Misfire Detection Monitor

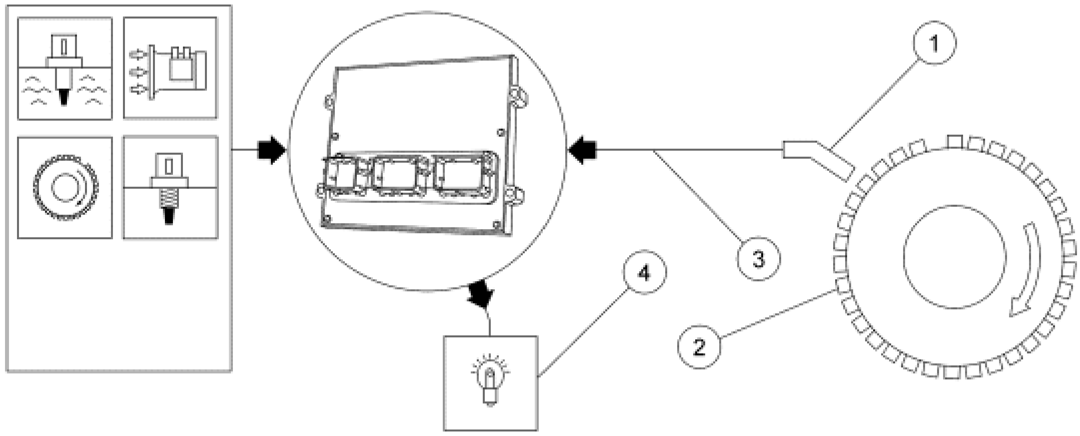
The misfire detection monitor is an on-board strategy designed to monitor engine misfire and identify the specific cylinder in which the misfire has occurred. Misfire is defined as lack of combustion in a cylinder due to absence of spark, poor fuel metering, poor compression, or any other cause. The misfire detection monitor is enabled only when certain base engine conditions are first satisfied. Input from the engine coolant temperature (ECT) or cylinder head temperature (CHT), intake air temperature (IAT), mass air flow (MAF) sensors is required to enable the monitor. The misfire detection monitor is also carried out during an on-demand self-test.

1. The powertrain control module (PCM) synchronized ignition spark is based on information received from the crankshaft position (CKP) sensor. The CKP signal generated is also the main input used in determining cylinder misfire.

2. The input signal generated by the CKP sensor is derived by sensing the passage of teeth from the crankshaft position wheel mounted on the end of the crankshaft.

3. The input signal to the PCM is then used to calculate the time between CKP edges and the crankshaft rotational velocity and acceleration. By comparing the accelerations of each cylinder event, the power loss of each cylinder is determined. When the power loss of a particular cylinder is sufficiently less than a calibrated value and other criteria are met, then the suspect cylinder is determined to have misfired.

4. The malfunction indicator lamp (MIL) is activated after one of the above tests fail on two consecutive drive cycles.



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Misfire Monitor Operation

There are two different misfire monitoring systems used: a low data rate (LDR) and a high data rate (HDR). The LDR system is capable of meeting the federal test procedure monitoring requirements on most engines and is capable of meeting the full-range of misfire monitoring requirements on 4-cylinder engines. The HDR system is capable of meeting the full-range of misfire monitoring requirements on 6-cylinder and 8-cylinder engines. The HDR on these engines meets the full-range of misfire phase-in requirements specified in the OBD regulations. The PCM software allows for detection of any misfires that occur six engine revolutions after initially cranking the engine. This meets the OBD requirement to identify misfires within two engine revolutions after exceeding the warm drive, idle RPM.

Low Data Rate System (LDR)

The LDR misfire monitor uses a low data rate CKP signal which indicates one position reference at 10 degrees before top dead center (BTDC) for each cylinder event. The PCM uses the CKP signal to calculate the crankshaft speed and acceleration for each cylinder. The crankshaft acceleration is then processed to detect a sporadic, single-cylider misfire patterns or multi-cylinder misfire patterns. The changes in overall engine RPM are removed by subtracting the median engine acceleration over a complete engine cycle. The resulting deviant cylinder acceleration values are used in evaluating misfire. Refer to the Generic Misfire Processing in this section for more information.

High Data Rate System (HDR)

The HDR misfire monitor uses a high data rate CKP signal which indicates 18 position references per crankshaft revolution. This high resolution signal is processed using two different algorithms. The first algorithm is optimized to detect hard misfires on one or more continuously misfiring cylinders. The low pass filter filters the high-resolution crankshaft velocity signal to remove some of the crankshaft torsional vibrations that degrade signal to noise. Two low pass filters are used to enhance detection capability – a base filter and a more aggressive filter to enhance single-cylinder capability at higher RPM. This significantly improves detection capability for continuous misfires on single cylinders up to redline. The second algorithm, called pattern cancellation, is optimized to detect low rates of misfire. The algorithm learns the normal pattern of cylinder accelerations from the mostly good firing events and is then able to accurately detect deviations from that pattern. Both the hard misfire algorithm and the pattern cancellation algorithm produce a deviant cylinder acceleration value, which is used in evaluating misfire in the Generic Misfire Processing section below.

Due to the high data processing requirements, the HDR algorithms may be implemented by the PCM in a separate chip. The chip carries out the HDR algorithm calculations and sends the deviant cylinder acceleration values to the PCM microprocessor for additional processing as described below. The chip requires proper operation of the CKP and camshaft position (CMP) sensor inputs. DTC P1336 will be set if the chip detects noise on the CKP sensor input or if the chip is unable to synchronize with the missing tooth location. A DTC P1336 points to noise present on the CKP sensor input or a lack of synchronization between the CMP and CKP sensors.

Generic Misfire Processing

The acceleration that a piston undergoes during a normal firing event is directly related to the amount of torque that cylinder produces. The calculated piston/cylinder acceleration value(s) are compared to a misfire threshold that is continuously adjusted based on inferred engine torque. Deviant accelerations exceeding the threshold are conditionally labeled as misfires.

The calculated deviant acceleration value(s) are also evaluated for noise. Normally, misfire results in a nonsymmetrical loss of cylinder acceleration. Mechanical noise, such as rough roads at high RPM with light load conditions, will produce symmetrical acceleration variations. Cylinder events that indicate excessive deviant accelerations of this type are considered noise. Noise-free deviant acceleration exceeding a given threshold is labeled a misfire.

The number of misfires are counted over a continuous 200 revolution and 1,000 revolution period. The revolution counters are not reset if the misfire monitor is temporarily disabled such as for negative torque mode. At the end of the evaluation period, the total misfire rate and the misfire rate for each individual cylinder is computed. The misfire rate is evaluated every 200 revolution period (Type A) and compared to a threshold value obtained from an engine speed/load table. This misfire threshold is designed to prevent damage to the catalyst due to sustained excessive temperature 899℃ (1,650℉) for Pt/Pd/Rh advanced washcoat and 982℃ (1,800℉) for Pd-only high tech washcoat. If the misfire threshold is exceeded and the catalyst temperature model calculates a catalyst mid-bed temperature that exceeds the catalyst damage threshold, the MIL blinks at a 1 Hz rate while the misfire is present. If the threshold is again exceeded on a subsequent driving cycle, the MIL is illuminated.

If a single cylinder is determined to be consistently misfiring in excess of the catalyst damage criteria, the fuel injector to that cylinder will be shut off to prevent catalyst damage for a calibrated period of time, typically 30 to 60 seconds. Up to two cylinders may be disabled at the same time on 6 and 8 cylinder engines and one cylinder on four cylinder engines. After the calibrated period of time has elapsed, the injector is re-enabled. If misfire on that cylinder is detected again after 200 revs (about 5 to 10 seconds), the fuel injector is shut off again and the process repeats until the misfire is no longer present. Note that ignition coil primary circuit failures trigger the same type of fuel injector disablement. For additional information, refer to Comprehensive Component Monitor (CCM) in this section.

The misfire rate is also evaluated every 1,000 revolution period and compared to a single (type B) threshold value to indicate an emission-threshold concern, which can be either a single 1,000 over-rev event from startup or 4 subsequent 1,000 over-rev events on a drive cycle after start-up. Many vehicles will set DTC P0316 if the type B threshold is exceeded during the first 1,000 revolutions after engine startup. This DTC is stored in addition to the normal P03xx DTC that indicates the misfiring cylinder. If the misfire is detected but it can not be attributed to a specific cylinder, a P0300 is stored.

Rough Road Detection

The misfire monitor may include a rough road detection system to eliminate false misfire indications due to rough road conditions. The rough road detection system uses data from the antilock brake system (ABS) wheel speed sensors for estimating the severity of rough road conditions. This is a more direct measurement of rough road over other methods which are based on driveline feedback via crankshaft velocity measurements. It improves accuracy over these other methods since it eliminates interactions with actual misfire.

In the event of an rough road detection system failure, the rough road detection output is ignored and the misfire monitor remains active. An rough road detection system failure could be caused by a failure in any of the input signals to the algorithm. This includes the ABS wheel speed sensors, brake pedal sensor, or controller area network (CAN) bus hardware failures. Specific DTCs indicate the source of these component failures.

A redundant check is also carried out on the rough road detection system to verify it is not stuck high due to other unforeseen causes. If the rough road detection system indicates rough road during low vehicle speed conditions where it is not expected, the rough road detection output is ignored and the misfire monitor remains active.

Profile Correction

Profile correction software is used to learn and correct for mechanical inaccuracies in the crankshaft position wheel tooth spacing. Since the sum of all the angles between the crankshaft teeth must equal 360 degrees, a correction factor can be calculated for each misfire sample interval that makes all the angles between individual teeth equal. The LDR misfire system learns one profile correction factor per cylinder (ex. 4 correction factors for a 4 cylinder engine), while the HDR system learns 36 or 40 correction factors depending on the number of crankshaft wheel teeth (ex. 36 for V6/V8 engines, 40 for V10 engines).

The corrections are calculated from several engine cycles of misfire sample interval data. The correction factors are the average of a selected number of samples. In order to assure the accuracy of these corrections, a tolerance is placed on the incoming values such that an individual correction factor must be repeatable within the tolerance during learning. This is to reduce the possibility of learning corrections on rough road conditions which could limit misfire detection capability and to help isolate misfire diagnoses from other crankshaft velocity disturbances.

To prevent any fueling or combustion differences from affecting the correction factors, learning is done during deceleration fuel shut-off (DFSO). This can be done during closed-throttle, non-braking, de-fueled decelerations in the 97 to 64 km/h (60 to 40 mph) range after exceeding 97 km/h (60 mph) (likely to correspond to a freeway exit condition). In order to minimize the learning time for the correction factors, a more aggressive deceleration fuel shut-off strategy may be used when the conditions for learning are present. The corrections are typically learned in a single 97 to 64 km/h (60 to 40 mph) deceleration, but may take up to 3 such decelerations or a higher number of shorter decelerations.

Since inaccuracies in the wheel tooth spacing can produce a false indication of misfire, the misfire monitor is not active until the corrections are learned. In the event of battery disconnection or loss of keep alive memory (KAM), the correction factors are lost and must be relearned. If the software is unable to learn a profile after three, 97 to 64 km/h (60 to 40 mph) deceleration cycles, DTC P0315 is set.

Neutral Profile Correction and Non-Volatile Memory

The neutral profile correction strategy is only available on selected vehicles. The 60-40 mph decel profile learning algorithm is active on all vehicles in current production.

Neutral profile learning is used at end of line to learn profile correction through a series of one or more neutral engine RPM throttle snaps. This allows the misfire monitor to be activated at the assembly plant. A scan tool command is required to enable neutral profile correction learning. Learning profile correction factors at high-speed (3,000 rpm) neutral conditions versus during 60-40 mph decels optimizes correction factors for higher rpms where they are most needed and eliminates driveline/transmission and road noise effects. This improves signal to noise characteristics which means improved detection capability.

The profile correction factors learned at the assembly plant are stored into non-volatile memory. This eliminates the need for specific customer drive cycles. However, misfire profiles may need to be relearned using a scan tool procedure if major engine work is done or the PCM is replaced. Re-learning is not required for a reflash.

Misfire Monitor Specifications

Misfire monitor operation: DTCs P0300 to P0310 (random and specific cylinder misfire), P1336 (noisy crank sensor, no crankshaft/camshaft sensor synchronization), P0315 (crankshaft position system variation not learned), P0316 (misfire detected on startup [first 1000 revolutions]). The monitor execution is continuous, misfire rate calculated every 200 or 1,000 revolutions. The monitor does not have a specific sequence. The CKP, CMP, MAF, and ECT or CHT sensors have to be operating correctly to run the monitor. The monitoring duration is the entire driving cycle (see disablement conditions below).

Typical misfire monitor entry conditions: Entry condition minimum/maximum time since engine start-up is 0 seconds, engine coolant temperature is -7℃ to 121° C (20℉ to 250℉), RPM range is (full-range misfire certified, with two revolution delay) two revolutions after exceeding 150 RPM below drive idle RPM to redline on tach or fuel cutoff, profile correction factors are learned in KAM, and the fuel tank level is greater than 15%.

Typical misfire temporary disablement conditions: Closed throttle deceleration (negative torque, engine being driven), Fuel shut-off due to vehicle-speed limiting or engine-RPM limiting mode, a high rate of change of torque (heavy throttle tip-in or tip out) and rough road conditions.

The profile learning operation includes DTC P0315 - unable to learn profile in three, 97 to 64 km/h (60 to 40 mph) decelerations; monitor execution is once per profile learning sequence; The monitor sequence: profile must be learned before the misfire monitor is active; The CKP and CMP sensors are required to be OK; CKP/CMP signals must be synchronized. The monitoring duration is 10 cumulative seconds in conditions (a maximum of three, 97 to 64 km/h (60 to 40 mph) de-fueled decelerations).

Customer drive cycle typical profile learning entry conditions: Entry conditions from minimum to maximum: Engine in deceleration fuel shut-off mode for four engine cycles, the brakes are not applied, the engine RPM is 1,300 to 3,700 RPM, the change is less than 600 RPM, the vehicle speed is 48 to 121 km/h (30 to 75 mph), and the learning tolerance is 1%.

Assembly plant or repair facility typical profile learning entry conditions: Entry conditions from minimum to maximum: Engine in deceleration fuel shut-off mode for four engine cycles, the vehicle in park/neutral gear, the engine RPM is 2,000 to 3,000 RPM, the learning tolerance is 1%.