



AEROSPACE STANDARD

AS29606™**REV. B**Issued 2014-06
Revised 2021-08

Superseding AS29606A

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

RATIONALE

AS6324 establishes requirements for the qualification of new aerospace alloys to be used in AS22759 insulated wire products.

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:

<u>M29606</u>	<u>-20</u>	<u>-SCC</u>	<u>-GP</u>	
				Conductor Diameter Tolerance (See 1.1.1.4)
			_____	Conductor Material and Coating (See 1.1.1.3)
		_____	_____	Conductor Size (See 1.1.1.2)
				Basic Part Number (See 1.1.1.1)

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

1.1.1.1 Basic Part Number

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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

Copies of these documents are available online at <https://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 +1 724-776-4970 (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

AS6324 Verification of New Conductor Alloys for AS29606 Conductors Qualification

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 National Conference of Standards Laboratories (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 - Association Connecting Electronics Industries Publications

Available from IPC 3000 Lakeside Drive, 309S, Bannockburn, IL 60015, 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., distributor, 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.

AS6324 was developed by the AE-8D Committee to verify interconnect system level performance of new copper alloys requesting qualification to AS29606. The qualification of new copper alloys is required to complete the test program identified in AS6324 prior to starting AS29606 qualification. A formal AS6324 test report will be submitted to the qualifying activity as part of the AS29606 qualification effort.

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 µin 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 µin 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 µin 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 µin 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 µin 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 µin 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 µin 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 µin 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 µin 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 µin 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 µin 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 µin 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 µin 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 µin 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 Tables 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 Tables 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 Tables 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 Tables 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 Tables 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 Tables 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.