voltage < 0.01 volts

Boost Pressure Monitor

Electronic Variable Response Turbocharger (EVRT) Check Operation:	
DTCs	P132B - Turbocharger/Supercharger Boost Control A Performance P2563 - Turbocharger Boost Control Position Sensor A Circuit Range/Performance
Monitor Execution	P132B - Continuous P2563 - Continuous
Monitor Sequence	None
Sensors OK	P132B - Not applicable – data obtained over CAN P2563 – EP (P0472, P0473), ECT (P0117, P0118), IAT (P0112, P0113)
Typical Monitoring Duration	P132B – 1 sec. P2563 – 2.5 sec.

Typical Electronic Variable Response Turbocharger (EVRT) P2563 Check Entry Conditions:		
Entry Condition	Minimum	Maximum
Engine running		
No DPF regeneration requested		
Exhaust Pressure (EP) setpoint absolute value of rate of change of stable for 5 sec.		20.07 hPa / sec
Engine Speed (N)	600 rpm	1000 rpm
Indicated torque setpoint	50 N.m	
Engine Coolant Temperature	70 deg C	
Intake Air Temperature	-50 deg C	

Typical Electronic Variable Response Turbocharger (EVRT) Check Malfunction thresholds:
P132B - Actuator performs tests and sends status via a CAN message. P2563 (test 1) - The difference between the VGT actuator commanded position and the feedforward VGT actuator commanded position is less than -60% for at least 7.5 seconds OR P2563 (test 2) - The difference between the VGT actuator commanded position and the feedforward VGT actuator commanded position is greater than +70% for at least 7.5 seconds

Thermostat Monitor

The Thermostat Monitor checks that the thermostat is operating properly by estimating Engine Coolant Temperature (ECT) based on engine fueling, engine speed, vehicle speed, and the ambient temperature Once that estimation reaches the thermostat start-to-open temperature, if the actual measured ECT has not reached a minimum warm-up temperature and the driver has not spent too much time in part fuel cut off (over 99.6%), too low load (over 80%), too high vehicle speed (over 99.6%), or too low vehicle speed (over 70%) - then the thermostat is determined to be stuck open. The monitor can also be exited due to a condition where the difference in Intake Air temperature when the engine coolant model reaches 86 deg C and the Intake Air temperature at start is less than -15 deg C. This protects against model inaccuracy in a condition such as a vehicle parked in a heated garage overnight driving out into much colder ambient temperatures.

Thermostat Monitor:			
DTCs	P0128 – Coolant Thermostat (Coolant Temp Below Thermostat Regulating Temperature)		
Monitor Execution	Once per driving cycle		
Monitor Sequence	None		
Sensors OK	Engine Coolant Temperature (ECT), Intake Air Temperature (IAT), Vehicle Speed (VS)		
Typical Monitoring Duration	Nominal time it takes for engine to warm up to Thermostat Start To Open Temperature – see approximate times below. (Note: Unified Drive Cycle is 23.9 minutes long)		
	Ambient Temperature	Drive Cycle	Completion Time
	-7 deg C	Unified Drive Cycle + 55mph cruise	~~27.4~~ **42** min
	21 deg C	Unified Drive Cycle	~~17.8~~ **23** min
	38 deg C	Unified Drive Cycle	~~14.6~~ **21** min

Typical Thermostat Monitor Entry Conditions:		
Entry condition	Minimum	Maximum
Estimated engine coolant temperature	~~86~~ **87** deg C	
Engine coolant at start	-7 deg C	58 deg C
Intake Air Temperature at start	-7 deg C	
The difference of Intake Air Temperature when the model reaches ~~86~~ **87**degC and Intake Air Temperature at engine startup		-15 deg C
ratio of time that the vehicle speed is above, 100km/hr, to the total monitoring time		99.6%
ratio of time that the engine fueling is below 17 mg/str to the total monitoring time		~~80~~ **60**%
ratio of time that the engine receives no fuel to the total monitoring time		99.6%
Ratio of time that the vehicle speed is below 30km/hr to the total monitoring time		~~70~~ **60**%

Typical Thermostat Monitor Malfunction Thresholds:
Measured Engine Coolant Temperature < 78 deg C

Glow Plug Monitor

Glow Plug Control, Comprehensive Component Monitors, and Wait to Start Indicator

The California glow plug system is composed of solid state Glow Plug Control Module (GPCM), glow plugs, glow plug light, and the associated wiring harness. The glow plug on time is controlled by the Powertrain Control Module (PCM) and is a function of oil temperature, barometric pressure and battery voltage. The PCM enables the GPCM that drives the individual glow plugs. Glow plug on time normally varies between 1 and 120 seconds. In addition to PCM control, the GPCM internally limits the glow plug operation to 180 seconds regardless of PCM commanded on time. The power to the glow plugs is provided through the GPCM solid-state drivers directly from the vehicle battery. The GPCM monitors and detects individual glow plug functionality and the control and communication links to the PCM. The failures detected by the GPCM are passed to the PCM using a serial communication signal on the glow plug diagnostic line.

Glow Plug Module Control Circuit Check:	
DTCs	P0670 – Glow Plug Module Control Circuit
Monitor Execution	Continuous
Monitor Sequence	None
Sensors OK	Not Applicable
Typical Monitoring Duration	5 sec.

Typical Glow Plug Module Control Circuit Check Entry Conditions:		
Entry condition	Minimum	Maximum
Glow plugs disabled		

Typical Glow Plug Module Control Circuit Check Malfunction Thresholds:
Actuator driver status indicates open/short

Glow Plug Module Diagnostic Communication Circuit Operation:	
DTCs	P0684 – Glow Plug Control Module to PCM Communication Circuit Range/Performance
Monitor Execution	Continuous
Monitor Sequence	None
Sensors OK	Not Applicable
Monitoring Duration	10 sec.

Typical Glow Plug Monitor Entry Conditions:		
Entry condition	Minimum	Maximum
None		

Typical Glow Plug Monitor Malfunction Thresholds:
The Glow Plug Control Module (GPCM) passes Glow Plug status information across the Glow Plug Diagnostic Line. If the diagnostic line is constant high or constant low, or the period of the signal is out of range, the P0684 fault is set.

Glow Plug Monitor Operation:	
DTCs	P0671 – Cylinder 1 Glow Plug Circuit P0672 – Cylinder 2 Glow Plug Circuit P0673 – Cylinder 3 Glow Plug Circuit P0674 – Cylinder 4 Glow Plug Circuit P0675 – Cylinder 5 Glow Plug Circuit P0676 – Cylinder 6 Glow Plug Circuit P0677 – Cylinder 7 Glow Plug Circuit P0678 – Cylinder 8 Glow Plug Circuit
Monitor Execution	Continuous (every 100 ms)
Monitor Sequence	None
Sensors OK	Not Applicable
Monitoring Duration	8.5 sec.

Typical Glow Plug Monitor Entry Conditions:		
Entry condition	Minimum	Maximum
Battery Voltage	7 Volts	18 Volts
Glow plug on time	8.5 sec	

Typical Glow Plug Monitor Malfunction Thresholds:
An open circuit is a current level < 4 Amps, a short circuit is a current level > 60 Amps.

Glow Plug Wait to Start Light Operation:	
DTCs	P0381 – Glow Plug/ Heater Indicator Circuit
Monitor execution	Continuous (20ms)
Monitor Sequence	None
Sensors OK	No CAN error from the Instrumental Panel, no vehicle CAN errors
Typical Monitoring Duration	5 seconds

Glow Plug Light Wait to Start Light Entry Conditions:		
Entry condition	Minimum	Maximum
Glow plugs enabled		

Glow Plug Light Wait to Start Light Malfunction Thresholds:
Smart driver status from Instrument Panel. A CAN message is sent from the Instrument Panel to the ECM indicating Wait to Start Light status.

Comprehensive Component Monitor - Engine

Engine Inputs (Analog)

Barometric Pressure (BP) Sensor Circuit Check:	
DTCs	P2228 - Barometric Pressure Circuit Low Input P2229 - Barometric Pressure Circuit High Input
Monitor Execution	Continuous
Monitor Sequence	None
Sensors OK	Not applicable
Typical Monitoring Duration	P2228, P2229 - 5 sec.

Typical Barometric Pressure Sensor Circuit Check Entry Conditions:		
Entry condition	Minimum	Maximum
Key-on		

Typical Barometric Pressure Sensor Circuit Check Malfunction Thresholds:
P2228 - Voltage less than 2.22 V . P2229 - Voltage greater than 4.36 V.

Barometric Pressure Sensor Intermittency Monitor (P2230) checks for a rate of change of indicated pressure that would not be possible.

Barometric Pressure Sensor Intermittency Monitor Operation:	
DTCs	P2230 – Barometric Pressure Sensor Intermittent
Monitor Execution	Continuous
Monitor Sequence	None
Sensors OK	None
Typical Monitoring Duration	0.3 sec

Typical Barometric Pressure Sensor Intermittency Monitor Entry Conditions:		
Entry condition	Minimum	Maximum
None		

Typical Barometric Pressure Sensor Intermittency Monitor Malfunction Thresholds:
Absolute value of rate of change is greater than 25 kPa/100 milliseconds.

Manifold Absolute Pressure (MAP) Sensor Circuit Check:	
DTCs	P0107 - Manifold Absolute Pressure/BARO Sensor Low Input P0108 - Manifold Absolute Pressure/BARO Sensor High Input
Monitor Execution	Continuous
Monitor Sequence	None
Sensors OK	Not applicable
Typical Monitoring Duration	P0107, P0108 - 5 sec.

Typical Manifold Absolute Pressure Sensor Circuit Check Entry Conditions:		
Entry condition	Minimum	Maximum
None		

Typical Manifold Absolute Pressure Sensor Circuit Check Malfunction Thresholds:
Voltage < 0.15 volts or voltage > 4.90 volts

Manifold Absolute Pressure Functional Check Operation:	
DTCs	P2262 - Turbo/ Super Charger Boost Pressure Not Detected – Mechanical P2263 - Turbo/ Super Charger Boost System Performance
Monitor Execution	P2262 - Continuous P2263 - Continuous
Monitor Sequence	None
Sensors OK	P2262 – P2228, P2229, P0107, P0108 P2263 – EP (P0472, P0473), ECT (P0117, P0118), IAT (P0112, P0113), CKP (P0336, P0337, P1336)
Typical Monitoring Duration	P2262 - 5 sec. P2263 (test 1) - 15 sec. P2263 (test 2) – 15 sec.

Typical Manifold Absolute Pressure Functional Check Entry Conditions:		
Entry condition	Minimum	Maximum
P2262		
EGR valve position		1%
Engine Speed (N) – Range (1)	600 rpm	800 rpm
Engine Speed (N) – Range (2)	2200 rpm	3600 rpm
Coolant Temperature (ECT)	80 deg C	
Torque setpoint	50 Nm	
P2263		
Engine speed (N)	550 rpm	
Indicated torque setpoint (TQI_SP)	50 Nm	
Coolant Temperature (ECT)	81 deg C	
Intake Air Temperature (IAT)	-50 deg C	
Diesel Particulate Filter (DPF) is not regenerating		
Absolute value of rate of change of Exhaust Pressure (EP)		20.07 hPa / sec for 5 seconds

Typical Manifold Absolute Pressure Functional Malfunction Thresholds:
P2262 – If the Manifold Absolute Pressure (MAP) is less than -10 kPa in speed range (1) or less than 5.0 kPa in speed range (2) for 30 seconds the fault is set. P2263 (test 1) – The difference between the gage Exhaust Gas Pressure (EP) and the exhaust gas pressure setpoint is less than a calibratable value determined as a function of engine speed and indicated torque setpoint (IP_EGBP_CTL_MIN_DIAG) for 15 seconds. P2263 (test 2) - The difference between the gage Exhaust Gas Pressure (EP) and the exhaust gas pressure setpoint is greater than a calibratable value determined as a function of engine speed and indicated torque setpoint (IP_EGBP_CTL_MAX_DIAG) for 15 seconds.

Manifold Absolute Pressure (MAP) / Barometric Pressure (BP) Rationality Check:	
DTCs	P0069 - MAP/BARO Correlation P0106 - Manifold Absolute Pressure/BARO Sensor Range/Performance
Monitor Execution	P0069 – Continuous P0106 - Continuous
Monitor Sequence	None
Sensors OK	P0069 - BARO (P2228, P2229), MAP (P0107, P0108) P0106 - MAP (P0107, P0108)
Typical Monitoring Duration	P0069 - 3 sec. P0106 - 5 sec.

Typical MAP / BP Rationality Check Entry Conditions:		
Entry condition	Minimum	Maximum
P0069 - MAP / BARO Correlation:		
Key-on		
ECU on time	0 sec	
Battery voltage (IVPWR)	10.96 V	17.96 V
P0106 - MAP / BARO Sensor Range/Performance:		
Idle speed control is requested		
Engine Speed (N)		750 rpm
Indicated torque setpoint		100 N.m
Vehicle is not moving		
Engine Coolant Temperature (ECT)	69 deg C	
Intake throttle command output	10%	100%
DPF regeneration not requested	10 sec	

Typical MAP / BP Rationality Check Malfunction Thresholds:
P0069 - The difference between MAP and BARO is greater than 300 hPa .
P0106 - The difference between BARO and MAP is greater than 300 hPa.

Manifold Absolute Pressure (MAP) / Exhaust Pressure (EP) Rationality Check:	
DTCs	P006B - MAP/EP Correlation
Monitor Execution	Continuous
Monitor Sequence	None
Sensors OK	MAP (P0107, P0108), EP (P0472, P0473), ECT (P0117, P0118), IAT (P0112, P0113), BP (P2228, P2229)
Typical Monitoring Duration	5 sec.

Typical MAP / EP Rationality Check Entry Conditions:		
Entry condition	Minimum	Maximum
Key-on	5 seconds	
Engine off	5 seconds	
Engine Coolant Temperature (ECT)	-40 deg C	
Intake Air Temperature (IAT)	-40 deg C	

Typical MAP / EP Rationality Check Malfunction Thresholds:
The absolute value of the difference between Manifold Absolute Pressure (MAP) and Exhaust Gas Back Pressure (EP) is greater than 300 hPa

Exhaust Pressure (EP) Sensor Circuit Check:	
DTCs	P0472 - Exhaust Pressure Sensor Low Input P0473 - Exhaust Pressure Sensor High Input
Monitor execution	Continuous
Monitor Sequence	None
Sensors OK	Not applicable
Typical Monitoring Duration	P0472, P0473 - 3 sec.

Typical Exhaust Pressure Sensor Circuit Check Entry Conditions:		
Entry condition	Minimum	Maximum
None		

Typical Exhaust Pressure Sensor Circuit Check Malfunction Thresholds:
Voltage < 0.15 volts or voltage > 4.90 volts

Engine Coolant Temperature (ECT) Sensor Circuit Check:	
DTCs	P0117 - Engine Coolant Temperature Sensor Circuit Low Input P0118 - Engine Coolant Temperature Sensor Circuit High Input
Monitor execution	Continuous
Monitor Sequence	None
Sensors OK	ECT (P0117,P0118) TFU (P0182, P0183)
Typical Monitoring Duration	P0117, P0118 - 1 sec.

Typical Engine Coolant Temperature Sensor Circuit Check Entry Conditions:		
Entry condition	Minimum	Maximum
P0117, P0118 – ECU powered on	5 sec	

Typical Engine Coolant Temperature Sensor Circuit Check Malfunction Thresholds:
Voltage < 0.04 volts or voltage > 4.74 volts

Engine Oil Temperature (EOT) Sensor Circuit Check:	
DTCs	P0197 - Engine Oil Temperature Sensor Circuit Low Input P0198 - Engine Oil Temperature Sensor Circuit High Input
Monitor execution	Continuous
Monitor Sequence	None
Sensors OK	Not applicable
Typical Monitoring Duration	P0197, P0198 - 5 sec.

Typical Engine Oil Temperature Sensor Circuit Check Entry Conditions:		
Entry condition	Minimum	Maximum
None		

Typical Engine Oil Temperature Sensor Circuit Check Malfunction Thresholds:
Voltage < 0.04 volts or voltage > 4.74 volts

Engine Oil Temperature (EOT) Functional Check Operation:	
DTCs	P0196 - Engine Oil Temperature Sensor Circuit Range/ Performance P0298 - Engine Oil Overtemperature Condition
Monitor Execution	P0196 - Continuous P0298 - Continuous
Monitor Sequence	None
Sensors OK	P0196 – EOT (P0197, P0198) P0298 - EOT (P0197, P0198), IAT (P0112, P0113)
Typical Monitoring Duration	P0196 – After ~~600~~ **1200** seconds of no change. P0298 – EOT dependent.

Typical Engine Oil Temperature Functional Check Entry Conditions:		
Entry condition	Minimum	Maximum
P0196 – Engine off for 36,000 seconds		
P0298 - None		

Typical Engine Oil Temperature Functional Thresholds:
P0196 – Engine Oil Temperature (EOT) is sampled when the engine starts to run. Fault sets if the difference between Engine Oil Temperature (EOT) and sampled temperature is less than ~~7~~ **5** deg C. P0298 - Fault sets if Engine Oil Temperature (EOT) exceeds 110 deg C for a given period of time (EOT- and Intake Air Temperature 1 (IAT) - dependent).

Intake Air Temperature (IAT) Sensor Circuit Check:	
DTCs	P0112 - Intake Air Temperature Sensor 1 Circuit Low Input P0113 - Intake Air Temperature Sensor 1 Circuit High Input
Monitor Execution	Continuous
Monitor Sequence	None
Sensors OK	Not applicable
Typical Monitoring Duration	5 sec.

Typical Intake Air Temperature Entry Conditions:		
Entry condition	Minimum	Maximum
Engine has been started.		

Typical Intake Air Temperature Sensor Circuit Check Malfunction Thresholds:
Voltage < 0.15 volts or voltage > 4.60 volts

Intake Air Temperature 2 (IAT2) Sensor Circuit Check:	
DTCs	P0097 - Intake Air Temperature Sensor 2 Circuit Low Input P0098 - Intake Air Temperature Sensor 2 Circuit High Input
Monitor execution	Continuous
Monitor Sequence	None
Sensors OK	Not applicable
Typical Monitoring Duration	P0097, P0098 - 5 sec.

Typical Intake Air Temperature 2 Sensor Circuit Check Entry Conditions:		
Entry condition	Minimum	Maximum
None		

Typical Intake Air Temperature 2 Sensor Circuit Check Malfunction Thresholds:
Voltage < 0.17 volts or voltage > 4.81 volts

Intake Air Temperature 1/2 Rationality Check #2	
DTCs	P2199 – Intake Air Temperature 1/2 Correlation
Monitor Execution	Continuous
Monitor Sequence	None
Sensors OK	IAT (P0112, P0113), IAT2 (P0097, P0098), EOT (P0197, P0198), ECT (P0117, P0118), EGRP (P0405, P0406)
Typical Monitoring Duration	40 seconds

Typical Intake Air Temperature 1/2 Rationality Check #2 Entry Conditions:		
Entry condition	Minimum	Maximum
Exhaust Gas Recirculation Valve Position (EGRP)	8% (0.08)	
Engine speed (N)	600 rpm	800 rpm
Indicated torque setpoint (TQI_SP)	53 Nm	184 Nm
Time After Engine Start (T_AST)	N/A	155 Sec
Engine Off Time (T_ES)	10 hours	N/A

Typical Intake Air Temperature 1/2 Rationality Check #2 Thresholds:
Upon satisfying the entry conditions, if the difference between IAT1 and IAT2 is greater than 20 C.

Keep Alive Memory Monitor (KAM) Operation:	
DTC	P0603 – Powertrain Control Module Keep Alive Memory (KAM) Error
Monitor execution	Continuous
Monitor Sequence	None
Sensors OK	Not applicable
Typical Monitoring Duration	50 sec.

Typical KAM Monitor Entry Conditions:		
Entry condition	Minimum	Maximum
Key- on		

Typical KAM Monitor Malfunction Thresholds:
Internal hardware status indicates non-volatile memory error such as VID-Block not or falsely programmed checksum of non-volatile-memory incorrect.

Sensor Supply Voltage Check:	
DTCs	P0642 - Sensor Reference Voltage A Circuit Low P0643 - Sensor Reference Voltage A Circuit High P0652 - Sensor Reference Voltage B Circuit Low P0653 - Sensor Reference Voltage B Circuit High
Monitor execution	Continuous
Monitor Sequence	None
Sensors OK	Not applicable
Typical Monitoring Duration	P0642, P0643 - 0.5 sec P0652, P0653 - 0.5 sec

Typical Sensor Supply Voltage Check Entry Conditions:
Key-on

Typical Sensor Supply Voltage Check Malfunction Thresholds:
P0642 – Sensor supply voltage 1 less than 4.75 V.
P0643 – Sensor supply voltage 1 greater than 5.25 V.
P0652 – Sensor supply voltage 2 less than 4.75 V.
P0653 – Sensor supply voltage 2 greater than 5.25 V.

DC/DC Converter Voltage Check:	
DTCs	P0A09 - DC/DC Converter Fault Circuit Low P0A10 - DC/DC Converter Fault Circuit High
Monitor execution	Continuous
Monitor Sequence	None
Sensors OK	Not applicable
Typical Monitoring Duration	P0A09 - 2 sec. P0A10 - 2 sec.

Typical DC/DC Converter Voltage Check Entry Conditions:
Key-on

Typical DC/DC Converter Voltage Check Malfunction Thresholds:
P0A09 – DC/DC converter voltage less than 42 V. P0A10 – DC/DC converter voltage greater than 96 V.

Engine-Off Timer Check:	
DTCs	P2610 - ECM/PCM Internal Engine Off Timer Performance
Monitor Execution	Tests 1 – Continuous Tests 2 – Once per driving cycle
Monitor Sequence	None
Sensors OK	Test 1 – Not applicable Test 2 – ECT (P0117, P0118)
Typical Monitoring Duration	Test 1 – 30 s Test 2 – On transition from engine “stopped” to "running" state

Typical Engine-Off Timer Plausibility Check Entry Conditions:		
Entry Conditions	Minimum	Maximum
ECT at previous key off (Test 2, long soak portion only)	78 Deg C	
Engine-off time (Test 2, long soak portion only)	28800 sec	
Engine-off time (Test 2, short soak portion only)		60 sec

Typical Engine Off Timer Thresholds:
Test 1: Loss of communication between the engine-off timer micro and ECM OR The absolute delta difference between the engine-off timer and ECM's internal task rate time is greater than 5 sec   Test 2: (The engine-off timer is greater than 288000 seconds AND the ECT at engine off is greater than 78 DegC AND the absolute value of the difference between the ECT at engine start and the ECT at engine off is less than 5 DegC) OR (The engine-off timer is less than 60 seconds AND the absolute value of the difference between the ECT at engine start and the ECT at engine off is greater than 5 DegC)

High Speed CAN Communication Check:	
DTCs	U0073 – Control Module Communication Bus A Off U0101 - Lost Communication with TCM P179A - CAN ECM/Turbocharger Boost Control A Actuator Circuit Malfunction
Monitor Execution	Continuous
Monitor Sequence	None
Sensors OK	Not applicable
Typical Monitoring Duration	U0073 – 300 ms U0101 – 200 ms P179A – 5 sec

Typical High Speed CAN Communication Check Entry Conditions:		
Entry Conditions	Minimum	Maximum
Time delay to enable CAN diagnostic of Bus-Off after ignition key-on		300 ms
Time delay to enable CAN diagnostic after ignition key-on		2000 ms
Battery threshold for CAN diagnostic	9.0 volts	
Engine RPM threshold for diagnostic	0	

Typical High Speed CAN Communication Check Malfunction Thresholds:
U0073 – CAN communication hardware bus-off for 300 ms
U0101 – Lost of CAN communication between ECM and TCM for 200 ms (automatic vehicle only)
P179A – Lost of CAN communication between ECM and VGT for 5 sec

Vehicle ID Block Check:	
DTCs	P1639 – Vehicle ID Block Corrupted, Not Programmed
Monitor Execution	Continuous
Monitor Sequence	None
Sensors OK	Not applicable
Typical Monitoring Duration	100 ms

Typical Vehicle ID Block Check Entry Conditions:		
Entry condition	Minimum	Maximum
On key-up or after VID block reprogramming		

Typical Vehicle ID Block Check Malfunction Thresholds:
Set on any of the following conditions:
VID block is not configured
VIN ID is not correct or configured
Tire size is not configured
Axle ratio is not configured
Primary Alternator is not configured
Secondary Alternator is not configured
Engine Only Traction Control is not configured
Vehicle Speed Source is not configured
Wheel Base is not configured
Snow Plow is not configured

The P0600 Serial Communication Link Diagnostic is a hardware diagnostic on a microcontroller for the SPI Bus. The outputs of the microcontroller are checked for open load, short to ground, and short to battery conditions.

Serial Communication Link:	
DTC	P0600 – Serial Communication Link
Monitor execution	Continuous
Monitor Sequence	None
Sensors OK	None
Typical Monitoring Duration	<1 sec

Serial Communication Link:		
Entry condition	Minimum	Maximum
None		

Serial Communication Link:
The outputs of the microcontroller are checked for open load, short to ground, and short to battery conditions.

Engine Inputs (Digital)

On the 6.4L application the Mass Air Flow (MAF) Sensor produces a frequency output. The diagnosis of the MAF sensor looks at the period of the MAF sensor signal and increments a counter based on the error found. For example, if the period of the MAF sensor is less than a minimum period an Out or Range Low Period Counter is incremented. There are 5 counters total, No Signal, Out of Range High, Out of Range Low, Gradient too High, Signal OK. To diagnose a failure the ratio of that counter to all 5 counters must be greater than a ratio threshold. For example, for the out of range low failure, the ratio of the Out of Range Low Period Counter to 5 counters is taken and compared to a ratio threshold and if it is higher than that ratio threshold P0102 is set.

Mass Air Flow (MAF) Sensor Circuit Check:	
DTCs	P0101 – Mass or Volume Air Flow Circuit A P0102 – Mass or Volume Air Flow Circuit A Low Input P0103 – Mass or Volume Air Flow Circuit A High Input P0104 – Mass or Volume Air Flow Circuit A Intermittent/Erratic
Monitor Execution	Continuous
Monitor Sequence	None
Sensors OK	Not applicable
Typical Monitoring Duration	P0101 – 200 ms. P0102 – 200 ms. P0103 – 200 ms. P0104 - 500 ms.

Typical Mass Air Flow Sensor Circuit Check Entry Conditions:		
Entry condition	Minimum	Maximum
Battery voltage and ignition voltage	11 V	

Typical Mass Air Flow Sensor Circuit Check Malfunction Thresholds:
P0101 – The No Signal Period counter is incremented when the period of the MAF sensor is 0µs. The ratio of No Signal Period Counter to 5 counters must be greater than 60%.
P0102 – The Out or Range Low Period Counter is incremented when the period of the MAF sensor is lower than 63µs. The ratio of Out of Range Low Period Counter to 5 counters must be greater than 60%.
P0103 – The Out or Range High Period Counter is incremented when the period of the MAF sensor is higher than 580µs. The ratio of Out of Range High Period Counter to 5 counters must be greater than 60%.
P0104 – The Gradient Too High counter is incremented when the gradient exceeds 50 µs/ms. The ratio of the Gradient Too High counter to 5 counters must be greater than 10%.

Mass Air Flow Sensor Functional Check Operation:	
DTCs	P1102 – Mass Air Flow Sensor In Range But Lower Than Expected P1103 – Mass Air Flow Sensor In Range But Higher Than Expected
Monitor Execution	Continuous
Monitor Sequence	None.
Sensors OK	MAF (P0101, P0102, P0103), EGRP (P0405, P0406, P0404, P0042E, P042F, P1335) BP (P2228, P2229)
Typical Monitoring Duration	P1102 - 15 sec. P1103 - 15 sec.

Typical Mass Air Flow Sensor Functional Check Entry Conditions:		
Entry condition	Minimum	Maximum
DPF regeneration not requested		
PTO not active		
EGR flow monitor not active		
EGRP setpoint	0%	45%
Engine Speed (N)	680 rpm	2700 rpm
Indicated Torque Setpoint (TQI_SP)	70 N-m	
Barometric Pressure	800hPa	

Typical Mass Air Flow Sensor Functional Check Malfunction Thresholds:
P1102 – If the Mass Air Flow (MAF) is less than a value specified as a function of Engine Speed (N) and indicated torque setpoint (IP_MAF_KGH_MAF_TOT_MIN_DIAG). P1103 - If the Mass Air Flow (MAF) is greater than a value specified as a function of Engine Speed (N) and indicated torque setpoint (IP_MAF_KGH_MAF_TOT_MAX_DIAG).

Camshaft Position Sensor (CMP) Check Operation:	
DTCs	P0341 - Camshaft Position Sensor A Circuit Range/ Performance
Monitor Execution	P0341 - Continuous
Monitor Sequence	None.
Sensors OK	Not applicable
Typical Monitoring Duration	P0341 – Internal to the engine control module.

Typical Camshaft Position Sensor Malfunction Entry Conditions:		
Entry condition	Minimum	Maximum
Key-on		

Typical Camshaft Position Sensor Malfunction Thresholds:
P0341 – If it cannot be determined which Camshaft Position Sensor (CMP) signal edge has been detected, a counter is incremented. If the counter is greater than 3, the fault is set.

Crankshaft Position Sensor (CKP) Monitor Operation:	
DTCs	P0336 - Crankshaft Position Sensor A Circuit Range/ Performance P0337 - Crankshaft Position Sensor A Circuit Low Input
Monitor Execution	P0336 (tests 1 & 2) - Continuous P0336 (test 3) – Continuous P0337 – Continuous
Monitor Sequence	None
Sensors OK	CKP (P0336, P0337)
Typical Monitoring Duration	P0336 (test 1) – 1 sec. P0336 (test 2) – 1 sec. P0336 (test 3) – 1 sec. . P0337 – 1 sec.

Crankshaft Position Sensor Malfunction Entry Conditions:		
Entry condition	Minimum	Maximum
P0336 - None		
P0337 - None		

Crankshaft Position Sensor Malfunction Thresholds:
P0336 – Incorrect number of crankshaft teeth detected OR
Tooth period out of the CKP acceptance window established as the nominal tooth period +/- 37.5% OR
Number of detected camshaft edges is greater than 3
P0337 – The crankshaft sensor voltage is sampled 50 times, and the minimum and maximum voltages determined over the sample period. The fault is set if the minimum sample voltage is less than 1.99 OR
The maximum sample voltage is greater than 3.29 OR
The difference between the maximum and minimum sampled voltage is greater than 0.5 Volts..

Crankshaft Position Sensor (CKP)/Camshaft Position Sensor (CMP) Performance Monitor Operation:	
DTCs	P1336 - Crankshaft/Camshaft Sensor Range/Performance
Monitor Execution	P1336 - Continuous
Monitor Sequence	None
Sensors OK	CMP (P0341)
Typical Monitoring Duration	P1336 (test 1) - 1 sec. P1336 (test 2) - 1 sec.

Crankshaft Position Sensor/Camshaft Position Sensor Performance Malfunction Entry Conditions:		
Entry condition	Minimum	Maximum
None		

Crankshaft Position Sensor/Camshaft Position Sensor Performance Malfunction Thresholds:
P1336 (test 1) - Detected edge position < -24 deg crank OR Detected edge position > 24 deg crank
P1336 (test 2) - Detected number of missing teeth is greater than 2 OR Detected number of additional teeth is greater than 2 OR Detected number of missing teeth is greater than 2 + 2 (accounting for reference gap)

Engine Outputs

ABS Vehicle Speed Diagnostic Operation:	
DTCs	P215A – Vehicle Speed / ABS Wheel Speed Correlation
Monitor execution	Continuous
Monitor Sequence	None
Sensors OK	Not applicable
Typical Monitoring Duration	10.0 seconds

ABS Vehicle Speed Diagnostic Entry Conditions:
No ABS CAN error detected. No Vehicle CAN error detected.

ABS Vehicle Speed Diagnostic Malfunction Thresholds:
If the vehicle speed signal being sent over CAN to the ECU by the ABS module is equal to FFFF(hex) then a fault is detected.

Output Shaft Speed Sensor Functional Check Operation:	
DTCs	P215B – Vehicle Speed / Output Shaft Speed Correlation
Monitor execution	Continuous
Monitor Sequence	None
Sensors OK	Not Applicable
Monitoring Duration	10.0 seconds

Typical OSS functional check entry conditions:		
Entry condition	Minimum	Maximum
No vehicle CAN error found No transmission CAN error found		

Typical OSS functional check malfunction thresholds:
If the vehicle speed signal being sent over CAN to the ECU by the Transmission module is equal to 7FFF (hex) then a fault is set.

Comprehensive Component Monitor - Transmission

General

The MIL is illuminated for all emissions related electrical component malfunctions. For malfunctions attributable to a mechanical component (such as a clutch, gear, band, valve, etc.), some transmissions are capable of not commanding the mechanically failed component and providing the remaining maximum functionality (functionality is reassessed on each power up)- in such case a non-MIL Diagnostic Trouble Code (DTC) will be stored and, if so equipped, a Transmission Control Indicator Light (TCIL) will flash.

5R110W does not have the ability to isolate a shift solenoid fault from the rest of the mechanical/hydraulic system – all detected ratio errors result in MIL illumination except those attributed to the Over Drive and Simpson On-Way Clutches (which cause Neutral condition failures which cannot be caused by an electrical component).

Transmission Inputs

Transmission Range Sensor Check Operation:	
DTCs	P0706 (Out of range signal frequency for PWM Sensor) P0707, P0708 (Low /High duty cycle for PWM Sensor)
Monitor execution	Continuous
Monitor Sequence	None
Sensors OK	
Monitoring Duration	30 seconds

Typical TRS check entry conditions:		
Auto Transmission Entry Conditions	Minimum	Maximum
Gear selector position	Faults can be detected independent of lever position	none

Typical TRS malfunction thresholds:
For Pulse Width Modulated (PWM) sensor: Frequency > 160 Hz or < 100 Hz, Duty Cycle > 90% or < 10% If an error is present for 5 seconds a fault code will be stored

On some applications vehicle speed is calculated in the PCM by using the transmission output shaft speed sensor signal and applying a conversion factor for axle ratio and tire programmed into the Vehicle ID block. A Vehicle Speed Output pin on the PCM provides the rest of the vehicle with the standard 8,000 pulses/mile signal.

On all other applications vehicle speed is provided by the Anti-lock Brake System (ABS) or a vehicle speed sensor. In either case the vehicle speed input is tested as a "VSS", using fault code P0500.

Note: If the Vehicle ID block has not been programmed or has been programmed with an out-of-range (uncertified) tire/axle ratio, a P1639 DTC will be stored and the MIL will be illuminated immediately.

Output Shaft Speed Sensor Functional Check Operation:	
DTCs	P0720
Monitor execution	Continuous
Monitor Sequence	None
Sensors OK	
Monitoring Duration	30 seconds

Typical OSS functional check entry conditions:		
Auto Transmission Entry Conditions	Minimum	Maximum
Gear selector position	Any forward range	
Engine rpm (above converter stall speed) OR	3000 rpm	
Turbine shaft rpm (if available) OR	800 rpm	
Intermediate shaft rpm	800 rpm	
Vehicle speed (if available)	10 mph	

Typical OSS functional check malfunction thresholds:
Vehicle is inferred to be moving with positive driving torque and OSS < 100 to 200 rpm for 5 seconds

Intermediate Shaft Speed Sensor Functional Check Operation:	
DTCs	P0791
Monitor execution	Continuous
Monitor Sequence	None
Sensors OK	
Monitoring Duration	30 seconds

Typical ISS functional check entry conditions:		
Auto Transmission Entry Conditions	Minimum	Maximum
Gear selector position	Any forward range	
Engine rpm (above converter stall speed) OR	3000 rpm	
Turbine shaft rpm (if available) OR	800 rpm	
Output shaft rpm	500 rpm	
Vehicle speed (if available)	10 mph	

Typical ISS functional check malfunction thresholds:
Vehicle is inferred to be moving with positive driving torque and ISS < 250 rpm for 5 seconds

Turbine Shaft Speed Sensor Functional Check Operation:	
DTCs	P0715
Monitor execution	Continuous
Monitor Sequence	None
Sensors OK	
Monitoring Duration	30 seconds

Typical TSS functional check entry conditions:		
Auto Transmission Entry Conditions	Minimum	Maximum
Gear selector position	Any forward range	
Engine rpm (above converter stall speed) OR	3000 rpm	
Intermediate shaft rpm OR	800 rpm	
Output shaft rpm	500 rpm	
Vehicle speed (if available)	10 mph	
Torque converter lock-up (some applications)	N/A	

Typical TSS functional check malfunction thresholds:
vehicle is inferred to be moving with positive driving torque and TSS < 200 rpm for 5 seconds

Vehicle Speed Sensor Functional Check Operation:	
DTCs	P0500
Monitor execution	Continuous
Monitor Sequence	None
Sensors OK	
Monitoring Duration	30 seconds

Typical VSS functional check entry conditions:		
Auto Transmission Entry Conditions	Minimum	Maximum
Gear selector position	Any forward range	
Engine rpm (above converter stall speed) OR	3000 rpm	
Turbine shaft rpm (if available) OR	800 rpm	
Intermediate shaft rpm	800 rpm	
Output shaft rpm	500 rpm	

Typical VSS functional check malfunction thresholds:
Vehicle is inferred to be moving with positive driving torque and OSS < 100 to 200 rpm for 5 seconds

NOTE: on stand alone systems (engine controlled by an ECM, transmission by a TCM) the VSS input (usually provided by the ABS system) is diagnosed by the Engine Control Module.

Transmission Fluid Temperature Sensor Functional Check Operation:	
DTCs (all MIL)	P0712, P0713 (open/short) P0711 (range/performance)
Monitor execution	continuous
Monitor Sequence	none
Sensors OK	(ECT substituted if TFT has malfunction if not in cold mode or conditions to exit cold mode have been met, see note below)
Monitoring Duration	5 seconds for electrical, 500 seconds for functional check

Typical TFT functional check entry conditions:		
Auto Transmission Entry Conditions	Minimum	Maximum
Engine Coolant Temp (hot or cold, not midrange)	> 100 ^{o}F	< 20 ^{o}F
Time in run mode	500 sec	
Time in gear, vehicle moving, positive torque	150 sec	
Time with engine off (soak time)	420 min	
Vehicle Speed	15 mph	

Typical TFT malfunction thresholds:

Electrical check: TFT voltage <0.05 or > 4.6 volts for 5 seconds

TFT functional check (TFT stuck at high temperature or stuck at low temperature): < 6 ^{o}F rise or fall in TFT after startup

NOTES: 5R110W has a feature called "Cold Mode". If TFT is below 0 deg F, the transmission will limit operation to 1st, 2nd, 3rd, and 4th gears (5th and 6th gears are disabled). Cold mode remains in effect until TFT rises above 0 deg F or vehicle operation (based on shift times or heat generated by driving) indicates that TFT should not be in the cold mode range, at which point normal operation is enabled.

Direct clutch apply times cold have forced the addition of this cold mode because the direct clutch takes an unacceptable amount of time to apply below –10 deg F).

TFT failure management – if TFT is failed at start up, the transmission will be placed in cold mode and remain there until TFT is no longer failed and above 0 deg F or the vehicle operating conditions listed above trigger an exit from cold mode. Once out of cold mode, a TFT failure will not trigger cold mode (transmission will only go into cold mode once per power-up).

TFT In-Range tests will continue to run until a fault is set or the transmission temperature enters normal operating range where all transmission OBD test are running.

Transmission Outputs

The 5R110W shift solenoids are functionally tested by monitoring ratio and shift events for proper execution. Clutch system fault codes (since the solenoid cannot be isolated from the rest of the system using ratio alone) are set if the clutch is in the incorrect state for 3 commanded cycles of the clutch.

NOTE: For the Intermediate Clutch, Direct Clutch, and Over Drive Clutch, once the 1st "bad" event is detected, a special test mode is triggered that will cycle a suspected clutch on/off and retest – the clutch system test modes described below typically complete within 30 seconds drive time (vehicle speed > 5mph) after the 1st event.

For the Coast Clutch and Low Reverse Clutch, the test must wait until the customer goes to closed pedal so the diagnostics can test for engine braking. Once the customer tips out, the tests quickly complete; but test mode duration depends on how long until the customer tips out.

Shift Solenoid Check Operation:	
DTCs	SS A - P0750 (SSA open circuit,) P0973 (SSA short to ground) P0974 (SSA short to power) SS B - P0755 (SSB open circuit) P0976 (SSB short to ground) P0977 (SSB short to power) SS C - P0760 (SSC open circuit) P0979 (SSC short to ground) P0980 (SSC short to power) SS D - P0765 (SSD open circuit) P0982 (SSD short to ground) P0983 (SSD short to power) SS E - P0770 (SSE open circuit) P0985 (SSE short to ground) P0986 (SSE short to power)
Monitor execution	electrical - continuous, functional - during off-to-on solenoid transitions
Monitor Sequence	None
Sensors OK	
Monitoring Duration	5 seconds

Typical Shift Solenoid electrical check entry conditions:		
Entry Conditions	Minimum	Maximum
Battery Voltage	11.0 Volts	18.0 Volts

Typical Shift Solenoid mechanical functional check entry conditions:		
Entry Conditions	Minimum	Maximum
Turbine, intermediate, and output shaft speed	200 rpm	
Gear	In a forward range (for CC and LRC off faults a manual gear must be selected)	
Monitor execution	Both shifting and non-shifting	

Coast Clutch System (functional test of SSA):	
DTCs	P2700 Coast Clutch Failed On or Off P0751 Coast Clutch Failed Off P0752 Coast Clutch Failed On
Monitor execution	CC failed off – detected in 1M, 3M, or 5M CC failed on – detected during 1-2 or 5-6 shifts, then tested in 1A, 3A, or 5A
Monitor Sequence	Tested in the steady state gear listed above, then after each bad event the clutch is cycled and tested again
Sensors OK	TSS, ISS
Monitoring Duration	3 bad events

Over Drive Clutch System (functional test of SSB):	
DTCs	P2701 Overdrive Clutch Failed On or Off P0756 Overdrive Clutch Failed Off P0757 Overdrive Clutch Failed On
Monitor execution	ODC failed off – detected in 2nd or 6th gear or during 1-2 or 5-6 shifts ODC failed on – detected in 1st, 3rd, or 5th gear or during shifts into 1M, 3M, or 5M
Monitor Sequence	Tested in the steady state gear listed above, then after each bad event the clutch is cycled and tested again
Sensors OK	TSS, ISS
Monitoring Duration	3 bad events

Intermediate Clutch System (functional test of SSC):	
DTCs	P2702 Intermediate Clutch Failed On or Off P0761 Intermediate Clutch Failed Off P0762 Intermediate Clutch Failed On
Monitor execution	IC failed off – detected in 3rd gear or during shifts into 3rd gear. IC failed on – detected in 1st or 2nd gear or during shifts into 5th or 6th
Monitor Sequence	Tested in the steady state gear listed above, then after each bad event the clutch is cycled and tested again
Sensors OK	ISS, OSS
Monitoring Duration	3 bad events

Direct Clutch System (functional test of SSD):	
DTCs	P2703 Direct Clutch Failed On or Off P0766 Direct Clutch Failed Off P0767 Direct Clutch Failed On
Monitor execution	DC failed off – detected in 5th or 6th gear or during shifts into 5th or 6th gear. DC failed on – detected in 1st or 2nd gear or during shifts into 3rd gear.
Monitor Sequence	Tested in the steady state gear listed above, then after each bad event the clutch is cycled and tested again
Sensors OK	ISS, OSS
Monitoring Duration	3 bad events

Low/Reverse Clutch System (functional test of SSE):	
DTCs	P2704 Low Reverse Clutch Failed On or Off P0771 Low Reverse Clutch Failed Off P0772 Low Reverse Clutch Failed On
Monitor execution	LRC failed off – detected in 1M or 2M. LRC failed on – detected during upshifts from 1st or 2nd to any higher gear, tested in 1st or 2nd after a bad shift event.
Monitor Sequence	Tested in the steady state gear listed above, then after each bad event the clutch is cycled and tested again
Sensors OK	ISS, OSS
Monitoring Duration	3 bad events

Torque Converter Clutch Check Operation:	
DTCs	P0740 TCC solenoid open circuit P0742 TCC solenoid short to ground P0744 TCC solenoid short to power P0741 TCC mechanical functional
Monitor execution	electrical - continuous, mechanical - during lockup
Monitor Sequence	none
Sensors OK	TSS
Monitoring Duration	3 lock-up events

Typical Torque Converter Clutch electrical check entry conditions:		
Entry Conditions	Minimum	Maximum
Battery Voltage	11.0 Volts	18.0 Volts

Typical Torque Converter Clutch mechanical functional check entry conditions:		
Entry Conditions	Minimum	Maximum
Throttle Position	steady	
Engine Torque	positive drive torque	
Transmission Fluid Temp	None (test runs any time TCC applied)	275 ^{o}F
Commanded TCC current (0 rpm slip)	None (tested whenever the TCC is commanded on)	None
Not shifting		

Typical TCC malfunction thresholds:
Electrical check: Output driver feedback circuit does not match commanded driver state for 5 seconds (> 1.0 volt if commanded on, < 2.0 volts if commanded off.) Mechanical check: Slip across torque converter > 100 rpm or (on some applications) speed ratio < 0.93

The Electronic Pressure Control solenoid controls line pressure. If EPC fails low, all gears will be failed (loss of all movement). If EPC fails high, engagements will be harsh; but all gears available (no impact on steady state ratio). Therefore, EPC is not functionally monitored on it's own; but is tested as each clutch system is tested (since loss of line pressure will cause result in detection of clutch faults if pressure is lower than required to keep the currently applied clutches from slipping).

Electronic Pressure Control Check Operation:	
DTCs	P0960 – open circuit P0962 – short to ground P0963 – short to power
Monitor execution	Continuous
Monitor Sequence	none
Sensors OK	
Monitoring Duration	Electrical: 5 seconds

Typical Electronic Pressure Control mechanical functional check entry conditions:		
Entry Conditions	Minimum	Maximum
Battery Voltage	11.0 Volts	18.0 Volts

Typical EPC malfunction thresholds:
Electrical check: Current feedback circuit is less than commanded current for > 5 seconds

5R110W has a single high side switch that provides power to all 7 Variable Force Solenoids (5 shift solenoids, TCC, and EPC). The high side switch has circuit diagnostics, and if failed open a fault code will be stored.

High Side Switch:	
DTCs	P0657 Actuator Supply Voltage A Circuit / Open
Monitor execution	Continuous
Monitor Sequence	none
Monitoring Duration	Electrical: 5 seconds
CAN Communication:	
DTCs	U0100 Loss of communication with the ECM over CAN link
Monitor execution	Continuous
Monitor Sequence	none
Monitoring Duration	5 Seconds

Typical CAN Communication entry conditions:		
Entry Conditions	Minimum	Maximum
Battery Voltage	11.0 Volts	18.0 Volts
Engine running	> 500 rpm	
Module initialization time delay from startup	7 seconds	

Typical CAN Communication thresholds:
Loss of CAN communication between TCM and ECM > 30 seconds

Transmission Control Module Function:	
DTCs	KAM - P0603 (Internal Control Module KAM Error) P1633 (KAM Voltage to Low) RAM - P0604 (Internal Control Module RAM Error) ROM - P0605 (Internal Control Module ROM Error) CPU - P0607 (Control Module Performance)
Monitor execution	continuous
Monitor Sequence	None
Monitoring Duration	< 5 seconds > 20 seconds for KAM low voltage test

Typical TCM Function entry conditions:		
Entry Conditions	Minimum	Maximum
Battery Voltage	11.0 Volts	18.0 Volts

5R110W (RWD) Transmission

Transmission Inputs

Transmission Range Sensor

The Non-contacting Pulse Width Modulated Transmission Range Sensor (TRS) provides a duty cycle signal for each position. This signal is transmitted at a frequency of 125 Hz. The PCM decodes the duty cycle to determine the driver-selected gear position (Park, Rev, Neutral, OD, 3, 2, 1). This input device is checked for out of range frequency, low duty cycle and high duty cycle input signals. (P0706, P0707, P0708)

Speed Sensors

The Turbine Shaft Speed (TSS) sensor, Intermediate Shaft Speed (ISS) sensor and Output Shaft Speed (OSS) sensor, if equipped, are hall effect inputs that are checked for rationality. The vehicle speed signal is provided from the ABS system to the PCM. If the engine rpm is above the torque converter stall speed and engine load is high, it can be inferred that the vehicle must be moving. If there is insufficient output from the VSS sensor, a malfunction is indicated (P0500). If there is insufficient output from the TSS sensor, a malfunction is indicated (P0715). If there is insufficient output from the ISS sensor, a malfunction is indicated (P0791). If there is insufficient output from the OSS sensor, a malfunction is indicated (P0720).

Transmission Fluid Temperature

The transmission fluid temperature sensor is checked for circuit continuity (P0712, P0173) and for being stuck (P0711)

Transmission Outputs

Shift Solenoids

The Shift Solenoid (SSA, SSB, SSC, SSD, and SSE) output circuits are checked for opens and shorts by the PCM by monitoring the status of a feedback circuit from the output driver. SSA (P0750, P0973, P0974), SSB (P0755, P0976, P0977), SSC (P0760, p0979, P0980), SSD (P0765, P0982, P0983), SSE (P0770, P0985, P0986) each have fault codes for open circuit, short to ground, and short to power malfunctions.

The shift solenoids will be tested for function as part of the clutch system the solenoid controls. This is determined by vehicle inputs such as gear command and gear ratio. Clutch system malfunction codes:

Coast Clutch (controlled by SSA)	P2700 Transmission Friction Element A apply time range/performance.
	P0751 Shift Solenoid A Performance or Stuck Off
	P0752 Shift Solenoid A Stuck On
Over Drive Clutch (SSB)	P2701 Transmission Friction Element B apply time range/performance.
	P0756 Shift Solenoid B Performance or Stuck Off
	P0757 Shift Solenoid B Stuck On
Intermediate Clutch (SSC)	P2702 Transmission Friction Element C apply time range/performance.
	P0751 Shift Solenoid C Performance or Stuck Off
	P0752 Shift Solenoid C Stuck On

Direct Clutch (SSD)	P2703 Transmission Friction Element D apply time range/performance.
	P0766 Shift Solenoid D Performance or Stuck Off
	P0767 Shift Solenoid D Stuck On
Low/Reverse Clutch (SSE)	P2704 Transmission Friction Element E apply time range/performance.
	P0771 Shift Solenoid E Performance or Stuck Off
	P0772 Shift Solenoid E Stuck On

Gears are enabled/disabled based on clutch faults. Example: if the OD clutch is failed off, all gears requiring the ODC to be on are disabled (2^{nd}, 4^{th}, and 6^{th} gear). If the OD clutch is failed on, only gears with the ODC on are commanded (only 2^{nd}, 4^{th}, or 6^{th} gear will be commanded, 1^{st}, 3^{rd}, and 5^{th} will be disabled).

Torque Converter Clutch

The Torque Converter Clutch (TCC) Solenoid for 5R110W is a Variable Force Solenoid (VFS) that is tested electrically by a PCM output driver that has the capability to detect and distinguish opens (P0740), shorts to ground (P0742), and shorts to power (P0744).

The TCC solenoid is checked functionally by evaluating torque converter slip under steady state conditions when the torque converter is fully applied. If the slip exceeds the malfunction thresholds when the TCC is commanded on, a TCC malfunction is indicated (P0741).

Electronic Pressure Control

The EPC solenoid is a variable force solenoid that controls line pressure in the transmission. The EPC solenoid has a feedback circuit in the PCM that monitors EPC current. If a EPC short to ground is detected (minimum pressure) a high side switch will be opened, causing all solenoids to lose power. This will result in Park, Reverse, Neutral, and 5M (direct drive with engine braking) as the only forward gear. For Open or short to power faults (maximum line pressure) no gears are disabled; but engine idle is raised (to prevent line pressure instability since at low rpm the pump can't meet the maximum pressure demand caused by these faults).

High Side Switch

The high side switch provides power to all 7 solenoids. During certain failure modes the high side switch is opened, providing Park, Reverse, Neutral, and 5M.

CAN Communication Error

TCM CAN communication with the ECM is monitored. If the TCM is unable to communicate with the ECM a U0100 fault code will be stored and the TCM high side electrical drivers will be commanded off, resulting in the transmission allowing only park, reverse, neutral and 5M.

Transmission Control Module (TCM) Function

The 5R110W TCM (Transmission Control Module) is tested for KAM errors - P0603 (Internal Control Module KAM Error) and P1633 (KAM Voltage to Low), RAM errors - P0604 (Internal Control Module RAM Error), ROM errors - P0605 (Internal Control Module ROM Error), and CPU function - P0607 (Control Module Performance).

KAM is tested for both KAM memory location integrity and for voltage supply. RAM is tested for read/write errors using time based and accumulated counters. ROM is tested using a checksum computation routine and comparing the resulting value with a checksum value generated from the calibration release tools. There are several checks for CPU function such as watchdog, machine check and other hardware and software failures. These CPU tests use time based and accumulated counters.