SURFACE VEHICLE RECOMMENDED PRACTICE

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OBD-II Communications Anomaly List

RATIONALE

This information report has been issued to promote awareness of SAE J1979 OBD communications anomalies that may be encountered during the course of normal communication attempts between vehicle emission OBD ECUs and Diagnostic Equipment.

FOREWORD

The SAE J1699-4 Task Force, a member of SAE E/E Diagnostics Steering Committee, has created this document to serve as a guide to common anomalies which may affect OBD communication using SAE J1850VPW, SAE J1850PWM, ISO 9141-2, ISO 14230-4, or ISO 15765-4 protocol between vehicle emission OBD ECUs and Diagnostic Equipment that utilizes generic services defined in SAE J1979.

Content of this document includes actual failures confirmed by investigation of actual vehicle units-in-operation, review and clarification of recommended practice documentation, and implementation guidance required to enable diagnosis on early model vehicles so that diagnostic equipment can obtain generic data content from vehicle systems that may have been released to the field with anomalous behavior.

Guidance in this document may not be compliant with currently published ISO or SAE Standards or Recommended Practices. Content within this document may also include items which have been the subject of misinterpretation of said Standards or Recommended Practices.

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1. SCOPE

To define a list of anomalies related to OBD Communications. Misinterpretations of various OBD Communications Standards and Recommended Practices have resulted in OBD "no-communications" situations in the field. This Information Report identifies the most prevalent of these.

1.1 Purpose

To provide guidance to diagnostic equipment (handheld scan tools, vehicle communication interfaces, inspection software systems) manufacturers, Vehicle OEMs, and Government Regulation authorities (CARB, EPA, etc.) in identifying issues with OBD Communications.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

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 J1850 Class B Data Communications Network Interface

SAE J1930 Electrical/Electronic Systems Diagnostic Terms, Definitions, Abbreviations, and Acronyms - Equivalent to ISO/TR 15031-2

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

SAE J1979 E/E Diagnostic Test Modes

SAE J2012 Diagnostic Trouble Code Definitions

SAE J2178-1 Class B Data Communication Network Messages - Detailed Header Formats and Physical Address Assignments

2.1.2 ISO Publications

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

ISO 9141-2 Road vehicles – Diagnostic systems – Part 2: CARB requirements for interchange of digital information

ISO 14230-4 Road vehicles – Diagnostic systems – Part 4: KWP 2000 requirements for emission related systems

ISO/DIS 15031-2 Communication Between Vehicle and External Equipment for Emissions-Related Diagnostics – Part 2: Terms, definitions, abbreviations and acronyms (Equivalent to SAE J1930)

ISO/DIS 15031-3 Communication Between Vehicle and External Equipment for Emissions-Related Diagnostics – Part 3: Diagnostic connector and related electrical circuits, specification and use (Equivalent to SAE J1962)

ISO/DIS 15031-4 Communication Between Vehicle and External Equipment for Emissions-Related Diagnostics (Equivalent to SAE J1978)

ISO/DIS 15031-5 Communication Between Vehicle and External Equipment for Emissions-Related Diagnostics – Part 5: Emissions-related diagnostic services (Equivalent to SAE J1979)

ISO/DIS 15031-6 Communication Between Vehicle and External Equipment for Emissions-Related Diagnostics – Part 6: Diagnostic trouble code definitions (Equivalent to SAE J2012)

ISO 15765-4 Road vehicles – Diagnostics on Controller Area Network (CAN) – Part 4: Requirements for emissions-related systems

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1 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 J1699-1 SAE J1850 Verification Test Procedures.

SAE J1699-2 OBD II Related SAE Specification Verification Test Procedures

SAE J1699-3 OBD II Compliance Test Cases.

2.2.2 ISO Publications

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

ISO 11898 – Road vehicles, Interchange of Digital information, Controller Area Network (CAN) for High Speed Communication.

ISO 14229 - Road Vehicles, Diagnostic Systems, Specification of Diagnostic Services.

2.2.3 Other Publications

CARB Regulation – Title 13, California Code Regulations, Section 1968.2, Malfunction and Diagnostic System Requirements for 2004 and Subsequent Model-Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles and Engines (OBD II). Web address: <http://www.arb.ca.gov/msprog/obdprog/obdregs.htm>

3. DEFINITIONS

3.1 Definition of Terms

The definitions of terms that are related to the use of this document may be found in the publications listed under Section 2.1, Applicable Publications.

3.2 Acronyms

The following are common acronyms used in this document:

Addr	Address
CALID	Calibration Identification
CAN	Controller Area Network
CVN	Calibration Verification Number
CARB	California Air Resources Board
ECU	Electronic Control Unit
EMC	Electromagnetic Compatibility
I/M	Inspection and Maintenance
ISO	International Standards Organization
INFTYP	Infotype
KWP	Key Word Protocol
OBD-II	On Board Diagnostics (level 2)
PDU	Protocol Data Unit
PID	Parameter Identification (number)
SAE	Society of Automotive Engineers
VIN	Vehicle Identification Number

4. OVERVIEW

This document defines known anomalies that may occur during tester to vehicle OBD Communications.

4.1 Documentation Conventions

All references to protocol specific parameters that are specified in other documents will be in italics (for example, *W0*).

5. COMMUNICATIONS ANOMALIES

This section provides a list of known anomalies that create issues during I/M testing.

5.1 Physical address assignments for legislated emission ECUs.

5.1.1 Problem Definition: SAE J2178-1, Table 11, defines suggested ranges of physical address assignments for different ECU types (e.g., address range $10-17 for engine, address range $18-1F for transmission) to be used in the header bytes of all SAE J1979 emission-related messages for Class B Communications. For all CARB approved legislated protocols except ISO 15765-4 11-bit CAN, past vehicle implementations have largely adhered to using the ECU address ranges as specified in SAE J2178-1. However, a small amount of ECU's use physical addresses which have been out of this range.

5.1.2 Suggested Guidance 1: diagnostic equipment manufacturers should reference the following table of known “out of range per SAE J2178-1” ECU addresses which are known to be used by emission ECUs. When the Diagnostic equipment is performing tester to ECU communications per SAE J1979 emission related messaging scenarios, the list of ECUs shown below should be included as address exceptions.

Address	ECU Range	ECU Description
$00	Engine	Engine control module
$01	Engine	Engine control module
$0D	Engine	Engine control module
$0E	Engine	Engine control module
$0F	Engine	Engine control module
$22	Engine	Power/Idle control module
$32	Transmission	Transmission control module
$40	Engine	Engine control module
$41	Transmission	Transmission control module
$64	Engine	Engine control module
$D1	Engine	Engine control module
$E8	Engine	Engine control module

TABLE 1 – OUT OF RANGE PER SAE J2178-1 ECU ADDRESSES

5.1.3 Suggested Guidance 2: vehicle OEMs, network engineers, and ECU developers should reference SAE J2178-1, Table 11 and ISO 15765-4 “29-bit legislated-OBD CAN identifiers recommendation” when assigning ECU addresses.

5.2 Incorrect Header Bytes supported by Vehicle ECU.

5.2.1 Problem Definition: after receiving a correctly formatted diagnostic equipment message request (as defined in Figure 11 of SAE J1979), the vehicle ECU responds with a message which contains incorrect header bytes.

For example, after a diagnostic equipment request, an ECU incorrectly responds with a "68 (or 61) 6B addr". Diagnostic equipment programmed to reject all messages from the ECU that do not conform to "48 (or 41) 6B addr" definition in Figure 1 of SAE J1979 may be unable to communicate to one or more of the ECUs on the vehicle.

5.2.2 Suggested Guidance 1: vehicle OEMs should review their ECU software implementation plans (which meet specification set forth in SAE J1979 document) to ensure that header bytes are properly programmed into the ECU communication handler software per Figure 11 of SAE J1979. Depending on the protocol, given a diagnostic equipment request message header of "68 (or 61) 6A Fx" an ECU response message shall be header bytes of "48 (or 41) 6B ECU_addr".

5.2.3 Suggested Guidance 2: for SAE J1850 VPW and PWM, and ISO 9141-2 protocols, diagnostic equipment manufacturers should not program their tools to reject all messages that do not conform to "48 (or 41) 6B ECU_addr".

5.3 Incorrect Header Bytes supported by Diagnostic Equipment.

5.3.1 Problem Definition: after initialization, some diagnostic equipment request SAE J1979 service $01 data using improper header bytes on the K-Line data bus.

For example, during tester to ECU initialization, an ECU may have identified itself as supporting ISO 14230-4 protocol using $8F KB2 ($E9, $6B, $6D, $EF) key bytes. In this case, regardless of the returned key byte value(s), some diagnostic equipment will utilize a Service $01 PID $00 request message of $68 6A F1 01 00 C4 (this message is not correct for the identified protocol of ISO 14230-4).

5.3.2 Suggested Guidance 1: diagnostic equipment manufacturers should adhere to the following key byte to message table after reading the ECUs key byte indication and before sending a Service $01 PID $00 request on the K-Line:

Init Type	To Address	Returned Key Bytes from ECU	Indicate Protocol	Header Byte Example: Service $01 PID $00 Request
5 Baud	$33	$08 08 or $94 94	ISO 9141-2	$68 6A F1 01 00 C4
5 Baud	$33	$8F E9 or $8F 6B or $8F 6D or $8F EF	ISO 14230-4	$C2 33 F1 01 00 E7
Fast	$33 (Use StartComm message)	$8F E9 or $8F 6B or $8F 6D or $8F EF	ISO 14230-4 Fast Init	$C2 33 F1 01 00 E7

TABLE 2 – EXAMPLE OF HEADER BYTES ON K-LINE PROTOCOLS

5.3.3 Note: the protocol determination process presented in this section applies to SAE J1979 services when requests for data are being performed on a K-line.

5.3.4 Some vehicles may require tighter timings for TiniL, as little as 25+/- 0.1 ms, rather than the standard 25 +/- 1ms timing given in ISO 14230-2.

5.4 K-Line Initialization

5.4.1 Problem Definition: many diagnostic software initialization errors stem from the fact that attempts at K-Line protocol initialization are performed without taking into account the three unique methods of initializing ECUs on a K-line network.

Examples of incorrect diagnostic equipment software behavior include attempting a fast initialization, then attempting a 5-baud initialization without waiting for any 5-baud modules to recover from the preceding low transition of the K-Line (Recommended to wait 2.6sec for sum of A1(2sec) + W1(300ms) + W5(300ms) to expire). As ECU's developed in a pre-KWP2000 time frame will not recognize KWP initialization and command structures, other conditions may occur due to a misunderstanding of CARB regulations and specification content outlined in SAE J1979, SAE J1978, and SAE J1699-3 documents.

Three OBD Communications protocols are defined on the K-Line:

5.4.1.1 ISO 9141-2 – this is identified by the use of a 5-baud initialization utilizing the keywords $08 08 or 94 94. Industry may also refer to this initialization method as "CARB-mode."

5.4.1.2 ISO 14230-4 with 5-baud initialization – also known as KeyWord Protocol 2000 (KWP2000) with 5-baud initialization. ISO 14230-4 5-baud initialization is differentiated from ISO 9141-2 5-baud initialization by the use of keywords 8F E9, 8F 6B, 8F 6D, or 8F EF. Only the functionality of keyword 8F E9 is allowed for OBD communications

5.4.1.3 ISO 14230-4 with fast initialization – also known as KeyWord Protocol 2000 (KWP2000) with fast initialization. Fast initialization utilizes a unique wakeup pattern that is a total of 50ms long.

5.4.2 Suggested Guidance 1: vehicle OEMs, network engineers, and ECU developers should note that vehicle emission ECUs are only allowed to respond on one protocol.

5.4.3 Suggested Guidance 2: vehicle OEMs, network engineers, and ECU developers should note that a single physical vehicle K-line network is not allowed to have one or more ECUs which support both 5-baud and fast initialization under ISO 14230-4, or any combination thereof. As noted earlier, the K-Line supports three protocols. Although ISO 14230-4 supports two variations, the 5-baud and fast initialization are considered separate and distinct by ECUs on a K-line network.

5.4.4 Suggested Guidance 3: diagnostic equipment manufacturers and diagnostic software developers should spend sufficient time in validating their K-line initialization approach on ISO 14230-4 equipped vehicles. Referencing guidance points above and use of the OBD Flow Chart is recommended.

5.5 Erratic vehicle response to Service $01 PID $00 requests.

5.5.1 Problem Definition: once a protocol initialization has occurred, vehicle emission OBD ECUs may respond erratically to SAE J1979 Service $01 PID $00 requests. Examples observed in the field:

5.5.1.1 Some vehicle emission OBD ECUs will respond with incorrect SAE J1979 PID support designation and do not report values for PIDs previously reported as supported.

5.5.1.2 Some vehicle emission OBD ECUs will respond with incorrect SAE J1979 PID support designation and report values for PIDs previously reported as unsupported.

5.5.1.3 Some vehicle non-emission OBD ECUs may have initialized along with the OBD-related modules. These modules will correctly respond with a “No supported PIDs” response to Service $01 PID $00.

5.5.2 Suggested Guidance 1: diagnostic equipment manufacturers and diagnostic software developers may consider a method where PID $00 data is read three times, and comparing the data returned from the ECU each time. To reduce inconsistencies, returned data values that remain the same over two or three PID $00 reads are then taken as accurate and requests for other PID data can be performed.

5.5.3 Suggested Guidance 2: vehicle OEMs, diagnostic equipment manufacturers, and technicians should capture field information about data reported by vehicle emission OBD ECUs.

5.6 Response Order for Multiple Emission ECUs.

5.6.1 Problem Definition: when a SAE J1979 functional request is sent by the diagnostic equipment to the vehicle emission ECU network, there will be at least one ECU responding, and perhaps additional ECUs depending on vehicle configuration. An example is a vehicle emission ECU network responding with engine and transmission ECUs after a functional request from the diagnostic equipment, and doing so not in any particular order. There is no prescribed response order for OBD related modules in vehicles with multiple module systems under any currently supported OBD protocol.

5.6.2 Suggested Guidance 1: diagnostic equipment manufacturers and diagnostic software developers must be prepared to handle multiple random-ordered responses during a SAE J1979 communication session.

5.6.3 Suggested Guidance 2: diagnostic equipment manufacturers and diagnostic software developers should not program application software to expect the engine control module to always be the first responding emission ECU. There is no guarantee that the first responding emission ECU will be the engine control module.