Module 24
On Board Diagnostics II - General Overview

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24 On Board Diagnostics - General Overview

In an effort to reduce vehicle emissions, the California Air Resource Board (CARB) required that an on board diagnostic system be added to all cars sold in California beginning in 1988. These systems were to monitor the effectiveness of the emission control system and notify the driver if a problem existed with the emission control systems. The first generation on board diagnostic systems were very basic, and became a building block for the current second generation systems.

24.1 On Board Diagnostics – I

24.1.1 General Information

CARB mandated that starting in 1988, all cars sold in California would be equipped with an on board emissions testing system. The system had to illuminate a "check engine" light to notify the driver of potential failures on emission components and systems and store a diagnostic trouble code (DTC) in memory. This system is now referred to as On Board Diagnostics - First Generation (OBD-I).

The OBD-I systems were required to monitor all inputs for a high / low range, the EGR system, the oxygen (O2) sensor, the fuel metering system, and the engine control module (ECM). The OBD-I regulations were relatively easy for most manufacturers to comply with since most manufacturers were already monitoring these systems. Many manufacturers were monitoring ECM operation, and storing DTCs as early as 1980. Data stream was also available on many domestic cars in the mid 1980s even though it was not required until the introduction of OBD-II systems in 1996.

The first Honda PGMFI systems used in 1985 complied with OBD-I regulations that did not go into effect until 1988. They monitored for fuel and emissions input malfunctions and stored a DTC when one was detected. DTC retrieval was done by counting the number of blinks from a light on either the dash, or the ECM itself.

A 3-pin data link connector (DLC) was added to 1992 Civics and Preludes for retrieval of data from the ECM. The 3-pin DLC was added to Accords in 1994. This DLC was the forerunner to the 16-pin OBD-II connector. To retrieve data from this DLC, you need a scan tool that is compatible with the Honda system. The Mastertech scan tool (utilizing the Honda/Acura aftermarket software) can be used. Other scan tools may be able to use this 3-pin DLC, check your operating manual.

The OBD-I system was a starting point and had much room for improvement. The OBD-II systems addressed all the shortcomings of the earlier OBD-I systems. The most significant shortcomings of the OBD-I systems were:

24.1.2 No consistency of DTCs

The assigning of DTCs for specific malfunctions was left up to each manufacturer. There was no consistency in the DTCs used from manufacturer to manufacturer.

24.1.3 No consistency in the DLC

For the manufacturers that offered data stream, there was no consistency in the DLC. The location, number of pins, and shape of the DLC usually varied from manufacturer to manufacturer. This required a different scan tool cable for each major manufacturer.

24.1.4 No consistency in DTC retrieval protocol

For the manufacturers that offered data stream, the protocol used by the scan tool to retrieve information was not consistent. This required the scan tool manufacturers to have a different program for each manufacturer.

24.1.5 Unable to Detect Emissions System Degradation

The OBD-I systems only checked input signals for extreme highs and lows. Many components would degrade to the point that they were creating increased emissions, but were not detected by the OBD-I system.

24.2 On Board Diagnostics – II

24.2.1 General Information

At the same time the OBD-I regulations went into effect, the standards for a second generation on-board diagnostic system (OBD-II) were released. The OBD-II standards were initially developed by CARB and the Society of Automotive Engineers (SAE). Their roles were as follows:

CARB	SAE
Developed: All the OBD-II requirements for the manufacturers. All the rules, regulations, and requirements of the OBD-II system were set forth in the California Code of Regulations: Title 13 Section 1968	Developed: **J1962** DLC Location / Scanner Protocols **J1930** Diagnostic / Component Terminology **J1979** Diagnostic Test Modes **J2012** DTC Standardization **J2190** Diagnostic Test Modes

CARB Office of Communications 2020 L Street Sacramento, CA 95814	SAE International 400 Commonwealth Dr Warrendale, PA 15096-0001

The OBD-II system is much more complicated and powerful than the earlier OBD-I systems. The implementation of OBD-II systems has been a challenge for the automotive industry with both the manufacturers and the service techs.

The "target" date for the OBD-II systems was 1994. The automotive industry was behind schedule on developing these systems and the mandatory year for OBD-II was pushed back to 1996. There were a few 1994 models (no Hondas) that had the OBD-II system. The first OBD-II system used by Honda was on a 1995 V-6 Accord. All Honda models went OBD-II in 1996.

In actuality, every single model did not go full OBD-II compliant in 1996. Many manufacturers petitioned CARB for waivers on certain parts of the OBD-II system. It is not uncommon to find 96 and up vehicles that do not have every OBD-II component installed and working per OBD-II regulations. CARB and EPA set 1998 as the year that all cars must have every component.

24.2.2 Features

The OBD-II system does all that the OBD-I system did, plus it has many more powerful features. Improvements were made in all areas with the biggest change in the actual monitoring techniques. The OBD-II system added ECM run tests, called monitors, that can test an entire subsystem for performance. Let's take a look at all the key features of the OBD-II systems.

24.2.3 Common Component Terminology

Most cars have components that perform the same function as a similar components on a different make car. These components may be called something different by each manufacturer. OBD-II established a common component terminology. This makes it easier for service techs that have to work on many different models. Here is a list of the Honda components that got new OBD-II names:

OBD-II Name	"Old" Name
ECT Sensor Engine Coolant Temperature Sensor	**TW Sensor** Temperature of Water Sensor
IAT Sensor Intake Air Temperature Sensor	**TA Sensor** Temperature of Air Sensor

IAC Valve Idle Air Control Valve	**EACV** Electronic Air Control Valve
BARO Sensor Barometric Pressure Sensor	**PA Sensor** Pressure of Air Sensor
TP Sensor Throttle Position Sensor	**TPS** Throttle Position Sensor
ECM / PCM Engine Control Module Powertrain Control Module	**ECU** Electronic Control Unit

24.2.4 Common DTC Terminology

Under the OBD-I system all the DTCs were different among manufacturers. The OBD-II regulations specified a common DTC numbering scheme. The SAE J2012 standard established the DTC numbering scheme. The DTC numbering scheme is covered in detail in the DTC / MIL / Freeze Frame Training Module.

24.2.5 Common DLC and Protocol

Prior to OBD-II, each manufacturer was free to use any DLC configuration and any scan tool protocol. This required a different cable and software for most manufacturers. The OBD-II regulations standardizes the DLC and the protocol. These regulations are based on the SAE J1962, J1979, and J2190 standards.

The OBD-II DLC is a standardized 16-pin connector that is accessible by using no tools, located along the edge of the dash, and is visible while squatting.

A standard protocol means that the OBD-II information can be retrieved from any car using a generic OBD-II compliant scan tool. Only a few wires in the DLC are used for OBD-II and the remaining pin locations are free to be used by the manufacturer any way they want. Many manufacturers use the OBD-II DLC for access to advanced diagnostic information. This information may not necessarily follow the OBD-II protocols. Only the information that has been specified by OBD-II regulations has to be available at the DLC using an OBD-II scanner protocol.

The OBD-II DLC and scan tool protocols are covered in greater detail in the Scan Tool Training Module.

24.2.6 Historical Fuel Trim Data

The OBD-II system is capable of storing some historical data. The OBD-II system monitors the deviation of the actual fuel injector's pulse width (PW) from the factory default base pulse width. It records this deviation as a parameter called long term fuel trim (LT FT). This information is used to trim the fuel while the engine is being run in the open loop (OL) mode. The information can also be used to detect problems with the fuel delivery system by the service techs.

The LTFT parameter is covered in greater detail in the Fuel System Monitor Training Module.

24.2.7 Expanded Malfunction Indicator Light

The operation of the malfunction indicator light (MIL) has changed significantly under the OBD-II system.

> **Illuminating the MIL**
> Prior to OBD-II, when a malfunction occurred the MIL was illuminated. With the OBD-II system, a malfunction may be required to occur on as many as three consecutive trips before the MIL is illuminated.
>
> **Extinguishing the MIL**
> Prior to OBD-II, the MIL was extinguished when the car was recranked. The MIL would not come back on unless the problem still existed. With OBD-II, the MIL is not extinguished until the fault does not re-occur on three consecutive trips.

The OBD-II MIL will also flash when a condition is present that could cause damage to the catalytic converter. This usually occurs during a misfire. The MIL is covered in greater detail in the DTC / MIL / Freeze Frame Training Module.

24.2.8 Stored Freeze Frame Data

On of the more useful features of the OBD-II system is its ability to take a snapshot of the engine's parameters when a DTC is set. This feature is called a freeze frame.

The system will capture a set of parameters when the first DTC is set. The freeze frame will be held in memory until power is lost on the ECM or it is cleared with a scan tool. Subsequent DTCs will not overwrite the freeze frame (unless it is a high priority DTC). The ECM can store multiple DTCs but only one freeze frame, which was taken at the first DTC. This is one of the reasons why after recording the data on the freeze frame, you should clear it. If the freeze frame is not cleared it will not be able to store any more data.

The freeze frame can be a great diagnostic tool since it is reflecting all the major engine parameters that were present when the fault occurred. Using this information a tech can try to "recreate" the situation that was present when the original fault occurred.

The freeze frame is covered in greater detail in the DTC / MIL / Freeze Frame Training Module.

24.2.9 Expanded Monitoring Capabilities

The expanded monitoring capabilities of the OBD-II system is where the major differences lie between OBD-I and OBD-II. In addition to monitoring input signals for a high low value, the OBD-II system checks input signals for rationality and output signals for functionality.

The OBD-II system also has a whole set of tests that are run on subsystems under certain conditions. The running of these monitors are controlled by the ECM programming. Some of the tests are run continuously and some are run once per trip, when certain enable criteria has been met.

The monitor requirements are specified in OBD-II regulations, but how each manufacturer accomplishes that is left up to the manufacturer. For example, OBD-II regulations require that a car with an EGR system on it must test it, once per trip for correct exhaust flow. How a manufacturer tests for proper flow is left up to the manufacturer. Like some manufacturers, Honda activates the EGR and watches for a change in the manifold absolute pressure (MAP) sensor input voltage. Some manufacturers activate the EGR and watch for a change in the oxygen content or a deviation in the engine's speed.

The main objective of an on board diagnostic system is was to detect the degradation or failure of an emission component or system that could cause vehicle emissions to rise by 50%. OBD-I was not catching degrading emissions components.

Here is a list of current monitors that are defined by OBD-II regulations:

Monitor	When Run
Comprehensive Component Monitor This monitor checks all the input / output signals for a good electrical signal. The comprehensive component monitor handles all the electrical checks that were run by the OBD-I system. To learn more about this monitor read the Comprehensive Component Monitor module.	**Continuous**
Misfire Monitor The misfire monitor checks the engine for signs of a misfire. The monitor primarily looks for fluctuation in the speed of the engine's crankshaft to determine if the engine is misfiring. To learn more about this monitor read the Misfire Monitor module.	**Continuous**

Fuel System Monitor The fuel system monitor compares the actual fuel injector PW with the factory default base pulse width and reports any major deviations. To learn more about this monitor read the Fuel System Monitor module.	**Continuous**
Catalyst Monitor The catalyst monitor actually runs an efficiency test on the car's catalytic converter once per trip. The OBD-II systems have a second O2 sensor located downstream of the catalytic converter. The readings from this O2 sensor are compared to the upstream O2 sensor to determine the catalyst's efficiency. . To learn more about this monitor read the Catalyst Monitor module.	**Once Per Trip**
EGR Monitor The EGR system is tested for proper EGR valve lift, and for proper exhaust gas flow in the system To learn more about this monitor read the EGR- Monitor module.	**Once Per Trip**
Evaporative Monitor The evaporative monitor checks the evaporative system for leaks and proper purging. This monitor is a once per tip monitor and to date has given most car manufacturers the most trouble. To learn more about this monitor read the Evaporative Monitor module..	**Once Per Trip**
Oxygen Sensor Monitor The OBD-II system tests the primary O2 sensor once per tip for its response time to rich and lean conditions. If the response time is too slow or the O2 sensor values stays fixed high or low, the system will store a DTC. . To learn more about this monitor read the Oxygen Sensor Monitor module.	**Once Per Trip**
Oxygen Sensor Heater Monitor The OBD-II system checks once per trip to verify that the O2 sensor heaters are working properly. The monitor is typically run right after the car is started. To learn more about this monitor read the Oxygen Sensor Heater Monitor module..	**Once Per Trip**

24.3 The Politics of OBD-II

The OBD-II system was a product of the Clean Air Act Amendment. One of the main goals of the CAAA was to have in place an on-board diagnostic system that was "universal" among car manufacturers. An equally important goal of the CAAA was for all automotive service personnel to have access (at a fair market price) to information and training about these systems. The standard was that any training, support, guidance, or help given to the dealership techs was to be made available (at a fair market price) to anybody else in the service industry. In some ways this was accomplished, but in many ways it wasn't.

In my opinion here are two areas where the standardization and information accessibility goals missed the mark:

24.4 What Is On The Car Is Not What You Expected

In theory a person should be able to read all the rules and regulations of the OBD-II system and have a good idea of what to expect under the hood of a car. That is not always the case. Some of the issues that contribute to this are:

24.4.1 Waivers

The manufacturer's engineering departments were having a problem meeting the deadline to get all the OBD-II equipment working on every model line. The original OBD-II implementation date of 1994 was pushed back to 1996. Even by 1996, some of the monitoring systems on some models was not developed to the satisfaction of the engineers.

Each manufacturer was allowed two waivers in 1996 and one waiver in 1997 for a specific OBD-II subsystem. If the manufacturer requested a waiver for a specific subsystem and could provide engineering reports to show that the system was not developed to the point that it was ready for production, a waiver was usually issued. This means you may fully expect to see a certain feature on a car and not find any part of that feature anywhere on the car!

Two more monitors will be added to cars between now and the year 2002.
The provisions also provide for a "phasing in" of these new monitors

24.4.2 Manufacturer's Interpretation

The "ground zero" document for OBD-II is CARB's Title 13 Section 1968 document. It is 45 pages long and is written in a leegaleeze / government regulation type format. Each manufacturer had to read the regulations and make their interpretation of exactly what they had to do or not.

In many instances you will not find what you expected to find because the manufacturer interpreted the regulation differently than you did. In some cases, manufacturer's interpretation has resulted in hefty fines from CARB/EPA who content that the interpretation was outside the intent of the OBD-II regulation.

24.4.3 Manufacturers Implementation

Contrary to what most people thought, the OBD-II regulations did not specify how a manufacturer was to comply with the requirements.

For example, the regulations state car as to be monitored for misfires, but exactly how that is done is left up to the individual manufacturers. Some look at crankshaft fluctuation, some look at O2 sensor waveforms, and some even monitor the current in the secondary ignition system

24.5 Limited Access To Service Information

Included in the CAAA, along with the requirement for the implication of an OBD-II system, was the accessibility to service information requirement. The concept was that close to 75% of vehicle repairs are done outside the dealership and to keep the OBD-II systems operating properly all service techs needed this service information.

In my humble opinion, I do not think this part of the CAAA has been implemented as was intended by the authors of the CAAA and the Congress who voted on the act. I will just leave it at that...

I have drawn a second conclusion about the accessibility of OBD-II service information. It is my opinion, but I think it is an accurate one. This issue actually overshadows issues of the CAAA service information requirement. Since each manufacturer implements the OBD-II requirements slightly differently, many manufacturers feel this information is a "trade secret" issue.

I do not know this for a fact, but my feeling is that the engineering department wants to let nothing out, and the training department wants to pass enough information along to its dealer techs so that they can properly diagnose and repair OBD-II systems. My observations are that some manufacturers do not give even its own techs adequate OBD-II service information. My opinion is that this is due to the engineering department not wanting this information to get outside the dealership network and the safest thing to do would be to not tell anybody.

In some cases OBD-II training material developed by independent companies will exceed the level of training given by the manufacturers to its own technicians.

24.6 The Future of OBD-II

The OBD-II system has worked well and is here to stay. The system will make evolutional changes over the next few years. Two new monitors will be added soon, the thermostat monitor and the PVC monitor. Two areas where OBD-II will make some major changes are in the I/M programs and in the yet to be officially named "OBD-III" program.

24.6.1 Integration With I/M Programs

OBD-II does a good job in monitoring a car for malfunctions. When it is working properly, it is actually more accurate than an emissions tail pipe test. Emissions officials are tying to figure out how to use the OBD-II system in conjunction with smog checks.

At present, most states will not allow a car to pass a smog check if the MIL is illuminated. The next step will probably be to require the car to be scanned for any stored DCTs. There are several pilot programs that are studying the feasibility of requiring the readiness status of the monitors to be checked to confirm that they have all ran to completion.

The most interesting pilot test going on now is one by CARB in which cars with illuminated MILs are being run on an IM 240 test (the most stringent of the smog checks) CARB and EPA wants to see how effective the OBD-II system is in catching malfunctions. They want to test 500 cars, but have already tested close to 100. So far only 4 of the 100 cars that had illuminated MILs flunked an IM240 test. It looks like using the vehicles own OBD-II system may be more accurate than even using a tail pipe test. This means in the future it may be that a car comes in for an annual "scan tool" test instead of a tail pipe test. The advantages here is that it is much faster for the customer and less expensive for the service facility to provide.

24.6.2 OBD-III

As covered in the last section, OBD-II does a good job of monitoring for malfunctions. So good that emissions experts are looking into the possibility of eliminating the annual tailpipe test if they could figure out a way to get a customer to bring a car in for repair when the MIL illuminates.

This next generation of OBD-II cars that report malfunctions are usually referred to as OBD-III cars. The implementation of this type of system is a long ways off, not because of the technology, but because of civil liberty, freedom, and liability issues. The goal of OBD-III is to minimize the time delay between detection of a malfunction by the OBD-III system and the actual repair of the vehicle. Some of the reporting technologies that are being studied are:

24.6.3 External Signal

The car would have some type of external indicator (like a light) that would indicate the car was being driven around with an illuminated MIL. Apparently the idea was to "shame" the owner into getting the car fixed. The civil liberties organizations and the manufacturers are fighting this one. This idea will not be one that will make it!

24.6.4 Driveability Modification

The idea to start having the car change its driveability the longer the owner went without getting the car fixed. Something like slowly reduce the top speed until the car is repaired. The civil liberties organizations and the manufacturers are fighting this one too and it is highly unlikely that this idea will be used either.

24.6.5 On-Board Transmitter

If there is ever going to be an OBD-III, it will probably use an on-board transmitter to report a MIL light on. The technology is available to handle this.

The most likely version will be the use of a roadside receiver to "query" cars as they pass. GM Hughes Electronics has already tested a roadside unit that can check every car on an eight lane interstate going 100 MPH. A violating car will transmit its VIN and stored DTCs to the roadside receiver.