The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

SURFACE VEHICLE STANDARD

SAE J1673

ISSUED JUL96

Issued 1996-07

Submitted for recognition as an American National Standard

HIGH VOLTAGE AUTOMOTIVE WIRING ASSEMBLY DESIGN

1. Scope—This SAE Recommended Practice covers the design and application of primary on-board wiring distribution system harnesses to road vehicles. This document applies to any wiring system which contains one or more circuits operating between 50 V DC or AC RMS and 600 V DC or AC RMS excluding automotive ignition cable.

2. References

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

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

SAE J163—Low Tension Wiring and Cable Terminals and Splice Clips
SAE J1127—Battery Cable
SAE J1128—Low Tension Primary Cable
SAE J1292—Truck-Tractor, Trailer, and Motor Coach Wiring
SAE J1654—High Voltage Cable
SAE J1742—Connections for High Voltage On-Board Road Vehicle Electrical Wiring

2.1.2 UL PUBLICATION—Available from Underwriter Laboratories Publications, 333 Pfingsten Road, Northbrook, IL 60062.

UL 1244—Electrical and Electronic Measuring and Testing Equipment

2.2 Related Publications—The following publication is provided for information purposes only and is not a required part of this document.

2.2.1 SAE PUBLICATION—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J2223—Connections for On-Board Road Vehicle Electrical Wiring Harnesses—Part 1, Part 2, Part 3

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3. General

3.1 Definitions

3.1.1 CIRCUIT PROTECTION DEVICE—A fuse, circuit breaker, PTC or NTC (Positive Thermal Coefficient or Negative Thermal Coefficient), intelligent contactor, or other device placed in an electrical circuit to provide current overload protection.

3.1.2 HIGH VOLTAGE—Any wiring system which contains one or more circuits operating between 50 V DC or AC RMS and 600 V DC or AC RMS.

3.2 Insulated Cable

3.2.1 All insulated cables carrying voltages greater than 50 V DC or AC RMS and less than or equal to 600 V DC or AC RMS and wire carrying less than 50 V which are combined into the same harness bundle with high voltage; wire shall conform to SAE J1654.

3.2.2 Select cable insulation in accordance with the vehicle's working environment. Systems must allow for physical and environmental factors such as flexing, heat, cold, bend, fluid exposure, dielectric, abrasion, short circuit, and pinch resistance among others.

Some cable insulations exhibit thermoplastic cold flow under certain conditions. Care should be taken in choosing cables passing through environmental cable seals or strain relief connectors to prevent moisture leaks.

3.2.3 SAE J1127 and J1128 specify normal cable fluid exposure test requirements. Specific applications will dictate whether these or additional fluid compatibility tests need to be added. Failure modes resulting in fluid exposure must also be considered.

3.2.4 It is desirable for the wire of any one circuit to be of uniform color code throughout the circuit regardless of the number of connections. A circuit is assumed to be continuous until it is interrupted by a relay, fuse, switch contact, or when it reaches a load (such as a motor, actuator, resistive device, etc.).

3.2.5 CABLE SIZE DETERMINATION

3.2.5.1 Cable size is determined by considering the following factors:

a. Maximum temperature rise above ambient with steady-state current or anticipated duty cycles
b. Maximum temperature rise in a fault condition in power distribution circuits
c. Cable size appropriate for selected connectors
d. Cable mechanical strength

3.2.5.2 The maximum steady-state temperature should not exceed the temperature rating of the wire insulation, connector material, or other materials which the cable may contact (it may be permissible to exceed the temperature rating of the wire for short periods of time per individual manufacturer specifications). Ampere capacity of cables is a function of many variables. Some of these are:

a. Conductor size (gauge)
b. Insulation material
c. Insulation wall thickness
d. Ambient temperature
e. Proximity to heat sinks and heat sources
f. Wiring bundle size
g. Conductor material

3.2.5.3 Cable selection is determined by analysis of the vehicle electrical system. A basic approach is as follows:

a. Determine the load characteristics of each electrical component in the circuit. This must include steady-state current levels, voltage requirements, transient conditions, and current levels and current wave form shape (steady on, pulsed, frequency, etc.). Consideration must be given to manufacturer re-ratings based on the operating environment.
b. Select each circuit protection device size based on total load current and some safety margin to prevent inadvertent opening under normal conditions. A determination must also be made as to whether circuit protection philosophy will be to protect the wiring only or the wiring and devices. If devices are to be protected, the current draw during failure must also be determined and taken into account.
c. Determine the cable type and size for each circuit that is to be protected by the circuit protection device selected in step (b). Steady-state continuous or anticipated duty cycle currents must not result in a total cable temperature that exceeds the continuous operation temperature of the insulation as specified by the manufacturer. Refer to manufacturer's specifications for cable ratings, if available. Conditions exceeding the steady-state cable rating for a short period of time without permanent degradation of the cable may be permissible. Refer to cable manufacturer's specifications. All applications must be tested theoretically or empirically.
d. The cable and circuit protection device must be properly matched. If cable thermal rating is exceeded, then a larger cable conductor or upgraded insulation must be selected or circuit protection must be re-evaluated.

3.2.5.4 Resistive heating of a given cable contained within a bundle of cables may be more or less since the surrounding cables will act as a heat sink or source. The "effective" ampere capacity may increase or decrease for a given cable in a wiring bundle. The effect of bundle size on cable ampere capacity is specific to each application and must be tested to determine if smaller cables may be used.

3.2.5.5 Determination of the optimal cable size also depends on allowable voltage drop and conductor resistance. Refer to manufacturer's specifications for resistance of cable to be used.

3.2.5.6 Cable selection for mechanical strength shall be based on factors such as susceptibility to damage during installation and use. Cables contained within a wire bundle may be smaller than those in harness branches or routed separately.

3.3 Conductor Splicing

3.3.1 In general, splices should be avoided whenever possible. If splices are required, conductors shall be mechanically attached, crimped, soldered, swaged, brazed, welded, etc., with other conductors to form a wire splice. All wire splices shall conform with the electrical specifications for splices per SAE J163.

3.3.2 Splices shall be electrically and mechanically secure to withstand all fabrication, installation, and vehicle environment abuse.

3.3.3 Splices shall be insulated. Insulated splices shall meet the insulation resistance and dielectric requirements of SAE J1654.

3.3.4 Insulated splices shall meet the fluid, coolant, and battery electrolyte compatibility requirements of SAE J1127, J1128, and J1654 if exposed to these fluids.