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Road vehicles — Implementation of World-Wide Harmonized On-Board Diagnostics (WWH-OBD) communication requirements —

Part 6: External test equipment

Véhicules routiers — Mise en application des exigences de communication pour le diagnostic embarqué harmonisé à l'échelle mondiale (WWH-OBD) —

Partie 6: Équipement d'essai externe

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

The committee responsible for this document is ISO/TC 22, *Road vehicles*, Subcommittee SC 3, *Electrical and electronic equipment*.

ISO 27145 consists of the following parts, under the general title *Road vehicles — Implementation of Word-Wide Harmonized On-Board Diagnostics (WWH-OBD) communication requirements*:

— *Part 1: General information and use case definition*

— *Part 2: Common data dictionary*

— *Part 3: Common message dictionary*

— *Part 4: Connection between vehicle and test equipment*

— *Part 6: External test equipment*

Introduction

Overview

This International Standard includes the communication between the vehicle's on-board diagnostics (OBD) systems and external test equipment within the scope of the World-Wide Harmonized On-Board Diagnostics Global Technical Regulations (WWH-OBD GTR).

This International Standard has been established in order to apply the unified diagnostic services (specified in ISO 14229-1) to WWH-OBD systems.

This International Standard includes the communication between the vehicle's WWH-OBD systems and external (off-board) "generic" test equipment within the scope of the country-specific regulatory requirements.

To achieve this, it is based on the Open Systems Interconnection (OSI) Basic Reference Model specified in ISO/IEC 7498-1 and ISO/IEC 10731, which structures communication systems into seven layers. When mapped on this model, the services specified by this International Standard are broken into:

— diagnostic services (layer 7), specified in ISO 27145-3 with reference to ISO 14229-1,

— presentation layer (layer 6), specified in ISO 27145-2 with reference to SAE J1930-DA, SAE J1939-DA, SAE J1939-73, Appendix A (FMIs), SAE J1979-DA, and SAE J2012-DA,

— session layer services (layer 5), specified in ISO 14229-2,

— transport layer services (layer 4), specified in ISO 27145-4 with reference to ISO 13400-2, ISO 15765-2, and ISO 15765-4,

— network layer services (layer 3), specified in ISO 27145-4 with reference to ISO 13400-2, ISO 15765-2, and ISO 15765-4,

— data link layer (layer 2), specified in ISO 27145-4 with reference to ISO 11898-1, ISO 11898-2, ISO 13400-3, ISO 15765-4, and IEEE 802.3, and

— physical layer (layer 1), specified in ISO 27145-4 with reference to ISO 11898-1, ISO 11898-2, ISO 13400-3, ISO 15765-4, and IEEE 802.3,

in accordance with Table 1.

Table 1 — WWH-OBD specification reference applicable to the OSI layers

<table>
<tr><th>Applicability</th><th>OSI seven layer</th><th colspan="4">WWH-OBD document reference</th></tr>
<tr><td rowspan="8">Seven layer according to ISO/IEC 7498-1 and ISO/IEC 10731</td><td>Application (layer 7)</td><td colspan="3">ISO 14229-1, 3</td><td rowspan="2">ISO 27145-6</td></tr>
<tr><td>Presentation (layer 6)</td><td colspan="3">ISO 27145-2,
SAE J1930-DA, SAE J1939-DA, SAE J1939-73, Appendix A (FMIs),
SAE J1979-DA, SAE J2012-DA</td></tr>
<tr><td>Session (layer 5)</td><td colspan="3">ISO 14229-2</td><td rowspan="5">—</td></tr>
<tr><td>Transport (layer 4)</td><td rowspan="2">ISO 15765-2 DoCAN,
ISO 15765-4 DoCAN</td><td rowspan="4">ISO 27145-4</td><td rowspan="2">ISO 13400-2 DoIP
TCP and IP</td></tr>
<tr><td>Network (layer 3)</td></tr>
<tr><td>Data link (layer 2)</td><td rowspan="2">ISO 11898-1 CAN DLL,
ISO 11898-2 CAN HS,
ISO 15765-4 DoCAN</td><td rowspan="2">ISO 13400-3 DoIP,
IEEE 802.3</td></tr>
<tr><td>Physical (layer 1)</td></tr>
</table>

SAE document reference concept

This International Standard references several SAE documents which contain all terms, data and diagnostic trouble code (DTC) definitions.

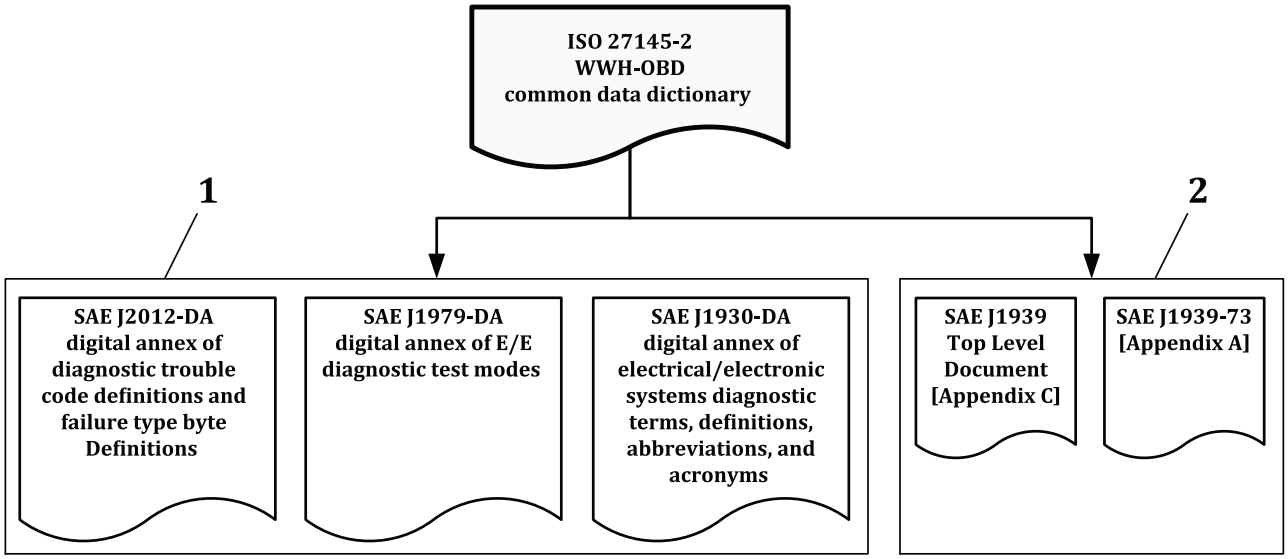
ISO 27145-2 defines a common data dictionary for this International Standard, according to the definitions in the following documents (Figure 1):

— SAE J1930-DA: this digital annex contains all standardized naming objects, terms, and abbreviated terms;

— SAE J1939-DA and SAE J1939-73: The Digital Annex indexes names for suspect parameter numbers (SPNs) that provide an alternative presentation format for SAE J2012-DA DTCs. SPNs are combined with failure mode indicators (FMIs) to form the full alternative presentation. These FMIs are described in SAE J1939-73, Appendix A;

— SAE J1979-DA: this digital annex contains all standardized data items such as data identifiers (DIDs), test identifiers (TIDs), monitor identifiers (MIDs), and infotype identifiers (ITIDs);

— SAE J2012-DA: this digital annex contains all standardized data items such as DTC definitions and FTB (failure type byte) definitions.



Key

1 SAE digital annexes: data definitions

2 SAE J1939 series of documents: DTC definitions

Figure 1 — SAE digital annex document reference

Road vehicles — Implementation of World-Wide Harmonized On-Board Diagnostics (WWH-OBD) communication requirements —

Part 6: External test equipment

1 Scope

This part of ISO 27145 defines the requirements for the external test equipment as listed:

— a means of establishing communications between a WWH-OBD-equipped vehicle and external test equipment;

— a set of diagnostic services, including addressing methods, to be provided by the external test equipment in order to exercise the services defined in ISO 27145-3.

This part of ISO 27145 describes the minimum capabilities or functions in the external test equipment. Additional functionality, e.g. non WWH-OBD protocols or retrieval of repair and maintenance information, can be integrated into the external test equipment according to the test equipment manufacturer needs. The external test equipment designer ensures that no such capability or function can adversely affect either a WWH-OBD-equipped vehicle connected to the equipment, or the equipment itself.

When the external test equipment implements functionality, which is not covered by ISO 27145-3, this functionality is not linked to the timing requirements defined in this International Standard.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 7637-2:2011, *Road vehicles — Electrical disturbances from conduction and coupling — Part 2: Electrical transient conduction along supply lines only*

ISO 13400 (all parts), *Road vehicles - Diagnostic communication over Internet Protocol (DoIP)*

ISO 14229-1, *Road vehicles — Unified diagnostic services (UDS) — Part 1: Specification and requirements*

ISO 14229-2, *Road vehicles — Unified diagnostic services (UDS) — Part 2: Session layer services*

ISO 15031-3, *Road vehicles — Communication between vehicle and external equipment for emissions-related diagnostics — Part 3: Diagnostic connector and related electrical circuits, specification and use*

ISO 15765-4, *Road vehicles — Diagnostic communication over Controller Area Network (DoCAN) — Part 4: Requirements for emissions-related systems*

ISO 16750-2:2010, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 2: Electrical loads*

ISO 27145-1:2012, *Road vehicles — Implementation of World-Wide Harmonized On-Board Diagnostics (WWH-OBD) communication requirements — Part 1: General information and use case definition*

ISO 27145-2:2012, *Road vehicles — Implementation of World-Wide Harmonized On-Board Diagnostics (WWH-OBD) communication requirements — Part 2: Common data dictionary*

ISO 27145-3:2012, *Road vehicles — Implementation of World-Wide Harmonized On-Board Diagnostics (WWH-OBD) communication requirements — Part 3: Common message dictionary*

ISO 27145-4:2012, *Road vehicles — Implementation of World-Wide Harmonized On-Board Diagnostics (WWH-OBD) communication requirements — Part 4: Connection between vehicle and test equipment*

SAE J1930-DA, *Digital Annex, Electrical/Electronic Systems Diagnostic Terms, Definitions, Abbreviations, and Acronyms*

SAE J1939, *Companion Spreadsheet (CS 1939)*

SAE J1939-73, *Recommended Practice for a Serial Control and Communication Vehicle Network — Application layer — Diagnostics*

SAE J1979-DA, *Digital Annex, E/E Diagnostic Test Modes*

SAE J2012-DA, *Digital Annex, Diagnostic Trouble Code Definitions*

3 Terms, definitions, symbols, and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 27145-1, ISO 27145-2, ISO 14229-1, and the following apply:

3.2 Abbreviated terms

CALID	calibration identification
CAN	Controller Area Network
DoCAN	Diagnostics over CAN
DoIP	Diagnostics over IP
DTC	Diagnostic Trouble Code
EMC	electromagnetic compatibility
ESD	electrostatic discharge
ETEREC	external test equipment recommendation
ETEREQ	external test equipment requirement
GTR	Global Technical Regulations
HMI	Human-Machine Interface
IP	Internet Protocol
IUPR	In Use (Monitor) Performance Ratio
MVCI	Modular Vehicle Communication Interface
MI	Malfunction Indication

MIL Malfunction Indication Lamp

NRC Negative Response Code

ODX Open Diagnostic data eXchange

4 Conventions

This International Standard is based on the conventions discussed in the OSI Service Conventions (ISO/IEC 10731) as they apply to diagnostic services.

5 Document overview

Figure 2 shows the reference documents for this International Standard.

This International Standard specifies the following references:

a) ISO 27145-1 specifies the general structure of this International Standard and the use cases applicable to WWH-OBD GTR;

b) ISO 27145-2 specifies the common data dictionary with references to the following:

   1) SAE J1930-DA, which defines the terms, definitions, abbreviated terms, etc.;

   2) SAE J1939-DA contains all SPNs (parameters), PGNs (messages), and other SAE J1939 data previously published in the SAE J1939 top level document;

   NOTE The SAE J1939 series of documents is concerned with the definition of emissions-related SPNs and FMIs for use as DTCs.

   3) SAE J1939-73, Appendix A, which specifies the FMIs;

   4) SAE 1979-DA, which specifies all data items;

   5) SAE J2012-DA, which specifies the DTC definitions and failure type byte definitions.

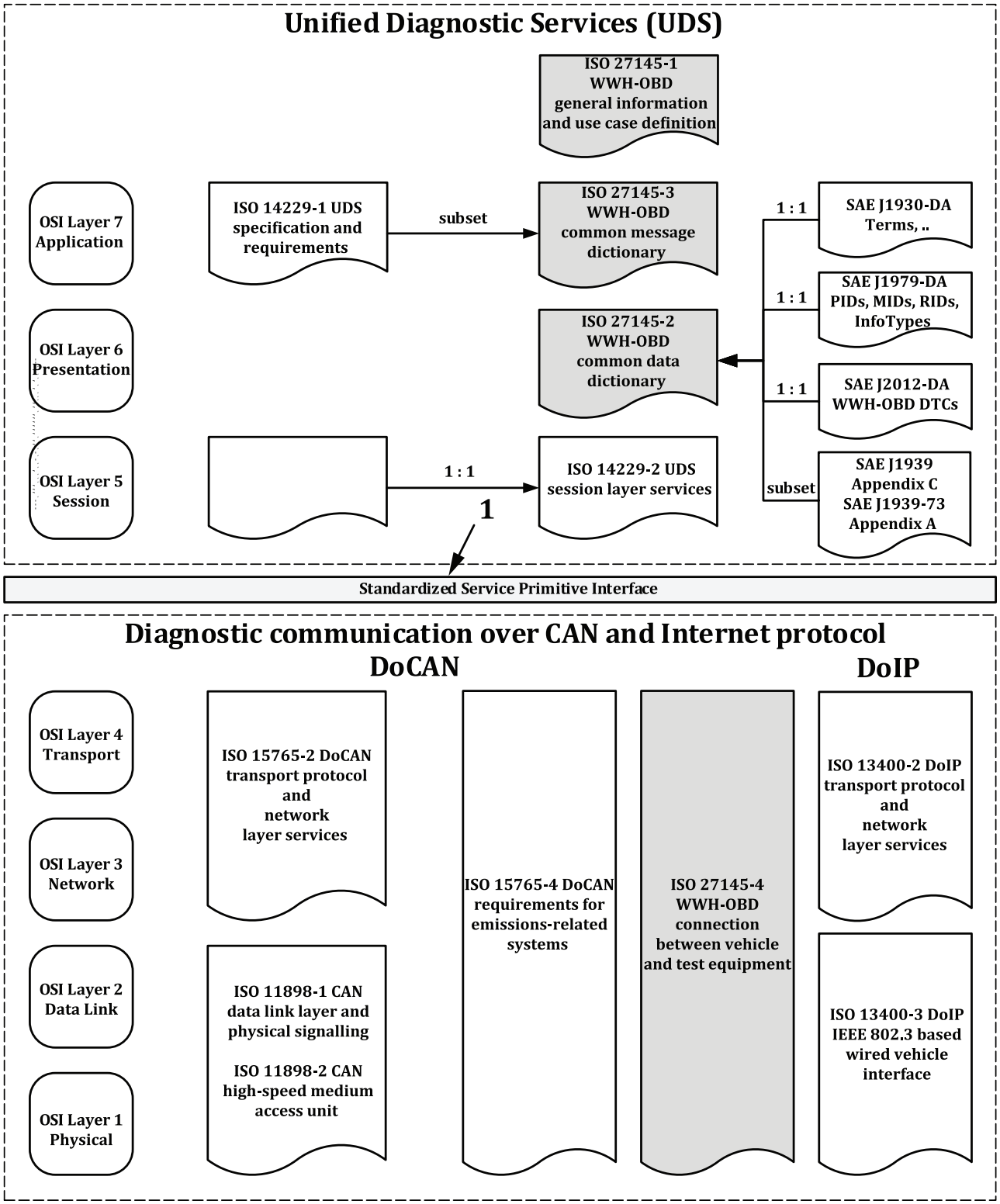
c) This part of ISO 27145 specifies the diagnostic services defined in ISO 14229-1 that are applicable to WWH-OBD GTR;

d) ISO 14229-2 specifies the standardized service primitive interface to separate application and session layers from protocol transport and network layers;

e) ISO 27145-4 specifies the initialization procedure and includes references to:

   1) ISO 15765-4 DoCAN;

   2) ISO 13400 (all parts) DoIP.



Key

1 The standardized service primitive interface is specified in ISO 14229-2.

Figure 2 — Reference documents for implementation of WWH-OBDonCAN and WWH-OBDonIP according to the OSI model

6 Requirements overview and principles

6.1 Basic principles for the graphical notation

The flow graphs show the behaviour of the external test equipment. Hierarchical references e.g. are shown using round edged transparent rectangles. Figure 3 shows the notation semantics.

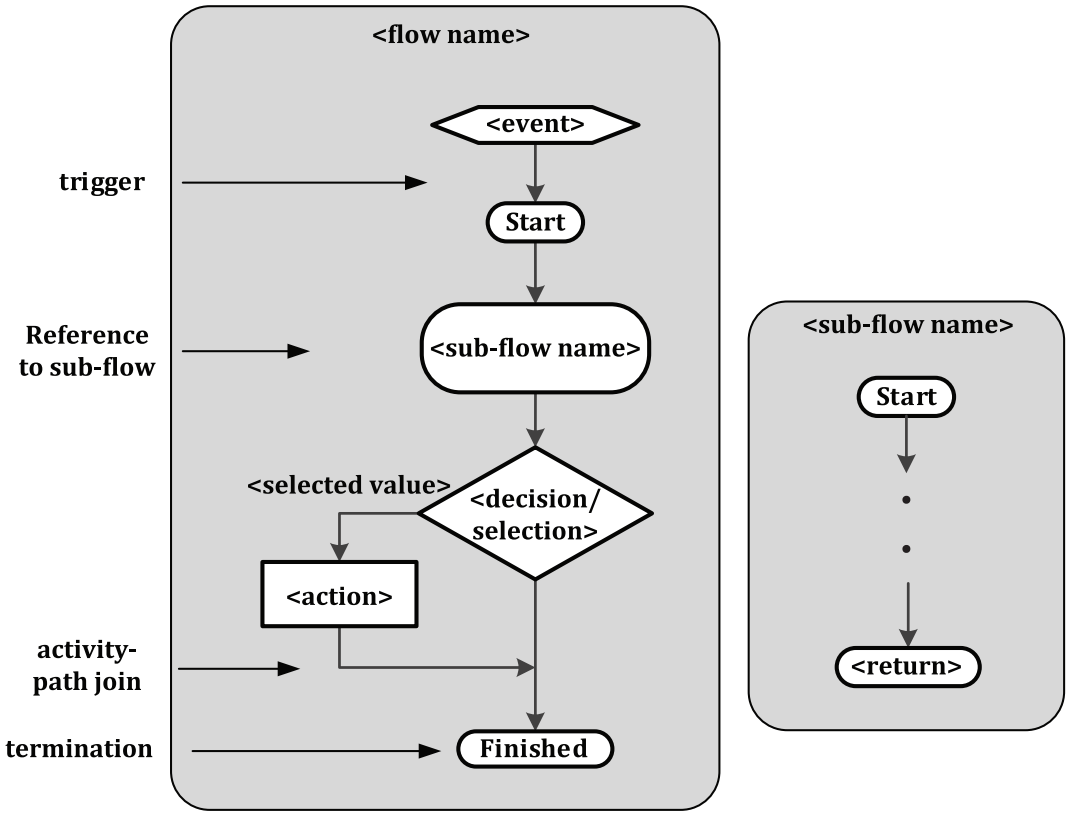


Figure 3 — Flow graph notation semantics used in this document

6.2 Requirements clustering

6.2.1 Overview

Each requirement in this part of ISO 27145 is assigned to one requirements cluster. The clusters cover technical areas where the assigned requirements apply for.

Table 2 lists the technical requirements clusters. The table provides an overview of all requirements clusters and the associated technical requirements. This list is a summary of the requirements included in this part of ISO 27145.

Each technical requirement is identified by the mnemonic "ETEREQ-" and an alpha-numeric number. In addition, the alpha-numeric number includes the requirement cluster classifier according to Table 2.

Recommendations intended to guide the implementation are identified by the mnemonic "ETEREC-", which is shown in italic style for differentiation.

6.2.2 Main requirements clusters

Table 2 provides an overview of the main clusters of external test equipment requirements. A requirement cluster has at least one requirement and optional recommendations.

Table 2 — Main requirements clusters

#	Main title of cluster	Classifier	Brief description	Related requirements
1	Mechanical requirements	M	Requirements to mechanically connect the external test equipment	ETEREQ-M01, ETEREQ-M02, ETEREQ-M03, ETEREQ-M04, ETEREQ-M05, ETEREQ-M06
2	Electrical requirements	E	Electrical hardware related requirements and recommendations	ETEREQ-E01, ETEREC-E02, ETEREQ-E03, ETEREQ-E04, ETEREQ-E05
3	Communication setup and session	S	Automatic hands-off determination of the communication interface — Hands-free DoCAN protocol initialization — Hands-free DoIP protocol initialization and setup initialization.	ETEREQ-S01, ETEREQ-S02, ETEREC-S03, ETEREQ-S04, ETEREQ-S05, ETEREQ-S06, ETEREQ-S07, ETEREQ-S08, ETEREQ-S09, ETEREQ-S10, ETEREQ-S11
4	Diagnostic messages	D	Requirements and recommendations related to the diagnostic messages, like addressing information, sequences, dependencies	ETEREQ-D01, ETEREQ-D02, ETEREC-D03, ETEREQ-D04, ETEREQ-D05, ETEREQ-D06, ETEREQ-D07, ETEREQ-D08

Table 2 *(continued)*

#	Main title of cluster	Classifier	Brief description	Related requirements
				ETEREQ-D09, ETEREQ-D10, ETEREQ-D11, ETEREQ-D12, ETEREQ-D13, ETEREQ-D14, ETEREQ-D15, ETEREQ-D16, ETEREQ-D17, ETEREQ-D18, ETEREQ-D19, ETEREQ-D20, ETEREQ-D21, ETEREQ-D22, ETEREQ-D23, ETEREQ-D24, ETEREQ-D25, ETEREQ-D26, ETEREQ-D27, ETEREQ-D28, ETEREQ-D29, ETEREQ-D30, ETEREQ-D31
5	Error handling	F	Requirements to have a proper communication error handling	ETEREQ-F01, ETEREQ-F02, ETEREQ-F03, ETEREQ-F04
6	Use case specific requirements	U	Requirements only related to specific use cases.	ETEREQ-U01, ETEREQ-U02, ETEREQ-U03, ETEREQ-U04, ETEREC-U05, ETEREQ-U06

7 External test equipment requirements

7.1 General

This clause specifies all requirements which are applicable to the external test equipment. The Introduction, Clause 9, and Clause 10 (respectively use cases 1, 2, and 3 as specified in ISO 27145-1) include references to the requirements stated in this clause. The term 'external test equipment' addresses

all equipment that will be used in compliance with the use cases stated in this part of ISO 27145, e.g. a repair shop external test equipment or an installed diagnostic data recorder. As the test equipment is to be used for legislated OBD, it can be mounted in the car and attached to the OBD diagnostic interface, but not integrated into the internal network.

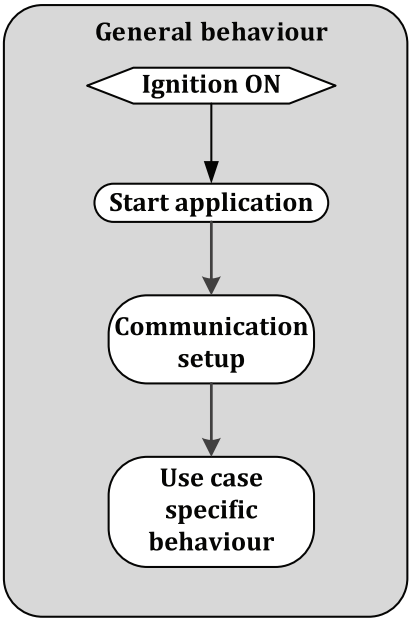


Figure 4 — General behaviour of external test equipment

7.2 Applicability of requirements according to local legislation

This part of ISO 27145 is based on the requirements established by the GTR #5, only. Local legislation can require additional data to be supported for each use case as specified in this part of ISO 27145. The additional data are defined in SAE J1979-DA.

7.3 User instructions and guidelines

ETEREQ-M01 If the chosen connector supports detection of ignition/run status, the external test equipment shall verify that ignition is active before starting any action.

ETEREQ-M02 If the chosen connector does not support the detection of ignition/run status, the external test equipment shall ask the user to confirm ignition/run status active before starting any action.

7.4 Cluster “Mechanical requirements”

ETEREQ-M03 To connect the external test equipment to the vehicle one of the following, ISO 15031-3 type connectors shall be used:

— type A (12 V DC) or

— type B (12 V DC or 24 V DC).

ETEREQ-M04 The length of the cable (from external test equipment interface transceiver to diagnostic connector) shall not exceed the recommended length for this data link (e.g. 5 m for CAN). More restrictive requirements always supersede less restrictive requirements.

Refer to ISO 13400-3 (DoIP) or ISO 15765-4 (DoCAN) for applicable cable length specification.

ETEREQ-M05 If the external test equipment supports the DoCAN protocol, the cable mechanical (and electrical) configuration and characteristics shall be in accordance with ISO 15765-4.

ETEREQ-M06 If the external test equipment supports the DoIP protocol, the cable mechanical (and electrical) configuration and characteristics shall be in accordance with ISO 13400-3.

7.5 Cluster "Electrical requirements"

ETEREQ-E01 If the external test equipment is powered from the vehicle diagnostic connector, it shall comply with the electrical characteristics of either 12 V DC or 24 V DC vehicle battery systems. External test equipment shall comply with diagnostic connector specifications for DoCAN (ISO 15031-3), or DoIP (ISO 13400) and requirements detailed in Table 3.

Table 3 — Additional interface requirements

Requirement definition	12 V DC	24 V DC	Unit
Survive a vehicle battery voltage for at least 10 min	24	36	V
Survive, non-operationally, a reverse vehicle battery voltage for at least 10 min	24	36	V

ETEREC-E02 During engine crank event, the external test equipment should withstand cranking so that communications and data shall not be lost during vehicle battery voltage reductions as specified in ISO 16750-2 or ISO 7637-2.

ETEREQ-E03 In regards to EMC, the external test equipment shall not interfere with the normal operation of the vehicle electrical system.

ETEREQ-E04 In regards to EMC, the normal operation of the external test equipment shall be immune from conducted and radiated emissions present in a service environment and when connected to a vehicle.

ETEREQ-E05 The external test equipment shall meet the electrical requirements specified in ISO 15031-3.

7.6 Cluster "Communication setup" and connections

7.6.1 Connections

A connection ends when the external test equipment does not communicate with any ECU for the time specified below.

ETEREQ-S01 The connection ends when the external test equipment does not send any request to the vehicle for more than 5 min.

ETEREQ-S02 If communication is to be performed after the connection has ended, the external test equipment has to restart with the communication setup process.

ETEREC-S03 If the external test equipment can be sure to be connected to the same vehicle, it can bypass the following steps asking for static information:

— Connector determination (DoIP or DoCAN)

  — DoCAN: Baudrate detection

  — DoCAN: 11 bit or 29 bit CANID support

— Build ECU table (but it has to send the functional $F8_{16}$, 10_{16} request to indicate a connection start; valid for 11-bit and 29-bit CANIDs).

— Read GTR (SAE J1979-DA specifies an InfoType to retrieve the WWH-OBD GTR number).

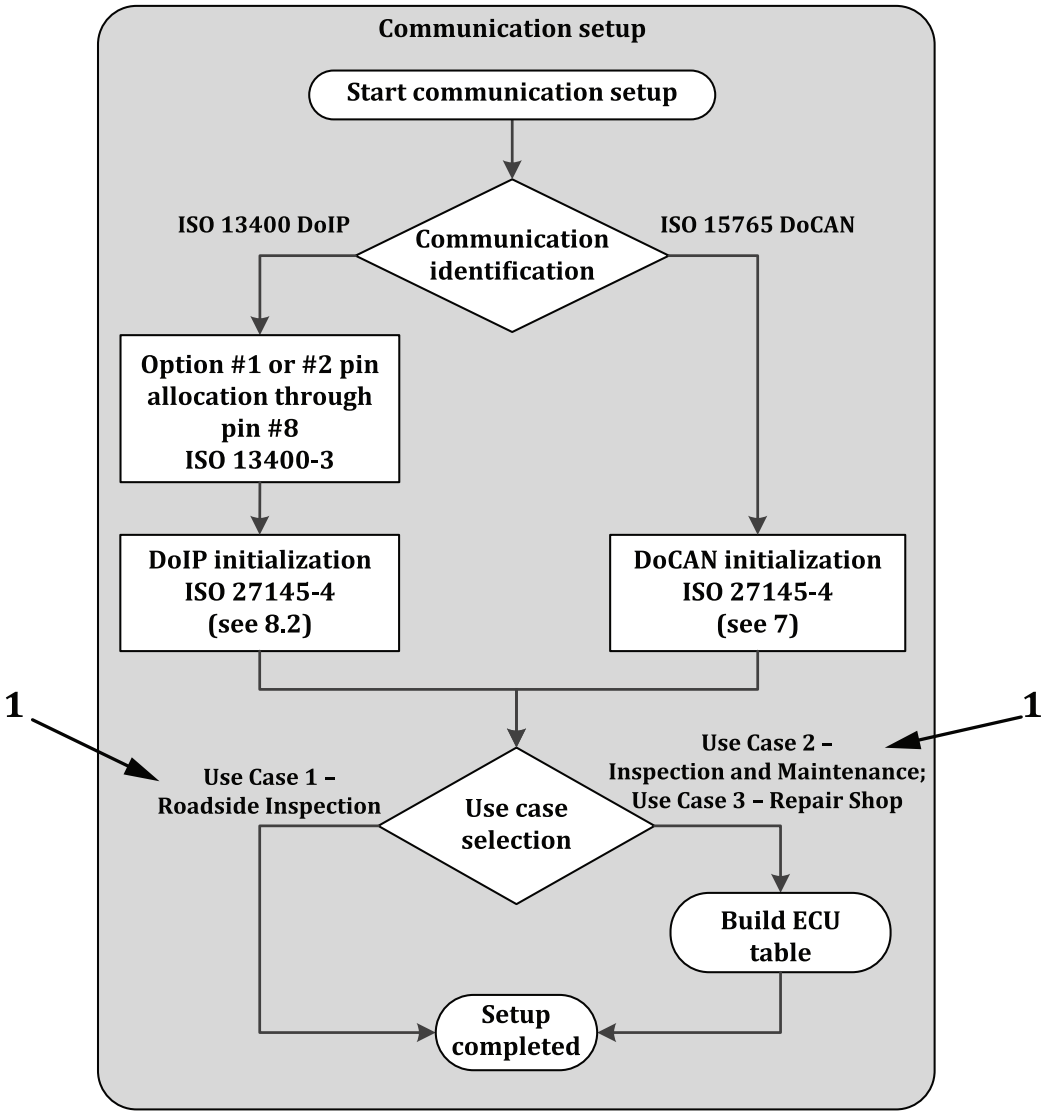
— Read VIN (SAE J1979-DA specifies an InfoType to retrieve the VIN number)

— Read the Software Calibration Identification number (CALID) (SAE J1979-DA specifies an InfoType to retrieve the CALID number)

— Read the calibration verification number (CVN) (SAE J1979-DA specifies an InfoType to retrieve the CVN number)

7.6.2 Communication setup

Figure 5 shows the communication setup.



Key

1 See ISO 27145-1

NOTE No simultaneous protocol determination.

Figure 5 — Communication setup

The communication setup defines the different steps needed to initialize communication to the vehicle. At first, the external test equipment has to determine the interface to be used, either by selection by the user or by probing the available interfaces using the respective initialization procedure (either DoCAN or DoIP). As a result, it constructs the ECU table, including the ECU names, which the external test equipment needs to perform the use case specific communications. Use cases 2 and 3 need ECU addressing information for the subsequent physical communication with the ECUs. Use case 1, which uses only functional requests, can bypass this step.

The communication setup has to be executed just once per connection; it queries only static information that does not change. This sequence is not to be part of any cyclic measurements.

ETEREQ-S04 The external test equipment shall employ an "Automatic Protocol Determination" feature to determine the communication protocol used in a given vehicle. No user intervention shall be required during this phase.

ETEREQ-S05 The external test equipment shall allow the user to select the protocol for WWH OBD, either before automatic interface determination or after the determination, when the detection process received an ambiguous result.

ETEREQ-S06 The connected external test equipment shall not cause failures on the in-vehicle network, e.g. CAN bus off.

ETEREQ-S07 The external test equipment shall perform an automatic DoCAN protocol initialization according to ISO 27145-4.

ETEREQ-S08 The external test equipment shall perform an automatic DoIP protocol initialization according to ISO 27145-4.

ETEREQ-S09 The external test equipment shall inform the user that initialization is occurring.

ETEREQ-S10 The external test equipment shall inform the user about the selected protocol in use.

7.7 Cluster “Diagnostic messages”

7.7.1 Overview

All ECU communication is done by diagnostic messages. To retrieve the information from the ECUs, the following diagnostic messages are used. Subclause 7.7 is divided into the different communication phases.

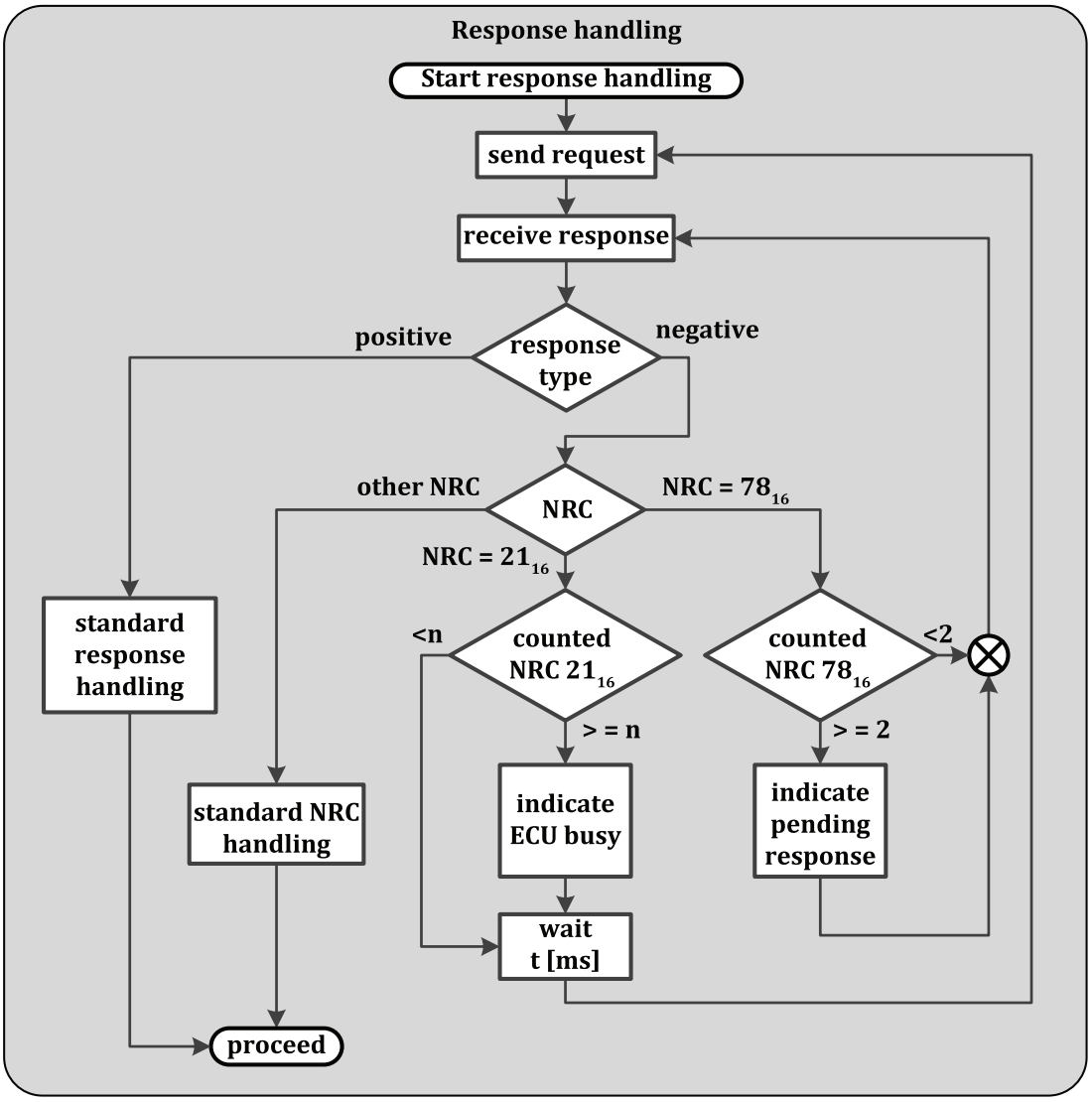
7.7.2 Timing

ETEREQ-D01 The client shall utilize the P_{Client} reload mechanism as described in ISO 14229-2 for DoCAN and ISO 27145-3 for DoIP.

7.7.3 Negative response handling

Besides the standard response codes that indicate non conformant communication, like missing parameters, unsupported functions, etc., there are two responses that have to be handled in a special way. For details, refer to ISO 14229-1.

Figure 6 shows the response handling.



Key

n 5 loops

t 200 ms

Figure 6 — Response handling

ETEREQ-D02 When the external test equipment receives a NRC 21_{16} (busyRepeatRequest), it shall retry to request the information. Between each retry, it shall wait for a minimum of 200 ms.

ETEREC-D03 When the external test equipment receives a NRC 21_{16} (busyRepeatRequest), the test equipment should use a 1 s interval between retries.

ETEREQ-D04 After receiving five consecutive NRC 21_{16} (busyRepeatRequest) or 1 s after the first NRC 21_{16} received, the external test equipment shall indicate to the user that the ECU is busy [e.g. “wait(busy)”].

ETEREQ-D05 When the external test equipment receives a NRC 78_{16} (requestCorrectlyReceived-ResponsePending), it shall wait for the specified time (ISO 27145-3, Table 13) to receive a further response.

ETEREQ-D06 After receiving two consecutive NRC 78_{16} (requestCorrectlyReceived-ResponsePending), the external test equipment shall indicate to the user that the response from the respective ECU is pending [e.g. “wait(response pending)”].

7.7.4 Error handling of no response from the vehicle

An ECU can fail to respond to a request message from the external test equipment because of incorrect transmission or because the module does not support that message. There might be several other reasons for an ECU to not respond to a request.

Figure 7 shows how to handle that situation.

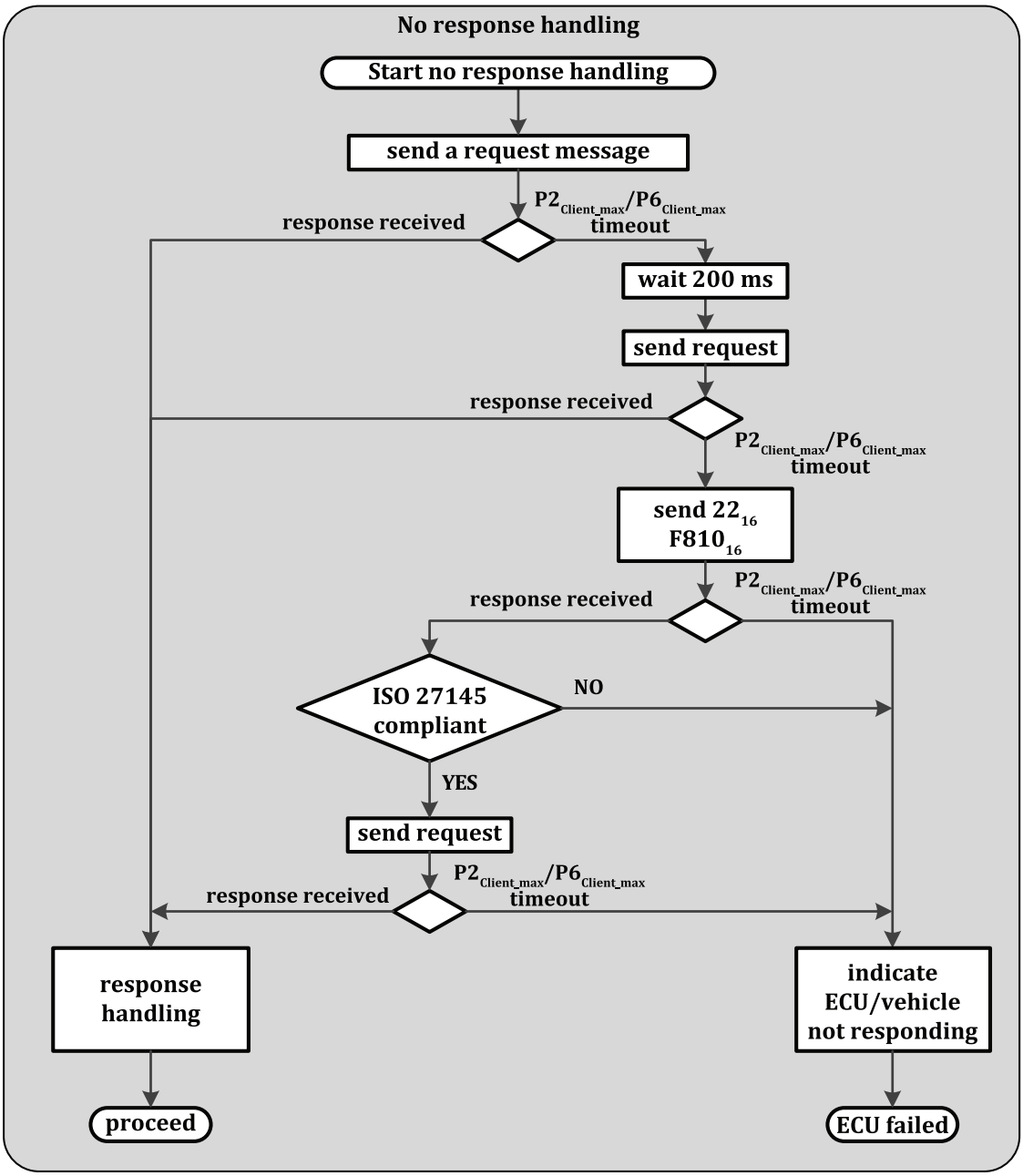


Figure 7 — No response handling

ETEREQ-F01 If a response is not received within the $P2_{Client\_max}$/$P6_{Client\_max}$ timeout period prescribed by the protocol, the test equipment shall

— retransmit the request message one more time after 200 ms;

— if there is still no response, transmit a service 22_{16} UDID $F810_{16}$ request message in order to determine if communication with the vehicle is still possible;

— if a service 22_{16} UDID $F810_{16}$ = 1 response is received, retransmit the original request one more time;

— if the previous step fails again then indicate to the user, as appropriate, that communication with the vehicle cannot be performed, that communication with the module cannot be performed or that the information the user has selected is not available.

ETEREQ-F02 If the server indicates that the information is supported (i.e. by setting the corresponding bit in the DID supported, i.e. $F400_{16}$ - $F5C0_{16}$, $F800_{16}$ - $F8C0_{16}$) but does not respond to a physical request or responds with a negative response code, then the data shall be presented as “Failed”.

ETEREQ-F03 The external test equipment shall inform the user about any communication errors that prevent the external test equipment from reading out information.

ETEREQ-F04 Communication errors, which the error handling process was not able to rectify, shall be reported to the user.

7.7.5 Setup of ECU list

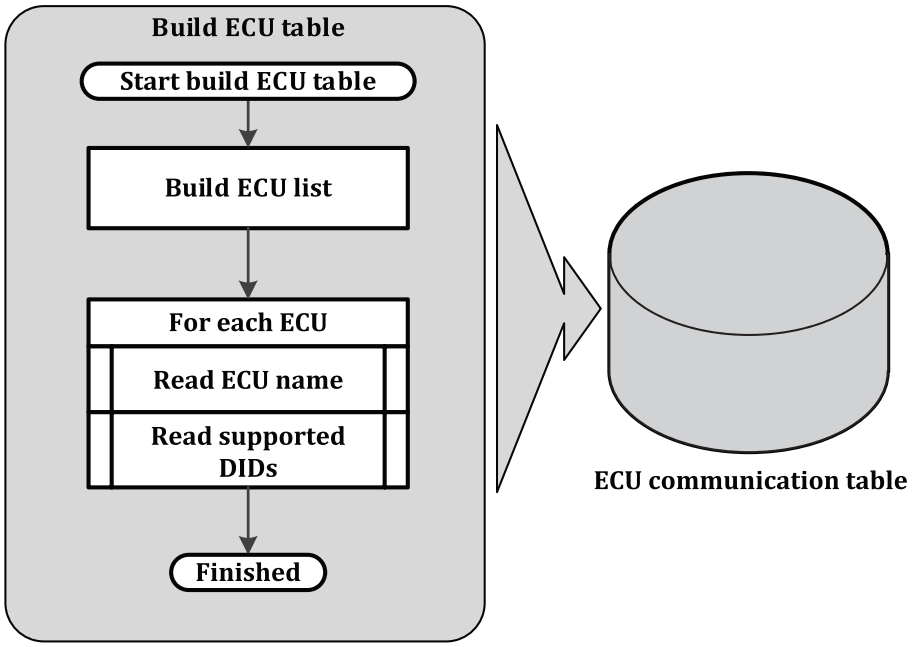
ETEREQ-D07 For use case 2 or 3, the external test equipment shall use the responses of functional service 22_{16}, $F810_{16}$ to collect the ECU addresses and store them in a list. Only those responses shall be stored, that indicate ISO 27145 compliance.

Table 4 defines the external test equipment initialization message sequence. For details refer to ISO 14229-1.

Table 4 — External test equipment initialization message sequence

Msg#	Description	Addressing type	Application message name	PDU message content
1	Read protocol identification	functional	ReadDataByIdentifier(ITID(F810))	22_{16} $F8_{16}$ 10_{16}
2	PositiveResponse to $F810_{16}$	physical	Read Protocol identification – positive response ITID (High Byte = $F8_{16}$) ITID (Low Byte = 10_{16}) only accept 01_{16} (see ISO 27145-4)	62_{16} $F8_{16}$ 10_{16} 01_{16}
OR				
2	NegativeResponse to $F810_{16}$	physical	NRC Request Service ID: ReadDataByIdentifier Negative Response Code	$7F_{16}$ 22_{16} < NRC_{16} >

7.7.6 Setting up ECU communication list



ETEREQ-D08 The client shall build a list of all ECUs responding to the functional Service 22_{16} $F810_{16}$ request and use this information for physical requests. This step is not necessary for use case 1, "roadside inspection", and can be bypassed there.

Figure 8 — Build ECU communication and data information lists

ETEREQ-D09 The external test equipment shall store the address of each ECU responding to service 22_{16} $F810_{16}$ with a result of 01_{16} (=WWH-OBD).

ETEREQ-D10 For each ECU, the external test equipment shall query the ECU's name using service 22_{16} $F80A_{16}$. Finally, the table has, as a minimum, the following data entries:

— ECU address

— ECU name

This information is static, so it is not necessary to have this as part of a cyclic reading.

ETEREQ-D11 The ECU table shall be built only once after communication setup.

7.7.7 Setting up data information list

ETEREQ-D12 The client shall send physically addressed Service 22_{16} ReadDataByIdentifier requests to gather all supported DIDs (PIDs, MIDs and ITIDs). It shall query those ECUs that have responded to the service 22_{16} $F810_{16}$ request during initialization [SAE J1979, Appendix A]. This step is not necessary for use case 1, "roadside inspection", and can be bypassed there.

— PIDs: $F400_{16}$; $F420_{16}$; $F440_{16}$; … $F5E0_{16}$

— MIDs: $F600_{16}$; $F620_{16}$; … $F7E0_{16}$

— ITIDs: $F800_{16}$; $F820_{16}$; … $F8E0_{16}$

ETEREQ-D13 Based on the results, the external test equipment shall store the information about the supported DIDs for each ECU.

ETEREQ-D14 The external test equipment shall only query those DIDs that have been marked to be supported by the respective ECU.

ETEREQ-D15 When the external test equipment requests DID data, it shall not mix different DID ranges in one request, i.e. it shall send separate requests for PIDs, for MIDs, and for ITIDs.

ETEREQ-D16 When the external test equipment requests ITID data, it shall request one ITID value per request.

ETEREQ-D17 The external test equipment shall send a maximum of six DIDs (PIDs or MIDs, not mixed) in one physical request (refer to ISO 27145-3).

7.7.8 Reading DTCs

DTCs can be read at any time after the communication setup, either once after setup, continuously, or on user request.

ETEREQ-D18 The client shall send physically addressed requests to all ECUs to read the applicable DTCs per class of DTC.

ETEREQ-D19 The client shall retrieve the class A, B1, B2, and C DTCs which are pending, confirmed, and active or previously active.

ETEREQ-D20 The client can request DTCs from all classes and at all stages, but needs to sort the DTCs into the different classes and states.

7.7.9 Setting up DTC information list

Figures 9 and 10 show the read DTC information and the updating of snapshot and extended data support. See definition in ISO 14229-1.

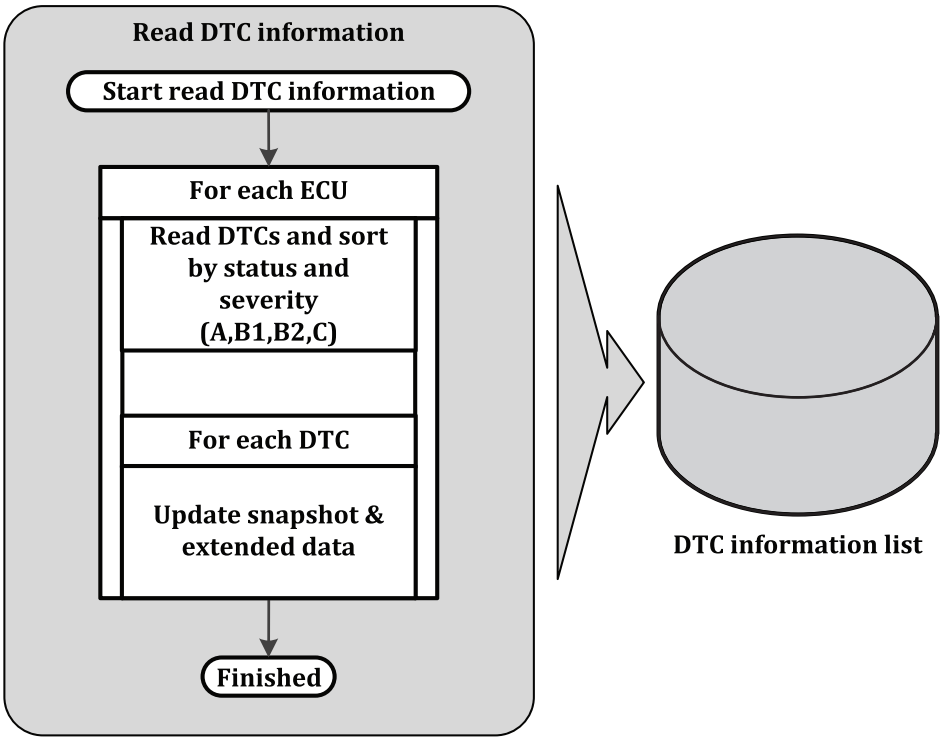


Figure 9 — Read DTC information

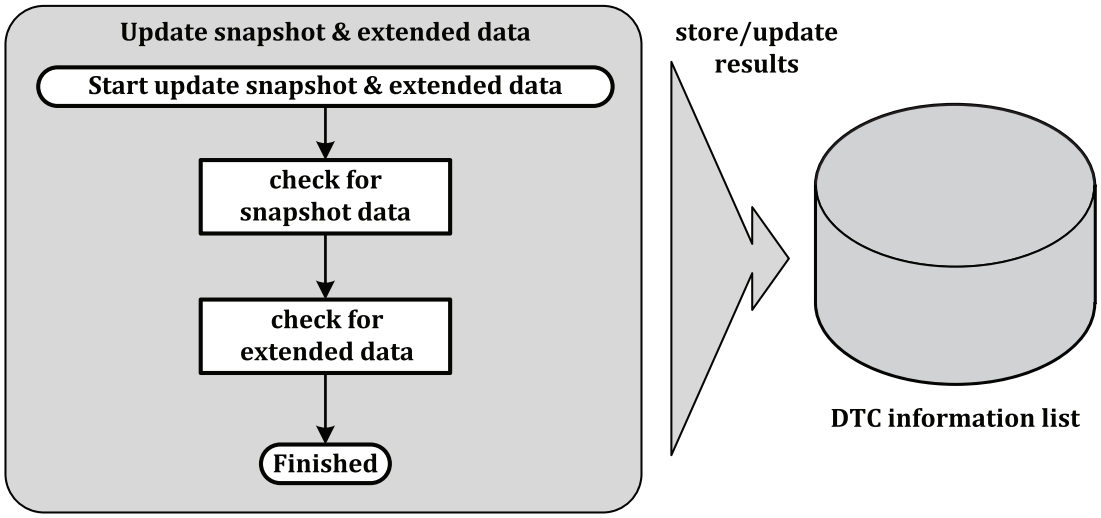


Figure 10 — Updating snapshot and extended data support

ETEREQ-D21 The external test equipment shall construct lists of all emissions-related DTCs for retrieving snapshot data and extended data. It shall use the following request for all relevant ECUs (for details refer to ISO 14229-1), with the DTCSeverityMask set according to the use case:

Table 5 — Use case related DTCSeverityMask

Use Case #	Relevant severity classes	DTCSeverityMask value
1	not applicable	not applicable
2	A, B1, B2	$0E_{16}$
3	A, B1, B2, C	$1E_{16}$

Table 6 — External test equipment DTC reading message sequence

Msg#	Description	Addressing type	Application message name	PDU message content
1	Read DTC information	physical	ReadDTCInformation	19_{16}
			sub-function = reportWWHOBDDTCBy-MaskRecord	42_{16}
			FunctionalGroupID = OBD	33_{16}
			DTCStatusMask	$0C_{16}$
			DTCSeverityMask (see Table 5)	$0E_{16}$ or $1E_{16}$
				XX_{16}

Table 6 *(continued)*

Msg#	Description	Addressing type	Application message name	PDU message content
2	Positive response	physical	ReadDTCInformation – positive response	59_{16}
			sub-function	42_{16}
			FunctionalGroupID	33_{16}
			DTCStatusAvailabilityMask	00_{16} – FF_{16}
			DTCSeverityAvailabilityMask	00_{16} – FF_{16}
			DTCFormatIdentifier	02_{16}/04_{16}
			DTCAndSeverityRecord[] = [	
			DTCSeverity #1	DTCS
			DTCHighByte #1 (MSB)	DTCHB
			DTCMiddleByte #1	DTCMB
			DTCLowByte #1	DTCLB
			statusOfDTC #1	SODTC
			:	:
			DTCSeverity #m	DTCS
			DTCHighByte #m (MSB)	DTCHB
			DTCMiddleByte #m	DTCMB
			DTCLowByte #m	DTCLB
			statusOfDTC #m]	SODTC
OR				
2	Negative response	physical	Negative Response Service Identifier	$7F_{16}$
			Request Service ID: ReadDTCInformation	19_{16}
			NRC	<NRC_{16}>

ETEREQ-D22 The external test equipment shall sort the DTC information according to the severity information (Class A, B1, B2, C), i.e. it shall maintain one list of DTCs per class.

ETEREQ-D23 The external test equipment shall evaluate the GTR-Status of each DTC as follows:

Table 7 — External test equipment GTR status evaluation (refer to ISO 27145-3)

GTR-status	statusOfDTC.bit3 (confirmedDTC)	statusOfDTC.bit2 (pendingDTC)
Pending[a]	0	1
Previously Active	1	0
Confirmed and Active	1	1

[a] "Potential" is the term used in the regulation for "Pending".

ETEREQ-D24 When reading Pending DTCs and the statusOfDTC.bit3 (confirmedDTC) = 0, the DTC status shall be displayed as Pending (Potential).

ETEREQ-D25 When reading Confirmed DTCs and the statusOfDTC.bit2 (pendingDTC) = 0, the DTC status shall be displayed as Previously Active.

ETEREQ-D26 When reading Pending DTCs and the statusOfDTC.bit3 (confirmedDTC) = 1, the DTC status shall be displayed as Confirmed and Active.

ETEREQ-D27 The external test equipment shall store the DTC format identifier for each DTC in order to be able to interpret DTC data. The DTC information list shall, as a minimum, cover the following entries per ECU per DTC:

— DTCFormat

— DTCStatus (GTR-status)

— DTCSeverity (Class A, B1, B2, or C)

— SnapshotData

— ExtendedData

DTCFormat is one of the supported formats specified in ISO 27145-3, Table 4.

If the ECU responds positively to a request for SnapshotData but the response does not include any SnapshotData related to a specific DTC, then that specific DTC does not have any snapshot data. The same holds true for ExtendedData.

ETEREQ-D28 The external test equipment shall continue to request the snapshot data for all DTCs and mark those DTCs which have snapshot data stored. For details refer to ISO 14229-1. Table 8 shows the message sequence.

Table 8 — External test equipment snapshot data reading message sequence

Msg#	Description	Addressing type	Application message name	PDU message content
1	Read DTC snapshot data information	physical	ReadDTCInformation	19_{16}
			sub-function. = reportDTCSnapshotRecordByDTCNumber	04_{16}
			DTCMaskRecord[] = [	
			DTCHighByte	12_{16}
			DTCMiddleByte	34_{16}
			DTCLowByte]	56_{16}
			DTCSnapshotRecordNumber	00_{16}

Table 8 *(continued)*

Msg#	Description	Addressing type	Application message name	PDU message content
2	Positive response	physical	ReadDTCInformation – positive response	59_{16}
			reportType = reportDTCSnapshotRecordByDTCNumber	04_{16}
			DTCAndStatusRecord[] = [	
			DTCHighByte	12_{16}
			DTCMiddleByte	34_{16}
			DTCLowByte	56_{16}
			statusOfDTC]	24_{16}
			DTCSnapshotRecordNumber	00_{16}
			DTCSnapshotRecordNumberOfIdentifiers	01_{16}
			dataIdentifier [byte#1] (MSB)	47_{16}
			dataIdentifier [byte#2] (LSB)	11_{16}
			DTCSnapshotRecord [data#1] = ECT	$A6_{16}$
			DTCSnapshotRecord [data#2] = TP	66_{16}
			DTCSnapshotRecord [data#3] = RPM	07_{16}
			DTCSnapshotRecord [data#4] = RPM	50_{16}
			DTCSnapshotRecord [data#5] = MAP	20_{16}
OR				
2	Negative response	physical	Negative Response Service Identifier	$7F_{16}$
			Request Service ID: ReadDTCInformation	19_{16}
			NRC	<NRC_{16}>

NOTE Table 8 includes example data.

ETEREQ-D29 The external test equipment shall continue to request the extended data for all DTCs and mark those DTCs which have extended data stored. For details refer to ISO 14229-1, Table 9 shows the message sequence.

Table 9 — External test equipment extended data reading message sequence

Msg#	Description	Addressing type	Application message name	PDU message content
1	Read DTC extended data information	physical	ReadDTCInformation	19_{16}
			sub-function = reportDTCExtDataRecordByDTCNumber	06_{16}
			DTCMaskRecord[] = [	12_{16}
			DTCHighByte	34_{16}
			DTCMiddleByte	56_{16}
			DTCLowByte]	90_{16}
			DTCExtendedDataRecordNumber (either FE_{16}, or selectively 90_{16} and 91_{16})	

Table 9 *(continued)*

Msg#	Description	Addressing type	Application message name	PDU message content
2	Positive response	physical	ReadDTCInformation – positive response	59_{16}
			reportType = reportDTCExtDataRecordByDTCNumber	06_{16}
			DTCAndStatusRecord[] = [	
			DTCHighByte	12_{16}
			DTCMiddleByte	34_{16}
			DTCLowByte	56_{16}
			statusOfDTC]	24_{16}
			DTCExtendedDataRecordNumber = FailureSpecificB-1Counter	90_{16}
			DTCExtDataRecord [byte#1] [29 h 6 min]	01_{16}
			DTCExtDataRecord [byte#2]	23_{16}
OR				
2	Negative response	physical	Negative Response Service Identifier	$7F_{16}$
			Request Service ID: ReadDTCInformation	19_{16}
			NRC	<NRC_{16}>

NOTE Table 9 includes example data.

7.7.10 Clear diagnostic information

To clear diagnostic information, the message sequence in Table 10 has to be used.

Table 10 — External test equipment clear diagnostic information message sequence

Msg#	Description	Addressing type	Application message name	PDU message content
1	Clear DTC information	functional	ClearDiagnosticInformation([DTCGroup])	14_{16}
			groupOfDTC[] = [	
			groupOfDTCHighByte	FF_{16}
			groupOfDTCMiddleByte	FF_{16}
			groupOfDTCLowByte]	33_{16}
			Delete all emissions-related DTC information	
2	Positive response	physical	ClearDiagnosticInformation – positive response	54_{16}
OR				
2	Negative response	physical	Negative Response Service Identifier	$7F_{16}$
			Request Service ID: ClearDiagnosticInformation	14_{16}
			NRC	<NRC_{16}>

7.7.11 Continuously reading ECU data

To be able to detect changes in the data read from the vehicle, it is necessary to read some data cyclically, the external test equipment has to resend some requests multiple times. Repeatedly requested values can be DTCs or measurement values that are to be monitored by the external test equipment. Figure 11 shows the cyclic data reading.

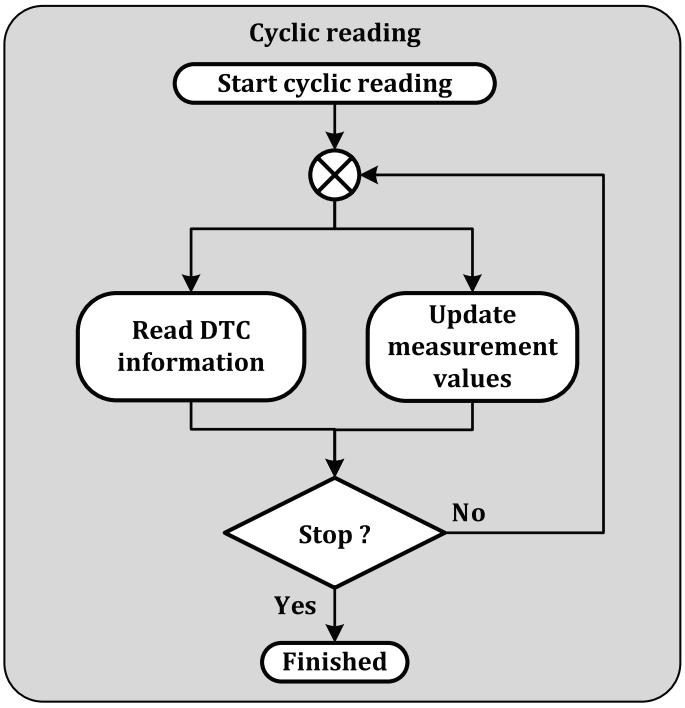


Figure 11 — Cyclic data reading

ETEREQ-D30 To minimize the busload, the external test equipment shall only re-read values which can change e.g. Engine Speed, Throttle Position, ...

ETEREQ-D31 The external test equipment shall only use physical addressing for repeatedly requested data.

8 Roadside inspection test equipment

8.1 Definition

The use case #1 Roadside Inspection (see ISO 27145-1) is intended for checking vehicles at the roadside. In the future, this might also be done in a drive-by (i.e. wireless communication to a road portal) scenario. The intention is to check if the vehicle has any malfunctions which cause illumination of the MI. For details refer to ISO 27145-1.

For the road side inspection test only limited functionality is necessary to check whether or not the vehicle is roadworthy. The general process is shown in Figure 12.

8.2 Related use cases

The use case is meant to give a quick indication of road worthiness of the vehicle under test. No further investigation has to be supported. If the vehicle is not roadworthy, further investigation will be covered by one of the other use cases.

The roadside inspection test equipment could be connected directly to the vehicle by one of the supported interfaces and could perform the check immediately after connecting. Future systems might use a wireless connection and can be without the need to stop the vehicle, i.e. it could be in some station near the road or within another vehicle.

8.3 Implementation requirements

8.3.1 Overview

ETEREQ-U01 The external test equipment shall only use functional requests for the roadside inspection.

ETEREQ-U02 The external test equipment shall read out the data once per connection cycle.

8.3.2 Application layer

Figure 12 shows use case 1.

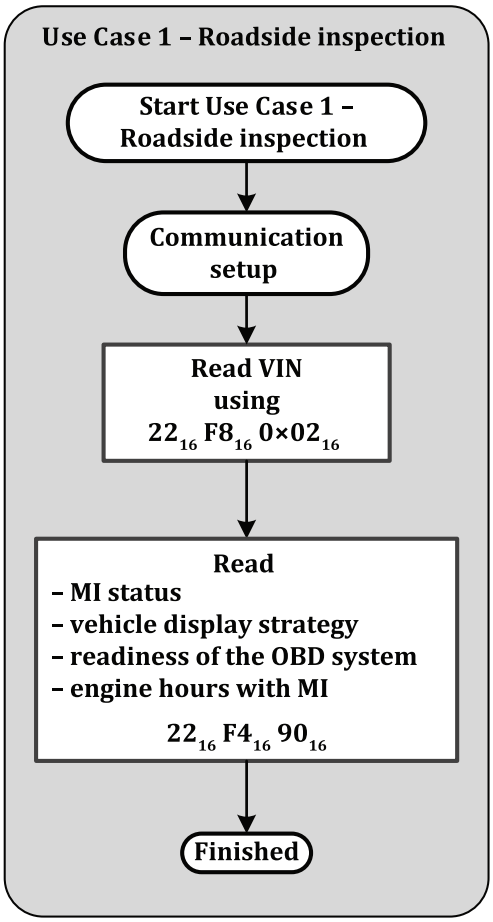


Figure 12 — Use case 1 – Roadside inspection

As specified in ISO 27145-3, within this use case, only functional requests are used. As the information is not a target for change, no cyclic reading is necessary.

ETEREQ-U03 The external test equipment shall read out the data using the sequence shown in Table 11 and in Figure 12, respectively.

Table 11 — Roadside inspection test equipment application message sequence definition

Msg#	Description	Addressing type	Application message name	PDU message content
1	Read VIN	functional	ReadDataByIdentifier($F802_{16}$)	22_{16} $F8_{16}$ 02_{16}

Table 11 *(continued)*

Msg#	Description	Addressing type	Application message name	PDU message content
2	Read vehicle display strategy Read status of MI Read readiness of the OBD system Read the number of engine hours during which a continuous-MI was activated.	functional	ReadDataByIdentifier($F490_{16}$) NOTE The $F490_{16}$ DID contains all data items as listed in the column "Description".	22_{16} $F4_{16}$ 90_{16}

9 Inspection and maintenance (I/M) test equipment

9.1 Definition

The use case #2 (see ISO 27145-1), Road Worthiness, is meant to be used to check vehicle readiness and characterize the malfunctions detected by the OBD system. For details, refer to ISO 27145-1.

9.2 Related use cases

For inspection and maintenance, more specific information is necessary than for use case 1. The test equipment has to be able to perform the use case 1 tests, and also read out data per ECU in order to be able to precisely classify and document the vehicle's readiness.

9.3 Implementation requirements

9.3.1 General

National legislation can require that specific DIDs are continuously reported by the external test equipment for I/M use. For those applications, the requirement of use case 3 can apply. It is up to the test equipment manufacturer to ensure that all legislated requirements are fulfilled.

9.3.2 Application layer

In addition to the use case 1, it is necessary that the external test equipment reads out detailed information from specific ECUs. Also, it might be necessary to continuously read out data in order to detect changes in the results. Figures 13 and 14 show the inspection and maintenance use case 2 and its measurement update sequence.

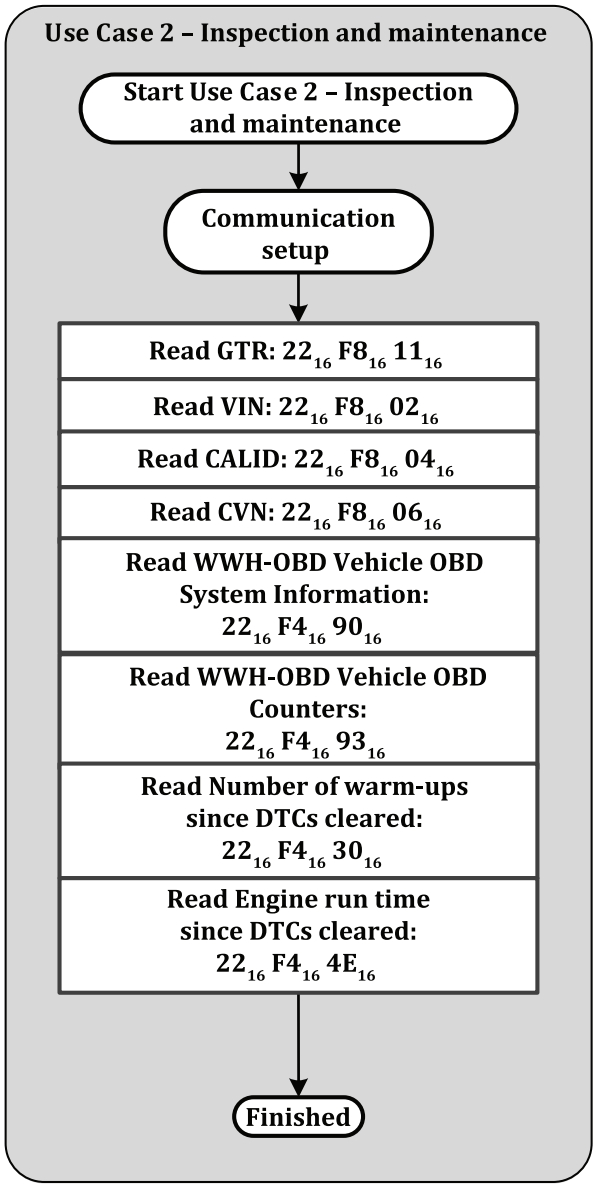


Figure 13 — Use case 2 – Inspection and maintenance

Table 12 defines the I/M test equipment application message sequence definition. The grey lines show the requests reading static values.

Table 12 — I/M test equipment application message sequence definition

Msg#	Description	Addressing type	Application message name	PDU message content
1	Read the GTR number	physical	ReadDataByIdentifier($F811_{16}$)	22_{16} $F8_{16}$ 11_{16}
2	Read VIN	functional	ReadDataByIdentifier($F802_{16}$)	22_{16} $F8_{16}$ 02_{16}
3	Read the Software Calibration Identification number	physical	ReadDataByIdentifier($F804_{16}$)	22_{16} $F8_{16}$ 04_{16}
4	Read the Calibration Verification Number	physical	ReadDataByIdentifier($F806_{16}$)	22_{16} $F8_{16}$ 06_{16}
5	Read the confirmed and Active DTCs for Class A, B1 and B2 malfunctions	physical	ReadDTCInformation. reportWWHOBDDTCByMaskRecord	19_{16} 42_{16} 33_{16} $0C_{16}$ $0E_{16}$

Table 12 *(continued)*

Msg#	Description	Addressing type	Application message name	PDU message content
6	Read Vehicle Display Strategy Read status of MI Read Readiness of the OBD system Read the number of engine operating hours during which a continuous-MI was activated Read the cumulated operating hours with a continuous-MI.	physical	ReadDataByIdentifier($F490_{16}$) NOTE The $F490_{16}$ DID contains all data items as listed in the column "Description".	22_{16} $F4_{16}$ 90_{16}
7	Read the value of the B1 counter with the highest number of engine operating hours.	physical	ReadDataByIdentifier($F493_{16}$)	22_{16} $F4_{16}$ 93_{16}
8	Read the number of warm-up cycles and number of engine operating hours since the recorded OBD information was last cleared	physical	ReadDataByIdentifier($F430_{16}$) ReadDataByIdentifier($F44E_{16}$)	22_{16} $F4_{16}$ 30_{16} 22_{16} $F4_{16}$ $4E_{16}$

10 Repair shop test equipment

10.1 Definition

The use case no. 3 (see ISO 27145-1), Repair Shop, is meant to be used to provide access to all OBD data required by legislation and available from the OBD system. For details, refer to ISO 27145-1.

10.2 Related use cases

Typical applications of this use case are in a workshop environment to diagnose and troubleshoot a vehicle or a system for periodic maintenance and repair. Other applications can include extended I/M functions that can be required by national legislations and are not covered by the previous use cases.

10.3 Implementation requirements

10.3.1 Overview

For this use case, the same requirements as for use case 2 are applicable. In addition, the following requirements apply. In general, for this use case, it is important to understand that a specific implementation should be designed in a way that it is as fault tolerant as possible in regards to communication, because the external test equipment is not intended to be used as a means to identify if the vehicle complies with the regulated communication requirements.

ETEREQ-U04 The tool shall not flag a delayed communication as a blocking failure but try to establish communication in as many cases as possible.

ETEREC-U05 The external test equipment can indicate a delayed communication to the user, e.g. effective use of NRCs.

ETEREQ-U06 If requested by the user, the external test equipment shall clear the OBD Information in accordance with the WWH-OBD, GTR No. 5.

10.3.2 Application layer

The test equipment for the repair shop use case is more advanced than for the previous use cases. It should help the service technician to pinpoint the root cause of the malfunction and to verify that the repair action resolved the problem

This part of ISO 27145 also does not cover the test procedure functionality, using Test ID's (TIDs), specified in SAE J1979-DA, Table C.2. It is up to the tool vendor to integrate test procedures into the diagnostic tool, if necessary.

Figures 14 and 15 show the repair shop use case 3 and its measurement update sequence.

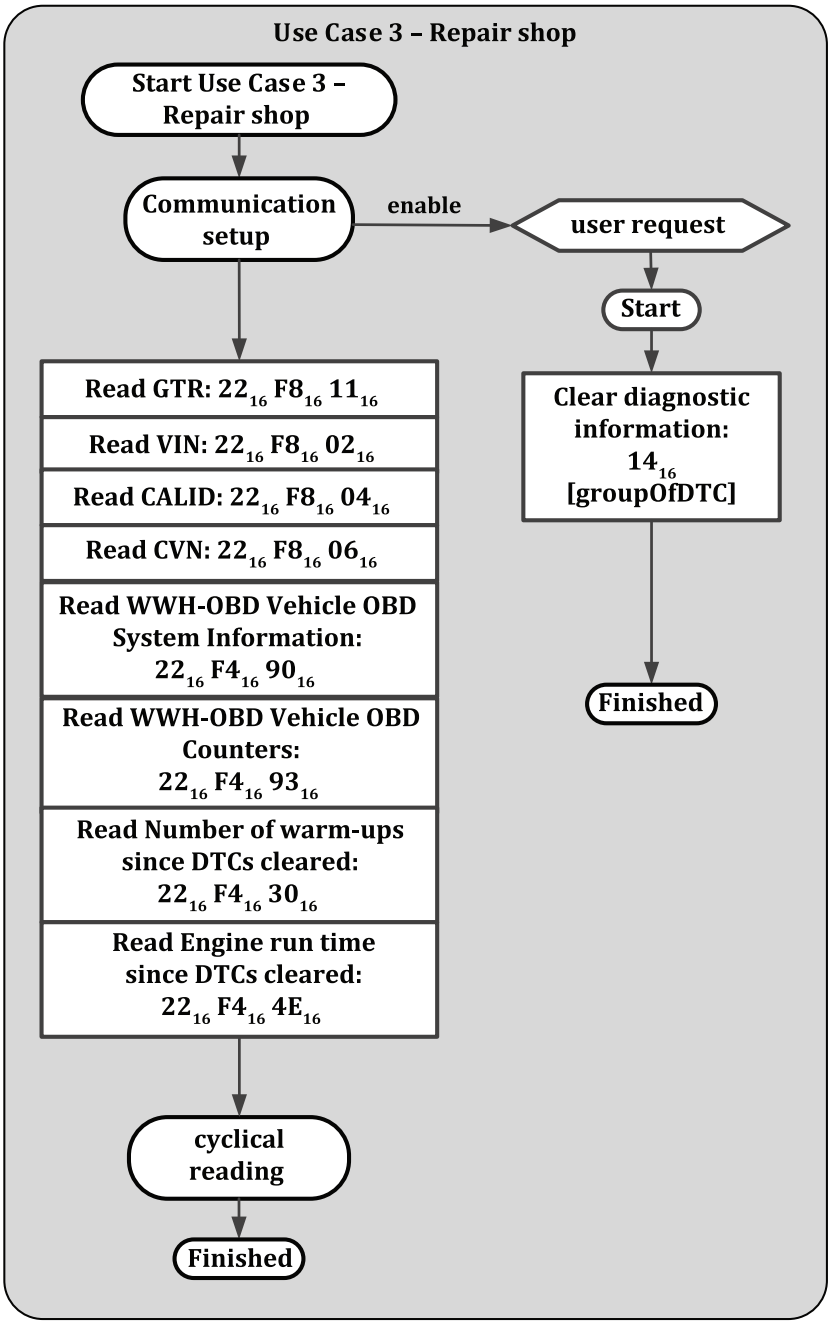


Figure 14 — Use case 3 – Repair shop

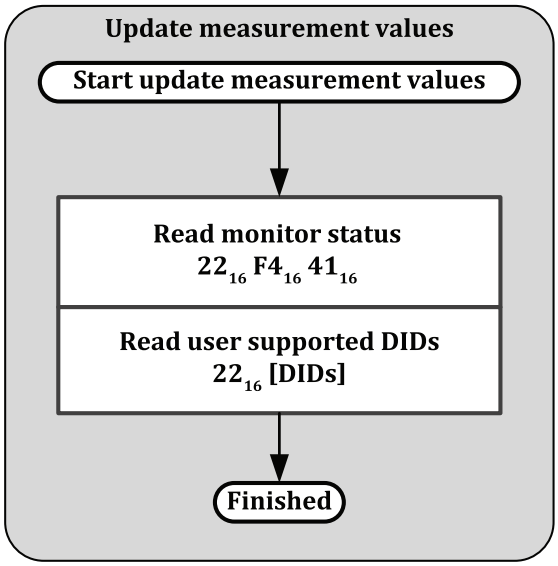


Figure 15 — Use case 3 – Measurement update sequence

Table 13 defines the repair shop test equipment application message sequence definition. The grey lines show the requests reading static values.

Table 13 — Repair shop test equipment application message sequence definition

Msg#	Description	Addressing type	Application message name	PDU message content
1	Read the GTR number	physical	ReadDataByIdentifier($F811_{16}$)	22_{16} $F8_{16}$ 11_{16}
2	Read VIN	functional	ReadDataByIdentifier($F802_{16}$)	22_{16} $F8_{16}$ 02_{16}
3	Read the software calibration identification(s)	physical	ReadDataByIdentifier($F804_{16}$)	22_{16} $F8_{16}$ 04_{16}
4	Read the calibration verification number	physical	ReadDataByIdentifier($F806_{16}$)	22_{16} $F8_{16}$ 06_{16}
5	Read the confirmed and Active DTCs for Class A, B1, B2, C malfunctions	physical	ReadDTCInformation. reportWWHOBDDTCByMaskRecord	19_{16} 42_{16} 33_{16} $0C_{16}$ $1E_{16}$
6	Read snapshot data	physical	ReadDTCInformation. reportDTCSnapshotRecordByDTCNumber	19_{16} 04_{16} [DTC] 00_{16}
7	Read extended data	physical	ReadDTCInformation. reportDTCExtendedDataRecordByDTCNumber	19_{16} 06_{16} [DTC] FE_{16} or 19_{16} 06_{16} [DTC] 90_{16}

Table 13 *(continued)*

Msg#	Description	Addressing type	Application message name	PDU message content
8	Read status of MI. Read Readiness of the OBD system. Read the number of engine operating hours during which a continuous-MI was activated. Read the cumulated operating hours during with a continuous-MI.	physical	ReadDataByIdentifier($F490_{16}$) NOTE The $F490_{16}$ DID contains all data items as listed in the column "Description".	22_{16} $F4_{16}$ 90_{16}
9	Read the value of the B1 counter with the highest number of engine operating hours.	physical	ReadDataByIdentifier($F493_{16}$)	22_{16} $F4_{16}$ 93_{16}
10	Read the number of warm-up cycles and number of engine operating hours since the recorded OBD information was last cleared.	physical	ReadDataByIdentifier($F430_{16}$) ReadDataByIdentifier($F44E_{16}$)	22_{16} $F4_{16}$ 30_{16} 22_{16} $F4_{16}$ $4E_{16}$
11	Read the monitor status (i.e. disabled for the remainder of the driving cycle) since last engine shut-off.	physical	ReadDataByIdentifier($F441_{16}$)	22_{16} $F4_{16}$ 41_{16}
12	Read real-time information of supported sensor signals, internal, and output signals.	physical	ReadDataByIdentifier([DID])	22_{16} [DIDs]

Table 14 shows the ClearDTCInformation request message which is sent by the external test equipment on user request only.

Table 14 — Repair shop test equipment ClearDTCInformation message sequence definition

Msg#	Description	Addressing type	Application message name	PDU message content
1	Clear DTC information	functional	ClearDiagnosticInformation([DTCGroup]) groupOfDTC[] = [groupOfDTCHighByte groupOfDTCMiddleByte groupOfDTCLowByte]	14_{16} FF_{16} FF_{16} 33_{16}

11 Multiple test equipment communication

11.1 General

If the vehicle utilizes in-vehicle (internal) test equipment (e.g. intelligent instrument clusters, Human-Machine Interface (HMI) modules, data loggers, or telematics gateways), then there is always a possibility that a second external test equipment sends a diagnostic request, while an ECU(s) is (are) busy processing a diagnostic request from the internal test equipment, and therefore does not receive the response message.

The correct behaviour is that a legislated request from the external test equipment shall always receive a response within P_{Client} timing. It shall be noted, that some ECUs will handle multiple requests from different test equipment simultaneously, other ECUs might not support this feature.

The behaviour within a multiple test equipment scenario depends on the capabilities of the transport layer used.

If the server can process multiple diagnostic requests simultaneously and the transport layer allows different sender and receiver addresses, then there is no conflict. The servers shall maintain separate state information for the different external test equipment instances and, thus, react depending on that state information. For more detailed information relative to possible server implementations, refer to ISO 14229-1.

11.2 Behaviour of external test equipment

The external test equipment can normally start a communication setup as specified and the internal external test equipment would detect it.

ETEREQ-S11 After 5 min without any diagnostic communication, the external client shall reinitialize the communication prior to sending any new diagnostic request message.

Bibliography

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ICS 43.180; 43.040.10

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