



SURFACE VEHICLE RECOMMENDED PRACTICE

J1614™

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Superseding J1614 NOV2018

Wiring Distribution Systems for Off-Road, Self-Propelled Work Machines

RATIONALE

Electrical wiring systems are becoming large and complex. There is a desire to reduce cable size to address large wiring system bundle sizes and also to address wiring to components that have small integral electrical connectors.

OEM's with machine or tractor designs produced in multiple global locations may desire the use of ISO 6722-1 cable sizes to facilitate local wiring system manufacture outside of North America.

This standard is being revised to address the potential use of smaller cable sizes and ISO 6722-1 cable types required by current and future off-road, self-propelled earthmoving machines and agricultural tractors.

Additional changes include correction to cable resistances and 1 volt drop run lengths, addition of data for smaller cable sizes and ISO 6722-1 cable types, added references to SAE AWG size, and added a section on Battery Disconnect Switch.

SAE J1614 has been reaffirmed to comply with the SAE Five-Year Review policy.

1. SCOPE

This SAE Standard specifies requirements and design guidelines for electrical wiring systems of less than 50 V and cable diameters from 0.35 to 19 mm² used on off-road, self-propelled earthmoving machines as defined in SAE J1116 and agricultural tractors as defined in ASAE S390.

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.

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For more information on this standard, visit https://www.sae.org/standards/content/J1614_202407/

Documents

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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 J163	Low Tension Wiring and Cable Terminals and Splice Clips
SAE J378	Marine Propulsion System Wiring
SAE J553	Circuit Breakers
SAE J1116	Categories of Off-Road Self-Propelled Work Machines
SAE J1127	Low Voltage Battery Cable
SAE J1128	Low Voltage Primary Cable
SAE J1493	Guarding of Starter System Energization
SAE J1908	Electrical Grounding Practice

2.1.2 IEC Publication

Available from International Electrotechnical Commission, 3, rue de Verambe, P.O. Box 131, 1211 Geneva 20, Switzerland, Tel: +41-22-919-02-11, www.iec.ch.

IEC 617	Graphical Symbols for Diagrams
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2.1.3 ASABE Publication

Available from ASABE, 2950 Niles Road, St. Joseph, MI 49085-9659.

ANSI/ASAE S390	Definitions and Classifications of Agricultural Equipment
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2.1.4 DIN Publication

Available from Deutsches Institut für Normung, Postfach 1107, D-1000 Berlin 30, Germany

DIN 76 722	Road Vehicles, Low tension cables, Composition of type codes
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2.1.5 ISO Publication

Available from International Organization for Standardization, 1, rue de Varembe, Case postale 56, CH-1211 Geneva 20, Switzerland, Tel: +41-22-749-01-11, www.iso.org.

ISO 6722-1	Road vehicles – 60 V and 600 V single-core cables – Dimensions, test methods and requirements
ISO 9247	Earth-moving machinery – Electrical wires and cables – Principles of identification and marking

2.1.6 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM B 1	Standard Specification for Hard-Drawn Copper Wire
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2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1 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 J562 Nonmetallic Loom

SAE J821 Electrical Wiring Systems for Construction, Agricultural, and Off-Road Machines

3. DEFINITIONS

3.1 ELECTRICAL CIRCUITS

An electrical circuit includes all the components and connecting cables, starting from the electrical energy source, going to the functional component(s) and the return route to the energy source.

3.2 ELECTRICAL COMPONENT

An electrical component is normally a combination of parts, sub-assemblies, or assemblies and is a self-contained element intended to store, generate, distribute, alter, or consume electrical energy.

3.3 CONDUCTOR(S)

The current carrying element(s) in a cable.

3.4 ELECTRICAL CABLE

Insulated stranded electrical conductor used to establish a single current path.

3.5 HARNESS

A group of two or more cables bundled together.

3.6 TERMINAL

An electrically conductive device attached to a cable to facilitate connection to an electrical component, cable, or termination.

3.7 CONNECTOR

A coupling device which provides an electrical and/or mechanical junction between two cables or between a cable(s) and an electrical component.

3.8 WIRING

Collectively, the cables, harnesses, connectors, terminations, and supporting components used in the electrical wiring distribution system.

4. WIRING DESIGN

4.1 Cable Selection

The preferred cable shall meet the requirements of SAE J1127 type SGX and SAE J1128 type SXL. Other cable types may be required for specific applications.

When changing cable sizes from SAE J1128 to ISO 6722-1, the cross-sectional area of the conductor will change. SAE J1128 specifies minimum cross-sectional area which is different than the SAE "cable size". ISO 6722-1 specifies minimum electrical resistance and references nominal conductor cross-sectional area. When changing from one specification to the other, it is necessary when the copper cross-sectional area is reduced to repeat the cable size selection process as specified in Section 4 of this specification to ensure adequate current carrying capability and meet maximum allowable voltage drop.

When changing cables sizes from SAE J1128 to ISO 6722-1, the wiring system designer will also need to verify that the selected terminal's conductor crimp range will accept the alternative conductor diameter. The cable insulation thickness is also different so that the cable seal diameter range for the connector must also be reviewed to ensure sealing to the new cable diameter and that the terminal's insulation crimp range is within tolerance.

The insulation naming convention for ISO 6722-1 cables can be found in DIN 76 722. The near equivalent to SAE type XLPO cable insulation is DIN 76 722 type FL2X.

4.2 Cable Size Determination

Cable size is determined by consideration of the following factors:

- a. Cable mechanical strength
- b. Maximum temperature rise
- c. System voltage drops
- d. Selected connectors

4.2.1 Apply the procedure in Figure 1, Cable Sizing Flowchart, for determining cable sizes.

These factors vary in importance depending upon the application. Details specific to each are found in the following paragraphs.

4.2.1.1 Configure the electrical circuit including grounds and connectors.

4.2.1.2 Determine current requirements and cable lengths.

4.2.1.3 Determine fuse, circuit breaker, or other requirements applying appropriate de-rating factors.

4.2.1.4 A minimum size cable, or larger, shall be selected which meets all the previous requirements.

4.2.2 For mechanical strength, the minimum cable size recommended shall be 0.8 mm² in harnesses and/or protected areas in exterior or unprotected interior applications. A cable size of 1 mm² shall be the minimum cable size in areas susceptible to physical damage, or where one or two cables are extended from the harness. For protected areas within an enclosed compartment such as a cab or operator accessible electronic enclosure, the minimum cable size shall be 0.35 mm².

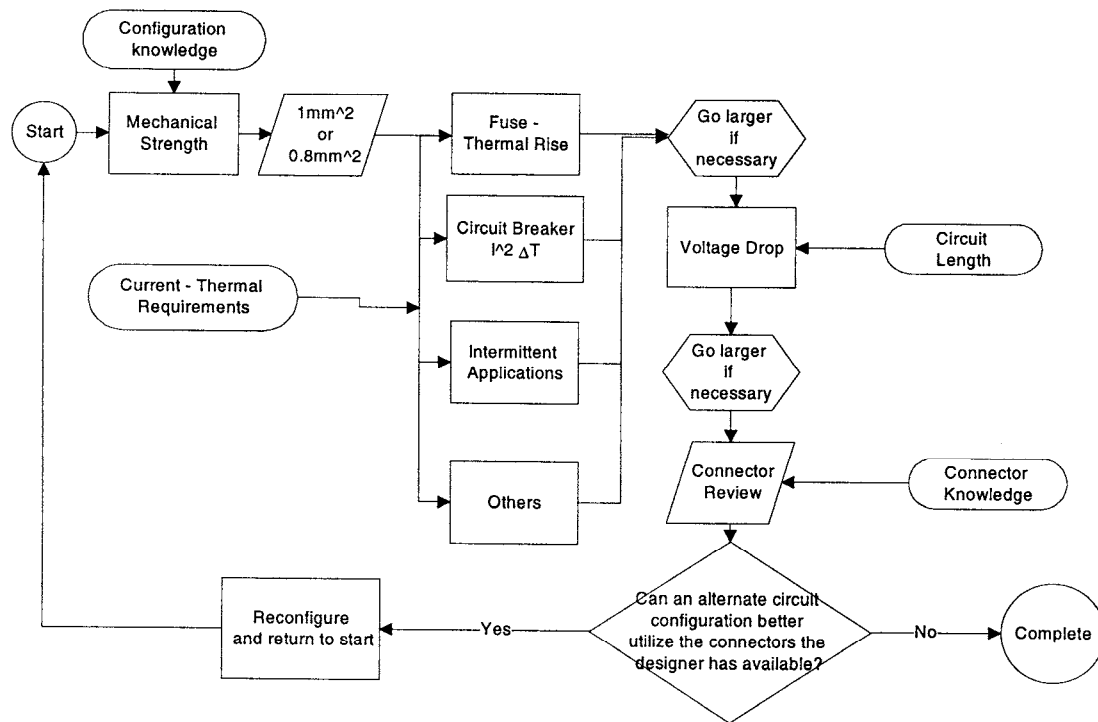


FIGURE 1 - CABLE SIZING FLOWCHART

4.2.3 The maximum temperature of the cable with steady-state currents shall not exceed the continuous duty temperature rating of the cable insulation, connector molding material, or other materials which the cable may come in contact with.

4.2.4 Fault Condition Maximum Temperature Rise

4.2.4.1 To control maximum temperature rise in a fault condition the cable must be sized for the circuit protection installed in the circuit. When a circuit breaker is used, it is important that the cable and the breaker be sized in such a way that the thermal circuit breaker "heats" at a rate higher than the cable to protect the cable from damage. Table 1 lists the minimum cable sized for given thermal circuit breakers. Table 1 is intended for manual reset breakers but can also be used for fuses. Auto-reset breakers require additional consideration to prevent overheating. See SAE J553 for additional guidance. In ambient temperatures up to 65 °C, the circuit breaker must be de-rated typically to 70% of its rating to prevent possible opening under steady-state conditions. In a fault condition, it is typical for the temperature of the cable to be raised by the fault current in the cable.

TABLE 1 - CABLE SIZED FOR THERMAL CIRCUIT BREAKERS

70% Load Operating Current (A)	Circuit Breaker Rating (Thermal type) (A)	Smallest SAE Cable Size Acceptable (mm ² /AWG) Calculations for this column are found in Appendix A.
2.8	4.0	0.35 / 22
3.5	5.0	0.5 / 20
5.2	7.5	0.8 / 18
7.0	10	1 / 16
10.5	15	2 / 14
14	20	3 / 12
21	30	5 / 10
28	40	8 / 8
42	60	13 / 6
56	80	19 / 4

- 4.2.5 For Steady-State Thermal Capacity, the selected cable size should be verified by load testing. Table 2 gives the values of currents permissible based on the assumptions of 30 °C rise for cables bundled in a harness and 10 °C rise of a single cable in free air due to steady-state current heating. Circuit protection should be sized for the smaller size cable within the circuit.

TABLE 2 - STEADY-STATE THERMAL CAPACITY⁽¹⁾

SAE Cable Size (mm ² /AWG)	SAE Ratings (A)
0.35 / 22	4.0
0.5 / 20	5.5
0.8 / 18	7.5
1 / 16	10
2 / 14	14
3 / 12	20
5 / 10	29
8 / 8	41
13 / 6	60
19 / 4	82

1. Dimensions used in calculating this table are typical industry values. Values found in this table are based on the calculations found in Appendix A.

4.2.6 Intermittent Load Cycles

For circuits where the electrical load is of a short duration, a 90-s rating can be used. As an example, a cable which is at a 40 °C ambient and is allowed to thermally rise to 150 °C. A short-term rating can be calculated based on its thermal mass. Based on the formula $\frac{\text{Current}}{\text{Area}} = 13.82$, the following ratings and sizings would be established. Please see Appendix A for the derivation of the constant.

8 mm² is rated 90 A
 13 mm² is rated 160 A
 19 mm² is rated 250 A