
TECHNICIAN
TRAINING
BY DORMAN PRODUCTS
DORMAN
Training Seminar Series
Presents
Heavy Duty OBD Part 1
"Making Life Easier"

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Aftermarket Innovators

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Your Instructor For This Class

Sulev "Swede" Oun

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- **ATTP Master Instructor, New York State**
- **Author, "Medium/Heavy Duty Truck Electricity and Electronics"**
- **Training provider for various Associations, industry and various NY State agencies**
- **Developed trainings that range from four hours to multiple days, specializing in brakes, electrical, regulations and many other subjects relating to our industry.**
- **Member of various organizations such as SAE, CVSA, TANY**

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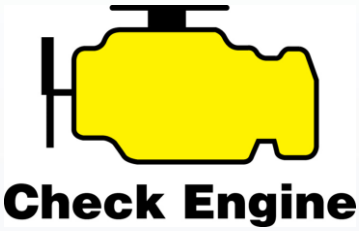
What will be covered

- **Brief History of HD-OBD**
- **Overview of HD-OBD**
- **Requirements**

Objective

- **Get a grasp about OBD and how it can help us diagnose emissions issues.**



Customer: My check engine light is on.
Technician: Did you check to see if the engine is still there? Maybe somebody stole it.

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On-Board Diagnostics (OBD)

What is it?

- Refers to a vehicles self-diagnostics.
- Gives "EVERYONE" access to the status of various vehicles subsystems.

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Brief History

- 1990 Clean Air Act Amendments passed.
  - California Air Resource Board (CARB) required all new cars sold in California since 1991 have "some" OBD capability (OBD-1).

Note: Some things like the data link connector were not standardized.

- 1996: OBD-II required in the US for all new cars.
  - SAE J1979 established standards for the connector and protocols to go along with it.
- J1979 defines specifications for LD-OBDII compliance.
  - Extended to include light and medium-duty trucks staring in MY 2004.
  - Extended to HD vehicles starting in 2010.

Note ISO 15031-5 is based on SAE J1979 to combine U.S. requirements with European OBD requirements for MY2000 and later.

"Think about the global vehicle platforms either manufactured or sold on a global level/market".

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Heavy Duty OBD

- **California OBD requirements for heavy-duty engines (vehicles with a GVWR greater than 14,000 lbs.) were introduced in two stages.**
  - **EMD- Started with the 2007 model year, requiring a basic diagnostic system referred to as Engine Manufacturer Diagnostic (EMD) system.**
  - **HD OBD- Started in 2010 with OBD requirements for heavy-duty engines phase in. By 2013, EMD systems were phased out and all heavy-duty engines offered for sale in California required OBD systems.**

NOTE: July 31,2013 amendment included revisions to accelerate the start date for OBD system implementation on alternate-fueled engines from the 2018 model year and on.

Also relaxed some requirements for heavy –duty hybrid vehicles for the 2013 through 2015 model years.

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- **HD-OBD applies to:**
  - **Diesel Compression Ignition (CI).**
  - **Gasoline Spark Ignition (SI) fully phased in all engine families by "2016)**
  - **Alternative Fuel (SI/CI) and**
  - **Hybrid vehicles**
- **Manufacturers must provide a very detailed testing results and documentation to show they comply with OBD requirements and get certified.**
- **California Air Resource Board (CARB) or often referred to as ARB has been instrumental in evolving OBD from the beginning.**
- **ARB has followed a process of revising OBD rules for vehicles about every 2 to 4 years.**
- **For Heavy-Duty OBD, CARB completed the rules in 2006 with a first compliance year in 2010 for the first engine family of each manufacturer and fully phased in all families by "2016".**

Note: Hybrid monitoring requirements were put in HD-OBD rule in 2019.

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Why HD-OBD?

Of course, the obvious answer would be "emissions". But wouldn't the existing engine parameters and diagnostics be enough to accomplish the goal?

- **Even though there are thousands of parameters defined by J1939/71 (Serial Control and Communication Heavy Duty Vehicle Network) and we have DTC's and over fifty diagnostic messages (DM's) defined in J1939/73, there was missing "requirements" to "monitor" powertrain and "emission control performance to meet regulation.**
  - **HD-OBD requires monitoring of all major emission control systems.**
  - **Detect malfunctions prior to emissions exceeding thresholds.**
  - **Requires that aftertreatment devices (DPF) and NOx reducing catalysts are monitored and failures are alerted to the driver.**
  - **Requires that all emission-related electronic sensors and actuators are monitored for proper operation.**

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Who is in charge of OBD regulation?

- **EPA and CARB establish OBD standards and requirements.**
  - **In September 2008, EPA granted a waiver from federal preemption to the state of California, allowing it to establish and implement HD-OBD requirements.**

Note: I guess the best answer might be, EPA works closely with CARB to define regulations across the U.S.

- **Third OBD option is called Worldwide Harmonized On-Board-Diagnostics (WWH-OBD).**
  - **Goal is to coordinate LD and HD-OBD reporting and enhance the information provided.**
  - **Implementers may choose any of these options to meet OBD requirements unless specified otherwise in government regulations.**
  - **As of now, vehicles sold in U.S. can use any of the three OBD options.**

Note: Volvo trucks use WWH-OBD as a common approach for EU and U.S.

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OBD requirements

OBD regulations have the following 4 main areas of requirements:

- Powertrain Diagnostic Design and development.
- Operator and service interface.
- Testing for certification.
- Postproduction level testing at the vehicle level.

The most important requirement for us is the first one. It deals with monitoring for malfunction of:

- Sensors
- Actuators
- Controllers
- Systems (emissions and/or performance)

Note: Required for the engine, aftertreatment, transmission and now also hybrid systems.

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HD-OBD has approximately 124 (constantly changing in updates) required component and system monitoring requirements.
In addition to the 124, there is a "Comprehensive Component Monitoring" (CCM) to capture each input and output component.

- Each input sensor has 6 monitoring requirements.
- Each actuator (output) has 4 monitoring requirements.

Basically, each sensor or actuator in the powertrain of the OBD vehicle is monitored.

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Second main area (operator and service interface) requires for a:

- Malfunction Indicator light (MIL) that is amber and is an engine icon.
- Standard diagnostic tool connector.
- Standard protocol with hundreds of parameters and messages to service providers with information that the OBD system must support such as:
  - Live data
  - Historic data
  - Drive cycle data

Note: The other two previous mentioned areas are manufacturer requirements.

Important: Another major requirement of OBD is to allow access by the manufacturers to service information and service tools available to independent repair shops and fleets.

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Some HD-OBD changes since October 2019

- New HD Diesel engine and aftertreatment monitoring requirements
- Complex NOx monitoring and tracking
- Additional data tracking such as:
  - Engine Runtime (engine run time, idle time, PTO time, run time with no reductant delivery and runtime with exhaust temperature below 200ºC. (392ºF.

This was a summary. Let's dig deeper

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MIL and Fault Code Requirements.

- On-board diagnostics for OBDII is incorporated into the hardware and software of the vehicle's on-board computer to monitor every component that can affect emissions performance.
- Each component is checked by a diagnostic routine to verify properly functioning components and systems.
- If a problem or malfunction is detected. The OBD II system illuminates a warning light .
- This light will typically display the phrase "Check Engine" or "Service Engine Soon".
- The system will also store important information about the detected malfunction.
- This information is very important, so a technician can accurately find and fix the problem.

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Lamps

- The MIL is located on the driver's side of the instrument panel.
- It will come on for a bulb check when the ignition key is turned on (KOEO). It has to illuminate at least 15-20 seconds.
- It will stay illuminated when the OBD system detects and confirms a malfunction that could increase emissions.

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Lamps

Not all lamps are specific to emissions fault codes. That is why HD-OBD equipped engines can have both OBD and non-OBD fault codes. Typically, non-OBD fault codes can illuminate either the Amber Warning Lamp (AWL) or Red Stop Lamp (RSL), typical of Cummins Inc. dash lamps.

OBD FAULTS WILL ALWAYS ILLUMINATE THE MIL.

However, in some cases the AWL or RSL are illuminated as well.

Malfunction Indicator Lamp (MIL) is:

- **Yellow in color and is the image of an engine.**

Amber Warning Lamp (AWL) is:

- **Amber in color and can either be the image of an engine featuring a wrench or can be the text: "Check" or "Check Engine". The AWL is used to indicate a non-OBD fault code is active or a maintenance condition exists.**

Red Stop Lamp (RSL) is:

- **Red in color and can be the image of an engine featuring an exclamation point, the outline of a STOP sign featuring the engine, or the text 'STOP" or "Stop Engine". The RSL is used to indicate an engine protection fault code or engine protection fault exists.**

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Stop the engine. There is a critical issue.

I think I can make it to the nearest truck stop.

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Vehicles using the SAE J1939 protocol, the following must happen before the MIL illuminates:

- **The first time a malfunction is detected a "pending code and freeze frame" is stored within 10 seconds.** ***At this point it has not matured into current code and the MIL is not on.***
- **If the malfunction is detected again before the next driving cycle in which the suspected component or system is monitored, the MIL will be turned on continuously.**
- **This time a confirmed fault code is generated and stored along with a freeze frame of engine data.**

Note: If a malfunction is not detected before the end of the next drive cycle in which monitoring occurs, the corresponding pending fault code shall be erased at the end of the driving cycle.

- **Except for misfires and fuel system faults:**

If malfunction is not detected in the next three drive cycles, the MIL will be turned off, but the trouble code will be stored for at least 40 warm –up cycles.

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Freeze frame requirements.

- **For 2010 through 2015 model year engines,** the OBD system shall store and erase freeze frame conditions in conjunction with the storage and erasure of either pending or confirmed fault codes.
- **For 2016 and subsequent model year engines,** the OBD system shall store freeze frame conditions in conjunction with the storage of a pending fault code.
  - If the pending fault code is erased in the next driving cycle which monitoring occurs and a malfunction is not detected, the OBD system may erase the corresponding freeze frame conditions.
  - If the pending fault code matures to a confirmed (active) fault code, the OBD system shall either retain the currently stored freeze frame conditions or replace the stored freeze frame conditions regarding the confirmed (active) fault code. The OBD system shall erase the freeze frame information in conjunction with the erasure of the confirmed fault code.

NOTE: Current freeze frame(s) may not be replaced with freeze frame conditions for another fault code except for certain confirmed fault codes and especially for gasoline and diesel misfire and fuel system monitors.

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Note: The freeze frame info can also deviate dependent upon allowed alternate strategies that store both a pending and confirmed fault code and illuminate the MIL upon the first detection of a malfunction. In those cases, the OBD system shall store and erase freeze frame conditions in conjunction with the storage and erasure of the confirmed fault code.

- **This is an "EXCEPT"**
  - If a fault code is stored when the maximum number of frames of freeze frame conditions is already stored in the diagnostic or emission critical PCM, the OBD system may NOT replace any currently stored freeze frame conditions in the control unit for the newly stored fault code.
- **For 2023 through 2026 model year engines,** if a misfire or fuel system fault code is stored when the maximum number of frames of freeze frame conditions is already stored in the diagnostic or emission critical PCM, the OBD system MAY replace any of the currently stored freeze frame conditions for a fault code in the control unit with freeze frame conditions for a fault code as allowed for gasoline and diesel misfire and fuel system monitors .

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Freeze frame quick summary

- ✓ Freeze frame is stored for at least one DTC
- ✓ Freeze frame can be overwritten with a higher priority fault code
- ✓ Freeze frames are usually erased when the DTC is erased

Important concept: Don't erase a fault code (DTC) before looking at freeze frame. Why? The Freeze Frame data provides critical engine parameters when a fault appears that stores a DTC.

- Freeze frame can show for example:
  - DTC description
  - Engine speed
  - Engine temperature
  - Engine load
  - Vehicle Speed

Information in freeze frame can help in pinpointing the cause of a failure, or at a minimum narrow your search. Also provide us with a similar condition window to duplicate the conditions to verify a repair.

Reminder: These are OBD requirements that allow you to go in with any scan tool to retrieve Generic OBD required info.

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Monitoring:

- Various **"Monitors"** are run during a specified trip or drive cycle to determine proper operation of components and systems that can affect emissions.
- **Monitoring occurs under conditions that are encountered in normal driving conditions.**
- Much effort is spent in avoiding false passes and false indications of malfunctions.
- **The monitoring should occur at least during one 1 vehicle trip in 10 for 2013 and later heavy-duty engines.**
- There are two types of monitoring:
  - Continuous- *Usually misfire and fuel related (trim).*
  - Non-continuous- *Comprehensive and specific components (once per trip)*

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Monitoring Examples

Misfire Monitoring
Malfunction Criteria:

- **The OBD system shall detect a misfire malfunction when one or more cylinders are continuously misfiring. Additionally:**
  - For 2013 through 2015 model year engines equipped with sensors that can detect combustion or combustion quality (e.g., for use in homogeneous charge compression ignition (HCCI) control systems) and 20 percent of 2016 model year diesel engines, 50 percent of 2017 model year diesel engines, and 100 percent of 2018 and subsequent model year diesel engines, the OBD system shall detect a misfire malfunction when the percentage of misfire is equal to or exceeds five percent.
- **The following are monitoring conditions:**
  - 2013 through 2019 model year engines, under positive torque conditions between 29% and 75% of peak torque with engine speeds up to 75% of the maximum engine speed.

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- **For 20% of 2019 model year diesel engines, 50% for 2020 model year diesel engines, and 100% of 2021 and subsequent model year diesel engines, under all positive torque engine speed conditions except within the following range:**
  - **The engine operating region bound by the positive torque line (i.e., engine torque with transmission in neutral) and the two following point:**
    - **Engine speed of 50% of the maximum engine speed with the engine torque at the positive torque line, and**
    - **100% percent of the maximum engine speed with the engine torque at 10% of peak torque above the positive torque line.**

Would you have known about this condition to duplicate for misfires?
Should you know?
Is it easy to find misfires on diesels?
Scan tool bidirectional?
Cylinder balance?
Fuel injector balance?
At idle?

What is the computer looking for?

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Heavy Duty OBD

The following are some examples of monitoring requirements.

System/Component	Parameter Requiring Monitoring
Fuel System	*Fuel system pressure control* *Injection timing* *Feed back control* *Injection Quantity*
Misfire	*Detect continuous misfire* *Determine % of misfiring cycles per 1000 engine cycles (2013 and later)*
EGR	*Low flow, High flow* *Slow response* *EGR cooler operation* *EGR catalyst performance* *Feedback control*

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Heavy Duty OBD

Standardizations

- **Standard data link connector.**
- **Standard protocol for communication with a scan tool.**
- **Engine manufacturer must provide the aftermarket service and repair industry emission – related service information.**
- **Standardized functions to allow information to be accessed by a universal scan tool. These functions include:**
  - **Readiness status**
  - **Data Stream**
  - **Freeze frame**
  - **Fault codes**
  - **Test results**

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DATA Connectors, also referred to as a diagnostic link connector (DLC) are used to connect the electronic service tool (EST) to the vehicle's electronics (PCM).

J1708 Data Connector:

- **Used to access a J1587 data bus.**
- **It's a 6-pin Duetsh Connector**

Various communication protocols are used in transmitting data such as vehicle data and diagnostic information. This J1708 was a common protocol in the 1990s and early 2000s.

It's all about speed.

OBD legislation and other factors led the change requiring trucks to utilize the 500kbs 9-pin or 16-pin OBD port.

Note: Old speed were 250kbs.

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J1939 Data Connector
Three types are available

- J1939 black 9-pin
- J1939 green 9-pin for EPA MY 2013
- J1962 16-pin ALDL (Volvo-Mack in 2014

Reduced "F" cavity to prevent designed to block access to older black version connector.

The first generation J1939 DLC incorporates J1587/1708, which may or may not be used.
The second generation is green in color and has a reduced "F" cavity (see next slide) to block access by the older black version.
Volvo-Mack opted to make the 16 pin "automotive assembly line diagnostic link" (ALDL) J1962 connector their data connector from MY 2014 on.

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J1939 Data Connector
J1939 green 9-pin for EPA MY 2013

A. Battery negative
B. Battery positive
C. J1939 Can busline, dominant high (+)
D. J1939 Can busline, dominant low (–)
E. Can shield
F. J1587 busline, dominant high (+)
G. J1587 busline, dominant low (–)

Note: The post 2013 green colored 9-pin data connector is backwards compatible with pre-2013 receptacles. A smaller F-pin cavity on the green receptacle is designed to block access by a black pre-2013 plug.

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J1939. What is it?

- From SAE " The SAE J1939 communications network is a high-speed ISO 11898-1 CAN-based communications network that supports real-time closed loop control functions, simple information exchanges, and diagnostic data exchanges between Electronic Units (ECUs), physical distributed throughout the vehicle".
- Think about a typical truck and the number of major manufactures and their components involved for the final end product.
  - Different truck manufacturers
  - Different engine manufacturers
  - Different transmission manufacturers
  - Different ABS manufacturers
  - Different other component manufacturers

They all need to communicate to each other.

- Your scan tool becomes another part of this communication network the minute you hook up to this system.

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- J1939 is a standard consisting of 16 companion documents with J1939 being the top-level document.
- J1939 is the master control for definitions common to all applications.
- For example, this document provides a comprehensive list of assigned data parameters and diagnostic identifiers (SPNs), all assigned messages (PGNs), and all assignments for NAME and Address identifiers.

Note: J1939 was developed for use in the heavy-duty environment, but J1939 communications network is also applicable for light-duty, medium-duty and appropriate stationary applications. Heavy-duty on-road or off-road.

- Benefit of J1939 is, connecting the vehicles electronic systems to one central network, enhancing vehicle monitoring and management. Because they are all connected to one network, the vehicles systems become more serviceable.

Note: J1939 Compliance. No validation in place. Developers are expected to design their products to the SAE recommended practices. J1939 gave OEMs the ability for customized communication,

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J1939 and CAN

J1939 uses the CAN protocol permitting any ECU to transmit a message on the network when the bus is idle. Each message uses an identifier to define:

- **The message priority**
- **From whom it was sent and**
- **The data contained within it**

- **The arbitration process that occurs while the identifier is transmitted resolves collisions non-destructively.**
- **This process permits high priority messages to get through with low delay times (it's about speed) because of equal access on the network for any ECU.**

Note: The highest priority message prevails.

- **CAN systems enable the use of a single command station (master) to control diagnostic systems and receive information such as:**
  - **Emission levels**
  - **Brake and transmission info (data)**
  - **Fuel efficiency**
  - **And anything else you can think of that relies on electronics.**

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- **Combining J1939 with CAN allows for the following benefits:**
  - **Reduced wiring (CAN requires only two wires between the nodes)**
  - **Easy implementation**
  - **Collision –free bus arbitration**
  - **Reliable communication**
  - **Improved service capabilities**
  - **Improved maintenance**
  - **Error detection**
  - **Fault confinement**

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J1939 Family Example (brief)

- **J1939-82**

  Compliance-Truck and Bus
  - **The purpose of these compliance procedures is to generate one or more test document that outline the tests needed to assure that an ECU that is designed to operate a node on an SAE J1939 network would so correctly.**
- **J1939-84**

  OBD communications Compliance Test Cases for Heavy Duty Components and Vehicles
  - **The purpose of this recommended practice is to verify that vehicles and/or components are capable of communicating a required set of information, in accordance with the diagnostic test messages specified in J1939-73, to fulfill the off-board diagnostic tool interface requirements contained in government documents.**

Putting CAN and Data Links Together

- **2017 saw the introduction of multiple CAN channels to compensate for the increase of sensors and ECUs. For example:**
  - **One CAN channel for powertrain components**
  - **Another CAN channel for everything else such as radios, body controllers, etc.**
- **Can1 has been used typically for the powertrain. In 2016 Peterbilt, Kenworth, and Volvo moved the powertrain traffic to CAN3. That is why the normal 9-pin connectors would not work. One way to overcome this is to purchase a CAN3 to CAN1 cross over cable.**

Reduced "F" cavity to prevent designed to block access to older black version connector.

Which plug should I use?

- **Mack and Volvo use the 16-pin OBDII plug/port.**
  - **But they also added the 9-pin port to allow repair facilities without the means to connect to the 16-pin configuration to connect to Macks and Volvos with Cummins engines and diagnose the truck with the 16-pin.**
- **The problem is that the 500k 9-pin doesn't always read the entire vehicle and may only provide diagnostic information from the drivetrain.**
- **Unfortunately, we are creatures of habit. Which plug do we go to first? Yes, the 9-pin.**
- **You will get engine information for diagnostics but fail to find issues related to the truck.**
- **Get in the habit of connecting to the 16-pin to identify all issues.**

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Reminder

It is possible to have a MIL-ON condition and Diagnostic Trouble Codes stored in the memory of an OBD vehicle computer and the vehicle seems to run perfectly.

OBD is designed to detect deterioration of system performance that can result in increased emissions.

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OBD Key Points

- **Rationality Tests:** Testing sensor inputs is a big part of OBD test strategies. OBD compares sensor input for accuracy while in the range of normal operation to another input to see if it makes sense. "You don't expect a MAP sensor indicating a high load condition when Throttle Position sensor is indicating a closed throttle".
- **Monitors:** Software programs inside the computer that test components and subsystems.
- **Enable Criteria:** A set of vehicle operating conditions needed to run a monitor. Each monitor has its own set of enabling criteria.

  The monitor will not run if the specific criteria is not met.

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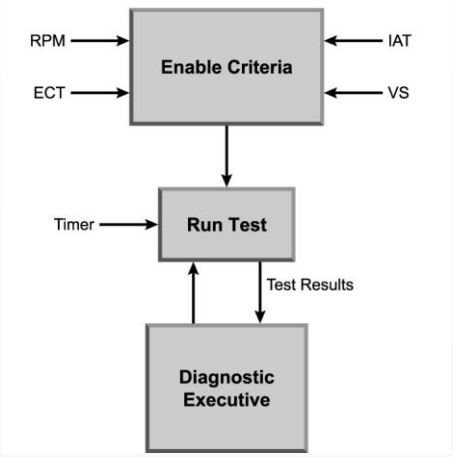
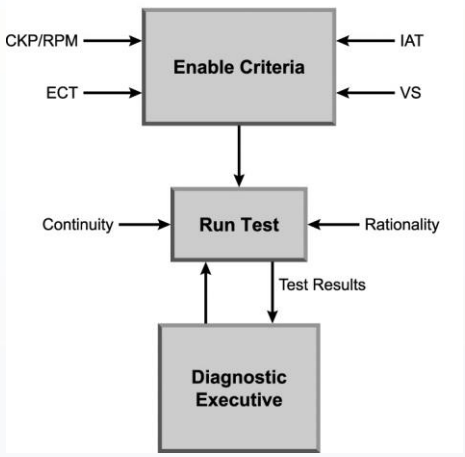
Comprehensive Component Monitoring Coolant Sensor



Comprehensive Component Monitoring Crankshaft Sensor (CKP)



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Three Types of Continuous Monitors

- **Comprehensive Component Monitor:** Constantly checks various sensors and actuators to see if they are functioning properly. Sensors are compared to test standards stored in the computer's memory. Checks for shorts or opens. "Functionality Test". Don't forget sensor input that doesn't make sense. "Rationality Test".
- **Fuel Monitor:** Looks for excessive fuel corrections and problems and other fuel problems.
- **Misfire Monitor:** Looks for an misfire. The OBD system will detect misfire in one or more cylinders. "To the extent possible without adding hardware for this specific purpose, the OBD system shall identify the specific misfiring cylinder".

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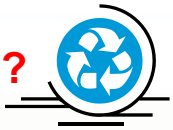
What is a "Driving Cycle"?



A driving condition that satisfy the enable criteria that let all the "MONITORS" run to completion.

a) Begins with engine start and ends with engine shutoff.
b) Begins with engine start and ends after four hours of continuous engine-on operation.
c) Begins at the end of the previous four hours of continuous engine-on operation and ends after four hours of continuous engine-on operation; or
d) Begins at the end of the previous four hours of continuous engine-on operation and ends with engine shutoff.

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For Monitors that run during engine-off conditions, the period of engine-off time following engine shutoff and up to the next engine start may be considered part of the driving cycle for conditions(a) and (d). For vehicles that employ engine shutoff strategies that do not require the vehicle operator to restart the engine to continue driving (e.g., hybrid bus with engine shutoff at idle), the manufacturer may request Executive Officer approval for definition for driving cycle.

Why would we care?

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General Requirements

The OBD System

- **If a malfunction is present, the OBD system will detect the malfunction, store a pending, confirmed, MIL-on, or previously MIL-on fault code in the onboard computer's memory, and illuminate the MIL.**
- **The OBD system shall be designed to operate for the actual life of the engine in which it is installed.**
- **May not be programmed or otherwise designed to deactivate based on age and/or mileage of the vehicle during the actual life of the engine.**
- **Computer-coded engine operating parameters may not be changeable without the use of specialized tools and procedures.**

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MIL and Fault Code Requirements.

- The MIL shall be located on the driver's side instrument panel and be of sufficient illumination and location to be readily visible under all lighting conditions and shall be amber in color when illuminated
- The ISO engine symbol will be displayed.
- Only one MIL shall illuminate in the key on, engine off position before engine cranking to indicate that the MIL is functional.

  NOTE: The MIL could be used at the manufacturer's option to indicate readiness status.

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MIL Illumination and Fault Code Storage Protocol.

Upon detection of a malfunction, a pending fault code will be stored

If the malfunction is again detected before the next drive cycle in which the monitoring occurs, the MIL will be illuminated continuously

If a malfunction is not detected before the end of the next drive cycle, the pending fault code shall be erased at the end of the drive cycle

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MIL Extinguishing and Fault Code Erasing

This is a generic version. Slight differences between ISO 15765-4 and SAE J1939 standards.

- **For Fuel System, Misfire, and EVAP system malfunctions, once the MIL has been illuminated, it may be extinguished after three successful driving cycles, indicating no malfunction.**
- **Erasing a confirmed fault code. Code will be erased if the identified malfunction has not been detected again for at least 40 engine warm-up cycles and the MIL is presently not illuminated for that malfunction.**
- **Erasing Permant Fault Code. The OBD system itself makes a decision and erases it.**

Or through the use of a scan tool or battery disconnect.

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Clearing Fault Codes

- **Clearing fault codes does not fix issues.**
- **Look at everything pertaining to the fault/issue such as:**
  - **Conditions for setting the fault code**
  - **Conditions for running the diagnostics**
  - **Actions taking when fault code is active**
  - **Conditions for clearing the fault code**

Important, more so with today's vehicles:

Performing a "RESET ALL" (Clear) may not clear the "MIL" and "ELIMINATE" the " "DERATE". There's a possibility that the conditions for running the diagnostics (trips) have not been met to for clearing the fault code and associated de-rate.
The fault code may clear, but the MIL lamp could remain on and derate still active.

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The following is an example from Cummins:

- **Conditions for setting the fault codes**
  - An internal circuit error has been detected in the aftertreatment outlet NOx sensor assembly.
- **Action Taken When the Fault Code is Active**
  - The ECM illuminates the **Amber CHECK ENGINE** lamp and/or the **Malfunction Indicator Lamp (MIL)** immediately when the diagnostic runs and fails.
  - Engine torque will be reduced after 10 hours of engine operation with the fault code active.
  - Vehicle speed will be limited to 5 mph after 40 hours of engine operation with the fault code active.

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Conditions for Clearing the Fault codes

- To validate repair, start and operate the engine to raise exhaust temperatures. (Can be done by either driving the vehicle or initiating a stationary regen).
- The exhaust gas temperature at the aftertreatment outlet NOx sensor must be **above 150ºC (302ºF)** before the sensor can run its internal diagnostics.
- The fault code status displayed by service tool will change to INACTIVE immediately after the diagnostic runs and passe.
- The ECM will turn off the amber CHECK ENGINE lamp after the diagnostic runs and passes.
- **For On-Board Diagnostic (OBD) engines, the ECM will turn off the MIL after three consecutive trips where the diagnostic runs and passes.**
- The Reset All Faults command on the electronic service tool can be used to clear active and inactive faults, as well as extinguish the MIL for OBD applications

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What is a Warmup Cycle?

"Warm-up cycle" means sufficient vehicle operation such as the coolant temperature has risen by at least 40 degrees Fahrenheit from engine start and reaches a minimum temperature of at least 160 degrees Fahrenheit (140 degrees Fahrenheit for applications with diesel engines).

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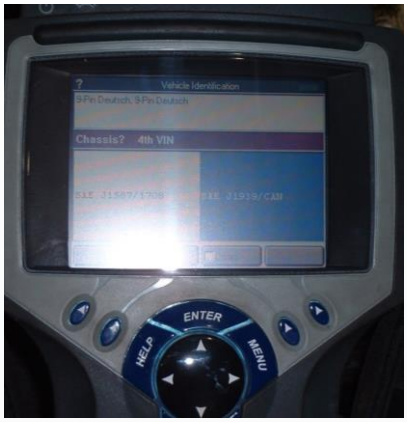
The next set of slides shows diagnostics in the day before OBD.
Trying to show the lack of information.
But there was just enough to help us.
We have come a long way.
Today, we have more information than we could have ever imagined and accessible for everyone.
OBD opened a whole new door for us.
Milk it for everything you can.

2000 IH / Model 8100 / Cummins ISM 350

Amber Check engine light on

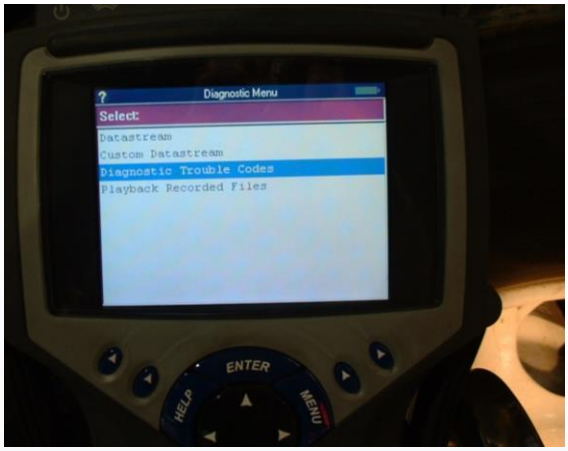
Red Stop Engine Warning On

52



Hooked up on J1939 side.

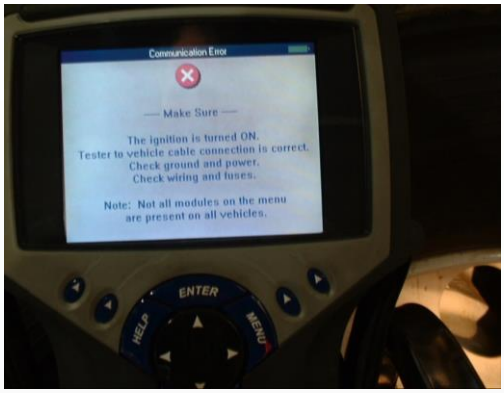
53



Scrolled to Diagnostic Trouble Codes.

Enter

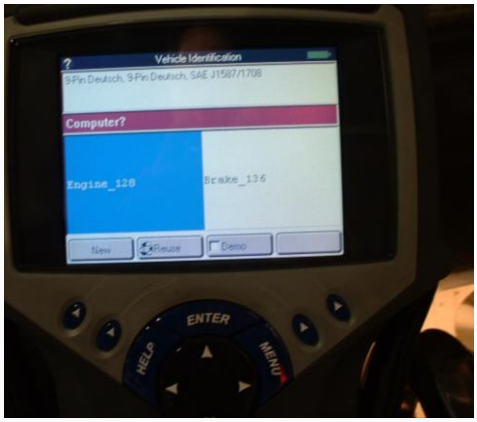
54



This time a communication error prompt came on. Note: The Key is ON.

Press EXIT to get out of this window.

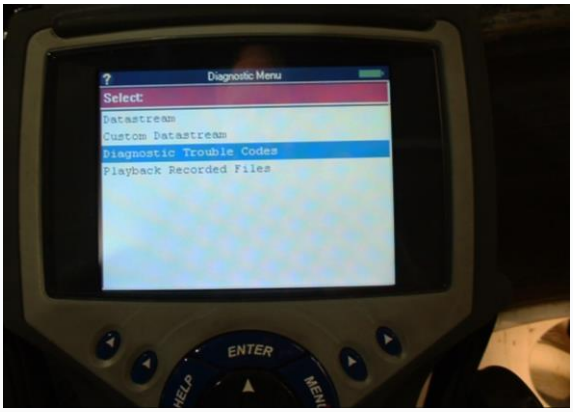
55



Scrolled back to the J1708 window and forward to this window to highlight Engine 128.

Enter

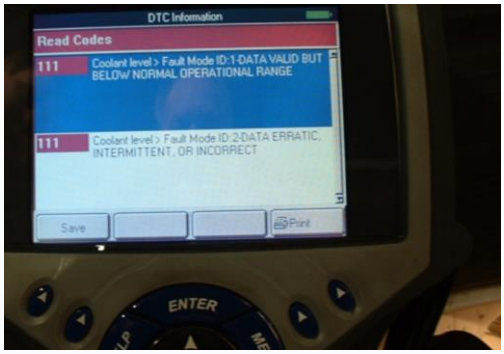
56



This time communication was established.
Scrolled to Diagnostic Trouble Codes.

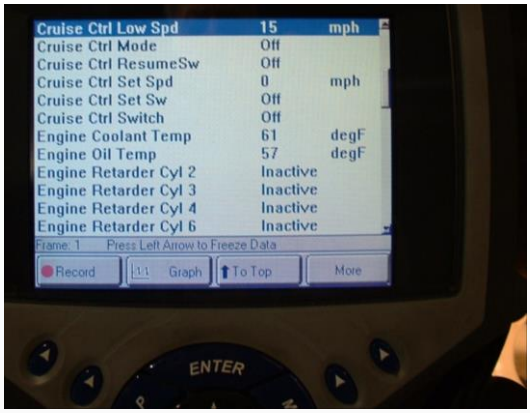
ENTER

57



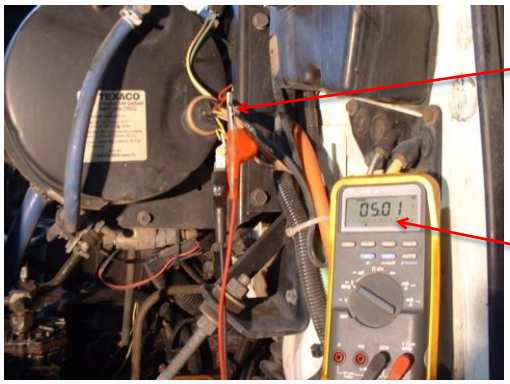
PID 111 is the Parameter Identification description(coolant level)
FMI ID:1 and FMI ID: 2 are the Failure Mode Identifiers.
These codes explain the reason for the Engine Shutdown warning. ECM is trying to protect the engine.

58



This Engine MID 128 did not have a coolant sensor PID. However, we got a set of codes and description very fast and easily. Enough information to jump into basic diagnostics.

59



4 Wire Coolant Lever Sensor in the Coolant Reservoir. DVOM hooked up ready to verify the sensors integrity.

5Volts is indicating a good reference voltage.

The coolant level was very low ,but I decided not to fill it yet. With the reservoir empty it makes it easier to make sure the sensor is working.

Trying to eliminate come-backs

60

Back-probed different pins to check continuity through sensor

61

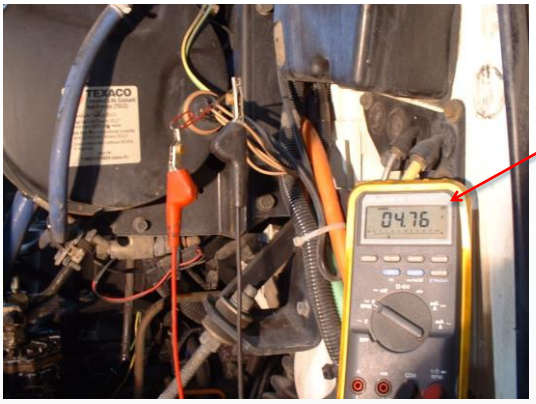
Note the new reading

Switched positive lead to terminal that is used to indicate:
NO LIQUID PRESENT.
All that was required was a wiring diagram. However, this simple circuit can be figured out without a diagram if you are comfortable with basic Electricity, circuits and using DVOM's.

62

Reservoir being filled with the DVOM still hooked up and key on.

63



Voltage Change

When the coolant level touched the sensor probe the voltage changed to indicate LIQUID present.

The coolant circuit is working and doing exactly what it was meant to do. (Time to find the leak)

64

65

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by engineering exclusive, labor-saving
and cost-effective repair solutions.

Thank You !

 66

66