SAE International

SURFACE VEHICLE RECOMMENDED PRACTICE

SAE J2496 JUN2011

Issued 2000-03
Stabilized 2011-06

Superseding J2496 FEB2007

Transport Area Network Cabling

RATIONALE

This document has been reviewed by the subcommittee to comply with the SAE 5-year Review Policy and has been found to be non-current.

STABILIZED NOTICE

This document has been declared "Stabilized" by the SAE Truck and Bus Low Speed Communication 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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Foreword—This series of SAE Recommended Practices have been developed by the Transport Area Network Cabling Standard Subcommittee of the Advanced Public Transportation System Technical Standards Task Force. The objectives of the subcommittee are to develop recommended practices, and standards concerned with the requirements design and usage of devices which transmit electronic signals and control information among vehicle components.

These SAE Recommended Practices are intended as a guide toward standard practice and are subject to change to keep pace with experience and technical advances.

1. Scope—This series of SAE Recommended Practices was developed to provide an open architecture system for on-board electronic systems. It is the intention of these documents to allow electronic devices to communicate with each other by providing a standard architecture. This particular document describes the Network Interface and Cabling which defines the requirements needed for communicating between devices that are on different segments of the SAE J2496 Transport Area Network. While these recommended practices may be used in retrofitting older vehicles, the primary intent is for implementation in new bus procurements.

1.1 Rationale—This document has been reviewed by the subcommittee to comply with the SAE 5-year Review Policy and has been found to be non-current.

2. References

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

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J1455—Joint SAE/TMS Recommended Environmental Practices for Electronic Equipment Design (Heavy-Duty Trucks)
SAE J1708—Serial Data Communications Between Microcomputer Systems in Heavy-Duty Vehicle Applications
SAE J1939—Serial Control and Communications Vehicle Network

2.1.2 DEFENSE ELECTRONICS SUPPLY CENTER (DESC) PUBLICATIONS—Available from DESC-EMT, Dayton, OH 45444.

DESC Drawing Number 89050—Contact, Electrical, Connector, High Power, Pin, Size 8, Straight, Solder
DESC Drawing Number 89051—Contact, Electrical, Connector, High Power, Socket, Size 8, Straight, Solder
DESC Drawing Number 89082—Electrical, Insert Arrangement Miniature, Thirty Two Size 20 Signal Contacts, With Four Size 8 Contact Cavities

2.1.3 INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC) PUBLICATION—Available from IEC Central Office, 3, rue de Varembe', 1211 Geneva 20, Switzerland.

IEC 512-4, 1976—Dynamic Stress Tests
IEC 512-6, 1984—Electrical Components for Electronic Equipment; Basic Testing Procedures and Measuring Methods
IEC 529 (2nd Edition)—Degree of Protection Provided By Enclosures (IP Code)
IEC 807-2 (2nd Edition)—Rectangular Connectors for Frequencies Below 3 MHz
IEC 807-3 (1st Edition)—Rectangular Connectors for Frequencies Below 3 MHz

2.1.4 NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA) PUBLICATION—Available from NEMA, 2101 L St. NW, Washington, DC 20037.

NEMA Standards Publication 250-1991—Enclosures for Electrical Equipment (1000 Volts Maximum)

2.1.5 ELECTRONIC INDUSTRIES ALLIANCE (EIA) PUBLICATION—Available from EIA, 2500 Wilson Blvd., Arlington, VA 22201-3834.

EIA RS-485 (April 1983)—Standard for Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems

3. Definitions

3.1 Transport Area Network (TAN) Power Feed Cable—This refers to the cable connected to the vehicle's power distribution panel and to the thirty six (36) contact male entry connector of the first Device Access Box of the TAN.

3.2 Thirty Six Contact Connector—A male or female Subminiature-D Connector configured in accordance with DESC drawing number 89082 containing thirty two (32) size 20 contacts cavities and four (4) size 8 power contact cavities.

3.3 Nine Contact Female Connector—A female Subminiature-D Connector configured in accordance with IEC 807-2 (second edition) performance level 2.

3.4 Nine Contact Male Connector—A male Subminiature-D Connector configured in accordance with IEC 807-2 (second edition) for fixed contact connectors or IEC 807-3 (first edition) for removable contact connector performance level 2.

3.5 Jackscrew System—A device used to couple, uncouple, and secure thirty six (36) contact and nine (9) contact connectors meeting the requirements of IEC 807-2 (second edition).

3.6 Device Access Box—An enclosure containing at a minimum one each Male 36 contact entry connector and Female 36 contact transport link component connector and two Female 9 contact transport link audio connectors. The Device Access Box shall employ soldered connection between connector contacts and an internal printed wiring board. The Device Access Box shall serve as the only interconnection for the SAE J2496 Transport Link Components.

3.7 Cablized Connector Assembly—A cable assembly utilizing the 36 contact connectors which shall meet the communication link requirements as specified in SAE J1708 OCT93.

3.8 Transport Link Components—All components interfacing with or receiving power from the TAN. These components may include but are not limited to Vehicle Control Head, Vehicle Signage, Door Status Units, Unit Inventory, Fare Collection, Route Adherence Unit, Vehicle Logic Unit, Smart Card Unit, Vehicle Location Unit, Automatic Enunciators, Trip/Event Recorder, Passenger Counter, Mobile Data Terminal, Vehicle Identification, Silent Alarm, and Vehicle Status Point Monitor.

4. Transport Area Network Cabling Standardized Distribution System—The distribution system shall consist of a minimum of 1 to a maximum of 8 Device Access Boxes and associated Cablized Connector Assemblies which shall satisfy the interface requirements and standards for connecting devices required in the transmission of electronic signals and information among vehicle components as set forth in SAE J1708 OCT93. See Figure 1.

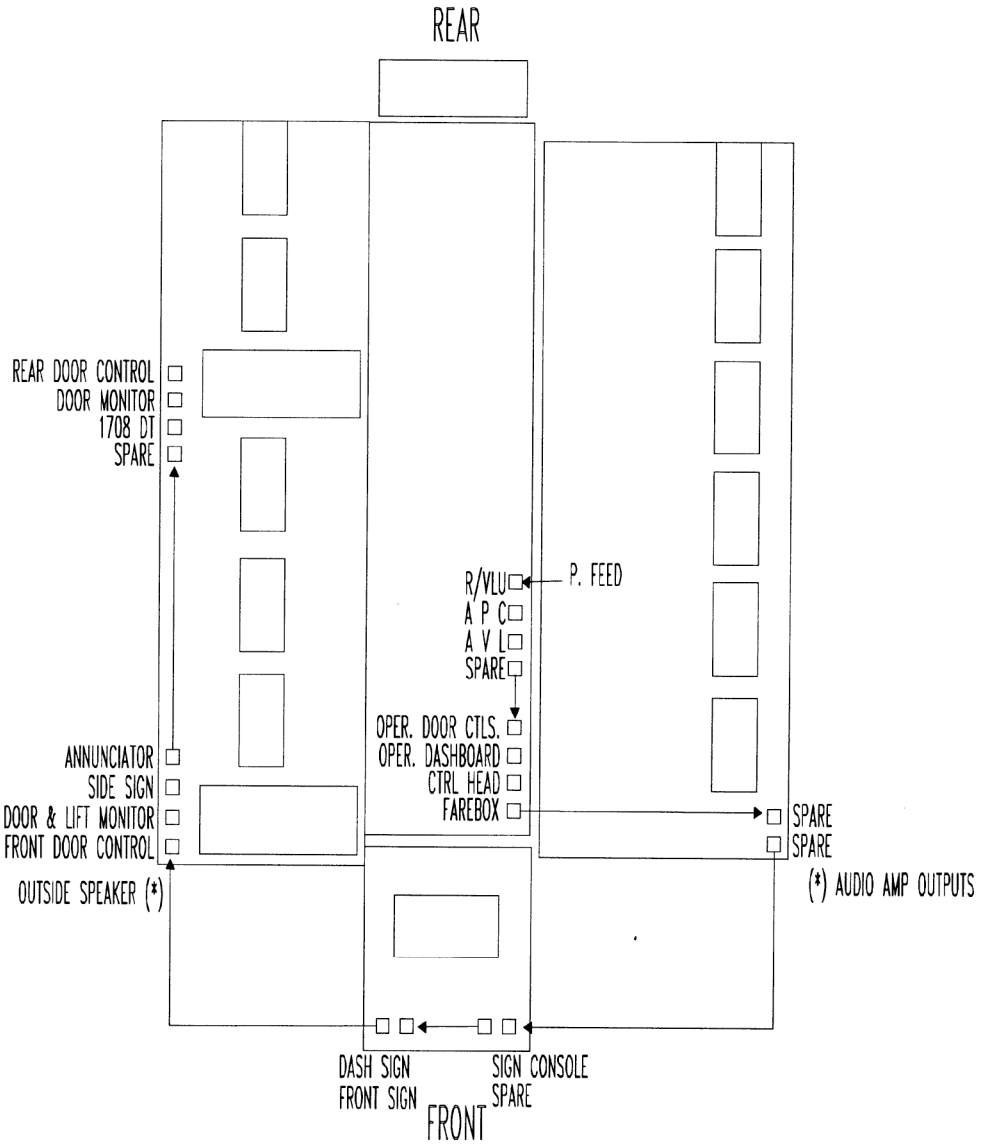

FIGURE 1—TYPICAL SAE J2496 TRANSPORT AREA NETWORK CABLE ROUTING PLAN

5. Electrical—The following requirements reflect the total power available from the SAE J2496 Transport Area Network (TAN).

5.1 The TAN shall provide power as two unregulated, unfiltered 24 V DC power sources, each with a respective ground return wire. One power circuit is active during the engine RUN condition, and the second power circuit is available at all times (24-h).

If the vehicle provides only a 12 V DC power source, then the distribution of unregulated, unfiltered 12 V DC will replace the references to 24 V DC.

5.1.1 RUN POWER—(Fused for 4.0 mm^2 [12 Awg] wiring): Available only when the vehicle is in the engine RUN condition.

5.1.2 24-H POWER—(Fused for 2.5 mm^2 [14 Awg] wiring): Full time power for systems requiring 24-h operation, memory retention voltage and/or other limited units defined as critical.

The combined power consumption of all devices obtaining power from the TAN shall not exceed these stated limits.

5.2 Power—The specifications in Table 1 are for a normally operating vehicle. The system designer must consider the possibilities of greater voltage fluctuations such as additional voltage drops during cold starting and over-voltage conditions arising from regulator failures and emergency starts. The system designer is referred to SAE J1455 section 4.11 AUG94 which specifies factors unique to the vehicular environment.

TABLE 1—POWER

Condition	12 V System Min. 9 V	12 V System Nom. 14.2 V	12 Volt System Max. 16V	24 V System Min. 18 V	24 V System Nom. 28.4 V	24 V System Max. 32 V
Normal Operating Volts	9 V	14.2 V	16 V	18 V	28.4 V	32 V

5.3 Data Signals—The data signals, electrical parameters, network parameters, and protocol shall be as defined in SAE J1708 OCT93.

5.4 Grounding—The electrical point of common connection between all shield grounds and to the vehicle's ground, shall be at only a single point on the vehicle. See Figure 2.

That point shall be within the female connector which is attached to the TAN power feed cable. This connector is inserted into the first Device Access Box. The combined shield grounds shall be connected to the vehicle's power distribution panel ground by a 2.5 mm^2 (14 Awg), or larger, insulated wire.

The shield grounds shall not be connected to each other at any other point; have electrical connection to any SAE J2496 Transport Link Components; or be used to carry electrical power.

5.4.1 POWER RETURN GROUND WIRES—The RUN and 24-h power return ground wires contained within the TAN power feed cable shall be separate, 4.0 mm^2 (12 Awg) or larger, insulated wires. One wire shall be connected to contact A1 and the other wire shall be connected to contact A4 of the female connector which is attached to this cable. The other end of each wire shall be connected to the vehicle's power distribution panel ground. Equipment connected to the TAN shall insure that the TAN power return wires are isolated from the equipment chassis or safety ground.

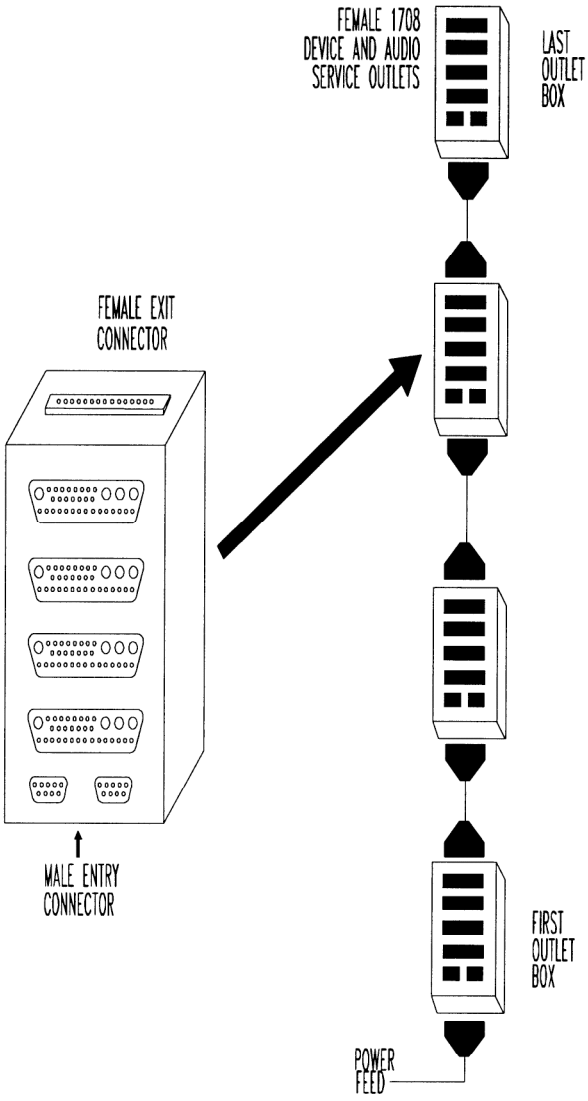

FIGURE 2—TYPICAL SAE J2496 DEVICE ACCESS BOX CONNECTIVITY

***6. Environmental Testing*—**The following tests and test methods are considered to be a realistic approach to environmental design validation and shall be performed to evaluate the effects on control, performance, and long-term reliability of the SAE J2496 Transport Area Network (TAN).

6.1 Vibration—The entrance cable and exit cable shall be properly connected to the Device Access Box for this test. All contacts of the input connector of the entrance cable and the output connector of the exit cable shall be monitored in the series with 100 mA minimum for a maximum discontinuity of 1 μs.

6.1.1 RECOMMENDED TEST METHOD—The mated assembly (includes 4.57 m [15 ft] length entrance cable, Device Access Box, and 4.57 m [15 ft] length exit cable) shall be tested in accordance with IEC 512-4, 1976 Test No. 6D using the sinusoidal vibration test method only.

6.2 Mechanical Shock—The entrance cable and exit cable shall be properly connected to the Device Access Box for this test. All contacts of the input connector of the entrance cable and the output connector of the exit cable shall be monitored in series with 100 mA minimum for a maximum discontinuity of 1 µs.

6.2.1 RECOMMENDED TEST METHOD—The mated assembly (includes 4.57 m [15 ft] length entrance cable, Device Access Box, and 4.57 m [15 ft] length exit cable) shall be tested in accordance with IEC 512-4, 1976, Test No. 6C.

6.3 Temperature Range –40 °C (–40 °F) to 80 °C (176 °F)—Upon completion of the rapid change of temperature test, the system shall meet the performance level 2 requirements set forth in IEC 807-2 (second edition).

6.3.1 RECOMMENDED TEST METHOD—The assembly shall be tested in accordance with IEC 512-6, 1984, Test No. 11d.

6.4 Humidity (Damp Heat, Steady-State 10 days)—Upon completion of the humidity test, the system shall meet the performance requirements set forth in IEC 807-2 (second edition).

6.4.1 RECOMMENDED TEST METHOD—The effects of steady-state humidity shall be tested as outlined in IEC 512-6, Test 11c.

6.5 Electromagnetic Interference (EMI)

6.5.1 RADIATED EMISSIONS (SIGNAL INJECTED INTO SYSTEM AND MEASURED OUTSIDE SYSTEM).

6.5.1.1 The field strength of radiated emissions at a distance of 3 m (9.84 ft) shall not exceed 40 dBµV/m over the frequency range of 10 kHz to 60 MHz and shall not exceed 50 dBµV/m over the frequency range of 10 kHz to 85 MHz.

6.5.2 RADIATED SUSCEPTIBILITY (SIGNAL TRANSMITTED OUTSIDE SYSTEM AND BERT [BIT ERROR RATE] MONITORED)

6.5.2.1 No bit errors shall be generated while being radiated with 3 V/m over the frequency range of 10 kHz to 1 GHz.

6.5.3 RECOMMENDED TEST METHOD—The set-up shall consist of a minimum of 8 Device Access Boxes connected in series. The total length of the interconnecting cables shall not be less than 39.62 m (130 ft).

6.5.3.1 For Radiated Emissions

6.5.3.1.1 A 10 Megabit/second signal shall be injected into a signal pair on the near end and looped back onto a different signal pair on the far end.

6.5.3.1.2 The looped back pair shall be terminated at the near end.

6.5.3.1.3 The emissions shall be measured at a distance of 3.0 m (9.84 ft) from the system under test.

6.5.3.2 For Radiated Susceptibility

6.5.3.2.1 A 10 Megabit/second signal shall be injected into a signal pair on the near end and looped back into a different signal pair on the far end.

6.5.3.2.2 A high power antenna shall be used to radiate the system under test with a 3V/m signal for frequencies between 10 kHz and 1 GHz.

6.5.3.2.3 The BERT (Bit Error Rate) shall be monitored during the test at the near end on the looped back pair.

7. ***Connectors***—The connectors shall ensure compatibility between system components, shall provide the required functional performance and shall maintain the reliability of the system over time. The connectors used with the cablized connector assembly and Device Access Boxes shall meet the following specifications.

7.1 Thirty Six Contact Male Connector

7.1.1 The 36 contact male connector shall be configured in accordance with DESC drawing number 89082. The size 20 contact termination shall be at the discretion of the cable and/or Device Access Box manufacturer. In addition, the contacts shall be plated 0.765 µm (0.000030 in) gold over a suitable underplate and meet the performance requirements of IEC 807-2 performance level 2.

7.1.2 The standard size 8 power contact shall be in accordance with DESC drawing number 89050 with the exception that the contact plating shall be plated 0.765 µm (0.000030 in) gold over a suitable underplate. The contact termination shall be at the discretion of the cable and/or Device Access Box manufacturer. The current rating for these contacts shall be established by the contact manufacturer based on the type of termination used. These contacts shall be located in connector positions A2 and A3.

7.1.3 The special size 8 power contacts shall be in accordance with DESC drawing number 89050 with the exceptions that the mating portion of the contact shall have a diameter of 2.38 mm ± 0.025 mm (0.094 in ± 0.001 in) and an additional length of 1.78 mm ± 0.25 mm (0.070 in ± 0.010 in) and that the contact plating shall be plated 0.765 µm (0.000030 in) gold over a suitable underplate. The additional length is to ensure first make grounding between connectors. The contact termination shall be at the discretion of the cable and/or Device Access Box manufacturer. The current rating for these contacts shall be established by the contact manufacturer based on the type of termination used. These contacts shall be located in connector positions A1 and A4.

7.1.4 When the thirty six (36) contact male connector is used on a cablized connector assembly, 9 of the size 20 contact termination shall be capable of accommodating 1.46 mm^2 (18 Awg) wire. The positions for the 1.46 mm^2 (18 Awg) wire are 1, 2, 6, 9, 10, 14, 25, 26, and 30.

7.2 Thirty Six Contact Female Connector

7.2.1 The 36 contact female connector shall be configured in accordance with DESC drawing number 89082. The size 20 contact termination shall be at the discretion of the cable and/or Device Access Box manufacturer. The contacts shall be of an open entry type plated 0.765 µm (0.000030 in) gold over a suitable underplate and meet the performance requirements of IEC 807-2 performance level 2.

7.2.2 The standard female size 8 power contact shall be in accordance with DESC drawing number 89051 with the exceptions that the contact plating shall be plated 0.765 µm (0.000030 in) gold over a suitable underplate and shall be of a closed entry type. The contact termination shall be at the discretion of the cable and/or Device Access Box manufacturer. The current rating for these contacts shall be established by the contact manufacturer based on the type of termination used. These contacts shall be located in connector positions A2 and A3.

7.2.3 The special female size 8 power contacts shall be in accordance with DESC drawing number 89051 with the exceptions that the mating portion of the contact shall accommodate a male contact with a diameter of 2.38 mm ± 0.025 mm (0.094 in ± 0.001 in) and an additional length of 1.78 mm ± 0.25 mm (0.070 in ± 0.010 in) and that the contact plating shall be plated 0.765 µm (0.000030 in) gold over a suitable underplate and shall be of a closed entry type. The additional length is to ensure first make grounding between connectors. The contact termination shall be at the discretion of the cable and/or Device Access Box manufacturer. The current rating for these contacts shall be established by the contact manufacturer based on the type of termination used. These contacts shall be located in connector positions A1 and A4.

7.2.4 When the 36 contact female connector is used on a cablized connector assembly, 9 of the size 20 contact termination shall be capable of accommodating 1.46 mm^2 (18 Awg) wire. The positions for the 1.46 mm^2 (18 Awg) wire are 1, 2, 6, 9, 10, 14, 25, 26, and 30.

7.3 Nine Contact Male Connector

7.3.1 The 9 contact male connectors shall be used only on Transport Link Component cables.

7.3.2 The 9 contact male connectors shall be in accordance with IEC 807-2 (second edition) for fixed contact connectors or IEC 807-3 (first edition) for removable contact connectors. The connectors shall meet performance level 2 requirements. The contact termination shall be at the discretion of the Transport Link Component cable manufacturer. Contact plating shall be 0.765 µm (0.000030 in) gold over a suitable underplate.

7.4 Nine Contact Female Connector

7.4.1 The 9 contact female connectors shall be used only on the Device Access Box.

7.4.2 The 9 contact female connectors shall be in accordance with IEC 807-2 (second edition) for fixed contact connectors. The connectors shall meet performance level 2 requirements. The contact termination shall be at the discretion of the Device Access Box manufacturer. Contact plating shall be 0.765 µm (0.000030 in) gold over a suitable underplate.

7.5 Connector Backshells—Each connector used on a cablized connector assembly shall be equipped with an appropriate backshell for protection and strain relief of contact termination.

7.6 Dust Covers—Each connector used on the Device Access Box shall be equipped with the correct connector shell size conductive plastic dust cover.

7.7 Jackscrew System

7.7.1 DEVICE ACCESS BOX—Each connector mounted on the Device Access Box shall include a fixed mechanical jackscrew system to secure the 36 contact and 9 contact connectors to the Device Access Box. The jackscrews shall be used to couple, uncouple, and secure the 36 contact and 9 contact connectors. The jackscrew system shall meet the requirements of section 4.5.1, Figure 8, International Standard IEC 807-2 (second edition).

Unless otherwise specified by the customer, the jackscrew threads shall be 4-40 UNC-2B.

7.7.2 CABLIZED CONNECTOR SYSTEM—Each connector used on a cablized connector assembly shall include a rotating mechanical jackscrew system to couple, uncouple, and secure the 36 contact and 9 contact connectors. The jackscrew system shall be compatible with the fixed jackscrew system defined in 7.7.1 of this document.

Unless otherwise specified by the customer, the jackscrew threads shall be 4-40 UNC-2A.

8. ***Transport Link Components*****—**Transport Link Components are those components connecting to or obtaining power from the TAN.

8.1 **Cabling—**All cabling from SAE J2496 Transport Link Components connecting to the Device Access Box shall be made of insulated wiring. The wiring shall be shielded, color coded, and clearly numbered with a wiring code and in a common sheath.

The Transport Link Component cables may not exceed 1.83 m (6 ft) in length and shall be terminated in a male connector that meets the applicable connector requirements specified in 7.3 of this document. The SAE J2496 Transport Link Components shall not have any electrical connection to the shield grounds (see 5.4).

9. ***Device Access Box*****—**The Device Access Box shall serve as the only interconnection for the SAE J2496 Transport Link Components.

9.1 **Dimensions—**The dimensions of the Device Access Box shall not exceed 152.4 mm (6 in) length by 88.9 mm (3.5 in) width and 50.8 mm (2 in) depth.

9.2 **Mounting—**Mounting tabs shall be provided for mounting the Device Access Box to the vehicle. The location of the tabs shall not prevent the boxes being directly connected to each other.

9.3 **Internal Printed Wiring Board—**Internally, the Device Access Box shall employ soldered connections between the connector contacts and an internal printed wiring board.

The printed wiring board shall be conformal coated.

9.4 **Device Access Box Configurations—**The Device Access Box shall be available only in the 6 configurations as shown in Table 2:

TABLE 2—TYPE AND NUMBER OF CONNECTORS VERSUS CONFIGURATION

Type Connectors	Config-uration 1	Config-uration 2	Config-uration 3	Config-uration 4	Config-uration 5	Config-uration 6
Male, 36 Contact, Entry Connector	1	1	1	1	1	1
Female, 36 Contact, Exit Connector	0	0	0	1	1	1
Female, 36 Contact, Transport Link Component Connector	1	2	4	1	2	4
Female, 9 Contact, Transport Link Audio Connector	2	2	2	2	2	2

9.5 **Device Access Boxes Per System—**The number of Device Access Boxes in each system shall not exceed 8.

9.6 **Connectors—**Each connector mounted on the Device Access Box shall meet the applicable requirements specified in Section 7 of this document.

9.7 **Device Access Box Enclosure—**When coupled to cablized connectors, the Device Access Box shall meet the applicable requirements of NEMA Publication 250-1991 (IEC 529-IP10) for a Type I enclosure, in addition to the requirements set forth in Sections 5 and 6 of this document.

10. Cablized Connector Assembly—The cablized connector assembly shall meet the communication link requirements as specified in SAE J1708 OCT93. Specifically, the cable used in the assembly shall consist of the following:

10.1 Cable Description

three (3) pairs, 1.46 mm^2 (18 Awg), 7 x 30 stranding, individually shielded, 1 twist per 25.4 mm (1 in)
seven (7) pairs, 0.34 mm^2 (22 Awg), individually shielded, 1 twist per 25.4 mm (1 in)
two (2) conductors, 4.0 mm^2 (12 Awg), stranded
two (2) conductors, 2.5 mm^2 (14 Awg), stranded
Overall foil shield with 0.5 mm^2 (20 Awg) drain wire
O/A jacket, OD not to exceed 15.75 mm (0.62 in)

10.2 Connectors—Each connector used on a cablized connector assembly shall meet the applicable requirements specified in Section 6 of this document.

10.3 Cable Length—The total cable length (including the wiring length from the SAE J2496 Transport Link Components to the Device Access Box), measured from the input to the system to any other point, shall not exceed 39.62 m (130 ft).

10.4 Cablized Connector Assembly—When coupled to the Device Access Box, the complete cablized connector assembly, including connectors, backshells and cable shall meet the requirements set forth in Sections 4 and 5 of this document. Multiple cables may be joined without the use of a Device Access Box as long as positive mechanical locking is assured.

11. Connector Contact Assignments

11.1 Thirty Six (36) Contact Connector—With associated wiring gauges (see Table 3).

TABLE 3—THIRTY SIX (36) CONTACT CONNECTOR

Pair No.	Pin No.	Assignment	Mnemonic
1	1 9 25	Transit SAE J1708 1.46 mm^2 (18 Awg)	Tip Ring Shield
2	2 10 26	Transit SAE J1939 1.46 mm^2 (18 Awg)	Tip Ring Shield
3	3 11 27	Spare Data #1 0.34 mm^2 (22 Awg)	Tip Ring Shield
4	4 12 28	Spare Data #2 0.34 mm^2 (22 Awg)	Tip Ring Shield
5	5 13 29	Spare Data #3 0.34 mm^2 (22 Awg)	Tip Ring Shield
6	6 14 30	Reserved for Drive Train SAE J1708 1.46 mm^2 (18 Awg)	Tip Ring Shield
7	7 15 31	Spare Data #4 0.34 mm2 (22 Awg)	Tip Ring Shield
8	16 17 18	Audio Pair #1 0.34 m2 (22 Awg)	Tip Ring Shield
9	19 20 21	Audio Pair #2 0.34 m2 (22 Awg)	Tip Ring Shield
10	22 23 24	Audio Pair #3 0.34 mm2 (22 Awg)	Tip Ring Shield
—	32	UL/Overall Shield	—
—	8	Not Assigned	—
P1	A1	24 h + 12/+24 2.5 mm^2 (14 Awg)	Negative return (zero volts to Chassis)
P2	A2	24 hour +12/+24 2.5 mm^2 (14 Awg)	Positive (to chassis)
P3	A3	Engine Run +12 /+24 4.0 mm^2 (12 Awg)	Positive (to chassis)
P4	A4	Engine Run +12/+24 40 mm^2 (12 Awg)	Negative return (zero volts to chassis)

11.2 Nine (9) Contact Connector—With associated wiring gauges (see Table 4).

TABLE 4—NINE (9) CONTACT CONNECTOR

Pair No.	Pin No.	Assignment	Mnemonic
1	1	Audio Pair #1 0.34 mm^2 (22 Awg) nom.	Tip
	2		Ring
	3		Shield
2	6	Audio Pair #2 0.34 mm^2 (22 Awg) nom.	Tip
	7		Ring
	8		Shield
3	4	Audio Pair #3 0.34 mm^2 (22 Awg) nom.	Tip
	5		Ring
	9		Shield

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