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On Board Diagnostics Implementation Guide

RATIONALE

SAE J1939-03 On Board Diagnostics Implementation Guide was developed in response to On Board Diagnostics regulations adopted for medium-duty and heavy-duty engines.

FOREWORD

The SAE J1939 series of SAE Recommended Practices has been developed by the Truck and Bus Control and Communications Network Subcommittee of the Truck and Bus Electrical and Electronics Committee. The objectives of the subcommittee are to develop information reports, recommended practices, and standards concerned with the requirements, design, and usage of ECUs, that transmit electronic signals and control information among vehicle components. The usage of these recommended practices is not limited to truck and bus applications. Other applications may be accommodated with immediate support being provided for construction and agricultural equipment, and stationary power systems. These documents are intended as a guide toward standard practice and are subject to change to keep pace with experience and technical advances.

The SAE J1939-03 On Board Diagnostics Implementation Guide identifies key requirements, guidelines, and recommendations on the design and integration of vehicle networks with service tools that query the vehicle for regulated diagnostics. ARB, US EPA, EU and WWH OBD regulations were considered for the development of SAE J1939-03.

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1. SCOPE

1.1 Introduction

SAE J1939-03 provides requirements and guidelines for the implementation of On Board Diagnostics (OBD) on heavy-duty vehicles (HDV) using the SAE J1939 family of standards. The guidelines identify where the necessary information to meet OBD regulations may be found among the SAE J1939 document set. Key requirements are identified here to insure the interoperability of OBD scan tools across individual OBD compliant vehicles.

Market-defined regulations permit the use of SAE J1939 to meet OBD requirements. Implementers are cautioned to obtain and review the specific regulations for the markets where their products are sold. This document is focused on guidelines and requirements to satisfy the State of California Air Resources Board (ARB), the authors of 13 CCR 1971.1, United States Environmental Protection Agency, Euro IV and V requirements from European Commission directives, and UN/ECE WP 29 GRPE WWH OBD Global Technical Regulation (GTR)

1.2 Identification of HDV Diagnostic Methods

There are three approaches for providing OBD services. SAE J1939 provides OBD services that are integrated with known powertrain control messages and methods for HDV. This document focuses on the use of SAE J1939 to satisfy OBD requirements.

ISO 15765-4 and ISO PAS 27145 are identified as comparative references. These standards define methods for on board diagnostics communications that are independent of vehicle's powertrain control and information methods. The three approaches are identified below.

1.2.1 SAE J1939 Approach for HD OBD, OBD II, and WWH OBD

SAE J1939 provides an open systems approach for the integration of HDV components. Within this approach, diagnostic methods and messages are provided to achieve HD OBD, OBD II, and WWH OBD requirements. This specification provides guidelines and requirements for the implementation of HD OBD, OBD II and WWH OBD requirements using SAE J1939 constructs.

The SAE J1939 series of standards does not define scan tool standards in a document structure that is equivalent to SAE J1978 (ISO 15031-4) or ISO PAS 27145. In SAE J1939, standardized scan tools are applications of the requirements given in SAE J1939, SAE J1939-01, SAE J1939-21, SAE J1939-31, SAE J1939-71, SAE J1939-73, SAE J1939-81, and SAE J1939-84. Section 4 discusses the SAE J1939 document structure and its application to scan tools. Subsequent sections discuss topics of particular interest in the development of standardized scan tool for SAE J1939.

1.2.2 ISO 15765 Approach for HD OBD and OBD II

ISO 15765-4 may be used as described therein to satisfy HD OBD and OBD II requirements for Heavy Duty Vehicles. ISO 15765-4 outlines the individual parts that comprise the diagnostic requirements for OBD. If ISO 15765 is selected, the implementer shall follow the directives given in ISO 15765-4. Under ISO 15765-4, ISO 15031 describes OBD Service Tool requirements and the OBD message interface in ISO-15031-4 and ISO 15031-5. SAE J1978 is equivalent to ISO 15031-4, and SAE J1979 is equivalent to ISO 15031-5.

1.2.3 ISO PAS 27145 Approach for WWH OBD

ISO PAS 27145 defines data and messaging to satisfy WWH OBD requirements. Implementers may choose to fulfill ISO PAS 27145 when required to meet WWH OBD requirements in local regulations. PAS 27145 defines a VOBD concept for providing a logical function for vehicle-level on-board diagnostics. The logical function may be implemented as a gateway or virtually within one or more compliant modules. This document discusses the process required when implementing the VOBD function for WWH OBD using messages defined in SAE J1939-73.

1.3 Verification of OBD Requirements

ARB and US EPA regulations require verification of OBD requirements to assure standardized scan tool interoperation. Compliance to standardized communication requirements for scan is determined by SAE J1939-84 and SAE J1699-3.

1.3.1 SAE J1939-84

SAE J1939-84 provides methods to verify interaction between the service tool and vehicle for the SAE J1939 approach. SAE J1939-84 standardizes the qualification of vehicles for use with HD OBD and OBD II scan tools that support SAE J1939. SAE J1939-84 adapts the concepts of SAE J1699.

1.3.2 SAE J1699-3

SAE J1699-3 describes the qualification of vehicles for use with scan tools for the ISO 15765-4 / ISO 15031-4 approach. SAE J1699-3 does not apply to vehicles using SAE J1939 diagnostics.

1.3.3 WWH OBD

The WWH OBD GTR recognizes SAE J1939-73 as a means to support WWH OBD. This document supports the definitions in SAE J1939-73 with specific requirements and process guidelines to eliminate misinterpretation of the messages defined in -73. Specific requirements for formal evaluation of engines or vehicles are not defined within the GTR.

2. REFERENCES

2.1 Applicable Publications

The following documents contain provisions, which through reference in this text constitute provisions for SAE J1939-03. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, users are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below, as may be required by local regulations. For undated references, the latest edition of the normative document referred to applies. ISO and IEC maintain registries of currently valid International Standards.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J1699-3 OBD II Compliance Test Cases

SAE J1939 Recommended Practice for Serial Control and Communications Vehicle Network

SAE J1939-01 Recommended Practice for Control and Communications Network for On-Highway Equipment

SAE J1939-11 Physical Layer, 250K bits/s, Twisted Shielded Pair

SAE J1939-13 Off-Board Diagnostic Connector

SAE J1939-15 Reduced Physical Layer, 250k Bits/Sec, Un-Shielded Twisted Pair (UTP)

SAE J1939-21 Data Link Layer

SAE J1939-31 Network Layer

SAE J1939-71 Vehicle Application Layer

SAE J1939-73 Application Layer—Diagnostics

SAE J1939-81 Network Management

SAE J1939-84 OBD II Communications Compliance Test Cases for Heavy Duty Components and Vehicles

SAE J1978 OBD II Scan Tool—Equivalent to ISO/DIS 15031-4: December 14, 2001

SAE J1979 E/E Diagnostic Test Modes

SAE J2284-2 High Speed CAN (HSC) for Vehicle Applications at 250 Kbps

2.1.2 Government Documents

HD OBD and WWH OBD regulations and related information are available at www.arb.ca.gov, www.epa.gov, eur-lex.europa.eu, and www.unece.org/trans.

California Code of Regulations Title 13 Section 1968.2 On-Board Diagnostics II

California Code of Regulations Title 13 Section 1971.1 On-Board Diagnostic System Requirements for 2010 and Subsequent Model-Year Heavy-Duty Engines (HD OBD)

United States Environmental Protection Agency Title 40 CFR Part 86

US EPA, Title 40, CFR 86.005-17 (Engines—8500 to 14 000 lbs) December 28, 2000

US EPA, Title 40, CFR 86.1806-05 (Vehicles - 8500 to 14 000 lbs) December 28, 2000

NOTE: Revisions to US EPA 2005 regulations for 2010, and 2013 era heavy-duty engines have not been published. 40 CFR 86.1806-yy will describe OBD requirements for vehicle certification and 40 CFR 86.yyy-17 will describe OBD for engine component certification.

European Directive 98/69/EC (as amended by 99/102/EC, 2001/1/EC, 2001/100/EC and 2002/80/EC) (Vehicles <7600 lbs)

European Union Heavy Duty OBD (vehicles above 7600 lbs) 29 November 2005 (EC Directive 2005/78)

Directive 2005/55/EC of the European Parliament and of the Council of 28 September 2005 as implemented by Commission Directive 2005/78/EC and amended by Commission Directive 2006/51/EC of 6 June 2006 amending for the purposes of adapting to technical progress Annex I to Directive 2005/55/EC of the European Parliament and of the Council and Annexes IV and V to Directive 2005/78/EC as regards requirements for the emission control monitoring system for use in vehicles and exemptions for gas engines

World Wide Harmonized OBD proposed Global Technical Regulation Draft by the Economic Commission for Europe, reference ECE/TRANS/WP.29/GRPE/2006/8/Rev.1/27 March 2006

2.1.3 ISO Publications

Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ISO 2575 AMD 2	Road vehicles—Symbols for controls, indicators and tell-tales (Amendment 2)
ISO 7498-1:1984	Information processing systems—Open systems interconnection—Basic reference model
ISO/IEC 10731:1994	Information technology—Open systems interconnection—Basic reference model—Conventions for the definition of OSI services
ISO 11898	Road Vehicles—Interchange of digital information—Controller area network (CAN) for high-speed communications
ISO 14229-1:2006	Road vehicles—Unified diagnostic services (UDS)—Part 1: Specification and requirements
ISO 15031-3	Road vehicles—Emission-related diagnostics—Communication between vehicle and external equipment—Part 3: Diagnostic connector and related electrical circuits: Specification and use
ISO 15031-4	Road vehicles—Communication between vehicle and external equipment for emissions-related diagnostics—Part 4: External test equipment

ISO 15031-5 Road vehicles—Communication between vehicle and external equipment for emissions-related diagnostics—Part 5: Emissions-related diagnostic services

ISO 15765-2 Road vehicles—Diagnostics on controller area network (CAN)—Part 2: Network layer services

ISO 15765-4 Road vehicles—Diagnostics on controller area network (CAN)—Part 4: Requirements for emissions-related systems

ISO PAS 27145-1 Road vehicles—Implementation of WWH-OBD communication requirements—Part 1: General information and use case definition

ISO/PAS 27145-2 Road vehicles—Implementation of WWH-OBD communication requirements—Part 2: Common emissions-related data dictionary

ISO/PAS 27145-3 Road vehicles—Implementation of WWH-OBD communication requirements—Part 3: Common message dictionary

ISO/PAS 27145-4 Road vehicles—Implementation of WWH-OBD communication requirements—Part 4: Connection between vehicle and test equipment

3. SYMBOLS AND ABBREVIATED TERMS

ARB Air Resources Board (of the State of California)
EPA (United States) Environmental Protection Agency
GTR Global Technical Regulation
HDV Heavy Duty Vehicle
HDD Heavy Duty Diesel
ISO the International Organization for Standardization
MI Malfunction Indicator (WWH OBD specific term for MIL)
MIL Malfunction Indicator Lamp
OBD On-Board Diagnostics
OEM Original Equipment Manufacturer
WWH World Wide Harmonized
VOBD Vehicle On Board Diagnostics

4. REQUIREMENTS AND GUIDELINES FOR OBD IMPLEMENTATION USING SAE J1939

The SAE J1939 family of specifications was developed using the Open System Network Layer Concepts for guidance. Figure 1 shows the application of SAE J1939 standards to Open System Network Layer Concepts. Some documents address more than one layer, and some layers are not used. Coverage for more than one layer by a document should not be interpreted that the layers are combined. More generally, SAE J1939 standards leverage the Controller Area Network (CAN) specification (subsequently standardized as ISO 11898) to the problem of heavy-duty vehicle integration. The following subsections below discuss key requirements from the SAE J1939 family of specifications for implementing scan tools to service SAE J1939 applications. Most of these requirements are common to vehicles, components and OBD scan tools, whether they are focused on Inspection and Maintenance (IM) or other service roles.

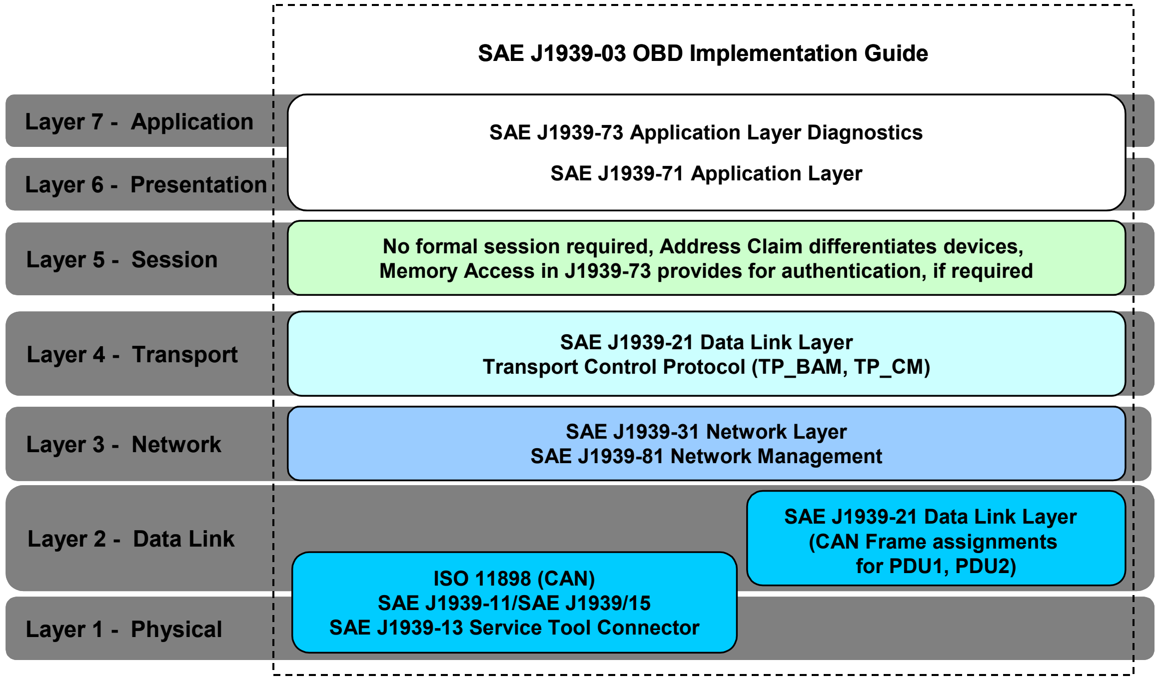


FIGURE 1 - APPLICATION OF SAE J1939 STANDARDS TO OPEN SYSTEM NETWORK LAYER CONCEPTS

4.1 Physical Layer Definition

SAE J1939-11 and SAE J1939-15 define physical layer implementations of the ISO 11898 Controller Area Network (CAN) specification. Network Topology requirements in SAE J1939-11 are relaxed in SAE J1939-15 to provide additional design flexibility to the OEM in the placement of network termination devices and for the use of the diagnostic connector. This allows the OEM to better optimize the cost/performance of his design.

4.1.1 Signal Definition

Section 3 of SAE J1939-15 defines the signal characteristics of the SAE J1939 network. SAE J1939-15 is harmonized with SAE J1939-11 allowing the backwards-compatible interoperation among components. SAE J1939-15 and SAE J1939-11 provide reference designs that are compatible with ISO 11898. Service tools must be capable of communicating with both SAE J1939-11 and SAE J1939-15 signal specifications.

4.1.2 Media

The physical media shall meet the requirements of SAE J1939-11 or SAE J1939-15 for a 120 Ohm cable. The insulation color of the CAN_HI and CAN_LO conductors must follow SAE J1939-11 Section 5.2.1. Cables must be capable of delivering the required signal levels to all network devices.

4.1.3 Topology

The OEM is responsible for the design and implementation of the SAE J1939 network topology in his vehicle, including backbone length, termination, and network device stub length. The OEM may elect to include backbone termination within selected modules; however, their service procedures should provide methods to terminate the backbone when the terminating device(s) is (are) not connected to the backbone.

Network device stub length includes the provision for the Inspection and Maintenance Tool connection through the diagnostic connector. This stub shall be capable of supporting a 5-meter cable to the OBD Scan Tool. This exceeds the recommended stub length of SAE J1939-11 by 4 meters. Implementers are recommended to minimize the distance from each node to the SAE J1939-13 diagnostic connector to provide design margins for off-board communications.

NOTE: The 5-meter cable is required by ARB regulation 13 CCR 1971.1 in 2013 for HDD engines. The requirement for a 5-meter cable adds additional constraints on topology designs that are not addressed by current SAE J1939-15 and SAE J1939-11 topology design rules. Design rules have not been developed for the 5-meter cable and are not available in the referenced versions of SAE J1939-11 and SAE J1939-15. Additional system design will be required until new topology design rules are available. The committee is studying SAE J1939-15 and SAE J1939-11 topology design rules to address the 5-meter cable design challenge.

4.2 Diagnostic Connector

The diagnostic connector defined in SAE J1939-13, Diagnostic Connector, shall be used as described therein. SAE J1939-13 physically describes the part and pin assignments. SAE J1939-13 also provides guidelines for the location of the connector. Market-defined regulations may provide specific guidance on connector selection and location.

4.2.1 Power Connection

The power connection described as Battery+ and Battery- in SAE J1939-13 shall be consistent with standards for 12 V and 24 V starting and charging systems. Higher voltages shall not be supplied through the diagnostic connector.

4.2.2 Battery+ Fusing

The Battery+ supply shall be fused as defined in SAE J1939-13.

4.3 Data Link Layer Definition

The data link layer for OBD implementation on SAE J1939 vehicle networks shall conform to SAE J1939-21. OBD service tools shall comply with SAE J1939-21 when connected to a SAE J1939 vehicle. Key provisions of SAE J1939-21 are reviewed below.

4.3.1 Physical Address Definitions

4.3.1.1 Preferred Address – OBD Devices for On-Highway Applications

OBD devices shall use the preferred addresses defined in SAE J1939 for Industry Group 1, On Highway Vehicles or Industry Group 0, Global. The OEM may assign fixed addresses that match the preferred addresses within these industry groups to suit the performance needs of the vehicle.

4.3.1.2 Preferred Address – Service Tool

OBD Inspection and Maintenance Tools shall use the preferred address for diagnostic tools given in SAE J1939. These addresses are given as 249_{10} and 250_{10}.

4.3.1.3 Addresses for OBD Functional Requests

Functional requests are presented to the network in search of specific information where the physical address of that information is not known *a' priori.* SAE J1939-21 defines the address 255_{10} (0xFF) as the physical address for functional requests. In SAE J1939-21 physical address 255_{10} is described as the global destination address. The request PGN in SAE J1939-21 describes the use of this feature. See Section 4.3.3 for more information on requests and responses.

4.3.2 PDU Format for CAN Identifiers

SAE J1939-21 defines the Protocol Data Units that implement information services on SAE J1939 networks. The content of the CAN identifiers shall meet the definitions in SAE J1939-21. Other specifications such as SAE J1939-71 and SAE J1939-73 define specific content to be used in PDU fields, for each CAN message.

4.3.3 Request/Response System

The diagnostic services described in SAE J1939-73 are implemented using the request-response mechanism described in SAE J1939-21.

4.3.3.1 Request

The request mechanism is described in SAE J1939-21 under PGN 59904. PGN 59904 supports both destination specific and global destination requests. Using the global destination request, all network nodes can be interrogated for selected diagnostic data by a single request. The form of the request and the nature of the information to be provided, determine the Transport Protocol facility to be used when the data in the reply exceeds 8 bytes.

4.3.3.2 Response

4.3.3.2.1 ACK/NACK

The Acknowledge message (ACK/NACK) is described in SAE J1939-21 under PGN 59392. PGN 59392 describes both a positive and negative acknowledgement facility. ACK and NACK responses indicate the performance status of a request or command. Destination specific requests received for unsupported data are responded to with NACK. SAE J1939-73 discusses the use of ACK/NACK on many of its service requests. ACK/NACK requirements should be strictly adhered to ensure service tool compatibility.

4.3.3.2.2 Data

Requests for data shall be responded to as described in SAE J1939-21 Section 5.4.

4.3.4 Transport Services

Transport services are described in SAE J1939-21 for data responses that exceed eight bytes in length. Two forms of transport services are provided.

4.3.4.1 Broadcast Announce Message (BAM)

The BAM form allows data exceeding 8 bytes in length to be sent globally. It is also used for the response to a request when the request was sent to the global destination address.

4.3.4.2 Request to Send/Clear to Send (RTS/CTS)

The RTS/CTS form is used for point-to-point communications. RTS/CTS provides flow control for large data transfers. It is used for the response to a request when the request was sent to a specific destination address and the response data exceeds 8 bytes.

4.4 Network Layer Definition

SAE J1939-31 defines the network layer provisions in the SAE J1939 family of specifications. SAE J1939-81 describes network management facilities for devices on a SAE J1939 network.

4.4.1 Network Layer

Any network router, bridge or gateway used to satisfy OBD requirements shall comply with SAE J1939-31.

4.4.2 Recommended Network Topology for OBD Devices

All devices that respond to OBD defined requirements are recommended to reside on the same network segment as the OBD connector. Minimizing the use of routers and bridges between the OBD Scan Tool and OBD compliant devices reduces message latencies and eliminates opportunities for messages to be misrouted.

4.4.3 Network Layer and Network Management

J1939-81 defines network management features of SAE J1939, including the communication of the mapping of device functions to network addresses on the network. This mapping may be fixed for an individual vehicle but could vary from vehicle to vehicle.

4.4.4 Address Claim

OBD components shall support the Address Claim Method described in SAE J1939-81 and identify the functions they support. Address claim for OBD components provides function names and addresses to the OBD scan tool. OBD devices on vehicles may have fixed addresses. Addresses shall follow the preferred address guidelines as discussed in paragraph 4.3.1.

4.4.5 Network Capabilities for Service Tools

Table 2 of SAE J1939-81 describes the network management capabilities for service tools and other network devices. Because more than one tool may become attached to a Heavy Duty Vehicle, service tools are required to support address claim and dynamic addressing to avoid address conflicts. This requirement is identified in SAE J1939-81 Table 2. SAE J1939-81 defines the address claim process and the dynamically assigned physical addresses that can result.

4.5 Application Layer

Parametric data relating to diagnostics and control applications is routinely broadcast as messages on a SAE J1939 network segment serving the vehicle's power train. This follows the open systems concept under which SAE J1939 was developed. Routine broadcast of fault information allows the development of fail-soft strategies within the components collaborating on a network segment.

There are two documents that define application layer requirements for OBD. SAE J1939-71 defines parametric data such as engine speed and some component operating limits like idle speed. SAE J1939-73 defines the diagnostics services and data content for diagnostics messages on a SAE J1939 Network. Table 1 of SAE J1939-73 matches services to specific OBD regulations.

4.5.1 Broadcast Messages

4.5.1.1 Parametric Data

SAE J1939-73 identifies the parametric data required by the regulations. These references define the SPNs that must be supported from the definitions in SAE J1939-71. SAE J1939-71 bundles these SPNs into specific messages using the Data Link layer constructs for point-to-point and broadcast information. The PGN identifier fields in message identifiers shall match the definitions provided for PGNs in SAE J1939-71.

As allowed by SAE J1939-71, parameters not used for OBD purposes and not estimated by the system shall be coded as "not available". Parameters that have failed shall be coded as "Error indicator" as described by SAE J1939-71 Table 2. Substitute estimates or default values shall not be broadcast instead of broadcasting "Error indicator".

Modules complying with HD OBD, OBD II (e.g. 13 CCR 1968.2 April 23, 2003), and WWH OBD are required to support PGN 64950 DM24, SPN Support. DM24 identifies the parametric data and freeze frame contents that are available from a given component.

4.5.1.2 MIL Status

The SAE J1939-73 message DM1 shall be used to communicate the MIL status to other on board devices. The MIL may only be used to communicate OBD failures and may not communicate non-OBD malfunctions. Devices that do not produce OBD faults shall report the MIL Status as 11_2 as defined by SAE J1939-73 of SPN 1213.

Additionally, components that support WWH OBD shall support PGN 64867 HRWS, Harmonized Road Worthiness – System. HRWS provides the indication of continuous MI, describes the MI as discriminatory or non-discriminatory, and the MI activation mode required by Module B of the GTR.

4.5.1.3 Failure Information

The SAE J1939-73 message DM1 shall include all active, confirmed OBD malfunctions and all active non-OBD malfunctions. Message DM12 can be used to see only those malfunctions that are OBD related. See SAE J1939-73 for more information.

4.5.2 Diagnostics Services

SAE J1939-73 describes diagnostic services available for diagnostics and regulated service procedures. Table 2 of SAE J1939-73 identifies the diagnostic services needed to comply with individual OBD regulations.

5. VEHICLE INTEGRATION PRINCIPLES FOR OBD

Some aspects of the OBD regulations introduce requirements onto areas of the vehicle other than major powertrain components. Of specific note is the required Malfunction Indicator Lamp (MIL). Other areas may be impacted as noted in the material below.

5.1 MIL Illumination and Diagnostics

The vehicle's OBD system must incorporate a MIL that is located in the driver's instrument panel. The MIL must meet requirements of color, symbol, bulb check, activation/deactivation and fault diagnostics as specified in the appropriate local OBD regulations. Standardized symbol examples are included in ISO 2575. There shall be only one MIL in the vehicle and it is not allowed to be used for other purposes, unless expressly permitted in the local OBD regulations.

Any OBD component on the vehicle must be able to illuminate the MIL, directly, or via the DM1 message. If a DM1 message from any device on the vehicle indicates that the MIL should be illuminated, then the device actually controlling the MIL should illuminate the MIL. The MIL shall remain illuminated as long as any OBD device is commanding it on via their DM1 messages. The aggregation function is the same as that given for the scan tool in paragraph 8.2.1.

The device operating the MIL must perform a bulb check on the MIL at key-on. The specific details of the bulb check requirements are defined in the subject local OBD regulatory documents. During the bulb check function, the DM1 messages should not indicate that the MIL is commanded on unless some other malfunction is commanding it on.

The MIL may be subject to OBD diagnostics itself. If the MIL is not capable of illuminating, due to failure, then the device controlling the MIL must set the appropriate fault codes. The device shall indicate the faults and command Mil_Status on with its DM1 message.

5.2 Additional Instrumentation Diagnostics

Some of the local OBD regulations require that any OBD-related input or output components be subject to OBD diagnostics. Some of these components may not be specifically included in the major powertrain components and may be associated with the general vehicle electronics system.

A specific example in the ARB OBD requirements is the Wait-To-Start lamp for diesel applications. If the vehicle employs an inlet-air or combustion chamber pre-heating device, and there is an indicator lamp to alert the operator of this device's operation, then that lamp is subject to OBD diagnostics. The lamp must be monitored for its ability to operate and if malfunction is detected, then the appropriate fault codes must be set and communicated via DM1.

5.3 Multiplexed Vehicle Architectures

Many of today's vehicles employ a multiplexed control system architecture where input signals and output components are distributed around the vehicle. Many OBD regulations require that any input signal or device or output component that can affect emissions (or are used as monitor entry or exit criteria) be subject to OBD diagnostics. These requirements are part of the Comprehensive Component Monitoring requirements. Some of these components may not be specifically included in the major powertrain components and may be associated with the general vehicle electronics system.

When input signals are multiplexed, the receiver shall record a fault for any missing or failed signal. These faults shall use FMI 19 to describe the loss of the signal in SAE J1939-73 fault messages including DM1, DM2, DM6, DM12, and DM23. Components, receiving multiplexed signals for OBD entry and exit criteria, should consider the use of alternate information as a proxy when the preferred signal is not available from the network. (See Section 4.5.1.1)

Distributed implementations must assure that they implement consistent means for earmarking driving cycles to maintain a synchronous state for reporting required data. OBD regulations define single driving cycle or multiple driving cycle logics to detect failures. Driving cycles must meet specific criteria given in the regulations. Driving cycle indications are particularly important for the bookkeeping needed to erase faults that have not recurred.

6. GENERAL SERVICE TOOL REQUIREMENTS

The requirements for *generic* scan tools are defined in SAE J1978 and ISO 15031 part 4 for OBD II scan tools. In general, these tools support SAE J1850, ISO 9141, and ISO 15765-4. The requirements described below integrate support for SAE J1939 into these tools. Service tools include additional functions beyond those described in SAE J1978, or identified in Table 1 of SAE J1939-73. The terms client and server are consistent with their use in ISO 15765-4 and ISO 15031-4. The IM tool is the client and the vehicle's ECUs are the servers.

6.1 Single Purpose SAE J1939 Service Tool

A service tool intending to meet only the requirements of SAE J1939 shall not be marked to indicate it is compatible with all OBD protocols.

6.2 Multi-Purpose Service Tools

The multi-purpose service tool shall be capable of mating to both the connectors defined in ISO 15031 part 3 and to the SAE J1939-13 connector. Implementers are cautioned that specific markets may require a specific choice of these connectors in a vehicle. The round, circular connector defined by SAE J1939-13 is the preferred choice for use with the SAE J1939 network in commercial vehicle applications.

Multi-purpose service tools must follow the principles outlined in Section 7 to identify how OBD is supported on the vehicle.

6.3 Power Connection

The service tool shall not draw more than 4 A at 18 VDC.

6.4 Application of SAE J1939

6.4.1 General Requirements

Service tools shall meet all the requirements given in Section 4. Service tools act as clients for SAE J1939-73 diagnostic services provided by the vehicle network. SAE J1939-73 provides a list of the required services in Table 1.

6.4.2 Diagnostic Services

Service tools shall be capable of displaying the parametric data and failure information described in SAE J1939-71 and SAE J1939-73, as discussed in Section 4.

7. SERVICE TOOL INITIALIZATION

Section 7 describes the initialization of the service tool to perform as a client for diagnostic services on a vehicle using SAE J1939 for OBD communications. This initialization shall be performed prior to requesting diagnostic services from any server. Section 8 describes a model inspection and maintenance (IM) process for HD OBD and OBD II.

7.1 Automatic Protocol Detection

Service tools intending to support both SAE J1939 and ISO 15765 part 4 communications shall provide a means for automatically detecting the relevant protocol and baud rate in use on the vehicle. Figure 2 provides process recommendations on the integration of SAE J1939 into the protocol detection process provided by ISO 15765-4 and amended by ISO PAS 27145-4. One key feature is the use of the 11-bit functional request (0x7DF) to identify 11-bit only networks that support ISO 15765-4. The process will awaken diagnostic gateways that do not broadcast until queried.

ISO 15031-4 describes the protocol selection process, using ISO 15765-4 to determine protocol support for ISO 15765-4 and communications data rate. The tool shall insure that the vehicle's OBD data link bus is not disturbed and placed in a bus-passive, bus-off, or other similar error condition as described in ISO 11898.

7.2 Identification of SAE J1939 OBD Support

Scan tool manufactures shall use a global request for DM5 and Address Claim data to distinguish a SAE J1939-73 diagnostics based network from an ISO 15765 based network. As discussed in SAE J1939-73, the content of any received DM5 indicates the available OBD support for the vehicle. The vehicle may support DM5 messages that indicate there is no OBD support for the device or vehicle.

7.3 OBD Network Device Identification

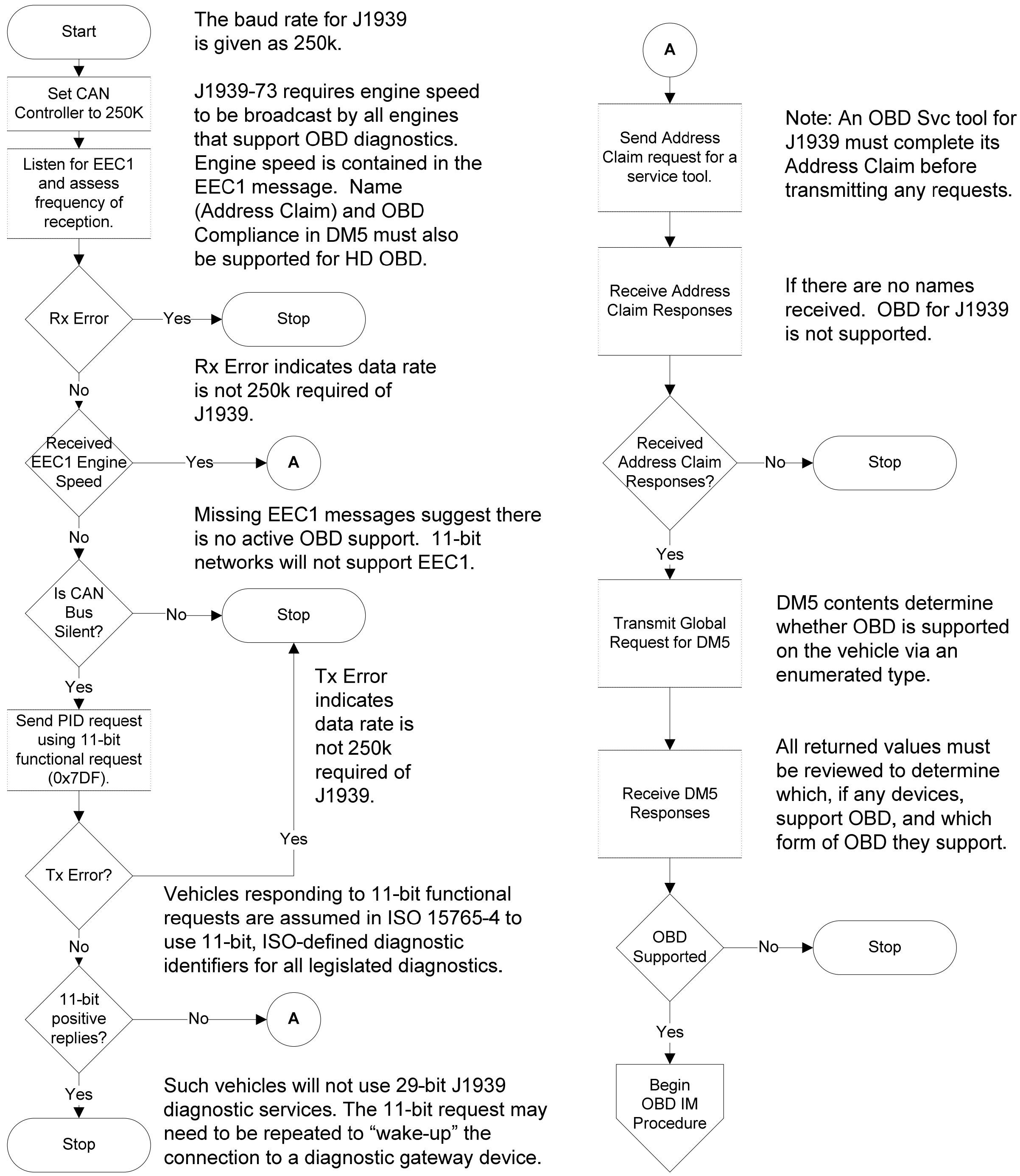
The service tool shall issue a global request for service DM5. Positive responses will identify the OBD Devices on the Network. Requests for diagnostic services during a Regulatory Inspection and Maintenance Process shall be restricted to those devices indicating OBD support in DM5 responses.

7.4 Identification of SAE J1939 WWH-OBD Support

Figure 2 does not show identification of WWH OBD support on a SAE J1939 network. Vehicles that support WWH OBD must support PGN 64868 HRWV, Harmonized Road Worthiness – Vehicle. Service tools that focus on WWH OBD should send a global request for HRWV (PGN 64868), after claiming an address and before requesting DM5 (See Figure 2.) To insure that failure of the VOBD function does not mask a negative condition, such tools may request HRWS (PGN 64867 Harmonized Road Worthiness – System) from the global destination address as a second step. Requesting HRWS will identify all components that support WWH OBD.

7.5 Parametric Data Table Construction

Tools shall use the information contained in PGN 64950 DM24 to identify the data available from an OBD compliant device. As discussed in SAE J1939-71, tools shall not request data that is routinely broadcast. Since some data is broadcast periodically after being initially requested, tools should listen for the desired information on a SAE J1939 network before requesting it. This principle will maintain network bus loading headroom and minimize the tool's contribution to network loading.



Notes:

1. See ISO 15765-4 to tell how to detect ISO 15765-4 and ISO 15031-5 as the OBD Diagnostic protocol.

2. SAE J1939-21 Defines the response time requirements for requests on J1939 networks.

3. Placing the CAN Controller in 250K mode may result in the reception of messages from the vehicle from messages defined in SAE J1939-71. While this would indicate network speed, responses to address claim and subsequently DM5 indicate a J1939 networks capable of OBD diagnostics.

4. Address claim is described in SAE J1939-81. Multiple responses could be received. See J1939-81 to interperet names and functions.

FIGURE 2 - AUTOMATIC PROTOCOL DETECTION PROCESS SUMMARY

8. HD OBD AND OBD II INSPECTION AND MAINTENANCE CLIENT SERVER INTERACTION

Figure 3 provides a process summary for HD OBD and OBD II inspection and maintenance (IM). Section 8 reviews Figure 3 and provides additional application notes on the process and the use of SAE J1939-73 PGNs displayed in Figure 3. Section 9 discusses the inclusion of the VOBD function for WWH OBD. The VOBD function provides vehicle level readiness and roadworthiness concepts.

8.1 Inspection and Maintenance Process Summary

The starting point of the process flowchart in Figure 3 assumes the process in Figure 2 was completed and reached the 'Begin OBD I/M Procedure' off-page reference. In particular, the process in Figure 3 assumes that the DM5 request has already been performed and the DM5 responses identify that the vehicle or engine is capable of supporting the IM process. Figure 3 omits the query for the VIN to focus on the use of SAE J1939-73 defined messages for readiness and fault codes used in obtaining the pass/fail result. This query may be inserted prior to determining MIL status.

Figure 3 shows the sequential inquiry of the vehicle for MIL Status, Fault Codes, and Readiness indicators. Then the results from the inquiries are assessed and a pass/fail result is determined. Individual readiness indicators and reported faults are interpreted according to local regulations. A vehicle with an illuminated MIL or confirmed and active faults reported by DM12 should clearly fail. A vehicle with no faults, but with some monitors indicated as incomplete, may pass upon examination of the indicators. IM procedures, as adopted by local regulation, define specific criteria for failure, because not all OBD vehicles support DM23 and DM28. A DTC that is both pending and permanent (DM6 and DM28) indicates a ‘clean screened’ vehicle that should not pass. A vehicle that has a pending and previously active DTC (DM6 and DM23) suggests a recurring problem that should be addressed with maintenance. Table 2 in paragraph 8.4.1 lists the possible combinations of fault codes and their outcomes.

NOTE: A clean screened vehicle is a vehicle where the confirmed faults have been erased, but the vehicle was not repaired.

8.2 MIL Status

The service tool shall aggregate the individual DM1 messages to establish the status of the MIL, when it is focused on the vehicle assessment. This will prevent occasions when display on the tool of MIL_Status = off, when one component demands it to be on. WWH OBD provides additional MI information in the HRWV and HRVS messages for Malfunction Indicator Display Strategy, Continuous Malfunction Indicator, and Malfunction Indicator Activation Mode.

8.2.1 Aggregation of DM1 MIL_Status for IM

SAE J1939 is developed to distribute systems over multiple components. Thus, one component may require the MIL to be illuminated, while others do not require MIL illumination. Aggregation is a prioritized logical OR function over the individual contributions. An operation table for aggregation is given in Table 1. The rows and columns are indexed by MIL_Status values. The Aggregated MIL_Status result is found by looking up the cell where the row and column intersect. The operation is commutative and associative. Note: The designation of Short MI (value 10_2) is used only for WWH OBD systems. The MIL_Status enumeration does not have a value for ‘error’. NA (value 11_2) stands for not available.

TABLE 1 - MIL_STATUS AGGREGATION OPERATOR

MIL_Status Aggregation Operator	Off (value 00_2)	On (value 01_2)	Short MI (value 10_2)	NA (value 11_2)
Off (value 00_2)	Off (value 00_2)	On (value 01_2)	Short MI (value 10_2)	Off (value 00_2)
On (value 01_2)	On (value 01_2)	ON (VALUE 01_2)	On (value 01_2)	On (value 01_2)
Short MI (value 10_2)	Short MI (value 10_2)	ON (VALUE 01_2)	Short MI (value 10_2)	Short MI (value 10_2)
NA (value 11_2)	Off (value 00_2)	On (value 01_2)	Short MI (value 10_2)	NA (value 11_2)

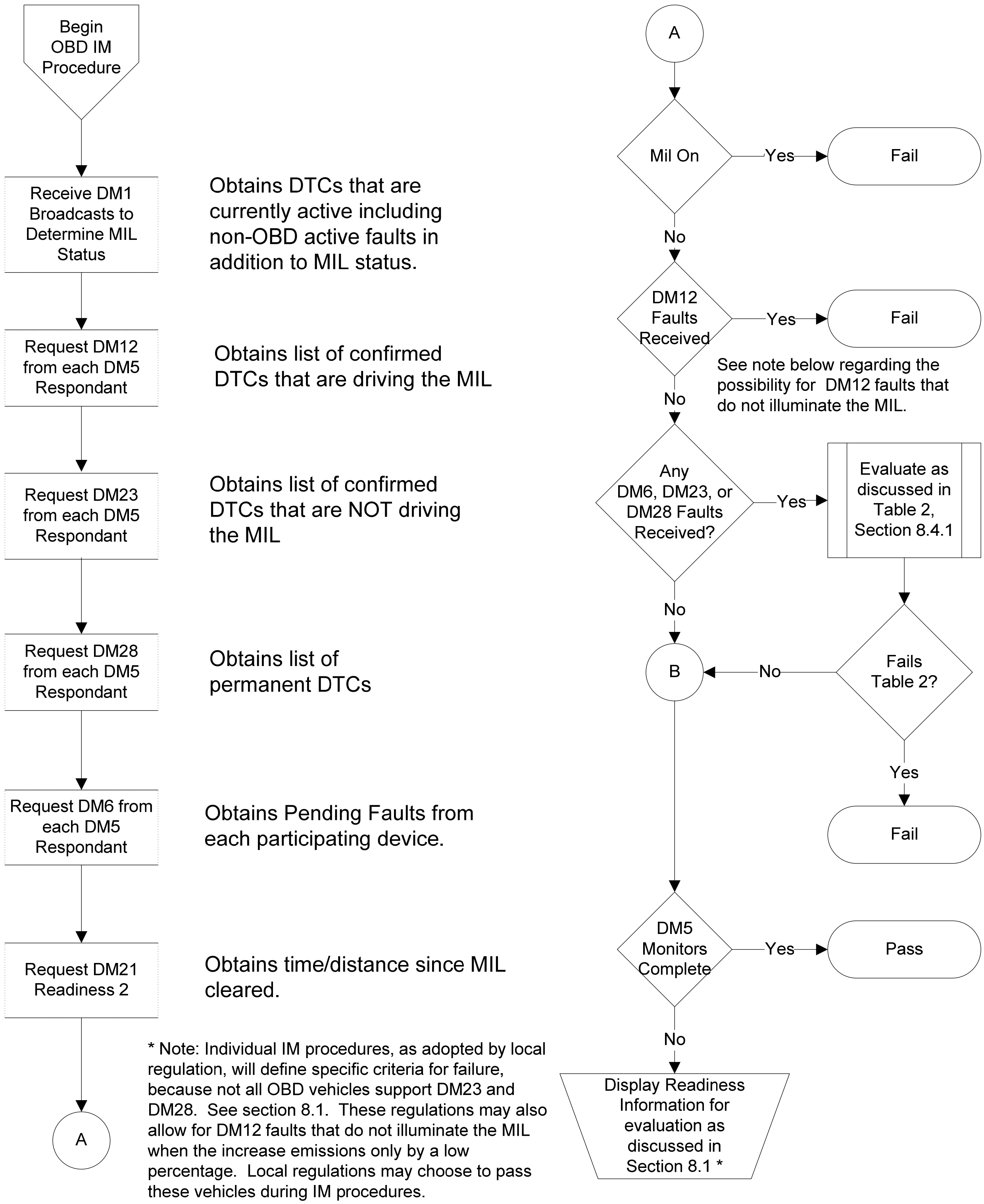


FIGURE 3 - HD OBD AND OBD II INSPECTION/MAINTENANCE (IM) PROCESS SUMMARY FOR SAE J1939

8.2.2 Scope of Aggregation

The scan tool shall aggregate the MIL Status using the MIL_Status values from all DM1 messages, including the DM1 messages from addresses not supporting DM5 and addresses for non-OBD components. DM1 is broadcast on a regular schedule by SAE J1939 devices, even when they do not have faults to report. In this way they maintain periodic communication of MIL status for multiplexed operator displays. The loss of the periodic DM1 message from an OBD compliant device is considered an OBD failure and the aggregated MIL_Status shall be ON.

8.3 Diagnostic Readiness and Monitor Status

SAE J1939-73 defines DM5 and DM21 to provide readiness status of individual monitors. Local regulations may require only some of the data defined for DM5 and DM21.

8.3.1 Service Tool Request

The service tool shall issue a global request for DM5. The service tool will identify the physical addresses of OBD compliant devices, based on the result obtained in the OBD Compliance field. The requests for DM26, DM21 and other messages which provide additional data definitions for readiness on SAE J1939-73 networks should be sent to the physical addresses of each of the OBD compliant devices.

8.3.2 OBD System Response

DM5 is purposefully limited to a single CAN frame, so the BAM method will not be used to reply to a global DM5 request. Each DM5 Reply includes

- Count of Active Trouble Codes
- Count of Previously Active Diagnostic Trouble Codes
- OBD Compliance
- Continuously Monitored Systems Support/Status
- Non-continuously Monitored Systems
- Non-continuously Monitored Systems Status

DM21 replies include

- Time Since Diagnostic Trouble Codes Cleared
- Minutes Run by Engine While MIL is Activated
- Distance Traveled While MIL is Activated

8.4 Detected Failures

SAE J1939-73 defines messages for communicating all detected failures required of OBD systems.

8.4.1 HD OBD and OBD II Detected Failures

Failures detected for HD OBD and OBD II are reported with DM6 (Pending), DM12 (Confirmed and Active), and DM23 (Confirmed and Previously Active). Some systems will also support DM28 (Permanent) fault codes.

Table 2 shows the IM Result for combinations of reporting conditions for a given (i.e. single) DTC. For example, in Row 3, an individual failure code is reported in DM6 (Pending) and in DM28 (Permanent). This DTC is not reported in DM12 (Active) or DM23 (Confirmed and Previously Active). The IM Result for Row 3 is fail because this combination of faults for a given DTC suggests the vehicle had its faults erased without an effective repair being made. Engines or vehicles with confirmed and active faults clearly fail IM. See SAE J1939-73 for definitions of DM6, DM12, DM23, and DM28.

TABLE 2 - IM FAILURE DETECTION FOR FAULT COMBINATIONS

Row	Confirmed and Active (DM12)	Permanent (DM28)	Pending (DM6)	Confirmed and Previously Active (DM23)	IM Result
1	True	Any	Any	Any	Fail – Mil should be on.
2	False	True	True	True	Fail – ***This condition is not a believable combination for a properly implemented system.***
3	False	True	True	False	Fail – This combination indicates a vehicle/ engine had its faults cleared without an effective repair being completed.
4	False	True	False	True	Fail – ***This condition is not a believable combination for a properly implemented system.***
5	False	True	False	False	Fail – without evidence of repair, likely clean screen vehicle. May Retest. Pass – with evidence of repair Note: Vehicles that are iteratively tested due to prior failures and related repairs may not have their readiness set in addition to having one or more permanent faults.
6	False	False	True	True	Pass – (The diagnostic condition is intermittent with a period under 40 warmup cycles. The engine/vehicle should pass because the MIL is off and the lack of a permanent fault code indicates it has not been clean-screened.)
7	False	False	True	False	Pass – Single trip monitor will show both Confirmed and Active (DM12) and Pending (DM6)
8	False	False	False	True	Pass – Lack of either a pending or permanent fault suggests that detection method has passed three or more consecutive evaluations, but has not progressed past 40 warm-up cycles.
9	False	False	False	False	Pass

NOTE: Local regulations may accept some failures that do not light the MIL when the emissions increase is a low percentage. (See row 1.)

8.4.2 WWH OBD Detected Failures

WWH OBD classifies failures as Class A, B1, B2, and C. Additionally failure status may be pending, confirmed and active, and previously active. SAE J1939-73 defines 12 services (DM41 through DM52) to request each class and status of DTC. Tables 25 and 26 of SAE J1939-73 define the mapping of PGNs to A, B1, B2, and C fault classes.

9. WWH OBD VOBD IMPLEMENTATION GUIDELINES

Section 9 describes the key points for the implementation of the Vehicle On Board Diagnostics (VOBD) Function required to support Use Case 1 of WWH OBD. Section 9.1 discusses the use cases identified in the WWH OBD GTR. Section 9.2 discusses the VOBD function definition. Section 9.3 describes architecture options for VOBD implementation. Section 9.4 discusses the aggregation of system information from HRWS messages into the vehicle's HRWV response for Use Case 1. Section 9.5 discusses considerations toward the implementation of Use Case 2.

9.1 WWH OBD Information Use Cases

The WWH OBD GTR defines three use cases of information within control modules complying with its provisions:

Use Case 1: Information about the emissions-related OBD system state
Use Case 2: Information about active emission-related malfunctions
Use Case 3: Information related to diagnosis for the purpose of repair

Use Case 1 provides information suited to the selection of vehicles for enforcement inspections at roadside inspection stations. This data provides information about the vehicle, or engine state with respect to required failure detection given in the WWH OBD GTR.

Use Case 2 provides information suited to the periodic inspection of vehicles or engines. Such inspections today for passenger cars are called 'smog checks' or Inspection/Maintenance (IM) checks. Use Case 2 data details the readiness monitor by monitor and provides the fault codes for pending, confirmed and active, and previously active statuses to support a pass/fail decision for the vehicle or engine.

Use Case 3 provides information to support the repair of the vehicle or engine. Use Case 3 defines the set of data that, at a minimum, must be provided to support the repair of the vehicle or engine.

9.2 VOBD Function for SAE J1939

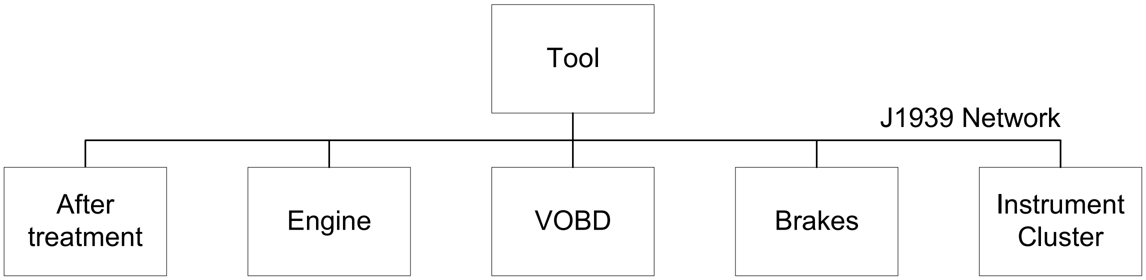
ISO PAS 27145-1 defines the VOBD function to provide the common access point for legislated diagnostics. A common point for access is particularly beneficial to facilitate Use Case 1 to sort vehicles at roadside inspection operations into those vehicles that may proceed without additional inspection and those vehicles that deserve additional inspection. A common access point can also be beneficial to implement Use Case 2 supporting inspection and maintenance (IM) operations after the vehicles have been sorted.

SAE J1939-73 implements a component-focused set of diagnostic services, to support (sub-) system repairs. The implementation of the VOBD function leverages this set, and adds methods for aggregating (sub-) system diagnostic status into a composite information set that supports sorting vehicles and identification of those (sub-) systems in need of repair. Networks that support WWH OBD must support PGN 64868 HRWV, Harmonized Road Worthiness – Vehicle. HRWV provides the vehicle-level assessment of roadworthiness, the MI, readiness, and the duration of MI illumination. PGN 64867 HRWS Harmonized Road Worthiness – System provides the individual (sub-) system contribution to aggregate into the vehicle level assessment. Section 9.3 discusses the architectures, which can be supported using the HRWV and HRWS messages. Section 9.4 describes the aggregation of HRWS messages into the HRWV message.

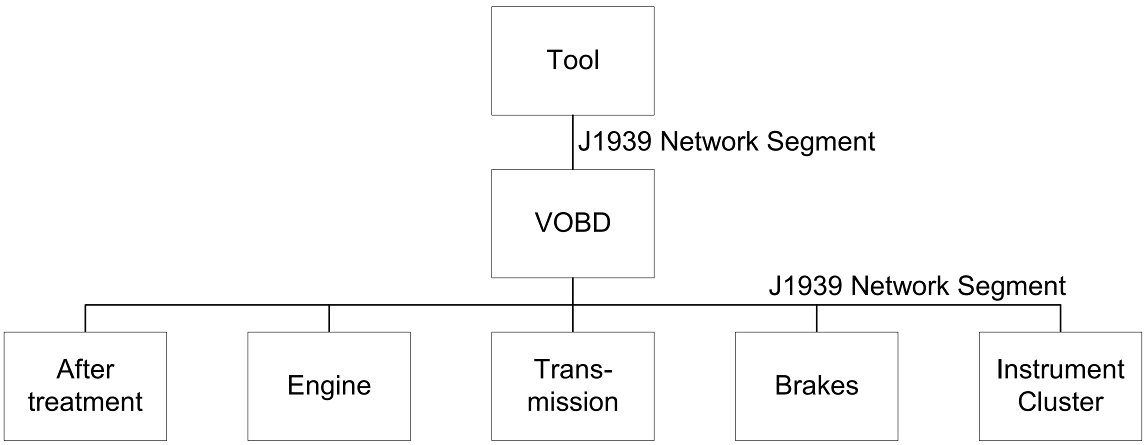
9.3 VOBD Function Implementation Architecture

The HRWV and HRWS messages are intended to function across a variety of physical architecture concepts. Example architecture concepts are illustrated in Figure 4. Figure 4A illustrates a common distributed architecture for a vehicle. The VOBD function is assigned to a unique physical device. Figure 4B illustrates a 'gateway' architecture where the VOBD function lies, as a unique physical device, between the tool and the vehicle network. Both the connections between the Tool and the VOBD function and the VOBD function and the vehicle are shown as SAE J1939 segments. Figure 4c shows the VOBD function co-located or embedded within the engine ECU. The VOBD function is not contained in its own unique physical device in Figure 4C.

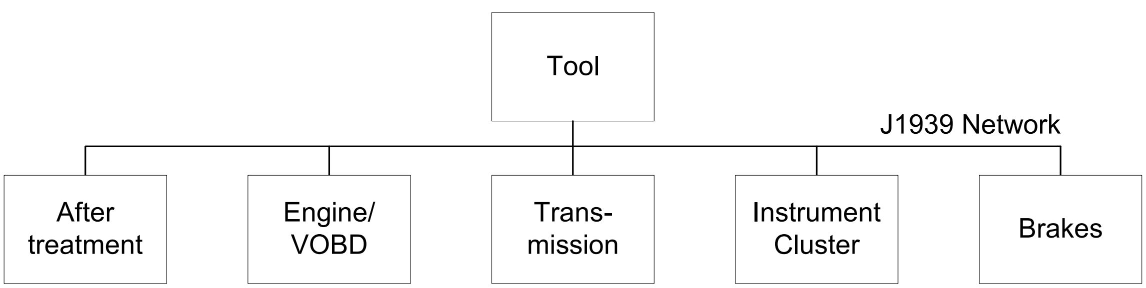
The structure of the HRWV and HRWS messages provides the flexibility to assign the logical VOBD function across multiple architectural concepts. The VOBD device must claim the OBD function and a physical address, if the device does not implement any other function. A device that integrates the VOBD function may claim the OBD function and an additional address, if a separate address for the OBD function is preferred. Since the only the VOBD function responds to requests for HRWV, the VOBD function is readily identified by a request for PGN 64868, independent of whether any SAE J1939 device claims the OBD function. Figures 4A and 4B show the VOBD in a distinct device, where the device would claim the OBD function. The OBD function will not be claimed for figure 4C, since the engine directly supports PGN 64868. A device that only implements the VOBD function will claim the OBD function (function 62) using the preferred address 164 as given in SAE J1939 Tables B2 or B3. If address 164 is not available under the rules established in SAE J1939-81, then the VOBD function may use address 43.



A) Distributed Architecture Example



B) Gateway Architecture Example



C) Embedded Architecture Example

FIGURE 4 - VOBD FUNCTION ARCHITECTURE EXAMPLES

9.4 VOBD Function Vehicle Level Aggregation

Figure 5 demonstrates the information flow for the HRWS and HRWV messages based on the functional architecture. The functional architecture is independent of the physical architectures illustrated in Figure 4. For Use Case 1, the tool only communicates with the VOBD function. The tool requests PGN 64868 HRWV, to determine MI and readiness status. A passing result would not require the tool to inquire upon the VIN, unless it is desired for inspection record keeping. To provide a common access point for Use Case 1, it is necessary to assign VIN access to the VOBD function. VIN (SPN 237, Vehicle Identification Number) is provided in response to a request for PGN 65260.

HRWV message content provides the overall view of vehicle roadworthiness and readiness. Vehicle Continuous Malfunction Indicator, Vehicle Malfunction Indicator Display Strategy, Vehicle Malfunction Indicator Activation Mode and Vehicle Current MI Accumulated Time MIL present the worst case answers from individual HRWS messages. Vehicle Non-Roadworthy Component Count and Vehicle Incomplete Monitor Count are sums of the individual system counts. Under this definition, zero values indicate that all regulated systems of the vehicle are roadworthy and all monitors completed execution. The HRWS messages (PGN 64867) are sent to the VOBD function periodically by individual systems. Referring to Figure 4, separate HRWS messages may be sent by the Aftertreatment System and by the Engine System. This demonstrates a functional assignment of WWH OBD requirements across individual (sub-) systems.

The VOBD function aggregates the individual HRWS messages by summing the System Non-Roadworthy Component Count(s) and System Incomplete Monitor Count(s). Worst case logic aggregates System Continuous Malfunction Indicator, System Malfunction Indicator Display Strategy, and System Malfunction Indicator Activation Mode. The VOBD function also uses worst case logic to select from the (sub-) system records of MI illumination (PGN 49408 DM21 SPN 3144 Minutes Run by Engine While MIL is Activated) to provide the maximum value as Vehicle Current MI Accumulated Time (SPN 4138).

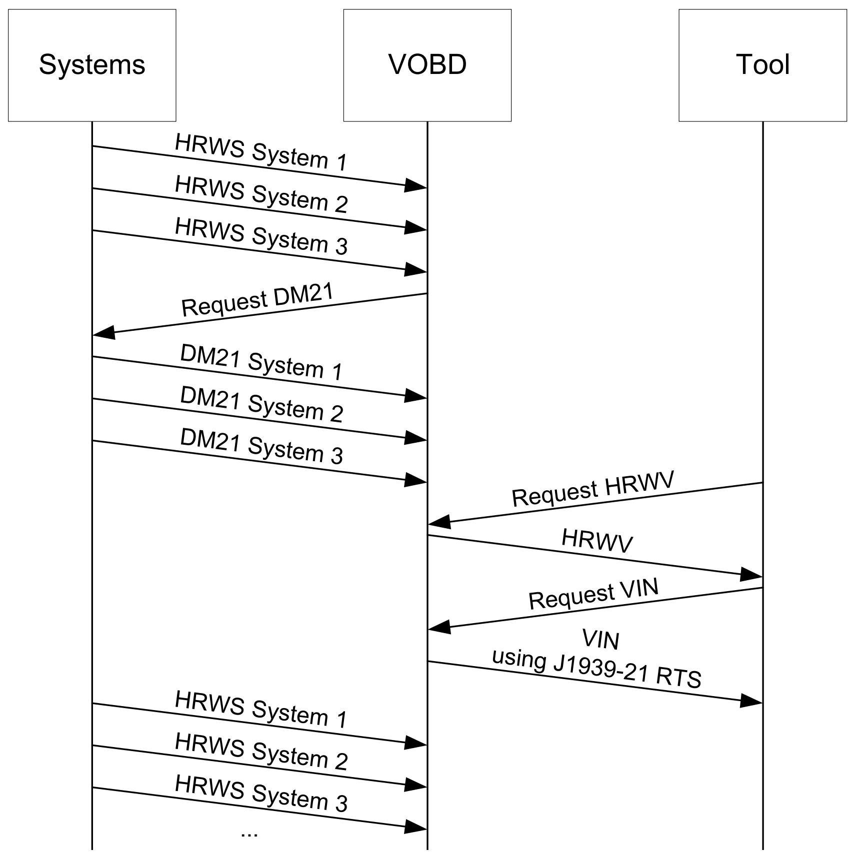
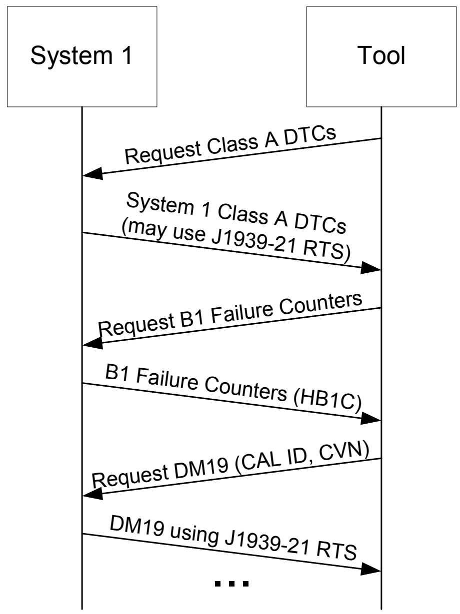


FIGURE 5 - VOBD FUNCTION VEHICLE READINESS AGGREGATION

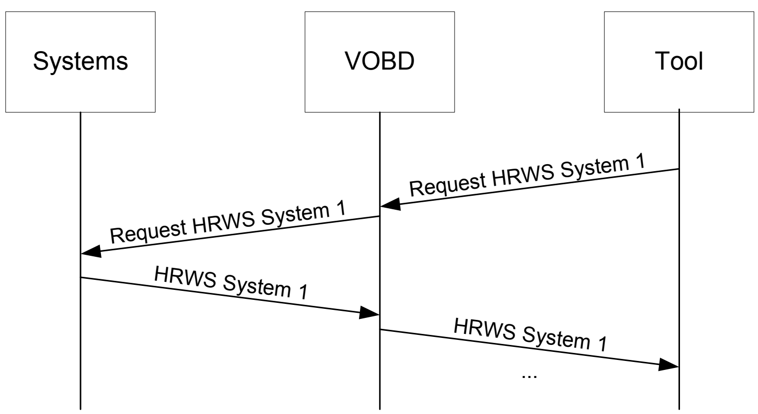
9.5 VOBD Function Use Case 2 and Use Case 3 Considerations

Since the scope of an inspection may be limited to a given (sub-) system of the vehicle, and in the future this (sub-) system will be other than the emissions control system, as discussed in WWH OBD GTR Module A, the component-centric approach in SAE J1939-73 is used for Use Case 2 and Use Case 3 information requests. In Use Case 2, the individual contributions provided by HRWS, PGN 64867, may be used to review the results of a specific subsystem, when only that (sub-) system is being inspected. HRWS message content will also indicate which system may have priority by making the greatest contribution to HRVW. Then, the services support from SAE J1939-73 may be used to assess and repair the vehicle. Example inquiries are shown in Figure 6. Figure 6A shows direct communication between a tool and an individual system, which follows from Figure 4A and 4C. Figure 6B shows the resulting message flow resulting from Figure 4B.

Providing a single access point for all Use Case 2 and Use Case 3 information on a SAE J1939 network duplicates existing SAE J1939 functions or results in the use of the transfer PGN (see SAE J1939-21). Given the distributed architecture examples in Figure 4A and 4C, inquiries to the VOBD function would be repeated from the VOBD function to the other network devices. Then the network devices would send their response back to the VOBD, Finally, the VOBD function would send the responses back to the tool. Since the tool, the network devices, and the VOBD function are on the same network segment, this functional process doubles the network air time used for a single request. To eliminate this duplication, SAE J1939-73 provides a uniform set of diagnostic services that all network devices can support.



A) Use Case 2 Inspection/Maintenance Direct Example



B) Use Case 2 Inspection/Maintenance Gateway Example

FIGURE 6 - USE CASE 2 EXAMPLES

10. NOTES

10.1 Marginal Indicia

A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

PREPARED BY THE SAE TRUCK AND BUS CONTROL AND COMMUNICATIONS NETWORK SUBCOMMITTEE
OF THE SAE TRUCK AND BUS ELECTRICAL AND ELECTRONIC COMMITTEE

APPENDIX A - INDEX OF WWH OBD SUPPORT

Appendix A maps the existing GTR into the support defined in SAE J1939 messages. Principally these messages are defined in SAE J1939-73 and SAE J1939-71. Three use cases are discussed in Section 4.7.1 of Module B of the WWH OBD GTR. The communication data for these use cases are found in Sections 4.7.1.1, 4.7.1.2, and 4.7.1.3. Section 4.7.1.1 documents Use Case 1. Section 4.7.1.2 documents Use Case 2, and Section 4.7.1.3 documents Use Case 3. The support for these use cases is reviewed in Sections B.1 through B.3 below.

The mapping shows the support developed in SAE J1939-73 Application Layer Diagnostics for Section 4.7.1.1 of Module B of the WWH OBD GTR. Section 4.7.1.1 describes Use Case 1, information about the engine state. The SAE J1939-73 definitions for Use Case 1 support the vision given in module A, by providing a means to communicate overall vehicle roadworthiness

These messages include support for the implementation of the VOBD function discussed in ISO PAS 27145-1. An indication of overall readiness, for roadworthiness reporting (commonly known as Use Case 1) is provided in the HRWV message. This message is capable of aggregating the GTR required emissions OBD information with information from other vehicle systems that may be subject to OBD in the future. A component (or subsystem) level message is defined to report the status from independent GTR requirements so that the VOBD can easily calculate the overall vehicle readiness.

Finally, failure reporting for class A, B1, B2, and C malfunctions is provided in new messages that further characterize these failures. Analysis of the required parametric data and freeze frame data requirements is beyond the scope of this report. This data is defined in Annex 5 of GTR Module B.

A.1 WWH OBD USE CASE 1 MAPPING

Table A1 below maps the GTR requirements into SAE J1939 SPNs and messages for Use Case 1, information about engine state.

TABLE A1 - WWH OBD USE CASE 1 MAPPING

Module B GTR Text	Mapping to SAE J1939-73/-71
4.7.1. Recorded information	Not a detailed requirement
- discriminatory/non-discriminatory display strategy	–73 PGN 64868 HRWV SPN 4135 Vehicle Malfunction Indicator Display Strategy
- the VIN (vehicle identification number)	–71 PGN 65260 SPN 237 Vehicle Identification Number
- presence of a continuous-MI	–73 PGN 64868 HRWV SPN 4134 Vehicle Continuous Malfunction Indicator –73 PGN 64868 HRWV SPN 4135 Vehicle Malfunction Indicator Activation Mode [–73 PGN 65226 DM1 SPN 1213 MIL_Status will also indicate a continuous MI in DM1 for a given component.]
- the readiness of the OBD system	–73 PGN 64868 HRWV SPN 4137 Vehicle Incomplete Monitor Count –73 PGN 64868 HRWV SPN 4133 Vehicle Non-Roadworthy Component Count
- the number of engine operating hours during which a continuous-MI was last activated (continuous-MI counter)	–73 PGN 64868 HRWV SPN 4138 Vehicle Current MI Accumulated Time –73 PGN 49408 DM21 SPN 3144 Minutes Run by Engine While MIL is Activated

This information shall be read only access (i.e. no clearing).

A.2 WWH OBD USE CASE 2 MAPPING

Table A2 below maps the GTR requirements into SAE J1939 SPNs and messages for Use Case 1, information about engine state.

TABLE A2 - WWH OBD USE CASE 2 MAPPING

Module B GTR Text	Mapping to SAE J1939-73/-71
4.7.1.2. Information about active emission-related malfunctions	Not a detail requirement
This information will provide any inspection station with a subset of engine related OBD data including the malfunction indicator status and associated data (MI counters), a list of active/confirmed malfunctions of classes A and B and associated data (e.g. B1-counter). [A typical use of this information package may be to establish detailed understanding of the emission road-worthiness of the engine system]	
The OBD system shall provide all information (according to the applicable standard set in module A annex 1) for the external inspection test equipment to assimilate the data and provide an inspector with the following information:	
- the gtr (and revision) number	–73 PGN 64866 HGRD SPN 4144 Global Technical Regulation Description
- discriminatory/ non-discriminatory display strategy	–73 PGN 64867 HRWS SPN 4141 System Malfunction Indicator Display Strategy
- the VIN (vehicle identification number)	–71 PGN 65260 SPN 237 Vehicle Identification Number
- the Malfunction Indicator status	–73 PGN 64867 HRWS SPN 4140 System Continuous Malfunction Indicator –73 PGN 64867 HRWS SPN 4142 System Malfunction Indicator Activation Mode [–73 PGN 65226 DM1 SPN 1213 MIL_Status will also indicate a continuous MI in DM1 for a given component.]
- the Readiness of the OBD system	–73 PGN 64867 HRWS SPN 4143 System Incomplete Monitor Count –73 PGN 64867 HRWS SPN 4139 System Non-Roadworthy Component Count ...and existing details from –73 PGN 65230 DM5 as shown below for Annex 3 [Note: Secondary Air [AIR_CMPL,] A/C (R12) Monitoring [ACRFCMPL,] O2_Sensor Heating Monitoring [HTR_CMPL] are not specified for WWH OBD]
Electric / Electronic Components Monitoring (Annex 3 - Appendix 1)	–73 PGN 65230 DM5 SPN 1221 Byte 4 Bit-7 Comprehensive Component Monitoring Status
Diesel Particulate Filter (DPF), Or Particulate Matter Trap (Annex 3 - Appendix 2)	–73 PGN 65230 DM5 SPN 1223 Byte 6 Bit-3 PM filter
Selective Catalytic Reduction (SCR) Monitoring (Annex 3 - Appendix 3)	–73 PGN 65230 DM5 SPN 1223 Byte 6 Bit-4 NOx converting catalyst and/or NOx adsorber
Lean-NOx Trap (LNT, or NOx Adsorber) (Annex 3 - Appendix 4)	–73 PGN 65230 DM5 SPN 1223 Byte 6 Bit-4 NOx converting catalyst and/or NOx adsorber
Diesel Oxidation Catalyst (DOC) Monitoring (Annex 3 - Appendix 5)	–73 PGN 65230 DM5 SPN 1223 Byte 6 Bit-5 NMHC Converting Catalyst System Monitoring Status
Exhaust Gas Recirculation (EGR) System Monitoring (Annex 3 - Appendix 6)	–73 PGN 65230 DM5 SPN 1223 Byte 7 Bit-8 EGR System Monitoring Status
Fuel System Monitoring (Annex 3 Appendix 7)	–73 PGN 65230 DM5 SPN 1221 Byte 4 Bit-6 Fuel System Monitoring Status

TABLE A2 - WWH OBD USE CASE 2 MAPPING (CONTINUED)

Module B GTR Text	Mapping to SAE J1939-73/-71
Air Handling And Turbocharger/Boost Pressure Control System (Annex 3 Appendix 8)	–73 PGN 65230 DM5 SPN 1223 Byte 6 Bit-2 Boost pressure control system
Variable Valve Timing (VVT) System (Annex 3 Appendix 9)	Reuse existing bit
Misfire Monitoring (Annex 3 Appendix 10)	–73 SPN 1221 PGN 65230 DM5 Byte 4 Bit-5 Misfire Monitoring Status
Crankcase Ventilation System Monitoring (Annex 3 Appendix 11)	Reuse existing bit
Engine Cooling System Monitoring (Annex 3 Appendix 12)	Reuse existing bit
Exhaust Gas Sensor Monitoring (Annex 3 Appendix 13)	–73 PGN 65230 DM5 SPN 1223 Byte-7 Bit-6 Oxygen Sensor Monitoring Status
Idle Speed Control System Monitoring (Annex 3 Appendix 14)	Reuse existing bit
- number of warm-up cycles and - number of engine operating hours since recorded OBD information was last cleared	–73 PGN 64952 DM26 SPN 3151 Number of Warm-ups Since DTCs Cleared –73 PGN 49408 DM21 SPN 3145 Time Since Diagnostic Trouble Codes Cleared
- the number of engine operating hours during which a continuous-MI was last activated (continuous-MI counter)	–73 PGN 49408 DM21 SPN 3144 Minutes Run by Engine While MIL is Activated
- the cumulated operating hours with a continuous-MI (cumulative continuous-MI counter)	–73 PGN 64865 HCMI SPN 4145 System Cumulative Continuous MI Time
- the value of the B1 counter with the highest number of engine operating hours	–73 PGN 64865 HCMI SPN 4146 System Greatest B1 Counter
- the confirmed and active DTCs for Class A malfunctions	–73 Tables 25 and 26
- the confirmed and active DTCs for Classes B (B1 and B2) malfunctions	–73 Tables 25 and 26 Reuse DM12 for all active DTCs.
- the confirmed and active DTCs Class B1 malfunctions	–73 Tables 25 and 26
- the software calibration identification(s)	–73 PGN 54016 DM19 SPN 1635 Calibration Identification (CAL ID)
- the calibration verification number(s).	–73 PGN 54016 DM19 SPN 1634 Calibration Verification Number (CVN)

This information shall be read only access (i.e. no clearing).

NOTE: It should be understood that loading a new calibration would likely change this data. Lists of DTCs and readiness have traditionally been cleared when DTCs are cleared.

A.3 WWH OBD USE CASE 3 MAPPING

Use Case 3 defines the required capabilities for repair of regulated equipment. The information in WWH OBD GTR Module B, Annex 5 is not mapped by this table. Annex 5 describes parametric data and freeze frame information content.

TABLE A3 - WWH OBD USE CASE 3 MAPPING

Module B GTR Text	Mapping to SAE J1939-73/-71
4.7.1.3. Information for repair	
This information will provide repair technicians with all OBD data specified in this module (e.g. freeze frame information).	
The OBD system shall provide all information (according to the applicable standard set in module A annex 1) for the external repair test equipment to assimilate the data and provide a repair technician with the following information:	
- the gtr (and revision) number	–73 PGN 64866 HGRD SPN 4144 Global Technical Regulation Description
- the VIN (vehicle identification number)	–71 PGN 65260 SPN 237 Vehicle Identification Number
- the malfunction indicator status	–73 PGN 64867 HRWS SPN 4140 System Continuous Malfunction Indicator –73 PGN 64867 HRWS SPN 4142 System Malfunction Indicator Activation Mode [–73 PGN 65226 DM1 SPN 1213 MIL_Status will also indicate a continuous MI in DM1 for a given component.]
- the readiness of the OBD system	See Use Case 2 breakdown
- number of warm-up cycles and - number of engine operating hours since recorded OBD information was last cleared	–73 PGN 64952 DM26 SPN 3151 Number of Warm-ups Since DTCs Cleared –73 PGN 49408 DM21 SPN 3145 Time Since Diagnostic Trouble Codes Cleared
- monitor status (i.e., disabled for the rest of this drive cycle complete this drive cycle, or not complete this drive cycle) since last engine shut-off for each monitor used for readiness status	–73 PGN 64952 DM26 SPNs 3152, 3153, 3254 with omissions as noted for Use Case 2 above for new monitor readiness status requirements.
- the number of engine operating hours since the malfunction indicator has been activated (continuous MI counter)	–73 PGN 49408 DM21 SPN 3144 Minutes Run by Engine While MIL is Activated
- the confirmed and active DTCs for Class A malfunctions	–73 Tables 25 and 26 as shown below
- the confirmed and active DTCs for Classes B (B1 and B2) malfunctions	–73 Tables 25 and 26 as shown below. Reuse DM12 for all active DTCs.
- the cumulated operating hours with a continuous-MI (cumulative continuous-MI counter)	–73 PGN 64865 HCMI SPN 4145 System Cumulative Continuous MI Time
- the value of the B1 counter with the highest number of engine operating hours	–73 PGN 64865 HCMI SPN 4146 System Greatest B1 Counter
- the confirmed and active DTCs for Class B1 malfunctions and the number of engine operating hours from the B1-counter(s)	–73 PGN 64952 HB1C SPN 4147 Failure Specific B1 Counter
- the confirmed and active DTCs for Class C malfunctions	–73 Tables 25 and 26
- the pending DTCs and their associated class	Reuse DM6 –73 Tables 25 and 26
- the previously active DTCs and their associated class	Reuse DM23 –73 Tables 25 and 26

TABLE A3 - WWH OBD USE CASE 3 MAPPING (CONTINUED)

Module B GTR Text	Mapping to SAE J1939-73/-71
- real-time information on OEM selected and supported sensor signals, internal and output signals (see paragraph 4.7.2 and Annex 5)	–73 PGN 64950 DM24 SPN Support (Indicates support for Freeze Frame, Broadcast and Request information. Identified information may be defined by SAE J1939-71)
- the freeze frame data requested by this module (see paragraph 4.7.1.4 and Annex 5)	–73 PGN 64950 DM24 SPN Support –73 PGN 64951 DM25 Expanded Freeze Frame
- the software calibration identification(s)	–73 PGN 54016 DM19 SPN 1635 Calibration Identification (CAL ID)
- the calibration verification number(s)	–73 PGN 54016 DM19 SPN 1634 Calibration Verification Number (CVN)
The OBD system shall clear all the recorded malfunctions of the engine system and related data (operating time information, freeze frame, etc…) in accordance with the provisions of this module, when this request is provided via the external repair test equipment according to the applicable standard set in module A annex 1	–73 PGN 65235 DM11 Diagnostic Data Clear/Reset of Previously Active DTCs

A.4 WWH OBD FAULT CLASSIFICATION REPORTING

WWH OBD GTR Module B provides for four fault classifications, A, B1, B2, and C. Separate services are defined for each classification. Table B4 shows messages are assigned by classification and status. Separate services are provided for Pending, Confirmed and Active, and Previously Active status.

TABLE A4 - WWH OBD FAULT REPORTING MESSAGES BY STATUS AND SEVERITY CLASS

Severity Class/ Status	Class A	Class B1	Class B2	Class C	*All*
Pending	DM41	DM44	DM47	DM50	DM6
Confirmed and Active	DM42	DM45	DM48	DM51	DM12
Previously Active	DM43	DM46	DM49	DM52	DM23

APPENDIX B - HD OBD AND OBD II IM PROCEDURE

Appendix B recommends an IM flow for vehicles that support SAE J1939 for OBD II and HD OBD.

B.1 HD OBD AND OBD II IM PROCEDURE INTRODUCTION

Section B.2 provides a procedure for Heavy Duty OBD Inspection and Maintenance. The procedure is documented as flowcharts with additional comments on the callouts. The process describes logical steps that may be used to perform the OBD portion of an Inspection and Maintenance test.

Wherever possible, the reasoning for such a sequence has been noted either directly on the chart or on the footnote list at the end of the flowchart so that if the sequence is modified, appropriate steps may be taken by the state to avoid a problem (and thus have a better experience). Section B.3 documents specific callouts in the flowchart that do not fit in the figures.

This document and EPA's guidance as to how the inspection should be performed are updated periodically, as more issues are uncovered, or as better technical solutions are discovered. Check with appropriate EPA personnel if you have questions regarding policy or technical decisions, or if field issues are determined to be concerns and industry should be notified.

B.2 SAE J1939/03 HEAVY DUTY HD-OBD I/M TEST PROCESS

Figures B1 through B14 define a model OBD I/M test process for vehicles using SAE J1939 messages to satisfy OBD regulations. The process starts with Figure B1 and ends with Figure B14. Off-page connectors are used to skip sections as may be appropriate. Some status variables are included to control iteration attempts, and store intermediate results.

The flowcharts do not represent the only way that such tests can be performed – they are a descriptive example based on industry conventions for passenger car IM. As such, individual steps, suggested wording, etc. can be altered, modified, re-ordered, etc. to meet an individual jurisdiction's needs. The sequences portrayed by this flowchart are based on actual in-field experiences learned by industry individuals and expert groups.

The flowcharts are not intended to provide a detailed software design description. They provide an abstract representation of the process without, for example, describing how to manage communications using a given CAN controller interface to read and write messages.

Wherever possible, suggestions are given to ease the effort of implementation. Process steps included here have been specifically designed to minimize the chance for mistakes during the I/M test and to address known vehicle problems before they are found during state inspection program operation. Since it is based on existing passenger car IM procedures, the flowchart does not include consideration for DM28 permanent fault codes. See Section 8.4.1 for more information about permanent fault codes.

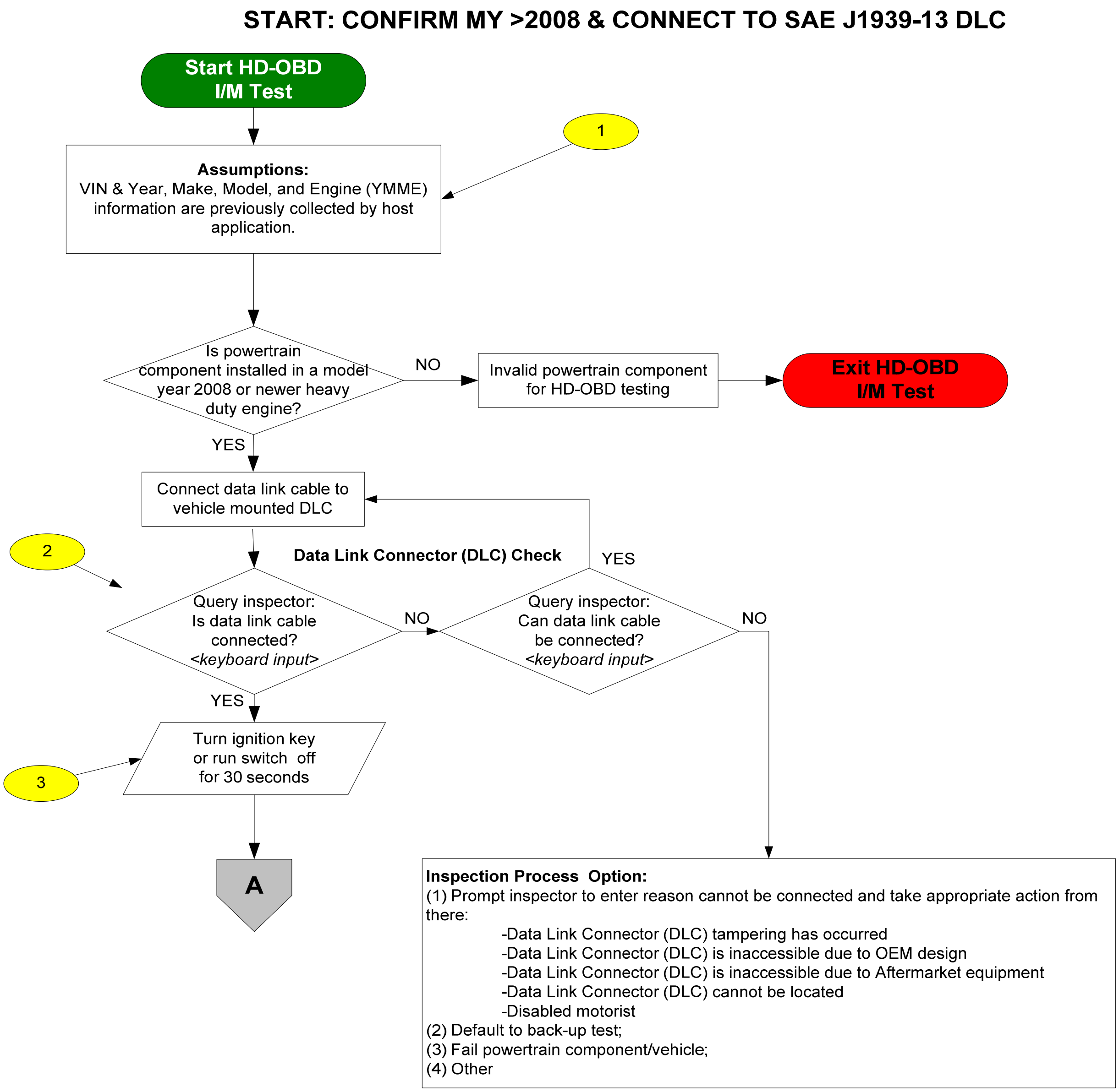


FIGURE B1 - SAE J1939-03 HEAVY DUTY HD-OBD I/M TEST PROCESS START

ON-BOARD DIAGNOSTIC MIL CHECK

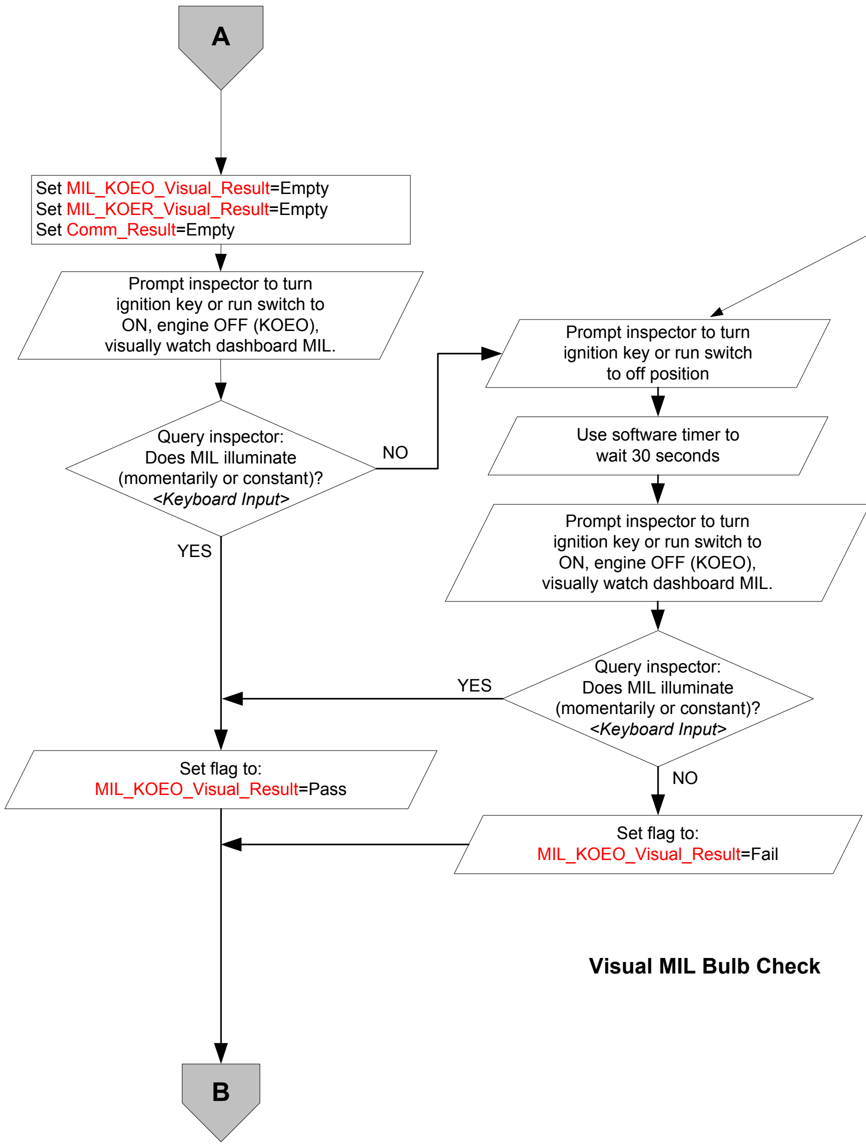


FIGURE B2 - SAE J1939-03 HEAVY DUTY HD-OBD I/M TEST PROCESS PAGE A

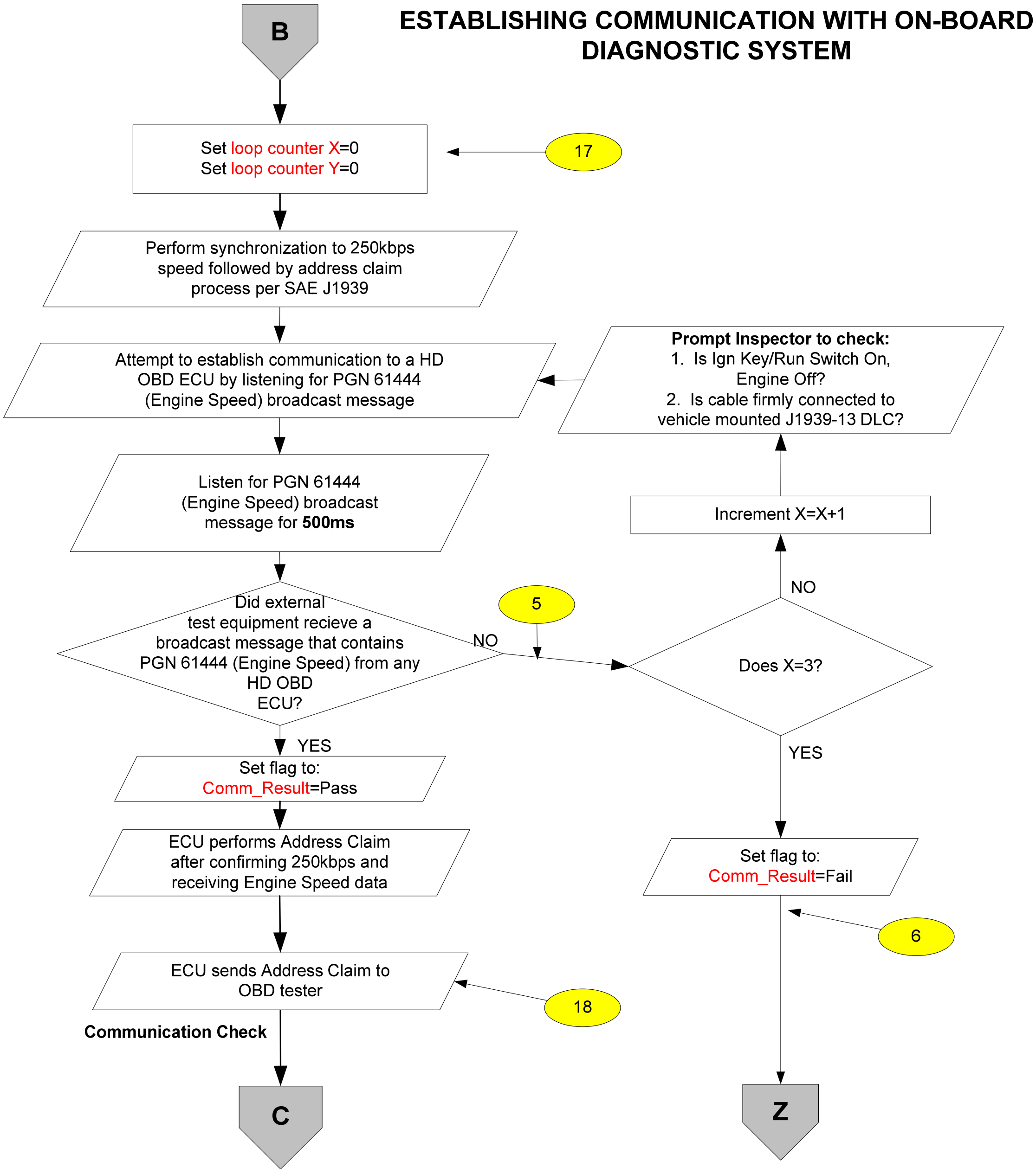


FIGURE B3 - SAE J1939-03 HEAVY DUTY HD-OBD I/M TEST PROCESS PAGE B

VERIFYING POWERTRAIN COMPONENT VALID FOR INSPECTION

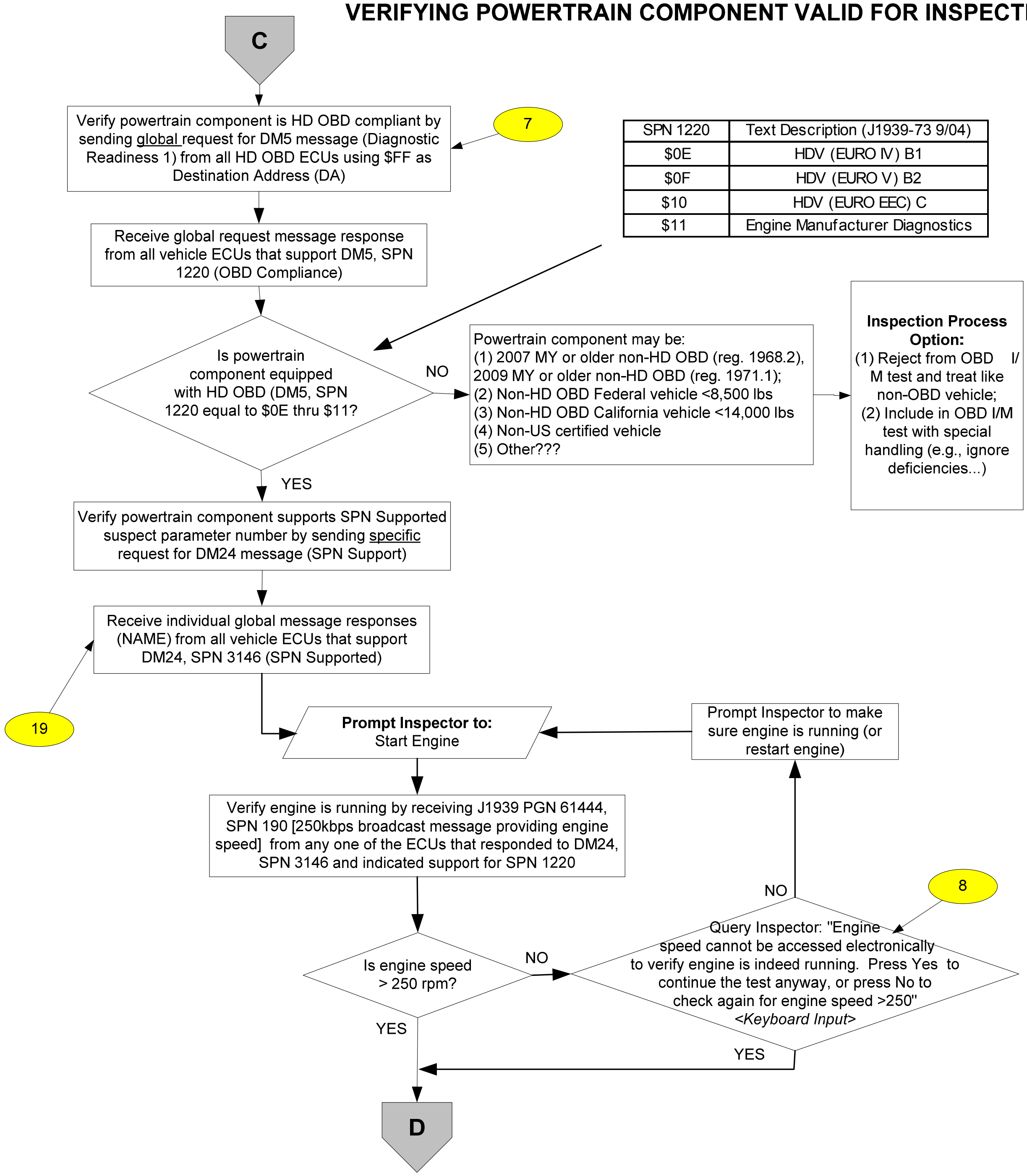


FIGURE B4 - SAE J1939-03 HEAVY DUTY HD-OBD I/M TEST PROCESS PAGE C

CHECK ELECTRONIC VIN SUPPORT

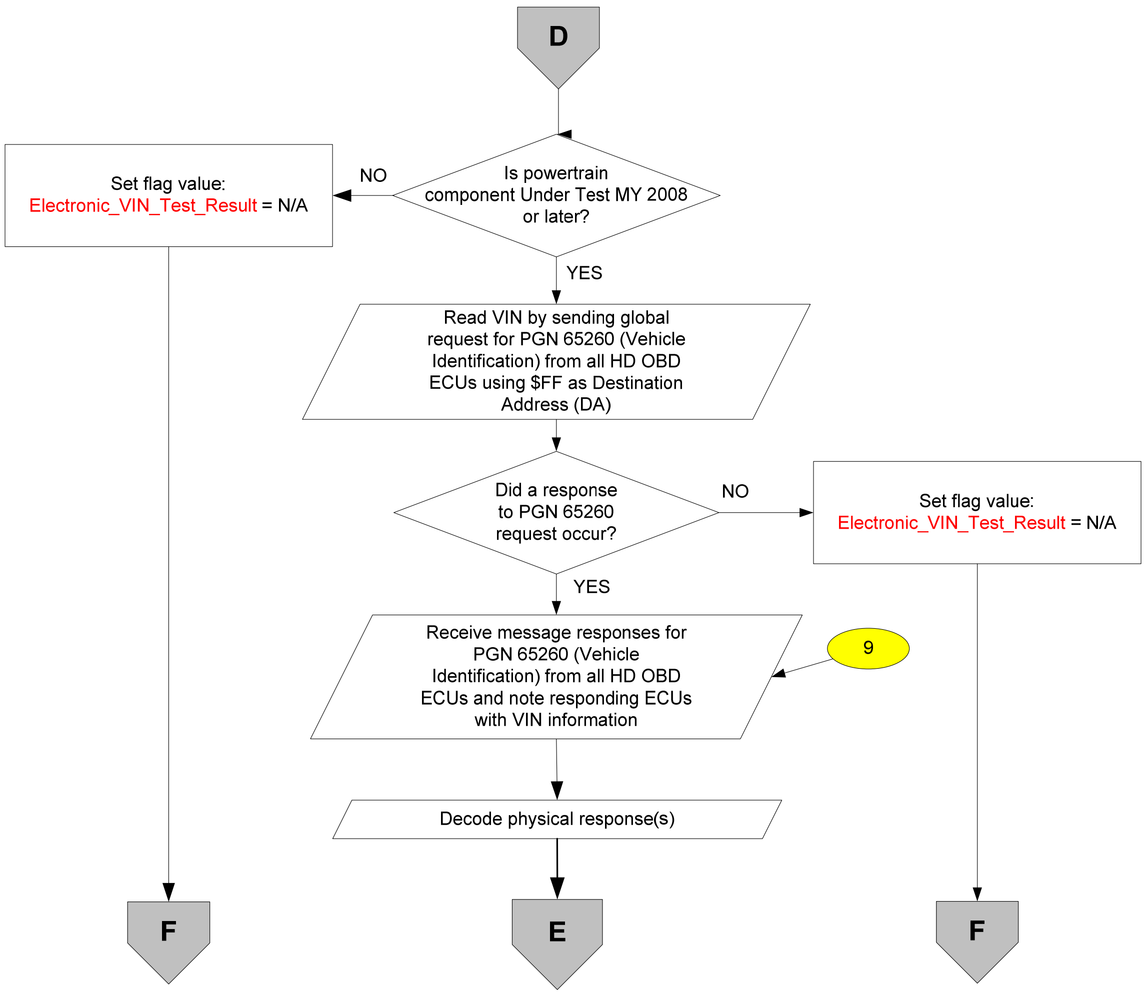


FIGURE B5 - SAE J1939-03 HEAVY DUTY HD-OBD I/M TEST PROCESS PAGE D

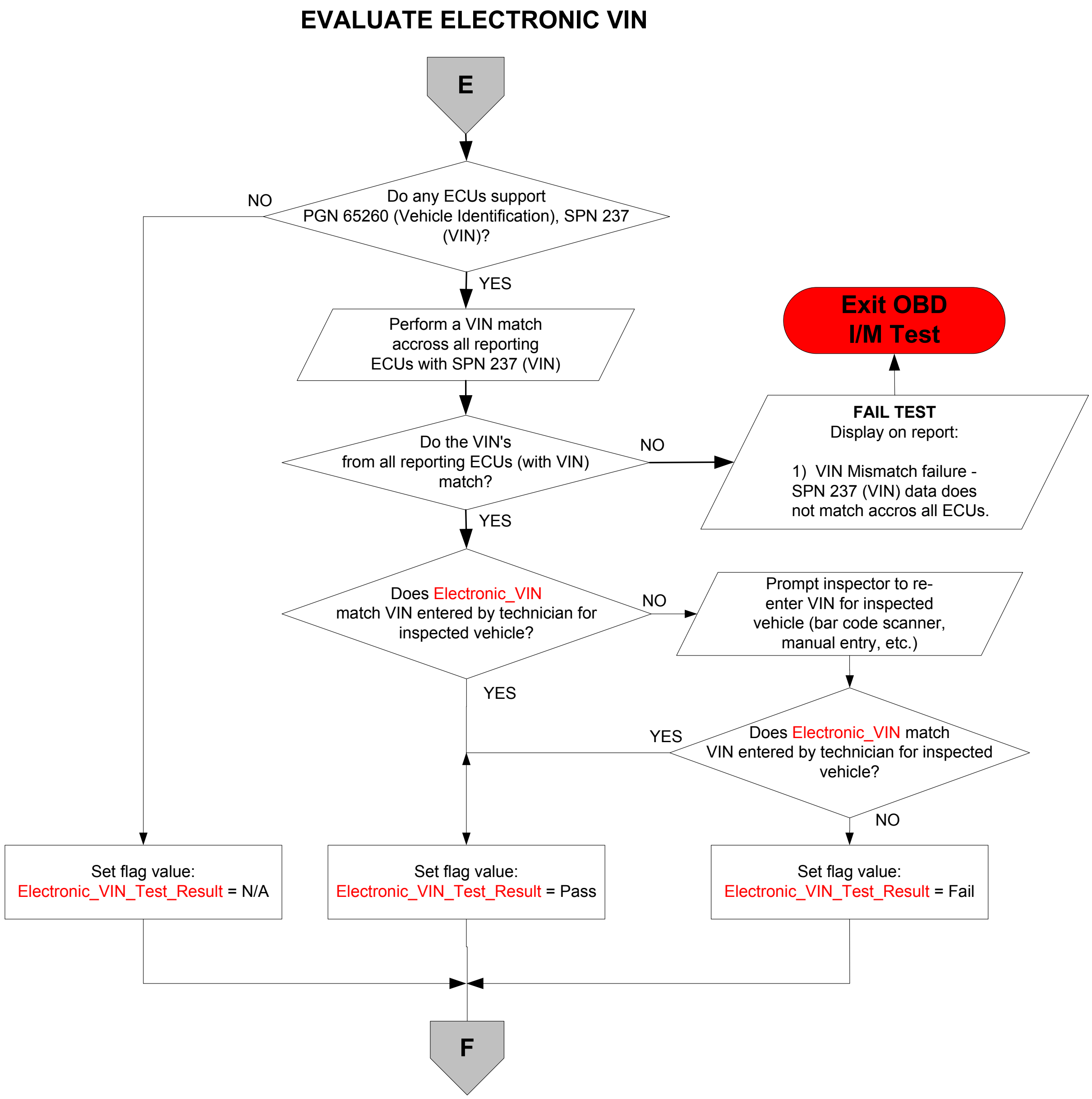


FIGURE B6 - SAE J1939-03 HEAVY DUTY HD-OBD I/M TEST PROCESS PAGE E

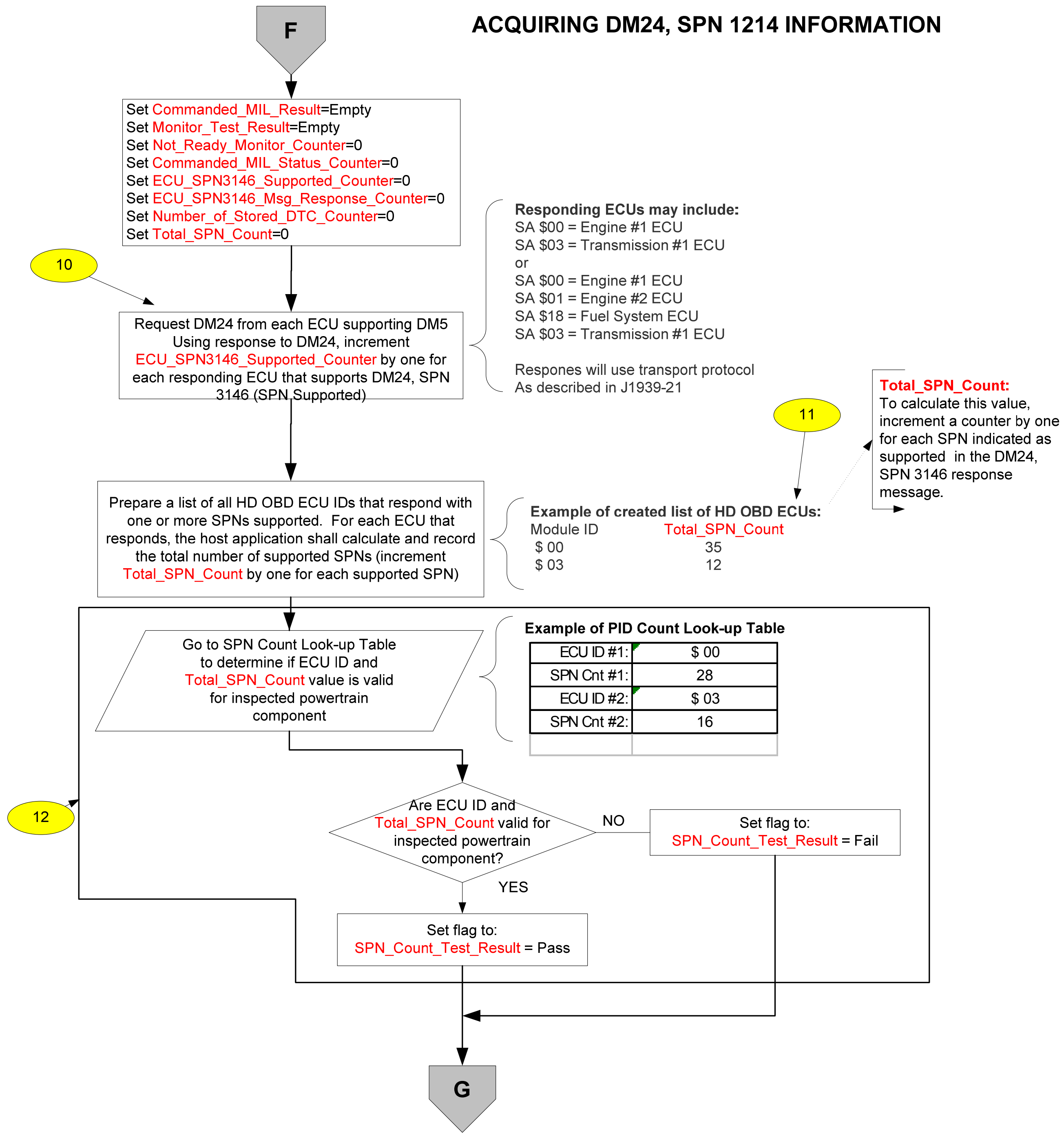


FIGURE B7 - SAE J1939-03 HEAVY DUTY HD-OBD I/M TEST PROCESS PAGE F

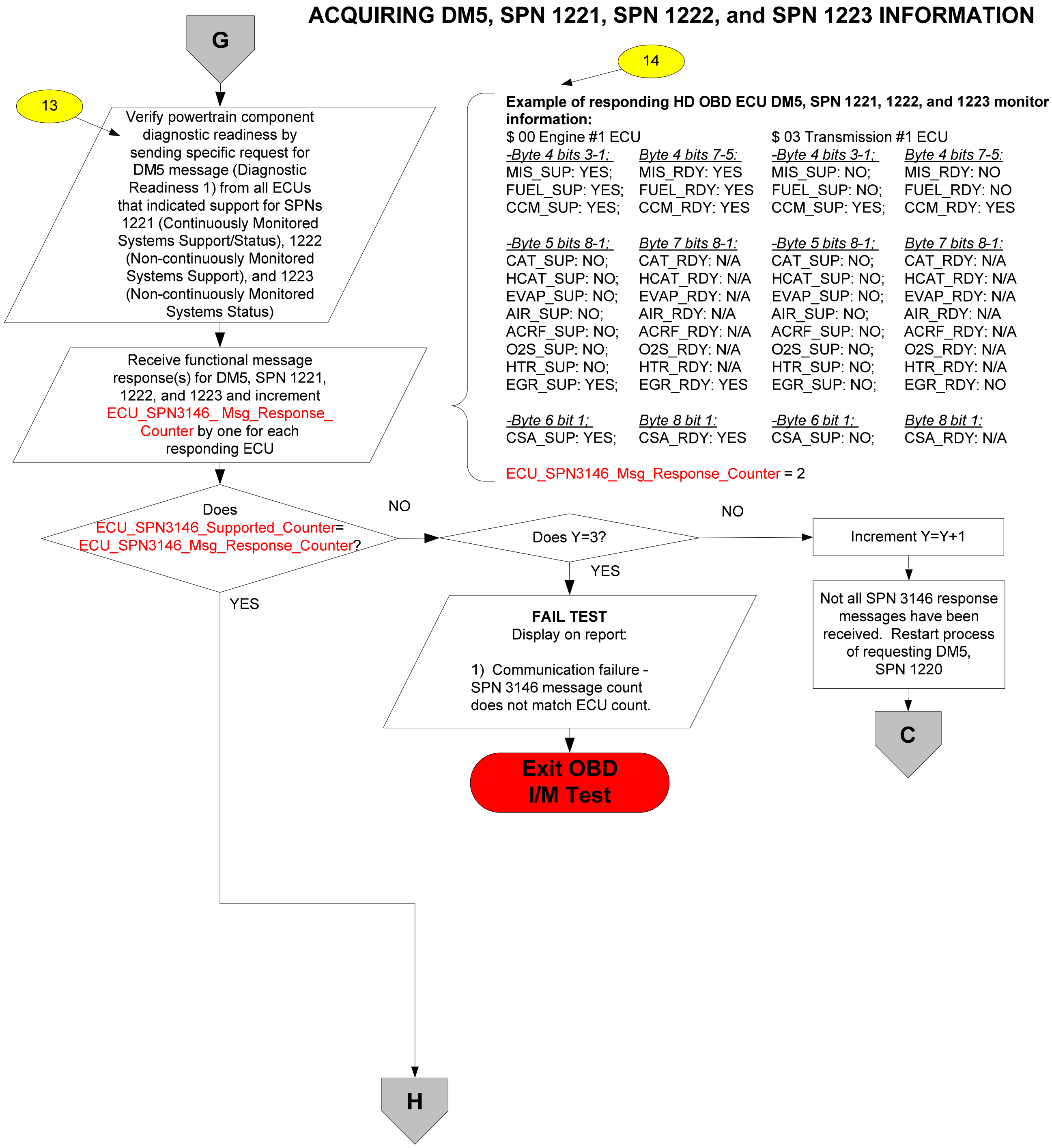


FIGURE B8 - SAE J1939-03 HEAVY DUTY HD-OBD I/M TEST PROCESS PAGE G

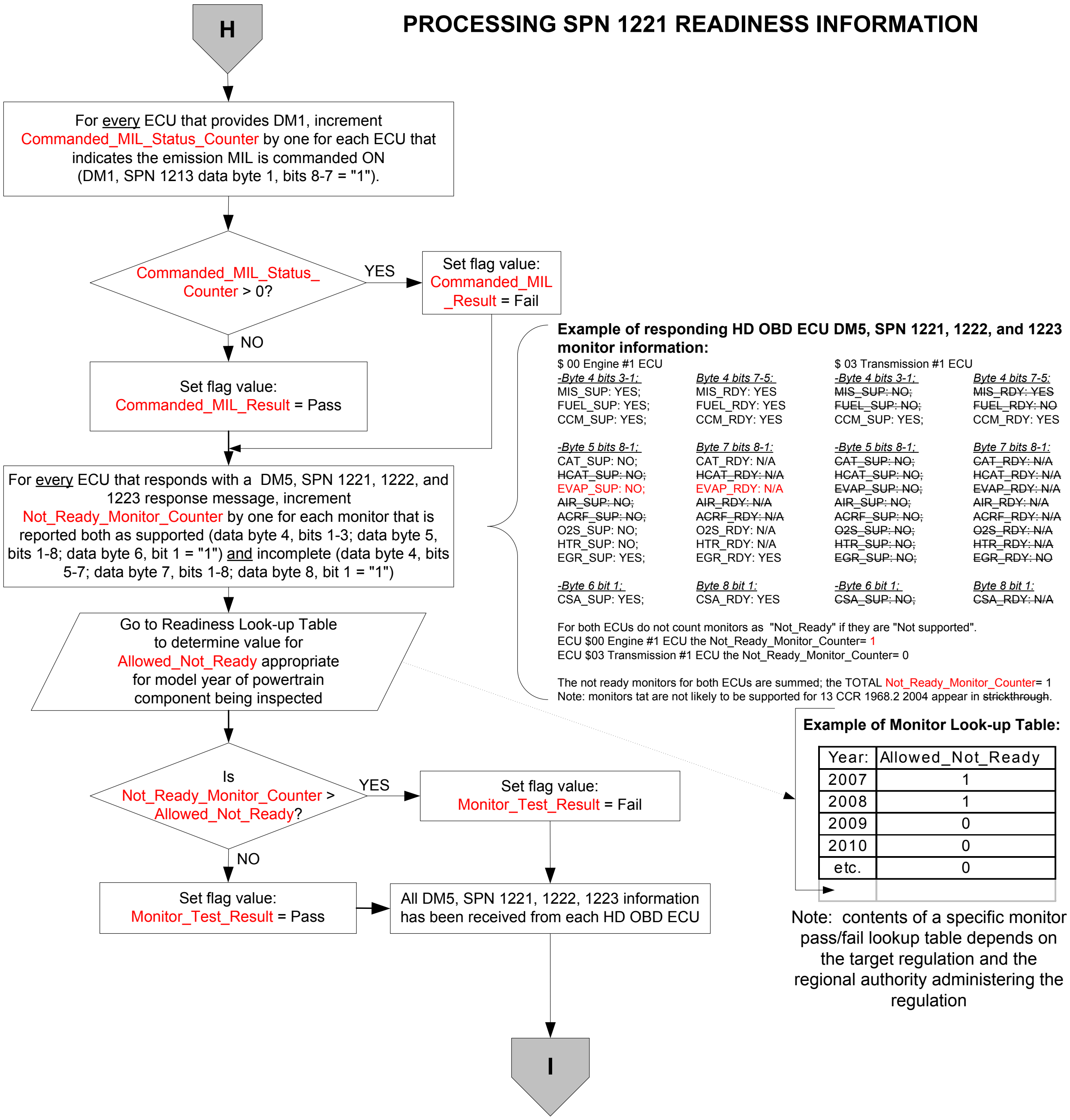


FIGURE B9 - SAE J1939-03 HEAVY DUTY HD-OBD I/M TEST PROCESS PAGE H

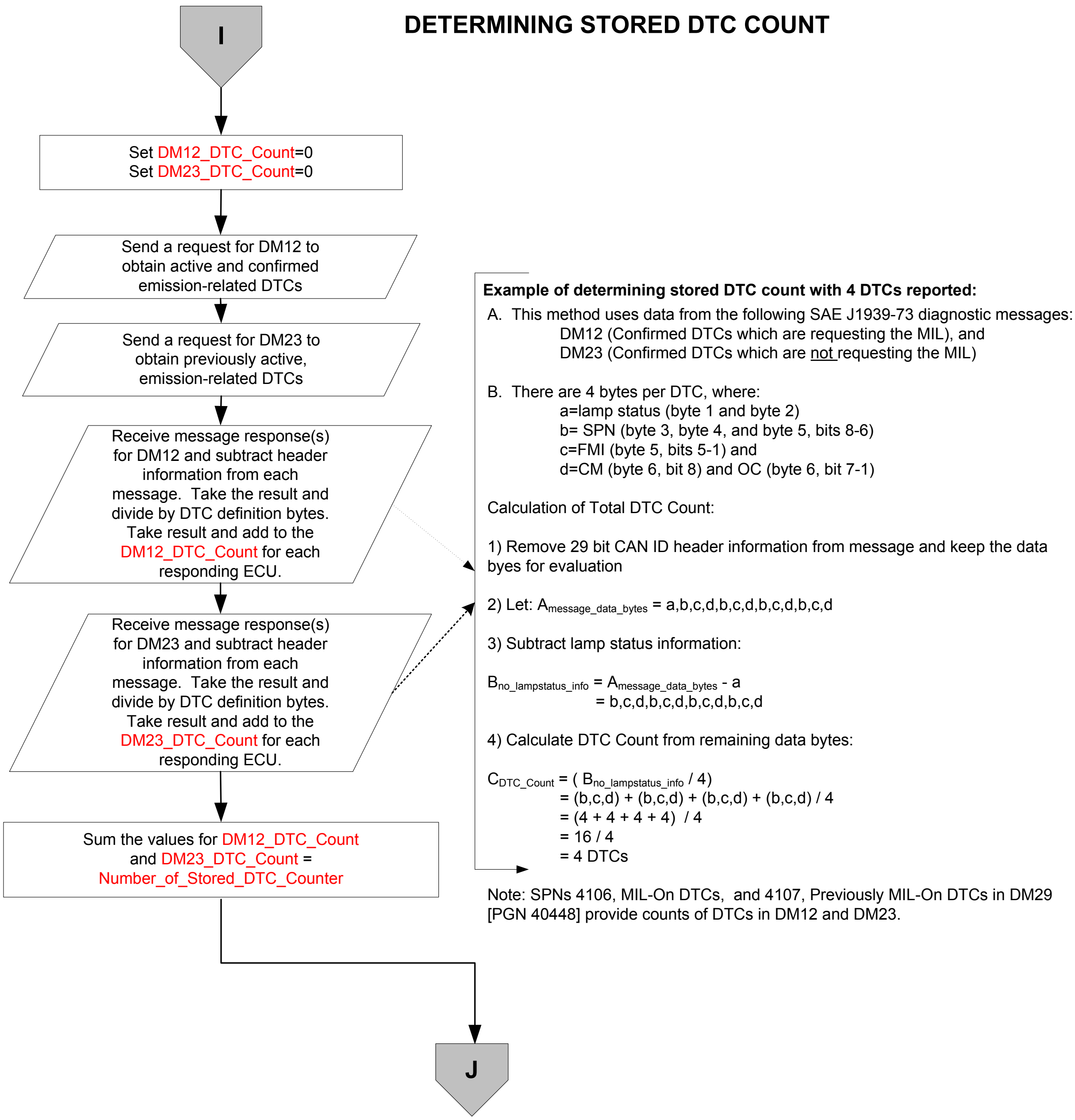
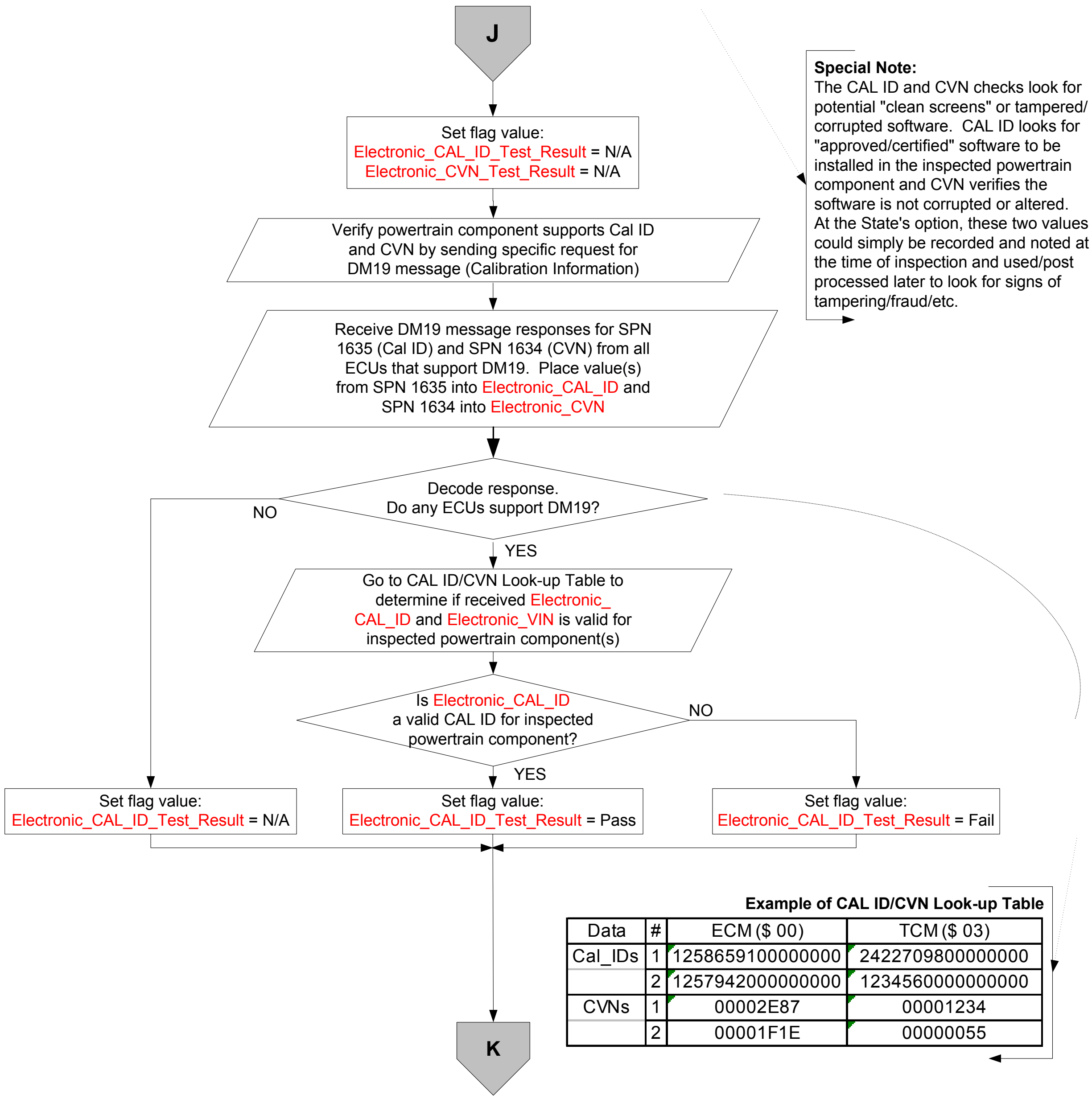


FIGURE B10 - SAE J1939-03 HEAVY DUTY HD-OBD I/M TEST PROCESS PAGE I

CHECK ELECTRONIC CAL ID AND CVN SUPPORT



Example of CAL ID/CVN Look-up Table

Data	#	ECM ($ 00)	TCM ($ 03)
Cal_IDs	1	1258659100000000	2422709800000000
	2	1257942000000000	1234560000000000
CVNs	1	00002E87	00001234
	2	00001F1E	00000055

FIGURE B11 - SAE J1939-03 HEAVY DUTY HD-OBD I/M TEST PROCESS PAGE J

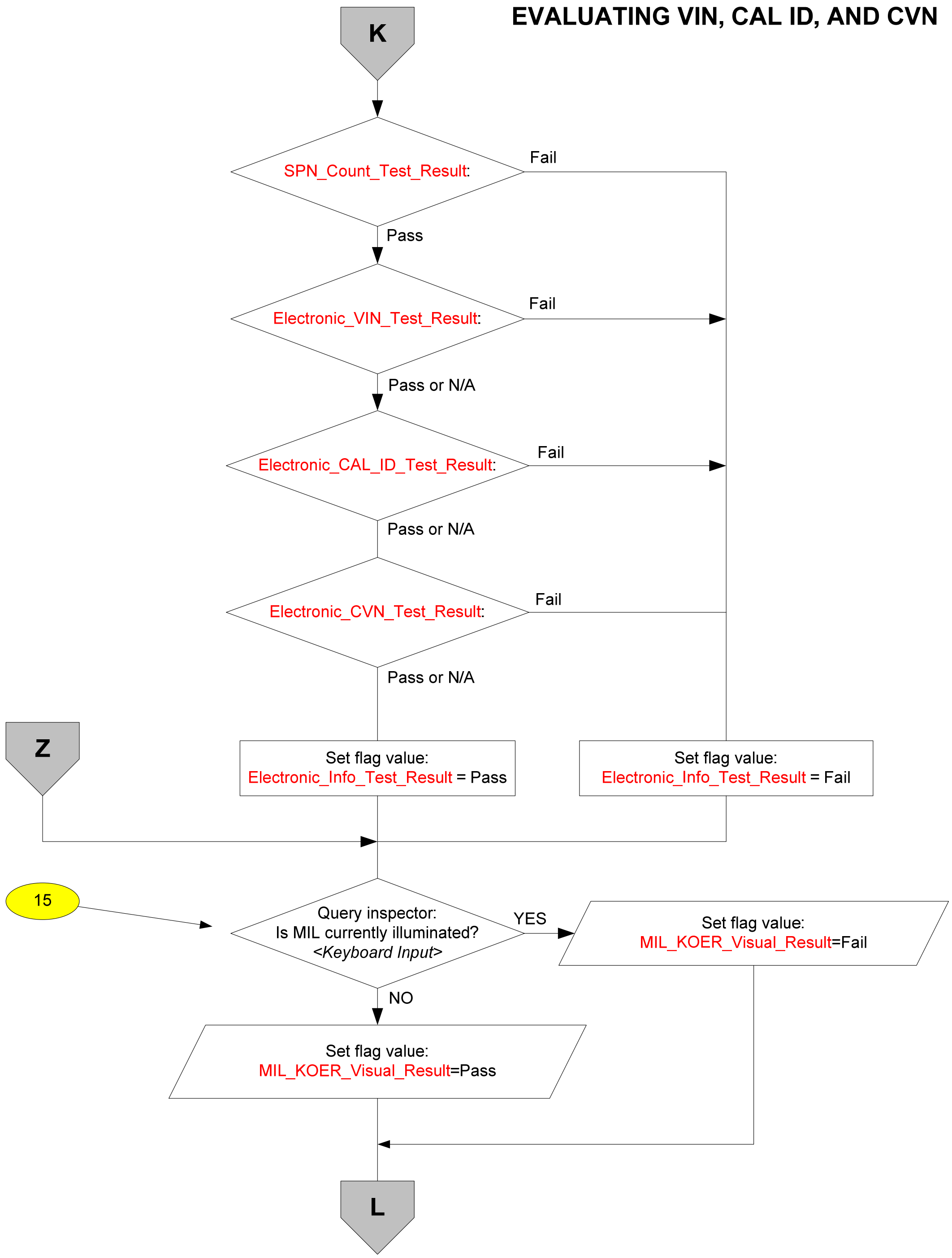


FIGURE B12 - SAE J1939-03 HEAVY DUTY HD-OBD I/M TEST PROCESS PAGE K

EVALUATING ON-BOARD DIAGNOSTIC MIL STATUS INFORMATION

Special Note:
This flowchart is constructed to only read DTCs from powertrain components that have failed one of the MIL criteria. It is not necessary to read DTCs from passing powertrain components. For passing powertrain components, DTCs should definitely not be read and printed out on the final report to avoid confusion.

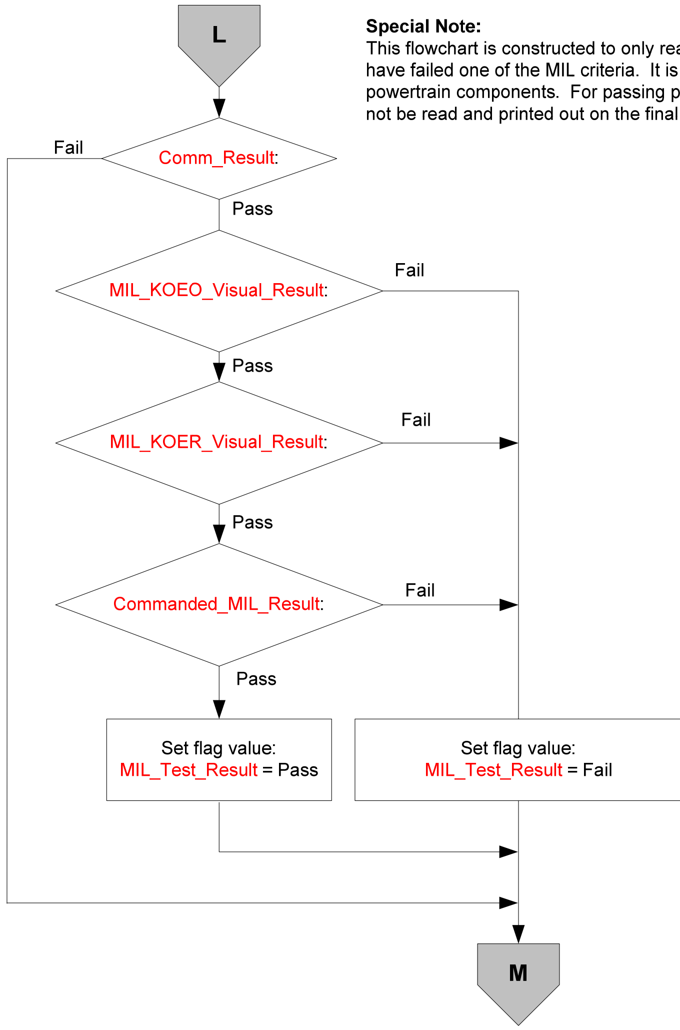


FIGURE B13 - SAE J1939-03 HEAVY DUTY HD-OBD I/M TEST PROCESS PAGE L

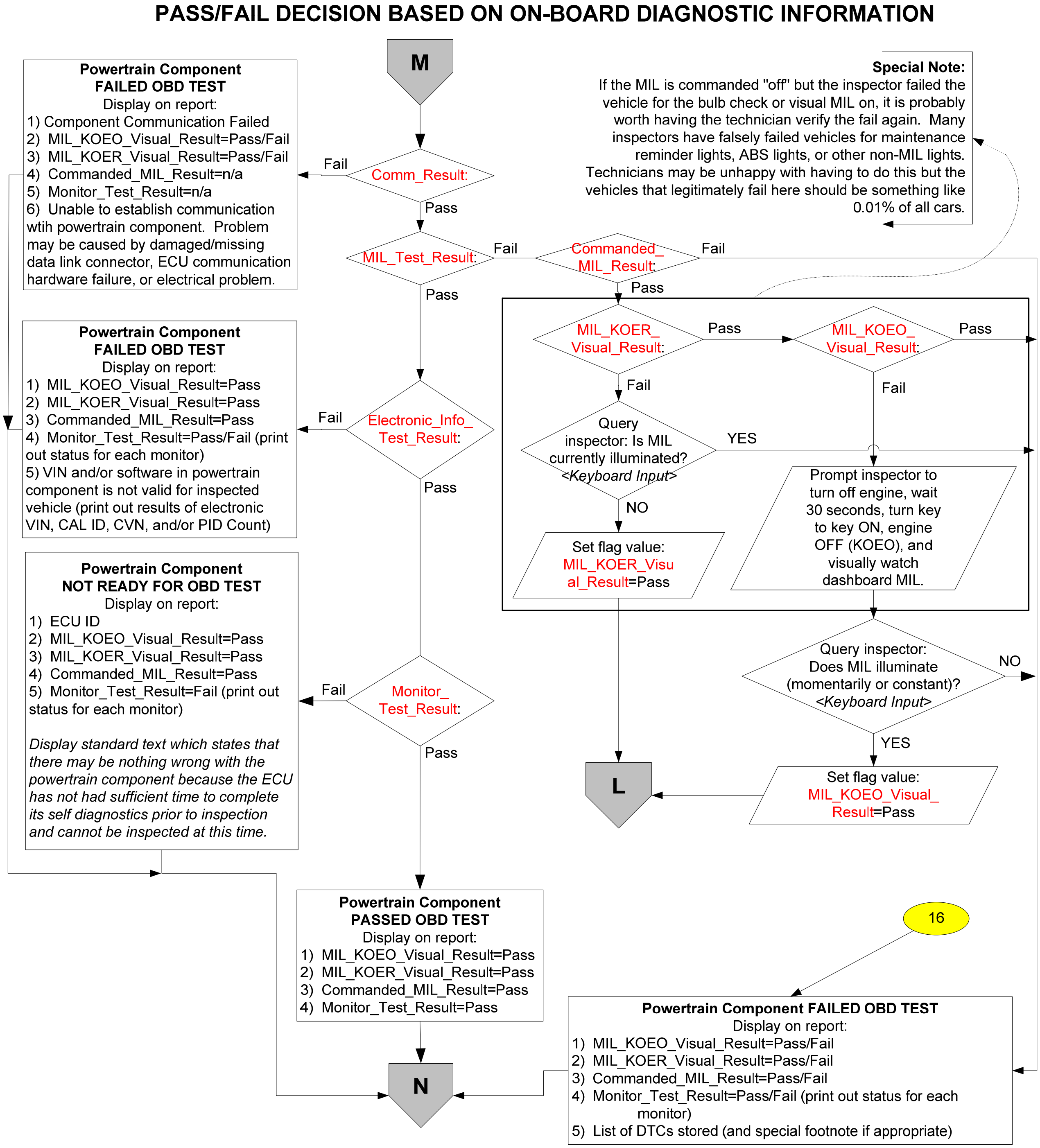


FIGURE B14 - SAE J1939-03 HEAVY DUTY HD-OBD I/M TEST PROCESS PAGE M

STOP: FINISH TEST & DISCONNECT FROM SAE J1939-13 DLC

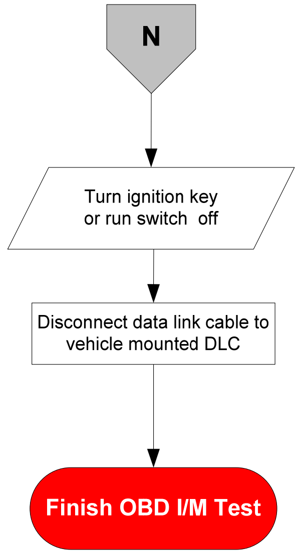


FIGURE B15 - SAE J1939-03 HEAVY DUTY HD-OBD I/M TEST PROCESS PAGE N

B.3 SAE J1939/03 HEAVY DUTY HD-OBD I/M TEST PROCESS NOTES

The following notes document the callouts given in the Section B.2 flowchart. The numbers below match the numbers on the figures.

1. Note that the definition of engine, or perhaps more definitively how the I/M inspector determines the engine make, shall be accomplished using a vehicle application database. This is required because the state DMV most likely has the vehicle that is subject for registration in a vehicle database, yet engine information may not be an attribute of that database. The engine therefore may have to be coupled somehow with the state vehicle database information, or the inspector may have to "intrusively" determine the engine information (make, model, serial number) and input that information into a Test Analyzer System.

2. In theory, there should not be any problems plugging the connector into a vehicle that has the engine running. HD vehicles that use SAE J1939-13 DLC have battery power to the connector pins so connecting while the run switch is on or off is not a concern. It should be noted that connection to the vehicle DLC was desired with the ignition key off to a) make connections with an electronic system when no power is applied is a sound approach, b) prevent errant concerns that may cause the OBD system to illuminate a MIL or worse, set DTCs because an external test device was connected during normal operation.

3. Required because some electronic control units require as much as 30 s to settle and restart their applications.

4. MIL bulbs should rarely ever "burn out". Most vehicles identified as failing the bulb check are likely inspector error (didn't see the MIL illuminate, didn't cycle the key off for a long enough period of time). This second loop was designed to make inspectors thoroughly verify a bulb check fail before sending a vehicle owner through the hassle of a false I/M fail. .

5. A loop was constructed to make sure communication was tried several times before deciding it was a communication failure. This approach ensures good connection possibility and minimizes communication failures between scan tool hardware and vehicle ECU(s). In any case, the extra time added to a test to repeat this process at least three times is minimal (about 5-10 seconds) and is highly recommended before concluding the vehicle is a fail for lack of communication.

6. Obviously, once a state inspection program is up and running successfully, the proper step in the case of unsuccessful communication is to fail the vehicle. However, during pilot stages, initial phase-in of the program, beta testing of software, etc., it is highly recommended that a state have a back-up alternative to failing the vehicles to minimize vehicle owner inconvenience due to I/M equipment bugs or failures. Alternatives could be other inspection tests, referee inspections, bypass, etc.

7. This is an important check to conduct in I/M testing. A read of the HD OBD ECU "system" will inform external test equipment if the vehicle under test is HD OBD compliant or not. In the future, this <u>may</u> also be helpful in identifying non-street legal on-board computers (e.g., off-road only ECUs or calibrations).

8. This check for engine speed makes sure the engine is running prior to reading the "commanded MIL" status to avoid falsely failing a truck that reads commanded on during bulb check. However, some hybrids or other future models will not have the engine running during idle so engine speed will properly read less than 250 rpm and we need to bypass this test. There may be other cases where there is a legitimate reason to bypass this step. It is recommended that the inspector is given a warning message and/or the ability to bypass this requirement and continue the test to accommodate special vehicles or other special circumstances.

9. A global request is used here because a) there may be other "non-emission" ECUs on board that can report the VIN electronically and b) ECUs that are emission based may not have VIN programmed into their memory. This step is recommended, even though HD OBD requires only a single VIN, because it is not a failure that the vehicle owner can be expected to repair for themselves, and VIN has been supported by more than one module in the past.

10. Match the SPN count from only devices responding to DM5, which was received earlier in the process.

11. There is a suggested formula to use for Total_SPN_Count that is included in the special note on the flow chart. It is highly recommended that SPN count always be calculated in this manner so that all I/M equipment vendors generate the same result and all states generate the number in the same manner. This also will foster the ability to create a national database of known SPN count and module ID to catch clean-scanning.

12. At this time, a lookup table of proper SPN count and Module ID relative to vehicle make/model/model year does not exist. Most states will likely need to create this on their own by collecting SPN count and Module ID for a few years to gather the data and then going back to create the master list to be used for subsequent future inspections of those vehicles. Other states have indicated that they may collect the data and post-process it as part of their QA analysis or enforcement work to catch clean-scanners or investigate suspect stations.

    It is important to note that adopting a SPN Count function, Module ID count function, and any accompanying lookup tables that would be used to post-process the data is up to the State's discretion.

13. A DM5 request is sent again to ECUs that support the appropriate SPN to refresh information, as the status may have changed since the test was initiated.

14. The new text strings defined here were due to many different approaches that labeled monitor states as “pass/fail”, “complete/incomplete”, “yes/no”, “ready/not ready”, “done/pending”, etc. and this has led to some confusion.

    The language used in this SAE J1939-03 example reflects the new terminology adopted by SAE J1939-73 and all I/M equipment vendors and scan tool manufacturers are <u>STRONGLY</u> encouraged to use it to help promote a consistent terminology for inspectors and repair technicians.

15. Desire to check if the MIL is on during Key On, Engine Running because the system could set a DTC and illuminate the MIL during the I/M test.

16. Pass/Fail criteria in this result case depends on the State's implementation.

17. Loop counter definition: "X" is the loop counter for receiving engine speed, "Y" is the loop counter for receiving readiness information.

18. ECU sends address claim result to external OBD tester.

19. NAME implies receipt of ECU physical address, function, instance, and manufacturer.