SURFACE VEHICLE RECOMMENDED PRACTICE

J1939™-5 JUN2020

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Marine Stern Drive and Inboard Spark-Ignition Engine On-Board Diagnostics Implementation Guide

RATIONALE

This technical report is being stabilized because it covers technology, products, or processes which are mature and not likely to change in the foreseeable future.

STABILIZED NOTICE

This document has been declared "Stabilized" by the SAE Truck Bus Control and Communications Network Committee and will no longer be subjected to periodic reviews for currency. Users are responsible for verifying references and continued suitability of technical requirements. Newer technology may exist.

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https://www.sae.org/standards/content/J1939-5_202006

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1. SCOPE

This document describes the application of the SAE J1939 recommended practices for compliance with on-board diagnostic malfunction detection system requirements for marine sterndrive and inboard spark ignition engines, as mandated by the California Air Resources Board (CARB). These Otto-cycle engines are not derived from automotive diesel-cycle engines.

1.1 Purpose

The purpose of this recommended practice is to provide a standard open interconnect architecture that allows a generic diagnostic tool to communicate with marine sterndrive and inboard spark ignition engine's on board diagnostic system. These on-board diagnostic malfunction detection system requirements are referred to as OBD-M in this document.

2. REFERENCES

2.1 Applicable Documents

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

In general, all requirements of the SAE J1939 document apply to OBD-M applications, except as noted in this document.

2.1.1 SAE Publication

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J1939	Serial Control and Communications Heavy Duty Vehicle Network - Top Level Document
SAE J1939-14	Physical Layer, 500 Kbps
SAE J1939-15	Physical Layer, 250 Kbps, Un-Shielded Twisted Pair (UTP)
SAE J1939-21	Data Link Layer
SAE J1939-31	Network Layer

SAE J1939-71 Vehicle Application Layer

SAE J1939-73 Application Layer - Diagnostics

SAE J1939-81 Network Management

SAE J1939DA J1939 Digital Annex

SAE/USCAR2-4 Performance Specification for Automotive Electrical Connector Systems

2.1.2 ABYC Publication

Available from American Boat and Yacht Council, 613 Third Street, Suite 10, Annapolis, MD 21403, Tel: 410-990-4460, www.abycinc.org.

ABYC E-11 2003-07 edition, AC and DC Electrical Systems on Boats

2.1.3 CARB Publication

Available from California Air Resources Board, 1001 “I” Street, P.O. Box 2815, Sacramento, CA 95812, Tel: 916-322-2990, www.arb.ca.gov.

CALIFORNIA CODE OF REGULATIONS (CCR), effective December 13, 2006
TITLE 13. Motor Vehicles
Chapter 9. Off-Road Vehicles and Engines Pollution Control Devices
Article 4.7. Spark-Ignition Marine Engines
§ 2444.2. On-Board Engine Malfunction Detection System Requirements – Model Year 2007 and Later Spark-Ignition Inboard and Sterndrive Marine Engines.

2.1.4 ISO Publication

Copies of these documents are available online at http://webstore.ansi.org/

ISO 2575 Seventh edition 2004-05-01, Road Vehicles - Symbols for controls, indicators, and tell-tales

3. DEFINITIONS

See Title 13 CCR §2441 and SAE J1939 for terms and definitions that are not defined in this document. In the event of conflicting definitions, those in Title 13 CCR §2441 shall take precedence.

4. ABBREVIATIONS

ABYC American Boat and Yacht Council
CARB California Air Resources Board
DC Direct Current
DLC Data Link Connector
DM Diagnostic Message
SPN Suspect Parameter Number

See SAE J1939 for other abbreviations not defined in this document.

5. TECHNICAL REQUIREMENTS

5.1 Physical Layer

The datalink physical layer shall be according to SAE J1939-15, except as noted. SAE J1939-14 shall not be used for connections to pins C and D in 5.2.5.

5.1.1 Wire

Wire and insulation type, color, and size shall be compliant with ABYC recommended practices. Where deviations from SAE J1939-15 occur, implementation should be according to the engine manufacturer's recommendation in order to ensure proper network functionality.

5.1.2 Network Architecture

The network must work properly if the only nodes are the engine ECU and the diagnostic scan tool, connected via a 5 m cable. If other integrated electronic control units perform OBD-M functions independent of the engine ECU, then it must be done according to the engine manufacturer's recommendation in order to ensure compliance with Title 13 CCR §2444.2. If 500K communcations like those defined in SAE J1939-14 are used in the vessel, the communcations shall reside on separate network segments.

5.1.3 Termination

Diagnostic tools intended to be connected to this network shall not include DC termination for the network segment backbone.

5.2 Marine Diagnostic Connector

The connector supports the unshielded twisted pair physical layer of SAE J1939-15. It also includes battery + and - from the engine, intended to power a diagnostic tool, and two spare pins reserved for future specification.

5.2.1 Data Link Connector Location

5.2.1.1 Engine Manufacturer Responsibilities

The OBD-M data link connector (DLC) shall be located on the engine in a spot that typically would be readily visible and accessible to a service technician after the engine has been installed in a boat. The DLC shall be constructed to withstand heat, vibration, and/or mechanical fatigue resulting from normal engine operation for a period of at least 10 years. These requirements shall apply separately to each engine in a multiple engine configuration except for engines belonging to the same OBD-M network, in which case a single DLC would suffice for that network.

5.2.1.2 Vessel Manufacturer Responsibilities

The DLC location may optionally be extended by the boat builder to reside within the passenger compartment of the vessel in a readily identifiable and accessible location. If the DLC location is hidden behind a removable panel or other obstruction, the panel or obstruction shall be clearly labeled to indicate the presence of the connector. If more than one DLC is present on a vessel, then each DLC shall be clearly labeled as to which engine it supports and/or shall be located relative to the other DLC(s) according to the corresponding relative locations of the engines using those DLCs.

5.2.2 Connector Sealing and Cap

The connector shall be sealed to meet the environmental requirements in 5.6 of SAE/USCAR2-4 for temperature Class 2 (Figure 5.1.4) components.

The connector shall be provided with a cap for sealing the front of the connector when not in use. The cap must have a method to retain it in order to prevent losing it when it is disconnected.

5.2.3 Connector Labeling

The DLC shall be labeled "OBD-M" on or near the connector.

5.2.4 Connect/Disconnect

The connector shall be rated for 200 connect/disconnect cycles.

5.2.5 Physical Requirements

The pinout shall be:

A - Vbatt +
B - Vbatt gnd
C - CAN-H
D - CAN-L
E - spare (reserved)
F - spare (reserved)

Unused pins shall be plugged.

5.2.6 Current Handling

The ‘Vbatt +’ and ‘Vbatt gnd’ circuits shall be capable of carrying (source and sink, respectively) a minimum of 5 A current to the diagnostic tool. Tools powered from this circuit shall not draw more than 5 A.

5.2.7 Mechanical Requirements

The engine-side of the connector shall be a plug style housing with socket style pins. See Appendix A for mating connector detail of the receptical style connector to be used for an OBD-M inspection tool.

5.3 Datalink Layer

The datalink layer shall conform to SAE J1939-21.

5.3.1 Preferred Addresses

OBD-M engines and diagnostic tools shall use the preferred addresses defined for Industry Group 0 (Global) or Industry Group 4 (Marine Equipment). Note that more than one engine may be connected to the network at a time.

5.3.2 Request/Response System

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

5.3.2.1 Request

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

5.3.2.2 Response

The response to a request may either be the requested data, an acknowledgement, or not-acknowledgement. In one case, no response is provided for the request.

5.3.2.2.1 ACK/NACK

PGN 59392 describes both a positive and negative acknowledgement facility. ACK and NACK responses indicate the performance status of a request or command. Requests received for unsupported data are responded to with NACK. SAE J1939-73 discusses the use of ACK/NACK on many of its service requests. ACK/NACK requirements should be strictly adhered to ensure service tool compatibility.

5.3.2.2.2 Data

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

5.3.2.2.3 No Response

No response is commonly provided for global requests, where the PGN supported is not available from receiving ECU. This is described in SAE J1939-21, 5.4. Exceptions to this policy is noted in Diagnostic Message (DM) descriptions in SAE J1939-73.

5.3.3 Transport Services

Transport services are described in SAE J1939-21 for data that exceeds eight bytes in length. Two forms of transport services are provided. Managed connections support flow control between the sender and receiver. Broadcast Announce Messages are sent without flow control.

Many of the replies, satisfying requests for diagnostic information, require ECUs to support the transport protocol mechanisms in SAE J1939-21, because they are longer than one data packet. Because diagnostic requests may be requested using either global or destination specific methods described in SAE J1939-21, the ability to provide both forms of reply will be required. Refer to the Connection Management topic in SAE J1939-21 for full details.

5.4 Network Layer

The Network Layer shall be according to SAE J1939-31.

5.4.1 Non SAE J1939 Communication

Non-J1939 protocols may exist on the network (e.g., proprietary 11-bit CAN, etc.), as long as they do not interfere with the OBD-M communication defined in this document, and are limited to 250K bps.

5.5 Network Management

Network management shall be according to SAE J1939-81.

5.5.1 Source Addresses

In applications with multiple engines communicating on the same network, the Source Addresses shall be as defined in SAE J1939 Tables B2 and B6.

5.5.2 Engine Location

OBD-M compliant devices shall support broadcasting a description in PGN 64965, SPN 2903 (ECU Location) of the relative location in the boat of the engine for which they are broadcasting fault codes. The description shall be a maximum of 16 characters long, intended to be displayed by the OBD-M scan tool (e.g., “PORT”, “STARBOARD”, etc.).

OBD-M scan tools should request this SPN globally and use it to help the technician relate the diagnostic data displayed with the appropriate engine in multiple engine applications.

It is the vessel manufacturer’s responsibility to configure the engine location according to the engine manufacturer’s recommendations.

5.6 Application Layer

There are two documents that define application layer requirements for OBD-M. SAE J1939-71 and SAE J1939DA define parametric data such as engine speed and some component operating limits like high idle. Scaling (range/resolution) and data length for parameters communicated on the SAE J1939 network are defined in SAE J1939-71. SAE J1939-73 defines the diagnostics services and data content for diagnostics messages on an SAE J1939 Network.

5.6.1 Parametric Data Support

At a minimum, the following SPNs shall be broadcast or available on request according to SAE J1939-71, if applicable:

Table 1 - SPNS required for broadcast if available

Parameter	SPN
Engine throttle position	51
Accelerator pedal position 1	91
Fuel level	96
Engine oil pressure	100
Engine intake manifold 1 temperature	105
Engine intake manifold #1 pressure (turbocharged applications only)	102
Engine air inlet pressure (normally aspirated applications)	106
Barometric pressure	108
Engine coolant temperature	110
Keyswitch battery potential	158
Battery potential / power input 1	168
Engine speed	190
Engine total hours of operation	247
accelerator pedal 1 low idle switch	558
Engine actual ignition timing	1436
ECU location	2903
Short-term fuel trim - bank 1	4236
Long-term fuel trim - bank 1	4237
Short-term fuel trim - bank 2	4238
Long-term fuel trim - bank 2	4239
Closed loop status, bank 1	4240
Closed loop status, bank 2	4241
Aftertreatment 1 exhaust gas temperature 1	3241
Aftertreatment 1 exhaust gas temperature 2	3249
Aftertreatment 1 exhaust gas temperature 3	3245
Aftertreatment 2 exhaust gas temperature 1	3275
Aftertreatment 2 exhaust gas temperature 2	3283
Aftertreatment 2 exhaust gas temperature 3	3279
Engine throttle actuator 1 control command	3464
Aftertreatment 1 Intake %O2	3217
Aftertreatment 1 Outlet %O2	3227
Aftertreatment 2 Intake %O2	3256
Aftertreatment 2 Outlet %O2	3266

5.6.2 Diagnostic Service Support

At a minimum, the following DM messages shall be supported according to SAE J1939-73:

- DM1, Diagnostic Message 1, Active Diagnostic Trouble Codes (DTCs)
- DM2, Diagnostic Message 2, Previously Active Diagnostic Trouble Codes (DTCs)
- DM3, Diagnostic Message 3, Diagnostic Data Clear/Reset for Previously Active DTCs
- DM5 Diagnostic Readiness 1 (bytes 1, 2, 3 with SPN 1220 = 19_{16}, “OBD-M (SI-SD/I)”)

- DM6, Diagnostic Message 6, Emission-Related Pending Diagnostic Trouble Codes (used to report faults that have occurred once, but not yet reported in DM1, for faults that require two occurrences before reporting the DTC)
- DM11, Diagnostic Message 11, Diagnostic Data Clear/Reset for Active DTCs
- DM12, Diagnostic Message 12, Emission-Related MIL-On Diagnostic Trouble CodesDM19 Calibration Information
- DM23, Diagnostic Message 23, Emission Related Previously MIL-On DTCs

5.7 Fault Code Storage and Erasure

All pending, active, and previously active OBD-M related faults (up to a minimum of 20) must be stored in non-volatile memory as diagnostic trouble codes, such that the codes are retained indefinitely even after all power is disconnected from the ECU. All fault codes shall be retained in computer memory, and shall remain accessible with a generic scan tool, until cleared by a technician, or as described below.

5.7.1 Pending Faults

When an OBD-M related fault occurs for the first time, the fault is “pending” and does not need to be indicated to the driver via the audio/visual alert device.

If an OBD-M diagnostic has caused a pending fault code to be stored in computer memory, but the same diagnostic passes during the next engine operating cycle in which it is run, the pending fault code must be erased from memory. Notwithstanding, a pending fault code for long-term fuel trim malfunctions and misfire (if so monitored) must be retained for up to two consecutive operating cycles after the initial setting of the pending fault code or until the next operating cycle during which engine operating conditions similar to those for which the pending code was recorded have been encountered without the recurrence of a malfunction.

Pending faults shall be broadcast (on request) using DM6.

Pending faults become “active” faults after two consecutive operating cycles in which the same diagnostic executes on each cycle and detects a malfunction both times.

Pending fault codes may be erased after 40 consecutive warm-up cycles for all OBD-M diagnostics, or 40 consecutive operating cycles for fuel trim malfunctions and misfire (if so monitored) ONLY if engine operating conditions similar to those under which the malfunction was originally detected have not been re-encountered.

5.7.2 Active Faults

When the same OBD-M related fault is detected in two consecutive engine operating cycles, the fault is “active” and shall be indicated as defined in 5.8 of this document.

Emissions related active faults shall be broadcast using DM1 (periodically) and DM12 (on request).

After a fault becomes active, it remains active until cleared with a scan tool or until it becomes a previously active fault (see 5.7.3 of this document).

Active fault codes may be erased after 40 consecutive warm-up cycles if the same diagnostic has either failed to execute during each of the cycles or has executed but failed to detect the same malfunction. Notwithstanding, the fault code must not be erased if the audio or visual alert device is still activated because of the fault.

5.7.3 Previously Active Faults

When an OBD-M related fault ceases to activate the audio/visual alert device after three subsequent consecutive operating cycles in which the diagnostic routine executes but does not identify a malfunction (see 5.8.1 and 5.8.2 of this document), the fault becomes “previously active.” Previously active faults are different than pending faults and shall not be used to reactivate the audio/alert device in combination with a subsequent detection of malfunction by the same OBD-M diagnostic routine. Previously active faults are retained as a historical record for service technicians to aid in the diagnosis and repair of intermittent malfunctions.

Emissions related previously active faults shall be broadcast (on request) using DM2 and DM23.

Previously active faults may be erased after 40 consecutive warm-up cycles if the same diagnostic has either failed to execute during each of the cycles or has executed but failed to detect the same malfunction. Notwithstanding, the fault code must not be erased, if the audio or visual alert device is still activated because of the fault.

5.8 Audio/Visual Alert Device

OBD-M compliant ECUs shall be able to support an audio and/or visual alert device, to be used to indicate when OBD-M related faults are currently active. It is the vessel manufacturer's responsibility to install the device according to the engine manufacturer's recommendations.

5.8.1 Visual Alert Device

If equipped with an OBD-M visual alert device, when an OBD-M related fault is active, the device shall be activated. The device shall also be briefly activated each time the engine is turned on, in order to indicate that the device is functional.

The visual alert device may be deactivated by the OBD-M system after three consecutive engine operating cycles in which the diagnostic routine responsible for activating the visual alert device has executed (or similar operating conditions have been encountered for fuel system or misfire monitoring), but has not detected the same malfunction. Notwithstanding, the visual alert device shall remain activated if more than one "active" fault remains in memory (see 5.7.2 and 5.7.3 of this document).

The visual device shall be labeled "Service Soon" or with ISO 2575 icon F.01.

The visual device shall only be used to indicate OBD-M related faults. Notwithstanding, an electronic display that is capable of dynamic or multiple visualizations may be used to indicate OBD-M malfunctions so long as OBD-M fault indication takes precedence over all other functions of the display and the display is activated continuously when a malfunction is present.

If equipped, each engine in a multiple-engine application shall have its own visual alert device, unless it is made apparent which engine(s) has an OBD-M related fault. The positioning of multiple visual alert devices within the vessel should, at a minimum, correspond to the positioning of engines on the vessel, otherwise there should be labeling (or other suitable identifiers) on the vessel clearly identifying the engine to which the visual alert device and/or DLC (in the case of multiple DLCs) corresponds.

5.8.2 Audio Alert Device

If equipped with an audio alert device intended for OBD-M indication, then when an OBD-M related fault is active, the audio alert device shall be turned on, continuously or discontinuously.

If the audio alert device is not sounded continuously, it shall be sounded for a 5 second continuous beep upon fault activation, followed by a chirp beep every minute.

The audio alert device may be deactivated by the OBD-M system after three consecutive engine operating cycles in which the diagnostic routine responsible for activating the audio alert device has executed (or similar operating conditions have been encountered for fuel system or misfire monitoring), but has not detected the same malfunction. Notwithstanding, the audio alert device shall remain activated if more than one "active" fault remains in memory (see 5.7.2 and 5.7.3 of this document).

The audio alert device may also be used to indicate non-emissions related events. These events may override emissions fault indication if they result in a continuous activation of the audio alert device. If they result in a discontinuous activation, then they must be interleaved or alternated with the emissions fault indication.

The audio alert device shall be briefly activated each time the engine is turned on, in order to indicate that the device is functional.

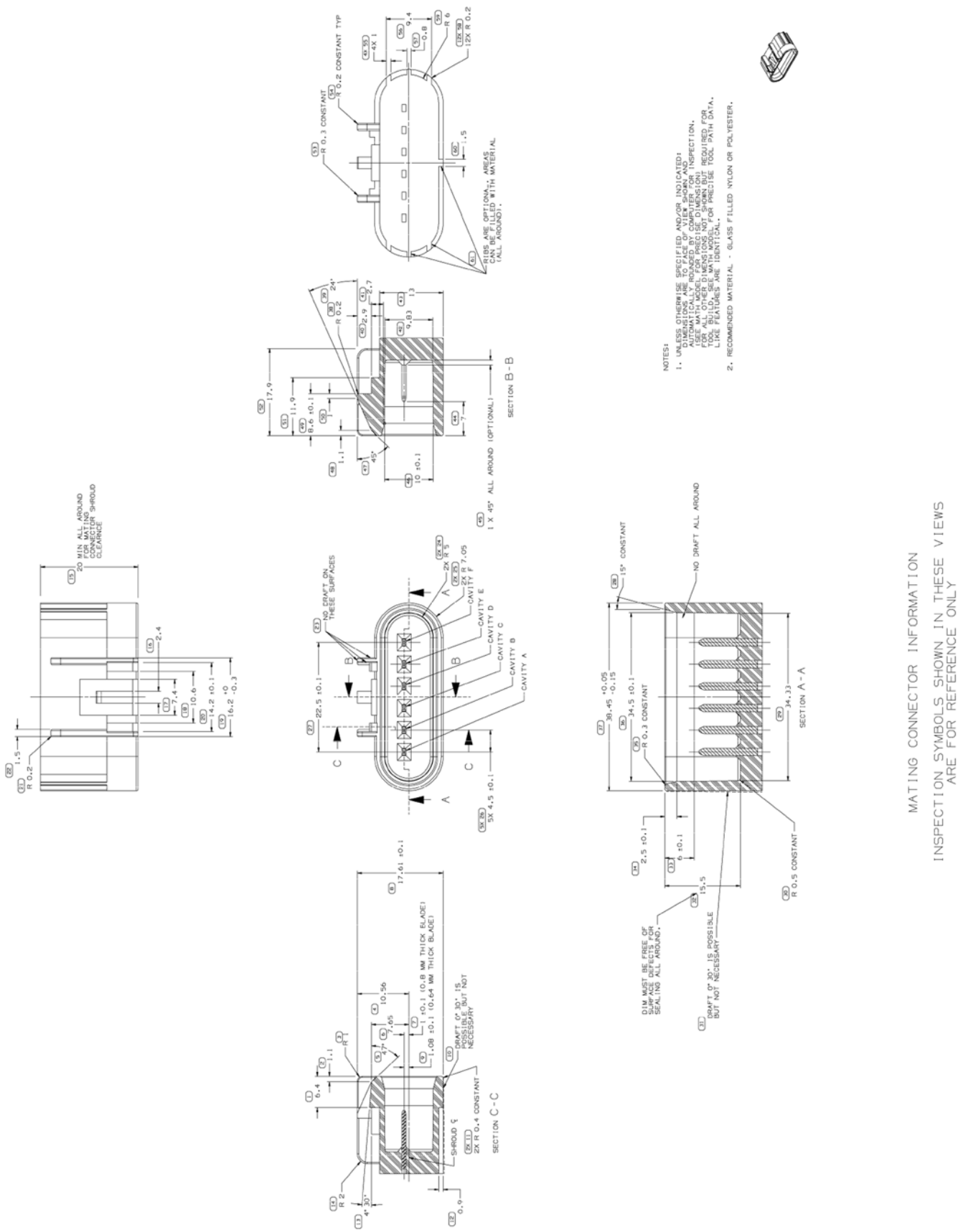
6. NOTES

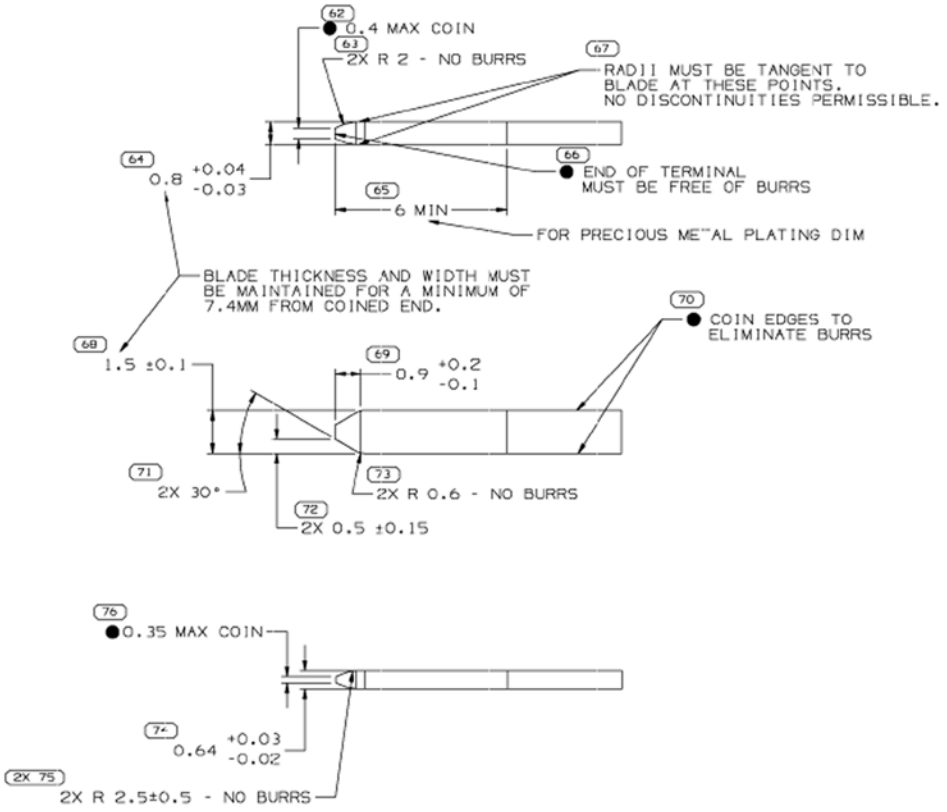
6.1 Revision Indicator

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

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

APPENDIX A - CONNECTOR DETAIL





FOR 0.64 THICKNESS

● THESE DIMENSIONS ARE CRITICAL TO THE MECHANICAL AND ELECTRICAL PERFORMANCE OF THE CONNECTION SYSTEM.

MATERIAL SPECIFICATIONS

RECOMMENDED

BASE METAL - CDA-210, EXTRA SPRING TEMPER

* TIN PLATING (WHERE APPLICABLE TO 125°C MAX CONTINUOUS USAGE):
  0.0025 +0.001/-0.0005 MM(100 +40 -20 μIN) THICK REFLOWED TIN OR
  0.0035±0.001 MM (140 ±40 μIN) ELECTROPLATED TIN.

* PRECIOUS METAL PLATING (WHERE APPLICABLE TO 150°C MAX CONTINUOUS USAGE):
  SURFACE LAYER - 0.0001MM (4 μIN) MIN HARD-GOLD ELECTROPLATE
  MIDDLE LAYER - 0.001MM (40 μIN) MIN PALLADIUM ELECTROPLATE
  BARRIER LAYER - 0.0012MM (50 μIN) MIN NICKEL ELECTROPLATE

* USAGE OF PLATING TYPES OTHER THAN RECOMMENDED MUST BE APPROVED

MINIMUMS

ELECTRICAL CONDUCTIVITY - ≥28% IACS AT 20 °C. USE OF A MATERIAL WITH CONDUCTIVITY <28% IACS MUST BE APPROVED.

TENSILE STRENGTH - 430 - 480 MPa

UNDERPLATING FOR TIN PLATING - FOR BASE MATERIALS CONTAINING 10% OR MORE ZINC, AN UNDERPLATE OF COPPER 0.0025 MM (100 μIN) MINIMUM THICK IS REQUIRED.

PROCESSING LUBRICANT - ANY PROCESSING LUBRICANT REMAINING ON TERMINALS MUST NOT VARNISH OR DEGRADE THE ELECTRICAL PERFORMANCE OF THE CONNECTION UP TO A MAXIMUM TEMPERATURE OF 150°C. PROCESSING LUBRICANTS MUST BE APPROVED.

MATING BLADE INFORMATION

SCALE 10:1

INSPECTION SYMBOLS SHOWN IN THESE VIEWS ARE FOR REFERENCE ONLY