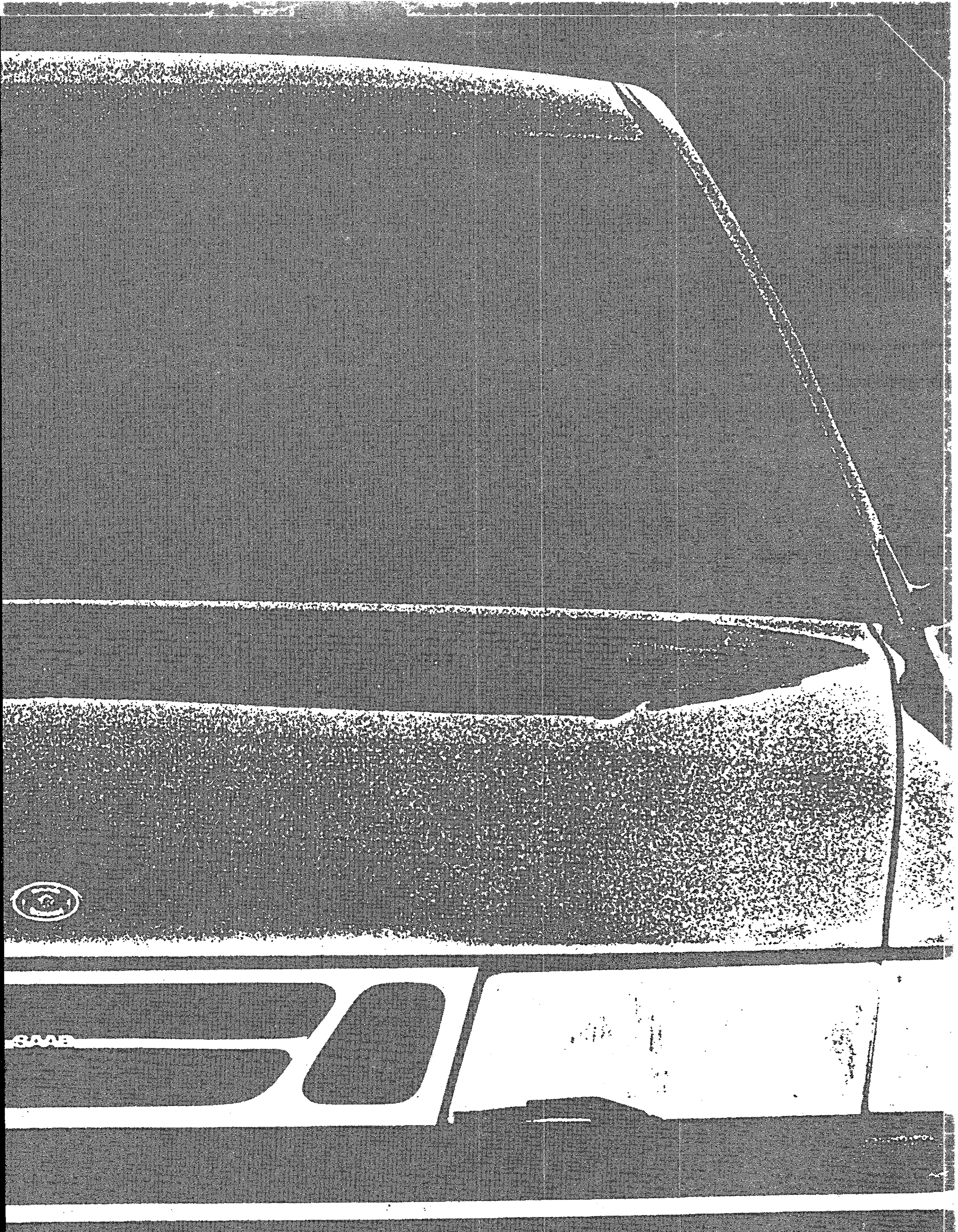

Service Manual

0:3 OBD II General Information

M 1996

ENG

SAAB

0:3 OBD II General Information M1996

The enclosed manual section is intended to introduce Saab service personnel to the OBD II (On Board Diagnostics, 2nd generation) emissions diagnostic system introduced in the 1996 model year on all automobiles sold in the United States, Canada and on American specification IDS (International & Diplomatic Sales) vehicles.

Unless otherwise stated, the hardware and diagnostic procedures discussed in this section are from the **TRIONIC** engine management system. **MOTRONIC** variants are mentioned only when they are significantly different. This is done to avoid the confusion which would result from discussing the same basic concept from several slightly different viewpoints.

The information in this manual section is based on prototype systems which may change slightly in final production. This section is meant to be used for **information and educational purposes only**. For diagnosis and repair work, always refer to the appropriate engine or transmission management system workshop manual.

Saab Automobile AB
Workshop & Customer Information

Saab 900/9000

SERVICE MANUAL

0:3 OBD II General Information M 1996

Foreword

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Saab Automobile AB

Warning, Important and Note

The headings "Warning", "Important" and "Note" occur from time to time in the Service Manual. They are used to draw the attention of the reader to information of special interest and seriousness. The importance of the information is indicated by the three different headings and the difference between them is explained below.

> ⚠ **WARNING**
>
> Warns of the risk of material damage and grave injury to mechanics and the driver, as well as serious damage to the car.

Important

Points out the risk of minor damage to the car and also warns the mechanic of difficulties and time-wasting mistakes.

Note

Hints and tips on how the work can be done in a way that saves time and labour. This information is not supplied for reasons of safety.

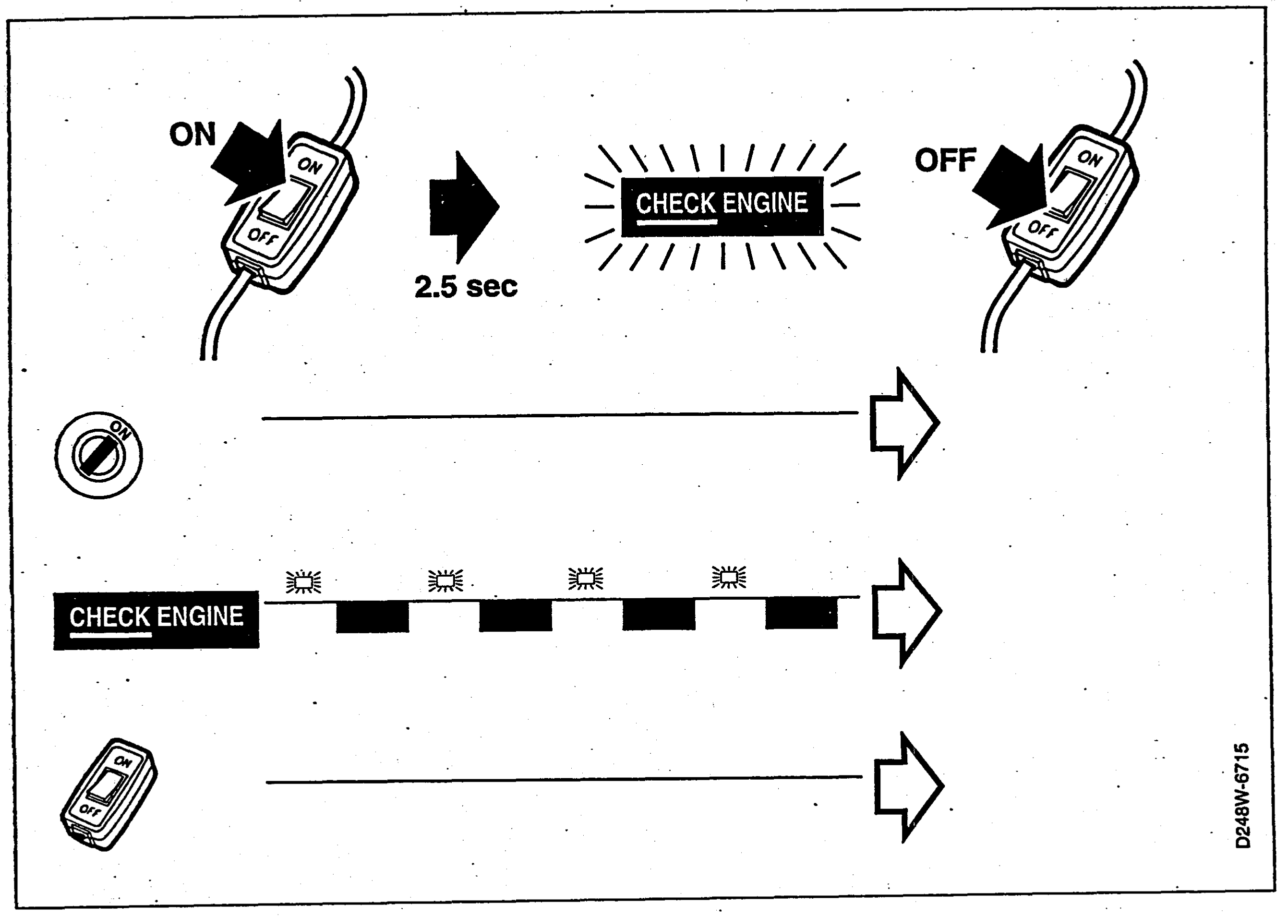
Market codes

The codes refer to market specifications

AT	Austria	GB	Great Britain
AU	Australia	GR	Greece
BE	Belgium	IS	Iceland
CA	Canada	IT	Italy
CH	Switzerland	JP	Japan
DE	Germany	ME	Middle East
DK	Denmark	NL	Netherlands
ES	Spain	NO	Norway
EU	Europe	SE	Sweden
FE	Far East	US	USA
FI	Finland	UC	US California
FR	France		

Production: Service Support, Saab Automobile AB, Trollhättan, Sweden

Background, On-Board Diagnostics

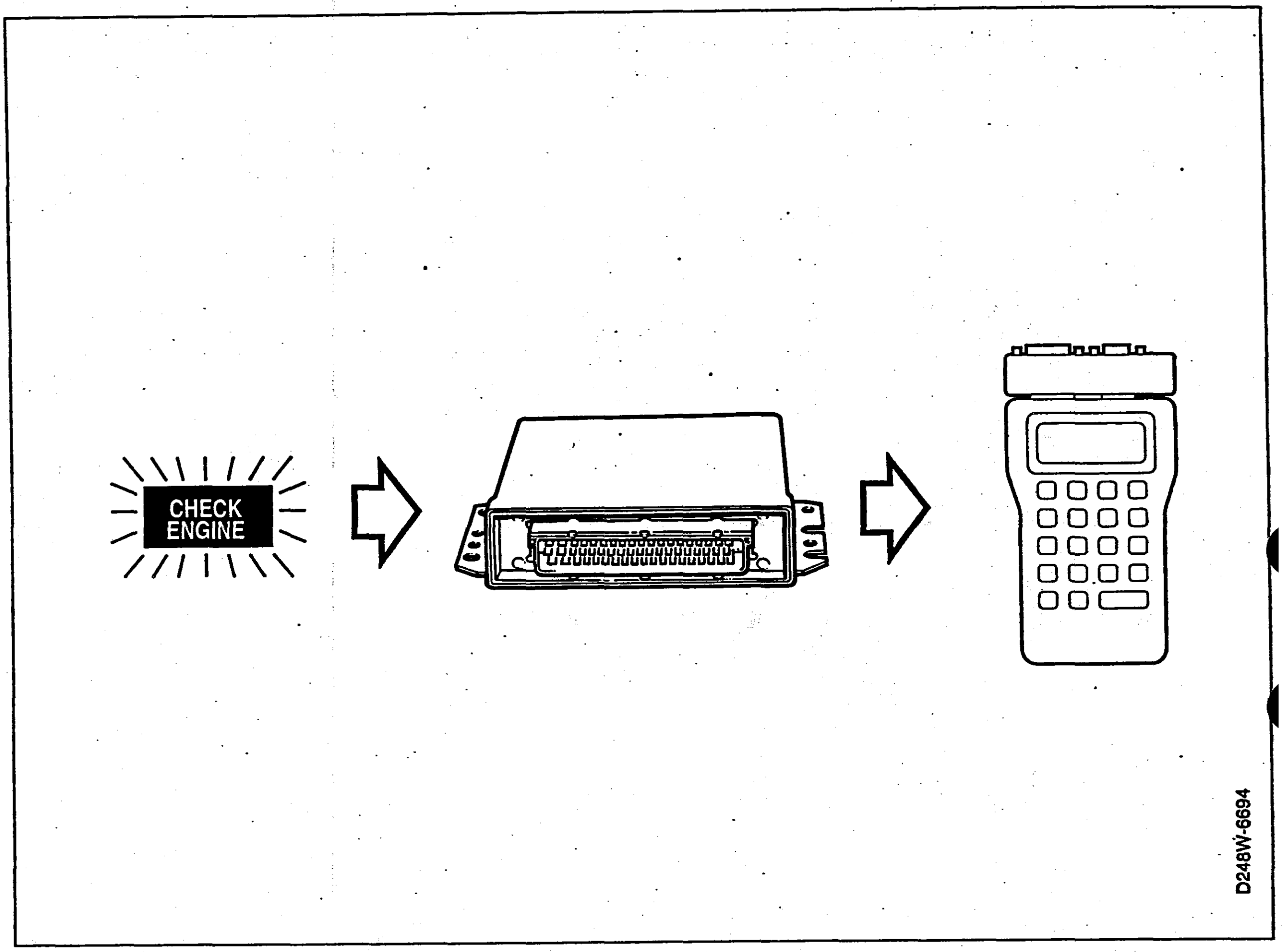


OBD I

1996 will be a year of major change for Saab. This change won't be readily apparent in the showroom but it's affect on the service department will be considerable. The source of this change is the government-mandated implementation of a new generation of on-board diagnostics, commonly referred to as OBD II. To better understand where we will be going, let us spend a few minutes reviewing where we have been.

The present generation of on-board diagnostics, known as OBD I, first appeared on 1988 Saabs equipped with the L.H. 2.4 fuel system. The California Air Resources Board (CARB) mandated the introduction of on-board diagnostics as a means of providing the service industry with the information needed to find and fix emissions-related faults. At the risk of oversimplification, here are some of the major characteristics and shortcomings of an OBD I system.

- Not all circuits or components which could affect emissions are monitored.
- An almost-complete failure must occur before a fault is detected. The systems lack the sophistication to "think" except in terms of black or white, on or off.
- Fault codes may be read by triggering the MIL (Check Engine light) and, in later production, with scan tools such as ISAT.
- A serious fault will turn on the MIL as soon as the fault is detected. Once the fault is no longer present, the MIL will be turned off at the next restart.
- The location and appearance of diagnostic connectors can vary from model to model and year to year. Each manufacturer has their own unique terminology, diagnostic routines and test equipment. It has become difficult for anyone other than a "factory" trained and equipped technician to diagnose and repair these vehicles.

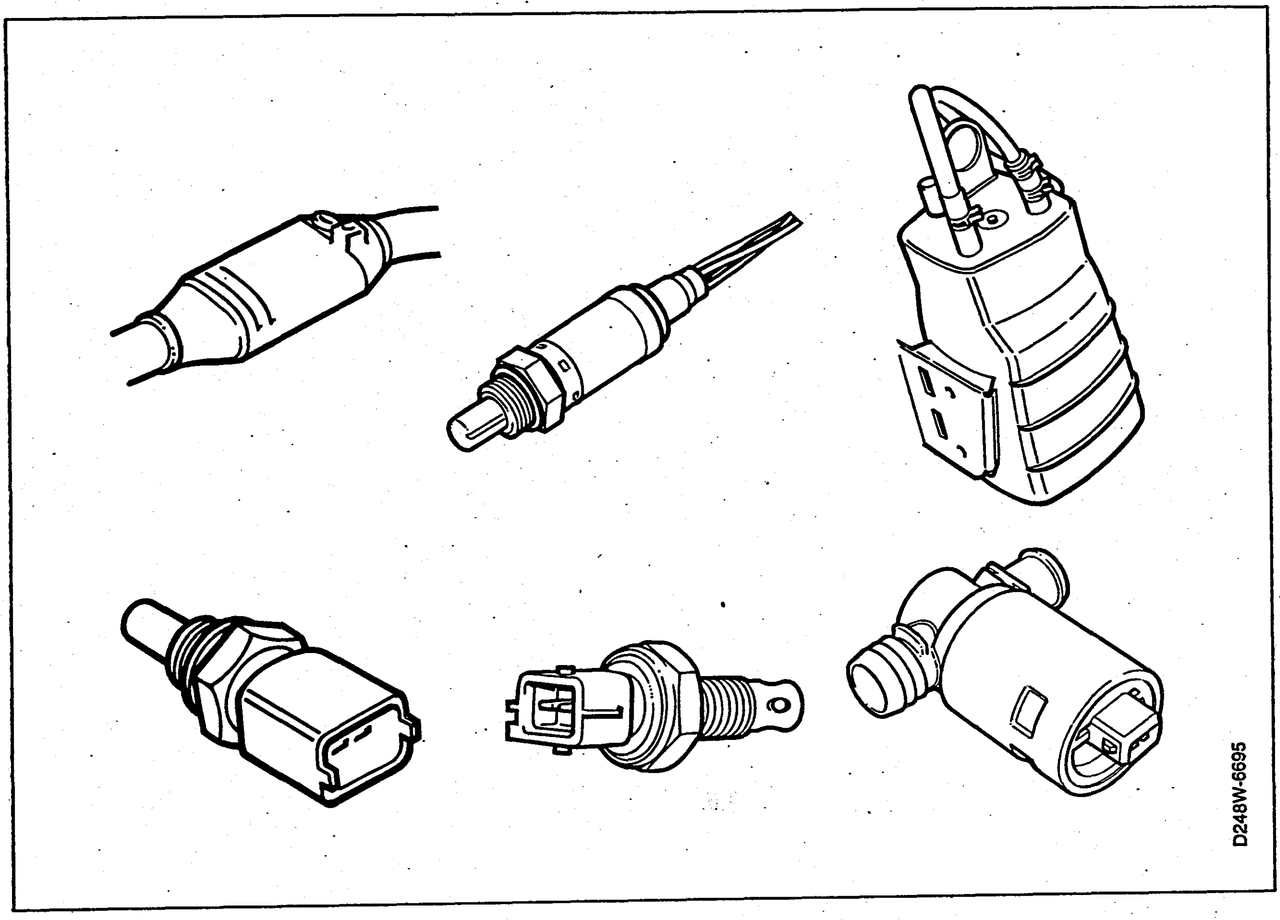


OBD II

The development of the standards which we now call OBD II began back in 1988, initially by CARB and later on as part of the 1990 revisions to the Federal Clean Air Act. The rest of this book is devoted to explaining just how OBD II works but here, as an introduction, are the basic objectives of the program.

- To quickly identify vehicles with emissions related problems. Studies show that a significant percentage of our current air quality problems are caused by a few poorly maintained or malfunctioning vehicles.
- To minimize the length of time between the occurrence of an emissions-related problem and its repair. Any significant increase in emissions will turn on the MIL (check engine light) and set a code. The driver will be warned that a problem exists and many state inspection programs will check for stored DTCs (fault codes). Cars with uncorrected problems won't have their registration renewed.
- To provide assistance in the diagnosis and repair of emission related problems. Technology has advanced to the point where traditional diagnostic methods are often inadequate. More and more often, only the control unit itself can judge the condition of the system.

Introduction to OBD II

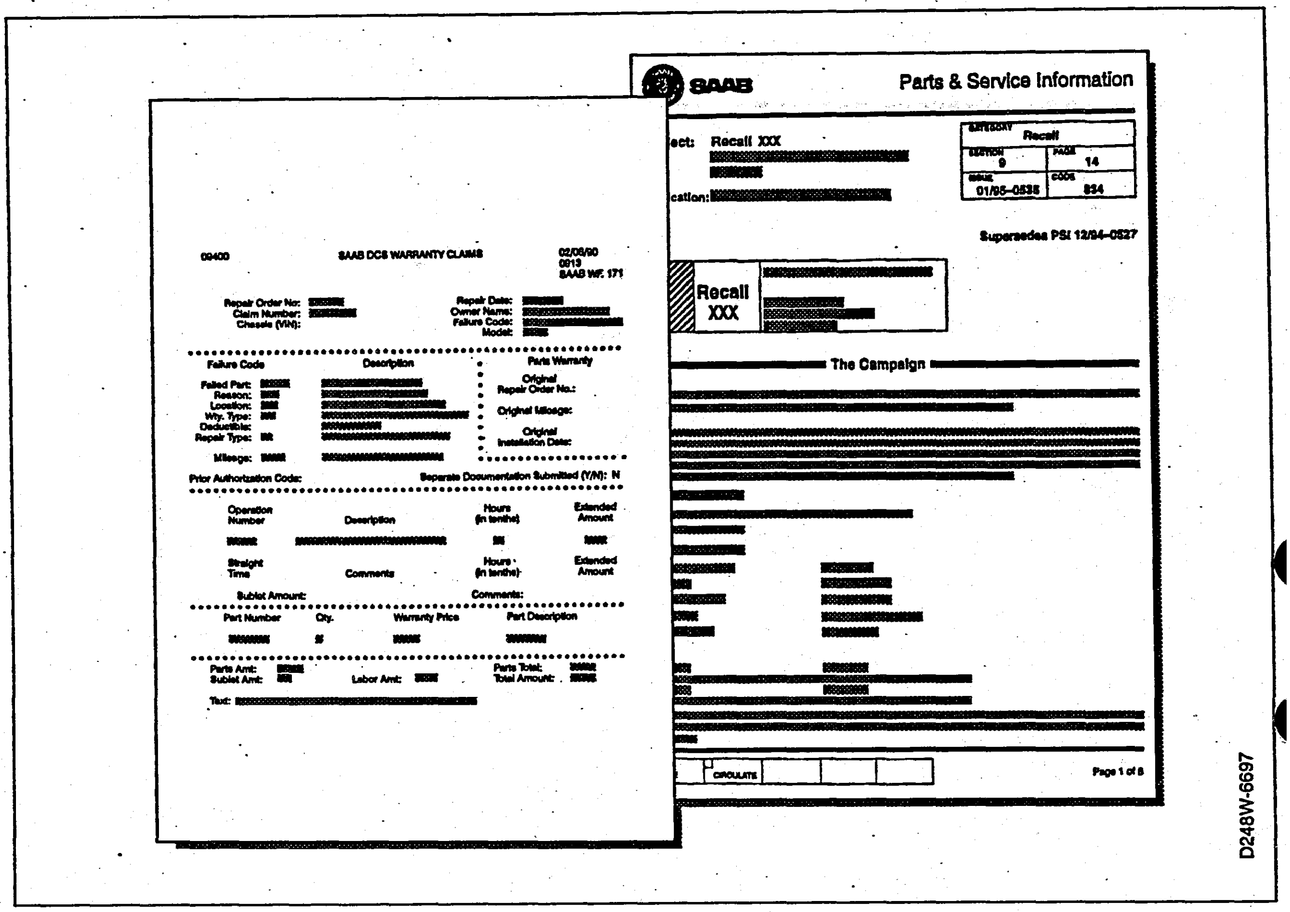


Systems & Components Monitored Under OBD II

OBD II regulations identify specific systems which must be monitored for any problem which would allow emissions to increase to a level above 1.5 times the federal standards which that vehicle was certified to meet when new. An OBD II system checks for:

- Catalytic Converter Efficiency
- Heated Catalytic Converter Heating Function (when applicable)
- Engine Misfire
- Evaporative Emission System Effectiveness
- Secondary Air Injection System Function
- R-12 A/C Refrigerant Leakage (Saab uses R134a)
- Fuel Trim System Monitoring
- Pre-catalyst oxygen sensor Efficiency
- Post-catalyst sensor Efficiency
- EGR System Function (when applicable)
- **Comprehensive Component Monitoring** (an extensive list of sensors and ECM controlled output devices which are monitored because their malfunction could affect emissions)

As you can see this is a generic list designed to apply to all manufacturers. Each of the systems which will be found on 1996 Saab models will be covered extensively latter on in this book.



Failure Reporting & Tracking

As part of OBD II, the government will be monitoring the results from state emissions testing programs and reviewing emissions-related warranty claims. If it appears that a particular model requires an abnormal number of emissions-related repairs the resulting investigation may trigger a recall campaign.

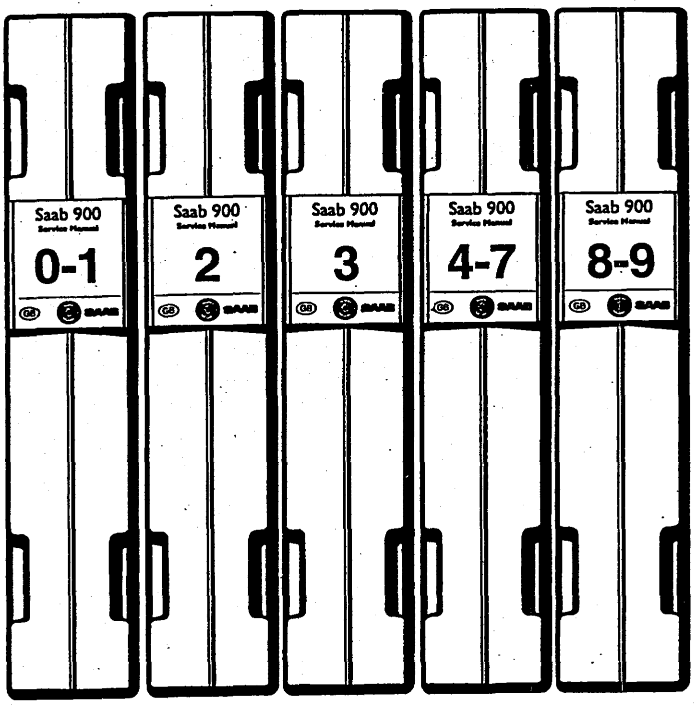
The purpose of this monitoring is to ensure that emissions systems will survive in the real world on cars driven and maintained by average drivers.

The familiar "shotgun" approach to diagnosis which is based on guesswork and throwing parts at a car rather than logically looking for the real cause of a problem will cause monumental headaches for both dealers and manufacturers under this new program.

You have all probably heard for years that the majority of ECMs and other parts which come back under warranty test out as "no fault found". Under the new monitoring program, the government won't be satisfied when a manufacturer says "things aren't really as bad as they look, most of those parts weren't really broken". This will only shift their attention to the effectiveness of our on-board diagnostics, training and repair procedures.

Naturally, our goal is to produce cars which never fail. Until we reach that point we must work together to ensure that cars which do break are repaired quickly and accurately.

In California, statistics shall be made based on the repairs performed under the regulated emissions warranty. At certain levels of warranty claims different activities are triggered. The warranty claims are accumulated throughout the useful life (10 years/100.000 miles) for each engine family in California. Note that the warranty claims used for this purpose are unscreened and include adjustment, inspection, repair or replacement of a component for which the workshop requests warranty compensations, regardless of whether the compensation is actually provided.



Federally Mandated Access to OBD II Repair Information

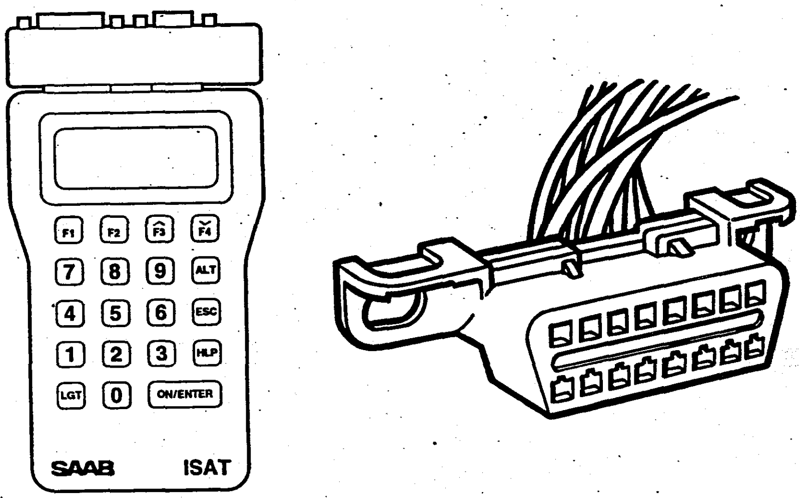
Availability Of OBD II Repair Manuals

One of the basic goals of OBD II is to make emissions-related diagnosis and repair information more accessible to the service industry. Legally, all manufacturers must make this information available to anyone who requests it. Most manufacturers will probably distribute their OBD II-related manuals through a third party, such as one of the publishers of aftermarket repair manuals.

Enhanced VS Generic Manuals

You, as a SAAB dealer, will receive what we will call an "enhanced" service manual for each one of our OBD II systems. This manual, to use the TRIONIC system as an example, will have all information found in the current 2:7 TRIONIC manual, modified and expanded to cover OBD II.

An independent repair shop will probably choose to purchase what we will call a "generic" manual. The name is derived from the fact that this manual will support the DTCs (fault codes) as they would be read on a generic scan tool such as those used in I/M 240 emissions testing facilities.



Federally Mandated Access to OBD II Repair Information (cont.)

Scan Tool Data

All manufacturers must write their OBD II diagnostic software in a way which will allow inspection stations and independent repair facilities to read emissions-related codes and data with any scan tool programmed to "talk" to OBD II systems.

As with the manuals, the intention is that the availability of information should not be the limiting factor in determining who can attempt to repair an OBD II car.

Generic vs Dedicated Scan Tools

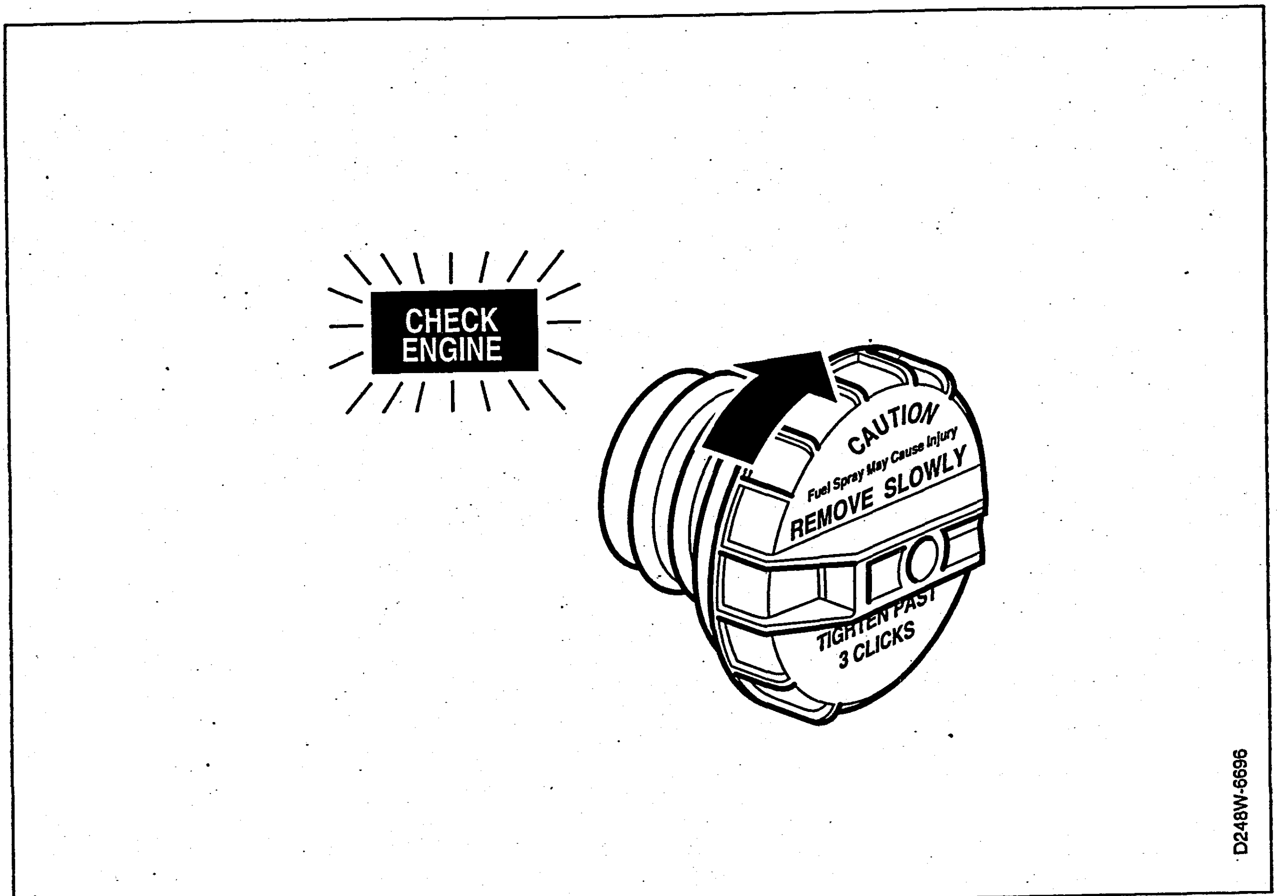
A very basic OBD II concept is that if the MIL is on, there will be a matching fault code. The reverse must also be true, you can't store an OBD II specified code (0 in the second position, I.E. P0300) without turning on the MIL.

Manufacturers are free to add codes in an effort to make the technician's life a little easier by providing additional information. These codes will have a 1 rather than a 0 in the second position. The rules governing these "1" codes are a bit more flexible.

As in OBD I, only emissions-related codes must turn on the MIL.

ISAT will display generic information in the format defined by the regulations (select GST on the main menu) PLUS an enhanced version of our traditional information (select TRIONIC OBD II/M96). The enhanced shop manuals are written to take full advantage of all the additional information available in the TRIONIC and MOTRONIC menus.

Generic tools will not access the TRIONIC OBD II/ M96 or similar MOTRONIC menus.



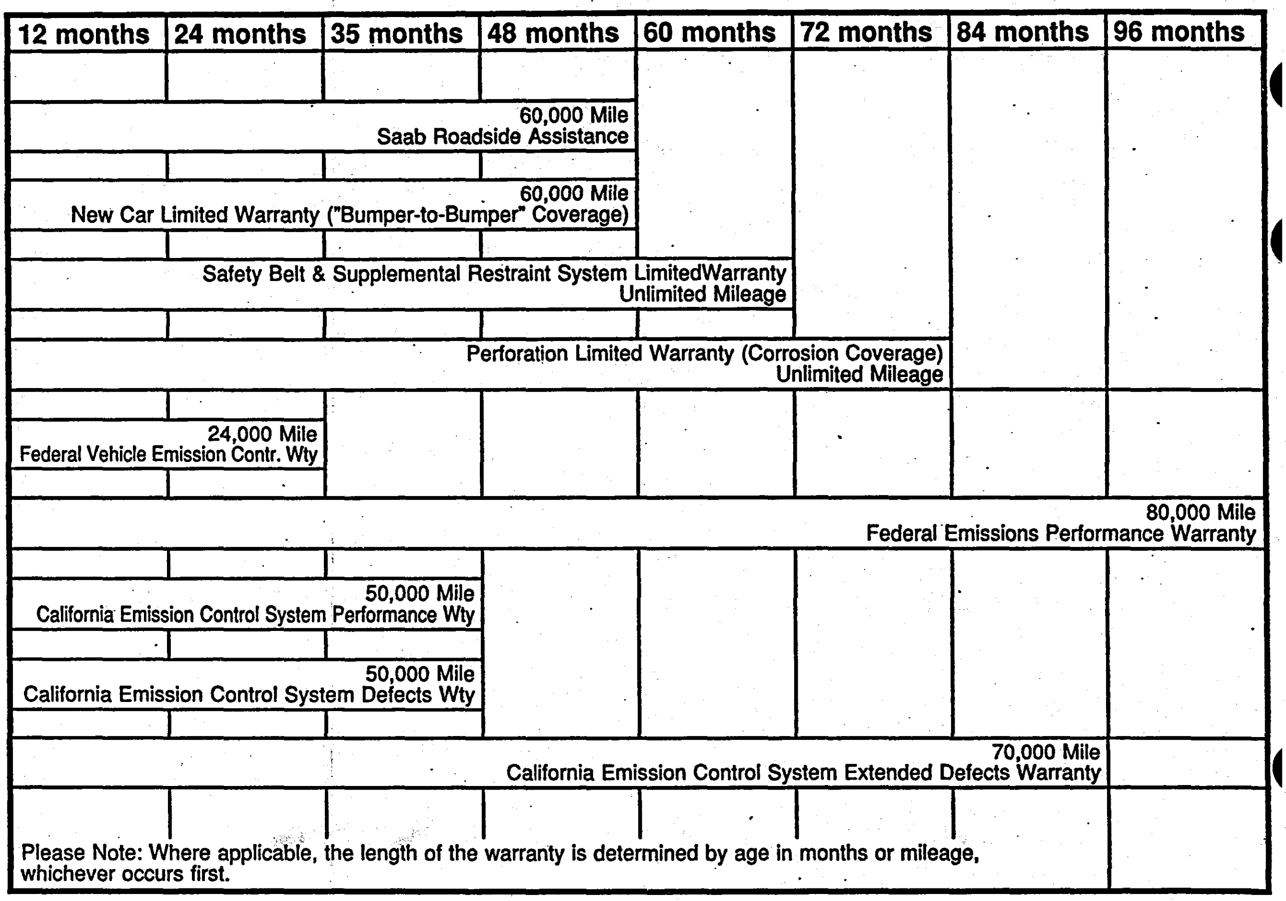
The Public & OBD II

The odds are that most owners will never know their car has an OBD II system unless the MIL comes on. At that point, it will probably be someone in the service department who will be called upon to explain it to them. Every person in the dealership who comes in contact with the consumer should be familiar with basic OBD II concepts and be able to explain how the MIL is controlled. A few of the important changes to MIL operation for 1996 are listed below:

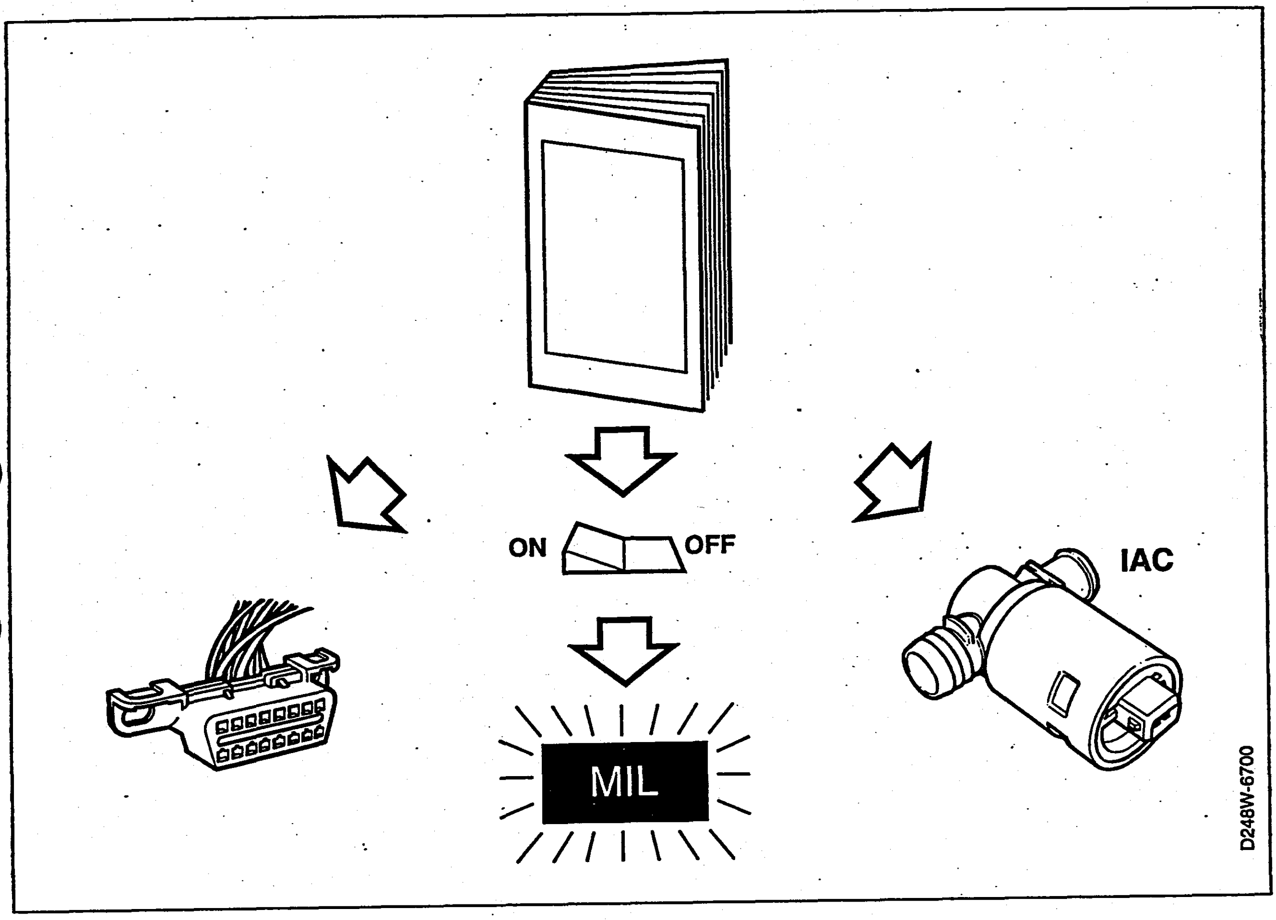
- Most importantly, there are a great many more "problems" capable of turning on the light. Some of these, such as a 900 EVAP system leak caused by a forgotten gas cap, scarcely fit the traditional concept of a failure.
- The chain of events which will turn on the light can be quite complex. With OBD I the MIL came on as soon as the fault was detected. With OBD II many of the faults must occur two times before the light will come on, these occurrences may be days or even weeks apart.
- With intermittent problems, OBD I would turn on the MIL as soon as a fault was detected but would turn the light off the next time you cycled the key if the fault was no longer there. Under similar circumstances, an OBD II system will leave the light on much longer, conceivably for days. The system is designed to make sure that the customer is aware of any problems and provide the motivation to get them fixed.

Emissions Warranty Coverage

Saab, like all other manufacturers, will provide an extended Federal Emissions Performance Warranty as part of the basic requirements of OBD II. The state of California also has specific warranty requirements for emissions systems coverage as shown on the following bar graph. For a more detailed explanation of warranty coverage, refer to the Warranty & Service Record Booklet which accompanies each vechicle and the Warranty Policies and Procedures Manual.

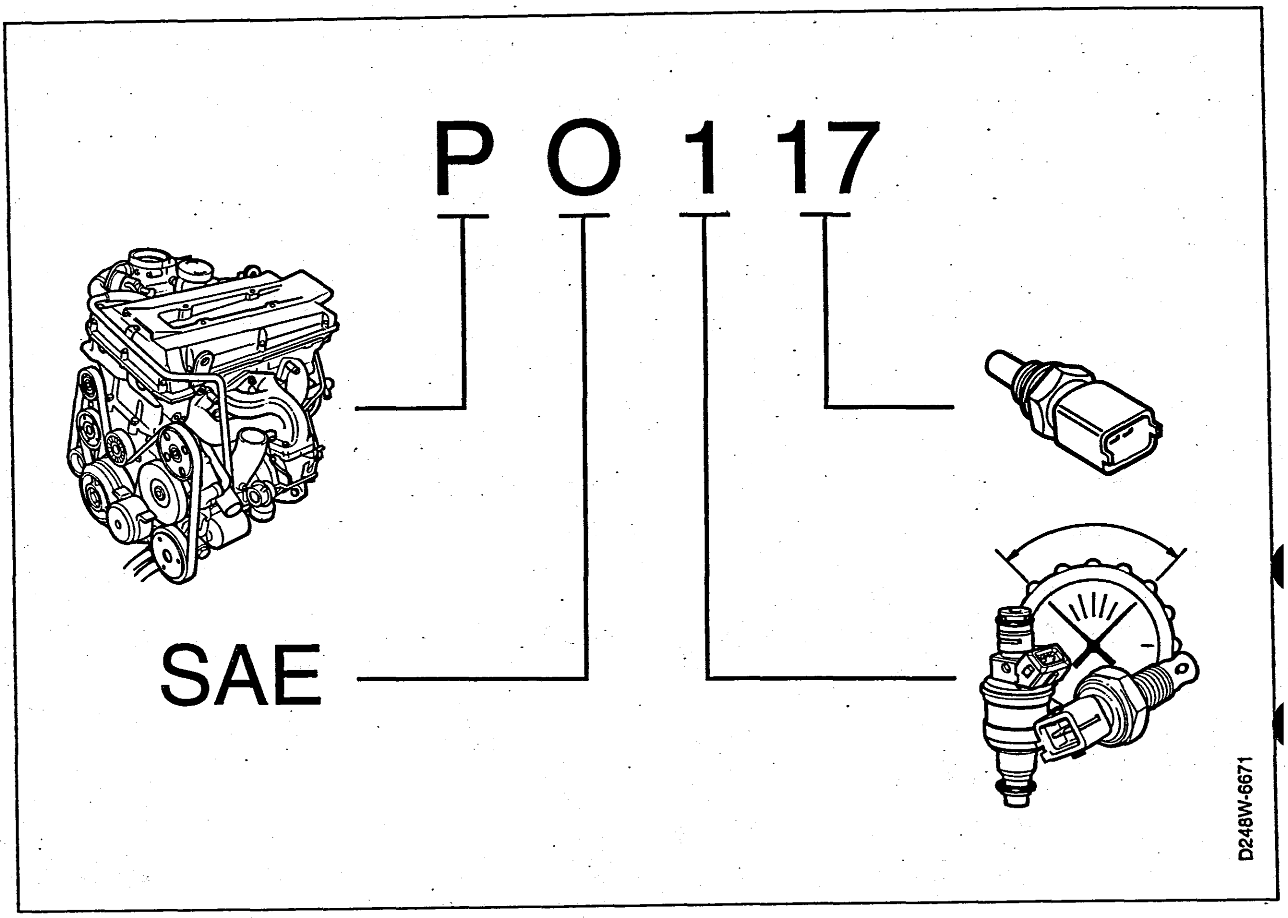


Universal OBD II Concepts



There is a tendency to view OBD II as monolithic concept which dictates a universal approach to all aspects of emissions controls. The truth of the matter is that manufacturers still have a great deal of freedom in the way they design and build their cars. Each car line and engine family may well require a slightly different solution for any given problem. Don't assume that, just because you understand one OBD II system, you understand them all.

There IS however, a high degree of standardization governing control of the MIL, the setting of fault codes, and of the terminology we must use to describe the process. The next few pages discuss concepts which will be the same no matter whose system you may be working upon.



OBD II Diagnostic Trouble Codes (DTCs)

OBD II regulations require that test modes and Diagnostic Trouble Codes (DTCs) be standardized between all automotive manufacturers. Saab first began to use the new five-character code structure in 1993 beginning with the TRIONIC system and has implemented it on all new systems introduced since then.

As shown above the first character in a OBD II DTC is a letter. This letter identifies the area of the vehicle the code applies to.

P-Powertrain
C-Chassis
B-Body

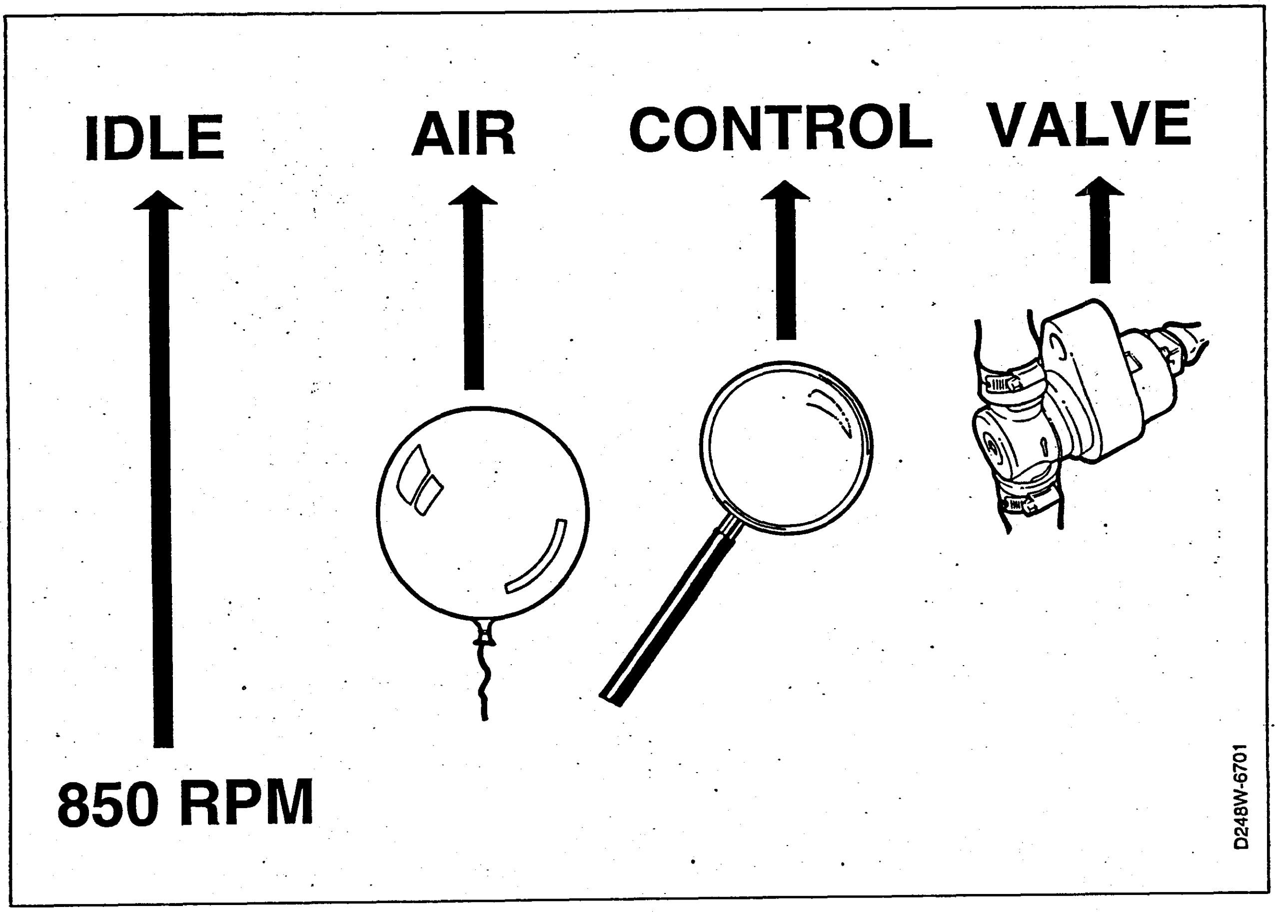
The second character indicates whether the code is a generic one as defined by SAE or a unique code specific to one manufacturer.

0-Generic
1-Manufacturer Specific

The third character identifies a specific vehicle system. Each system in the vehicle is assigned a series designation such as 100, 200. 300, and so on. These series are defined as follows:

100-Fuel and Air Metering
200-Fuel and Air Metering
300-Ignition System or Misfire
400-Auxiliary Emissions Controls
500-Vehicle Speed Control and Idle Control System
600-Computer Output Circuits
700-Transmission
800-Transmission

The final two characters are the actual codes which fall within the 100 series designator.

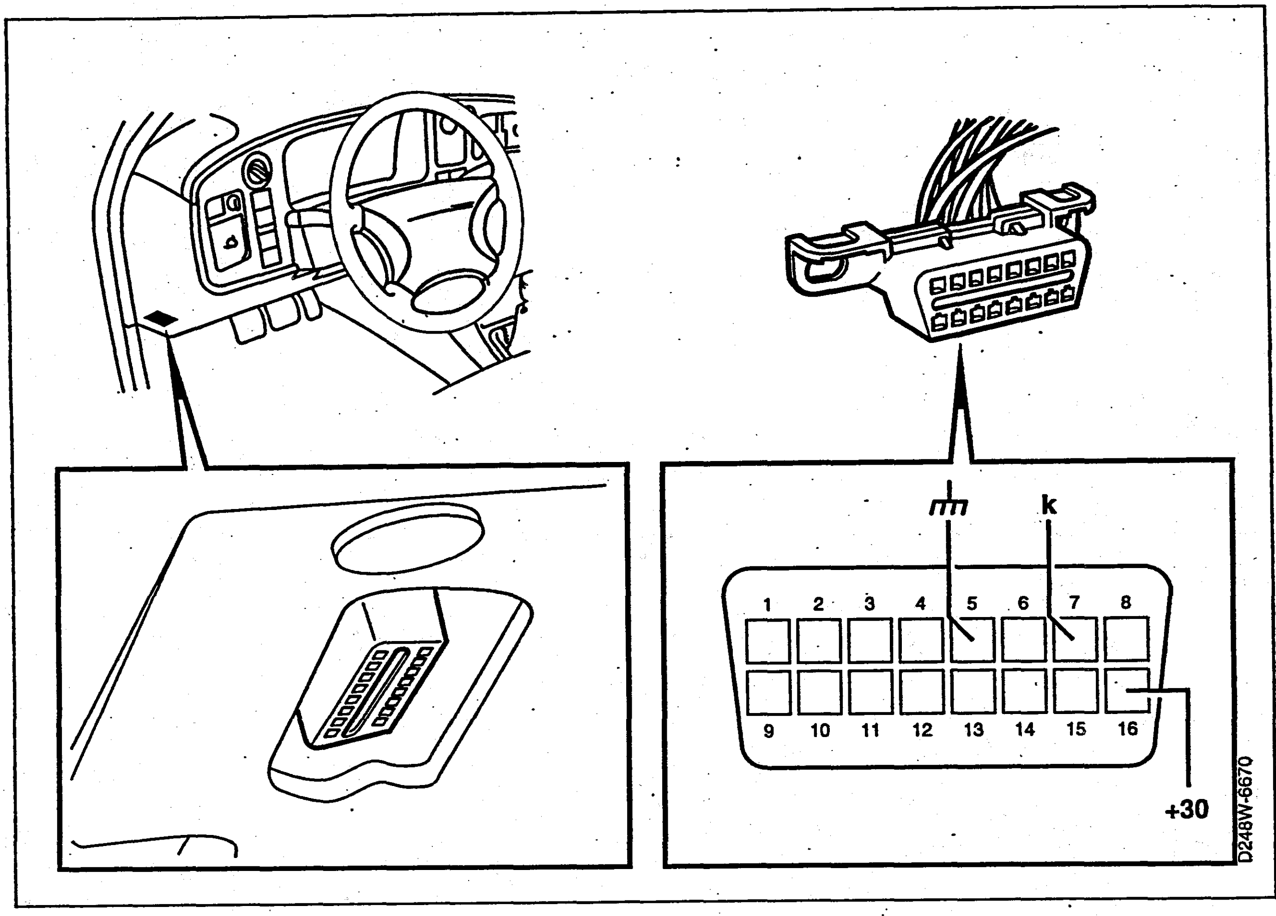


OBD II Terminology In Accordance With SAE Standard J1930

Every profession seems to have it's own secret language. The automotive trade has been no exception, with manufacturers creating their own special names and acronyms for even common components. The SAE committee responsible for terminology has created a procedure for creating names by following the logical progression shown above. This process has generated a list of standard terms for components already in use and insures that manufacturers will create names which will convey meaning rather than obscure it when naming new components.

To use the above example: **"Idle Air Control Valve":**

- The basic concept is **Valve.**
- **Control** indicates that the valve has a controlling function.
- **Air** tells us that the valve controls air (airflow)
- **Idle** finally, tells us what sort of air the valve controls, i.e. idling air.



Universal Data Link Connector (DLC)

All OBD II certified vehicles must use a standardized 16 pin DLC. The regulations also control it's location (visible from the kneeling position looking under the driver's side of the dash). The pins carrying power, ground and OBD II communications have standardized locations, load and data stream characteristics. Manufacturers are free to utilize the remaining pins in the connector for communicating with their other systems.

The way that all the different manufacturers utilize these "extra" pins may vary a great deal. If everyone has does a good job of designing safeguards into their systems you may not hurt anything by plugging a scan tool designed for one make of car into the diagnostic plug for another. But you can't be sure! A true "generic" scan tool will use only those pins whose function is fixed by law and would be safe to plug into any vehicle. There is no requirement that dedicated scan tools such as ISAT or TECH I must be compatible with other OBD II cars just because they share the same connector.

Until informed otherwise, the safest course will be use only ISAT when working on a Saab and to resist the temptation to try it on other makes.

OBD II Terminology

In order to make sense out of the rest of this book you must understand just what each of the following terms or concepts mean as they will appear on almost every page.

ENABLE CRITERIA

Enable criteria are the operating conditions which must be met before a particular diagnostic test will run. There are almost as many different "enable criteria" as there are fault codes, the objective being to make sure that each circuit or component is tested under the proper conditions. For example, it would not make any sense to try to monitor the efficiency of a cold catalyst which has not had time to reach operating temperature. Some typical catalyst monitor enabling criteria are shown below.

- Coolant temperature above 140°F (60°C).
- Vehicle speed between 20 & 60 mph (30-100 km/h).
- Fuel system operating in closed loop.
- Throttle open
- All above conditions have been met for more than 120 seconds
- More than 3 minutes have passed since starting

WARM-UP CYCLE

In order for a warm-up cycle to take place the following things must happen after starting the engine:

- Coolant temperature must **increase** by at least 40°F (22°C)
- The final temperature must reach a **minimum** of 160°F (71°C)

DRIVING CYCLE

One driving cycle has occurred when the following condition is met:

- The engine has been started and shutoff

OBD II Terminology (Continued)

TRIP

A trip has occurred when:

- The engine has been started
- The vehicle has been driven in such a way that **ALL** components and functions covered by OB-D II have been monitored

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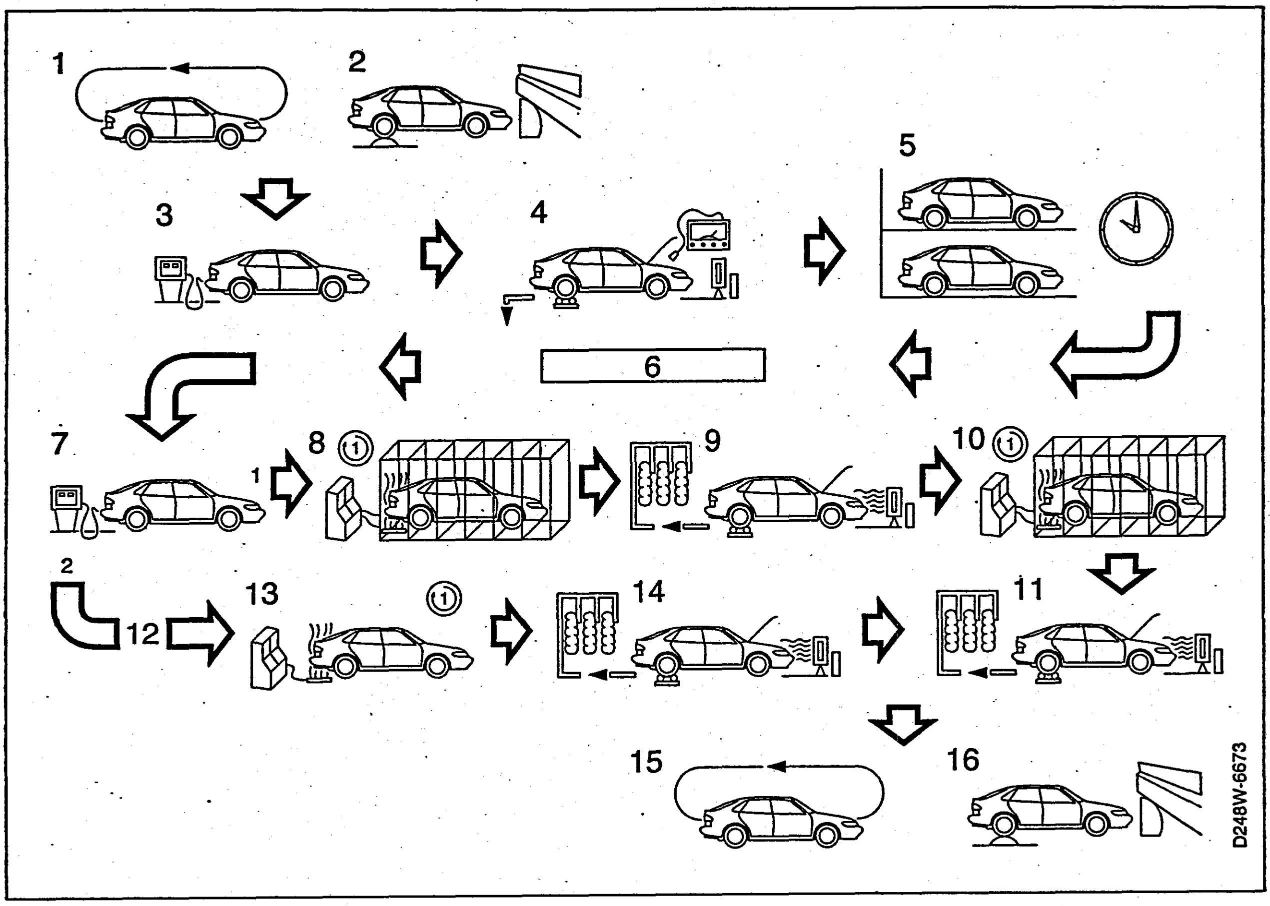
NOTE:

For most people a "trip" is what happens during the time between starting the car and turning it off again, regardless if they have driven for five minutes or five hours. In OBD II terms, a trip has not occurred until every single enable criteria for each diagnostic procedure has been met and every test has had a chance to pass or fail. Depending on local driving conditions, it may take many "trips" to work or the corner store before you have completed one official OBD II trip.

SIMILAR DRIVING CONDITIONS

Some faults will not illuminate the MIL, turn it off or erase a DTC until the test has been failed (or passed) a given number of times under "similar" driving conditions. Similar driving conditions are when:

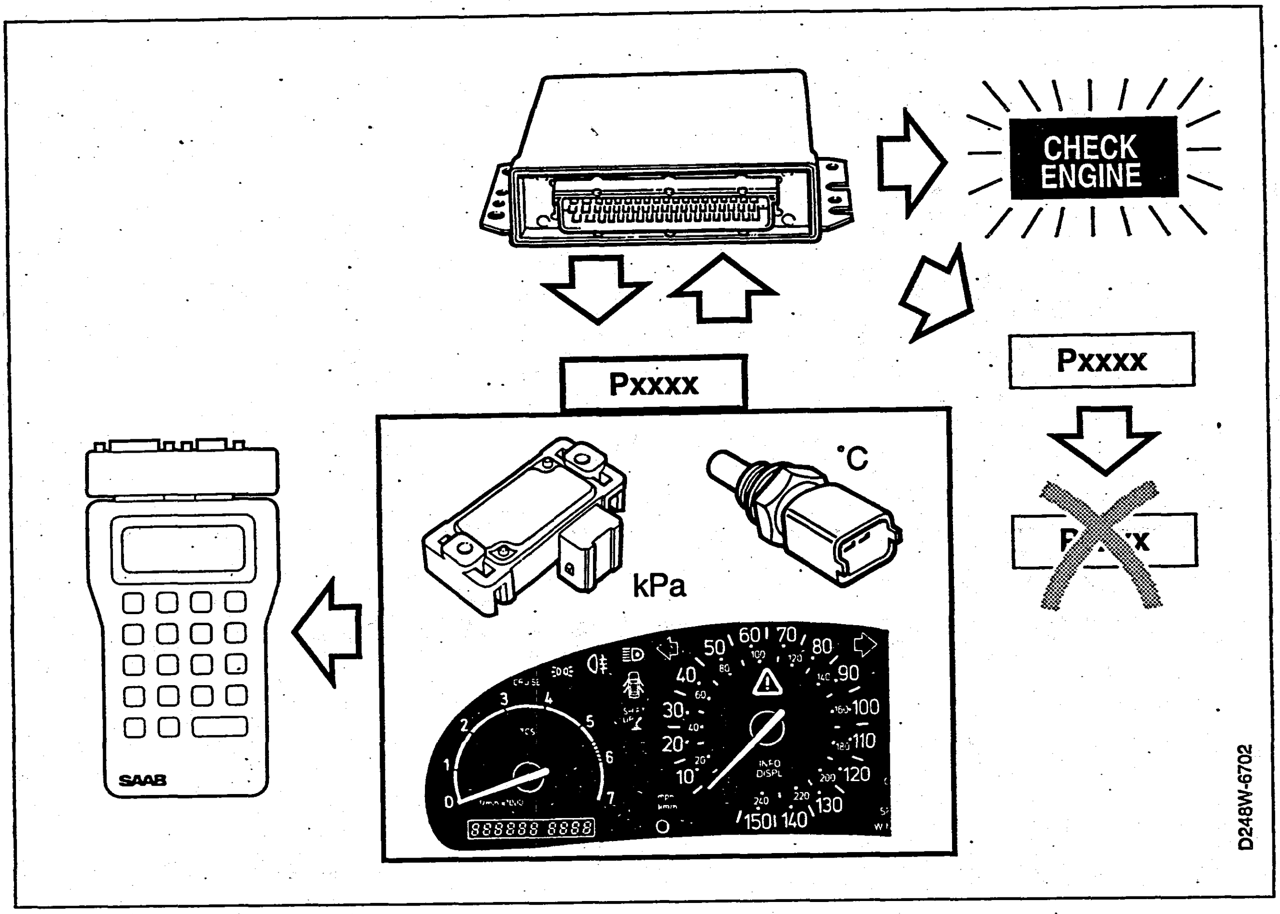
- Engine speed is within ±375 RPM
- Engine load is within ±10%
- Coolant temperature is either higher or lower than 160 F (71 C) depending on which side of this breakpoint the original fault occurred.



FEDERAL TEST PROCEDURE (FTP)

The Federal Test Procedure, or FTP, is the series of stringent tests the Environmental Protection Agency (EPA) has developed to certify every automotive model sold in the United States. The FTP consists of programmed driving cycles for mileage accumulation, fueling, cold and hot soaks, and emissions tests as pictured on the following page.

Throughout the remainder of this book, references will be made to the FTP standard. Most of on-board diagnostics are designed to turn on the MIL when the vehicle exceeds the FTP standards by a certain amount (usually 1.5 times the FTP standard).



OBD II Diagnostic Software

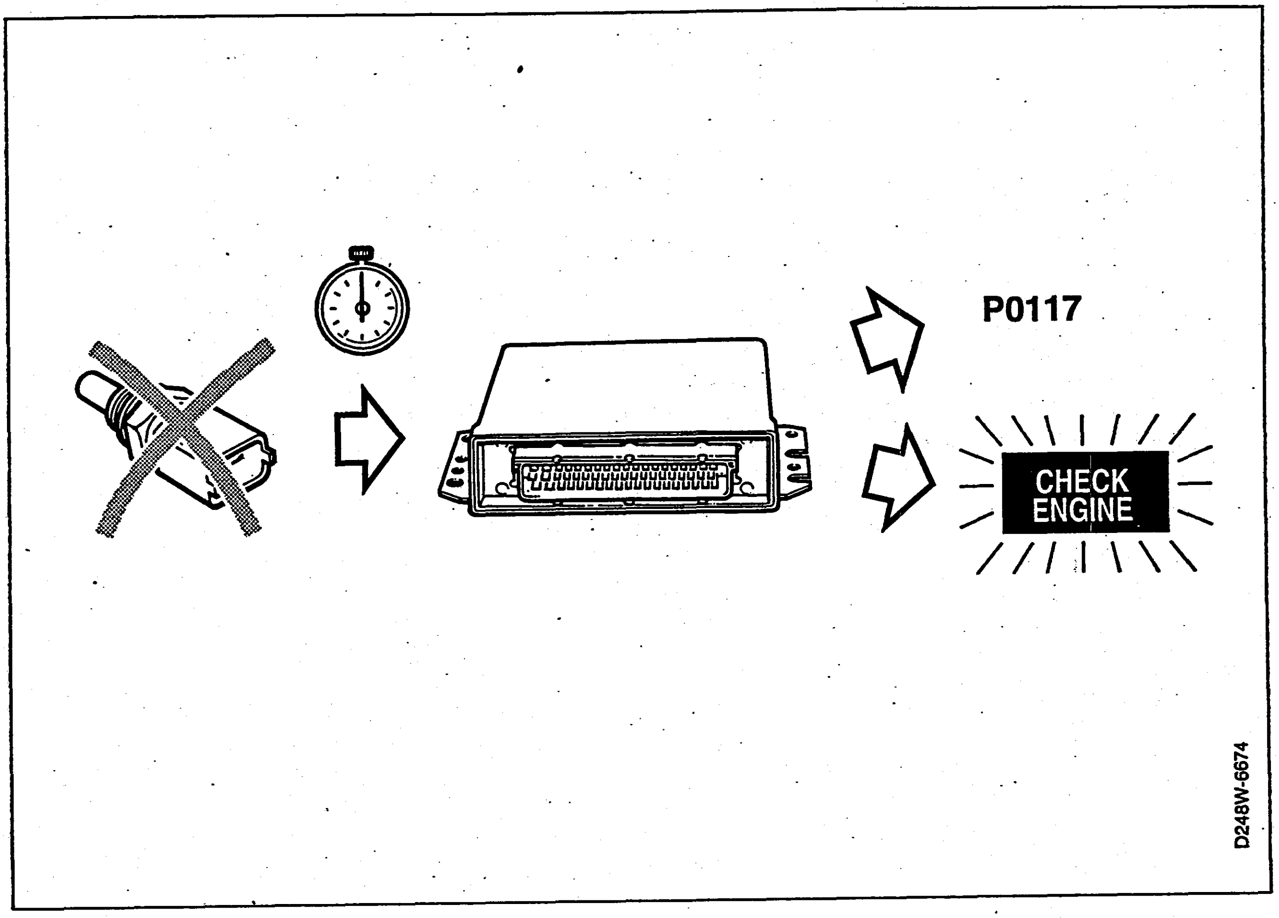
The process of controlling the MIL on an OBD I system was quite simple. If something major broke, the light came on as soon as the problem was detected and stayed on until the fault was fixed. If an intermittent fault "fixed" itself the light would go out automatically when the key was cycled off, then on again.

OBD II diagnostics are more complex. Every time the vehicle is driven, numerous system diagnostic procedures run. Some tests happen once per trip and some run continuously. Most tests will only run when specific operating requirements such as a minimum coolant temperature, RPM, vehicle speed, etc. have been met. In addition, most faults must occur more than once before the MIL will be illuminated, but a serious misfire must turn the light on immediately.

Keeping track of all these factors is a complicated task, it undoubtedly takes more memory than we had in our entire fuel system a few years ago just to decide when, and in what order, to run the diagnostics.

The diagnostic software in an OBD II system must:

- Turn the MIL on and off.
- Record and clear DTCs.
- Capture freeze frame data for the **FIRST** emissions-related DTC recorded (data for a severe problem like misfire will replace data stored for a less serious fault).
- Remember the operating conditions present the first time certain faults occur so that following tests can be run under similar conditions.
- Tell you if each individual diagnostic test has had the opportunity to run since the codes were last cleared.



DTC and MIL Operation

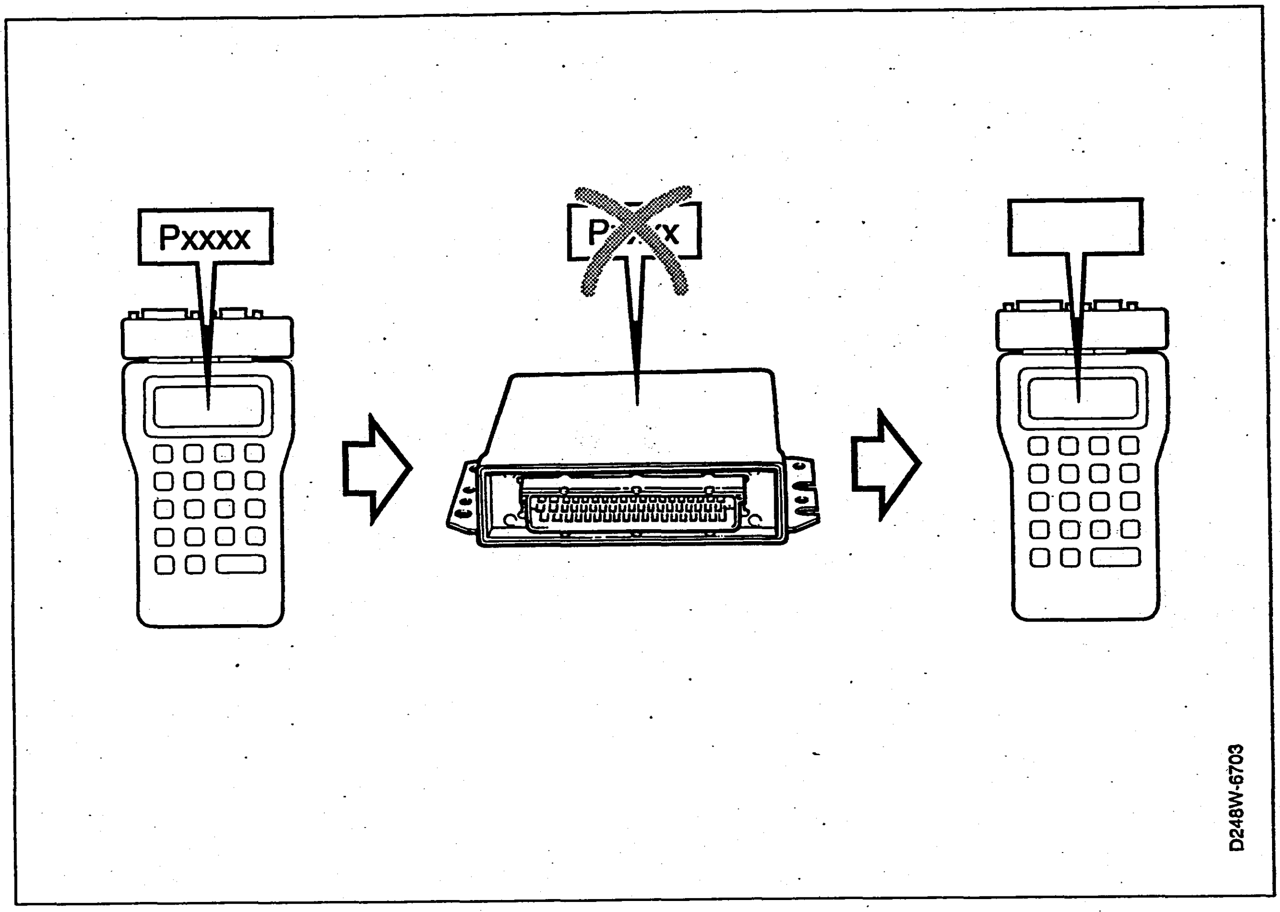
OBD II regulations include carefully defined minimum requirements for actions relating to fault detection, including:

- How quickly the on-board system must be able to detect each type of failure, set a DTC and turn on the MIL.
- Under what conditions the On-board system may turn off the MIL for a fault which happened in the past but is no longer present.
- Under what conditions the on-board system may erase stored DTCs for a fault which is no longer present.
- The categories of scan tool information which must be available to technicians.

Illuminating the MIL and Setting DTCs

Unlike OBD I which had one basic procedure for turning the MIL on & off for any major fault, OBD II employs several different strategies. These will be covered in detail later in the book but here are the major points.

- A serious misfire problem which could result in catalyst damage will turn on the MIL and set a DTC as **soon** as the fault is detected. The MIL will flash on & off until the severity of the misfire is reduced to the point where the catalyst is no longer in danger. At that point the MIL will stay on steadily.
- All other faults must occur during a second driving cycle before they will turn on the MIL and set a DTC.
- The MIL will be triggered by a fault in the 900 automatic transmission which would increase emissions above allowable limits. The TCM requests that the ECM turn on the MIL. (The "Check Gearbox" light will also be on).



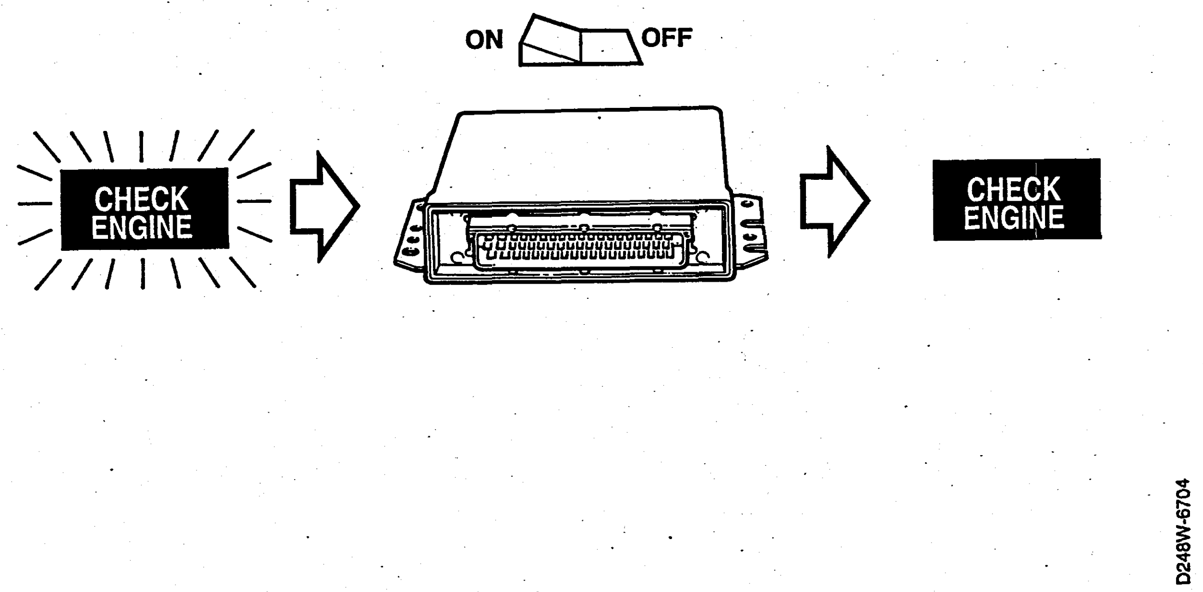
Clearing OBD II Diagnostic Trouble Codes (DTCs)

DTCs can be cleared in three ways:

1. If the fault that caused the DTC to set has been corrected, the ECM counts the number of "warm up cycles" which have occurred since the last "test failed" was recorded by the ECM. In a "warm-up cycle" the engine temperature must reach at least 160°F (71°C) and must increase by at least 22°C (40°F) during the trip. When you have driven 40 warm-up cycles without a failure the DTC will automatically be cleared from memory.
2. DTCs can be cleared with a scan tool such as ISAT.
3. If the battery goes dead or the ECM loses +30 (constant) power for any reason, all DTC information, freeze frame data and inspection/ maintenance readiness information will be lost after approximately 30 seconds.

⚠ IMPORTANT

Do not clear codes unless directed to do so by the diagnostic procedure in the Service Manual. When DTCs are cleared you also wipe out the freeze frame data which could help you diagnose the fault.

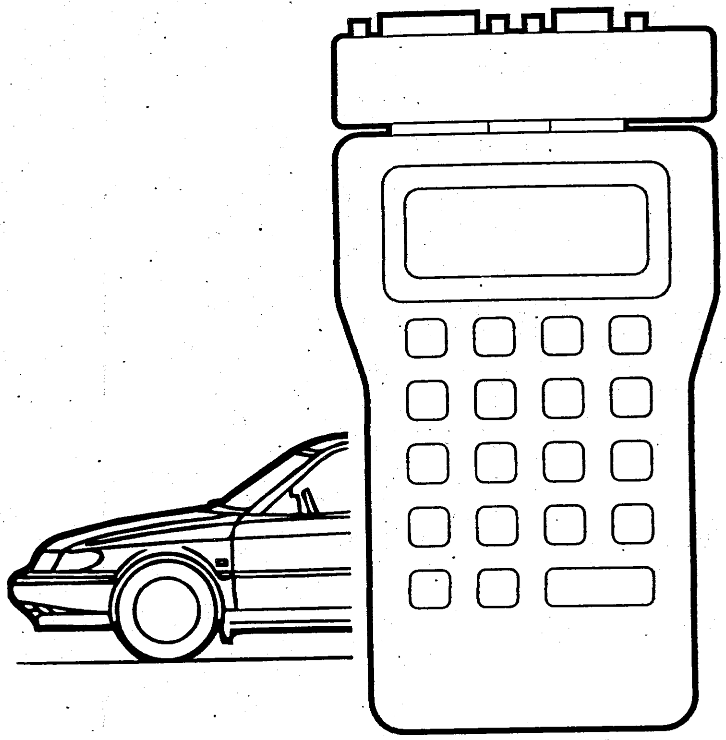


Extinguishing the MIL

Once the MIL is turned on by an emissions diagnostic, that diagnostic must run and pass for three consecutive driving cycles in order for the MIL to go out automatically.

Misfire and fuel trim faults have unique requirements. If the DTCs were set by either a misfire or fuel trim problem the MIL will stay on until the fault does not reappear during 3 consecutive driving cycles under similar operating conditions (coolant temperature, engine rpm and load).

Clearing the fault codes with ISAT or by disconnecting the battery will also turn off the MIL. Pulling a battery cable as a quick & dirty means of turning off the MIL and clearing codes should be avoided as it will also crash the memories in other systems, affecting quite a few calibration and adaption functions.



OBD II Test Driving

Planning Your Test Drive

Few repairs to an OBD II system will be complete without a test drive. Virtually every diagnostic procedure is built around the fact that, no matter how good your equipment, only the car's ECM can really tell if the problem is fixed. Because of the extensive enabling criteria for most diagnostics, it will be necessary to drive the car to give the ECM a chance to check for codes and verify your repair.

Each test in the enhanced shop manual will give you a driving cycle which will run the diagnostic in the least possible time. ALWAYS follow the drive cycle for the particular fault(s) you have been repairing.

When driving, keep in mind that there are many variables affecting the time needed for the diagnostic to run. All of the following factors will increase the time a test takes to run.

1 Traffic conditions. Having to brake or change speed substantially will cause some tests to abort and restart.

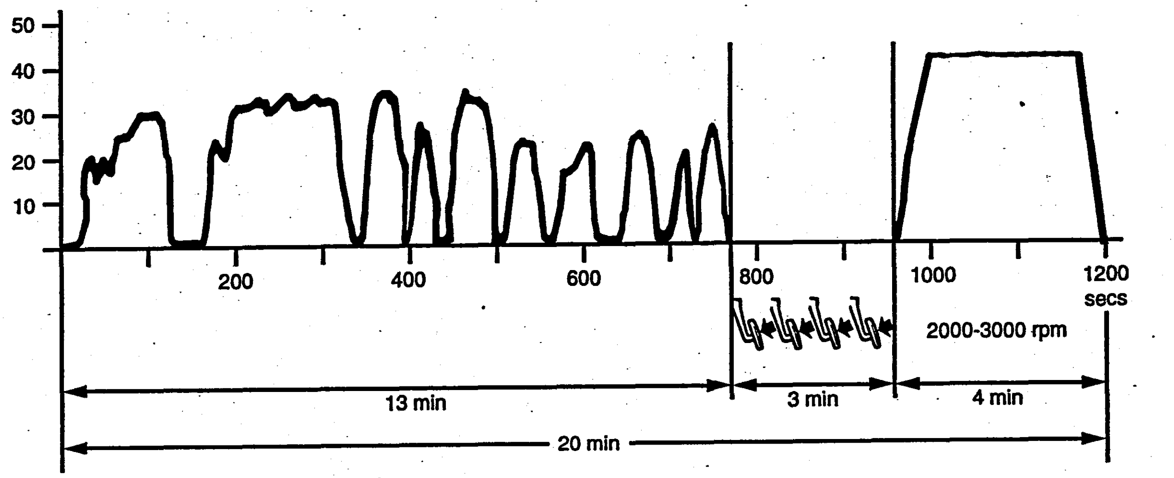
2 Driving style. Any abrupt changes in engine load will increase the time it takes to run some tests.

3 Engine variant. Some fuel systems take longer than others to run the same test.

4 The type and number of faults. A fault in one system may prevent the diagnostic for another system from running.

5 Climate. Many of these tests are affected by changes in engine load. A hot day where the A/C and cooling fan are cycling can lengthen the test considerably.

6 Combine several of the above and you increase the time even more.



Driving a TRIONIC OBD II Trip

By definition, a TRIP will give EVERY diagnostic test a chance to run. For this reason, a trip is going to take a lot longer to drive than a drive cycle designed to run just one diagnostic. Not only must a trip run many diagnostics but it runs them in sequence. These two factors make it difficult to drive a quick, uninterrupted trip.

Normally the only justification for driving a complete trip would be if the repairs have been so extensive (such as drivetrain R & R) that a great many systems and components have been affected.

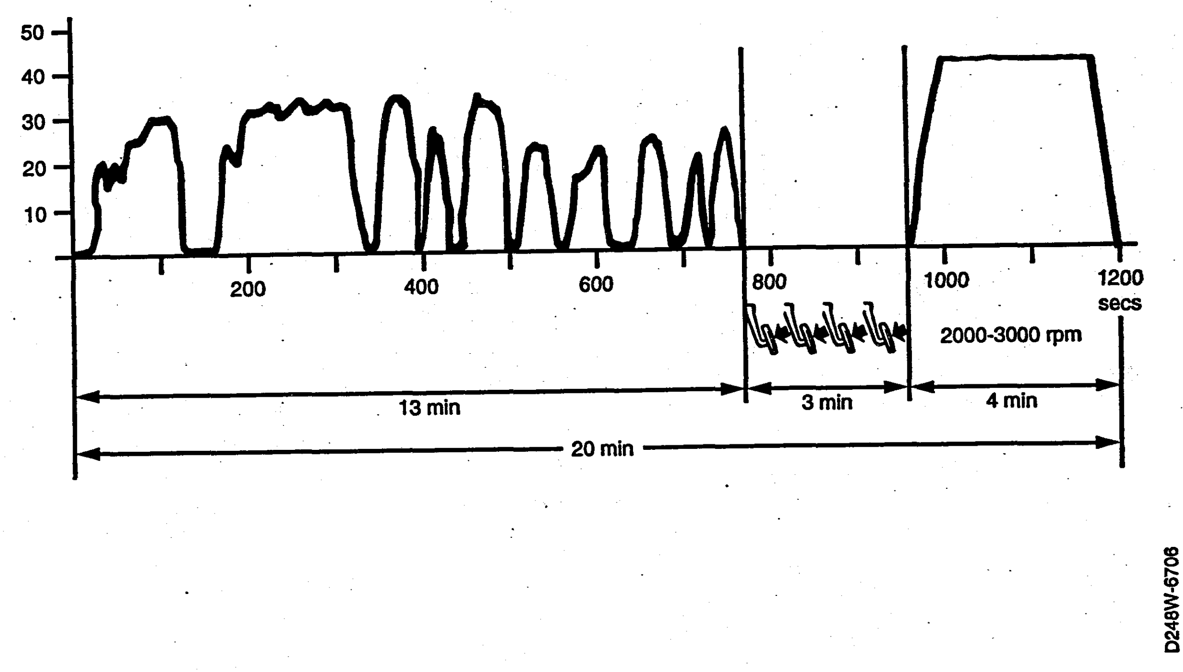
To give you an idea of what is involved, here is the procedure you would follow to drive a TRIP on a 1996 TRIONIC 900:

1 Prepare for the test by:

- Turning the cooling fan on low speed by unplugging the ICE/EDU coolant sensor.
- Planning your route according to terrain, traffic patterns, etc.

2 First, run the diagnostics for all systems except EVAP, Post-Catalyst Oxygen sensor and the Catalyst. Simulate driving in city traffic by:

- Being in motion for a total of 10 minutes.
- During that 10 minutes, accelerate to above 25 mph and brake to a complete stop 6 times.



Driving a TRIONIC OBD II Trip (Continued)

3 Next, run the diagnostics for the Post-Catalyst Oxygen sensor and EVAP system by:

- Parking with the handbrake on, select P or N. Once again, remember that the cooling fan should be running constantly to keep the load constant.
- Avoid changing the engine load. Turn off the A/C, don't turn the steering wheel, switch on lights, etc.
- Open the throttle, then let the engine idle for 30 seconds. Repeat this cycle three more times.
- Reconnect the ICE engine coolant temperature sensor.

4 Finally, run the Catalyst Efficiency diagnostic by:

- Driving with very little change in throttle opening at 25-55 mph for 4 minutes.
- Choosing a gear which will allow you to run at between 2-3,000 rpm.
- Driving on a road which allows you to maintain both road speed and rpm with a minimum of throttle movement. A steady throttle setting is more important than constant road speed. Avoid hilly terrain or using cruise control.

5 At the end of the test, record, repair and erase all DTCs.

- Don't forget to erase the ICE or EDU code you set by unplugging the coolant temperature sensor.
- Is the car an automatic? A throttle position fault will set a code in both the ECM and the TCM. Always clear ALL OBD II systems.

"Generic" OBD II Scan Tool Information

A new ISAT menu option for 1996 is GST (Generic Scan Tool), the information is displayed here as it will appear on a generic scan tool. Here are the menu choices which will come up when you select GST.

OBD II

READ CURRENT DATA
READ FREEZE FRAME
READ FAULT CODES
CLEAR FAULT CODES

Freeze Frame

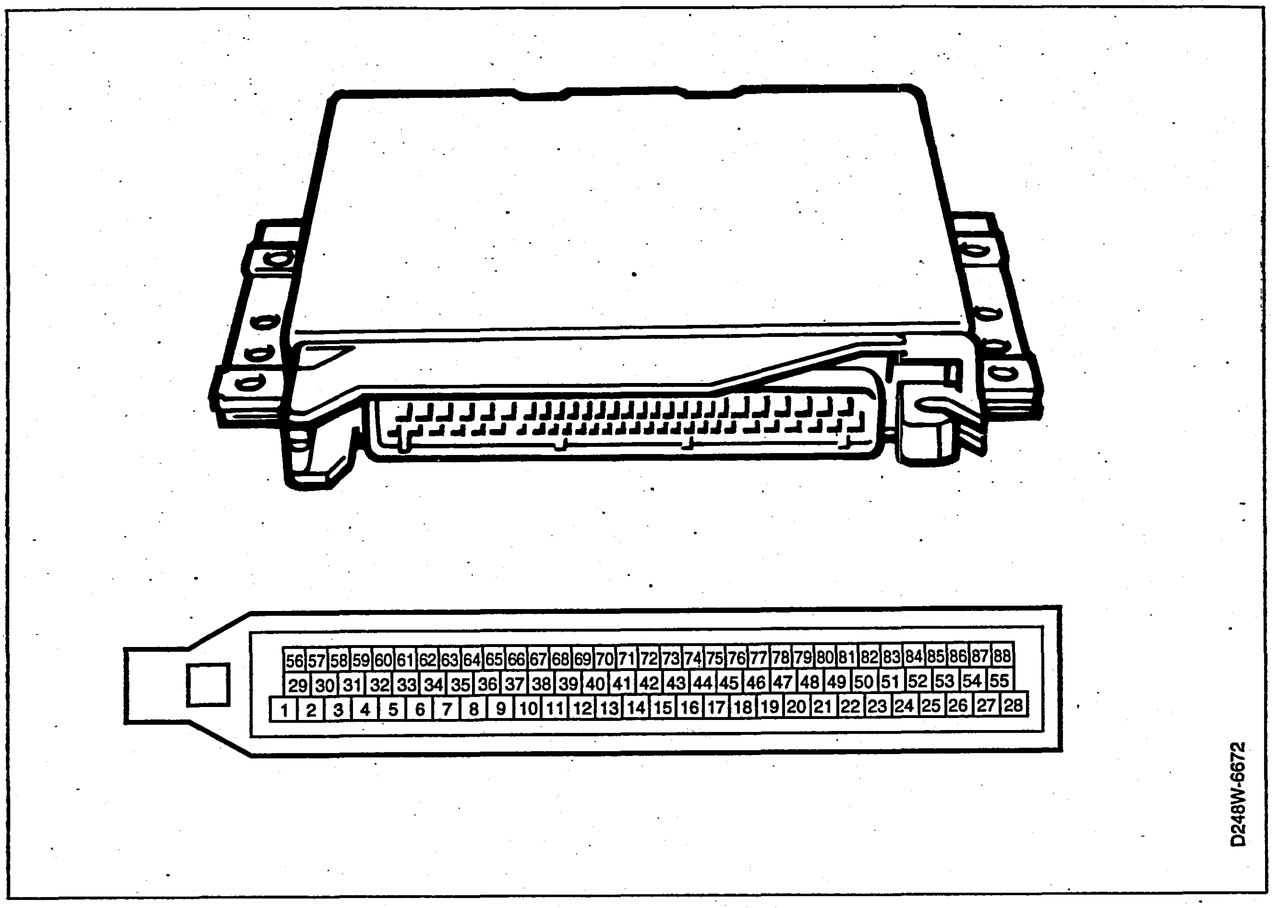
OBD II diagnostic systems will record freeze frame data in the appropriate ECM at the instant an emissions-related fault is detected but this information will not be accessible until and the MIL is commanded ON. Freeze frame data is part of the information which must be displayed on any "generic" scan tool. To read the freeze frame with ISAT you must call up the GST menu. Keep in mind that this information represents only the operating conditions at the instant that the fault was first detected. This function does not provide the "snapshot" or "movie" capability found in some other systems to review data acquired before and after the event.

The contents of a freeze frame include:

- The DTC which initiated the freeze frame
- Closed loop status
- Calculated load value
- Engine coolant temperature
- Intake air temperature
- Short term fuel trim
- Long term fuel trim
- Intake manifold pressure
- Engine RPM
- Vehicle speed

Notes:

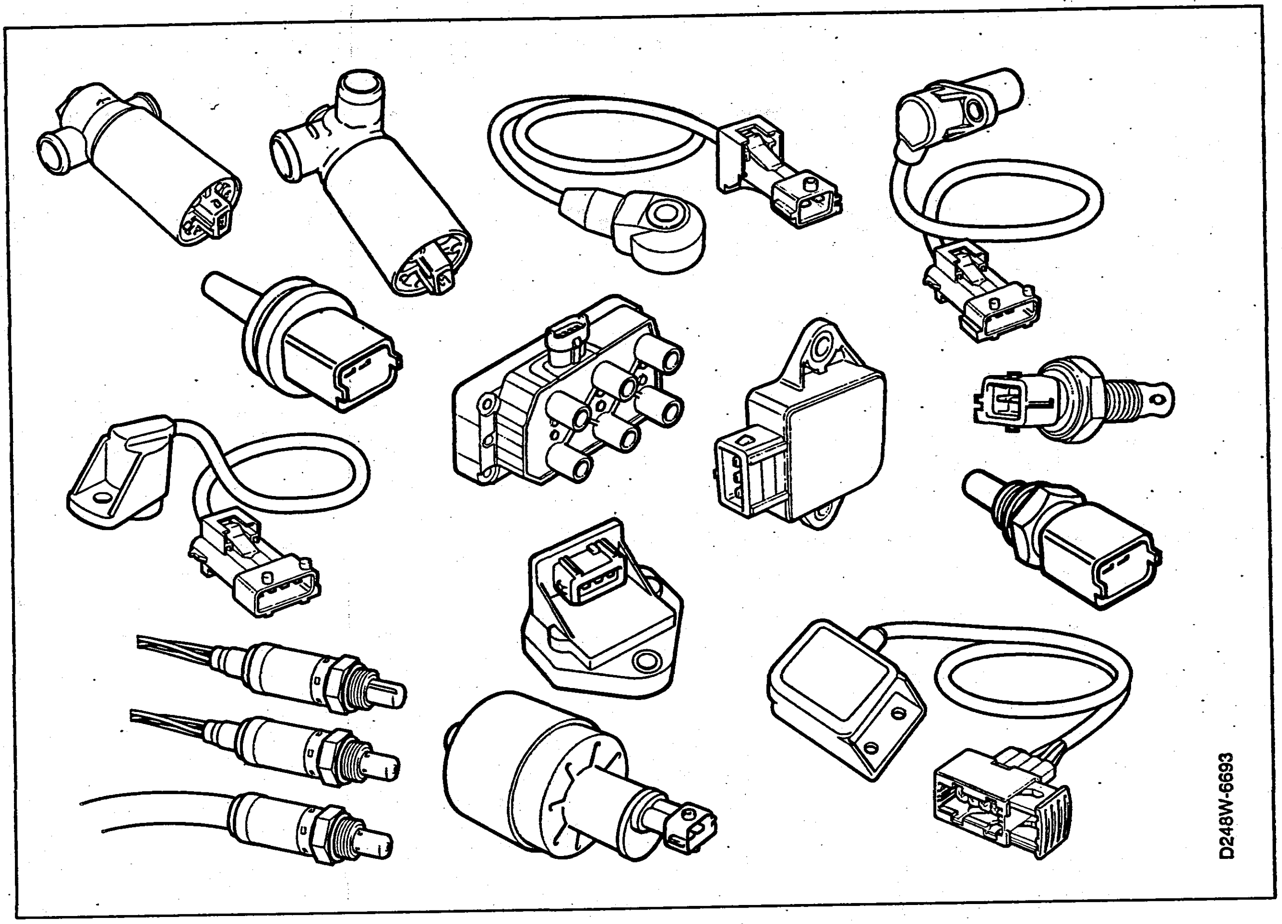
Saab Implementation of OBD II



1996 Saab OBD II Control Modules

Beginning with the 1996 model year, all Saab automobiles built to US specification have at least one major system managed by a control module which supports OBD II functions. These control modules are:

Engine Control Modules	**900**	**9000**
TRIONIC	Turbo engines	All 4 cyl engines
MOTRONIC 5.2	2.5 Liter V6	3.0 Liter V6
MOTRONIC 4.1	Non-Turbo 4 cyl engines	
Transmission Control Module		
TCM	900 Automatic Transmission	



New or Revised Hardware for OBD II

The major system changes needed to implement OBD II take place on the software side but there are some additions and modifications to the hardware as well. The following list covers electrical/electronic components. The non-electronic components would form an even longer list although most of the changes would not be readily apparent as they tend to take the form of upgraded hoses, better check valves and so on.

The following components are completely new:

- Post-catalyst Heated Oxygen Sensor, used on all models. This sensor has a fourth wire providing a sensor reference ground and is easily identified by the small vent slots on the working end of the sensor.
- Fuel Tank Pressure Sensor, initially used on 900 V6 models and on all 900s by M96.5. Mounted on the filler pipe above the rear axle.
- Canister Close Valve, used on 900 (at first just V6) models. This solenoid valve is connected to a redesigned EVAP canister.
- Vehicle Vertical Acceleration Sensor, found on 4.1 (4 cyl.) MOTRONIC models. Located behind the upper mount for the driver's side front strut.

The following components have redesigned connectors or upgraded contacts:

All MOTRONIC Knock Sensors

All MOTRONIC Crankshaft Position Sensors

5.2 MOTRONIC Camshaft Position Sensor

All Engine Coolant Temperature Sensors

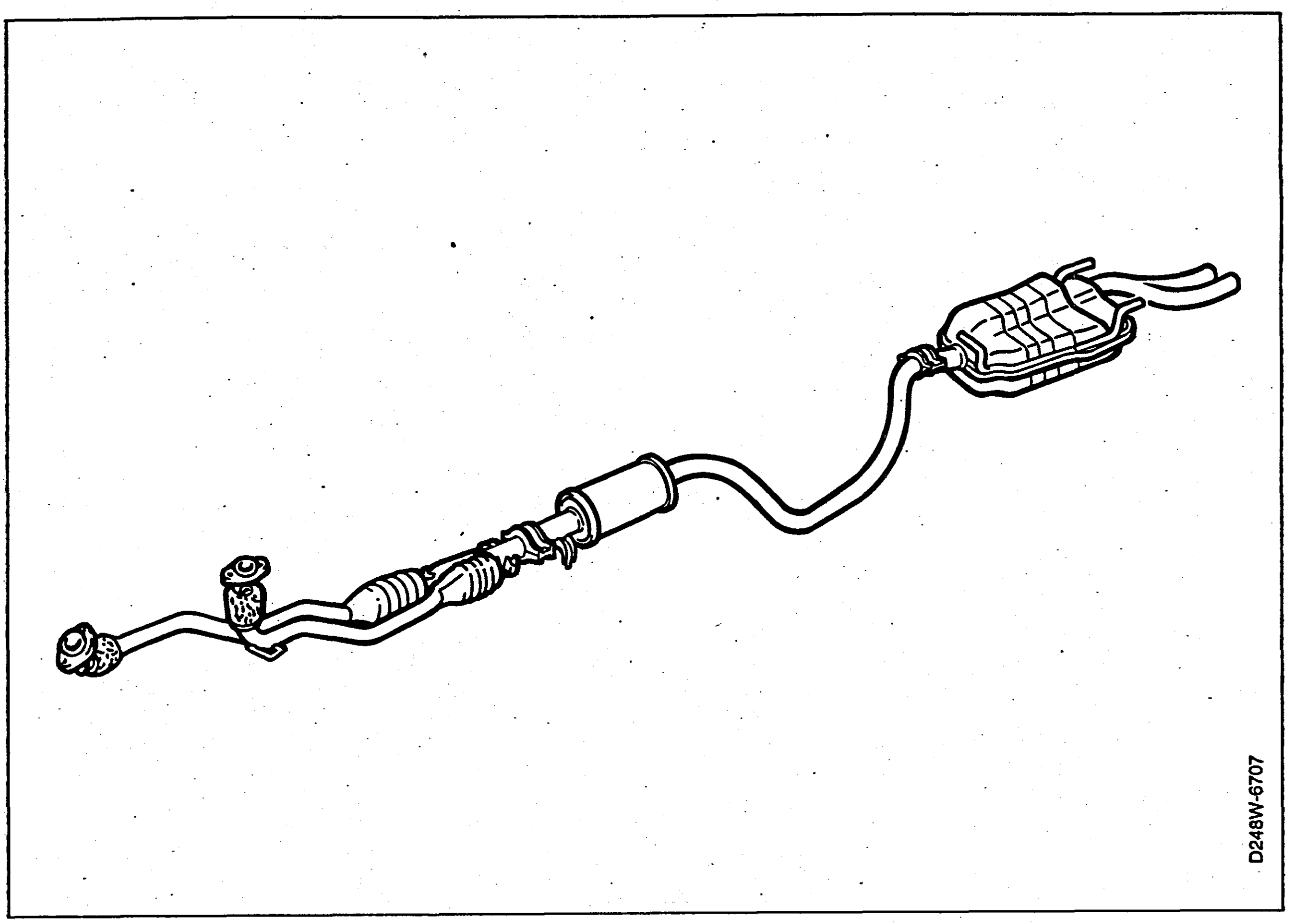
TRIONIC & 5.2 MOTRONIC Intake Air Temperature Sensors

All Throttle Position Sensors

5.2 MOTRONIC Ignition Coil

IAC Valves Have Been Modified as follows:

- The 900 V6 MOTRONIC system now uses a three wire IAC valve.
- All MOTRONIC IAC valves have an increased air-flow capacity

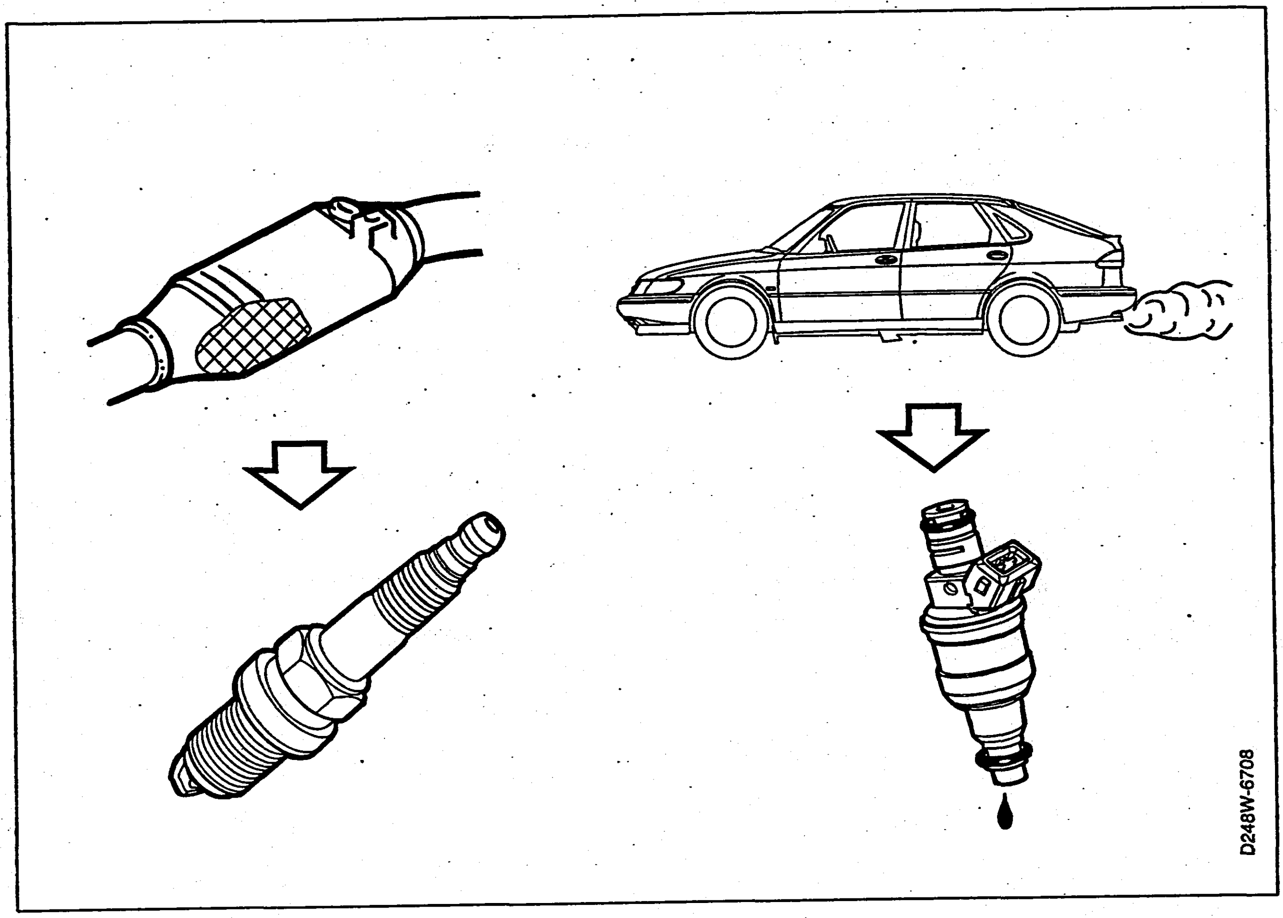


Catalyst & Oxygen Sensor Configurations

The heart of any emissions system is the catalytic convertor and it's accompanying oxygen sensor(s). The following pages will discuss how these components function in an OBD II system. As you can see, there have been some major changes to our 1996 exhaust system configurations.

All V6 models use a pair of catalysts merging into a single outlet pipe. Double wall pipe is used all the way back to the catalysts to help the catalysts reach operating temperature as quickly as possible. This configuration requires the use of two post-catalyst oxygen sensors with heavily-armored sheathing to protect the wiring as it passes under the car.

With their simpler, single-pipe system, four cylinder models need just one pre- & post-catalyst sensor.



Misfire Monitoring

Requirements

An OBD II system must be able to detect and react to two different misfire situations. The difference lies in the severity of the fault. If the problem is mild we react accordingly, a severe problem demands a more rapid and forceful response. The two types of misfire are:

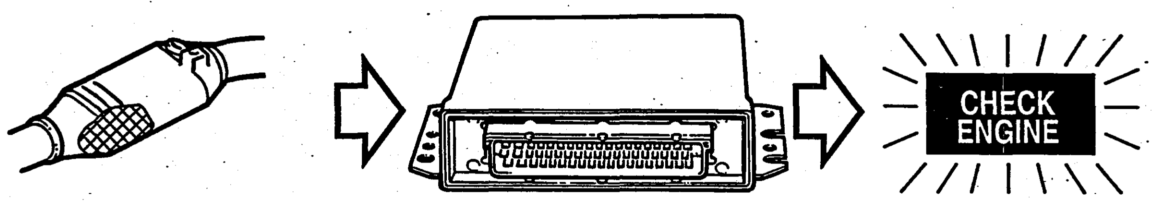
Catalyst Damaging Misfire

A level of misfire so severe that there is danger of damaging the catalyst.

Emissions Related Misfire

Misfire which will result in the vehicle failing an inspection/maintenance (I/M) test or which causes emissions to exceed the federal test procedure (FTP) standards by 50%.

Regulations require misfire monitoring under all positive speed and load conditions (defined as cruise, acceleration and idle). The diagnostic procedure must discriminate between single versus multiple (random) cylinder misfiring. If a single cylinder misfires, the diagnostic must identify the specific cylinder. The conditions under which the misfire occurs must be identified, even if this requires overwriting freeze frame data stored for a less critical fault.



Catalyst-Damaging Misfire

Theory of Diagnostic Operation

The diagnostic check for catalyst damaging misfire runs constantly once the enabling criteria have been met. For every possible combination of engine operating conditions (rpm, load, temperature, etc.), the ECM has a value stored in it's memory telling it the maximum number of misfires which can take place every 200 crankshaft revolutions without harming the catalyst. Any time the number of misfires exceeds this value the MIL must begin to flash even if it is already illuminated steadily for another problem.

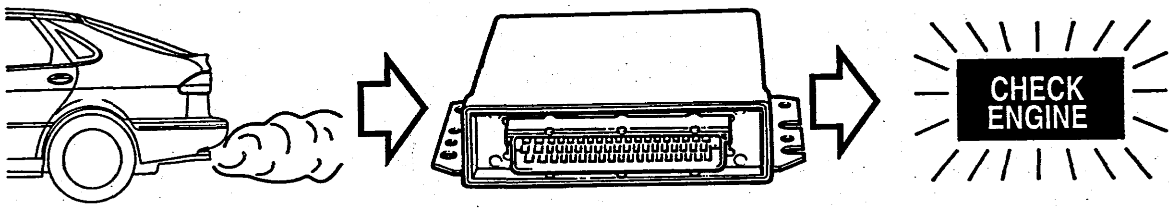
Flashing the MIL is intended to get the driver to back off the throttle before catalyst damage can occur. Once the engine is no longer misfiring severely enough to cause catalyst damage the MIL will change from flashing to steady illumination. A DTC will be set as soon as the MIL begins to flash..

The MIL will be switched off if there is no misfire under similar driving conditions for three driving cycles.

The DTC will be erased automatically when the MIL is **off** and there has been no misfire detected for 40 warm-up cycles

Low Fuel DTC

Any time there is a misfire or fuel trim code and the fuel level has dropped low enough to turn on the low fuel warning light on the dash there will also be a Low Fuel DTC set in the TRIONIC or MOTRONIC system menu. Always check for this code so you don't waste time and money looking for a complicated explanation for fault codes set on an engine which stopped running because the tank was empty.



Emissions-Related Misfire

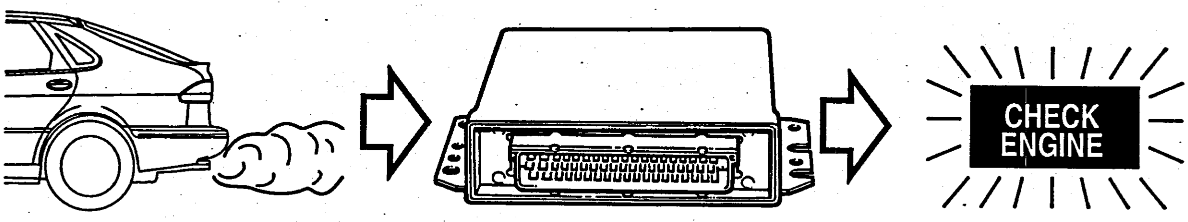
Theory of Diagnostic Operation

To determine if the misfire is not severe enough to harm the catalyst but would raise emissions to an unacceptable level, we use a different strategy. The ECM constantly counts misfires during sample periods which are 1,000 crankshaft revolutions in length. Once again, it compares the number of misfires for each period with the values stored in its memory for similar operating conditions. The MIL is **not** turned on the first time that this type of misfire is detected. A misfire code will be set in the TRIONIC or MOTRONIC ISAT diagnostic menu but not in the ISAT GST (Generic Scan Tool) menu which, by law, cannot register a code until the MIL is turned on. The ECM will prepare to turn the light on if the misfire returns on a subsequent trip by creating what is usually described as a "pending" code.

NOTE

The term "pending code" is used to describe a concept rather than a real code. At this time the ISAT GST menu does not display pending codes.

Think of it in terms of getting a warning ticket for having a burned out brake light. You won't get a real ticket unless the same officer catches you again and the light is still out. If you are smart and fix the light you can tear up the warning ticket.



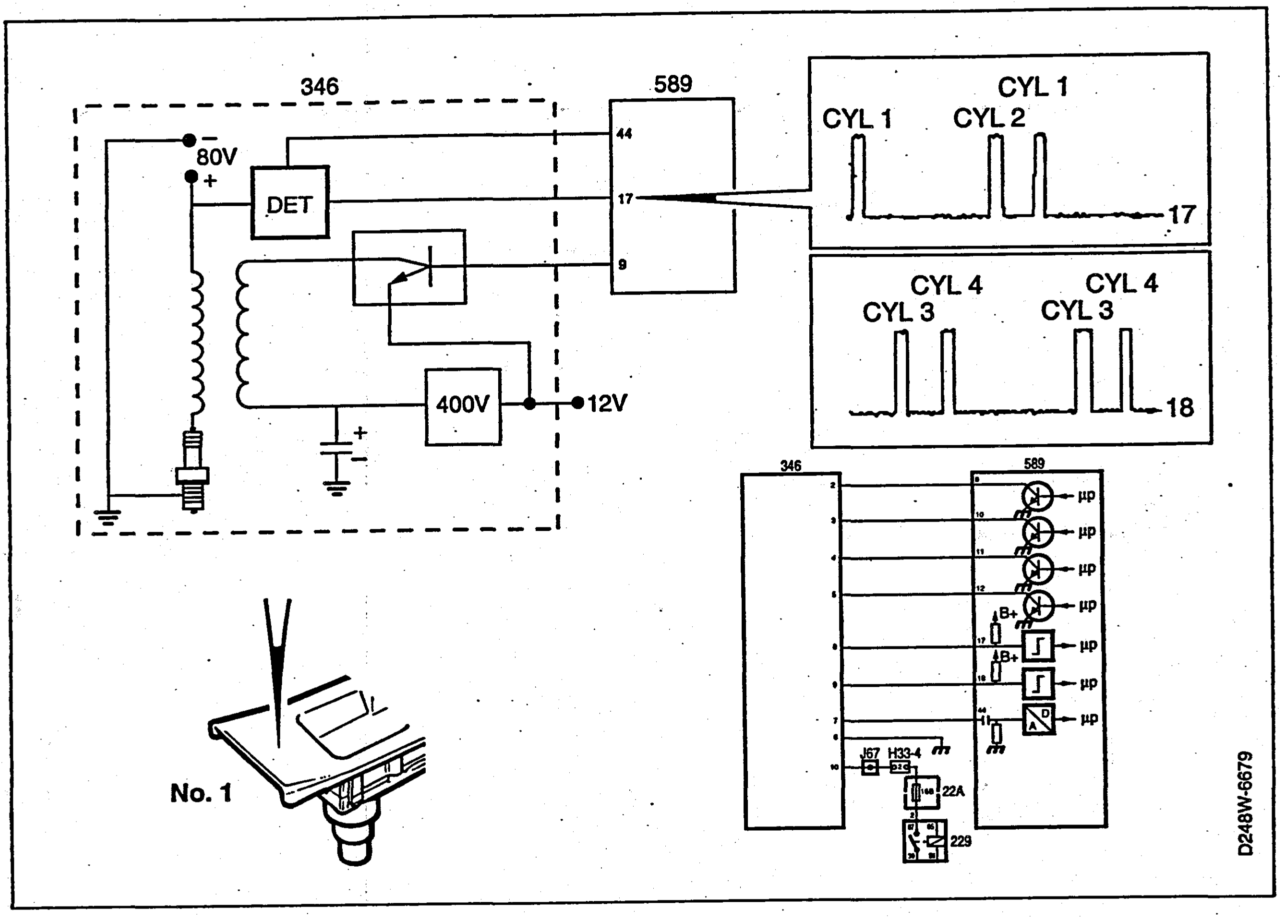
Emissions Related-Misfire (continued)

The ECM will memorize the operating conditions which were present when it first spotted the misfire and begin counting trips, warm-up and driving cycles. There are several possible results depending on what happens next. Here are the options:

1. The "pending" code will be erased as soon as, on a subsequent driving cycle, there is no misfire when similar operating conditions are present. The "pending" code will also be erased if 80 driving cycles take place without ever encountering driving conditions similar to those present when the code was originally set.
2. The MIL will be turned on constantly if misfire occurs within the next 80 driving cycles.
3. Once on, it takes three consecutive driving cycles, with similar operating condition, without misfire to turn the light off.
4. The DTC will be automatically erased if the MIL is off and there has been no misfire for 40 warm-up cycles.

Low Fuel DTC

Once again, always remember to check for a low fuel DTC anytime you find a misfire DTC. If you find a low fuel code don't jump to conclusions, there may still be a real problem. The benefit is that you will know enough to ask a few more questions. With a little luck the customer might remember that the MIL came on after his son borrowed the car and ran out of gas.



TRIONIC Misfire Detection

Theory of Diagnostic Operation

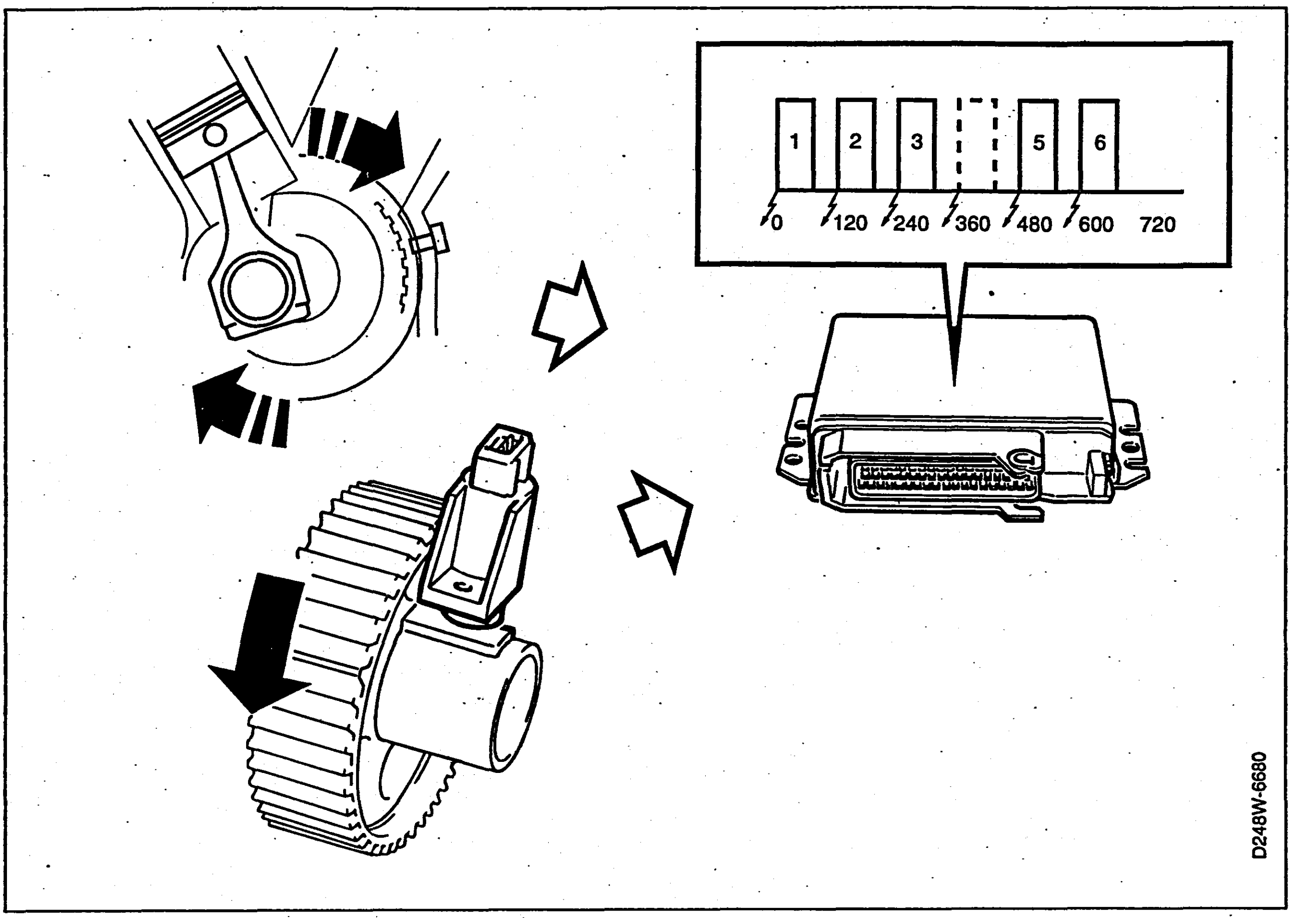
Monitoring the Combustion Chamber

All Saab turbos use the TRIONIC Engine Management system which is ideally suited for detecting misfire. The ionization feature of this system allows us to monitor combustion chamber temperature. If a cylinder is cold when, according to the firing order, it should be hot, it is easy to conclude that misfire has just occurred. One very big advantage of this method of detecting misfire is that it gives us a true indication of misfire without the danger of false readings caused by rough roads or unusual driving habits.

The following paragraphs from the TRIONIC shop manual do a good job of explaining just how the ionization circuits work.

> "One pole of the secondary winding of each of the four ignition coils is connected in the usual way to the appropriate spark plug. The other pole is not grounded directly but is connected to an 80 volt source. As a result, there is a potential of 80 volts across the spark plug gap at all times except at the moment when the spark is produced.
>
> When combustion takes place, the temperature in the combustion chamber is extremely high. The gases are ionized and begin to conduct current. This causes a current to pass across the spark plug gap (without producing a spark)."

The TRIONIC system has always monitored the ionization current to determine the firing order and detect knock. Adding misfire detection became a matter of modifying the software in the ECM, the hardware was already in place.



MOTRONIC Misfire Detection

Theory of Diagnostic Operation

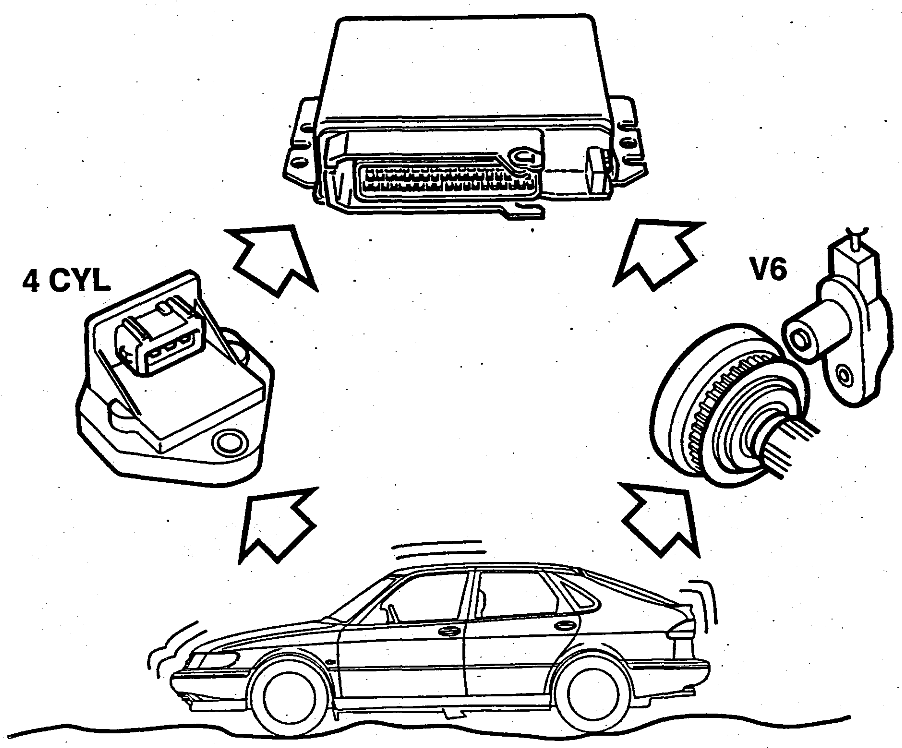
Crankshaft Speed Monitoring

1996 Saab vehicles equipped with a MOTRONIC engine management system (V6 and non-turbo 4 cylinder engines) use very precise monitoring of crankshaft speed to detect engine misfire. The principle involved is as follows:

The crankshaft does not travel at the same speed through all 360 degrees of rotation. It speeds up slightly each time a cylinder fires and then begins to slow down or "coast" until the next cylinder in the firing order fires. Plotted on a graph, the change in crankshaft speed of a smooth running engine would be very predictable and form a sine wave.

If one or more cylinders are "dead" the sine wave becomes irregular as the engine slows down even further instead of speeding up each time a cylinder misses rather than firing.

By combining the information provided by the crankshaft position sensor with input from the camshaft position sensor the Motronic ECM is able to identify the offending cylinder and a DTC will be set identifying the bad cylinder. Some types of misfire (such as that caused by a fuel starvation problem) occur in a random pattern, making it impossible to pinpoint an individual cylinder. This type of problem would set the DTC P0300 "Random Misfire Detected".



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MOTRONIC Misfire Detection (continued)

Theory of Diagnostic Operation

Rough Road Detection

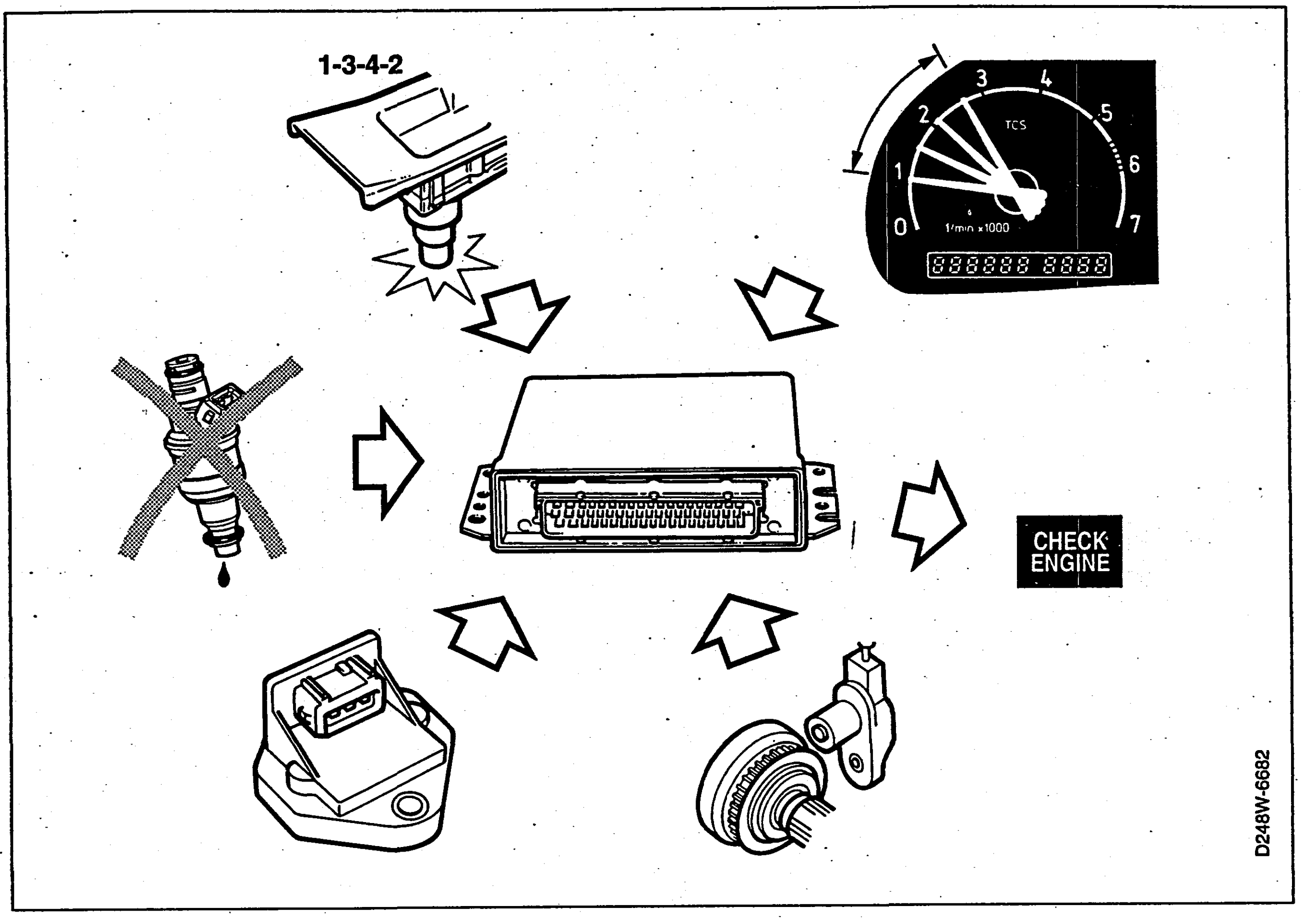
One complicating factor when using crankshaft speed as a means of calculating misfire is the fact that driving on rough roads may cause false misfire readings. A rough road will cause rapid changes in wheel speed which, when fed back through the drivetrain, can affect engine speed enough to create a false misfire diagnosis. The solution to this problem is to prevent the misfire diagnostic routine from running when driving on rough roads.

4 Cylinder Motronic

1996 4 cylinder Saabs with a MOTRONIC engine management system have a Vehicle Vertical Acceleration (VVA) Sensor mounted in the engine bay behind the top of the driver's side strut. This sensor is calibrated to respond to the rapid up and down body movements which are characteristic of driving on a rough road. The ECM is constantly monitoring this sensor and will not allow a misfire DTC to set if the "misfire" occurs on a rough road.

V6 MOTRONIC

Vehicles with 6 cylinder engines **do not** have a VVA sensor. Rough road detection is accomplished by looking at wheel speed input from the ABS system. A surface which is rough enough to create a false misfire signal will also create rapid changes in wheel speed and, the misfire diagnostic will be disabled.



Misfire Enabling and Malfunction Criteria

All of the following conditions must be met in order for the misfire diagnostic routine to be carried out.

- Motor running
- Ionization circuit synchronization has taken place (TRIONIC)
- No deceleration fuel shut-off taking place
- Vehicle vertical acceleration (VVA) sensor inactive (4 cyl MOTRONIC)
- No significant variations in ABS wheel speed input (6 cyl MOTRONIC)

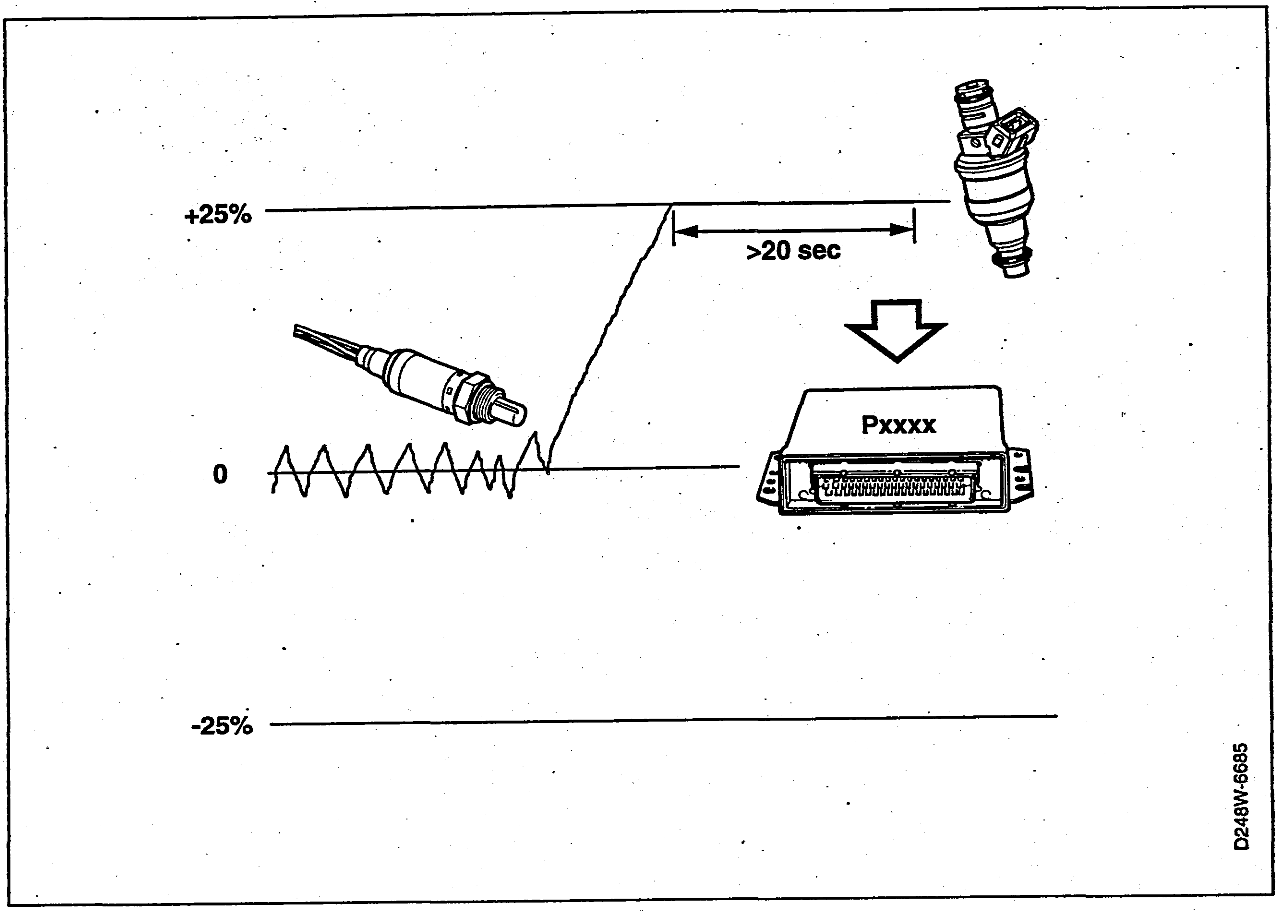
Hardware Required

The TRIONIC engine management system requires no new hardware to accomplish misfire detection as it utilizes the existing ionization function.

The MOTRONIC misfire diagnostic makes use of a revised version of the existing inductive crankshaft position sensor and the Hall-effect camshaft position sensor. The only totally new piece of hardware is the Vehicle Vertical Acceleration Sensor on 4 cylinder cars.

Concerns

The misfire DTC may be triggered by conditions beyond our control such as bad fuel, running out of fuel, erratic driving habits, etc. To meet the legal requirements, the diagnostic must be designed in such a way that it may take days or even months between the time that knock was first detected and the point at which the MIL was finally illuminated. As you may recall, it takes two failures to turn on the light in a case of emissions-related misfire.



Fuel Trim System Monitoring

Regulations

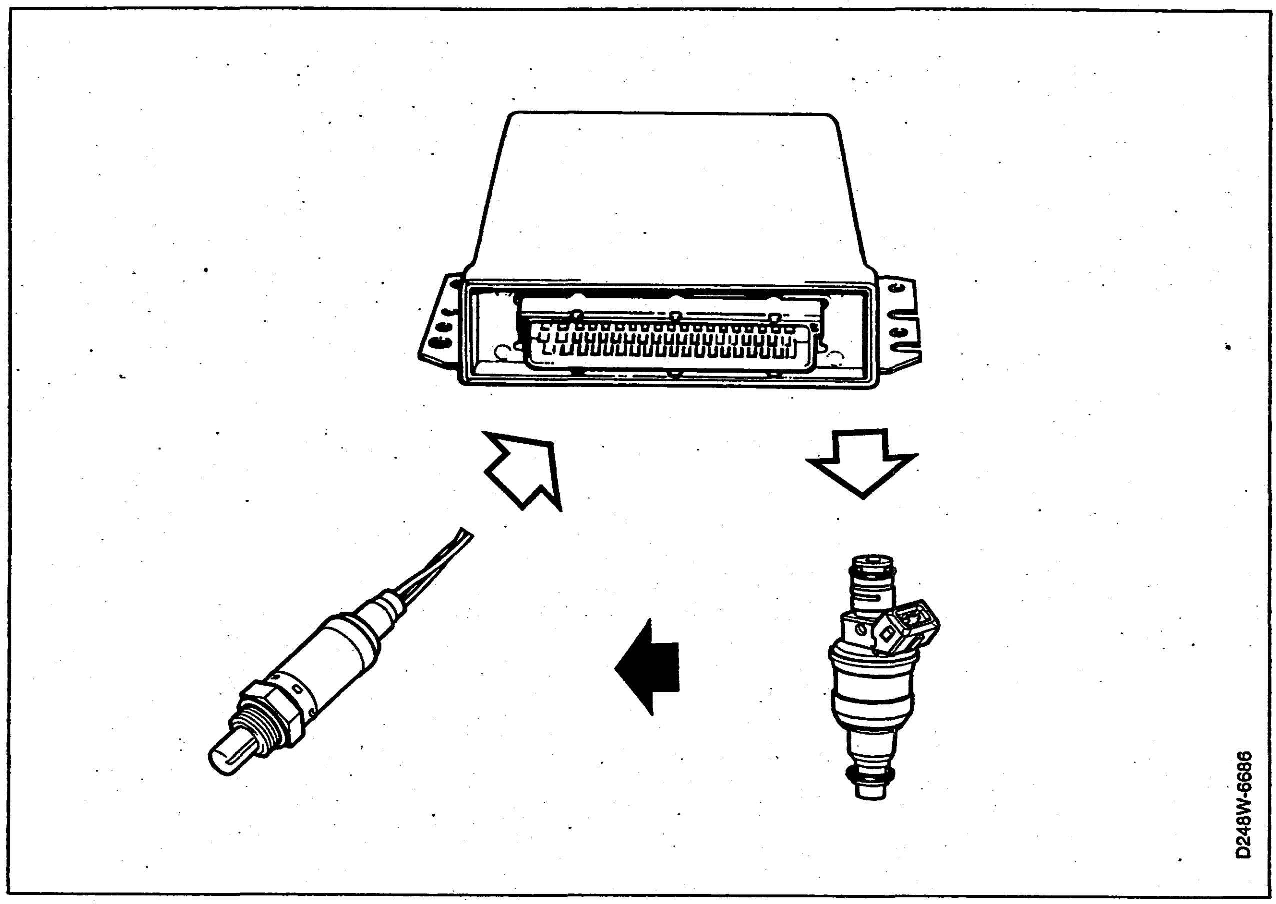
The OBD II requirements for fuel system monitoring state that the fuel delivery system must be continuously monitored for the ability to provide compliance with emissions standards. The fuel system will be considered to be malfunctioning when it causes the emissions levels to exceed 1.5 times the FTP emissions standards.

Fuel Trim

Long-term & short-term fuel trim are J1930 terms which will probably be new to many Saab technicians. In fact, they are just another way of describing how the pre-catalyst oxygen sensor and the ECM work together to fine tune the fuel mixture, familiar concepts in new clothes.

Fuel Trim (previously, Saab used the term "adaptation") is the ability of engine management systems to "reprogram" themselves based on feedback provided by the oxygen sensor. We aren't actually changing the baseline values the ECM pulls from it's memory when calculating how long to trigger the injectors for each possible combination of coolant temperature, rpm, load, etc.

We use information from the oxygen sensor to fine tune the system by applying a correction factor to that calculation. The term adaptation came into general use with Saab in 1988 when we began to store this information in a type of memory which stayed alive even after the car was turned off (as long there was +30 power to the ECM). The next time the car was started it remembered what it had learned and modified it's calculations using this information, even when operating in open loop with a cold oxygen sensor. The fuel system was "adapting" itself to it's environment.



Short term Fuel Trim

Short-Term Fuel Trim (Lambda Control) occurs when the pre-catalyst Oxygen sensor voltage has an immediate impact on injection duration during closed loop operation. For example, the ECM might find it necessary to increase injector duration to compensate for the affects of an air leak. Depending on the cause and the severity of the problem it might be necessary to make this correction only under full load or over a broader range of conditions. The TRIONIC system has the ability to change the "normal" injection times by ±25%.

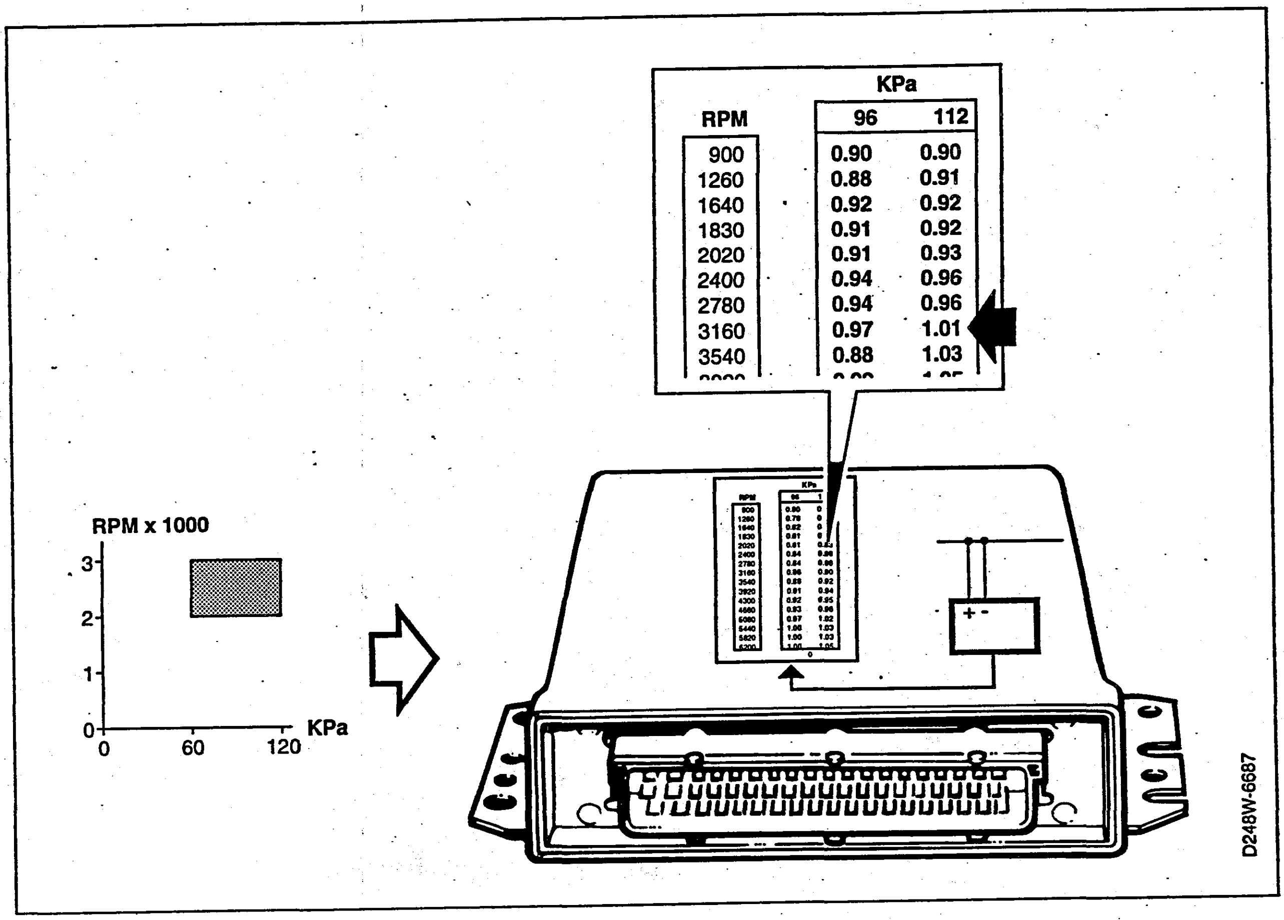
Theory of Diagnostic Operation, Short-Term Fuel Trim

The short-term fuel trim diagnostic runs continuously once it's enabling criteria have been met. The MIL will not be illuminated until the problem has occurred twice anytime within 80 trips. In this respect it is very much like the emissions-related misfire diagnostic discussed earlier. The diagnostic will fail if fuel trim stays locked at it's limits (< -25% or > +25%) for more than 20 seconds.

TRIONIC Short-Term Fuel Trim Enabling Criteria

The short-term fuel trim diagnostic will run when:

- The engine is running
- Coolant temperature is above 140 F (60 C)
- The fuel system is operating in closed loop



Long-Term Fuel Trim

Long-Term Fuel Trim (Global & Spot Adaptation) occurs while the vehicle is being driven within a specific load and RPM window. As an example of Long-term Adaptation, it might become necessary to increase injector times slightly under all operating conditions to compensate for a line pressure regulator which is slightly below specification at all manifold pressures. This corrective factor will be stored in memory so that the ECM won't have to relearn how to cope with this problem every time you start the car.

Theory of Diagnostic Operation, Long Term Fuel Trim

A long-term fuel trim DTC will be recorded, freeze frame data stored and the MIL requested on a TRIONIC vehicle when, on two occasions, the fuel system attempts to store a global correction factor for **all** points in it's memory which exceed it's maximum or minimum limits (< -100% or > +100%).

Long-Term Fuel Trim Enabling Criteria

The long-term fuel trim diagnostic will run when:

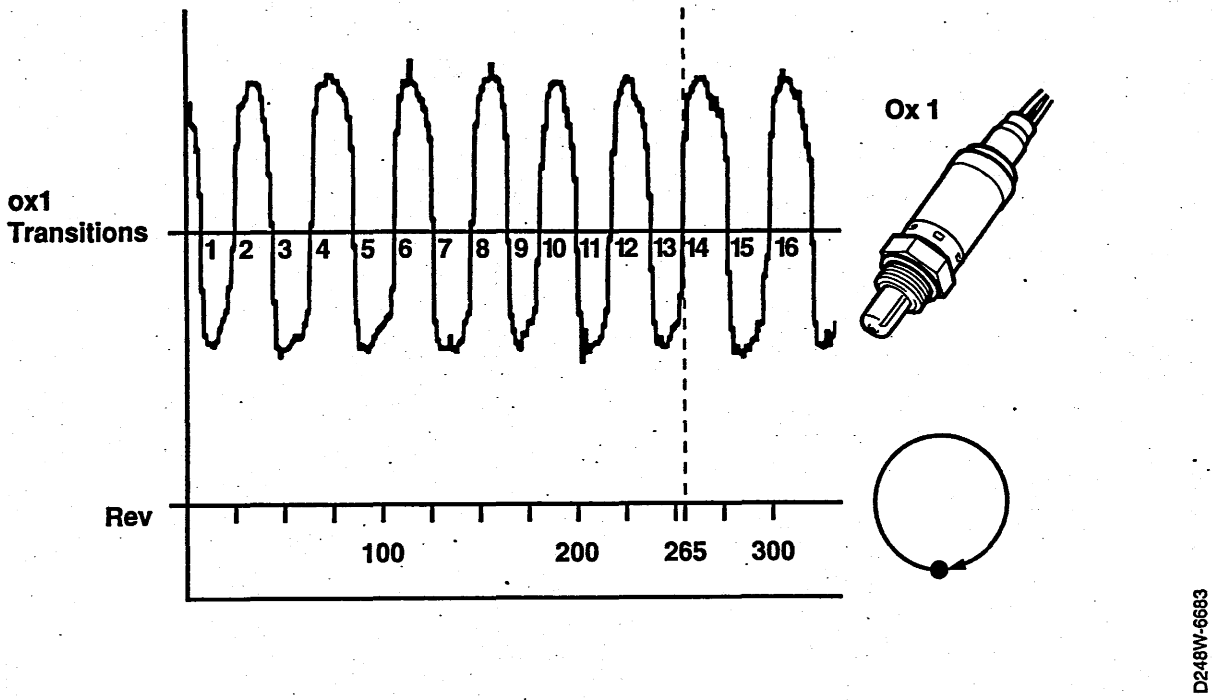
- The key is on

Hardware Required

No additional hardware is needed for either of the fuel trim diagnostics.

Concerns

The diagnostics for heated oxygen sensors, coolant temperature sensors, catalyst monitoring, etc are all for individual components. In contrast, the fuel trim diagnostic is for an entire system which is made up of many components. It is important to remember that a fuel trim DTC may be triggered by any one of a very long list of possible faults. Always take time to collect and evaluate **all** available information such as other stored DTCs, driveability complaints, etc. when troubleshooting a fuel trim fault.



Pre-catalyst Heated Oxygen Sensor Monitoring

Requirements

The diagnostic for the pre-catalyst oxygen sensor is designed to monitor the number of times the oxygen sensor makes the rich/lean or lean/rich transition in a given period of time.

The sensor will be considered to be malfunctioning when it's output voltage, response rate or other parameters reach a level which cause the vehicle to exceed 1.5 times the FTP emissions standards for that vehicle.

Theory of Diagnostic Operation

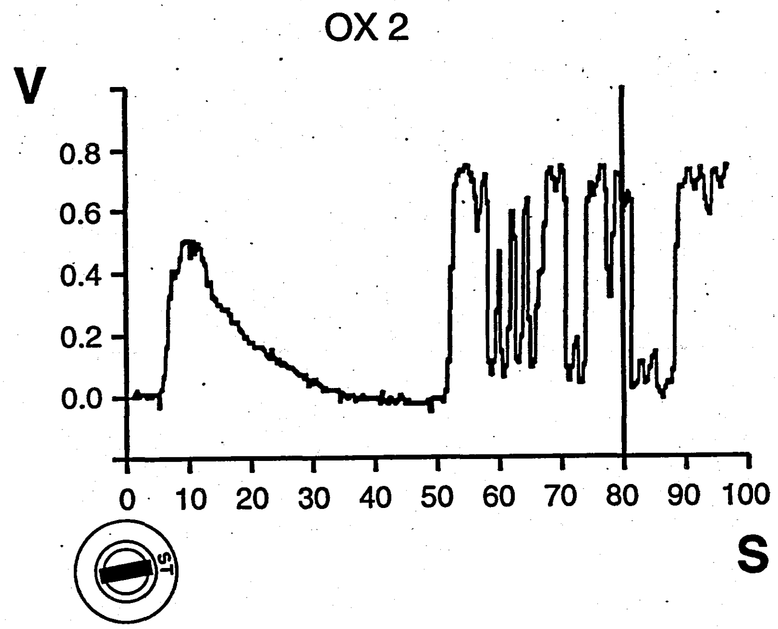
Once the enable criteria for the pre-catalyst oxygen sensor diagnostic have been met, the ECM will begin to monitor sensor output. A healthy oxygen sensor in a properly functioning fuel system will constantly switch back and forth from rich (sensor voltage approaching 1) to lean (sensor voltage approaching 0).

As a sensor deteriorates it will take longer and longer to make these transitions. In the 900 TRIONIC system, a sensor is considered good if there are more than 12 transitions per 265 engine revolutions. The oxygen sensor only needs to pass this test **once** per trip. If, for some reason, the number of transitions is too low on the first test, the sensor will be retested a second and, if needed, a third time before a failure is recorded. The MIL will not be turned on unless diagnosis is failed in two consecutive driving cycles.

Pre-Catalyst Oxygen Sensor Enabling Criteria

The pre-catalyst oxygen sensor diagnostic will run when:

- The diagnostic test has not been completed yet this trip.
- Vehicle speed is 0.
- The engine is idling.
- The fuel system is operating in closed loop.
- Coolant temperature is above 140 F (60 C)
- Oxygen sensor heater current is below 1500 mA.
- There are no load changes (A/C, cooling fan, etc. should not be cycling)



Post-catalyst Heated Oxygen Sensor Monitoring

Requirements

The post-catalyst oxygen sensor diagnostic is designed to monitor:

- How much the sensor output voltage changes.
- How long it takes sensor voltage to change by a given amount. The sensor will be considered to be malfunctioning when it's output voltage, response rate or other parameters reach a level which cause the vehicle to exceed 1.5 times the FTP emissions standards for that vehicle.

Theory of Diagnostic Operation

Once the enabling criteria for the post-catalyst heated oxygen sensor have been met, the ECM begins to monitor sensor output. If the catalyst is doing it's job properly the rate of change in the output from the rear sensor will be fairly slow when compared to the front sensor. The test for the post-catalyst sensor will run once per trip. There is no second or third chance to pass the test as was the case with the pre-catalyst sensor.

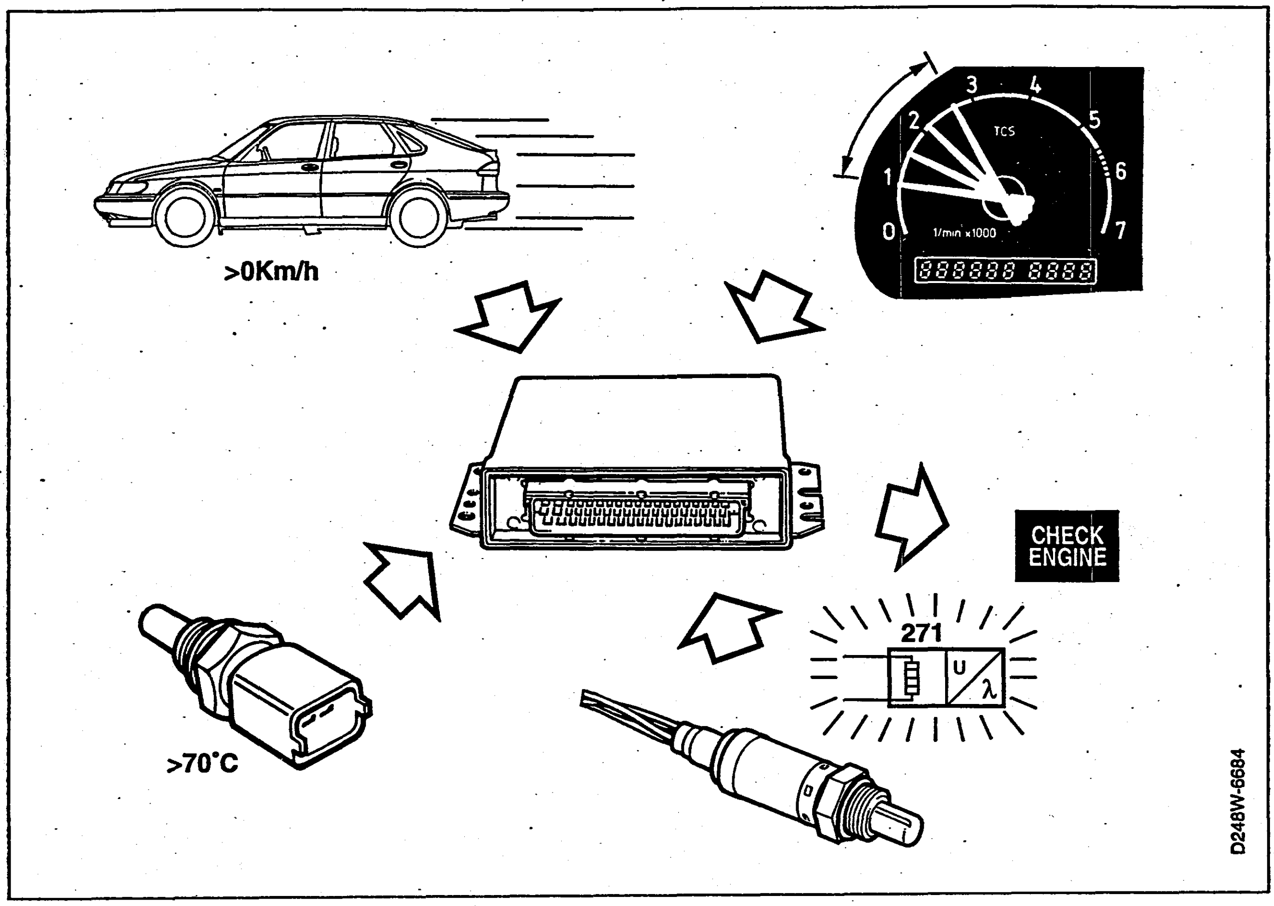
Once all the enabling criteria have been fulfilled a sensor will pass the diagnostic test IF:

1 Sensor voltage rises once to above 400 mV within 500 seconds.

AND

2 Sensor voltage changes by more than 500 mV within 500 seconds.

If either one of these requirements has not been met during each of two consecutive driving cycles, the MIL will be turned on and a DTC set.



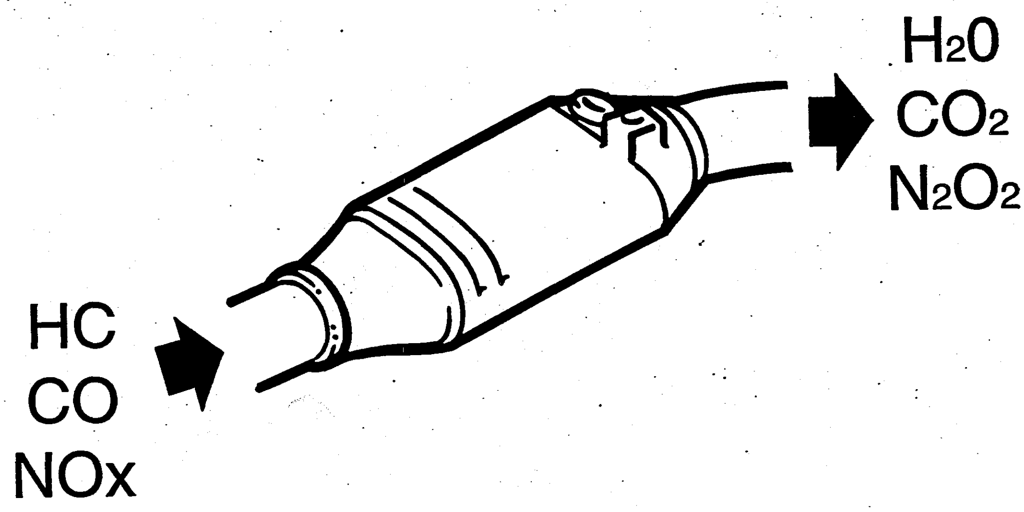
Post-Catalyst Oxygen Sensor Enabling Criteria

The post-catalyst oxygen sensor diagnostic procedure will run when:

- The diagnostic test has not been completed yet this trip.
- The motor is running.
- The vehicle is moving (anything above 0 mph).
- Coolant temperature is above 70°C
- The sensor preheater function is activated.

Hardware Required

No additional components are needed to monitor either the pre- or post-catalyst oxygen sensors. The sensors themselves are completely new of course. In addition to having a slightly different configuration harness connector, you will find that the slots in the metal shroud around the working end of the post-catalyst sensor are much smaller than those found on front sensors.



Catalyst Monitoring

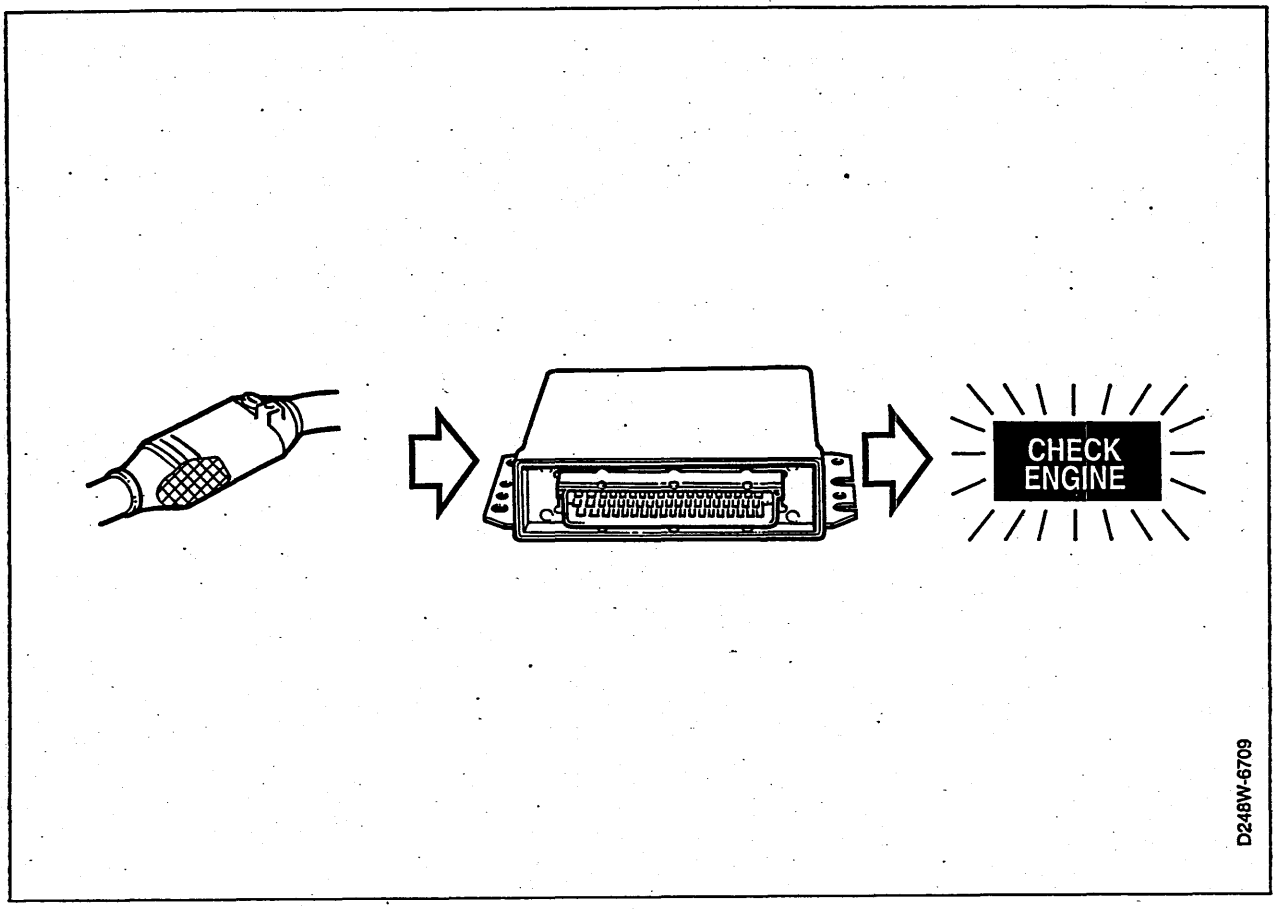
Requirements

Regulations require the on-board diagnostic system to monitor the catalyst once per trip. The catalyst is considered to be malfunctioning when hydrocarbon (HC) output exceeds 1.5 times the FTP standards.

Review of Catalyst Function

Three-way catalytic converters contain one or more precious metals (palladium, platinum & rhodium) used to catalyze the unburned hydrocarbon (HC), carbon monoxide (CO) and oxides of nitrogen (NO_x) which result from the combustion of gasoline. When the catalyst is working properly, the unburned hydrocarbon is oxidized by combining with oxygen, forming water vapor (H_2O). Carbon monoxide is also oxidized to form carbon dioxide (CO_2). Oxides of nitrogen are reduced to nitrogen and oxygen.

To help in these processes, most three-way catalysts also contain a base metal known as cerium. Cerium has the ability to absorb and release excess oxygen in the exhaust stream. This stabilizes the operation of the catalyst and enhances the effectiveness of the precious metals in converting undesirable combustion byproducts to harmless gases. As a catalyst becomes less efficient due to factors such as aging, poisoning or overheating, it's capacity to store and release oxygen generally degrades as well. The OBD II catalyst monitoring diagnostic is based on this correlation between conversion efficiency and oxygen storage capacity.

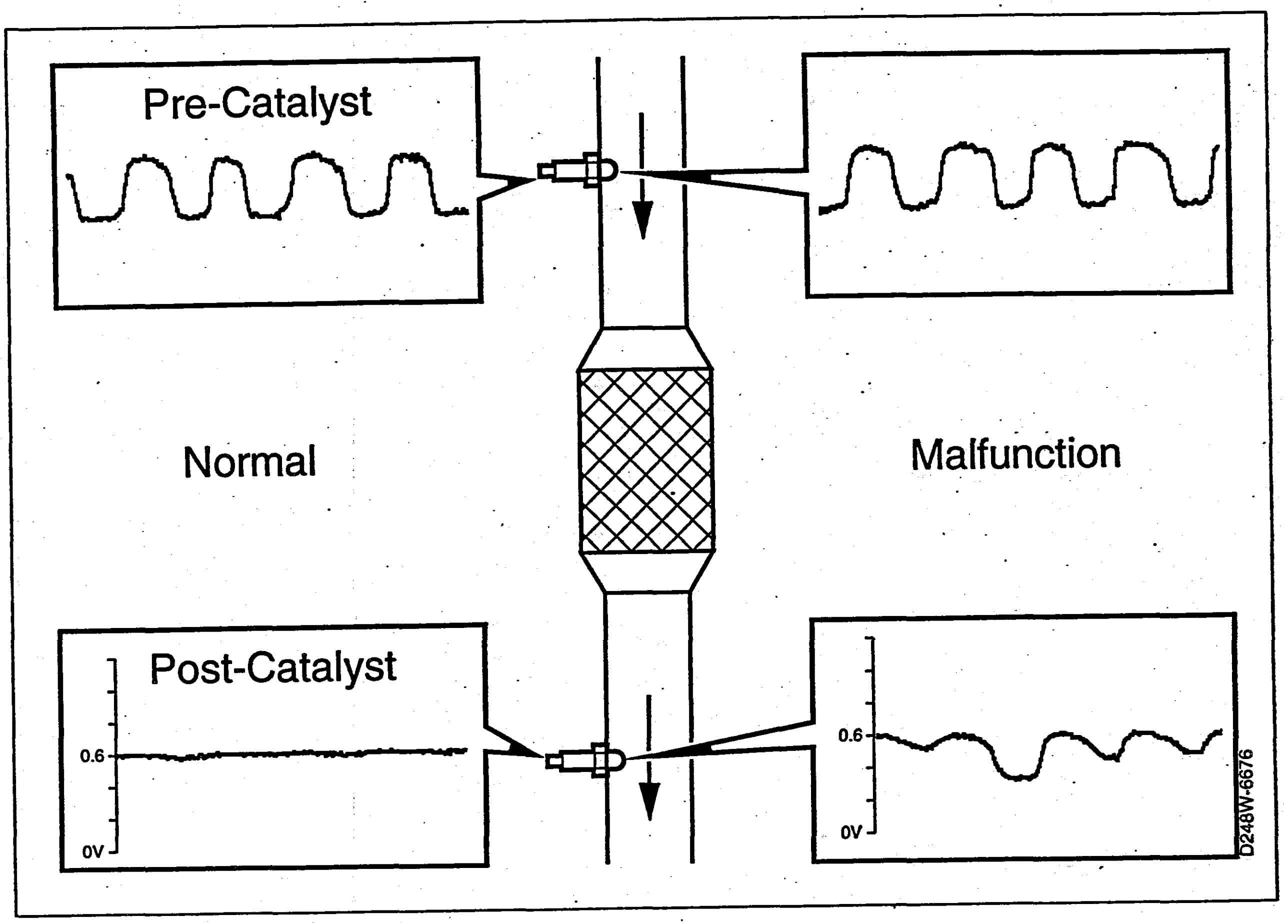


Catalyst Monitoring (continued)

Theory of Diagnostic Operation

One of the few new components visible on an OB-D II SAAB is a "post-catalyst" oxygen sensor mounted downstream of the catalyst. In addition to it's primary role of monitoring catalyst efficiency, the output from the post-catalyst sensor also helps fine tune the fuel mixture in much the same manner as the front sensor always has. The ECM is able to calculate catalyst efficiency by comparing the output from the pre-catalyst sensor with the signal from this new, post-catalyst sensor. This difference in these two readings will result from a characteristic of catalysts known as oxygen storage capacity.

Once the enabling criteria for the catalyst monitoring diagnostic have been met, the ECM compares the frequency and amplitude of the voltage from the pre & post-catalyst sensors. The catalyst monitoring diagnostic procedure takes place once per trip and takes a minimum of 60 seconds to complete.

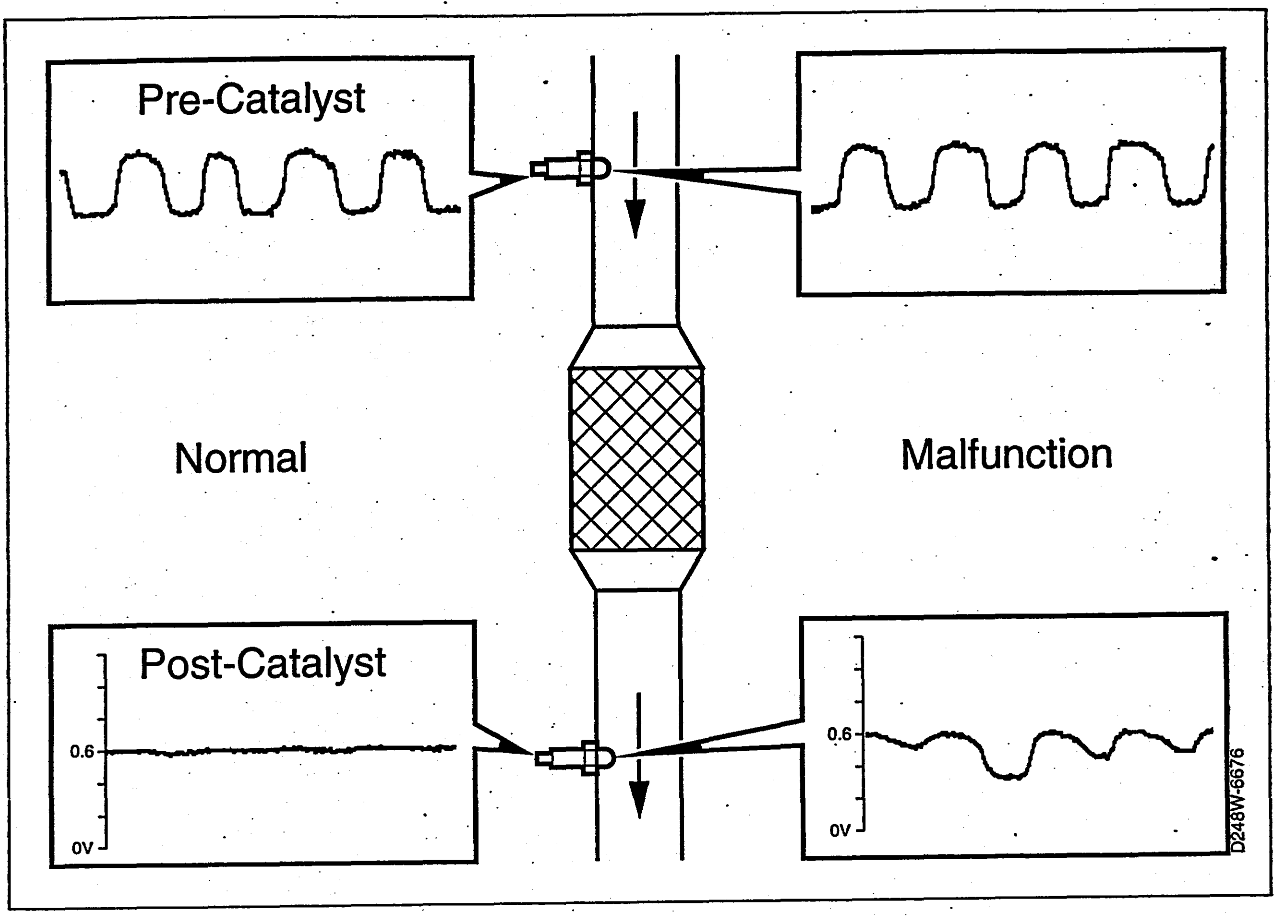


Measuring Oxygen Storage Capacity

A good catalyst will show a relatively flat output of the post-catalyst heated oxygen sensor. A poor catalyst will show substantial peaks and valleys in the sensor's output voltage, indicating that the catalyst is having little affect on the exhaust and both oxygen sensors are sampling similar gases. By monitoring the post-catalyst oxygen sensor voltage fluctuations during 50 pre-catalyst oxygen sensor voltage cycles, it is possible to determine the oxygen storage/release capacity of the catalyst. From this we can determine the overall condition of the catalyst. High oxygen storage capacity indicates a good catalyst, low storage capacity means the catalyst is failing.

If the diagnostic fails on two consecutive driving cycles the MIL will be illuminated and a DTC set.

Like many OBD II diagnostic procedures, it is impossible for you to "manually" evaluate the condition of the catalyst by monitoring the sensor outputs with a scope or scan tool. Only the OBD II diagnostic software built into the ECM has access to all the information needed to make this decision. In this respect OBD II is very much like our SRS (airbag) systems where the system itself must be the final judge of whether or not a problem exists.



Catalyst Monitor Enabling and Malfunction Criteria

There is no point in trying to monitor catalyst efficiency until both the engine and the catalyst have warmed up and the engine is operating in a steady state. A complete test may take as long as 60 seconds to complete after all the enabling criteria have been met as it requires calculating the average values of 50 samples of the rate of change in amplitude of the post-catalyst sensor.

Once it has begun, the test will be aborted if any of the Evaluation Criteria move out of range. The test will restart as soon as all the Catalyst Warm-up Criteria have been met again.

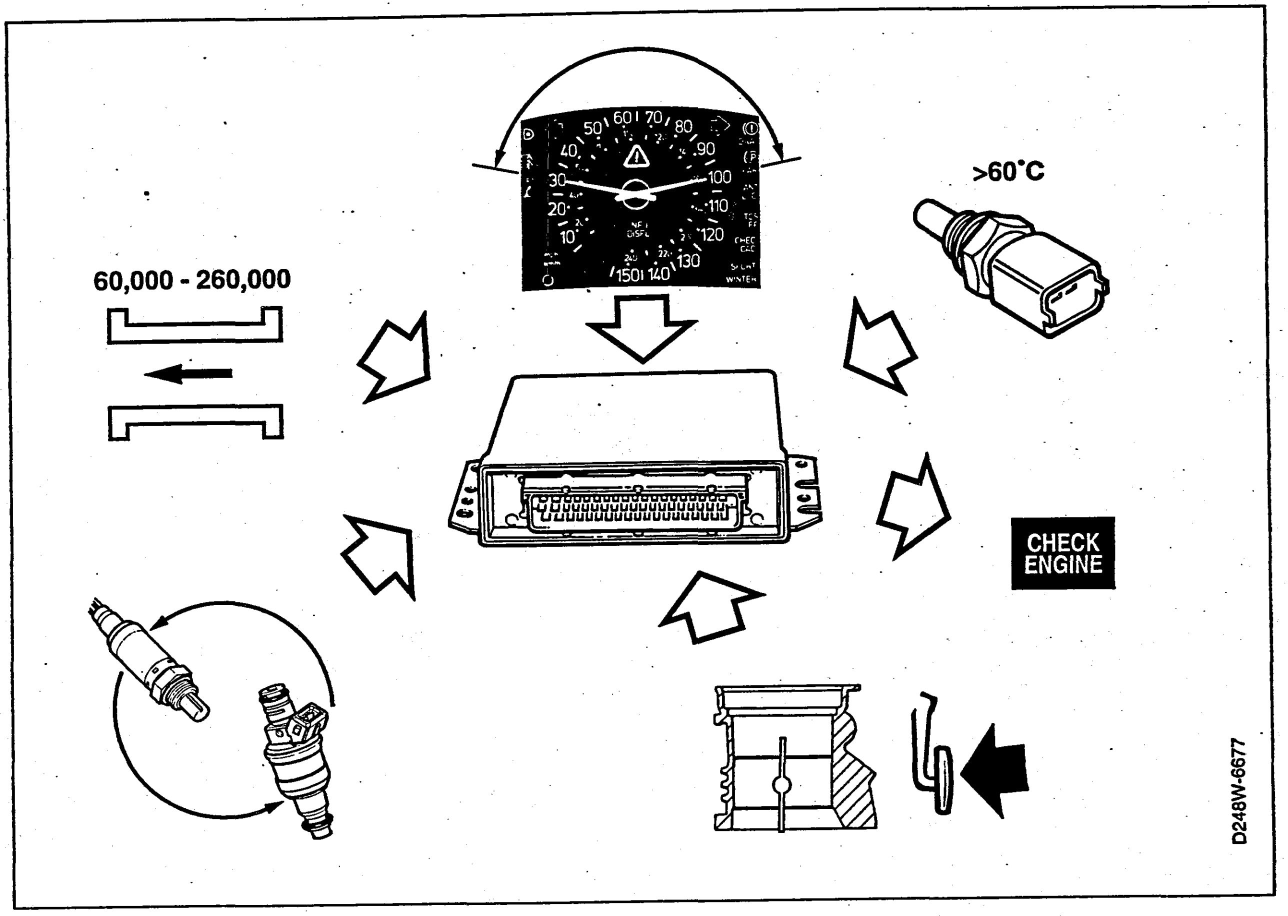
The complete catalyst monitoring criteria can be broken down as follows:

Preliminary Condition
(In order to begin the test sequence)

- The diagnostic test must not have been completed (either passed or failed) yet this trip.

Catalyst Warm-up
(Prepares the catalyst for testing)

- Speed > 0
- Open Throttle
- RPM x Load > 60,000
- Time accelerating > 15 seconds
- Time at idle < 40 seconds
- Total fuel cut-off time (decel) < 10 seconds
- Above conditions fulfilled for 120 seconds



Catalyst Monitor Enabling and Malfunction Criteria (continued)

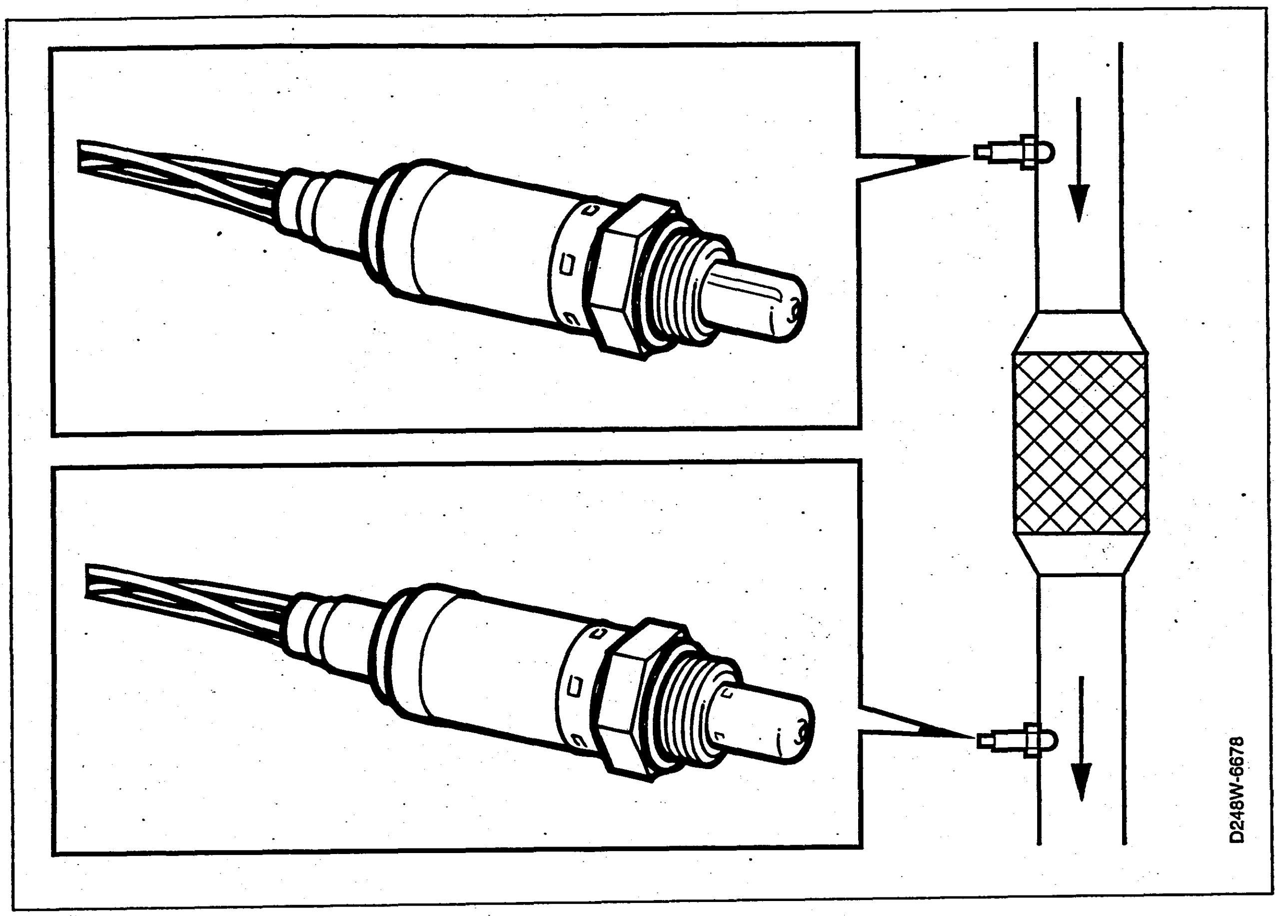
Catalyst Evaluation (Operating conditions while actively testing)

- Speed between 30-100 kph
- Open throttle
- System operating in closed loop
- RPM x Load = 60,000-260,000
- Coolant > 60°C
- The post-catalyst oxygen sensor has been > 0.4V once during this driving cycle

If you count them, you will find that there are 14 criteria for this one diagnostic. As if that isn't enough, they must also occur in the proper sequence which is why it is critical to always carefully follow the road test instructions in the shop manual for each particular diagnostic.

The road test procedure for catalyst evaluation is to:

- Erase DTCs
- Drive the vehicle under varying load and RPM until coolant temperature reaches 60°C, however you must drive at least 5 minutes even if you start with a hot engine.
- Drive with a constant throttle opening at 40-90 km/h for four minutes, select a gear which will allow you to drive at 2-3,000 RPM.
- Choose a test route which will allow you to avoid changes in throttle setting. When traffic permits, it is better to let the speed change a bit rather than moving the throttle.
- Conntect ISAT and read ON/OFF, DIAGNOSIS STATUS, CATALYST. If ISAT rads "READY" then select READ FAULT CODES tosee if the repair has been successful.



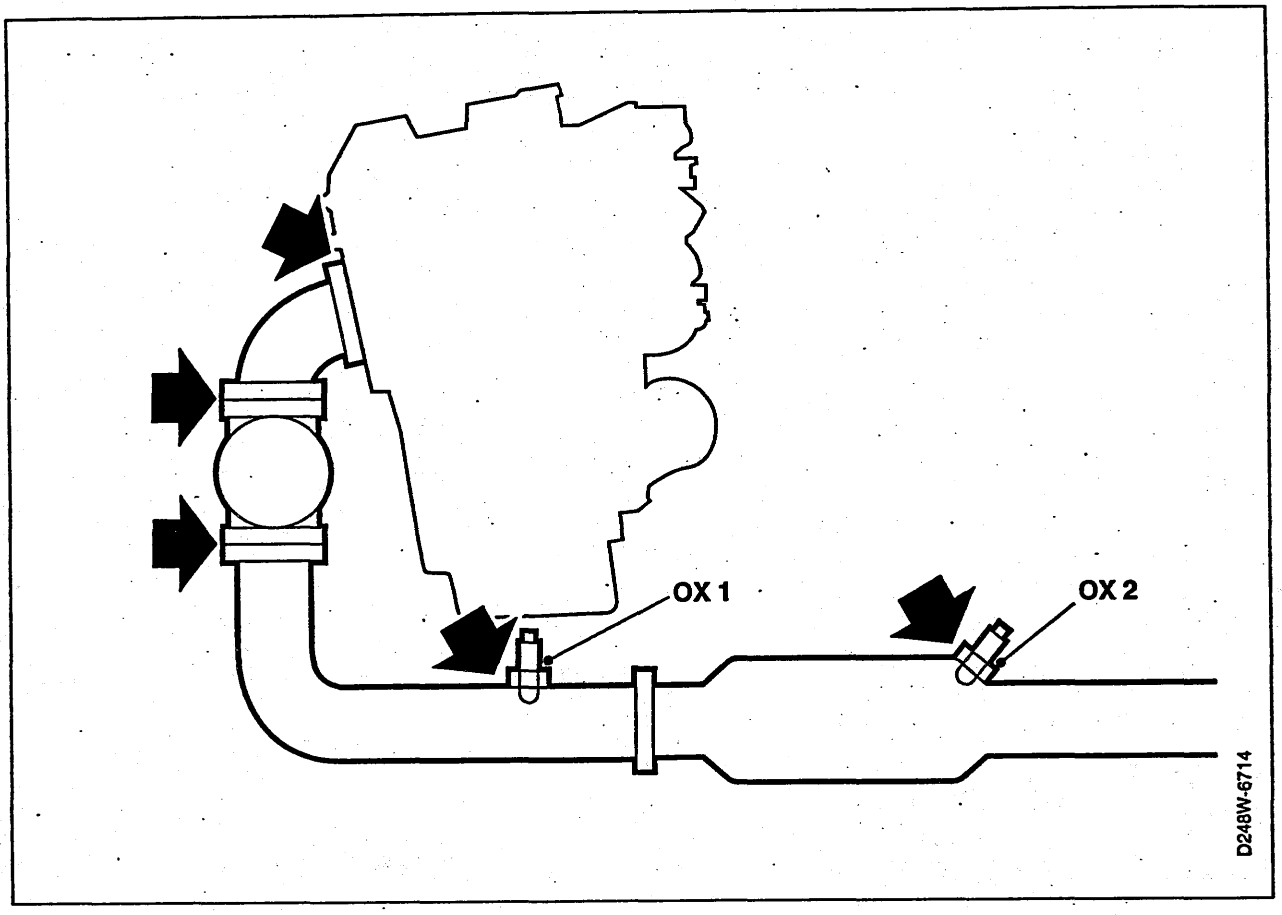
Catalyst Diagnostic Hardware

Catalysts & Front Pipes

As you have seen on page 27, all V6 engines receive two new catalysts, front pipes and accompanying changes to the exhaust system. This change allows the two cylinder banks to operate a bit more independently of each other than if we had a single catalyst and post-catalyst sensor.

Four Wire Oxygen Sensors

All 1996 oxygen sensors (both pre and post-catalyst) are of the four wire variety instead of the three wire preheated type we have used for the last ten years. The additional wire provides a ground at the ECM for the sensor itself instead of relying on the condition of the sensor threads, exhaust pipe, ect. as we do on the older versions. Pre- and post-catalyst sensors are significantly different, connectors are indexed to prevent the crossed signals which would result from hooking the output from sensor 1 to the ECM input for sensor 2.



Catalyst Monitoring Diagnostic

Concerns

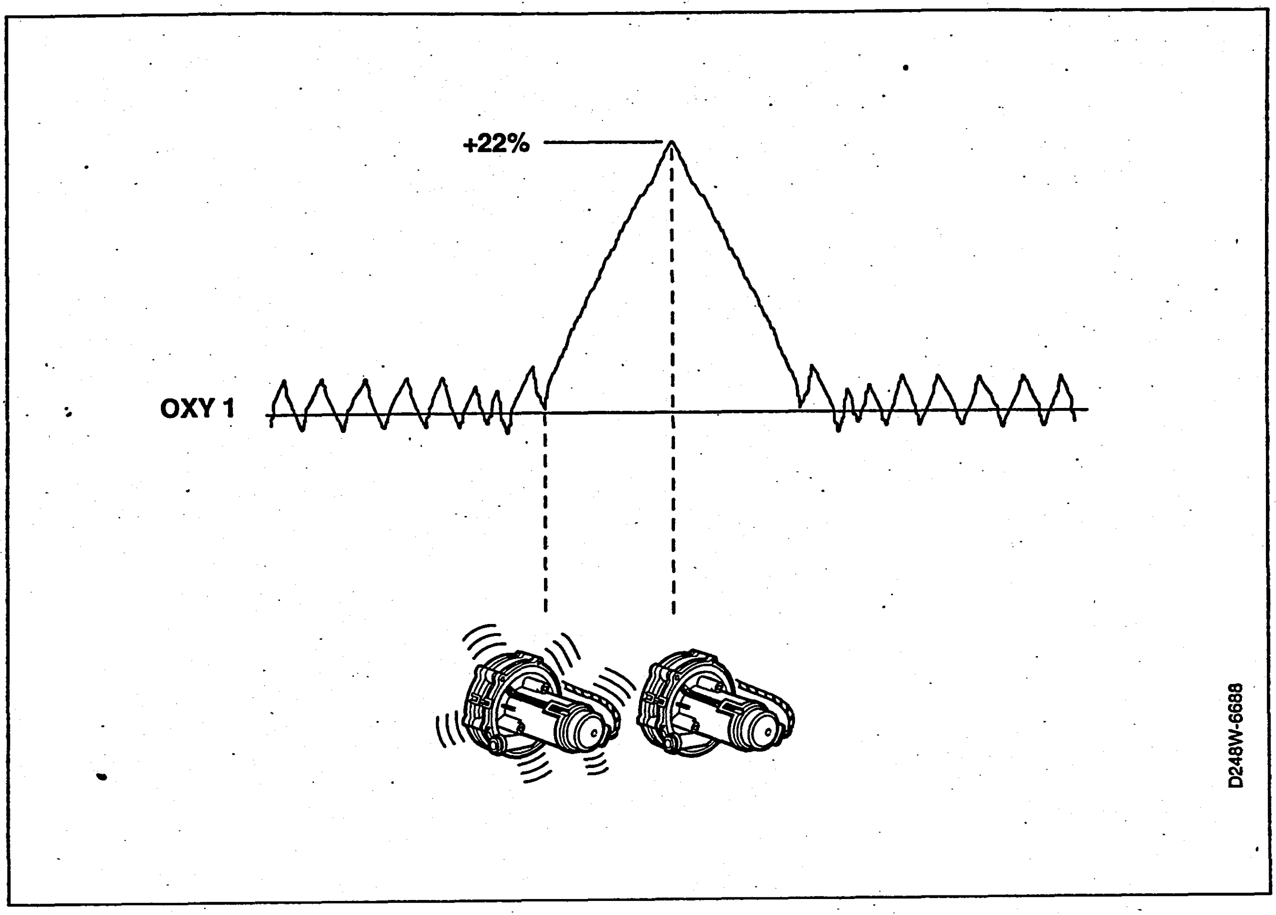
Concerns associated with the monitoring of catalyst efficiency include the unpredictable effects that exhaust leaks, the use of aftermarket parts, alternate fuels and other factors beyond the manufacturers control may have on the oxygen storage capacity of the catalyst.

Exhaust leaks may adversely affect the diagnostic procedure. Even relatively small leaks can introduce ambient oxygen into the exhaust stream. Depending on their size and location, they may:

- Prevent a bad catalyst from failing the diagnostic check.
- Cause a good catalyst to fail
- Prevent the diagnostic procedure from even running

Contamination of the catalyst has always been a concern. Some of the poisons which may be encountered are phosphorous, lead, silica and sulfur. These may prevent the catalyst from working properly and can affect the relationship between oxygen storage capacity and emissions performance. These and other contaminants are typically introduced through the fuel or from the improper use of sealants such as RTV or other shop chemicals.

Vehicles in the Canadian market may be exposed to fuel with an additive known as MMT. MMT affects the oxygen storage capacity of the catalyst monitoring diagnostic.



Secondary Air Injection (AIR) System Diagnostic (MOTRONIC Only)

Requirements

The secondary air injection diagnostic must verify that turning on the electrically-driven secondary air pump has a real and measurable effect on the operation of the system. The secondary air injection system will be considered to be malfunctioning when it's failure to operate or improper operation will cause emission levels to increase to more than 1.5 times the FTP standards.

Theory of Diagnostic Operation

A secondary air system failure will turn on the MIL if a malfunction is detected during two consecutive driving cycles. The diagnostic procedure runs once per trip and is based on observing the reaction of the short term fuel after the secondary air pump has been turned on. The large increase in oxygen entering the exhaust system when the pump is running will drive down the output voltage from the pre-catalyst heated oxygen sensor, affecting the short term fuel trim. If, on two consecutive trips, the short term fuel trim does not increase by ≈12% within 20 seconds when the secondary air system is active, the MIL will be requested and a DTC set.

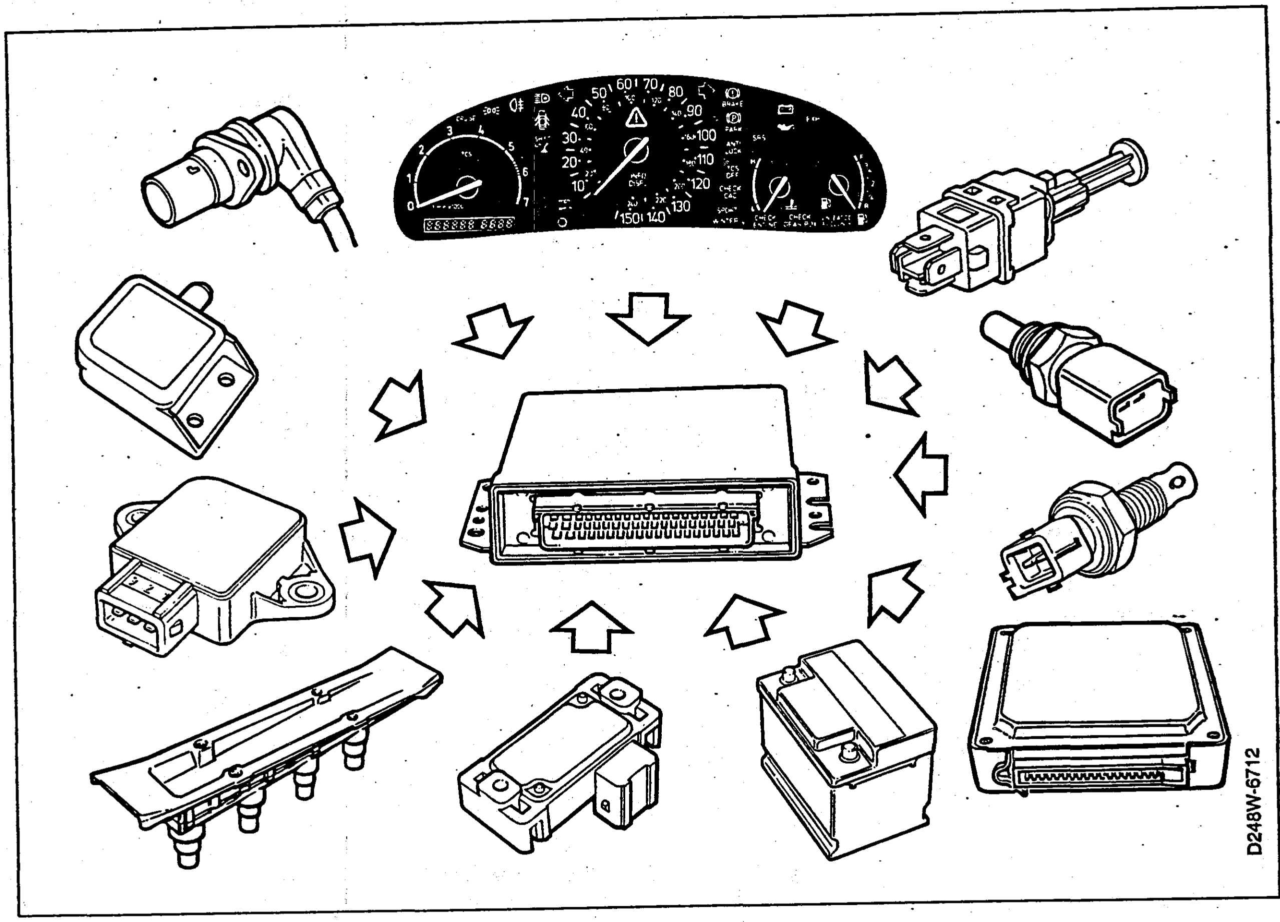
Secondary Air Injection Enabling Criteria

The secondary air diagnostic test will run when:

- The diagnostic check has not been completed yet this trip.
- Vehicle speed is 0.
- The engine is idling.
- The fuel system is operating in closed loop.

Hardware Required

No additional equipment needed to be added to permit diagnosis of the secondary air injection system. Diagnosis is carried out by observing the activity of existing components.



Comprehensive Component Monitoring

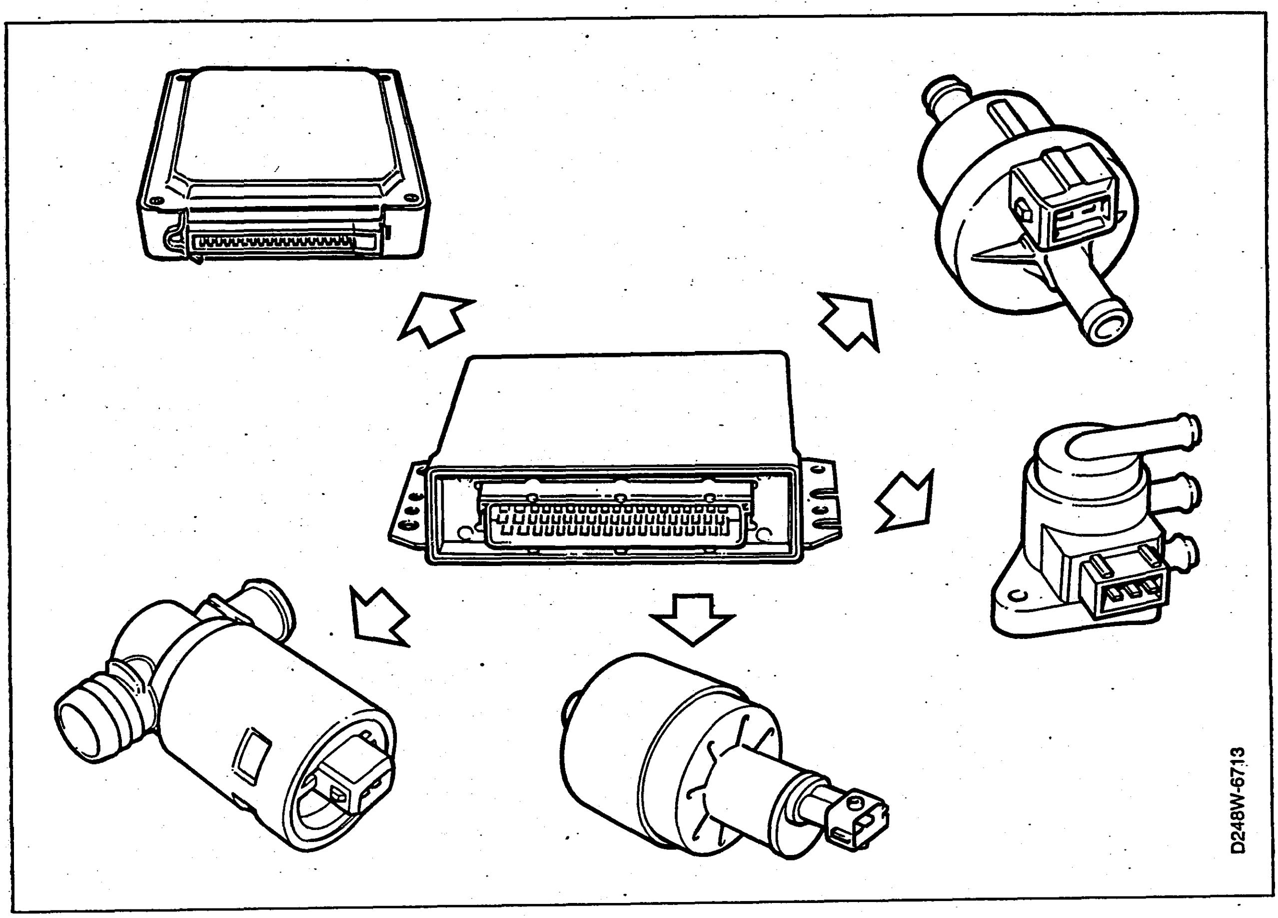
Requirements

Comprehensive component monitoring diagnostics are required to monitor the operation of those inputs and outputs to powertrain components whose failure or malfunction would increase emissions to more than 1.5 times FTP standards.

Input Components

Input components are to be monitored for a minimum circuit continuity and out of range values. Input components for a TRIONIC vehicle include:

- Manifold absolute pressure sensor
- Intake air temperature sensor
- Engine Coolant Temperature sensor
- Throttle position sensor
- Knock sensor (TRIONIC calculates knock, there is no actual sensor)
- Camshaft position sensor (TRIONIC calculates this information)
- Crankshaft position sensor
- EVAP pressure sensor (900)
- Vehicle speed
- Battery voltage
- Brake light switch
- CHECK ENGINE request from the 900 automatic transmission control module
- 900 Automatic transmission sensors



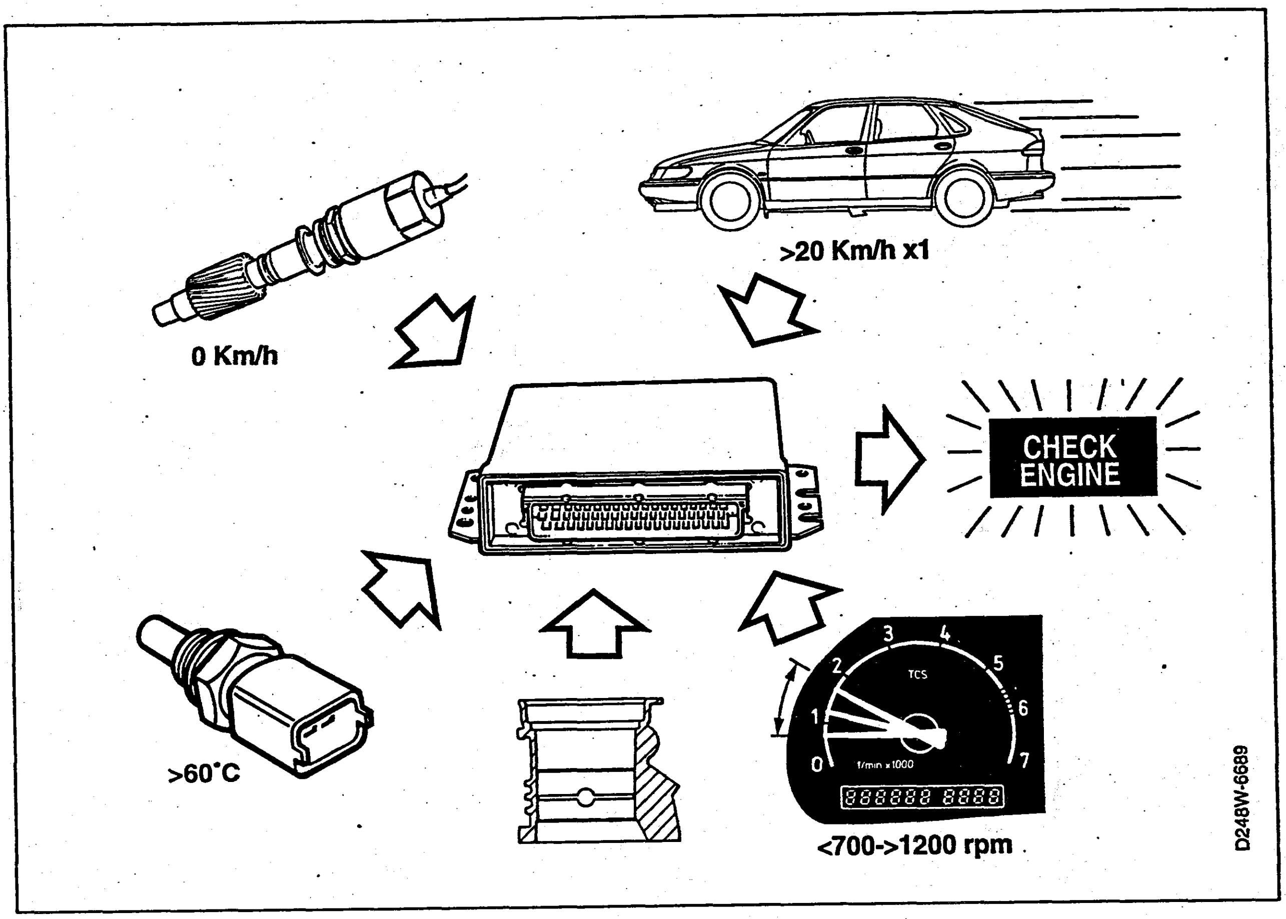
Comprehensive Component Monitoring (continued)

Output Components

Output components are monitored for proper response to ECM commands. Components for which functional monitoring is not feasible will be monitored for circuit continuity and out of range values, if applicable. Output components for a TRIONIC vehicle include:

- EVAP canister close valve (900)
- EVAP canister purge valve
- Idle air control valve
- Boost pressure control valve
- 900 Automatic transmission solenoids

As examples of comprehensive component monitoring, the idle air control (IAC) system monitoring, EVAP system monitoring and engine coolant monitoring (ECT) diagnostics are described on the following pages. For diagnostic theory, enabling and malfunction criteria for all the other components on this list refer to the shop manual.



Idle Air Control (IAC) System Monitoring

Requirements

The idle air control system must be monitored for it's ability to maintain a stable idle speed. The system will be considered to be malfunctioning If the difference between actual engine idle speed and the programmed idle speed exceeds fixed limits.

Theory of Diagnostic Operation

The idle air control diagnostic procedure is carried out continuously and compares actual engine idle speed to the idle speed requested by the ECM. If the actual idle speed is lower than 700 rpm or higher than 1200 rpm for two consecutive driving cycles the MIL will be illuminated and a DTC set.

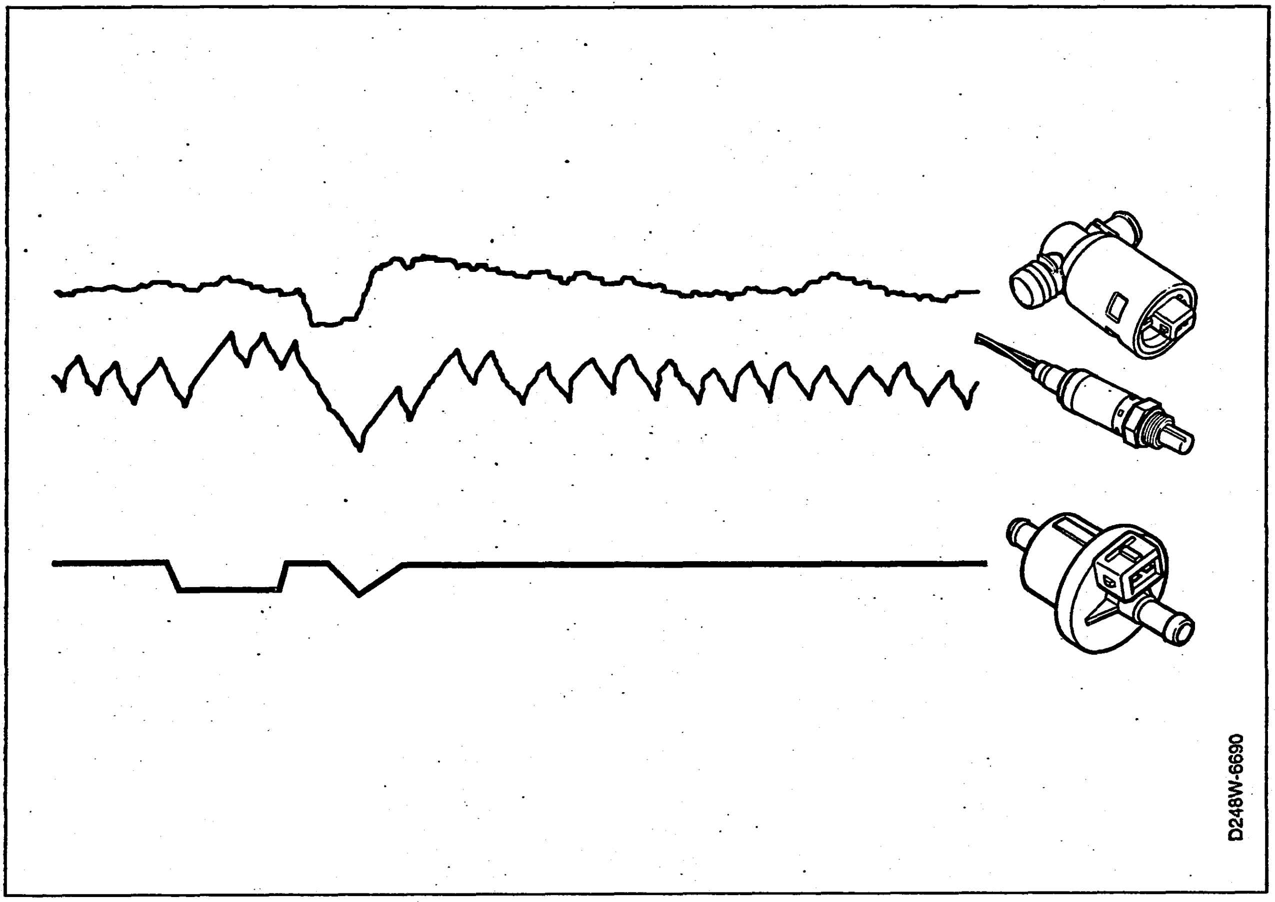
Enabling Criteria

The idle air control diagnostic procedure will run when:

- Vehicle speed has once exceeded 20 km/h this driving cycle
- Vehicle speed = 0
- Coolant temperature >60°C
- Throttle closed

Hardware Required

No additional hardware is required for this diagnostic.



Evaporative Emissions Canister Flow Monitor

Vehicles Using the Flow Check Diagnosis

Evap system operation can be monitored using several different approaches, Saab will use two in 1996. The models using the flow check method are:

- All 9000s
- 4-cyl Motronic 900s
- M96-M96.5, Turbo 900s

Theory of Diagnostic Operation

If the Evap Canister purge valve, wiring, hoses, etc. are ok we should see a change in the fuel trim and idle control circuits when we open and close the purge valve.

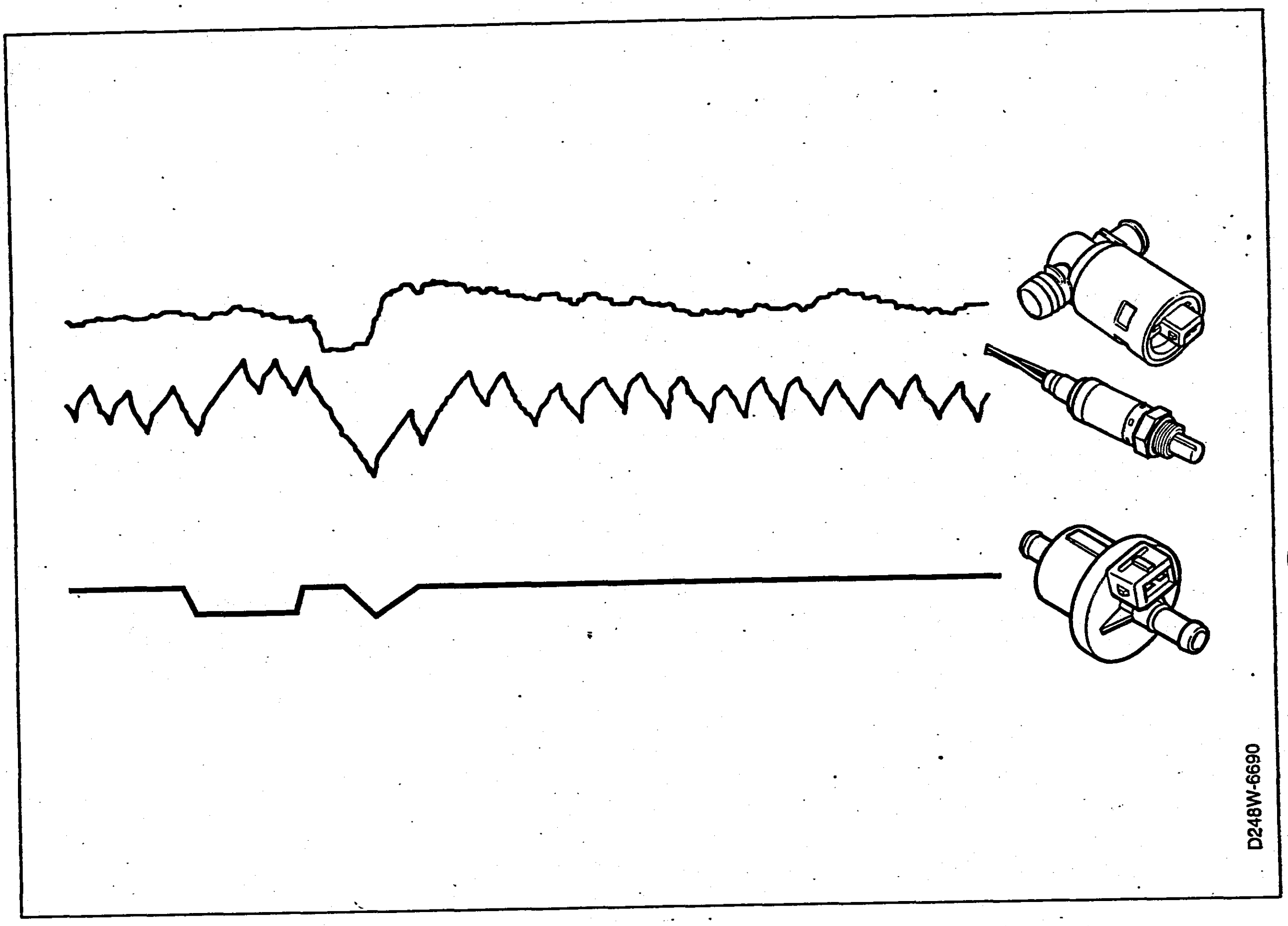
1 Once normal purging starts, the system is allowed to run for a while to establish stable short term fuel trim and IAC operation.

2 The duty cycle for the purge valve tapers down until the valve is completely closed (0% duty cycle). The short term fuel trim and IAC valve duty cycle are sampled. Their average values over a period of time are calculated to provide a reference point for the next step.

3 The purge valve is opened and, as the volume of flow from the Evap canister increases, the system looks for changes in short term fuel trim and IAC duty cycle. The purge valve will continue to open until **either** the total fuel trim change has reached 6% **or** the IAC duty cycle changes by more than 1%. At this point the test will have been passed and the diagnostic will be terminated.

If the purge valve duty cycle reaches 90% without passing the test, we will store a new idle air reference value and then taper back the purge valve duty cycle to 0%. As this is happening we will monitor just the IAC duty cycle. If we see a change of more than 1%, the test will pass. Anything less than 1% and the system will fail.

If the diagnostic fails for two consecutive driving cycles the MIL will be illuminated and a DTC set.



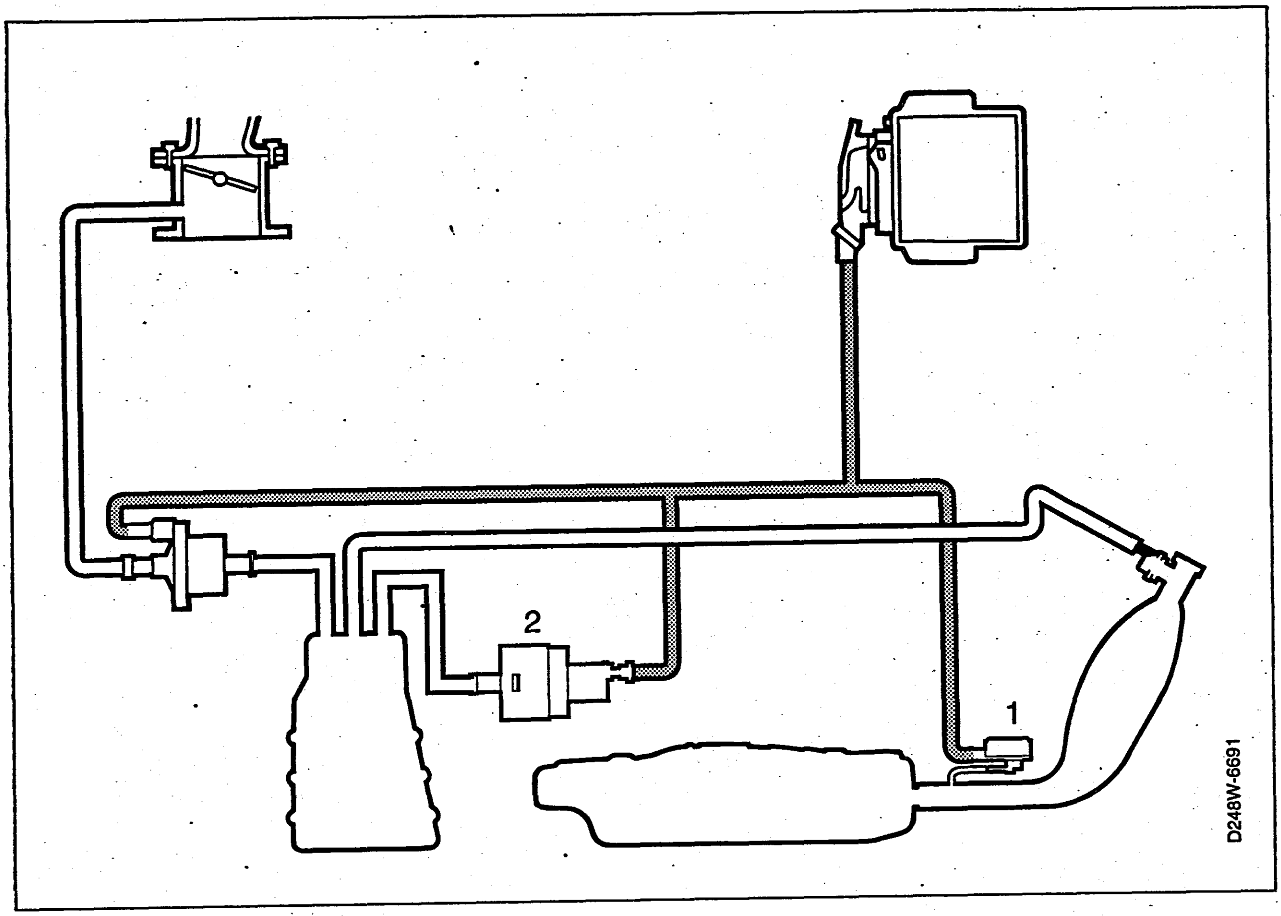
EVAP Canister Purge Valve Monitor Enabling Criteria:

The diagnostic check for the EVAP canister purge valve will run when:

- The diagnostic test has not been completed yet this trip.
- The pre-catalyst oxygen sensor transition diagnosis has passed
- The engine is operating in closed loop.
- The vehicle is stationary.
- The throttle is closed.
- The EVAP canister purge valve is active
- There are no load changes
- The idle speed is stable

Hardware Required

No additional hardware is required to perform the purge system diagnostic.



EVAP System Integrity Monitoring

Vehicles Using This Method

- M96- 900 V6 models
- M96.5- All 900 Turbo

Theory of Diagnostic Operation

This diagnostic will check EVAP system flow and detect any leak, from filler cap to intake manifold, larger than the equivalent of a 1 mm (0.040″) hole. We do this by monitoring pressure changes in the fuel tank as we control the purge cycle.

If the diagnostic fails on two consecutive driving cycles the MIL will be illuminated and a DTC set.

To accomplish this, we have added two new parts to the EVAP system. There is an Fuel Tank Pressure Sensor (1) mounted on the filler neck and a Canister Close Valve (2) which, when closed, blocks the previously unrestricted flow of fresh air into the canister.

The EVAP system leakage test is carried out as follows:

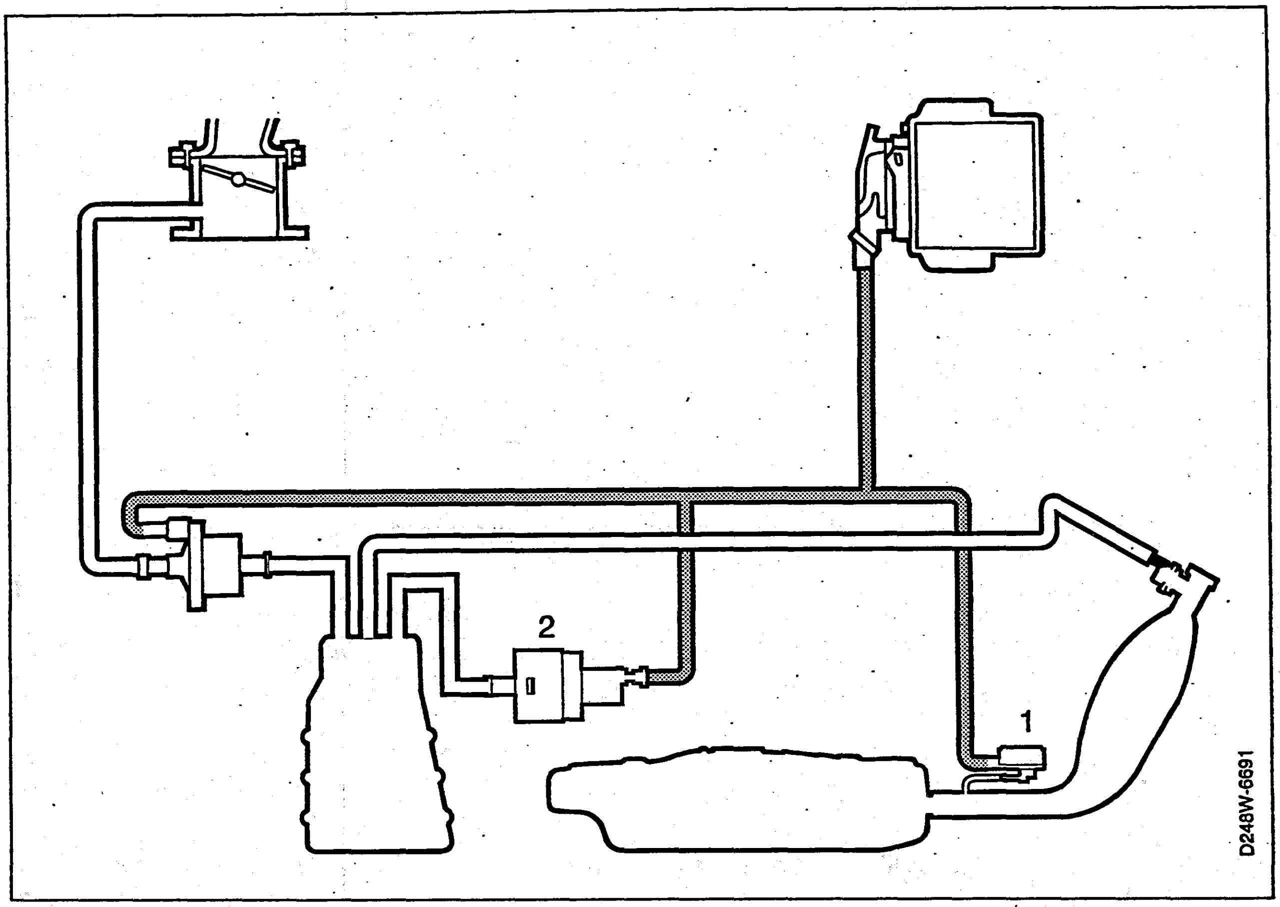
1 Tank pressure is measured during normal purge system operation. This establishes a reference point for evaluating the results of the following steps.

2 The EVAP canister close valve is closed. The EVAP canister purge valve continues normal operation.

3 Tank pressure is monitored for a ten second period. As soon as pressure drops by more than 0.4 kPa we will move to the next step. If, after ten seconds, pressure has not dropped > 0.4 kpa the diagnostic has failed and testing stops.

4 The EVAP canister purge valve is closed, sealing off the fuel tank and EVAP system.

5 Tank pressure is monitored for another ten second period. Pressure should remain constant or increase only slightly. The diagnosis fails if there is a significant increase in pressure.



EVAP System Integrity Monitoring (continued)

Enabling and Malfunctioning Criteria

The EVAP system leakage diagnostic runs once per trip. Before it will let the diagnostic run the ECM looks for:

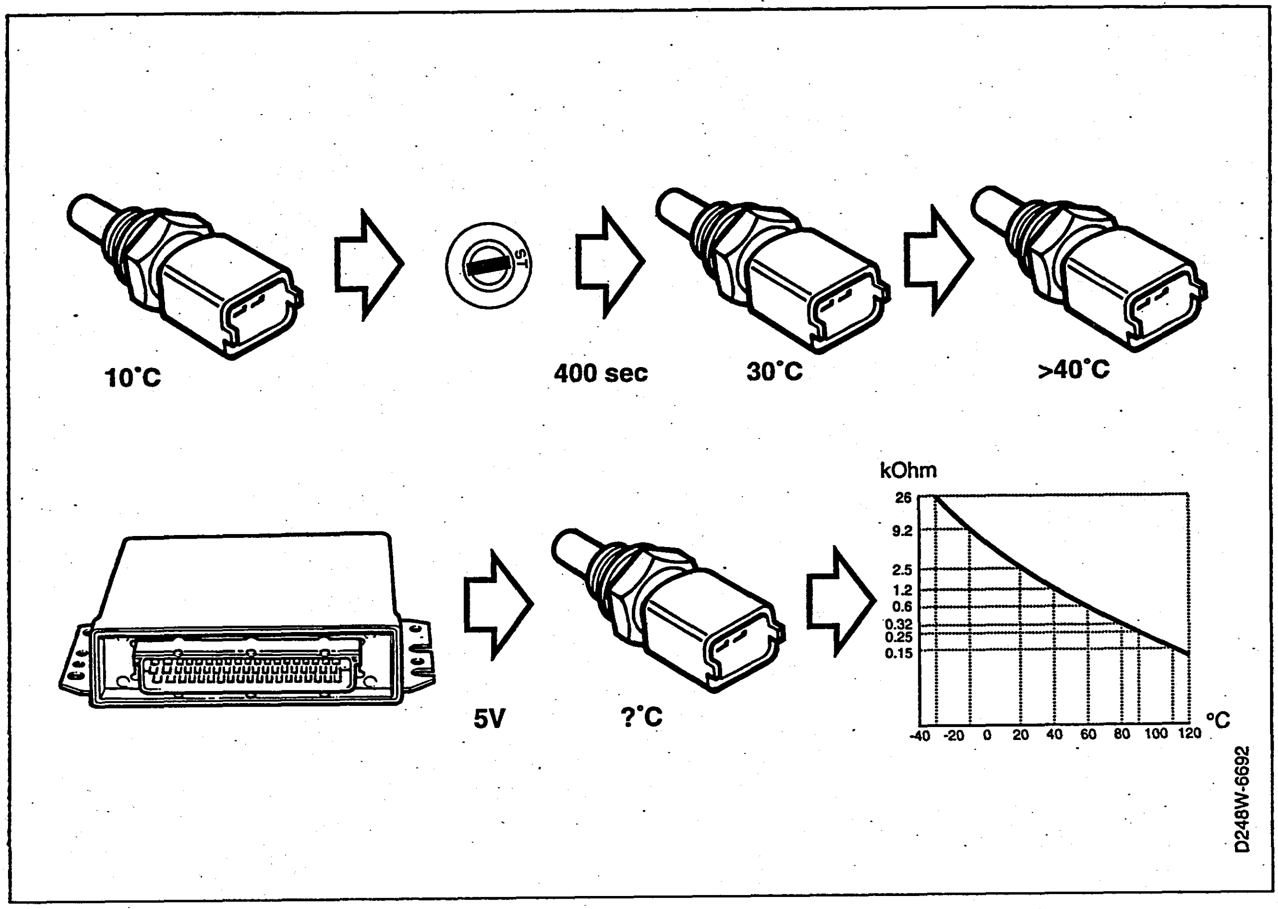
- The diagnostic must not have been run yet during this trip.
- Pre-catalyst oxygen sensor transition diagnosis passed.
- Vehicle speed = 0.
- The engine must be idling.
- The EVAP canister purge valve must be active.
- Less than 10% of the total fuel entering the combustion chamber is coming from the EVAP system.

Hardware Required

The EVAP pressure sensor, canister close valve, filler cap with a high quality two-way check valve, filler tube modified to match the cap and pressure sensor and high quality vent hoses are all new pieces of hardware required for this diagnostic.

Concerns

The most vulnerable part of the EVAP system is the fuel filler cap. It will be necessary to educate owners about the need to fully tighten the cap every time they stop for gas.



Engine Coolant Temperature (ECT) sensor Monitoring

Theory of Diagnostic Operation

There are two separate engine coolant temperature (ECT) diagnostics. In the first, the sensor is checked for an out-of-range condition where the sensor voltage is too low or too high indicating a short to ground, to the 5v reference voltage or an open circuit.

Sensors are also checked for activity to make sure that sensor output changes as the engine warms up. A sensor which had failed in such a way that the sensor voltage was a constant 2.3v would pass the out-of-range test but would fail this second test which expects to see a change in coolant temperature after the engine has been running for a while.

If the diagnostic fails on two consecutive driving cycles the MIL will be illuminated and a DTC set.

ECT Monitor Enabling Criteria

The ECT sensor Out-of-Range diagnostic is run continuously. The conditions which must be met in order for the test to run are:

- Ignition on.
- No DTC for intake air temperature.
- Intake air temperature above -20°C.

The diagnostic to detect a lack of activity in the sensor circuit runs one time per trip and has another set of criteria. They include:

- Engine is running.
- Test has not already run.
- Vehicle speed above 12 mph for more than 400 seconds.
- Coolant temperature at the beginning of the trip less than 40°C.
- Coolant temperature has not risen more than 20°C since the start.

Glossary

< A mathematical symbol meaning "less than". Usually in the context of "the reading at pin #1 should be < 5 volts.

> The symbol for "more than".

≤ Equal to or less than, no higher than. "The voltage at pin #2 should be ≤ 10 volts".

≥ Equal to or greater than, no less than.

≈ Approximately, close to. "Engine coolant temperature sensor voltage at 68°F should be ≈ 2.4 volts".

ACRONYM

A word formed from the first letters of the words of a compound term. For example: ISAT (Intelligent Saab Tester).

AIR

An abbreviation for Secondary Air Injection. An emissions system which pumps fresh air into the exhaust stream to reduce HC and CO emissions.

CARB

The acronym for California Air Resources Board. The legislative body which originated the OBD I and OBD II regulations.

CKP

Crankshaft Position (sensor).

CO

Carbon monoxide. An exhaust byproduct of incomplete combustion.

CP

Cannister Purge (valve). The solenoid valve controlling venting of the EVAP cannister into the intake manifold.

DIAGNOSTIC

Any of a number of on-board tests run by the vehicle's powertrain management systems which check for malfunctions in the vehicle's emission system.

DLC

An acronym for Data Link Connector. This is the standardized 16 pin connector located under the driver-side instrument panel which will be common to all OBD II vehicles.

DRIVING CYCLE

An important OBD II term used to define a series of events which, when completed, can trigger an action such as turning on or off the MIL.
A Driving Cycle occurs when the engine has been started.

DTC

Diagnostic Trouble Code. Also frequently known as a fault code or just, code.

ECT

Engine Coolant Temperature (sensor).

ECM

Engine Control Module

ENABLE CRITERIA

Operating conditions such as coolant temperature, road speed, etc. which must be met before a diagnostic procedure will run.

EPA

Environmental Protection Agency. The federal department responsible for regulating all forms of environmental pollution.

EVAP

An abbreviation for the Evaporative control system. Normally used as the first word in a J1930 term such as "EVAP Emission Canister".

EVAP CANISTER CLOSE VALVE

An ECM controlled solenoid valve which regulates the flow of purge air from the atmosphere into the evaporative emission canister.

FREEZE FRAME

Operating conditions which are stored in the memory of a controller at the instant which a fault is recorded.

FTP

The acronym for Federal Test Procedure, the automotive emissions tests used by the EPA to measure the emissions output of all cars and light-duty trucks sold in the United States.

FUEL TANK PRESSURE SENSOR

A pressure sensor mounted on the filler neck of some 900 models. This sensor is part of the hardware needed to monitor EVAP system integrity.

FUEL TRIM

The short- and long-term fuel trim diagnostic procedure used by the engine management system to monitor rich or lean conditions in the engine's air/fuel mixture.

HC

An abbreviation for Hydrocarbon. A major component of automotive exhaust. HC is normally associated with raw or unburned fuel, either from a misfire, excessively rich mixture or evaporative loss/leakage.

HO2S

Heated Oxygen Sensor.

IAC

Idle Air Control. Usually seen as a preface for "IAC valve".

IAT

Intake Air Temperature (sensor).

I/M 240

A federally mandated, state administered automobile inspection and maintenance program to improve air quality in designated parts of the country.

ISO

International Standards Organization. In some ways the international equivalent of our SAE.

ISO 9141

The ISO specification data communication network protocol used by Saab and other European vehicles for scan tool communications.

MAF

Mass Airflow. The MAF sensor (previous Saab term was Air Mass Meter) is used by MOTRONIC systems provide the information needed to calculate load.

MAP

Manifold Absolute Pressure. The MAP sensor on the TRIONIC engine management system is one of the primary inputs used to calculate load.

MIL

Malfunction Indicator Lamp, previously often referred to as the "check engine" light.

MISFIRE

When, for whatever reason, combustion does not take place in a cylinder.

NOX

Oxides of Nitrogen. Any of several possible nitrous oxide compounds emitted by automotive exhaust.

OBD I

On-Board Diagnostics Generation One. The on-board automotive diagnostic system required by the California Air Resources Board since 1988.

OBD II

On-Board Diagnostics Generation Two. An expanded on-board system required on all light duty vehicles sold in the United States beginning in 1996.

SAE

Society of Automotive Engineers.

SAE J1850

The SAE document which defines OBD II data stream requirements. This is the scan tool communications protocol used by domestic manufacturers.

SAE J1930

The SAE document which standardizes all powertrain and emissions component names and acronyms used by all manufacturers.

SAE J1962

The SAE document which provides the specifications for the size, shape and pin configuration of OBD II diagnostic tool cable connectors.

SAE J2008

The SAE document which establishes guidelines for making OBD II diagnostic information available to anyone who wants it.

SAE J2012

The SAE document which defines the new 5 digit OBD II diagnostic trouble code format.

TP

Throttle Position Sensor

VVA

Vehicle Vertical Acceleration (sensor). A device used on 4 cylinder MOTRONIC systems to disable the misfire detection diagnostic when driving on rough roads.

WARM-UP CYCLE

An OBD II method for determining when a vehicle has been started from a "cold" condition and run long enough to reach "normal" operating temperature.
This has happened when:

1 Coolant temperature has increased by at least 40°F

AND

2 The final temperature has reached at least 160°F

Workshop Information

User feedback

To

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SWEDEN

Telefax phone no.: +46 520 84370

From

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Comments/suggestions

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Manual concerned: ....

It is important that Saab technicians in the field regard the Workshop Service Manual as their bible, and we therefore strive to make the manual easy to use and to provide accurate information.

By letting us have your views on this manual you will be helping us to maintain a high standard in our literature.

Note down any comments or suggestions you may have on a sheet of paper or take a copy of this page and send us your views at the above address. For greater convenience, you are also welcome to send your comments by fax, using the telephone number shown.

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