SAE INTERNATIONAL

SURFACE VEHICLE RECOMMENDED PRACTICE

J2698™ JUN2022

Issued 2008-01
Reaffirmed 2022-06

Superseding J2698 OCT2018

Primary Single Phase Nominal 120 VAC Wiring Distribution Assembly Design - Truck and Bus

RATIONALE

SAE J2698 has been reaffirmed to comply with the SAE Five-Year Review policy.

1. SCOPE

1.1 This SAE Recommended Practice covers the design and application of primary on-board wiring distribution system harnessing for surface vehicles. This document is intended for single phase nominal 120 VAC circuits that provide power to truck sleeper cab hotel loads so that they may operate with the main propulsion engine turned off. The power supply comes from alternative sources such as land-based grid power, DC-AC inverters and auxiliary power generators. The circuits may also provide power to improve vehicle performance through charging batteries or operating cold-weather starting aids.

1.2 This document is not intended to provide guidance for electric or hybrid electric vehicle wiring circuits. Refer to SAE J1673 for high voltage automotive wiring assembly design.

1.3 Engine block heaters are 120 VAC devices that are used on a multitude of vehicle platforms in addition to trucks with sleeper cabs. Generally, the engine block heater circuit is wired independent of hotel loads. SAE J2698 does not apply to independently wired engine block heater circuits. Engine block heaters that are integrated with hotel loads are subject to the guidelines in this recommended practice.

1.4 It is understood that drivers may choose to operate 120 VAC devices with the truck moving or at rest. For example, a passenger may operate the microwave or watch television and need to operate an inverter. The environment that these devices are operated in can also vary with exterior ambient temperature extremes. Exposure to oil and vibration are other elements that typical household 120 VAC wiring would not normally be exposed to; therefore, the construction of this power distribution is made more robust for a mobile trucking environment. Driver interaction with the 120 VAC power through use of appliances or connection of cord sets requires special attention to safety aspects dictated in regulatory standards from Nationally Recognized Testing Laboratories (NRTLs) approved labs like Underwriter's Laboratories (UL), Canadian Standards Association (CSA) or from the National Electric Code (NEC) that are not common practice with typical 12 VDC vehicle wiring. This recommended practice supports that all electrical materials, devices, components, appliances, fittings and equipment shall be Listed, Labeled or Certified to UL and CSA standards and shall be connected in an approved manner when installed. Detailed requirements are listed hereafter.

2. REFERENCES

2.1 Applicable Publications

The following publications form a part of this specification to the extent specified herein. Any undated reference to a code or standard appearing in the requirements of this document shall be interpreted as referring to the latest edition of that code or standard.

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: http://www.sae.org

For more information on this standard, visit
https://www.sae.org/standards/content/J2698_202206/

2.1.1 SAE Publications

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

SAE J447 Prevention of Corrosion of Motor Vehicle Body and Chassis Components

SAE J560 Primary and Auxiliary Seven Conductor Electrical Connector for Truck-Trailer Jumper Cable

SAE J1128 Low Voltage Primary Cable

SAE J1455 Recommended Environmental Practices for Electronic Equipment Design in Heavy-Duty Vehicle Applications

SAE J1654 High Voltage Primary Cable

SAE J1673 High Voltage Automotive Wiring Assembly Design

SAE J1742 Connections for High Voltage On-Board Road Vehicle Electrical Wiring Harnesses—Test Methods and General Performance Requirements

SAE J1908 Electrical Grounding Practice

SAE J2223-2 Connections for On-Board Road Vehicle Electrical Wiring Harnesses—Part 2: Tests and General Performance Requirements

2.1.2 Underwriters Laboratories, Inc. Publications

Available from Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096, Tel: 847-272-8800, www.ul.com.

UL 20 Standard for General-Use Snap Switches

UL 50 Standard for Enclosures for Electrical Equipment

UL 62 Standard for Flexible Cord and Fixture Wire

UL 83 Standard for Thermoplastic-Insulated Wires and Cables

UL 310 Standard for Electrical Quick-Connect Terminals

UL 467 Electrical Grounding and Bonding of Equipment

UL 489 Standard for Molded-Case Circuit Breakers and Circuit-Breaker Enclosures

UL 498 Standard for Attachment Plugs and Receptacles

UL 514A Standard for Outlet Boxes

UL 514B Standard for Fittings for Conduit and Outlet Boxes

UL 514C Standard for Outlet Boxes, Flush-Device Boxes and Covers, Nonmetallic

UL 817 Standard for Cord Sets and Power-Supply Cords

UL 943 Standard for Ground Fault Circuit Interrupters

UL 1077 Supplementary Protectors for use in Electrical Equipment

2.1.3 National Fire Protection Association Publication

Available from the National Fire Protection Agency, 1 Batterymarch Park, Quincy, MA 02169-7471, Tel: 617-770-3000, www.nfpa.org.

ANSI/NFPA 70-2008 National Electrical Code (NEC)

2.1.4 Canadian Standards Association Publications

Available from Canadian Standards Association, 170 Rexdale Boulevard, Toronto, Ontario, Canada M9W 1R3, www.csa.ca.

C22.1 Canadian Electrical Code—Part 1, Electrical installations (CEC)

C22.2 No. 0 General Requirements—CEC Part II

C22.2 No. 0.4 Bonding and Grounding of Electrical Equipment

C22.2 No. 5 Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures

C22.2 No. 18 Outlet Boxes, Conduit Boxes, Fittings and Associated Hardware

C22.2 No. 21 Cord Sets and Power Supply Cords

C22.2 No. 42 General Use Receptacles, Attachment Plugs and Similar Wiring Devices

C22.2 No. 49 Flexible Cords and Cables

C22.2 No. 65 Wire Connectors

C22.2 No. 75 Thermo-Plastic Insulated Wires and Cables

C22.2 No. 94 Special Purpose Enclosures

C22.2 No. 111 General-Use Snap Switches

C22.2 No. 144 Ground Fault Circuit Interrupters

C22.2 No. 152 Quick Connect Terminals

C22.2 No. 235 Supplementary Protectors

2.1.5 National Electrical Manufacturers Association

Available from the National Electrical Manufacturers Association, 1300 North 17th Street, Suite 1847, Rosslyn, VA 22209, Tel: 703-841-3200, www.nema.org.

NEMA WD6 2000 Wiring Devices—Dimensional Specifications

3. DEFINITIONS

3.1 Arc Fault

Discharges of current from one conductor to another in varying amounts of energy that result in some form of circuit damage or hazard.

3.2 Cord Connector

A device that, by insertion into a truck inlet, establishes an electrical connection to the truck for the purpose of providing power for the on-board electric loads.

3.3 Dead Front

(As applied to switches, circuit breakers, switchboards, distribution panelboards, etc). Designed, constructed, and installed so that no live parts are normally exposed on the front or on the operating side of the equipment.

3.4 Distribution Panelboard

A single panel or group of panel units designed for assembly in the form of a single panel, including buses, and with or without switches and/or automatic overcurrent-protective devices for the control of light, heat, or power circuits of small individual as well as aggregate capacity; designed to be placed in a cabinet or cutout box placed in or against a wall or partition and accessible only from the front.

3.5 Enclosed Wiring

All wiring in equipment enclosures or equivalent that is protected from environmental abuse other than temperature and vibration. The enclosures may be internal or external to the cab.

3.6 Exterior Wiring

All wiring external to the cab interior. Includes interconnecting wires and cables. Requires protection from all exterior environmental elements.

3.7 GFCI – Ground Fault Circuit Interrupter

A device intended for protection of personnel that functions to de-engergize a circuit or portion thereof within an established period of time when a current to ground exceeds value established for a Class A device (4 mA to 6 mA).

3.8 Interior Wiring

All wiring internal to the cab but external to component enclosures. Includes interconnecting wires and cables. Requires protection from in cab environmental elements.

3.9 Low Voltage

Considered to be ≤ 60 VDC (25 VAC).

3.10 Nominal 120 VAC

Standard electrical voltage as supplied by electric utilities may vary in tolerance from 100 VAC to 125 VAC but is referenced as nominal 120 VAC.

3.11 Shore Power

A fixed pedestal or other fixture that provides the interface to the truck for electricity from the land based power grid. A cord set with cord connector couples to the truck flanged surface inlet to provide electric energy.

3.12 Truck Flanged Surface Inlet

The device(s) on the truck into which the cord connector(s) is inserted for providing shore power electric energy.

3.13 Voltage Drop

The voltage drop of a circuit is in direct proportion to the resistance of the conductor and the magnitude of the current. If you increase the length of a conductor, you increase its resistance—and you thus increase its voltage drop. If you increase the current, you increase the conductor voltage drop.

4. WIRING

4.1 Interior and Exterior Wiring

4.1.1 Flexible cord or cable used for interior and exterior wiring shall be of a hard-usage type or extra hard-usage suitable for outdoor use and be rated for oil compatibility per UL Std. No. 62 and CSA C22.2 No.29.

4.1.2 Flexible cord or cable shall be rated a minimum of 90 °C and rated for outdoor use at –40 °C or lower.

4.1.3 Flexible cord or cable shall meet the fluid compatibility requirements of SAE J1128 (para. 6.7) for gasoline, diesel fuel, engine oil and engine coolant. This requirement is in addition to those listed in 4.1.1.

4.2 Enclosed wiring used in adequately protected junction boxes, raceways or enclosed areas of the vehicle may be the same as that defined for interior wiring or UL/CSA approved appliance wiring material or fixture wire. Appliance or fixture wires shall be rated to 105 °C.

4.3 All conductors shall be stranded copper or copper alloy only.

4.4 The voltage rating of the cable shall exceed the maximum operating voltage of the circuit. Cable used in this application is normally rated to either 300 V or 600 V. 300 V minimum is recommended.

4.5 Ampacities for flexible cords and cables shall conform to NEC Article 400.

4.6 Wire and cable is class-coded per UL/CSA standards. Interior and exterior 120 VAC harnesses must be covered with an orange covering material per SAE J1673 para. 3.5 to identify them as high voltage.

5. TERMINAL AND CONNECTION FUNCTION (NON-SUPPLY POINT)

5.1 Terminal Selection

5.1.1 A corrosion resistant conductive plating is recommended for the terminals. Consult terminal manufacturer for material details.

5.1.2 Terminal materials and plating shall be chosen to reduce dissimilar metals and the resulting galvanic corrosion when mated. Consult SAE J447 para. 4.3.3 for details on galvanic corrosion.

5.1.3 Terminal and/or connector body device (includes molded connectors) shall have cable insulation support to provide strain relief to the terminal. Support requirements are defined in UL 498 and CSA C22.2 No.42.

5.1.4 Conductors shall be crimped only or crimped and soldered to the terminals per the manufacturer's recommendations and that connection shall withstand the tensile strength of terminal to wire connection and vibration tests of SAE J2223-2 para. 4.4 and 4.11.

5.2 Connector Selection

5.2.1 Connectors are to be UL Recognized or Listed and/or CSA Certified, and rated to the required voltage and current. The regulatory tests cover key electrical tests such as dielectric strength, terminal secureness, insertion/retention forces, polarity and temperature rise. SAE J2223-2 para. 4.10 and 4.11 shall be used for additional temperature/humidity and vibration for interior and exterior connections. Water protection and corrosion testing shall be performed for exterior connections as per SAE J2223-2 para. 4.9 for sealed connector water tightness and para. 4.16 for salt spray.

5.2.2 Connectors should have positive locking features when mating. Refer to SAE J2223-2 para. 4.5.

5.2.3 Connectors shall be keyed for polarity.

6. SUPPLY CONNECTIONS

6.1 Connection to grid-based AC (line voltage) power supply (shore power).

6.1.1 The following shore power connection configurations are recommended at the flanged surface inlet.

- 15 amp 120 VAC truck flanged surface inlet shall be NEMA 5-15P configuration
- 20 amp 120 VAC truck flanged surface inlet shall be NEMA 5-20P configuration (desired)

NOTE: The number of truck flanged surface inlet(s) is not limited. The designer should keep in mind, though, that a minimum of two 20 amp/120 VAC receptacles has been recommended by truck OEMs to the facilitators of truck stops and rest areas electrified for truck hook-ups. It is likely that the multiple power supplies may not be phase synchronized and circuits should be isolated per para. 15.2.

6.1.2 The truck flanged surface inlet should be located on the driver's side of the vehicle in a location that is easily visible to the driver. This will help in the prevention of the driver pulling away with the supply cord still attached to service outlet and will simplify truck stop power pole location layouts. The connection point shall be located forward of the back of cab at a height of not less than 0.6 M and not more than 1.6 M above the parking surface.

6.1.3 The voltage and current rating of the truck flanged surface inlet shall be indicated in proximity to the fixed connection point. A warning label near the shore power connection shall state the following: "WARNING SHOCK HAZARD". More detailed warnings shall be included in the Operator's Manual where there shall be indication of the shock hazard and a recommendation that, when possible, all 120 VAC loads are to be disconnected prior to connection or disconnection of the extension cord set to the vehicle. Periodic inspections tables in the owner's manual shall include inspection of the 120 VAC truck flanged surface inlet. Allowance should be made for replacement of the inlet due to wear or damage.

NOTE: A device that locks out current transfer (interlock) until the cord set is fully seated in the truck flanged surface inlet will help to automatically reduce the arcing effect on the terminals when they are connected under load.

6.1.4 The truck flanged surface inlet terminals shall be properly sealed from the elements with a fixed mount housing or cover when the mating connector is disengaged. Individual truck OEMs will define sealing needs for the application based on mounting location. Reference SAE J1455 para. 4.4 test method for splash testing to water, chemicals and oils.

6.2 APU Genset connections and inverter connections are intended to be connected on a more permanent basis and are generally subject to disconnect only for repair or replacement, as such the terminal and connection requirements listed in Section 5 are applicable. These connections are to be UL recognized and/or CSA certified for the specific application. It is recommended that the ground terminals on these plugs engage first when the connectors are mated.

6.3 Transfer switching between multiple power supplies by relay or other device shall ensure that one power supply cannot supply power to another. I.e. the invert or APU backfeeds power to the shore power connection(s) making that connection live.

7. RECEPTACLES

7.1 Interior receptacle shall be fixed to the cab structure in an area that is readily open and available to the user. Receptacles are not permitted in the following locations:

- In the face-up position
- In clothes closets
- Within a bathtub or shower space
- Above any electric or other fuel powered heaters
- In wall spaces behind doors that can be fully opened against the wall space

7.2 Receptacles shall be NEMA 5-15R or 5-20R and listed or certified to UL/CSA regulations.

7.3 Receptacles shall be wired with the minimum size conductors in accordance with Table 1.

TABLE 1 - RECEPTACLE RATINGS CHART

Circuit Rating	15 A	20 A	30 A
Minimum Conductor Size, (AWG)	14	12	10
Overcurrent Protection	15 A	20 A	30 A
Receptacle Rating	15 A	15 or 20 A	30 A
Maximum Load	15 A	20 A	30 A

8. OVERCURRENT AND FAULT PROTECTION

8.1 All branch circuits shall be GFCI protected and provided with overcurrent protection (on-board circuit breaker or resettable fuse) per Table 1. Engine block heaters are excluded unless they are integrated with the hotel load branch circuits.

8.2 Individual loads shall not exceed 80% of the circuit protection rating per NEC and CEC guidelines.

8.3 Over current protection devices shall be installed in an accessible location on the vehicle that is protected against weather and physical damage. Devices can be mounted in any approved distribution center (panel board) or junction box with access from the vehicle interior. Appliances, compressors and some motors may have additional overcurrent protectors that are integral to the equipment. These overcurrent protectors may be inaccessible per the specific regulatory requirements of that equipment. For example the NEC allows compressors to have inaccessible overcurrent protectors per NEC article 440.52(1) and (2).

8.4 The selection and location of the circuit protector should include the required ambient temperature in which it will operate.

8.5 All protection devices shall be UL/CSA recognized or certified to the set voltage and current.

9. SWITCHES AND CONTROLS

9.1 Relays are generally used in this wiring for automatic open neutral switching, for switching between power supplies, and/or for switching power indication systems. Relays and other switching devices shall have current and voltage ratings adequate for the application. Relays and other switching devices shall comply with the requirements of SAE J1455 for mechanical vibration and temperature.

9.2 Automatic relay switching for APU's shall be in the normally closed position for the APU.

9.3 All current carrying conductors are to be switched simultaneously.

10. GROUNDING AND BONDING

10.1 All circuits shall have a grounded conductor (neutral) and a grounding conductor. For other than the grounded (neutral) conductor at the power supply (see 10.3), current carrying conductors (hot and neutral) shall not be bonded anywhere on the vehicle chassis.

10.2 The grounded (neutral) conductor shall be identified by a continuous white or gray outer finish or by three continuous white stripes on other than green insulation along its entire length.

10.3 The grounding and grounded (neutral) conductors shall be separated throughout the circuit and shall only be bonded together at the high voltage power source (shore power transformer, inverter, generator). The grounding conductor shall have a continuous outer finish that is either green or green with one or more yellow stripes. Conductors with insulation or individual covering that is green, green with one or more yellow stripes, shall not be used for ungrounded or grounded (neutral) circuit conductors.

10.4 The grounding connection from the shore power truck flanged surface inlet shall be bonded to the grounding terminal of the distribution panelboard and shall be sized based on the supply rating. All exposed non-current carrying metal parts, enclosures, frames, lamp fixture canopies, and so forth shall be effectively bonded to the grounding terminal or enclosure of the distribution panelboard. The grounding connection between the distribution panelboard and accessible secondary ground node, as defined in SAE J1908, shall meet the ground bond test in 10.6.

10.5 Grounding terminals shall be recognized or certified for the wire size used.

10.6 Ground Bond Test

A current derived from a source having a no-load voltage not exceeding 50 V DC, and equal to twice the maximum current of the power supply circuit, or 30 A, whichever is the greater, is passed between any two exposed conductive parts for at least 5 s. The voltage drop between any two exposed conductive parts is measured. The resistance calculated from the current and the measured voltage drop shall not exceed 0,1 Ω.

$$\text{resistance} = \text{voltage drop}/\text{current} \qquad \text{(Eq. 1)}$$

NOTE: Care shall be taken, that neither the resistance of the supply cord nor the contact resistance between the tip of the measuring probe and the exposed conductive parts under test affect the test results.

11. COMPONENT/SYSTEM TESTING AND APPROVAL

11.1 Suppliers of electrical wiring harnesses should be mandated by truck manufacturers to ensure the harnesses are approved to UL or CSA standards prior installation on the vehicle. In addition, harness suppliers should perform the following tests/inspections:

11.1.1 Dielectric voltage withstand test 100% of product. The harness shall pass without breakdown an AC potential of 1250 volts of a frequency between 50 Hz and 60 Hz, or a DC voltage applied for one second between the different sections of the electrical circuit and the exposed parts as follows:

- Between parts of opposite polarity
- Between all high voltage conductors/circuits and all low voltage conductors/circuits where both are contained in the same harness or are dependent upon separation, barriers and the like
- Between all current carrying conductors/circuits (both high and low voltage) and the chassis, including all non-current carrying conductive parts bonded to the chassis
- Between different high voltage AC and DC circuits, provide by other electrical sources, converters, batteries, and so forth

When a direct-current potential is used for an AC circuit, a test potential of 1.414 times the applicable RMS value of alternating-current voltage specified is to be applied. The test may be conducted on the entire system at one time or on individual subsystems or assemblies.