## 4.2 Misfire Monitoring

### 4.2.1 Description

The method of engine misfire detection is based on evaluating engine speed fluctuations.

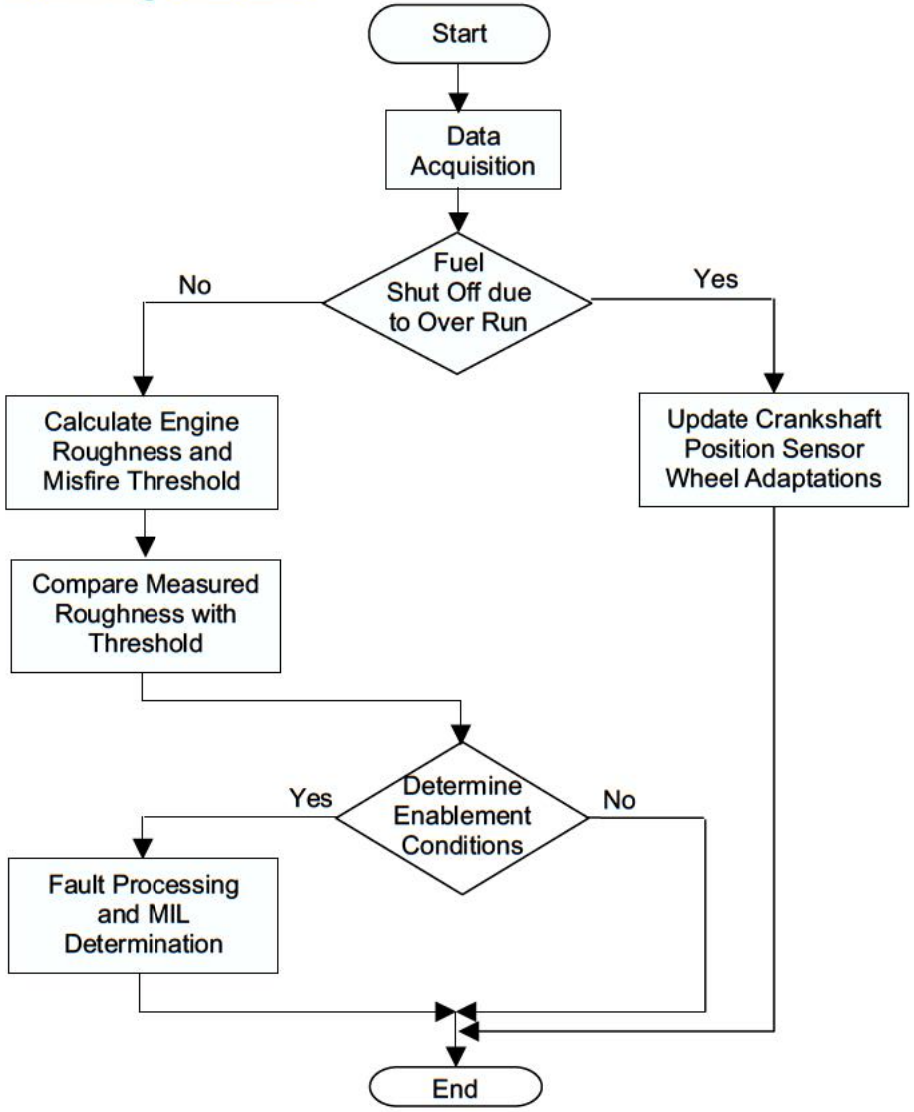
In order to detect misfiring in any cylinder, the torque of each cylinder is evaluated by recording the time between two ignition events; this is a measure of the mean value of the speed for this angular segment. Since a change in the engine torque results in a change of the engine speed. Additionally, the influence of the load torque at the wheels needs to be determined. This is to take account of the influences of different road surfaces, e.g. pavement, pot holes etc.

If the mean engine speed is measured, influences caused by road surfaces have to be eliminated.

This method consists of the following main parts:

- Data acquisition, including adaptation of the sensor wheel.
- Calculation of engine roughness.
- Comparison with a threshold, which depends on the operating conditions.
- Identification of extreme conditions, during which misfire detection cannot be enabled due to a risk of falsely detecting misfire.
- Fault processing, counting procedure of single misfire events, recording of any diagnostic trouble codes and MIL illumination.

### 4.2.2 Monitoring Structure



**1. Data Acquisition**

The duration of the crankshaft segments is measured continuously for every combustion cycle.

**2. Crankshaft Position Sensor Wheel Adaptation**

Within a defined engine speed range and during fuel cut-off, the adaptation of the crankshaft position sensor wheel tolerances is performed. As the adaptation process progresses, the sensitivity of the misfire detection is increased. The adaptation values are stored in non-volatile memory and are taken into consideration during the calculation of the engine roughness.

**3. Misfire Detection**

The following steps are performed for each measured segment, corrected by the appropriate crankshaft position sensor wheel adaptation.

**3.1 Calculation of the engine roughness**

The engine roughness is derived from the differences of the segment durations. Different statistical methods are used to distinguish between normal changes of the segment duration and any changes due to misfiring.

**3.2 Detection of multiple misfiring**

If several cylinders are misfiring (e.g. alternating one combustion/one misfire event), the calculated engine roughness values may be so low, that the threshold is not exceeded during misfiring and, therefore, misfiring would not be detected.

Based on this fact, the periodicity of the engine roughness value is used as additional information during multiple misfiring. The engine roughness value is filtered and a new multiple filter value is created. If this filter value increases due to multiple misfiring, the roughness threshold is decreased. By applying this strategy, multiple misfiring can be detected.

**3.3 Calculation of the engine roughness threshold value**

The engine roughness threshold value consists of the base value, which is determined from a load and speed dependent map. During warm-up an ECT dependent correction value is added. For multiple misfiring the threshold is reduced by an adjustable factor. Before sufficient crankshaft position sensor wheel adaptation has occurred, the engine roughness threshold is limited to a speed dependent minimum value. A change of the threshold towards a smaller value is limited by a variation constant.

**4.0 Determination of misfiring**

Misfire detection is performed by comparing the engine roughness threshold with the engine roughness value.

### 4.1 Statistics, fault processing

Within an interval of 1000 crankshaft revolutions the detected misfire events are summed for each cylinder. If the sum of all cylinder misfire incidents exceeds a predetermined value, the preliminary diagnostic trouble code for emission relevant misfiring is stored. If only one cylinder is misfiring, a cylinder selective diagnostic trouble code is stored. If more than one cylinder is misfiring, the diagnostic trouble code for multiple misfiring is also stored. If the misfire is again detected on a subsequent drive cycle, then the MIL is illuminated and the appropriate diagnostic trouble code is stored.

Within an interval of 200 crankshaft revolutions the detected number of misfiring events is weighted and calculated for each cylinder. The weighting factor is determined by a load and speed dependent map.

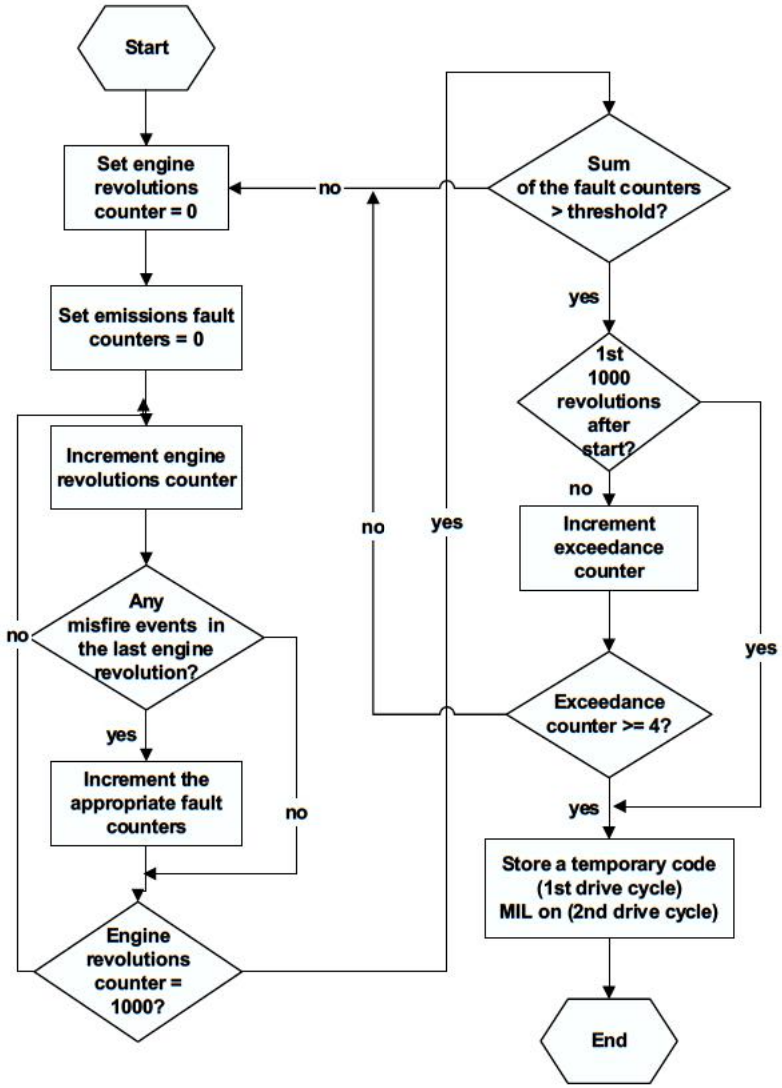
If the sum of cylinder misfire incidents exceeds a predetermined value the diagnostic trouble code for indicating catalyst damage relevant misfiring is stored and the MIL is illuminated at once (flashing).

If the cylinder selective count exceeds the predetermined threshold the following measures are instituted:

- The oxygen sensor closed loop system is switched to open loop.
- The appropriate cylinder selective DTCs is/are stored.
- If more than one cylinder is misfiring, the DTC for multiple misfire is also stored.

All misfire counters are reset after each interval.

### 4.2.3 Fault Processing for Emissions Relevant Misfire



| Misfire Monitoring Operation - Discovery | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Component/ System | Fault Codes | Monitoring Strategy Description | Malfunction Criteria | Threshold value | Secondary Parameter | Enable Conditions | Time Required | MIL Illumination |
| **Misfire** | P0301 to P0308 P0300 P1300 | crankshaft speed fluctuation multiple misfire | Federal Test Procedure (FTP) emissions Threshold | > 1.875 %/ 1000 revolutions | engine speed load change (after start) speed change (after start) engine load rough road (ABS) gear change traction control transfer gears re-enablement delay (not active after engine start) | 520 < rpm < 5400 < 1.20 ms/rev (< 130.8 ms/rev) < 4000 rpm/sec (< 20 000 rpm/sec) Positive not set not active not active high range 20 revolutions | 1000 revolutions up to twice in one drive cycle/ continuous | two driving cycles |
| | | | catalyst damage | 8.6 to 16.8 % at 600 rpm<br>7.4 to 14.6 % at 1000 rpm<br>2.0 to 10.7 % at 2000 rpm<br>1.9 to 9.9 % at 3000 rpm<br>1.8 to 8.3 % at 4000 rpm<br>1.8 to 5.0 % at 5000 rpm | | | 200 revolutions/ continuous | immediately |

If the above table does not include details of the following enabling conditions: - IAT, ECT, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.

| Misfire Monitoring Operation – Range Rover | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Component/ System | Fault Codes | Monitoring Strategy Description | Malfunction Criteria | Threshold value | Secondary Parameter | Enable Conditions | Time Required | MIL Illumination |
| **Misfire** | P0301 to P0308 P0300 P1300 | crankshaft speed fluctuation multiple misfire | FTP emissions threshold | > 2.0 %/ 4000 ignitions | engine speed load change speed change engine load rough road (ABS) traction control transfer gears time after start | 520 < rpm < 5400 < 0.10 ms/ignition < 720 rpm/sec positive not set not active high range > 5.0 sec | 1000 revolutions/ continuous | two driving cycles |
| | | | catalyst damage<br>4.0 litre<br>4.6 litre | 4.0 % to 15.9 %<br>3.8 % to 19.3 %<br>for the speeds and loads encountered during the FTP | | | 200 revolutions/ continuous | immediately |

| Misfire Monitoring Operation – Range Rover | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Component/ System | Fault Codes | Monitoring Strategy Description | Malfunction Criteria | Threshold value | Secondary Parameter | Enable Conditions | Time Required | MIL Illumination |
| | P1319 | low fuel level check | Fuel level | < 15% | misfire detection status | diagnostic trouble code stored | Immediately/ continuous | immediately |

If the above table does not include details of the following enabling conditions: - IAT, ECT, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.