AEROSPACE STANDARD

AS29606

Issued 2014-06

Wire, Electrical, Stranded, Uninsulated Copper, Copper Alloy, or Aluminum, or Thermocouple Extension, General Specification For

RATIONALE

SAE version of MIL-DTL-29606, which includes enhancements for quality assurance provisions and establishes qualification requirements for the coated copper and copper-alloy conductors furnished under the specification.

1. SCOPE

This specification covers concentric lay stranded and rope-lay stranded round electrical conductor fabricated from copper, copper alloy or aluminum. This specification also covers thermocouple extension conductor fabricated from nickel/chromium or nickel/aluminum/manganese. The conductors in this specification are suitable for use in insulated wires used in aerospace and other applications.

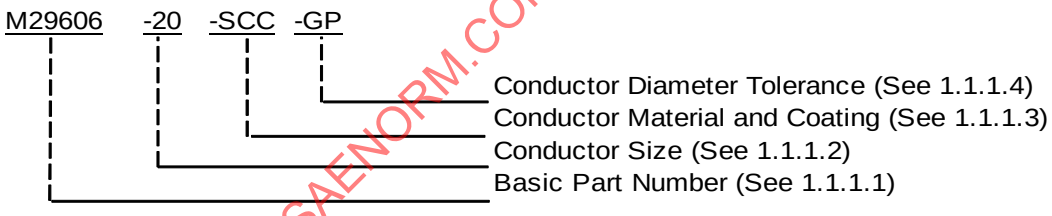
1.1 Classification

Stranded conductors are classified herein. The classifications are as follows:

Conductor Material
Conductor Coating
Conductor Stranding
Conductor Dimensions

1.1.1 Part or Identifying Number (PIN)

PINS to be used for the wire acquired to this specification are created as in the following example:



The above conductor is a size 20 conductor of silver coated annealed copper conductor with general purpose diameter control.

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
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http://www.sae.org/technical/standards/AS29606

1.1.1.1 Basic Part Number

The conductor part number consists of the letter “M,” the basic number of the applicable specification and the applicable alpha-numeric characters formulated in the example (see 1.1.1).

1.1.1.2 Conductor Size

A one- or two-digit designator from Table 4 is used to designate the conductor size.

1.1.1.3 Conductor Material and Coating Designator

An alphabetic designator from Table 3 is used to designate the conductor material and conductor coating.

1.1.1.4 Conductor Diameter Tolerance

The conductor diameter dimensional tolerance is designated as follows:

GP - General Purpose (see Table 4)
SD - Small Diameter (see Table 4)

NOTE: The GP conductors are inactive for new design for copper and copper alloy conductors. All conductors without a distinct diameter tolerance (GP or SD) are designated as general purpose (GP) diameter tolerance conductors.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 U.S. Government Publications

Available from DLA Document Services, Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6396, http://quicksearch.dla.mil/.

2.1.1.1 Federal Standard

FED-STD-228 Cable and Wire, Insulated; Methods of Testing

2.1.1.2 Department of Defense Standards

MIL-STD-202 Electronic and Electrical Component Parts

MIL-STD-2223 Test Methods for Insulated Electric Wire

SD-6 Provisions for Governing Qualification

2.1.1.3 Department of Defense Specifications

MIL-C-3993 Copper and Copper-Base Alloy Mill Products; Packaging of

2.1.2 Non-Government Publications

2.1.2.1 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.

AIR4487 Investigation of Silver Plated Conductor Corrosion (Red Plague)

ARP6400 Recommended Practice for Processing and Handling Wire and Cable with Silver Plated Conductors and Shields

AS9100 Quality Management Systems - Requirements for Aviation, Space and Defense Organizations

2.1.2.2 ASQ Publications

Available from American Society for Quality, 600 North Plankinton Avenue, Milwaukee, WI 53203, Tel: 800-248-1946 (United States or Canada)), 001-800-514-1564 (Mexico) or +1-414-272-8575 (all other locations), www.asq.org.

ASQ Z1.4 Sampling Procedures and Tables for Inspection by Attributes

2.1.2.3 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 B230/B230M Aluminum 1350 - H19 Wire for Electrical Purposes (DoD adopted)

ASTM B263 Determination of Cross-Sectional Area of Stranded Conductors (DoD adopted)

ASTM B286 Copper Conductors for Use In Hookup Wire for Electronic Equipment (DoD adopted)

ASTM B298 Wire, Copper, Silver-Coated Soft or Annealed (DoD adopted)

ASTM B355 Nickel-Coated Soft or Annealed Copper Wire (DoD adopted)

ASTM B624 Wire Copper Alloy, High Strength, High Conductivity, for Electronic Application (DoD adopted)

ASTM B961 Standard Specification for Silver Coated Copper and Copper Alloy Stranded Conductors for Electronic Space Application

ASTM B965 Standard Specification for High Performance Tin-Coated Annealed Copper Wire Intended for Electrical and Electronic Application for Solderability

ASTM E230/E203M Standard Specification and Temperature – Electromotive Force (EMF) Tables for Standardized Thermocouples

2.1.2.4 TechAmerica Publications

Available from TechAmerica, 1001 19th St. North, 20th Floor, Arlington, VA 22209, Tel: 202-682-9110, www.techamerica.org.

EIA-557 Statistical Process Control Systems (DoD adopted)

2.1.2.5 NCSL Publications

Available from NCSL International, 2995 Wilderness Place, Suite 107, Boulder, CO 80301, Tel: 303-440-3339, www.ncsli.org.

NCSL-Z540 Laboratories, Calibration, and Measuring and Test Equipment. (DoD adopted)

2.1.2.6 IPC Publications

Available from IPC 3000 Lakeside Drive, Suite 309S, Bannockburn, Illinois 60015-1249, Tel 847-615-7100, www.ipc.org

IPC/JEDEC J-STD-002 Solderability Tests for Component Leads, Terminations, Lugs, Terminals and Wires

2.2 Definitions

2.2.1 CONCENTRIC LAY

Concentric lay is defined as a central strand surrounded by one or more layers of helically wound strands.

2.2.2 LOT

All the stranded conductors of one part number made under the same essential conditions, produced on a substantially continuous basis, and offered for inspection at one time are considered a lot for purposes of sampling.

2.2.3 SAMPLE

The sample is the group of sample units selected from the lot for the purpose of inspection.

2.2.4 SAMPLE UNIT

The sample unit consists of a single piece of finished conductor of sufficient length to permit all applicable examinations and tests. Not more than one sample unit for each group of tests should be taken from a single unit of product.

2.2.5 UNIT OF PRODUCT

A unit is one continuous length of conductor.

2.2.6 QUALIFICATION INSPECTION

Qualification inspection is a process that demonstrates that a component is capable of fully conforming to all the requirements defined in a standard. Qualification inspection includes definition of the measurements, tests, analysis, and associated data which provides consistent rationale for acceptance of a particular supplier's design as meeting the standard requirements typically prior to acquisition by the Purchaser.

2.2.7 QUALIFIED PRODUCTS LIST

A Qualified Products List is a list of suppliers whose products have been evaluated to a defined standard using a defined process and who are authorized to provide those products to a purchaser upon request. When a Qualified Products List is specified only approved suppliers are authorized to provide products under the part number defined in the component standard. A Qualified Products List is established and maintained by a Qualifying Activity.

2.2.8 QUALIFYING ACTIVITY

A Qualifying Activity is a function established by an SAE specification that has a defined process used to consistently evaluate all suppliers products in accordance with the component standard.

2.2.9 QUALITY CONFORMANCE INSPECTION

Quality Conformance Inspection is a process which includes measurements, non-destructive test, analysis, and associated data that will provide verification that a particular individual component continually conforms to the requirements defined in the standard.

2.2.10 QUALIFICATION BY SIMILARITY

An alternate Qualification Inspection process accomplished without completing all of the measurements, test, and analysis requirements defined in the standard. Acceptance and the extent of similarity, is determined by the Qualifying activity. Similarity is established through a rationale that certain designs, materials, and/or processes are identical to those already approved through qualification of the components. Verification testing for the new product is not required or reduced for designs, materials, and/or processes already approved.

2.2.11 PURCHASER

A purchaser is an activity that can issue a purchase order or contract.

2.2.12 SUPPLIER

A supplier is an original component manufacturer or a value added component manufacturer (i.e. distributer, assembly plant, etc.) which has design and production control of the processes used to produce the final component in accordance with the standard.

2.2.13 QPL SOURCE

In order to be considered for listing on a Qualified Products List (QPL), a supplier has to comply with the conditions listed below.

1. The potential source has to have control of the engineering drawings for manufacturing the products.

2. The potential source has to do final inspection and shipping from the location to be listed on the QPL.

3. The potential source had to be responsible for all the initial and periodic qualification requirements identified in the specification.

3. REQUIREMENTS

3.1 Qualification (see 4.4)

The coated copper and copper-alloy conductors furnished under this specification shall be products, which are authorized by the qualifying activity for listing on the applicable qualified products list at the time set for opening of contract bids (see 4.1 and 7.5.6) or purchase orders. Qualification requirements are in accordance with 4.4 herein.

3.1.1 Conformity to Qualified Sample

It is understood that conductors supplied under contract shall be the same material formulations, material sources, and manufacturing processes as approved by the qualifying activity. Any unapproved changes made after the qualification approval date, unless accepted by the qualifying activity, may constitute cause for rejection.

3.2 Detail Specification

The individual item requirements shall be as specified herein and in accordance with the ASTM document when applicable. In the event of any conflict between requirements of this specification and the ASTM standards (see 2.1.2), this specification shall govern.

3.3 Conductor Strand Material

All strands used in conductors specified herein shall conform to the applicable ASTM standards for the proper material listed in Table 3. After stranding conductor, strands shall be free from lumps, kinks, splits, scraped or corroded surfaces, and skin impurities. In addition, the strands shall conform to the following requirements as applicable.

3.3.1 Tin Coated Copper Strands (Type TCC)

Tin coating shall be in accordance with ASTM B965, except steam conditioning is not required for solderability testing.

3.3.2 Silver Coated Copper Strands

3.3.2.1 Type SCC

The strands shall have a coating thickness of not less than 40 micro-inches of silver when measured in accordance with ASTM B298.

3.3.2.2 Type SCC1

The strands shall have a coating thickness of not less than 80 micro-inches of silver when measured in accordance with ASTM B298. After stranding, the coating thickness on each of the individual conductor strands shall nowhere be less than 40 micro-inches of silver when inspected using micro-section analysis in accordance with ASTM B961.

3.3.3 Nickel Coated Copper Strands (Type NCC)

The strands shall have a coating thickness of not less than 50 micro-inches of nickel when measured in accordance with ASTM B355.

3.3.4 Heavy Nickel Coated Copper Strands (Type NHC)

The copper strands shall have a coating thickness of not less than 27% by weight of nickel when measured in accordance with ASTM B355.

3.3.5 Silver Coated Copper Alloy Strands

3.3.5.1 Type SCA

The copper alloy strand base material shall conform to ASTM B624. The strands shall have a coating thickness of not less than 40 micro-inches of silver when measured in accordance with ASTM B298.

3.3.5.2 Type SCA1

The copper alloy strand base material shall conform to ASTM B624. The strands shall have a coating thickness of not less than 80 micro-inches of silver when measured in accordance with ASTM B298. After stranding, the coating thickness on each of the individual conductor strands shall nowhere be less than 40 micro-inches of silver when inspected using micro-section analysis in accordance with ASTM B961.

3.3.6 Nickel Coated Copper Alloy Strands (Type NCA)

The copper alloy strand base material shall conform to ASTM B624. The strands shall have a coating thickness of not less than 50 micro-inches of nickel when measured in accordance with ASTM B355.

3.3.7 Heavy Nickel Coated Copper Alloy Strands (Type NHA)

The copper alloy strand base material shall conform to ASTM B624. The copper strands shall have a coating thickness of not less than 27% by weight of nickel when measured in accordance with ASTM B355.

3.3.8 Silver Coated Ultra-High Strength Copper Alloy Strands (Type SCU)

The ultra-high strength copper alloy strands shall be made of a copper alloy material capable of meeting all requirements herein. The strands shall have a coating thickness of not less than 40 micro-inches of silver when measured in accordance with ASTM B298.

3.3.9 Nickel Coated Ultra-High Strength Copper Alloy Strands (Type NCU)

The ultra-high strength copper alloy strands shall be made of a copper alloy material capable of meeting all requirements herein. The strands shall have a coating thickness of not less than 50 micro-inches of nickel when measured in accordance with ASTM B355.

3.3.10 Aluminum Strands (Type ALU)

The aluminum strand material shall conform to ASTM B230/B230M.

3.3.11 Type K Thermocouple Extension Conductor (Type KPH, KPS, KNH, and KNS)

Type KPH and KPS strands shall be made from an alloy of 90% nickel - 10% chromium. Type KNH and KNS strands shall be made from an alloy of 95% nickel - 2% aluminum - 2% manganese - 1% silicon and minor traces of other materials and shall conform to ASTM E230/230M.

3.3.12 Silver Coated Extra-High Strength Copper Alloy Strands (Type SCS)

The extra-high strength copper alloy strands shall be made of a copper alloy material capable of meeting all requirements herein. The strands shall have a coating thickness of not less than 40 micro-inches of silver when measured in accordance with ASTM B298.

3.3.13 Silver Coated Extra-High Strength Copper Alloy Strands (Type SCS1)

The extra-high strength copper alloy strands shall be made of a copper alloy material capable of meeting all requirements herein. The strands shall have a coating thickness of not less than 80 micro-inches of silver when measured in accordance with ASTM B298. After stranding, the coating thickness on each of the individual conductor strands shall nowhere be less than 40 micro-inches of silver when inspected using micro-section analysis in accordance with ASTM B961.

3.3.14 Nickel Coated Extra-High Strength Copper Alloy Strands (Type NCS)

The extra-high strength copper alloy strands shall be made of a copper alloy material capable of meeting all requirements herein. The strands shall have a coating thickness of not less than 50 micro-inches of nickel when measured in accordance with ASTM B355.

3.3.15 Heavy Nickel Coated Extra-High Strength Copper Alloy Strands (Type NHS)

The extra-high strength copper alloy strands shall be made of a copper alloy material capable of meeting all requirements herein. The copper strands shall have a coating thickness of not less than 27% by weight of nickel when measured in accordance with ASTM B355.

3.4 Conductor Stranding

Conductor stranding shall be in accordance with Tables 4A through 4G. No metallic coatings or platings are permitted over the stranded conductor after stranding.

3.4.1 Concentric Stranding

The conductors with 7, 19, or 37 strands shall be concentric-lay stranded as specified in Table 4A through 4G. The direction of lay shall be alternately reversed (true concentric lay) or in the same direction (unidirectional lay). The strands shall be assembled in a geometric arrangement of concentric layers, producing a smooth and uniform conductor, circular in cross-section and free of any crossovers of adjacent strands, high strands, or other irregularities. The direction of lay of the individual strands in the outer layer of the concentrically stranded conductors of the finished wire shall be left hand. The lay length of the outer layer shall be 8 to 16 times the maximum conductor diameter as specified in Table 4.

3.4.2 Rope-Lay Stranding

The conductors with more than 37 strands shall be rope-lay stranded as specified in Table 4A, 4B, and 4D. Rope-lay stranded conductors shall be laid up concentrically with a central member surrounded by one or more layers of helically wound members. The direction of lay of successive layers shall be alternately reversed (true concentric lay), or in the same direction (unidirectional lay). The length of the lay of the outer layer of rope-lay stranded conductor shall be 8 to 14 times the outside diameter of the completed conductor. The direction of lay of the outside layer shall be either left or right hand.

3.4.2.1 Rope-Lay Members

The individual members of the rope-lay stranded conductors may be either bunched or concentric stranded. The length of lay of the stranded members shall not be greater than 16 times the outside diameter of the member.

3.5 Splices

For conductor types TCC, SCC, SCC1, NCC, NHC, SCA, SCA1, NCA, NHA, SCS, SCS1, NCS, NHS, SCU, and NCU, splices in individual strands or members shall be butt brazed, or a similar process shall be used that does not damage the outer coating integrity. There shall not be more than one strand splice in any two lay lengths of a stranded concentric-lay conductor or in any two lay lengths of any member in a rope-lay conductor, except that not more than one splice of the entire member shall be permitted in any two lay lengths of rope-lay conductor. Splices in members of a rope-lay construction shall be finished such that the conductor diameter is not increased at the point of joining. In no case shall the whole conductor be spliced at any one point.

For conductor type ALU, splices in individual strands shall not be closer than two lay lengths of any member. Splices in members of rope-lay constructions shall not be closer than 10 feet. In no case shall the whole conductor be spliced at any one point.

For conductor types KPH, KPS, KNH, and KNS, splices in individual strands or groups of individual strands shall be butt brazed with silver solder. Splices shall be so constructed and disposed throughout the conductor that the diameter, configuration, conductor resistance, flexibility, and mechanical strength of the completed conductor are not adversely affected.

3.6 Properties of Individual Strands before Stranding

The individual strands must comply with the ASTM requirements, when applicable (see Table 3), and the plating thickness requirements for the specific conductor.

3.7 Properties of Stranded Conductors

3.7.1 Conductor Diameter

The diameter of the conductor shall be as specified in Table 4A through 4G. Applicability of the “general purpose” or of the “small diameter” Table 4 requirements for the maximum conductor diameter shall be as indicated by the part number. All measurements shall fall within the specified range. The diameter shall be measured in accordance with 5.2. All conductors without a distinct diameter tolerance (GP or SD) shall be designated as general purpose (GP) diameter tolerance conductors (see 1.1.1).

3.7.2 Solderability

The stranded conductor shall have a minimum coverage of 95% when examined after testing to the method specified in 5.3. Solderability requirements are not applicable to aluminum, thermocouple extension, or nickel coated conductors.

3.7.3 Elongation

The elongation of the entire conductor shall be measured on all sizes of copper alloy and on size 22 and smaller annealed copper. Elongation measurements on single strands removed from the stranded constructions shall be measured on larger sizes of annealed copper and all sizes of aluminum. The minimum elongation shall be not less than the values in Tables 4A through 4E and 4G as measured in accordance with 5.4. Elongation requirements are not applicable to thermocouple extension conductors.

3.7.4 Tensile Strength

The break strength of all copper alloy conductors shall be measured. The minimum break strength shall not be less than the values in Table 4C, 4E, and 4G. Tensile strength values of aluminum conductors shall be as specified in Table 4B. There are no requirements for tensile strength on the annealed copper conductors and thermocouple extension conductors. The tensile strength or break strength shall be measured in accordance with 5.4.

3.7.5 Conductor Resistance

The DC resistance of the conductor shall be not greater than the values in Table 4A through 4G as measured in accordance with 5.5. In addition, for thermocouple extension conductors only, the DC resistance of the conductor shall be greater than the minimum values in Table 4F as measured in accordance with 5.5.

3.7.5.1 Electromotive Force (Thermocouple Extension Conductor Only)

The temperature-electromotive force relationship of the type K positive and negative legs formed together as a thermocouple shall conform to requirements of ASTM E230/230M for type K compositions when measured in accordance with 5.5.1.

3.7.6 Continuity of Coating

For all coated conductors, the coating on the strands shall be continuous in accordance with the workmanship requirements of ASTM B286 and when tested in accordance with 5.6 herein. The specimen is considered to have failed if exposed base metal is revealed due to the stranding operation or as a pre-existing condition prior to stranding. No exposed base metal shall be identified during magnification-aided visual inspection of the stranded conductor.

3.7.7 Cross-Sectional Area

The minimum cross-sectional area of the stranded conductor shall conform to Table 4A through 4G requirements, as measured in accordance with 5.7.

3.7.8 Conductor Strand Adhesion

For conductor types SCA, SCA1, NCA, SCS, SCS1, NCS, SCU, and NCU, the conductor shall be tested for strand adhesion in accordance with 5.8. When 19-wire conductors are examined, the total number of un-bonded single strands plus the number of metallic bonded pairs and metallic bonded groups of strands in the specimen shall not be less than 13. For all other conductors, (7 strands, etc.), the total count of unbonded single strands, metallic bonded pairs of strands, and metallic bonded groups of strands shall not be less than 0.70 times the number of strands in the conductor.

NOTE: Adherence occurs between individual strands of conductors that are heat treated after the stranding process. The requirements (3.7.8) and test method (5.8) can be applied to other conductor types if processed in this manner.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspections

Unless otherwise specified herein, the contract or purchase order, the supplier is responsible for the performance of all contract inspection requirements. Except as otherwise specified herein, the contract or purchase order, the supplier may use any facilities suitable for the performance of the inspection requirements. The Qualifying Activity has the right to perform any of the inspections set forth in the standard where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for Compliance

All items must meet all technical requirements of the product standard. The inspection set forth in this standard shall become a part of the supplier's overall inspection system or quality program. The absence of any inspection requirements in the standard shall not relieve the supplier of the responsibility of assuring that all products comply with all requirements of the contract or purchase order. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, nor does it commit the purchaser to acceptance of defective material.

4.1.2 Test Equipment and Inspection Facilities

Test and measuring equipment and inspection facilities of sufficient accuracy, quality and quantity to permit performance of the required inspection shall be established and maintained by the supplier. The establishment and maintenance of a calibration system to control the accuracy of the measuring and test equipment shall be in accordance with ANSI/NCSL Z540-1 or equivalent standards.

4.1.3 Quality Assurance Compliance

The supplier's reliability assurance program for conductors and manufacturing procedures shall comply with the AS9100 Aerospace standard for Quality Management System requirements. Other established and industry recognized quality assurance standards that assure all products produced conform to the contract requirements are acceptable. However, if used, it is the responsibility of the supplier to provide evidence of compliance to AS9100. The Qualifying Activity (QA) authority reserves the right to monitor, measure, and validate compliance at their discretion.

4.2 Classification of Inspections

a. Strand Inspection (see 4.3)

b. Qualification Inspections (see 4.4)

c. Quality Conformance Inspections (see 4.5)

4.2.1 Inspection Conditions

Unless otherwise specified herein, all inspections shall be performed in accordance with the test conditions specified in the general requirements of FED-STD-228.

TABLE 1A - QUALITY CONFORMANCE INSPECTIONS

Inspection Test	Requirement	Test Method
Conductor Strand Material 1/	3.3 & 3.6	5.1
Conductor Stranding	3.4	5.1
Conductor Splices	3.5	5.1
Conductor Diameter	3.7.1	5.2
Solderability 2/	3.7.2	5.3
Elongation	3.7.3	5.4
Tensile Strength	3.7.4	5.4
Conductor Resistance	3.7.5	5.5
Electromotive Force 3/	3.7.5.1	5.5.1
Coating Workmanship Examination	3.7.6	5.6
Cross-Sectional Area	3.7.7	5.7
Conductor Strand Adhesion	3.7.8	5.8

1/ Coating Thickess test (see 5.1.1.1) is prior to stranding. See 4.3.

2/ For silver coated conductors, only initial and qualification inspection is required. Quality conformance inspection is not required.

3/ Thermocouple extension conductors only.

TABLE 1B - INITIAL AND RETENTION OF QUALIFICATION INSPECTIONS

Inspection Test 1/	Requirement	Test Method
Conductor Strand Material 2/	3.3 & 3.6	5.1
Conductor Stranding	3.4	5.1
Conductor Splices	3.5	5.1
Conductor Diameter	3.7.1	5.2
Solderability	3.7.2	5.3
Elongation	3.7.3	5.4
Tensile Strength	3.7.4	5.4
Conductor Resistance	3.7.5	5.5
Coating Workmanship Examination	3.7.6	5.6
Cross-Sectional Area	3.7.7	5.7
Conductor Strand Adhesion	3.7.8	5.8

1/ Qualification test shall only be performed by the qualifying activity unless otherwise specified (see 5.1).

2/ Coating Thickess test (see 5.1.1.1) is prior to stranding. See 4.3.

4.3 Strand Inspection

When required by the procuring or qualifying activity, strand inspection shall consist of certification to the ASTM standard when applicable (see Table 3), verification of coating thickness (if applicable), and any additional inspections required to ensure the strands meet the requirements of the individual strand specification (if applicable).

4.3.1 Statistical Process Control

An SPC program shall be established and maintained in accordance with EIA-557 to monitor the silver coating electroplating process for process control conditions. When required by the procuring activity, evidence of SPC methodologies in use and traceable to the completed conductor shall be provided for review.

4.4 Qualification Inspections

Qualification inspection shall be in accordance with Table 1B. Qualification inspections include the initial qualification inspection (4.4.1) and inspection for retention of qualification (4.4.2). Qualification test shall only be performed by the qualifying activity unless otherwise specified (see 5.1).

4.4.1 Initial Qualification Inspection

Initial qualification inspection shall consist of all the test and examinations of this specification except the examination of packaging. The samples shall be from current production and shall be inspected by the qualifying activity in accordance with Table 1B. Sequential testing is not required except as specified by a test method.

4.4.1.1 Sampling for Initial Qualification

A finished conductor length shall be obtained from the continuous length qualification lot. Except as provided under qualification by similarity, a finished wire sample of approximately 40 feet shall be selected for each sample for which qualification is desired.

4.4.1.2 Samples for Initial Qualification by Similarity

Qualification by similarity is applicable where a group of two or more conductors are identical in materials and construction. In such event, the qualification applicant may select the sample from any size range or ranges in the similarity group listed in Table 2. Approval of the qualification sample shall also qualify any size range or ranges listed in the sample similarity group as the qualifying sample. Also, where a requirement is more rigorous for a conductor being qualified by similarity than for the conductor undergoing complete test, the sample undergoing complete test must meet the more rigorous requirement of the similar conductor in order to qualify the similar conductor. Similarity groups not defined in Table 2 shall be coordinated with the qualifying activity prior to testing.

TABLE 2 - CONDUCTOR QUALIFICATION SIMILARITY GROUPS

Group	Material/coating	Construction
1	Annealed copper/Silver	7 wires
2	Annealed copper/Silver	19 wires
3	Annealed copper/Silver	37 wires
4	Annealed copper/Silver	133 wires
5	Annealed copper/Silver	Over 133 wires
6	Annealed copper/Tin	7 wires
7	Annealed copper/Tin	19 wires
8	Annealed copper/Tin	37 wires
9	Annealed copper/Tin	133 wires
10	Annealed copper/Tin	Over 133 wires
11	Annealed copper/Nickel	7 wires
12	Annealed copper/Nickel	19 wires
13	Annealed copper/Nickel	37 wires
14	Annealed copper/Nickel	133 wires
15	Annealed copper/Nickel	Over 133 wires
16	High strength copper-alloy/Silver	7 wires
17	High strength copper-alloy/Silver	19 wires
18	High strength copper-alloy/Nickel	7 wires
19	High strength copper-alloy/Nickel	19 wires
20	Extra-high strength copper-alloy/Silver	7 wires
21	Extra-high strength copper-alloy/Silver	19 wires
22	Extra-high strength copper-alloy/Nickel	7 wires
23	Extra-high strength copper-alloy/Nickel	19 wires
24	Ultra-high strength copper-alloy/Silver	19 wires
25	Ultra-high strength copper-alloy/Nickel	19 wires

4.4.1.3 Submission of Qualification Samples

A duplicate group of qualification samples shall be taken from the same lot or lots as tested by the supplier and submitted to the qualifying activity for qualification inspection. The samples shall be plainly identified by securely attached durable tags marked with the information listed below. The tags must be stamped by the supplier's and/or qualifying activity designated Quality Assurance Representative (QAR) inspector as representative samples of the manufacturer's normal production capability. Samples submitted without the stamp will not be accepted.

a. Sample for Qualification test: WIRE, ELECTRIAL, STRANDED, UNINSULATED COPPER, COPPER ALLOY, OR ALUMINUM, OR THERMOCOUPLE EXTENSION, GENERAL SPECIFICATION FOR

b. Detail specification part number

c. Manufacturer's identification (manufacturer's name and/or CAGE code)

d. Manufacturer's part number

e. Place and date of manufacture of sample

f. Submission information: Submitted by (name) (date) for qualification tests in accordance with the requirements of AS29606 under authorization (reference authorizing letter).

g. Material composition: When specifically requested, a comprehensive description and prime manufacturer's name and formulation number of the base materials from which the product is made shall be provided (this information will not be divulged by the qualifying activity)

4.4.2 Retention of Qualification

Inspections of product for retention of qualification shall be made at three year intervals after the supplier's initial acceptance date for qualification approval. The qualifying activity may establish a different retention of qualification due date to accommodate testing schedules, but no later than 18 months from the retention of qualification due date. Failure of the supplier to submit retention of qualification samples or certification within 30 days after the end of the three-year reporting period may result in the removal of the product or products from the qualified products list (QPL).

4.4.2.1 Retention of Qualification Test and Samples

One conductor size from each initial qualification approved similarity group listed in Table 2 shall be tested, unless otherwise specified by the qualifying activity. The samples shall be from current production and shall be inspected by the qualifying activity in accordance with Table 1B.

4.4.2.2 Procedure for Retention of Qualification Inspection

It is the supplier's responsibility to submit retention qualification samples at the required interval established by the qualifying activity. Unless otherwise notified by the qualifying activity, the samples shall be provided in same format as provided for initial qualification. The qualifying activity will provide an authorization notice to begin the retention of qualification submittal.

4.4.2.3 Effect of Failure in Retention of Qualification Inspection

If a failure occurs in the test for retention of qualification, no conductor represented by the sample, nor any other conductor manufactured with the same materials and processes, which has not already been submitted for quality conformance inspection, shall be offered for acceptance until the cause for failure has been determined and concurred with by the qualifying activity as not affecting the ability of the wire to meet qualification inspection requirements.

4.4.2.4 Retention of Qualification by Certification

If there has been no production since the last retention of qualification interval, retention of qualification shall consist of a completed DD Form 1718, "Certification of Qualified Products". The form shall be submitted to the qualifying activity by the periodic qualification due date. When production resumes following a certification submission, the manufacturer shall obtain retention of qualification samples from the production lot and submit in accordance with the retention of qualification requirements.

4.5 Quality Conformance Inspection

Quality conformance inspection shall be in accordance with Table 1A. Inspection shall be performed on every lot of conductors purchased in accordance with this specification.

4.5.1 Sampling for Visual and Dimensional Inspection

From each lot (see 7.5.2), sample units (see 7.5.4) shall be selected at random in accordance with ASQ Z1.4. The inspection level shall be S-2 unless otherwise specified in the ordering data (see 7.2). No allowance will be made for defects.

4.5.2 Sampling for Conformance Inspection

From each lot, sample units shall be selected at random in accordance with ASQ Z1.4. The inspection level shall be S-2 unless otherwise specified in the ordering data (see 7.2).

4.5.3 Inspection of Packaging

The sampling and inspection of the preservation, packaging, and container marking shall be in accordance with the requirements of MIL-C-3993.

5. TEST METHODS

5.1 Process Control Inspection Test Methods

This inspection comprises tests and examinations that are impractical to perform on the finished conductor or any other requirements not covered by a specified test method. Process control inspection is, therefore, conducted at the most appropriate stage of the manufacturing operations.

5.1.1 Conductor Strand Material

Test data or control processes used to demonstrate compliance to the conductor strand material requirements shall be provided to the qualifying activity or purchaser upon request. Certification data from the manufacturer may be used by the qualifying activity as an alternative to performing the tests.

5.1.1.1 Coating Thickness

Coating thickness of nickel and silver coated strands shall be measured in accordance with the ASTM B355 and ASTM B298 test procedures respectively. Certification data from the manufacturer may be used by the qualifying activity as an alternative to performing the tests.

5.1.1.2 Coating Thickness of Material Types SCC1, SCA1, and SCS1

For silver coated material types SCC1, SCA1, and SCS1, micro-section inspection samples shall be prepared in accordance with ASTM B961. Micro-section inspections shall be in accordance with ASTM B961, except that the coating thicknesses specified herein shall be in effect (see 3.3.2.2, 3.3.5.2, and 3.3.13). When required by the procuring activity, photographs shall be captured and saved as proof of inspection. The magnification scale of photographs shall be identified.

5.1.2 Conductor Stranding

Test data or control processes used to demonstrate compliance to the conductor stranding requirements shall be provided to the qualifying activity or purchaser upon request. Certification data from the manufacturer may be used by the qualifying activity as an alternative to performing the tests.

5.1.3 Conductor Splices

Control processes used to demonstrate compliance to conductor splice requirements shall be provided to the qualifying activity or purchaser upon request.

5.2 Diameter

The diameter shall be measured at three locations along the length of each sample. Each measurement shall be the average of two readings taken 90 degrees apart on the conductor. Micrometers, calipers, or optical measurement devices capable of reading to the nearest 0.0001 inch for sizes 12 and smaller or to the nearest 0.001 inch for sizes 10 and larger shall be used.

5.3 Solderability

Samples shall be tested per MIL-STD-202, Method 208 except as noted below, according to the plating/coating material and base material, as applicable.

5.3.1 Silver Coated Conductor

Exceptions to MIL-STD-202, Method 208:

a. Wrapping wire in accordance with IPC/JEDEC J-STD-002 Test C is not necessary.

b. For qualification inspection, the test shall require steam aging as specified in MIL-STD-202, Method 208. For conformance testing, no steam aging is required.

5.3.2 Tin Coated Conductor

Exceptions to MIL-STD-202, Method 208:

a. Wrapping wire in accordance with IPC/JEDEC J-STD-002 Test C is not necessary.

b. Steam aging shall not be required.

5.3.3 Nickel Coated Conductor

No solderability testing is required for nickel coated conductors.

5.3.4 Aluminum Conductor

No solderability testing is required for aluminum conductors.

5.3.5 Thermocouple Extension Conductor

No solderability testing is required for thermocouple conductors.

5.4 Conductor Elongation, Tensile Strength, and Break Strength

5.4.1 Soft or Annealed Copper

Elongation tests of soft or annealed copper conductors shall be performed in accordance with MIL-STD-2223, Method 5002, except that the elongation at break of the individual strand or of the first strand of the whole conductor, as applicable, shall be determined by means of a recording chart, or other means, on the testing machine rather than by measuring the specimen after the break. For sizes 22 and smaller, the tests shall be performed upon the whole conductor and the elongation measured when the first strand of the conductor breaks. For conductors larger than 22, strands shall be carefully removed from the conductor and tested for elongation. Tensile or break strength measurements are not required for annealed copper conductors.

5.4.2 High Strength, Extra-High Strength, and Ultra-High Strength Copper Alloy

Elongation and tensile strength tests of high strength, extra-high strength, and ultra-high strength copper alloy conductors shall be performed in accordance with MIL-STD-2223, Method 5002, except that the grip separation speed shall be 2 inches per minute. The tensile strength (reported as the tensile breaking strength of the conductor rather than in pounds per square inch) and elongation shall be determined by the means of a recording chart, or other means, on the testing machine. Tests shall be performed upon the whole conductor and the break strength and elongation measured when the first strand of the conductor breaks.

5.4.3 Aluminum Conductors

Elongation and tensile strength tests of aluminum conductors shall be performed in accordance with MIL-STD-2223, Method 5002. A sample of single strands shall be carefully removed from the conductor and tested for tensile strength and elongation.

5.5 Conductor Resistance

The DC resistance of the conductor shall be measured in accordance with MIL-STD-2223, Method 5003.

5.5.1 Electromotive Force (Thermocouple Extension Only)

A thermocouple shall be formed between the positive and negative leg conductors from a sample taken from each coil or reel to be supplied in the contract or purchase order. The electromotive force characteristics of the wire shall be determined at 0 °C, 200 °C, 400 °C, 600 °C, 800 °C, and 1000 °C.

The electromotive force characteristics shall meet the following tolerances:

LIMITS OF ERROR FOR THERMOCOUPLE

Thermocouple Range °C	Standard Limits (Whichever is greater)	Special Limits (Whichever is greater)
0 to 1250 °C	±2.2 °C or ±0.75% x T	±1.1 °C or ±0.4% x T

Where T = Test temperature

5.6 Continuity of Coating

Continuity of coating inspection shall be in accordance with ASTM B286 examination for workmanship of finished un-insulated stranded conductor. Optical magnification employed during inspection shall be at least 10x and up to 20x to referee suspect exposed copper locations. A white background shall be used for the inspection. Inspection for exposed copper shall be performed using stranded conductor material not less than 12 inches in length. The outer surface of all stranded conductors shall be examined. For stranded conductors of more than one layer (i.e., 19 and 37 strand, etc.), it is necessary to open up the conductor and perform the optical examination on each inner layer. For rope constructions, two members from each layer of the conductor shall be examined. Detection of excessive exposed base metal due to the stranding process such as indications along one side of the sample due to excessive localized abrasion during stranding constitutes rejection. Continuous lines or patterns of exposed base metal constitute rejection.

5.7 Cross Sectional Area

The stranded conductor shall be tested according to ASTM B263. Use K-values given in Tables 4A through 4G. If no K-value is given, then use K=0.

5.8 Conductor Strand Adhesion

The conductor strand adhesion shall be tested in accordance with MIL-STD 2223 (Method 5005).

6. PACKAGING

The conductor shall be delivered on spools or reels in a regular and uniform manner. Packaging material(s) shall be sufficient to provide appropriate protection during shipment and not affect the material delivered. Special packaging requirements shall be agreed upon between the manufacturer and purchaser.

7. NOTES

7.1 Intended Use

These conductors are used primarily in insulated wires for aerospace, electrical, electronic and other high performance applications.

7.1.1 Metric Cross-Reference Tables

Soft metric conversions provided in Tables 5A, 5B, 5C, 5D, 5E, 5F, and 5G provides a cross reference for corresponding titled Tables 4A, 4B, 4C, 4D, 4E, 4F, and 4G for information.

7.1.2 Red Plague

Silver plated copper wire is susceptible to red plague; a galvanic corrosion reaction between silver and copper that occurs when the copper substrate (conductor) is exposed to oxygen and moisture. Refer to AIR4487 and ARP6400 for mitigation techniques.

7.2 Acquisition Requirements

Acquisition documents must specify the following:

a. Title, number, and date of this specification.

b. Part number (see 1.1.1).

c. Quantity of conductor required.

d. Inspection conditions and classification of inspection, if other than specified (see 4.2).

e. Additional strand inspection/requirements (see 4.3).

f. If evidence of SPC methodology or photographs are required (see 4.3.1.1 and 4.3.1.2).

g. Inspection level (see 4.5)

h. Packaging requirements (see Section 6)

7.3 Qualification Compliance

With respect to products requiring qualification by the government, awards will be made only for products, which are at the time set for opening of bids, qualified for inclusion in the applicable Qualified Products List (QPL), whether or not such products have actually been so listed by that date. The attention of the contractors (purchasers) is called to these requirements, and manufacturers (suppliers) are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts for the products delineated in this specification. Qualification is required by U.S. Government procurement.

7.3.1 Qualified Products List Evaluating Activity

The QPL Evaluating Activity (qualifying activity), for U.S. Department of Defense procurement purposes, is the Naval Air System Command (Code 4.4.5.3), 48298 Shaw Road, Building 1461, Patuxent River, MD 20670. Application for qualification tests shall be made in accordance with provisions governing qualification in SD-6 (see 2.1).

7.3.2 QPL Publication

The qualifying activity is required to provide a summarized list of all qualified sources on a public accessible electronic site. The summary shall include but is not limited to the supplier approved part number and related specification part number, a dedicated approval reference number, a supplier location where purchases maybe requested and the manufacturing location of the component. The suppliers and products qualified to this specification are available on the qualifying activity website (http://www.navair.navy.mil/qpl/).

7.4 Conductor Cross-Sectional Area

The conductor cross-sectional area is expressed as a Circular Mill Area (CMA) value. One circular mill is equal to the area of a circle with a diameter of 0.001 inch (1 mm). The nominal CMA was determined by calculating the CMA of a single strand and multiplying it by the number of strands in the conductor. The minimum CMAs were determined by different methods depending on the wire size. For sizes 8 and larger, the minimum strand size from the ASTM for the strand was determined and the minimum strand CMA calculated. The minimum strand CMA was multiplied by the number of strands excluding allowable missing strands, to obtain the minimum CMA of the stranded conductor. The values for sizes 10 and smaller were set lower than that required by the ASTM minimum strand size and higher than that required by the maximum conductor resistance requirements. Other factors considered included military specification insulated wire weight and conductor diameter requirements. The K-values needed to calculate the CMAs from the stranded conductor weights were calculated by the Naval Air Warfare Center Aircraft Division, Indianapolis, based on the conductor stranding requirements, including length of lay, in this specification.

7.5 Preparing Activity

The SAE AE Division is the responsible Preparing Activity for all AE-8 Committee specifications. The AE Division has posted on each AE-8 committee work forum the Preparing Activity processes required to be followed by each AE-8 committee. The SAE AE-8 Committee responsible for this specification is listed below. For changes to this specification submit all requests to SAE International Headquarters, 400 Commonwealth Drive, Warrendale, PA 15096-4841 (attn: Standards Division).

PREPARED BY SAE SUBCOMMITTEE AE-8D, WIRE & CABLE OF
COMMITTEE AE-8, AEROSPACE ELECTRICAL/ELECTRONIC DISTRIBUTION SYSTEMS

TABLE 3 - CONDUCTOR STRAND MATERIAL AND COATING

Designator	Strand material	Coating	Application ASTM standard
SCC	Annealed copper	Silver	ASTM B298
SCC1	Annealed copper	Silver	ASTM B298 ASTM B961
SCA	High strength copper alloy 1/	Silver	ASTM B298 ASTM B624
SCA1	High strength copper alloy 1/	Silver	ASTM B298 ASTM B624 ASTM B961
SCS	Extra-high strength copper alloy 2/	Silver	ASTM B298
SCS1	Extra-high strength copper alloy 2/	Silver	ASTM B298 ASTM B961
SCU	Ultra-high strength copper alloy 1/	Silver	ASTM B298 (Coating only)
NCC	Annealed copper	Nickel	ASTM B355
NCA	High strength copper alloy 1/	Nickel	ASTM B355 ASTM B624
NCS	Extra-high strength copper alloy 2/	Nickel	ASTM B355
NCU	Ultra-high strength copper alloy 1/	Nickel	ASTM B355 (Coating only)
NHC	Annealed copper	Nickel (27%)	ASTM B355
NHA	High strength copper alloy 1/	Nickel (27%)	ASTM B355 ASTM B624
NHS	Extra-high strength copper alloy 2/	Nickel (27%)	ASTM B355
TCC	Annealed copper	Tin	ASTM B965
ALU	Aluminum 1350-H19 (extra hard)	None	ASTM B230/230M

TABLE 3 - CONDUCTOR STRAND MATERIAL AND COATING (CONTINUED)

Designator	Strand material	Coating	Application ASTM standard
KPH	Special limits Type K - thermocouple extension nickel/chromium (positive leg)	None	ASTM E230/E230M
KPS	Standard limits Type K - thermocouple extension nickel/chromium (positive leg)	None	ASTM E230/E230M
KNH	Special limits Type K - thermocouple extension nickel/aluminum (negative leg)	None	ASTM E230/E230M
KNS	Standard limits Type K - thermocouple extension nickel/aluminum (negative leg)	None	ASTM E230/E230M

1/ High strength and ultra-high strength copper alloy conductors have a higher conductor resistance (lower conductivity) than annealed copper conductors of the same size.

2/ Extra-high strength copper alloy conductors have a higher conductor resistance (lower conductivity) than annealed copper of the same size, but equal conductor resistance to high strength copper alloy and greater strength than high strength copper alloy.

TABLE 4A - DETAILS OF ANNEALED COPPER CONDUCTORS

Size Designation	Conductor Area (Circular Mils) Nominal 2/ (All)	Conductor Area (Circular Mils) Minimum	K-Value	Stranding (No. of Strands X AWG of Strands)	Allowable No. of Missing Strands (Max)	Nominal Dia. of Individual Strands (inch) 2/	Diameter of Stranded Conductor Min (inch)	Diameter of Stranded Conductor Max (inch) Sm Dia. (SCC/ SCC1)	Diameter of Stranded Conductor Max (inch) Sm Dia. (NCC/ TCC)	Diameter of Stranded Conductor Max (inch) Gen'l Purpose (SCC/ SCC1)	Diameter of Stranded Conductor Max (inch) Gen'l Purpose (NCC/ TCC)	Max Resistance of Conductor (ohms/1000 feet at 20 °C) Silver Coated (SCC/ SCC1)	Max Resistance of Conductor (ohms/1000 feet at 20 °C) Nickel Coated (NCC)	Max Resistance of Conductor (ohms/1000 feet at 20 °C) Tin Coated (TCC)	Elongation (% Min)
30	112	102	0.77	7x38	0	0.0040	0.0105	0.0124	0.0134	0.0124	0.0134	100.7	110.7	108.4	6
28	175	161	1.05	7x36	0	0.0050	0.0135	0.0154	0.0164	0.0154	0.0164	63.8	67.9	68.6	6
26	304	275	1.34	19x38	0	0.0040	0.0175	0.0194	0.0204	0.0204	0.0214	38.4	42.2	41.3	6
24	475	434	1.18	19x36	0	0.0050	0.0225	0.0244	0.0244	0.0254	0.0264	24.3	25.9	26.2	6
22	754	694	1.87	19x34	0	0.0063	0.0285	0.0304	0.0314	0.0324	0.0334	15.1	16.0	16.2	10
20	1216	1127	1.34	19x32	0	0.0080	0.0365	0.0384	0.0394	0.0404	0.0414	9.19	9.77	9.88	10
18	1900	1770	1.34	19x30	0	0.0100	0.0455	0.0484	0.0494	0.0504	0.0514	5.79	6.10	6.23	10
16	2426	2261	1.19	19x29	0	0.0113	0.0515	0.0544	0.0554	0.0574	0.0584	4.52	4.76	4.81	10
14	3831	3570	1.38	19x27	0	0.0142	0.0645	0.0684	0.0694	0.0724	0.0734	2.88	3.00	3.06	10
12 1/	6088	5672	1.67	19x25	0	0.0179	0.0815	0.0854	0.0864	0.0904	0.0924	1.81	1.89	1.92	10
12 1/	5874	5473	1.26	37x28	0	0.0126	0.0835	0.0874	0.0894	0.0894	0.0904	1.90	1.98	2.02	10
10	9354	8716	1.35	37x26	0	0.0159	0.106	0.110	0.112	0.112	0.114	1.19	1.24	1.26	10
8 3/	16 983	16 645	2.29	133x29	0	0.0113	0.158	0.166	0.169	0.169	0.173	0.658	0.694	0.701	10
6 3/	26 818	26 284	2.31	133x27	0	0.0142	0.198	0.208	0.212	0.213	0.217	0.418	0.436	0.445	10
4 3/	42 615	41 767	2.55	133x25	0	0.0179	0.250	0.263	0.268	0.268	0.274	0.264	0.275	0.280	10
2 3/	66 500	64 981	3.21	665x30	2	0.0100	0.320			0.340	0.340	0.170	0.177	0.183	10
1 3/	81 700	79 878	2.89	817x30	2	0.0100	0.360			0.380	0.380	0.139	0.144	0.149	10
01 3/	104 500	102 126	3.24	1045x30	3	0.0100	0.395			0.425	0.425	0.108	0.113	0.116	10
02 3/	133 000	130 059	3.15	1330x30	3	0.0100	0.440			0.475	0.475	0.085	0.089	0.091	10
03 3/	166 500	162 795	3.09	1665x30	4	0.0100	0.500			0.540	0.540	0.068	0.071	0.071	10
04 3/	210 900	206 213	3.32	2109x30	5	0.0100	0.565			0.605	0.605	0.054	0.056	0.056	10

1/ For size 12, 37x28 is the preferred construction. 19x25 is inactive for new design.
2/ Nominal values are for information only. Nominal values are not requirements.
3/ SCC1 conductors are limited to 30 - 10 AWG sizes.

TABLE 4B - DETAILS OF ALUMINUM CONDUCTORS

Size Desig-nation	Conductor Area (Circular mils)		Stranding (No. of Strands X AWG of Strands)	Allowable No. of Missing Strands (Max)	Nominal Dia. of Individual Strands (inch) 1/	Diameter		Max Resistance (ohms per 1000 feet @ 20 °C)	Tensile Min-Max (KPSI)	Elongation Min (%)
	Nominal 1/	Minimum				Min (inch)	Max (inch)			
8	16 564	15 571	41x24	0	0.0201	0.150	0.160	1.093	23 - 35	1
6	28 280	26 891	70x24	0	0.0201	0.201	0.211	0.641	23 - 35	1
4	43 229	41 105	107x24	0	0.0201	0.248	0.262	0.427	23 - 35	1
2	67 874	63 771	168x24	2	0.0201	0.315	0.330	0.268	23 - 35	1
1	88 478	83 363	219x24	2	0.0201	0.353	0.368	0.214	23 - 35	1
01	104 639	98 345	259x24	3	0.0201	0.400	0.418	0.169	23 - 35	1
02	134 939	127 157	334x24	3	0.0201	0.454	0.478	0.133	23 - 35	1
03	172 512	162 500	427x24	4	0.0201	0.511	0.535	0.109	23 - 35	1
04	211 297	198 995	523x24	5	0.0201	0.563	0.587	0.085	23 - 35	1

1/ Nominal values are for information only. Nominal values are not requirements.

TABLE 4C - DETAILS OF HIGH STRENGTH COPPER-ALLOY CONDUCTORS

Size Desig-nation	Conductor Area (Circular Mils)		K-Value	Stranding (No. of Strands X AWG of Strands)	Allowable No. of Missing Strands (Max)	Nominal Dia. of Individual Strands (inch) 1/	Diameter of Stranded Conductor					Max Resistance of Conductor (ohms/1000 feet at 20 °C)		Min Breaking Strength (pounds) (SCA/ SCA1/ NCA)	Elon-gation (% Min)
								Max (inch)							
								Sm Dia.		Gen'l Purpose					
	Nominal 1/ (All)	Minimum					Min (inch)	(SCA/ SCA1)	(NCA)	(SCA/ SCA1)	(NCA)	Silver Coated (SCA/ SCA1)	Nickel Coated (NCA)		
30	112	102	0.77	7x38	0	0.0040	0.0105	0.0124	0.0134	0.0124	0.0134	117.4	129.6	5.2	6
28	175	161	1.05	7x36	0	0.0050	0.0135	0.0154	0.0164	0.0154	0.0164	74.4	79.0	8.2	6
26	304	275	1.34	19x38	0	0.0040	0.0175	0.0204	0.0204	0.0204	0.0214	44.8	49.4	14.2	6
24	475	434	1.18	19x36	0	0.0050	0.0225	0.0244	0.0254	0.0254	0.0264	28.4	30.1	22.4	6
22	754	694	1.87	19x34	0	0.0063	0.0285	0.0314	0.0314	0.0324	0.0334	17.5	18.6	35.8	6
20	1216	1127	1.34	19x32	0	0.0080	0.0365	0.0395	0.0404	0.0404	0.0414	10.7	11.4	58.1	6
18	1900	1770	1.34	19x30	0	0.0100	0.0465	0.0467	0.0467	0.0504	0.0514	6.43	6.79	90.3	6
16	2426	2261	1.19	19x29	0	0.0113	0.0515	0.0530	0.0530	0.0574	0.0584	4.90	5.16	115	6

1/ Nominal values are for information only. Nominal values are not requirements.

TABLE 4D - DETAILS OF 27% NICKEL COATED (NHC/NHA/NHS) CONDUCTOR

Size Desig-nation	Conductor Area (Circular Mils)		K-Value	Stranding (No. of Strands X AWG of Strands)	Allowable No. of Missing Strands (Max)	Nominal Dia. of Individual Strands (inch) 1/	Minimum Diameter of Stranded Conductor (inch)	Maximum Diameter of Stranded Conductor (inch)	Max Resistance of Conductor (ohms/1000 feet at 20 °C		Elongation (%, Min)	
	Nominal (All) 1/	Minimum							(NHC)	(NHA/NHS)	(NHC)	(NHA/NHS)
22	754	694	1.87	19x34	0	0.0063	0.0290	0.0336	23.7	25.6	10	6
20	1216	1127	1.34	19x32	0	0.0080	0.0365	0.0415	14.6	15.3	10	6
18	1900	1770	1.34	19x30	0	0.0100	0.0455	0.0520	9.14	9.59	10	6
16	2426	2261	1.19	19x29	0	0.0113	0.0520	0.0610	6.85	7.30	10	6
14	3831	3570	1.38	19x27	0	0.0142	0.0650	0.0740	4.32		10	
12	6088	5672	1.67	19x25	0	0.0179	0.0820	0.0940	2.78		10	
10	9880	8716	1.35	49x27	0	0.0142	0.123	0.129	1.68		10	
8	16 983	16 645	2.29	133x29	0	0.0113	0.158	0.179	0.936		10	
6	26 818	26 284	2.31	133x27	0	0.0142	0.198	0.218	0.591		10	
4	42 615	41 767	2.55	133x25	0	0.0179	0.250	0.272	0.375		10	
2	66 500	64 981	3.21	665x30	2	0.0100	0.320	0.345	0.241		10	
1	81 700	79 878	2.89	817x30	2	0.0100	0.355	0.384	0.196		10	
01	104 500	102 126	3.24	1045x30	3	0.0100	0.395	0.432	0.153		10	
02	133 000	130 059	3.15	1330x30	3	0.0100	0.440	0.490	0.120		10	
03	166 500	162 795	3.09	1665x30	4	0.0100	0.500	0.548	0.096		10	
04	210 900	206 213	3.32	2109x30	5	0.0100	0.565	0.615	0.077		10	

1/ Nominal values are for information only. Nominal values are not requirements.

TABLE 4E - DETAILS OF ULTRA HIGH STRENGTH COPPER ALLOY CONDUCTORS 1/

Size Desig-nation	Conductor Area (Circular Mils)		K-Value	Stranding (No. of Strands X AWG of Strands)	Allowable No. of Missing Strands (Max)	Nominal Dia. of Individual Strands (inch) 2/	Diameter of Stranded Conductor		Maximum Resistance (ohms/ 1000 feet) at 20 °C Nickel Coated NCU	Maximum Resistance (ohms/ 1000 feet) at 20 °C Silver Coated SCU	Min Break Strength (pounds)	Elon-gation (% Min)
	Nominal 2/	Minimum					Min (inch)	Max (inch)				
26	304	275	1.34	19x38	0	0.0040	0.0175	0.0204	58.4	56.4	21.5	6

1/ Applies to silver and nickel coated conductors, unless otherwise noted.
2/ Nominal values are for information only. Nominal values are not requirements.

TABLE 4F - DETAILS OF TYPE KPH, KPS, KNH, AND KNS EXTENSION CONDUCTORS

Size Desig-nation	Conductor Area (Circular Mils)		Stranding (No. of Strands X AWG of Strands)	Allowable No. of Missing Strands (Max)	Nominal Dia. of Individual Strands (inch) 1/	2/ General Purpose Conductor Diameter		Resistance (ohms per 1000 feet @ 20 °C)			
						Min (inch)	Max (inch)	KP (H or S)		KN (H or S)	
	Nominal 1/	Minimum						Min	Max	Min	Max
22	754	694	19x34	0	0.0063	0.029	0.033	546.7	604.3	228.2	252.3
20	1216	1127	19x32	0	0.0080	0.037	0.041	339.2	375.0	141.5	156.5
18	1900	1770	19x30	0	0.0100	0.046	0.051	217.0	240.0	90.5	100.2
16	2426	2261	19x29	0	0.0113	0.052	0.058	169.7	187.7	70.6	78.2
14	3831	3570	19x27	0	0.0142	0.065	0.073	107.6	119.0	44.9	49.7

1/ Nominal diameters are for information only. Nominal values are not requirements.
2/ No small diameter thermocouple conductors exist at this time.

TABLE 4G - DETAILS OF EXTRA-HIGH STRENGTH COPPER ALLOY CONDUCTORS

Size Desig-nation	Conductor Area (Circular Mils)		K-Value	Stranding (No. of Strands X AWG of Strands)	Allowable No. of Missing Strands (Max)	Nominal Dia. of Individual Strands (inch) 1/	Diameter of Stranded Conductor					Max Resistance of Conductor (ohm/1000 feet at 20 °C)		Min Breaking Strength (pounds) (SCS/ SCS1/ NCS)	Elon-gation (% Min)
								Max (inch)							
								Sm Dia.		Gen'l Purpose					
	Nominal 1/ (All)	Minimum					Min (inch)	(SCS/ SCS1)	(NCS)	(SCS/ SCS1)	(NCS)	Silver Coated (SCS/ SCS1)	Nickel Coated (NCS)		
30	112	102	0.77	7x38	0	0.0040	0.0117	0.0124	0.0134			117.4	129.6	6.69	6
28	175	161	1.05	7x36	0	0.0050	0.0147	0.0154	0.0164			74.4	79.0	10.6	6
26	304	275	1.34	19x38	0	0.0040	0.0184	0.0204	0.0204			44.8	49.4	18.2	6
24	475	434	1.18	19x36	0	0.0050	0.0231	0.0244	0.0254			28.4	30.1	28.7	6
22	754	694	1.87	19x34	0	0.0063	0.0293	0.0314	0.0314	N/A	N/A	17.5	18.6	45.9	6
20	1216	1127	1.34	19x32	0	0.0080	0.0373	0.0395	0.0404			10.7	11.4	74.5	6
18	1900	1770	1.34	19x30	0	0.0100	0.0467	0.0467	0.0467			6.43	6.79	117	6
16	2426	2261	1.19	19x29	0	0.0113	0.0524	0.0533	0.0530			4.90	5.16	147	6

1/ Nominal values are for information only. Nominal values are not requirements.