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Road vehicles — Communication between vehicle and external equipment for emissions-related diagnostics —

Part 4: External test equipment

Véhicules routiers — Communications entre un véhicule et un équipement externe pour le diagnostic relatif aux émissions —

Partie 4: Équipement d'essai externe

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 15031-4 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 3, *Electric and electronic equipment*.

ISO 15031 consists of the following parts, under the general title *Road vehicles — Communication between vehicle and external test equipment for emissions-related diagnostics*:

— *Part 1: General information*

— *Part 2: Terms, definitions, abbreviations and acronyms*

— *Part 3: Diagnostic connector and related electrical circuits, specification and use*

— *Part 4: External test equipment*

— *Part 5: Emissions-related diagnostic services*

— *Part 6: Diagnostic trouble code definitions*

— *Part 7: Data link security*

Introduction

ISO 15031 consists of a number of parts which, taken together, provide a coherent self-consistent set of specifications to facilitate emissions-related diagnostics. Each part is based on an SAE recommended practice.

This part of ISO 15031 is based on SAE J1978 FEB98, OBD Scan tool (On-board diagnosis).

ISO 15031 specifies a set of standard diagnostic services to be provided by vehicles (OBD services). This International Standard specifies a complementary set of facilities, to be provided by external test equipment, which will include scan tool facilities. These facilities provide complete, efficient and safe access to all of the public OBD (on-board diagnosis) services on any vehicle, which is compliant with ISO 15031.

Only external test equipment passing the conformance tests specified in ISO 15031-4 may claim or advertise that it meets or exceeds the requirements of ISO 15031-4.

Partially conforming external test equipment, which does not accommodate all approved protocols is permitted but shall be so marked.

ISO 15031-4 conformance allows potential purchasers to identify external test equipment which shall work correctly with a variety of vehicle types and provides assurance for external test equipment users that they shall not inadvertently cause damage, obtain incorrect results or be unable to access all available OBD (on-board diagnosis) services. Diagnostic authors who base their test strategies on ISO 15031-4 facilities do not need to concern themselves with the details of specific types of external test equipment. ISO 15031-4 provides vehicle manufacturers with a level of protection against misdiagnosis or damage to their products resulting from external test equipment unavailability or inadequacies.

ISO 15031-4 does not preclude the inclusion of additional capabilities or functions in external test equipment. However, it is the responsibility of the external test equipment designer to ensure that no such capability or function can adversely affect either an OBD-equipped vehicle, which may be connected to the equipment or the equipment itself.

ISO 15031-1 provides an introduction to the International Standard.

Road vehicles — Communication between vehicle and external equipment for emissions-related diagnostics —

Part 4:
External test equipment

1 Scope

The document specifies:

— a means of establishing communications between an OBD-equipped vehicle and external test equipment,

— a set of diagnostic services to be provided by the external test equipment in order to exercise the services defined in ISO 15031-5,

— conformance criteria for the external test equipment.

2 Normative references

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

ISO 7637-2:1990, *Road vehicles — Electrical disturbance by conduction and coupling — Part 2: Commercial vehicles with nominal 24 V supply voltage — Electrical transient conduction along supply lines only*

ISO 9141-2: 1994, *Road vehicles — Diagnostic systems — Part 2: CARB requirements for interchange of digital information*

ISO 9141-2:1994/Amd.1:1996, *Road vehicles — Diagnostic systems — Part 2: CARB requirements for interchange of digital information — Amendment 1*

ISO 11898-1, *Road vehicles — Controller area network (CAN) — Part 1: Data link layer and physical signalling*

ISO 11898-2, *Road vehicles — Controller area network (CAN) — Part 2: High-speed medium access unit*

ISO 14230-4:2000, *Road vehicles — Diagnostic systems — Keyword protocol 2000 — Part 4: Requirements for emission-related systems*

ISO TR 15031-2, *Road vehicles — Communication between vehicle and external equipment for emissions-related diagnostics — Part 2: Terms, definitions, abbreviations and acronyms*

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 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 15031-6, *Road vehicles — Communication between vehicle and external equipment for emissions-related diagnostics — Part 6: Diagnostic trouble code definitions*

ISO 15765-4, *Road vehicles — Diagnostics on Controller Area Networks (CAN) — Part 4: Requirements for emissions-related systems*

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

SAE J1850:MAY2001, *Class B Data Communications Network Interface*

SAE J1939, *Recommended Practice for Serial Control and Communications Vehicle Network*

SAE J1939-11, *Physical layer, 250 kbps , twisted shielded pair*

SAE J1939-13, *Off-Board diagnostic connector*

SAE J1939-21, *Data link layer*

SAE J1939-71, *Vehicle application layer*

SAE J1939-73, *Application layer — Diagnostics*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/TS 15031-2 and SAE J1939 apply.

4 Required functions of the external test equipment

The following are the basic functions that the external test equipment is required to support or provide:

— automatic hands-off determination of the communication interface used to provide OBD services on the vehicle,

— obtaining and displaying the status and results of vehicle on-board diagnostic evaluations,

— obtaining and displaying OBD emissions-related diagnostic trouble codes (DTCs),

— obtaining and displaying OBD emissions-related current data,

— obtaining and displaying OBD emissions-related freeze frame data,

— clearing the storage of OBD emissions-related diagnostic trouble codes, OBD emissions-related freeze frame data storage and OBD emissions-related diagnostic tests status,

— obtaining and displaying OBD emissions-related test parameters and results as described in ISO 15031-5 or SAE J1939-73,

— provide a user manual and/or help facility.

5 Communication protocols

The following communication protocols shall be supported:

a) ISO 9141-2;

The following specifications clarify and, if in conflict with ISO 9141-2, override any related specifications in ISO 9141-2:

1) The maximum sink current to be supported by the external test equipment is 100 mA.

2) The range for all tests performed relative to ISO 7637-2 is −1,0 to +40,0 V.

3) The minimum bus idle period before the external test equipment shall transmit an address, shall be 300 ms.

b) SAE J1850 41,6 kbps PWM (pulse width modulation);

c) SAE J1850 10,4 kbps VPW (variable pulse width);

d) ISO 14230-4 (Keyword protocol 2000);

e) ISO 15765-4 (CAN);

f) SAE J1939-73 (CAN).

A fully compliant external test equipment shall support all communication protocols as specified in Clause 5.

Only one protocol is allowed to be used in any one vehicle to access all legislated emission-related functions. The external test equipment is not required to support simultaneous use of different protocols.

6 Connections to the vehicle

To connect the external test equipment to the vehicle, the SAE J1939-13 connector for the SAE J1939-73 protocol shall be used and for all other protocols the ISO 15031-3 connector shall be used.

7 Network access

7.1 Automatic determination of communication interface

The external test equipment shall have an “Automatic hands-off determination of the communication interface” built in to determine the communication protocol used in a given vehicle.

Prior to connecting the external test equipment to the vehicle's diagnostic connector, the ignition key of the vehicle shall be turned to position “ON”.

The tests to determine the communication interface and protocol may be performed in any order and, where possible, may be performed simultaneously. The specified sequence for each test shall be used to determine the interface to be used to access OBD services on a vehicle:

a) The electrical interface in the external test equipment for the manufacturer discretionary contact assignments shall be effectively open circuit as a default condition or state whilst this procedure is being performed.

b) The equipment shall inform the user that initialization is occurring.

c) The equipment shall, using only the following tests, attempt to determine the OBD communications protocol used by the vehicle. No user intervention is allowed during this stage. The test equipment shall not cause bus failures such as CAN bus off.

1) Test for SAE J1850 41,6 kbps (kilobits per second) PWM (pulse width modulation):

i) enable the SAE J1850 41,6 kbps PWM interface;

ii) send a service $01 PID $00 request message;

iii) if a service $01 PID $00 response message is received, then SAE J1850 41,6 kbps PWM is the vehicle's OBD protocol.

2) Test for SAE J1850 10,4 kbps VPW (variable pulse width):

i) enable the SAE J1850 10,4 kbps VPW interface;

ii) send a service $01 PID $00 request message;

iii) if a service $01 PID $00 response message is received, then SAE J1850 10,4 kbps VPW is the vehicle's OBD protocol.

3) Fast initialization of ISO 14230-4:

i) Refer to Annex B.1 ISO 14230-4:2000.

4) 5 baud initialization of ISO 14230-4/ISO 9141-2:

i) Refer to Annex B.2 ISO 14230-4/ISO 9141-2 how to perform the 5 baud initialization and protocol detection of the ISO 14230-4 / ISO 9141-2 protocols.

5) Test for ISO 15765-4:

i) legacy vehicles previously were allowed to use the contacts now defined for CAN communication as manufacturer discretionary. The external test equipment shall ensure adequate protection from these legacy signals,

ii) perform the “External Test Equipment Initialization Sequence” defined in ISO 15765-4,

iii) if the initialization sequence specified in ISO 15765-4 is completed successfully, then ISO 15765-4 is the vehicle's OBD protocol.

6) Test for SAE J1939:

i) Once concluded that the OBD protocol is not ISO 15765-4, then proceed to the sequence to see if the vehicle is SAE J1939 OBD capable.

ii) Set CAN controller as appropriate for SAE J1939 and perform the initialization sequence specified in J1939-73.

iii) If this SAE J1939 initialization sequence is completed successfully, then SAE J1939 is the vehicle's OBD protocol.

The service $01 PID $00 request is used to identify the ISO 15765-4 protocol in step 5. Vehicles supporting OBD diagnostics with SAE J1939-73 diagnostics will not respond to this request.

Both ISO 9141-2 and ISO 14230-4 specify a time within which a module(s) that has successfully been initialized must receive a message or the module(s) will return to the address mode. To maintain communication with the vehicle in case no service request is needed at this moment, the external test equipment shall send an idle message.

For vehicles using ISO 9141-2, service $01 PID $00 request shall be used as the idle message.

For vehicles using ISO 14230-4, the service TesterPresent is the recommended way to satisfy the idle message requirement as specified in ISO 14230-4. Alternatively, the service $01 PID $00 as specified in ISO 15031-5 may be used.

If during the initialization of the ISO 15765-4 (CAN) protocol the external test equipment receives a negative response message(s) from the emissions-related ECU(s) with the negative response code (NRC) $21 busy-RepeatRequest the external test equipment is required to perform five (5) retries (repeat request message as specified in ISO 15765-4). The reception of NRC $21 busy-RepeatRequest during the initialization indicates that an On-board diagnostic tester may be active and is currently diagnosing one or multiple emissions-related ECUs. The On-board tester and vehicle ECU(s) shall complete the in-progress communication. This may take several seconds. The external test equipment shall continue to initialize the ISO 15765-4 (CAN) protocol until it receives a positive response or aborts after five (5) seconds have expired (measured after the completion of the fifth (5th) re-try).

If none of the protocol tests shown above succeeds, the equipment shall repeat all of them and advise the user:

a) that communication with the vehicle could not be established,

b) to confirm that the ignition key is still in the “ON” position,

c) to check the emissions label or vehicle service information to confirm that the vehicle is OBD equipped,

d) to confirm that the external test equipment is connected to the vehicle correctly.

The equipment shall continue to repeat the protocol tests shown above until either one of them passes or the user chooses to abandon the attempt. The equipment may also indicate the number of failed initialization attempts to the user.

7.2 Handling of no response from the vehicle

A vehicle module may 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. If a response is not received within the time-out period prescribed by the protocol, the external test equipment shall:

a) retransmit the request message,

b) if there is still no response, transmit a service $01 PID $00 request message, in order to determine if communication with the vehicle is currently possible, and if the data desired is available,

c) if a service $01 PID $00 response is received, transmit other messages, if available, to determine whether the desired data is supported by the vehicle,

d) if the above steps fail 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 unavailable.

7.3 Handling of multiple responses from the vehicle

The external test equipment shall be capable of interfacing with a vehicle in which multiple modules support OBD requirements.

The external test equipment shall inform the user when multiple modules respond to the same request.

The external test equipment shall inform the user when multiple modules respond with different values for the same data item.

The external test equipment shall provide the user with the ability to select for display, as separate items, the responses received from multiple modules for the same data item.

7.4 Message structure

Communication between the external test equipment and the vehicle consists of repeated cycles of the external test equipment issuing a request message to the vehicle module(s) and the vehicle module(s) responses. The structure of these messages is specified in ISO 15031-5. ISO 15031-6 specifies the usage of diagnostic trouble codes, which may be contained in response messages. Message structures for SAE J1939 are described in SAE J1939-73 and SAE J1939-71.

7.5 Diagnostic trouble codes monitoring

The external test equipment shall be capable of continuously obtaining, converting and displaying OBD emissions-related diagnostic trouble codes from the vehicle. Either the diagnostic trouble code, its descriptive text or both shall be displayed. Diagnostic trouble codes and their descriptive text are specified in ISO 15031-6, or SAE J1939 and SAE J1939-73. The external test equipment shall continuously obtain and display DTCs (diagnostic trouble codes) whilst this facility is selected.

If the protocol is ISO 15031-5 and the response message includes a DTC number equal $0000, the data reported may not be valid and shall not be displayed.

7.6 Obtain and display OBD emissions-related current data, freeze frame data, and test parameters and results

The external test equipment shall create an internal table in its memory to maintain a list of supported PIDs/OBDMIDs/TIDs/INFOTYPEs for each ECU that responds to a service request message with the requested “Supported PID/OBDMID/TID/INFOTYPE” ($00, $20, ... $C0). If bit 0 of Data D is reported as “0”, that indicates that no additional PIDs/OBDMIDs/TIDs/INFOTYPEs are supported by that ECU. If bit 0 of Data D is reported as “1”, that indicates that additional PIDs/OBDMIDs/TIDs/INFOTYPEs are supported by that ECU. The external test equipment does not need to request any additional “Supported PIDs/OBDMIDs/TIDs/INFOTYPEs” if bit 0 of Data D is reported as “0” by all ECUs.

The external test equipment shall test for support of PID $4F and $50. If supported, the external test equipment shall override the data scaling of those PIDs included in the definition of ISO 15031-5 Annex B.

The external test equipment shall only display data from an ECU if that ECU indicated it supports that data item. The external test equipment shall not display data from an ECU if that ECU indicated it does not support that data item.

The external test equipment shall be capable of obtaining, converting, and displaying:

a) OBD emissions-related current data as described in ISO 15031-5 and SAE J1939-73 specifying all emission-related data. For each data item, an external test equipment display text string and the formatting of the data value is specified (e.g. RPM: xxxxx min^{-1}),

b) OBD emissions-related freeze frame data [same data display as specified in a)], and

c) test parameters and results data as described in ISO 15031-5 and SAE J1939-73. ISO 15031-5 and SAE J1939-73 details what data is available, the messages to be used to request the data, the messages to be used to return the data, the conversion values for the data and the format to be used to display the data.

When current data items are selected for display, the external test equipment will continuously request of the vehicle the data to be displayed and will display the data received in the corresponding response messages. When freeze frame or test parameters and results are selected for display, the external test equipment does not need to continuously request and display those items.

Where applicable, the external test equipment shall indicate whether a test limit is a high limit or a low limit. Where applicable, the display of test results shall also show the test ID (identifier) and component ID.

Data from the vehicle may indicate which items are supported, in which case this information shall be made available to the user by the external test equipment. The external test equipment shall also allow users to specify requests for services, parameters, test IDs, etc. irrespective of whether the vehicle has indicated support for such items.

7.7 Code clearing

The external test equipment shall be capable of sending a request to clear OBD emissions-related diagnostic trouble codes, freeze frame data and diagnostic tests status information. The external test equipment shall require the user to confirm such a request prior to transmission.

7.8 On-board diagnostic evaluations

7.8.1 Completed on-board system readiness tests

Immediately after the equipment has successfully established communication with the vehicle, it shall check the status of the system readiness tests. If the supported tests have not all been completed, the equipment shall indicate to the user: “Not all supported on-board system readiness tests have been completed” or equivalent. The equipment shall also allow the user to identify any readiness tests that have not been completed.

7.8.2 Supported on-board system readiness tests

The external test equipment shall indicate to the user which of the tests specified by ISO 15031-5 service $01 PID $01 data B - D, or SAE J1939-73 DM5 bytes 4-8, are supported and which of these have been completed.

7.8.3 Malfunction Indicator Lamp — status and control

The external test equipment shall be capable of indicating whether the MIL (Malfunction Indicator Lamp) has been commanded ON and if so, by which module or modules.

7.9 Use of StopCommunication service associated with ISO 14230-4 (optional)

When ISO 14230-4 is being used to support OBD requirements in a vehicle, the external test equipment may provide to the operator the ability to select the StopCommunication service defined for ISO 14230-4.

8 User interface

8.1 Display

The external test equipment shall be capable of displaying simultaneously at least two items of OBD emissions-related current data items, emissions-related freeze frame data items, or emissions-related diagnostic trouble codes. A list of the OBD current data and freeze frame data items, their parameter IDs, data resolution and data conversion information, units and display formats is provided in ISO 15031-5. The display shall be capable of displaying alphanumeric characters. The display shall at least support the SI-units as specified in ISO 15031-5. The unit conversions specified in ISO 15031-5 shall be used.

If the protocol is SAE J1939-73, then data parameters shall be displayed as specified in SAE J1939-73 using the SI-units and unit conversions. DTCs shall be displayed as specified in Annex A.

As a minimum, the data values of two data items shall be displayed simultaneously. A display of the parameter IDs of the data items and the IDs of the modules that supplied the data items shall be easily accessible if not displayed with the data values.

The units of measurement associated with the data items shall either be:

— displayed with the data values,

— easily accessible on the display, or

— readily available to the user (e.g. on the body of the external test equipment).

Having this information available in a user manual separate from the body of the external test equipment does not satisfy this requirement.

8.2 User input

The external test equipment shall allow the user these services as specified by ISO 15031-5:

a) Select between the basic functions required by OBD, e.g.:

   1) system readiness test status display,

   2) MIL (Malfunction Indicator Lamp) status and control,

   3) display current data,

   4) display freeze frame data,

   5) display diagnostic trouble codes,

   6) clear emissions-related data,

   7) display test parameters and results,

   8) read vehicle identification.

b) Select for simultaneous display at least two OBD emissions-related items of any one of the following categories:

   1) current data,

   2) freeze frame data,

   3) diagnostic trouble codes,

   4) test parameters and results.

c) Confirm a request to clear and/or reset OBD emissions-related diagnostic information.

d) Request operation of an on-board system, test or component.

Responses from multiple modules to requests for a current data item or a freeze frame data item are treated as separate data items for selection and display purposes.

9 Power requirements

9.1 Vehicle battery voltage support

9.1.1 External test equipment supports only 12 V D.C. vehicle battery voltage

If the test tool manufacturer chooses to develop external test equipment with only 12 V D.C. vehicle battery voltage support, the following requirements shall apply:

— operate normally within a vehicle battery voltage range of 8,0 to 18,0 V D.C.,

— survive a vehicle battery voltage of up to 24,0 volts D.C. for at least 10 m,

— survive, non-operationally, a reverse vehicle battery voltage of up to 24,0 V D.C. for at least 10 m.

Preferably the external test equipment will withstand cranking, in that communications and data shall not be lost during vehicle battery voltage reductions to 5,5 V for up to 0,5 s. The display need not function during this period. This is not a requirement for compliance.

9.1.2 External test equipment supports 12 V D.C. and 24 V D.C. vehicle battery voltage

If the test tool manufacturer chooses to develop external test equipment with 12 V D.C. and 24 V D.C. vehicle battery voltage support the following requirements shall apply:

— operate normally within a vehicle battery voltage range of 8,0 to 32,0 volts D.C.,

— survive a vehicle battery voltage of up to 36,0 volts D.C. for at least 10 minutes,

— survive, non-operationally, a reverse vehicle battery voltage of up to 36,0 Volts D.C. for at least 10 minutes.

Preferably the external test equipment will withstand cranking, in that communications and data shall not be lost during vehicle battery voltage reductions as specified in ISO 16750-2. The display need not function during this period. This is not a requirement for compliance.

9.2 Vehicle battery current consumption

The maximum current drawn by the external test equipment through the power contacts of the diagnostic connector shall not exceed that specified in ISO 15031-3 as the minimum current carrying capacity supplied by the vehicle.

10 Electromagnetic compatibility (EMC)

The external test equipment shall not interfere with the normal operation of the vehicle electrical system.

The normal operation of the external test equipment shall be immune to conducted and radiated emissions present in a service environment and when connected to a vehicle.

EMC and ESD measurements and limits shall be in accordance with the standards prevailing in the country in which the tester is to be sold.

11 Conformance testing

11.1 General

Conformance testing specifies the tests required to be passed in order for external test equipment to be type approved as “conforms to ISO 15031-4”. Only external test equipment that passes all tests may be so labelled. External test equipment shall support all the listed protocols (specified in Clause 5) as allowed by national/regional legislation of the country where the equipment will be offered to the market. Equipment that passes all tests shall be labelled “Conforms to ISO 15031-4” and shall list the protocols supported as shown in Clause 5.

The external test equipment manufacturer may optimize the Automatic determination of communication interface sequence to test only for those protocols allowed by the national/regional legislation of the country.

EXAMPLE If national/regional specific legislation only allows e.g. 500 kbps data rate of ISO 15765-4 (CAN) although the standard allows 250 kbps, the external test equipment manufacturers are allowed to only support that baudrate.

Validation of the conformance test is the responsibility of the equipment manufacturer, and the equipment manufacturer may elect to self-certify.

The tests in this clause, shall be performed successfully five (5) consecutive times, on each sample unit to be considered passed.

Three (3) examples of at least production intent level external test equipment shall pass all these tests in order for a given version of external test equipment hardware and software to be considered passed, and the equipment manufacturer shall ensure consistent quality of manufacture to meet this standard, to ensure consistent compatibility between external test equipment and vehicle.

Any changes to the hardware or software used in an external test equipment for the functions described in this International Standard shall require a retest of these tests or an explanation from the external test equipment manufacturer as to why the change shall not require a retest. Where an explanation is submitted in lieu of a retest due to a change, the organization originally performing these tests shall determine whether the explanation is acceptable or whether a retest is required. Reasonable normal engineering criteria shall be used when determining whether to accept an explanation.

For every product type which is labelled as conforming to, or compatible with the requirements of ISO 15031-4 OBD access facilities, or other labelling to that effect, the manufacturer shall record:

a) clear indication of the versions of product hardware, software and protocols supported,

b) the methods used to make these tests,

c) the results of the tests.

Both proper and improper response messages will be employed during these tests. Improper responses for ISO 15031-5 are those that have incorrect header information, an incorrect Service Identifier, an incorrect PID, an incorrect length of the response message, or an incorrect CRC or checksum. Improper responses for J1939 are those that have incorrect addresses or message labelling, incorrect parameter identification, an incorrect length of the response message, or an incorrect CRC or checksum. The external test equipment must ignore all improper response messages and perform as if no response was received.

Situations involving multiple ECUs responding to a single request message, single ECUs responding with multiple response messages to a single request message and multiple ECUs responding with multiple response messages to a single request message will be tested.

The interval between the end of the request message and the beginning of the response message(s) will be varied from 0 ms up to the delay required to show a no response message indication on the external test equipment. This delay that causes the no response message indication will be compared to the value defined in ISO 15031-5 or the value defined in SAE J1939-21 specifications.

The format, content and order of messages transmitted on the data links referenced in ISO 15031-5 and SAE J1939-73 will be observed and reviewed for correctness.

The ability to obtain and report the results of the on-board system readiness tests shall be verified. The ability to report which tests the vehicle supports and which have been completed shall be verified.

The requirements described in 11.3 through 11.7 (inclusive) shall be verified on each protocol specified in Clause 5.

When performing these tests, observation of the indications and displays provided to the user and the signals of each protocol specified in Clause 5 (bus + and bus –, K and L lines if applicable) will be the criteria for proper performance.

Testing shall be conducted at a temperature of (23 ± 5) °C and between 25 % and 95 % relative humidity.

Testing information and results shall be made available to the buying public.

11.2 Determine OBD communication type

Items to be tested:

— automatic determination of interface and protocol type when the ISO 15031-3 or SAE J1939-13 connector is plugged into its mating connector in the vehicle and/or OBD support is selected, where such a selection is necessary,

— all supported OBD communication interfaces at least once per scan,

— the interface contacts related to protocols not supported by the external test equipment are not activated during the test cycle,

— the scan of all interfaces continues until successful or until terminated by the user,

— some indication is provided to the user that the scan of interfaces is being performed,

— a failure to successfully find an OBD interface during a scan of all the possible interfaces is indicated to the user at the completion of each and every scan,

— when an OBD interface is successfully found, the external test equipment automatically prompts the user for function selection,

— the external test equipment provides and uses the facilities and/or messages specified in ISO 15031-5, ISO 9141-2, SAE J1850, ISO 14230-4, ISO 15765-4, ISO 15031-6 SAE J1939 and SAE J1939-73

— the external test equipment does not exceed the polling rates specified in ISO 15031-5 and SAE J1939-21,

— the external test equipment provides the proper bias for the K and L lines as specified in ISO 9141-2 and ISO 14230-4,

— the external test equipment performs the initialization tests according to 7.1 and the external test equipment supports the use of an idle message when ISO 9141-2 and ISO 14230-4 are used.

The interface determination tests shall be performed:

— with no modules connected,

— with one ISO 9141-2 module connected,

— with one ISO 14230-4 module connected,

— with one SAE J1850 41,6 kbps PWM module connected,

— with one SAE J1850 10,4 kbps VPW module connected,

— with one ISO 15765-4 module connected,

— with one SAE J1939-73 module connected. (This module shall support DM5.)

For unsupported interfaces, it is only necessary to ensure that the specific contacts related to that protocol remain open circuit and that no damage occur, either to the external test equipment or vehicle.

Table 1 lists the required vehicle response dependant on the protocol in use.

Table 1 — Vehicle configuration and required responses for supported protocols

Vehicle configuration	Required response
ISO 9141-2 module connected	ISO 9141-2 session initiated and maintained
ISO 14230-4 (KWP2000) module connected	ISO 14230-4 session initiated and maintained
SAE J1850 41,6 kbps PWM module connected	SAE J1850 41,6 kbps PWM protocol selected
SAE J1850 10,4 bps VPW module connected	SAE J1850 10,4 kbps VPW protocol selected
ISO 15765-4 module connected	ISO 15765-4 protocol selected
SAE J1939-73 module connected	SAE J1939-73 protocol selected
No module connected	Operator warning issued after five retries; equipment continues to retry until operator acts to discontinue

11.3 On-board system readiness test

Confirm, using each supported protocol specified in Clause 5, that the external test equipment automatically requests and correctly reports the results of the supported on-board system readiness tests.

11.4 Select functions

Confirm, using each supported protocol specified in Clause 5:

— that the external test equipment offers all of the diagnostic facilities described in Clause 4,

— that the user is able to navigate between these facilities.

11.5 Select and display items

Confirm, using each supported protocol specified in Clause 5:

a) that the user is able to select and display simultaneously at least two items from any one of:

   1) available DTCs,

   2) current data items,

   3) available freeze frame data items, and

4) test parameters and results;

b) that the module IDs and parameter names associated with all the items mentioned above can also be displayed either:

1) simultaneously with the displayed items, or

2) in some alternate method;

c) that the units-of-measurement information associated with all the possible current data items and freeze frame data items are easily available, either as a part of the data display, displayed separately, or otherwise available on or with the external test equipment body itself;

d) that the external test equipment is able to handle multiple responses from the same module due to one request;

e) that the external test equipment is able to handle responses from multiple modules due to one request;

f) that the external test equipment is able to handle multiple responses from multiple modules due to one request;

g) that the external test equipment informs the user whenever multiple modules respond to a particular request. Responses from multiple modules to a request are to be made available to the user as separate items for display;

h) that the external test equipment informs the user whenever multiple modules produce differing responses to a single request.

The criteria for successfully passing this test are to navigate between all the items and observe the results.

11.6 Confirm requests to clear codes

Confirm, using each supported protocol specified in Clause 5:

— that the selection of the Clear Codes function incorporates a request to the user for confirmation,

— that both yes and no responses to the request to the user to confirm the selection of the clear codes function are processed appropriately.

When performing this test, the presence or absence of DTCs shall be verified both before and after the clear codes function is selected.

11.7 General diagnostic communication tests

When performing tests involving diagnostic messages, tests are to be made of the external test equipment's ability to handle an immediate response, a slow response and a response delayed longer than the maximum allowed by each of the protocols.

The external test equipment shall be able to process all responses that are received within the maximum time allowed by each protocol and indicate a no response condition to the user when the response is delayed longer than the maximum allowed by each protocol.

The external test equipment shall support the transmission of its node address as an in-frame-response during the transmission of any response messages from modules on an SAE J1850 bus and shall be able to handle both the presence and the absence of an in-frame-response during the external test equipment's transmission of request messages.

11.8 Capacitance and impedance at the diagnostic connector

Confirm, using each supported protocol specified in section 5, that the capacitance and impedance of the external test equipment, its connecting data cables and the diagnostic connector are within the limits specified in SAE J1850, ISO 9141-2, ISO 14230-4, ISO 15765-4, ISO 15031-3, and SAE J1939-11. Measurement of these parameters shall be performed by a testing agency at their discretion following generally accepted engineering standards.

11.9 Operating voltage and current requirement

Confirm, using each supported protocol specified in Clause 5:

— that the external test equipment shall correctly operate throughout the voltage range specified in 9.1 and shall not require more than the maximum current specified in 9.2,

— that the external test equipment shall accept without causing damage the use of supply voltages of up to the maximum survival voltage and survive reverse voltage specified in 9.1.

During other conformance tests, the voltage supplied to the external test equipment is to be varied throughout the specified range and a check for continuous operation performed. Also, the supply current is to be compared with the limit specified.

11.10 Protocol check

Confirm, using each supported protocol specified in Clause 5, that all the request and response messages, as specified in Clause 7 are properly and appropriately used by the external test equipment.

11.11 Alphanumeric display

Verify that the external test equipment is able to display alphanumeric characters.

11.12 User manual and help facility

Verify that:

a) a user manual and/or HELP facility is available with the external test equipment;

b) the user manual and/or HELP facility at least includes:

1) parameter specifications and service IDs as described in ISO 15031-5, and SAE J1939-73,

2) all abbreviations used by the external test equipment,

3) how to select the functions,

4) how to select items for simultaneous display,

5) how to determine the PID, item name and module ID of data returned for display,

6) how to confirm the selection of the clear codes function,

7) how to obtain and display OBD emissions-related test parameters and results as described in related documentation for each protocol,

8) how multiple responses from one request are indicated,

9) how different responses to the same request are indicated,

10) what current and freeze frame data items are available through OBD.

The external test equipment shall be tested for a HELP facility and/or the availability and coverage of a user manual.

Annex A
(informative)

Recommended external test equipment common user interface displays

A.1 General data display guidelines

The following are recommendations about the display layout and formatting of the external test equipment when data parameters, DTCs, OBD Monitor test results and vehicle/ECU identification data are to be displayed. The support of various protocols with two (2) different data parameter formats, DTC formats, and information types require general implementation guidelines for the external test equipment how to display information to the automotive technicians in a common user interface format. The examples provided in this annex neither address nor show provisions for multiple languages, e.g. reserved text string space per text string.

General data display guidelines shall be followed to achieve a common user interface format when displaying emissions-related data on an external test equipment display.

The following guidelines apply:

— Each information/data shall be displayed in conjunction with the ECU/module name or address in order to simplify the relation between functional emissions-related data and physical ECU/module.

— External test equipment with smaller type displays shall use the abbreviated terms as defined in ISO 15031-2, ISO 15031-5 and ISO 15031-6. External test equipment with larger type displays shall use the full text descriptors as defined in ISO 15031-2, ISO 15031-5 and ISO 15031-6. When SAE J1939-73 protocol is used then the text displays will follow the SAE J1939-73 descriptors.

— A consistent display layout shall be followed to ease readability.

A.2 Select menu display

The external test equipment shall provide a “Select Menu” which displays all available features depending on the supported services/diagnostic modes of the identified protocol of all emissions-related modules installed in the vehicle. The external test equipment shall only display the menu items supported by the protocol. Table A.1 — Select menu display example, provides an example as well as test menu text strings to be displayed depending on the protocol identified.

Table A.1 — Select menu display example

Select Task	ISO 15031-5	SAE J1939
Read Confirmed DTCs	applicable	applicable
Read Previously Active DTCs	not applicable	applicable
Read Pending DTCs	applicable	applicable
Review Freeze Frame Data	applicable	applicable
Current/Monitor Data Display	applicable	applicable
Clear DTC Information	applicable	applicable
OBD Monitor Data Display	applicable	applicable
Identification Data Display	applicable	applicable
Activate OBD Tests	applicable	applicable
In-Use Performance Tracking Data	applicable	applicable

The key press or touch navigation of the “select menu” should provide scroll capability if the display size is too small to display all menu selections. By no means shall above example limit the external test equipment developers to add other features e.g. function key for each menu item or change the order or appearance of the menu items.

External test equipment manufacturer are free to implement a different menu structure to promote their test equipment.

A.3 Diagnostic trouble codes displays

A.3.1 Diagnostic trouble code summary display

The external test equipment shall be capable of continuously obtaining, converting and displaying OBD emissions-related DTCs from the vehicle. The diagnostic trouble code, its descriptive text or both shall be displayed. The same displays should be used to show “Active”, “Previously Active DTCs” and “Pending DTCs”.

Table A.2 — Summary of active DTC display template and example, provides a DTC list (Active, Previously Active, Pending) from all emissions-related systems/components. A sample of a DTC summary display is shown below. The left display shows a summary DTC template and the right display shows an example with DTCs stored in the vehicle's ECUs/modules.

The “Addr” column on the left displays the ECU/module address derived from the message header of the protocol (SAE J1939 address information e.g. 00 or 01 hex = Engine, 03 or 04 hex = Transmission, 0B hex = ABS). The middle column displays the ECU/module name. If the external test equipment does not know the ECU/module name which matches the ECU/module address (Addr), the hex number shall be displayed. The right column indicates the number of DTCs stored per ECU/module.

Table A.2 — Summary of active DTC display template and example

Menu item			Summary of Active DTCs		
Addr	ECU/Module descriptor	# of DTCs	Addr	ECU/Module descriptor	# of DTCs
aa	ECU/Module #1	xx	00	Engine	2
aa	ECU/Module #2	xx	03	Transmission	1
…	…	…	0B	ABS/Traction Control	0
aa	ECU/Module #n	xx			

A.3.2 Diagnostic trouble code display

A.3.2.1 ISO 15031-5/ISO 15031-6 protocol DTC display template and examples

The following sample displays provide a list of active DTCs per ECU/module. The left display shows a DTC template and the middle and right displays show examples with DTCs stored in the vehicle's ECU/module.

The DTC template should be the recommended display layout for “Active DTCs, Previously Active DTCs, and Pending DTCs”.

Table A.3 — ISO 15031-5/ISO 15031-6 protocol DTC display template and examples, should be used for the ISO 15031-5/ISO 15031-6 based DTC format.

In the upper left, the selected menu item should be displayed, e.g. “Active DTCs”. In the upper right, the ECU/module name (if available) or the ECU/module address e.g. 11, 18, etc. should be displayed. The “DTC #” text string should be followed by the converted DTC number. The “Count” text string indicates the occurrence of a DTC. The occurrence count should be displayed as a three (3) digit decimal number. In the next line the DTC descriptor associated with the DTC number should be displayed as specified in ISO 15031-6. Depending on the display size and features multiple DTCs can be displayed.

Table A.3 — ISO 15031-5/ISO 15031-6 protocol DTC display template and examples

Menu item		Addr	aa	Active DTCs		Addr	11	Active DTCs		Addr	18
DTC #	xxxxx	Count	xxx	DTC #	P0118	Count	---	DTC #	P2700	Count	---
DTC descriptor (ISO 15031-6)				Engine Coolant Temperature Circuit				Transmission Friction Element “A”			
				High				Apply Time Range/Performance			
DTC #	xxxxx	Count	xxx	DTC #	P0113	Count	---				
DTC descriptor (ISO 15031-6)				Intake Air Temperature Circuit High							

A.3.2.2 SAE J1939-73 protocol DTC display template and examples

Table A.4 — SAE J1939-73 protocol DTC display template and examples, should be used for the SAE J1939-73 based DTC format.

The format and layout of the DTC display is the same as specified for the ISO 15031-5/ISO 15031-6 based protocol and DTCs. There is a minor difference in the DTC number format, which derives from a “base DTC number” (DTC circuit) and a “DTC symptom” (DTC failure type). Both values are converted into a single DTC number. The hyphen (-) separates the base DTC number from the DTC symptom. The DTC description is a concatenation of the base DTC text descriptor and the DTC symptom DTC text descriptor.

Table A.4 — SAE J1939-73 protocol DTC display template and examples

Menu item		ECU/Module		Active DTCs		Engine		Active DTCs		Transmission	
DTC #	xxxxxx-xx	Count	xxx	DTC #	110-01	Count	6	DTC #	2908-03	Count	4
DTC descriptor (SAE J1939-73)				Engine Coolant Temperature –				Transmission Boost Pressure Valve			
				Data valid but below normal operational				Actuator – Voltage Above Normal, or			
				Range – Most Severe Level				Shorted to High Source			
DTC #	xxxxxx-xx	Count	xxx	DTC #	105-02	Count	3	DTC #	604-03	Count	1
DTC descriptor (SAE J1939-73)				Intake Manifold 1 Temperature – Data				Transmission Neutral Switch – Voltage			
				Erratic, Intermittent or Incorrect				below normal, or shorted to low source			

A.4 Current/Monitor data display

A.4.1 Current/monitor data display template

As a minimum, the data values of two data items shall be displayed simultaneously. A display of the parameter abbreviation or description of the data items and the ECU's/module's address that supplied the data item(s) shall be displayed with the data values.

Table A.5 — ISO 15031-5 and SAE J1939-73 protocol current/monitor data display template, shows the layout of the external test equipment data display. The upper row of the display should show the selected menu item e.g. “Current/Monitor Data Display”. The left column displays the “Addr” which is the source of the data item. This is the ECU/module address derived from the ISO 15031-5 or SAE J1939-73 message header address information. Each parameter is comprised of a “parameter name”, “current/freeze frame data”, and the associated “unit” (if parameter is not state encoded).

Table A.5 — ISO 15031-5 and SAE J1939-73 protocol current/monitor data display template

Menu Item (ISO 15031-5)				Menu Item (SAE J1939-73)			
Addr	Parameter description	Data	Unit	Addr	Parameter description	Data	Unit
11	Calculated LOAD Value	xxx.x	%	00	EGR Mass Flow Rate	xxxx.x	kg/h
11	Fuel system 1 status	8 states/1 byte		00	Exhaust Gas Recirculation (EGR) Valve Control	xxx.x	%
11	Engine RPM	xxxxx	min^{-1}	00	Turbo Oil Temperature	xxxx	°C
11	Engine Coolant Temperature	xxx	°C	00	Turbocharger 1 Boost Pressure	xxxx.x	kPa
11	Misfire monitoring supported	2 states/1 bit		00	Turbocharger 1 Compressor Inlet Pressure	xxx.x	kPa
11	Misfire monitoring ready	2 states/1 bit		00	Turbocharger 1 Compressor Inlet Temperature	xxxx	°C
11	Fuel system monitoring supported	2 states/1 bit		00	Engine Test Mode Switch	4 states/2 bit	
11	Fuel system monitoring ready	2 states/1 bit		00	Exhaust Gas Oxygen Sensor Closed Loop Operation	4 states/2 bit	
11	Catalyst monitoring supported	2 states/1 bit		00	Start Enable Device 1	4 states/2 bit	
11	Catalyst monitoring ready	2 states/1 bit		00	Start Enable Device 2	4 states/2 bit	
11	Oxygen sensor monitoring supported	2 states/1 bit		03	Transmission Reverse Direction Switch	4 states/2 bit	
11	Oxygen sensor monitoring ready	2 states/1 bit		00	Particulate Trap Inlet Pressure	xxx	kPa

NOTE The above table illustrates that the format of the data for ISO 15031-5 and SAE J1939-73 can follow the same display layout approach. This table is not meant to compare the data available with one protocol versus the other.

A.4.2 ISO 15031-5 protocol current/freeze frame data display examples

Table A.6 — ISO 15031-5 protocol current/freeze frame data display examples, shows data display examples of current/freeze frame data as defined in the ISO 15031-5 specification. The smaller display on the left shows the parameter acronyms as specified in ISO 15031-2 and -5. The larger display on the right shows the full parameter descriptors as specified in ISO 15031-5. A mixture of parameters from two (2) emissions-related ECUs/modules is also shown in the same display.

Table A.6 — ISO 15031-5 protocol current/freeze frame data display examples

Current/Freeze Frame Data Display				Current/Freeze Frame Data Display			
Addr	Param. description	Data	Unit	Addr	Parameter description	Data	Unit
11	DTCFRZF	P0118		11	DTC that caused required freeze frame data storage	P0118	
11	VSS	0	km/h	11	Vehicle Speed Sensor	0	km/h
11	MIL	ON		11	Malfunction Indicator Lamp (MIL) Status	ON	
11	MIS_SUP	YES		11	Misfire monitoring supported	YES	
11	FUEL_SUP	YES		11	Fuel system monitoring supported	YES	
11	ECT	36	°C	11	Engine Coolant Temperature	36	°C
11	RPM	744	min^{-1}	11	Engine RPM	744	min^{-1}
18	CCM_SUP	YES		18	Comprehensive component monitoring supported	YES	
18	CCM_RDY	NO		18	Comprehensive component monitoring ready	NO	

A.4.3 SAE J1939-73 protocol current/freeze frame data display examples

Table A.7 — SAE J1939-73 protocol current/freeze frame data display examples, shows data display examples of current/freeze frame data as defined in the SAE J1939-73 specification. The smaller display on the left shows the PGN (Parameter Group Number) acronyms as specified in SAE J1939-73. The larger display on the right shows the full parameter descriptors as specified in SAE J1939-73. A mixture of parameters from two (2) emissions-related ECUs/modules is also shown in the same display.

Table A.7 — SAE J1939-73 protocol current/freeze frame data display examples

Current/Monitor Data Display				Current/Monitor Data Display			
Addr	Param. description	Data	Unit	Addr	Parameter description	Data	Unit
00	DTCFRZF	110-03-05		00	DTC that caused required freeze frame data storage	110-03-05	
03	VSS	0	km/h	03	Vehicle Speed Sensor	0	km/h
00	MIL	ON		00	Malfunction Indicator Lamp (MIL) Status	ON	
00	MIS_SUP	YES		00	Misfire monitoring supported	YES	
00	FUEL_SUP	YES		00	Fuel system monitoring supported	YES	
00	ECT	36	°C	00	Engine Coolant Temperature	36	°C
00	RPM	744	min^{-1}	00	Engine RPM	744	min^{-1}
03	CCM_SUP	YES		03	Comprehensive component monitoring supported	YES	
03	CCM_RDY	NO		03	Comprehensive component monitoring ready	NO	

A.5 Clear DTC information

The display, which belongs to the “Clear DTC Information” menu item, is not specified in this annex. The layout and user interface of this display is the responsibility of the external test equipment manufacturer.

A.6 OBD I/M Readiness Monitor data display

A.6.1 OBD I/M Readiness Monitor selection and test result data display requirements

This clause provides general guidelines for the test equipment manufacturer industry on how to design the technician user interface of the external test equipment to display OBD Monitor data in combination with I/M Readiness status information in a useful manner to support the technician in making meaningful judgements.

All OBD I/M Readiness Monitor templates and displays are based on ISO 15765-4/ISO15031-5 (CAN) protocol derived data. Alternative protocols are not considered because the majority of related data is vehicle manufacturer specific. However, the guidelines provided may be used in a similar manner (e.g. Component ID should be displayed as Monitor ID and Test ID should be displayed as specified below).

When the technician has selected an OBD Monitor, a test equipment screen shall be displayed with ECU/module address, combined Malfunction Indicator Lamp (MIL) status, number of DTCs stored in this ECU, OBD I/M Readiness monitoring status information and OBD Monitor test results (test values/limits).

Each Test ID shall be displayed with the status of 'Passed', 'Failed' or 'Not Completed'. The overall monitor status, however, should be obtained from service $01 PID $01/$41. An OBD Monitor ID shall be displayed with one or multiple Test IDs (all IDs in hexadecimal notation) and test results with test values and limits depending on the display size and capabilities. The test equipment shall provide appropriate user interface functionality to display all associated Test IDs and values, which belong to a single OBD Monitor ID. Each OBD Monitor ID shall be displayed with the overall monitor status. This information shall be obtained from service $01 PID $01/$41 for the ISO15765-4/ISO 15031-5 protocol and from DM5 and other readiness information services in SAE J1939-73 protocol.

A.6.2 OBD Monitor selection and data display template

A.6.2.1 OBD Monitor selection display template

Table A.8 — OBD I/M Readiness Monitor selection display template, should be used as a recommended guideline for the selection of an OBD Monitor. The left column of the display shows the ECU/module address. The upper row shall be used to display the selected menu item e.g. “OBD Monitor Selection”. Each OBD Monitor parameter is displayed with supported status information (Yes/No). OBD Monitor groups may be created to minimize the selection list.

Table A.8 — OBD I/M Readiness Monitor selection display template

Addr	OBD Monitor Selection	
aa	Monitor name (service $01, PID $01/$41)	Status
bb	Monitor name (service $01, PID $01/$41)	Status
cc	Monitor name (service $01, PID $01/$41)	Status
dd	Monitor name (service $01, PID $01/$41)	Status
:	:	:
aa	Monitor name (service $01, PID $01/$41)	Status
bb	Monitor name (service $01, PID $01/$41)	Status

A.6.2.2 OBD Monitor selection display example

Most often, only one ECU/module will support each of the OBD I/M Readiness Monitors. The Comprehensive component monitor should be supported by all emissions-related ECUs/modules. The following example shows a list of supported and unsupported OBD I/M Readiness Monitors:

—	Engine:	Misfire monitoring supported	Yes	(service $01, PID $01)
—	Engine:	Fuel system monitoring supported	Yes	(service $01, PID $01)
—	Engine:	Catalyst monitoring supported	Yes	(service $01, PID $01)
—	Engine:	Heated catalyst monitoring supported	No	(service $01, PID $01)
—	Engine:	Evaporative system monitoring supported (0.020”)	Yes	(service $01, PID $01)
—	Engine:	Secondary air system monitoring supported	No	(service $01, PID $01)
—	Engine:	A/C system refrigerant monitoring supported	No	(service $01, PID $01)
—	Engine:	Oxygen sensor monitoring supported	Yes	(service $01, PID $01)
—	Engine:	Oxygen sensor heater monitoring supported	Yes	(service $01, PID $01)
—	Engine:	EGR system monitoring supported	No	(service $01, PID $01)
—	Engine:	Comprehensive component monitoring supported	Yes	(service $01, PID $01)
—	Transmission:	Comprehensive component monitoring supported	Yes	(service $01, PID $01)

Table A.9 — OBD I/M Readiness Monitor selection display example, is an example of how to provide OBD I/M Readiness Monitor selection to the technician. The test equipment shall provide a select capability e.g. by cursor, by function key, etc. to allow the technician to view the test results of the selected OBD I/M Readiness status and OBD Monitor.

It is recommended to show all OBD I/M Readiness Monitors, even if a monitor is not supported. This way, data can be seen even if a calibration weakness specifies a monitor, which is supported by the software but not enabled in the calibration (appropriate bit set to 'not supported'). The option to show only supported monitors can be used as well.

The left column of the display shows the ECU/module address. The upper row is used to display the selected menu item e.g. “OBD I/M Readiness Monitor Selection”. Each OBD I/M Readiness Monitor parameter is displayed with supported status information (Yes/No).

Table A.9 — OBD I/M Readiness Monitor selection display example

Addr	OBD I/M Readiness Monitor Selection	Supported Status
11	Misfire monitoring supported	Yes
11	Fuel system monitoring supported	Yes
11	Catalyst monitoring supported	Yes
11	Heated catalyst monitoring supported	No
11	Evaporative system monitoring supported (0,020”)	Yes
11	Secondary air system monitoring supported	No
11	A/C system refrigerant monitoring supported	No
11	Oxygen sensor monitoring supported	Yes
11	Oxygen sensor heater monitoring supported	Yes
11	EGR system monitoring supported	No
11	Comprehensive component monitoring supported	Yes
18	Comprehensive component monitoring supported	Yes

A.6.3 OBD I/M Readiness Monitor data display

A.6.3.1 OBD I/M Readiness Monitor data display template

Table A.10 — OBD I/M Readiness Monitor data display template, should be used as a recommended guideline for combination of service $01 PID $01/$41 monitor status and service $06 OBD Monitor data items as specified in ISO 15031-5 and the appropriate diagnostic message defined in SAE J1939-73. The display below shows an OBD Monitor template to display “Malfunction Indicator Lamp (MIL) Status”, “Number of DTCs stored in this ECU”, “OBD Monitor ID Text Descriptor” for monitoring ready, cycle enabled, cycle completed status, “Test ID(s)”, Test ID(s) “Result”, “Minimum Test Limit”, “Test Value”, “Maximum Test Limit”, and the associated “data” and “unit”.

The Test ID “Result” shall be calculated by the test equipment according to the following equations:

— Passed = (Minimum Test Limit <= Test Value) AND (Test Value <= Maximum Test Limit)
— Failed = (Minimum Test Limit > Test Value) OR (Test Value > Maximum Test Limit)
— Not Completed = (Minimum Test Limit = 0) AND (Test Value = 0) AND (Maximum Test Limit = 0)

Table A.10 — OBD I/M Readiness Monitor data display template

Addr	($xx) 'Selected OBD Monitor Text Descriptor' data display		Status
aa	Malfunction Indicator Lamp (MIL) Status		(service $01, PID $01)
aa	Number of DTCs stored in this ECU		(service $01, PID $01)
aa	OBD Monitor ID Text Description (monitoring ready)		(service $01, PID $01)
aa	OBD Monitor ID Text Description (cycle enabled)		(service $01, PID $41)
aa	OBD Monitor ID Text Description (cycle completed)		(service $01, PID $41)
aa	Test ID	xx	Result
aa	Minimum Test Limit	xxxxx	Unit
aa	Test Value	xxxxx	Unit
aa	Maximum Test Limit	xxxxx	Unit
aa	:	:	:
aa	Test ID	xx	Result
aa	Minimum Test Limit	xxxxx	Unit
aa	Test Value	xxxxx	Unit
aa	Maximum Test Limit	xxxxx	Unit

A.6.3.2 OBD I/M Readiness Monitor data display example

This example assumes the ISO 15765-4/ISO15031-5 protocol is identified.Table A.11 — OBD I/M Readiness Monitor data display example, displays data items which were received from one emissions-related ECU/module (see Addr. 11 hex). It shows that only parts of the enabled Evaporative system are completed (e.g. which is caused by the leak size). The Evaporative system monitoring cycle can show completed based on service $01 PID $01 response data, but it is very likely that some of the Evaporative system monitoring cycle Test IDs will show “Passed”/“Failed”, yet others will show “Not Completed”. If service $01 PID $01 response data shows the monitor as complete, then it is done, even if not every test within that monitor has run.

The following parameters shall be displayed for the Evaporative system:

—	Evaporative system monitoring ready:		YES	(service $01, PID $01)
—	Evaporative system monitoring cycle enabled:		YES	(service $01, PID $41)
—	Evaporative system monitoring cycle completed:		NO	(service $01, PID $41)
—	Evaporative system monitor (0,020”):		3C	(service$06, Monitor ID $3C)
—	Test ID:	1	Passed	(service $06, Test ID number)
—	Minimum Test Limit:		0 kPa	(service $06, Minimum Test Limit Value)
—	Test Value:		0.67 kPa	(service $06, Test Value)
—	Maximum Test Limit:		1.74 kPa	(service $06, Maximum Test Limit Value)
—	Test ID:	2	Failed	(service $06, Test ID number)
—	Minimum Test Limit:		0 kPa	(service $06, Minimum Test Limit Value)
—	Test Value:		0.72 kPa	(service $06, Test Value)
—	Maximum Test Limit:		0.62 kPa	(service $06, Maximum Test Limit Value)
—	Test ID:	3	Not Completed	(service $06, Test ID number)
—	Minimum Test Limit:		0 kPa	(service $06, Minimum Test Limit Value)
—	Test Value:		0 kPa	(service $06, Test Value)
—	Maximum Test Limit:		0 kPa	(service $06, Maximum Test Limit Value)

Table A.11 — OBD I/M Readiness Monitor data display example

Addr	(3C) Evaporative system monitor (0.020”) data display		
11	Malfunction Indicator Lamp (MIL) Status	On	
11	Number of DTCs stored in this ECU	2	
11	Evaporative system monitor (0,020”) ID	3C	
11	Evaporative system monitoring ready (0,020”)	Yes	
11	Evaporative system monitoring cycle enabled (0,020”)	Yes	
11	Evaporative system monitoring cycle co mpleted (0,020”)	No	
11	Test ID	1	Passed
11	Minimum Test Limit	0	kPa
11	Test Value	0.67	kPa
11	Maximum Test Limit	1.74	kPa
11	Test ID	2	Failed
11	Minimum Test Limit	0	kPa
11	Test Value	0.72	kPa
11	Maximum Test Limit	0.62	kPa
11	Test ID	3	Not Completed
11	Minimum Test Limit	0	kPa
11	Test Value	0	kPa
11	Maximum Test Limit	0	kPa

A.7 Vehicle and ECU identification data display

A.7.1 Identification data display template

The following identification data display template should be used as a recommended guideline for service $09 Read vehicle information InfoTypes as specified in ISO 15031-5 and for the appropriate diagnostic message defined in SAE J1939-73.

In Table A.12 — Identification data display template, the left column of the display shows the ECU/module address. The upper row is used to display the selected menu item e.g. “Identification Data”. Each row of the display should show an InfoType comprised of an “InfoType Text Descriptor” and identification “data”. A space separator (ASCII 20 hex) is inserted between numbers, which consist of more than four (4) digits e.g. VIN, Calibration ID, CVN, etc. to ease readability of large numbers.

InfoTypes, which belong together, should be listed next to each other.

Table A.12 — Identification data display template

Addr	Menu item	
aa	InfoType #2	x xxxx xxxx xxxx xxxx
aa	InfoType #4	xx xxxx xxxx
aa	InfoType #6	xx xx xx xx
aa	InfoType #4	xx xxxx xxxx
aa	InfoType #6	xx xx xx xx

A.7.2 Identification data display example

This Identification data display example shows data items which were received from two (2) emissions-related ECUs/modules (see Addr. 11, 18). The data items and numbers derive from the example section of service $09 as specified in ISO 15031-5.

In Table A.13 — Identification data display example, the display on the left is shown with abbreviated terms and the display on the right shows full descriptors as defined in ISO 15031-5.

Table A.13 — Identification data display example

Addr	ID. Data	ECU/Module	Addr	Identification Data	Engine
11	VIN	1 G1JC 5444 R725 2367	11	VIN	1 G1JC 5444 R725 2367
11	CALID#1	JMB* 3676 1500	11	Calibration ID#1	JMB* 3676 1500
11	CVN#1	1791 BC82	11	Calibration Verification Number #1	1791 BC82
11	CALID#2	JMB* 4787 2611	11	Calibration ID#2	JMB* 4787 2611
11	CVN#2	16E0 62BE	11	Calibration Verification Number #2	16E0 62BE
18	CALID#1	JMA* 4312 9911 0000	18	Calibration ID#1	JMA* 4312 9911 0000
18	CVN#1	9812 3476	18	Calibration Verification Number #1	9812 3476

A.8 Activate OBD tests

The display, which belongs to the “Activate OBD Tests” menu item, is not specified in this annex. The layout and user interface of this display are the responsibility of the external test equipment manufacturer.

A.9 In-use performance tracking data display

A.9.1 IPT (In-use performance tracking) data display template

The In-Use Performance Tracking (IPT) data items as specified in ISO 15031-5 and SAE J1939-73 shall be displayed to show the current counts of each IPT data item.

The following In-Use Performance Tracking (IPT) template should be used to display IPT data items as specified in ISO 15031-5 and SAE J1939-73.

In Table A.14 — IPT (In-use performance tracking) data display template, the left column of the display shows the ECU/module address. The upper row shall be used to display the selected menu item e.g. “In-Use Performance Tracking”.

Each row displays the “IPT Data Item Text Descriptor”, Number (xxxxx) and Unit.

Table A.14 — IPT (In-use performance tracking) data display template

Addr	Menu item		
aa	IPT Data Item #1 Text Descriptor	xxxxx	Unit
aa	IPT Data Item #2 Text Descriptor	xxxxx	Unit
aa	IPT Data Item #3 Text Descriptor	xxxxx	Unit
aa	IPT Data Item #4 Text Descriptor	xxxxx	Unit
aa	IPT Data Item #5 Text Descriptor	xxxxx	Unit
aa	IPT Data Item #6 Text Descriptor	xxxxx	Unit
aa	IPT Data Item #7 Text Descriptor	xxxxx	Unit
aa	IPT Data Item #8 Text Descriptor	xxxxx	Unit
aa	IPT Data Item #9 Text Descriptor	xxxxx	Unit
aa	IPT Data Item #10 Text Descriptor	xxxxx	Unit
aa	IPT Data Item #11 Text Descriptor	xxxxx	Unit
aa	IPT Data Item #12 Text Descriptor	xxxxx	Unit
aa	IPT Data Item #13 Text Descriptor	xxxxx	Unit
aa	IPT Data Item #14 Text Descriptor	xxxxx	Unit
aa	IPT Data Item #15 Text Descriptor	xxxxx	Unit
aa	IPT Data Item #16 Text Descriptor	xxxxx	Unit

A.9.2 IPT (In-use performance tracking) data display example

This IPT data display example shows data items which were received from one emissions-related ECU/module (see Addr. 11). The data items and numbers derive from the example section of service $09 as specified in ISO 15031-5 or service DM20 specified in SAE J1939-73.

In Table A.15 — Display in-use performance tracking data example, the display on the left is shown with abbreviated terms and the display on the right shows full descriptors as defined in ISO 15031-5.

Table A.15 — Display in-use performance tracking data example

Addr	Menu item			Addr	In-Use Performance Tracking Data		
11	OBDCOND	1024	counts	11	OBD Monitor Conditions Encountered Counts	1024	counts
11	IGNCYCCNTR	3337	counts	11	Ignition Cycle Counter	3337	counts
11	CATCOMP1	824	counts	11	Catalyst Monitor Completion Counts Bank 1	824	counts
11	CATCOND1	945	counts	11	Catalyst Monitor Conditions Encountered Counts Bank 1	945	counts
11	CATCOMP2	711	counts	11	Catalyst Monitor Completion Counts Bank 2	711	counts
11	CATCOND2	945	counts	11	Catalyst Monitor Conditions Encountered Counts Bank 2	945	counts
11	O2SCOMP1	737	counts	11	O2 Sensor Monitor Completion Counts Bank 1	737	counts
11	O2SCOND1	924	counts	11	O2S Monitor Conditions Encountered Counts Bank 1	924	counts
11	O2SCOMP2	724	counts	11	O2 Sensor Monitor Completion Counts Bank 2	724	counts
11	O2SCOND2	833	counts	11	O2S Monitor Conditions Encountered Counts Bank 2	833	counts
11	EGRCOMP	997	counts	11	EGR/VVT Monitor Completion Condition Counts	997	counts
11	EGRCOND	1010	counts	11	EGR/VVT Monitor Conditions Encountered Counts	1010	counts
11	AIRCOMP	937	counts	11	AIR Monitor Completion Condition Counts (Sec. Air)	937	counts
11	AIRCOND	973	counts	11	AIR Monitor Conditions Encountered Counts (Sec. Air)	973	counts
11	EVAPCOMP	68	counts	11	EVAP Monitor Completion Condition Counts	68	counts
11	EVAPCOND	97	counts	11	EVAP Monitor Conditions Encountered Counts	97	counts

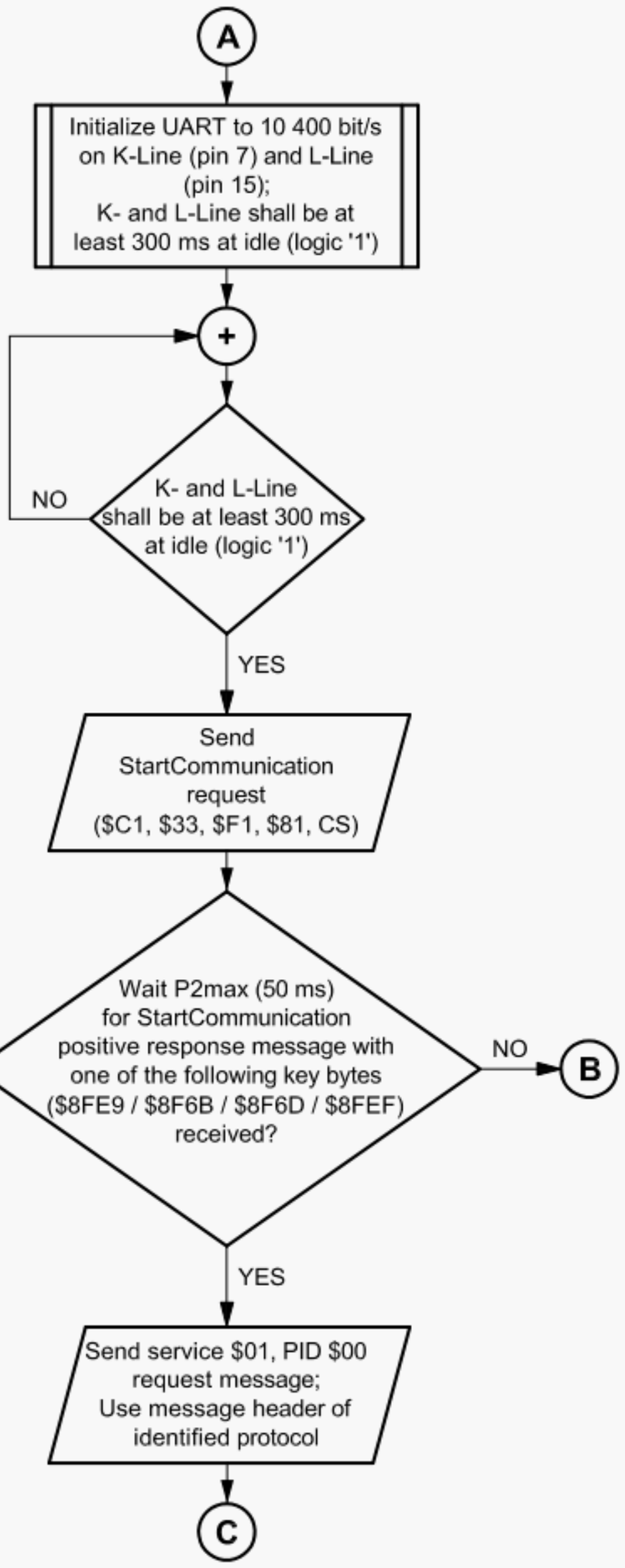
Annex B
(normative)

Initialization and identification of ISO 14230-4/ISO 9141-2 protocols

This annex describes the principle initialization of ISO 14230-4/ISO 9141-2 to be performed by the external test equipment.

B.1 ISO 14230-4 – Fast initialization

ISO 14230-4 specifies two (2) different methods of initializing the protocol. This section specifies the “Fast Initialization” sequence. The external test equipment expects the ISO 14230-4 protocol being supported by the server/ECU. Figure B.1 — Fast initialization of ISO 14230-4 Keyword protocol 2000, specifies the external test equipment “Fast Initialization” sequence of ISO 14230-4 protocol.



Key

A start fast initialization

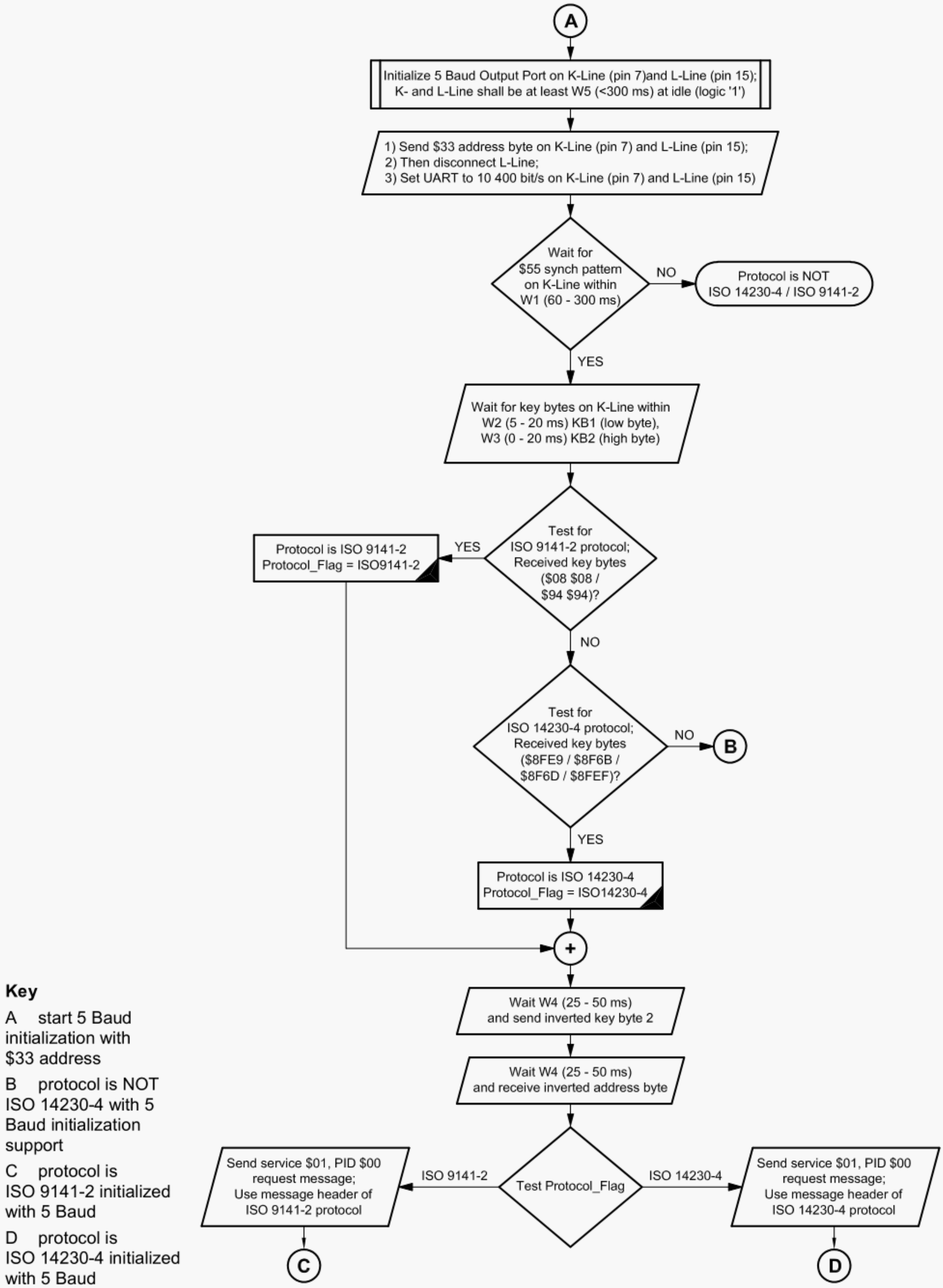
B protocol is NOT ISO 14230-4 with fast initialization support

C protocol is ISO 14230-4 with fast initialization support

Figure B.1 — Fast initialization of ISO 14230-4 Keyword protocol 2000

B.2 ISO 14230-4 / ISO 9141-2 - 5 baud initialization

This section specifies the “5 Baud Initialization” sequence of ISO 14230-4/ISO 9141-2. The external test equipment expects either the ISO 14230-4 or the ISO 9141-2 protocol being supported by the server/ECU. Figure B.2 — 5 Baud initialization of ISO 14230-4 / ISO 9141-2 protocol, specifies the external test equipment “5 Baud Initialization” sequence of ISO 9141-2/ISO 14230-4 protocols.



Key

A start 5 Baud initialization with $33 address

B protocol is NOT ISO 14230-4 with 5 Baud initialization support

C protocol is ISO 9141-2 initialized with 5 Baud

D protocol is ISO 14230-4 initialized with 5 Baud

Figure B.2 — 5 Baud initialization of ISO 14230-4 / ISO 9141-2 protocol

B.3 Key bytes indicating support of ISO 15031-5 services

Each K-Line protocol ISO 14230-4 and ISO 9141-2 support several key bytes, which indicate to the external test equipment which header and timing parameter set shall be used for subsequent communication.

B.3.1 ISO 14230-4 protocol defined key bytes

For legislated diagnostics ISO 14230-4 and ISO 9141-2 are allowed on the K-Line. Table B.1 — ISO 14230-4 key bytes, specifies the key bytes to be supported by the external test equipment.

Table B.1 — ISO 14230-4 key bytes

Key byte #2 High Byte	Key byte #1 Low Byte	Description	Normal timing
0x8F	0xE9	Key byte = 2025_{10}: 3 byte header including target and source address	P1 = 0 – 20 ms P2 = 25 – 50 ms P3 = 55 – 5000 ms P4 = 0 – 20 ms
0x8F	0x6B	Key byte = 2027_{10}: 3 byte header including target and source address, with or without additional length byte	
0x8F	0x6D	Key byte = 2029_{10}: 1 byte header or 3 byte header including target and source address	
0x8F	0xEF	Key byte = 2031_{10}: 1 byte header or 3 byte header including target and source address, with or without additional length byte	

The key bytes inform the external test equipment about the message format (header type), which shall be used by the server/ECU and external test equipment for all consecutive message exchange.

The following apply to an emissions-related server/ECU:

— all emissions-related servers/ECUs in a vehicle shall implement the identical key bytes in order to exchange emissions-related information with the same request and response message format,

— emissions-related servers/ECUs may have different key bytes if installed in a different family of vehicles even if the server/ECU hardware and principle communication software derives from a similar vehicle family,

— the request and response message format for enhanced diagnostic communication in emissions-related servers/ECUs shall use the identical key bytes as implemented for emissions-related diagnostics as reported during the initialization,

— if the initialization sequence specified in ISO 9141-2 and ISO 14230-2 is completed successfully, then ISO 9141-2 or ISO 14230-4 shall be the vehicle's OBD protocol.

B.3.2 ISO 9141-2 protocol defined key bytes

Table B.2 — ISO 9141-2 key bytes specifies the key bytes, to be supported by the external test equipment.

Table B.2 — ISO 9141-2 key bytes

Key byte #2 High Byte	Key byte #1 Low Byte	Description	Timing parameter
0x08	0x08	Key byte = $1\,032_{10}$: this key byte informs the external test equipment that the server(s)/ECU(s) shall wait at least P_2min = 25 ms when sending a response message	P1 = 0 – 20 ms **P2 = 25 – 50 ms** P3 = 55 – 5 000 ms P4 = 0 – 20 ms
0x94	0x94	Key byte = $2\,580_{10}$: this key byte informs the external test equipment that the server(s)/ECU(s) may send the response message immediately (P_2min = 0 ms) after receiving a request message	P1 = 0 – 20 ms **P2 = 0 – 50 ms** P3 = 55 – 5 000 ms P4 = 0 – 20 ms

B.4 Examples of byte flow and timing measured on the K-Line

The following tables show traces on the K-Line of ISO 14230-4 protocol with fast and 5 baud initialization and ISO 9141-2 protocol to show the bytes which are the same and which are different.

B.4.1 Byte flow and timing example of ISO 14230-4 with fast initialization

This example shows a K-Line data acquisition between external test equipment and a vehicle equipped with two (2) emissions-related servers/ECUs (ECM and TCM). The external test equipment uses the fast initialization of ISO 14230-4 Keyword protocol 2000. After the successful initialization, the external test equipment requests supported PIDs (PID $00) of service $01 as specified in ISO 15031-5.

The left column in Table B.3 — Byte flow and timing example of ISO 14230-4 with fast initialization, shows the time between bytes (stop bit of last byte and start bit of next byte). The next column shows the bytes as recorded on the K-Line. The 3rd column shows the “Msg. Type” (message type) either “Request” or “Response”. The column on the right includes a description of each byte.

Table B.3 — Byte flow and timing example of ISO 14230-4 with fast initialization

Fast initialization with $33 address		Msg. Type	Description of data bytes
Time in ms between bytes	Byte in hex		
N/A	N/A		Wake-up pattern
N/A	C1	Request	Functional addressing, length = 1 data byte
7,4	33		Target address (emissions-related ECUs)
7,3	F1		Source address (external test equipment/OBD Scan Tool)
7,5	81		Service Identifier of StartCommunication request message
7,2	66		Checksum
28,4	83	Response #1	Physical addressing, length = 3 data bytes
3,2	F1		Target address (external test equipment/OBD Scan Tool)
3,6	11		Source address ECM
3,4	C1		Service Identifier of StartCommunication positive response message
3,1	E9		Key byte #1 (Low byte): 2025 decimal
3,2	8F		Key byte #2 (High byte): 2025 decimal
3,5	BE		Checksum
35,1	83	Response #2	Physical addressing, length = 3 data bytes
5,2	F1		Target address (external test equipment/OBD Scan Tool)
5,6	18		Source address TCM
5,4	C1		Service Identifier of StartCommunication positive response message
5,1	EF		Key byte #1 (Low byte): 2031 decimal
5,2	8F		Key byte #2 (High byte): 2031 decimal
5,5	CB		Checksum
71,6	C2	Request	Functional addressing, length = 1 data byte
6,2	33		Target address
6,2	F1		Source address (external test equipment/OBD Scan Tool)
6,2	01		Service request $01
6,2	00		PID $00 (request supported PIDs)
6,2	E7		Checksum

Table B.3 (*continued*)

Fast initialization with $33 address		Msg. Type	Description of data bytes
Time in ms between bytes	Byte in hex		
29,4	86	Response #1	Header response
3,2	F1		Target address (external test equipment/OBD Scan Tool)
3,6	11		Source address ECM
3,4	41		Service response $41, PID $00
3,1	00		Echo of PID $00 (request supported PIDs)
3,2	BF		Supported PID data byte #1 (support for PIDs 01, 03-08)
3,5	BF		Supported PID data byte #2 (support for PIDs 09, 0B-10)
3,4	A8		Supported PID data byte #3 (support for PIDs 11, 13, 15)
3,3	91		Supported PID data byte #4 (support for PIDs 19, 1C, 20)
3,7	80		Checksum
35,1	86	Response #1	Header response
5,2	F1		Target address (external test equipment/OBD Scan Tool)
5,6	18		Source address TCM
5,4	41		Service response $41, PID $00
5,1	00		Echo of PID $00 (request supported PIDs)
5,2	80		Supported PID data byte #1 (support for PID 01)
5,5	01		Supported PID data byte #2 (support for PID 0D)
5,4	00		Supported PID data byte #3 (no support for PIDs 11-18)
5,3	00		Supported PID data byte #4 (no support for PIDs 19-20)
5,6	51		Checksum
130,7	C2	Request	Next Request
:	:		:
:	:		:

B.4.2 Byte flow and timing example of ISO 14230-4 / ISO 9141-2 protocol

This example shows a K-Line data acquisition between external test equipment and a vehicle equipped with two (2) emissions-related servers/ECUs (ECM and TCM). Both protocols, ISO 14230-4 and ISO 9141-2 are shown in parallel to illustrate differences and commonalities. The external test equipment uses the 5 Baud initialization without knowing which protocol is supported on the K-Line. After the interpretation of the key bytes the external test equipment inverts the key byte #2 and sends it to the vehicle. The vehicle servers/ECUs respond with the inverted 5 baud address byte. After the successful initialization the external test equipment requests supported PIDs (PID $00) of service $01 as specified in ISO 15031-5.

ISO 14230-4: The left column in Table B.4 — Byte flow and timing example of ISO 14230-4 / ISO 9141-2 protocol, shows the time between bytes (stop bit of last byte and start bit of next byte). The next column shows the bytes as recorded on the K-Line.

ISO 9141-4: The third column in Table B.4 — Byte flow and timing example of ISO 14230-4 / ISO 9141-2 protocol, shows the time between bytes (stop bit of last byte and start bit of next byte). The fourth column shows the bytes as recorded on the K-Line.

The fifth column shows the “Msg. Type” (message type) either “Request” or “Response”. The column on the right includes a description of each byte.

Table B.4 — Byte flow and timing example of ISO 14230-4 / ISO 9141-2 protocol

5 Baud initialization with $33 address				Msg. Type	Description of data bytes
ISO 14230-4		ISO 9141-2			
Time in ms between bytes	Byte in hex	Time in ms between bytes	Byte in hex		
173,5	55	186,4	55	N/A	Synchronization byte at 10400 bit/s
10,0	E9	10,1	08	N/A	ISO 14230-4: Key byte #1 (Low byte): 2025 decimal ISO 9141-2: Key byte #1 (Low byte): 1032 decimal
10,0	8F	10,1	08	N/A	ISO 14230-4: Key byte #2 (High byte): 2025 decimal ISO 9141-2: Key byte #2 (Low byte): 1032 decimal
31,0	70	31,0	F7	N/A	Inverted Key byte #2
29,0	CC	29,3	CC	N/A	Inverted 5 baud address byte
71,6	C2	70,8	68	Request	1st header byte
10,2	33	10,2	6A		2nd header byte
10,2	F1	10,2	F1		Source address (external test equipment/OBD Scan Tool)
10,2	01	10,2	01		Service request $01
10,2	00	10,2	00		PID $00 (request supported PIDs)
10,2	E7	10,2	C4		Checksum
37,5	86	39,1	48	Response #1	1st header byte
3,0	F1	3,0	6B		2nd header byte
3,4	11	3,4	11		Source address ECM
3,4	41	3,4	41		Service response $41, PID $00
3,1	00	3,1	00		Echo of PID $00 (request supported PIDs)
3,2	BF	3,2	BF		Supported PID data byte #1 (support for PIDs 01, 03-08)
3,5	BF	3,5	BF		Supported PID data byte #2 (support for PIDs 09, 0B-10)
3,4	A8	3,4	A8		Supported PID data byte #3 (support for PIDs 11, 13, 15)
3,3	91	3,3	91		Supported PID data byte #4 (support for PIDs 19, 1C, 20)
3,7	80	3,7	BC		Checksum
41,5	86	41,5	48	Response #1	1st header byte
3,0	F1	3,0	6B		2nd header byte
5,6	18	5,6	18		Source address TCM
5,4	41	5,4	41		Service response $41, PID $00
5,1	00	5,1	00		Echo of PID $00 (request supported PIDs)
5,2	80	5,2	80		Supported PID data byte #1 (support for PID 01)
5,5	01	5,5	01		Supported PID data byte #2 (support for PID 0D)
5,4	00	5,4	00		Supported PID data byte #3 (no support for PIDs 11-18)
5,3	00	5,3	00		Supported PID data byte #4 (no support for PIDs 19-20)
5,6	51	5,6	1A		Checksum
130,7	C2	130,7	C2	Request	Next Request
:	:	:	:		:
:	:	:	:		:

Bibliography

[1] ISO 15031-1, *Road vehicles — Communication between vehicle and external equipment for emissions-related diagnostics — Part 1: General Information*

[2] SAE J1939-15, *Physical layer, 250 kbps, twisted unshielded pair*

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