



## Single-Core Stranded Aluminum ISO Cable

### 1 Introduction

**Note:** Nothing in this standard supercedes applicable laws and regulations.

**Note:** In the event of conflict between the English and domestic language, the English language shall take precedence.

**1.1 Scope.** This standard specifies the dimension, test methods, and requirements for single-core aluminum conductor cables. The performance of aluminum conductor cables is, in general, not expected to be the same as copper conductor cables in a one-to-one comparison basis. For single core copper conductor cables, see GMW15626.

**1.2 Mission/Theme.** This standard defines test and validation requirements for single-core aluminum conductor cables. It also applies to individual cores in multi-core cables.

**1.3 Classification.** Single-core cables are classified by nominal voltage of the system where the cables are used, by the wall dimension of the cable insulation, and by the operating temperature.

#### 1.3.1 Nominal System Voltage Classes.

- 60 V cables intended for use in road vehicle applications where the nominal system voltage is  $\leq 60$  Volts Direct Current ( $V_{DC}$ ) and  $\leq 25$  Volts Alternating Current ( $V_{AC}$ ).
- 600 V cables intended for use in road vehicle applications where the nominal system voltage is  $> 60 V_{DC}$  and  $> 25 V_{AC}$  to  $\leq 600 V_{AC}$  and  $\leq 900 V_{DC}$ .

**Note:** For 600 V applications, where the nominal system voltage is  $> 60$  V, the cable shall meet the 600 V performance requirement of ISO 6722-2 regardless of wall thickness construction.

**1.3.2 Temperature Classes.** Five cable classes have been defined in Table 1 to respond to the various temperatures encountered on vehicles.

Table 1: Temperature Class Rating

| Class | Operating Temperature | Equivalent to Temperature Class |
|-------|-----------------------|---------------------------------|
| A     | -40 °C to +85 °C      | T1                              |
| B     | -40 °C to +100 °C     | T2                              |
| C     | -40 °C to +125 °C     | T3                              |
| D     | -40 °C to +150 °C     | T4                              |
| E     | -40 °C to +175 °C     | T5                              |
| F     | -40 °C to +200 °C     | T6                              |

### 2 References

**Note:** Only the latest approved standards are applicable unless otherwise specified.

**Note:** In the event of a conflict between the text of this specification and the documents cited herein, the text of this specification shall take precedence.

## 2.1 External Standards/Specifications.

**Note:** The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

|            |                             |            |            |
|------------|-----------------------------|------------|------------|
| ASTM B231  | EN 573-1                    | ISO 6722-1 | ISO 6892-1 |
| ASTM B231M | EN 573-3:2009 <i>Note 1</i> | ISO 6722-2 |            |

**Note 1:** See 4.2.

## 2.2 GM Standards/Specifications.

|         |         |         |          |
|---------|---------|---------|----------|
| GMW3059 | GMW3173 | GMW3176 | GMW15626 |
|---------|---------|---------|----------|

## 3 Test Preparation and Evaluation

### 3.1 Resources.

**3.1.1 Calibration.** The test facilities and equipment shall be in good working order and shall have a valid calibration label.

**3.1.2 Alternatives.** Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

**3.1.3 Facilities.** Laboratory with sufficient resources and equipment to execute the tests in Section 5.

**3.1.4 Equipment.** See each individual test in Section 5. For ovens, see ISO 6722-2.

**3.1.5 Test Vehicle/Test Piece.** Number of test samples is specified in each individual test of Section 5. The cables to be tested shall be manufactured under full production conditions. No parts out of prototype tools shall be used.

**3.1.6 Test Time.** See each individual test in Section 5.

**3.1.7 Test Required Information.** See 3.7.1.

**3.1.8 Personnel/Skills.** General familiarity with wire and wire testing.

**3.1.9 Test Required for Certification.** The cables shall be submitted to the tests specified in Table A1 in Appendix A. Initial qualification tests shall be performed by a certified, independent laboratory, unless otherwise agreed to by the appropriate GM department.

**3.2 Preparation.** See each individual test in Section 5. Direct contact of aluminum wire to any other metal shall not occur with any of the test methods.

### 3.3 Conditions.

**3.3.1 Environmental Conditions.** See ISO 6722-2.

**3.3.2 Test Conditions.** Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

**3.4 Instructions.** See each individual test in Section 5.

**3.5 Data.** See 3.7.1.

**3.6 Safety.** This standard may involve hazardous materials, operations, and equipment. This standard does not propose to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

**3.7 Documentation.** Samples of components or material released to this standard shall be tested for conformity with the requirements of this standard and approved by the responsible GM department prior to the start of delivery of production level components or materials.

Any change to the component or material, e.g., design, function, properties, manufacturing process and/or location of manufacture requires a new release of the product. It is the sole responsibility of the supplier to provide the customer, unsolicited, with documentation of any change or modification to the product/process, and to apply for a new release.

If not otherwise agreed to, the entire verification test shall be repeated and documented by the supplier prior to start of delivery of the modified or changed product. In some cases, a shorter test can be agreed to between the responsible GM department and the supplier.

**3.7.1 Test Results.** The results shall be reported in the test report. See Test Report example in Appendix C. The test report shall include as minimum:

- Name of the supplier.
- Date.
- Supplier Product Designation.
- GM Wire Code Designation.
- Production Location.
- Designation of Compound.
- International Material Data System (IMDS) Identification (ID) and information, if the IMDS datasheet has been approved by the customer.
- Test result and interpretation of test result.

## 4 Requirements and Procedure

### 4.1 General.

**4.1.1 Caution.** See ISO 6722-1.

**4.1.2 Cable Types.** See Figure B1, GM Wire Name Code System in Appendix B on defining the cable types, based on construction, conductor, temperature class, wall thickness, and insulation materials.

**4.2 Conductor.** The conductors shall consist of annealed or annealed compressed/compacted aluminum or aluminum alloy strands. The specifications for the conductors shall be according Table 2 and shall be completed by material specifications. Elongation requirements shall be established by agreement between customer and supplier.

The individual strands of the aluminum conductor shall be manufactured per 1000 series aluminum pursuant to EN 573-1 with a chemical composition per Table 1 in EN 573-3:2009 (only the dated edition cited applies).

The conductor shall be free of oil or lubricant to prevent welding issues.

**Table 2: Aluminum Conductor Specification**

| Tensile Strength<br>Notes 1, 2 | Elongation at Break<br>Note 1 | K20 Conductivity      |               | Recommended Aluminum Conductor Material |                   |
|--------------------------------|-------------------------------|-----------------------|---------------|-----------------------------------------|-------------------|
|                                |                               | (Sm/mm <sup>2</sup> ) | % IACS Note 5 | Alloy Designation                       | Type Note 6       |
| 70 to 120                      | ≥ 16                          | ≥ 35.5                | ≥ 61.2        | AA-1350 or AA-1370                      | EC Grade Aluminum |
| 90 to 140                      | ≥ 8 Notes 3, 4                | ≥ 33.5 Note 4         | ≥ 57.8        | AA-8176                                 | Aluminum Alloy    |

**Note 1:** Determined pursuant to ISO 6892-1 (Reference ASTM B231 and ASTM B231M).

**Note 2:** Measured at clamping length of 200 mm.

**Note 3:** Not applicable for compressed conductors. The tensile strength, elongation, and chemical composition requirements shall be established by agreement between customer and supplier.

**Note 4:** Additional aluminum alloys may be used upon approval from GM. The conductivity, tensile strength, elongation requirements, and chemical composition shall be established by agreement between customer and supplier.

**Note 5:** IACS is International Annealed Copper Standard.

**Note 6:** EC is Electrical Conductor (Grade Aluminum (AL) ≥ 99.5% AL content).

**4.3 Insulation.** Conductors shall be insulated with material complying with the requirements in this standard. Insulation shall be smooth and free from cracks, pitting and other defects visible to the naked eye.

**4.4 Colors.** A list of the ten (10) colors to be used, including stripe combinations and abbreviations of the colors, are specified in GMW3176.

**4.5 Marking.** The usage of marking is to be established between customer and supplier.

## 5 Test and Performance Requirements

**5.1 Outside Cable Diameter.** The measurement is carried out according to ISO 6722-1. All measurements shall be within the limits of the appropriate maximum and minimum outside cable diameter in Table 4.

**5.2 Insulation Thickness.** The measurement is carried out according to ISO 6722-1. The insulation thickness shall be in accordance with the required insulation thickness in Table 4.

**5.3 Diameter of Strand.** The measurement is carried out according to ISO 6722-1. The strand diameter and number of strands shall be in accordance with the required values and figures given in Table 3.

**5.4 Conductor Diameter.** The measurement is carried out according to ISO 6722-1. All measurements shall be within the limits of the appropriate maximum outside conductor diameter in Table 4.

**Table 3: Conductor Stranding and Dimensions** <sup>Note 1</sup>

| Conductor Size (mm <sup>2</sup> ) | Structure A (symmetrical)           |                              | Structure B (asymmetrical) |                              | Structure C (flexible) |                              |
|-----------------------------------|-------------------------------------|------------------------------|----------------------------|------------------------------|------------------------|------------------------------|
|                                   | Number of Strands <sup>Note 2</sup> | Strand Diameter maximum (mm) | Number of Strands          | Strand Diameter maximum (mm) | Number of Strands      | Strand Diameter maximum (mm) |
| 0.75                              | 7                                   | 0.38                         | 11 <sup>Note 3</sup>       | 0.30 <sup>Note 3</sup>       | 19                     | 0.23                         |
| 1                                 | 7                                   | 0.43                         | 16 <sup>Note 3</sup>       | 0.29 <sup>Note 3</sup>       | 19                     | 0.27                         |
| 1.5                               | 19                                  | 0.32                         | 16 <sup>Note 3</sup>       | 0.35 <sup>Note 3</sup>       | 37                     | 0.23                         |
| 2                                 | 19                                  | 0.37                         | 15                         | 0.42                         | 37                     | 0.27                         |
| 2.5                               | 19                                  | 0.43                         | NA <sup>Note 4</sup>       |                              | 37                     | 0.30                         |
| 3                                 | 19                                  | 0.46                         | 23                         | 0.42                         | 37                     | 0.33                         |
| 4                                 | 37                                  | 0.38                         | 30                         | 0.42                         | 47                     | 0.33                         |
| 5                                 | 37                                  | 0.41                         | 36                         | 0.42                         | 58                     | 0.33                         |
| 6                                 | 37                                  | 0.46                         | 45                         | 0.42                         | 70                     | 0.33                         |
| 8                                 | NA <sup>Note 4</sup>                |                              | 59                         | 0.42                         | 98                     | 0.33                         |
| 10                                |                                     |                              | 50                         | 0.52                         | 126                    | 0.33                         |
| 12                                |                                     |                              | 60                         | 0.52                         | 154                    | 0.33                         |
| 16                                |                                     |                              | 78                         | 0.52                         | 209                    | 0.33                         |
| 20                                |                                     |                              | 95                         | 0.52                         | 247                    | 0.33                         |
| 25                                |                                     |                              | 122                        | 0.52                         | 323                    | 0.33                         |
| 30                                |                                     |                              | 141                        | 0.52                         | 361                    | 0.33                         |
| 35                                | 121                                 | 0.62                         | 172                        | 0.52                         | 456                    | 0.33                         |
| 40                                | 134                                 | 0.62                         | 193                        | 0.52                         | 494                    | 0.33                         |
| 50                                | 172                                 | 0.62                         | 247                        | 0.52                         | 646                    | 0.33                         |
| 60                                | 201                                 | 0.62                         | 289                        | 0.52                         | 741                    | 0.33                         |

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| Conductor Size (mm <sup>2</sup> ) | Structure A (symmetrical)           |                              | Structure B (asymmetrical) |                              | Structure C (flexible) |                              |
|-----------------------------------|-------------------------------------|------------------------------|----------------------------|------------------------------|------------------------|------------------------------|
|                                   | Number of Strands <sup>Note 2</sup> | Strand Diameter maximum (mm) | Number of Strands          | Strand Diameter maximum (mm) | Number of Strands      | Strand Diameter maximum (mm) |
| 70                                | 180                                 | 0.72                         | 351                        | 0.52                         | 855                    | 0.33                         |
| 85                                | 213                                 | 0.72                         | 420                        | 0.52                         | 1064                   | 0.33                         |
| 95                                | 238                                 | 0.72                         | 463                        | 0.52                         | 1178                   | 0.33                         |
| 120                               | 234                                 | 0.82                         | 305                        | 0.72                         | NA <sup>Note 4</sup>   |                              |
| 160                               | 243                                 | 0.92                         | 398                        | 0.72                         |                        |                              |

**Note 1:** For Structure A and B, cross-sections consisting of more than 80 strands, a minor deviation in number of strands ( $\pm 3\%$ ) is acceptable, provided that the electrical resistance and the maximum strand diameter still are met.

**Note 2:** For size 0.75 mm<sup>2</sup> to 2.5 mm<sup>2</sup>, Structure A stranding is recommended for all new programs.

**Note 3:** Possible structure for a smooth body, compressed conductor. The strand diameter specified is for non-compressed conductors. No strand diameter is specified for compressed conductors. Compressed conductor must be authorized and approved by GM.

**Note 4:** NA = Not Applicable.

**Table 4: Dimensions** <sup>Note 1</sup>

| ISO Conductor           |               | Thin Wall             |       |                           |      | Thick Wall            |       |                           |      |
|-------------------------|---------------|-----------------------|-------|---------------------------|------|-----------------------|-------|---------------------------|------|
| Size (mm <sup>2</sup> ) | Diameter (mm) | Outside Diameter (mm) |       | Insulation Thickness (mm) |      | Outside Diameter (mm) |       | Insulation Thickness (mm) |      |
|                         | max           | min                   | max   | nom                       | min  | min                   | max   | nom                       | min  |
| 0.75                    | 1.30          | 1.70                  | 1.90  | 0.30                      | 0.24 | 2.20                  | 2.50  | 0.60                      | 0.48 |
| 1.0                     | 1.50          | 1.90                  | 2.10  | 0.30                      | 0.24 | 2.40                  | 2.70  | 0.60                      | 0.48 |
| 1.5                     | 1.80          | 2.20                  | 2.40  | 0.30                      | 0.24 | 2.70                  | 3.00  | 0.60                      | 0.48 |
| 2.0                     | 2.00          | 2.50                  | 2.80  | 0.35                      | 0.28 | 3.00                  | 3.30  | 0.60                      | 0.48 |
| 2.5                     | 2.20          | 2.70                  | 3.00  | 0.35                      | 0.28 | 3.30                  | 3.60  | 0.70                      | 0.56 |
| 3.0                     | 2.40          | 3.10                  | 3.40  | 0.40                      | 0.32 | 3.80                  | 4.10  | 0.70                      | 0.56 |
| 4.0                     | 2.80          | 3.40                  | 3.70  | 0.40                      | 0.32 | 4.00                  | 4.40  | 0.80                      | 0.64 |
| 5.0                     | 3.10          | 3.90                  | 4.20  | 0.40                      | 0.32 | 4.50                  | 4.90  | 0.80                      | 0.64 |
| 6.0                     | 3.40          | 4.00                  | 4.30  | 0.40                      | 0.32 | 4.60                  | 5.00  | 0.80                      | 0.64 |
| 8.0                     | 4.30          | 4.60                  | 5.00  | 0.40                      | 0.32 | 5.00                  | 5.90  | 0.80                      | 0.64 |
| 10.0                    | 4.50          | 5.30                  | 6.00  | 0.60                      | 0.48 | 5.90                  | 6.50  | 1.00                      | 0.80 |
| 12.0                    | 5.40          | 5.80                  | 6.50  | 0.60                      | 0.48 | 6.60                  | 7.40  | 1.00                      | 0.80 |
| 16.0                    | 6.30          | 6.40                  | 7.20  | 0.65                      | 0.52 | 7.70                  | 8.30  | 1.00                      | 0.80 |
| 20.0                    | 6.90          | 7.00                  | 7.80  | 0.65                      | 0.52 | 8.10                  | 9.10  | 1.10                      | 0.88 |
| 25.0                    | 7.80          | 7.90                  | 8.70  | 0.65                      | 0.52 | 9.40                  | 10.40 | 1.30                      | 1.04 |
| 30.0                    | 8.30          | 8.70                  | 9.60  | 0.80                      | 0.64 | 9.70                  | 10.90 | 1.30                      | 1.04 |
| 35.0                    | 9.00          | 9.40                  | 10.40 | 0.80                      | 0.64 | 9.60                  | 11.60 | 1.30                      | 1.04 |
| 40.0                    | 9.60          | 10.0                  | 11.10 | 0.90                      | 0.71 | 11.20                 | 12.40 | 1.40                      | 1.12 |