



AEROSPACE STANDARD	AS23053™	REV. B
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Superseding A23053A		
Insulation Sleeving, Electrical, Heat Shrinkable, General Specification for (Federal Supply Class 5970)		

RATIONALE

In 7.7 of revision A, the paragraph and transitional qualification were removed since the QPL has been established. Clarification for dimensional life was added per AE-8D; added optional length for value-add operations per committee direction. Added allowance for cut-lengths for cutting value-add operation.

1. SCOPE

1.1 Form

This specification establishes the requirements for various types and colors of electrical insulating sleeving that will shrink to a predetermined size upon the application of heat. This specification includes provisions for demonstrating compliance with qualification requirements (see Section 4 and 7.3), in process inspection, and statistical process control inspections (see 4.4). The continuous operating temperature ranges for the sleeving classes covered by this specification are from -112 to +482 °F (-80 to +250 °C). The continuous operating temperature range for each sleeving class is given in the applicable detail specification.

1.2 Classification

The heat shrinkable sleeving class shall be defined and specified in the applicable detail specification.

1.3 Color

The color shall be identified in accordance with the following:

Table 1

Designator	Color	Designator	Color
0	Black	7	Violet (Purple)
1	Brown	8	Gray (Slate)
2	Red	9	White
3	Orange	C	Clear
4	Yellow	P	Pink
5	Green	T	Tan
6	Blue		

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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 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.

AMS1424	Fluid, Aircraft Deicing/Anti-Icing, SAE Type I
AIR1351	Manufacturers' Identification of Aerospace Electrical and Electronic Wiring Devices and Accessories
AIR7930	Dimensional Life of Heat-Shrinkable Sleeve
AS23053/1*	Insulation Sleeving, Electrical, Heat Shrinkable, Crosslinked Chlorinated Polyolefin, Flexible
AS23053/2*	Insulation Sleeving, Electrical, Heat Shrinkable, Polyvinyl Chloride, Flexible, Crosslinked and Non-Crosslinked
AS23053/3*	Insulation Sleeving, Electrical, Heat Shrinkable, Polyvinyl Chloride, Semi-Rigid, Crosslinked and Non-Crosslinked
AS23053/4*	Insulation Sleeving, Electrical, Heat Shrinkable, Polyolefin, Dual-Wall, Outer Wall Crosslinked
AS23053/5*	Insulation Sleeving, Electrical, Heat Shrinkable, Polyolefin, Flexible, Crosslinked
AS23053/6*	Insulation Sleeving, Electrical, Heat Shrinkable, Polyolefin, Semi-Rigid, Crosslinked
AS23053/7*	Insulation Sleeving, Electrical, Heat Shrinkable, Polyethylene Terephthalate, Non-Crosslinked
AS23053/8*	Insulation Sleeving, Electrical, Heat Shrinkable, Polyvinylidene Fluoride, Semi-Rigid, Crosslinked
AS23053/10*	Insulation Sleeving, Electrical, Heat Shrinkable, Silicone Rubber, Flexible
AS23053/11*	Insulation Sleeving, Electrical, Heat Shrinkable, Fluorinated Ethylene Propylene, Non-Crosslinked
AS23053/12*	Insulation Sleeving, Electrical, Heat Shrinkable, Polytetrafluoroethylene
AS23053/13*	Insulation Sleeving, Electrical, Heat Shrinkable, Fluoroelastomer, Flexible
AS23053/14*	Insulation Sleeving, Electrical, Heat Shrinkable, Ethylene-Tetrafluoroethylene Fluoropolymer, Semi-Rigid
AS23053/15*	Insulation Sleeving, Electrical, Heat Shrinkable, Polyolefin, Heavy-Wall, Coated, Flexible, Outer Wall Crosslinked
AS23053/16*	Insulation Sleeving, Electrical, Heat Shrinkable, Crosslinked, Elastomeric Polyolefin, Flexible

AS23053/17* Insulation Sleeving, Electrical, Heat Shrinkable, Flame Retarded, Modified Polyolefin, Flexible, Crosslinked

AS23053/18* Insulation Sleeving, Electrical, Heat Shrinkable, Modified Fluoropolymer, Crosslinked

* AS23053 detail specifications. Detail specification document numbers assigned to follow the numbers of previous specifications AMS-DTL-23053, MIL-I-23053, MIL-DTL-23053, and AMS-I-23053 (see 7.2 and 7.6).

2.1.2 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 D149 Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies

ASTM D150 Standard Test Methods for AC Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulation

ASTM D374/D374M Standard Test Methods for Thickness of Solid Electrical Insulation (Metric)

ASTM D570 Standard Test Method for Water Absorption of Plastics

ASTM D746 Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact

ASTM D792 Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

ASTM D876 Standard Test Methods for Non-rigid Vinyl Chloride Polymer Tubing used for Electrical Insulation

ASTM D2671 Standard Test Methods for Heat-Shrinkable Tubing for Electrical Use

ASTM G21 Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi

2.1.3 ISO Publications

Copies of these documents are available online at <http://webstore.ansi.org/>.

ISO 846 Plastics - Evaluation of the Action of Microorganisms

ISO 9001 Quality management systems - Requirements

ISO 10012 Measurement Management Systems - Requirements for Measurement Processes and Measuring Equipment

2.1.4 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 Z540.3 Requirements for the Calibration of Measuring and Test Equipment

2.1.5 U.S. Government Publications

Copies of these documents are available online at <https://quicksearch.dla.mil>.

A-A-694 Sodium Chloride, Technical

MIL-DTL-83133 Turbine Fuels, Aviation, Kerosene Types, NATO F-34 (JP-8), NATO F-35, and JP-8+100

MIL-PRF-5606	Hydraulic Fluid, Petroleum Base; Aircraft, Missile, and Ordnance
MIL-PRF-7808	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base
MIL-PRF-23699	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, NATO code Number O-156
MIL-STD-104	Limit for Electrical Insulation Color
SD-6	Provisions Governing Qualification

2.2 Definitions

2.2.1 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.

2.2.2 QUALIFIED PRODUCTS LIST (QPL)

A qualified products list is a list of suppliers whose products have been evaluated to 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 by a qualifying activity.

2.2.3 QUALIFYING ACTIVITY (QA)

The qualifying activity, for U.S. Department of Defense procurement purposes, is the Naval Air Systems Command (Code 4.4.5.3), 48298 Shaw Road, Bldg. 1461, Patuxent River, MD 20670. Application for qualification tests shall be made in accordance with provisions governing qualification in SD-6 (see 2.1.5).

2.2.4 QUALITY CONFORMANCE INSPECTION

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

2.2.5 PURCHASER

A Purchaser is an individual or group of individuals that can issue a purchase order.

2.2.6 SUPPLIER

A Supplier is a manufacturer which has design and production control of the processes used to produce a component.

2.2.7 REBRAND SUPPLIER

A rebrand supplier is a manufacturer or distributor approved by the qualified supplier and the qualifying activity to sell the original supplier's product as the rebrand supplier's own product defined by the rebrand supplier part number. A rebrand supplier is also known as a private labeler.

2.2.8 DATE OF MANUFACTURE

The date at which the sleeving is expanded to its final "as supplied" ID.

3. REQUIREMENTS

3.1 Detail Specifications

In the event of a conflict between the text of this document and the references cited herein (except for related associated specifications or detail specifications), the text of this document takes precedence. Nothing in the document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3.2 Dimensions and Tolerances

Dimensions and properties in inch/pound units and the Fahrenheit temperatures are primary; dimensions and properties in SI units and the Celsius temperatures are shown as the approximate equivalents of the primary units and are presented only for information.

3.2.1 Inside Diameter (ID)

3.2.1.1 As Supplied

When determined in accordance with 5.3.1, the "as supplied" ID shall conform to the requirements of the applicable detail specification.

3.2.1.2 After Unrestricted Shrinkage

When determined in accordance with 5.3.2, the sleeving ID after unrestricted shrinkage shall conform to the requirements of the applicable detail specification.

3.2.2 Wall Thickness

The wall thickness after unrestricted shrinkage shall be determined in accordance with 5.3.3 and shall conform to the requirement in the detail specification.

3.2.3 Longitudinal Change

When tested as specified in 5.4, the longitudinal change shall not exceed the value specified in the detail specification.

3.2.4 Concentricity

When tested as specified in 5.3.4, the "as supplied" concentricity shall not be less than that specified in the detail specification.

3.2.5 Unit of Issue

Unit of issue for all sleeving shall be feet (meters). The sleeving shall be supplied as a straight piece, coiled, on reels or spools.

3.2.5.1 Straight Pieces

Unless otherwise specified in the applicable detail specification, the standard straight piece unit of issue shall be 4 feet $+2/-0$ inches (121.9 cm $+5/-0$ cm).

3.2.5.2 Reels, Spools, and Coils

Unless otherwise specified in the purchaser's contract or order (see 7.3.d), sleeving length on reels shall be as specified in Table 2.

Table 2 - Reel lengths ^{1/}

ID, As Supplied Inches (mm)	Min Length Feet (m)	Number of Lengths Max	Shortest Length Min Feet (m)
0.015 to 0.063 (0.38 to 1.60)	500 (152.3)	3	125 (38.1)
0.064 to 0.499 (1.60 to 12.7)	200 (61.0)	3	50 (15.2)
0.500 to 1.00 (12.7 to 25.4)	100 (30.5)	3	25 (7.6)
Over 1.00 (Over 25.4)	50 (15.2)	2	13 (4)

^{1/} As reel length increases above minimum footage, the number of individual lengths permitted shall be increased proportionately. When this calculation results in a fraction of 1/2 or less, round down to the lower number.

3.2.5.3 Altered Length Sleeves

An altered length sleeve shall be defined as straight sleeves that are cut-to-length intended for sale in lengths not defined herein. Altered length sleeves shall be cut from bulk sleeves as defined herein (i.e., spooled or straight) which the bulk sleeve and the producer/rebrander are listed on the latest version of QPL and in good standing. Sellers of altered length sleeves shall be permitted to reference the QPL military part number designation when in compliance with the following:

- a. Altered length sleeves shall be made from bulk sleeves listed on QPL and from a producer/rebrander on the QPL and in good standing.
- b. Altered length sleeve label and/or marking when applicable shall be as follows:

CAGE Code-QPL military part number-QPL source CAGE code-altered length in inches/(mm).

e.g., xxxxx-M23053/5-106-4-nnnnn-2.00/(50.8)

where:

xxxxx: CAGE code where cutting is done

M23053/5-106-4: QPL military part designation

nnnnn: CAGE Code of the QPL sleeve source

2.00/(50.8): Cut length in inches/(mm). Part number length is for reference only and shall not be used for inspection.

Significant figures of cut-lengths shall be at altered-length-sleeve-producer's discretion based on the cut length. Note: When altered length operation is done by a QPL source, xxxxx is equal to nnnnn.

- c. The declared dimensional life for the altered length sleeve shall be equal to the original producer's declared dimensional life (see 3.6.2).
- d. The cut edge shall be clean and free of cut-edge imperfections, visible without any magnification, that may become a split nucleation point.
- e. Altering operation shall not change the properties of the original sleeve except for the length of unrecovered sleeves.
- f. Altered length items shall be subject to acceptance inspection per 4.9.3.c. Any loose recovery over the diameter d, a failure to fit over the "A" section of the test mandrel, and/or any evidence of a split after the recovery shall be considered as a failure. Any sleeves cut between passing result to failing result shall be non-conforming. Alteration shall not continue until the root cause(s) and corrective action(s) is implemented and verified.
- g. Sources cutting QPL listed sleeves for sale shall notify the qualifying activity the intent indicating the detail specification number(s), the class(es) and the qualified sleeve(s), source CAGE code(s) of bulk sleeve listed on QPL every 36 months or bulk sleeve source change, whichever is sooner. Sleeve producers and rebranders listed on QPL and in good standing shall be exempt from this notification requirement when cutting CAGE code is same as the source CAGE code.
- h. Altered length sleeve delivery form factor (i.e., bulk packed, tape mounted, etc.) and/or formed to a specific shape for end user application shall be outside of the scope of this specification.

3.3 Properties

3.3.1 As Supplied

3.3.1.1 Heat Shock

When tested as specified in 5.8, the sleeving shall show no sign of cracking, flowing, or dripping. After bending through 360 degrees, the sleeving shall show no sign of cracking except that side cracking of the flattened sleeving shall not be cause for rejection.

3.3.1.2 Restricted Shrinkage

After testing as specified in 5.6, the shrunk sleeving shall fit snugly over the mandrel without cracking and shall withstand the voltage application specified in 5.6.2.c.

3.3.1.3 Modulus

See detail specification for secant modulus or tensile stress requirement as applicable. Testing shall be as specified in 5.12.

3.3.1.4 Cold Impact

When tested as specified in 5.7.2, the sleeving shall meet the requirement of the applicable detail specification.

3.3.2 After Unrestricted Shrinkage

When tested as specified herein and the applicable detail specification, the sleeving shall conform to the requirements of Table 3 or the applicable detail specification.

Table 3 - Properties after unrestricted shrinkage

Characteristics	Requirement	Test Method
Color	Detail specification	MIL-STD-104 <u>1/</u>
Color stability	Conform to "as received" limits	5.15
Clarity stability	3.4 and detail specification	5.16
Specific gravity	Detail specification	ASTM D792
Dielectric constant	Detail specification	ASTM D150
Fungus resistance	Detail specification	5.17
Tensile strength	Detail specification	5.13
Ultimate elongation	Detail specification	5.13
Dielectric strength	Detail specification	ASTM D2671
Volume resistivity	Detail specification	ASTM D876
Low temperature flexibility	Detail specification	5.7.1
Corrosion	Detail specification	<u>2/</u>
Heat resistance	Detail specification	5.9
Water absorption	Detail specification	ASTM D570, 24 hours at 23 °C <u>3/</u>
Flammability	Detail specification	5.14
Fluid resistance	Detail specification	5.11
Sealing efficiency	Detail specification	AS23053/4

1/ For pink and tan color limits, see 3.3.3.

2/ See detail specification for test method.

3/ When testing small (ID) sleeving, special care shall be taken to remove all surface water from the inner wall before reweighing.

3.3.3 Color and Marking

The after unrestricted shrinkage color of the sleeving shall be in accordance with the requirements of MIL-STD-104. MIL-STD-104 does not include limits for pink and tan colors. Munsell color notations for these colors shall be as follows:

Table 4 - Munsell color notations

Color	Light Limit	Nominal	Dark Limit
Pink	3.75R—6.5/9.0	2.5R—6.0/7.0	1.25R—5.5/6.0
Tan	5YR—5.5/6.0	5YR—5.0/5.0	5YR—4.5/4.0

Marking (part number, supplier name, etc.) is not required on the sleeve. Unless otherwise specified by the purchaser or in detail specification, marking is required on the shipping spool label or the smallest unit container and shall be as follows:

- a. AS23053 insulation sleeving part number. Example as shown:

$$\frac{M23053/4}{|} - \frac{1}{|} \frac{01}{|} - \frac{1}{|}$$
 _____ Color code designator (see 1.3)
 _____ Size identifier (see detail specification)
 _____ Class (see detail specification/use 0 when unspecified)
 _____ SAE part number designator (M), basic and detail specification number

- b. Supplier or rebrand supplier name (see 2.6) and CAGE code as registered on AIR1351.
- c. Production code number.
- d. Date of manufacture.
- e. Dimensional life.

3.4 Clarity Stability

The protected marking shall be readable through the sleeving, after the exposures specified in 5.16.

3.5 Workmanship

When examined visually, the sleeving, both before and after shrinkage, shall be free from internal voids, blisters, lumps, dents, tears, pinholes, cracks, foreign matter, or other defect that would be detrimental to fabrication, appearance, or performance. After shrinkage, the sleeving surface shall be smooth and uniform. When the sleeving is of a spirally wound construction or contains a single bonded seam, the overlaps and seams normally associated with these manufacturing techniques shall be acceptable.

3.6 Dimensional Life

The initial dimensional life from the date of original manufacture on the label (see 3.3.3.e.), i.e., without any extension (see 7.5), shall not be less than as specified in the detail specification. When validated within the initial dimensional life and in accordance with 5.18, supplied ID (see 3.2.1.1), unrestricted recovered ID (see 3.2.1.2) and unrestricted recovery wall thickness (see 3.2.2) shall be as specified in the detail specification. The initial dimensional life shall be applicable to products sold by the manufacturer, distributors, and rebrand supplier.

Refer to AIR7930 for additional information regarding the dimensional life.

3.6.1 Required Dimensional Life

Required dimensional life (RDL) shall be specified in detailed specification as “dimensional life.” RDL shall be minimum time a sleeve must be dimensionally stable (i.e., dimensionally in compliance) after the date of manufacturing without any extension(s).

3.6.2 Declared Dimensional Life

Declared dimensional life (DDL) is the use-by date a producer declares on product documents such as product literature, certificate of conformance, product label, etc. DDL shall meet the minimum RDL requirement here in and in detail specifications.

3.6.3 Dimensional Life Compliance

Dimensional life in compliance shall be such that DDL is equal to or longer than RDL.

3.6.4 Dimensional Life Extension

If needed, the dimensional life may be extended for a period. The extension shall not exceed one-half of the original dimensional life and the dimensions shall be within the specification limits of applicable detail specification. However, no sleeving 12 years or older shall be extended by the manufacturer, distributors, or rebranders. See 7.5 for an aged sleeve use exception.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

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 (QA) 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.

4.2 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.

4.3 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 NCSL Z540.3, ISO 10012, or equivalent standards.

4.4 Quality Assurance Compliance

The supplier's reliability assurance program for AS23053 sleeve procedures shall comply with the ISO 9001 at a minimum 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 authority reserves the right to monitor, measure, and validate compliance at their discretion.

4.5 Classification of Inspection

The inspections specified herein are classified as follows:

- a. Initial qualification inspection (see 4.6).
- b. Retention of qualification inspection (see 4.7).
- c. Quality conformance inspections (see 4.9).

4.5.1 Inspection Conditions

All inspections shall be performed in accordance with the test conditions specified in applicable paragraphs and all test data shall be compiled in accordance with an acceptable method, such as Chapter 4 of SD-6.

4.5.2 Test Time Tolerance

When tolerance to time is not specified +60 seconds/-0 seconds shall apply. Unless otherwise specified, the time shall begin when specified temperature is reached.

4.6 Initial Qualification Inspection

A request for qualification shall be made to the QA (see 7.4.1) prior to initiating testing. Testing cannot begin until the supplier has received an authorization letter. The supplier is recommended to provide the QA a test plan based on the authorization letter to ensure the supplier and QA maintain communication and document changes as needed. The QA shall not approve a component that does not meet the requirements specified herein. The QA has the authority to impose specific specification test requirements to resolve test failures/discrepancies and to waive testing to verify specific part manufacturing changes or qualifications by similarity. Any change in the supplier's process control inspections, quality conformance inspections, or manufacturing control drawings (editorial changes are acceptable) without the express approval of the QA shall result in loss of qualification for that part.

4.6.1 Qualification Samples

Qualification inspection shall be performed on sample units produced with equipment and procedures normally used in production. Qualification samples shall be from a single production run for each standard type submitted. Unless otherwise specified in the applicable detail specification, 50 feet of heat shrinkable sleeving of the class and size for which approval is desired shall constitute the qualification sample. The number of specimens (test results) per part number tested (sample) shall be as specified in Table 5. Approval of the sample will automatically extend qualification approval to all sizes included in the size ranges identified in Table 6.

4.6.2 Rebrand Suppliers Qualification Inspection

A rebrand supplier (see 2.2.7) may be qualified at the request of the qualified supplier. A rebrand supplier is required to have a quality conformance inspection system that includes marking (see 3.3.3). The qualifying activity shall require the rebrand supplier to be certified to the inspection requirements and provide the rebrand supplier part numbers for qualified product listing. The rebrand supplier shall be listed on the qualified product list as a separate supplier, but the manufacturing site shall be the same as the qualified supplier.

4.7 Retention of Qualification Inspection

Retention of qualification inspection shall occur every 36 months after the initial qualification date. The qualifying activity will notify the supplier of the due date. The date may vary by 6 months to accommodate the qualifying activity workload. Unless there is a known issue provided by a purchaser, the qualifying activity shall only impose the quality conformance requirements (see 4.9) and the qualifying activity tests of Table 5. The test report shall be a summary of the quality conformance results showing the total number of sleeves, by part number, which passed or failed during the 36 month reporting period. Any change in the supplier's manufacturing control drawings (editorial changes are acceptable) that required additional testing by the supplier quality conformance department shall also be included in the report. The qualifying activity has the authority to impose specific specification test requirements to resolve test failures/discrepancies.

4.7.1 Retention of Qualification of Rebrand Suppliers

At the 36-month interval, the supplier shall request the qualifying activity to recertify the rebrand supplier for qualification approval. The qualifying activity shall require the rebrand supplier to certify to the inspection requirements, to provide the rebrand supplier part numbers for qualified product listing, and to submit a summary of their quality conformance inspection results for the interval (see 4.6.2).

4.8 Noncompliance

If a sample fails any inspection test, the supplier shall take corrective action on the materials or processes, or both, as warranted. Corrective action reports for all failures shall be submitted to the qualifying activity with the qualification report. Additional tests may be requested by qualifying activity prior to final approval.

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Table 5 - Qualification inspections

Property	Requirement	Test Method	Number of Test Results per Sample	Qualification Size Ranges to be Tested for Initial Qualification	Qualification Size Ranges to be Tested for Retention of Qualification	Results Reported As	
						Pass or Fail <u>1/</u>	Average of Multiple Test Results <u>2/</u>
Inside diameter, as supplied <u>4/</u>	3.2.1.1	5.3.1	Two	All	All	X	
Inside diameter, after unrestricted shrinkage <u>4/</u>	3.2.1.2	5.3.2	Two	All	All	X	
Wall thickness, after unrestricted shrinkage <u>4/</u>	3.2.2	5.3.3	Two	All	All	X	
Longitudinal change	3.2.3	5.4	Two	All	All	X	
Straight length size	3.2.5.1	3.2.5.1	One	All	All	X	
Color	3.3.3	MIL-STD-104	One	All	All	X	
Color stability	3.3.2	5.15	Three	Size range 3	Size range 3	X	
Clarity stability	3.4	5.16	Three	All	All	X	
Concentricity	3.2.4	5.3.4	Two	All	All	X	
Workmanship	3.5	3.5	One	All	All	X	
Specific gravity	3.3.2	ASTM D792	Three	Size range 3			X
Dielectric constant	3.3.2	ASTM D150	Three	Size range 3			X
Fungus resistance <u>5/</u>	3.3.2	5.17	Three	Size range 3		X	
Corrosion <u>5/</u>	3.3.2	5.10	Three	All		X	
Tensile strength	3.3.2	5.13	Five	All	All		X
Ultimate elongation	3.3.2	5.13	Five	All	All		X
Dielectric strength	3.3.2	ASTM D2671	Five	All	All	X	
Volume resistivity	3.3.2	ASTM D876	Three	Size range 3		X	
Low temperature flexibility <u>4/</u>	3.3.2	5.7.1	Three	All	All	X	
Heat resistance	3.3.2	5.9	<u>3/</u>	All	All		<u>3/</u>
Water absorption	3.3.2	ASTM D570	Three	All			X
Flammability <u>4/</u> <u>5/</u>	3.3.2	5.14	Three	All	All	X	
Fluid resistance <u>5/</u>	3.3.2	5.11	<u>3/</u>	All			<u>3/</u>
Sealing efficiency	3.3.2	AS23053/4	Three	All		X	
Heat shock	3.3.1.1	5.8	Three	All	All	X	
Restricted shrinkage <u>4/</u>	3.3.1.2	5.6	Three	All		X	
Cold impact	3.3.1.4	5.7.2	Three	All		X	
Modulus	3.3.1.3	5.12	Five	All	All		X

1/ Nonconformance of one test result shall constitute failure of the sample. A description or the numerical failure shall also be recorded.

2/ All values on which the average is based shall be recorded.

3/ Sample must pass all requirements in the detail specification. See tensile strength, ultimate elongation, and dielectric strength (as applicable) for number of test results per sample and reporting of results.

4/ Tests to be performed by qualifying activity.

5/ Not required for AS23053/11 and AS23053/12 because of their relative inertness. However, acquiring activity (see 7.3) may, at its option, specify the performance to any or all of these requirements.

Table 6 - Qualification size ranges

Size Range	ID, As Supplied Inches (mm)
1	Less than 0.046 (less than 1.15)
2	0.046 to 0.186 (1.16 to 4.74)
3	0.187 to 0.999 (4.75 to 25.39)
4	1.00 to 5.00 (25.4 to 127.00)
5	All larger sizes

4.9 Quality Conformance Inspection

Quality conformance inspection shall consist of the inspections and tests as shown in Tables 7 and 8. The number of specimens (test results) shall be accordance with Table 5.

4.9.1 Lot Formation

- a. Production batch compound: A production batch compound shall consist of the entire compound prepared in one mixing operation at one time, using the same formulation. The sleeving made from the aforementioned production batch of compound shall be tested as specified in 4.9.2.a.
- b. Production sleeving lot: Unless otherwise specified, a lot shall consist of sleeving of one detail specification, class, color, and size that has been made at the same plant under essentially the same conditions, processed in a continuous operation from acceptable production compound batches that is available for inspection at one time.

4.9.2 Sampling

- a. Production batch compound: A sufficient quantity of material (batch compound and/or sleeving) to perform the tests specified in 4.9.3.a shall be selected from the compound batch or the first sleeving production lot of the batch compound. Physical property tests performed at this time qualify subsequent sleeving lots produced from the same batch compound. Physical properties shall be tested at any stage in processing provided they are not affected by subsequent processing.
- b. Production sleeving lot: Samples for visual and dimensional inspection of the production sleeving lot shall be selected in accordance with Table 7. Unless otherwise specified in Table 8, the sample unit shall be 4 feet (1.22 m) of sleeving. Each sample shall be inspected as specified in 4.9.3.b.

Table 7 - Sampling plan

Lot Size (Feet)	No. of Samples
2 to 25	2
Over 25 to 150	3
Over 150 to 1200	5
Over 1200 to 35000	8
Over 35000	13

Table 8 - Visual and dimensional inspection

Inspection	Requirement
As supplied:	
Workmanship	3.5
Inside diameter	3.2.1.1
Concentricity	3.2.4
Straight length size <u>1/</u>	3.2.5.1
Spool, coil length <u>2/3/</u>	3.2.5.2
After unrestricted shrinkage:	
Inside diameter	3.2.1.2
Wall thickness	3.2.2
Longitudinal change	3.2.3
Color	3.3.3
Marking (final packaging)	3.3.3

- 1/ The lot size shall be the number of straight lengths; the sample unit shall be one straight length.
- 2/ The lot size shall be the number of spools or coils. The sample unit shall be one spool or coil.
- 3/ If the average length per spool or coil of the selected samples is less than the quantity per spool or coil specified in the contract or order, the lot represented by the sample shall be rejected.

4.9.3 Inspection and Tests

- a. Production batch compound: Test specimens prepared from the sample selected in 4.9.2a shall be tested to the requirements of Table 9. The number of specimens tested and reporting of results shall be in accordance with Table 5. Nonconformance of the sample to a single requirement shall be cause for rejection of the batch compound and all sleeving production lots represented by the sample.

Table 9 - Physical property tests 1/

Property	Requirements	Test Method
Tensile and Elongation	3.3.2	5.13
Low Temperature Flex or Cold Impact	3.3.2	5.7
Heat Shock	3.3.1.1	5.8
Secant Modulus or Tensile Stress	3.3.1.3	5.12
Flammability	3.3.2	5.14
Clarity stability <u>2/</u>	3.4	5.16

- 1/ The purchaser, at its option, may require conformance to additional requirements specified herein.
- 2/ As required by the applicable detail specification.

- b. Production sleeving lot: Samples selected in 4.9.2.b shall be examined for conformance to the requirements in Table 8. There shall be no defects. The number of test results on each sample shall be as specified in Table 5. Statistical process control data may be used to demonstrate conformance in place of these inspections (see 4.4).
- c. Minimum in-process inspection (applicable for 3.2.5.3 only): Five altered length items shall be tested for split resistance at the beginning and the end of the cutting operation, and if applicable, every hour of cutting operation in accordance with 5.6.2.

5. TEST METHODS

5.1 Conditioning Prior to Test

Unless otherwise specified herein, the heat shrinkable sleeving and measurement gages shall be at room temperature with ambient relative humidity prior to testing before or after heat shrinking. Unless otherwise specified in the detail specification, an oven with a circulating air velocity of 100 to 200 feet (30.5 to 61.0 m) per minute shall be used whenever heating is required.

5.2 ASTM Tests

ASTM tests shall be performed in accordance with ASTM Standard Methods of Test (see 2.1.2) with any exceptions that shall be specified herein or in the detail specifications.

5.3 Dimensional Inspections

Dimensional inspections shall be conducted as specified below. Micrometer measurements shall be made in accordance with ASTM D374/D374M. Contemporary methods of inspection and/or automated control processes, such as continuous monitoring by laser micrometers and ultrasonic gauging shall be used provided such methods ensure quality levels and inspection accuracy equal to or better than the methods described below.

5.3.1 Inside Diameter (ID) as Supplied

To measure the ID of the sleeving, select a smooth gage rod that has a diameter equal (+0/-0.002 inch [+0/-0.051 mm], or 2%, whichever is less) to the minimum acceptable ID of the "as supplied" sleeving. The ID shall be considered acceptable when the gage rod passes freely into the sleeving sample without expanding the wall of the sleeving. If the gage rod tends to stick, the gage rod shall be dipped in talc or water to facilitate insertion of the rod.

5.3.2 Inside Diameter (ID) after Unrestricted Shrinkage

For sleeving shrunk as specified in 5.5.1, select a smooth gage rod that has a diameter equal (-0/+0.002 inch [-0/+0.051 mm], or 2%, whichever is less) to the maximum acceptable sleeving ID after unrestricted shrinkage. The maximum ID dimension of the sleeving shall be considered acceptable when the wall of the sleeving is expanded by the insertion of the gage rod, when there is no visible air space between the end of the sleeving and the rod, or when the gage rod cannot be inserted in the sleeving. For sleeving shrunk as specified in 5.5.2, the maximum ID dimension of the sleeving shall be considered acceptable only if the sleeving is snug on the mandrel and there is no air space between the mandrel and the sleeving.

5.3.3 Wall Thickness

After the unrestricted shrinkage specified in 5.5, the wall thickness shall be determined by one of the following methods:

- a. Micrometer method: The sleeving shall be split lengthwise into two hemi cylindrical pieces. A smooth gage rod shall be selected, measured and placed in contact with the inside surface of the sleeving. The total thickness of the gage rod plus sleeving wall shall then be measured. The maximum and minimum wall thickness shall be calculated by subtracting the gage rod measurement from the measurement of the gage rod plus sleeving wall.
- b. Optical method: The wall thickness shall be measured with a calibrated microscope.
- c. Alternate method: Wall thickness shall be determined in accordance with of ASTM D2671.

5.3.4 Concentricity

Concentricity shall be determined in accordance with ASTM D2671.

5.4 Longitudinal Change

The longitudinal change of the sleeving shall be determined in accordance with ASTM D2671, by measuring in the “as supplied” condition and after the unrestricted shrinkage specified in 5.5.

5.5 Unrestricted Shrinkage

Unrestricted shrinkage shall be accomplished using one of the following methods:

5.5.1 Unsupported Method

Lay a 6-inch (15.2 cm) length of the sleeving on a tray in an oven at the temperature and for the time specified in the detail specification. If the sleeving becomes tacky in the oven, a small amount of powdered talc shall be placed on the tray to prevent sticking. Evaluate in accordance with 5.3.2.

5.5.2 Mandrel Method

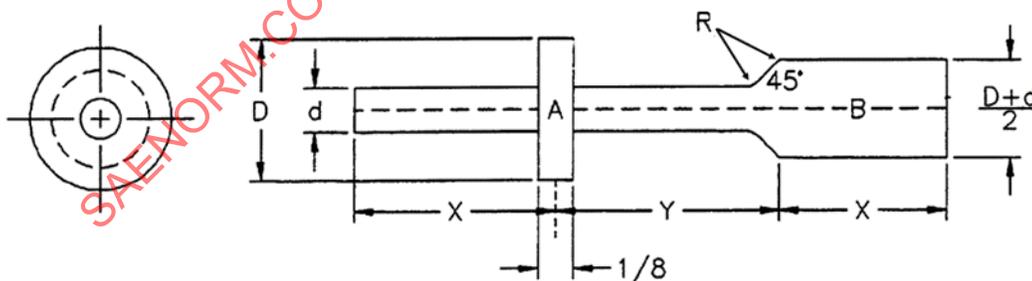
Select a smooth, clean, metallic mandrel that has a diameter equal to the maximum acceptable sleeving ID (after unrestricted shrinkage) $-0/+0.002$ inch ($-0/+0.051$ mm) or 2%, whichever is less. Slip a 6 inch (15.2 cm) length of sleeving on the mandrel and heat in an oven at the temperature and for the time specified in the applicable detail specification. Evaluate in accordance with 5.3.2.

5.6 Restricted Shrinkage

After shrinking as specified below, the sleeving shall conform to the requirements of 3.3.1.2 and pass the voltage withstand test of 5.6.2.c.

5.6.1 Specimen Preparation

A smooth, clean, metallic mandrel of the configuration shown on Figure 1 shall be prepared for each sleeving size. Sleeving length shall be such that each end of the mandrel is slightly exposed for electrical connections after shrinkage. The sleeving and the mandrel shall be conditioned in accordance with 5.1, then shrunk using one of the following methods.



d = max ID of sleeving, nominal, after unrestricted shrinkage +5, -0%

D = min ID, nominal, of “as supplied” sleeving +5, -0%

A = that part of the mandrel shaped as shown with a width of 1/8 inch and a diameter D

B = that part of the mandrel shaped as shown with a 45 degree angle between the $(D + d)/2$ and d dimensions

R = 0.020 inch (0.51 mm) reference radius

Figure 1 - Restricted shrinkage mandrel

All edges involved in this mandrel shall have no burrs.

Section B can be provided with a longitudinal V-groove to allow easy cutting off of the sample with a knife or razor blade after the testing is complete.

Table 10 - Mandrel section dimensions

Max ID of Sleeving (Nominal) After Unrestricted Shrinkage Inches (mm)	Mandrel Section in Inches (mm) ^{2/}	
	X	Y
Less than 0.050 (1.27) ^{1/}	0.50 (12.7)	0.25 (6.4)
0.050 to 0.125 (1.27 to 3.18)	0.50 (12.7)	0.25 (6.4)
0.126 to 0.374 (3.20 to 9.50)	1.00 (25.4)	0.50 (12.7)
0.375 to 2.000 (9.53 to 50.80)	2.00 (50.8)	2.00 (50.8)
2.001 to 3.000 (50.83 to 76.20)	3.00 (76.2)	3.00 (76.2)
3.001 to 4.000 (76.23 to 101.60)	4.00 (101.6)	4.00 (101.6)
4.001 to 5.000 (101.63 to 127.00)	5.00 (127.0)	5.00 (127.0)

^{1/} For sleeving sizes less than 0.050 ID inch (after unrestricted shrinkage), a straight cylindrical mandrel shall be made with an OD equal to D.

^{2/} The lengths X and Y tolerances: ± 0.01 inch (0.3 mm).

5.6.2 Shrink Procedures

- a. Procedure A: The mandrel shall be free of debris or residue that may adversely affect the test results. The mandrel shall be at room temperature when inserted into the sleeving. The method of heat application is optional. The specimen shall be heated for 30 minutes at the temperature specified in the applicable detail specification. When an oven is used as the heat source, it shall be capable of maintaining a ± 9 °F (± 5 °C) tolerance from the specified temperature.
- b. Procedure B: The mandrel shall be preheated a minimum of 30 minutes at the temperature specified in the applicable detail specification before insertion into the sleeving. Shrinkage shall be as specified in Procedure A.
- c. Voltage withstand: Tightly wrap the first layer of the outer electrode, a strip of metal foil, around the sleeving specimen. The outer electrode shall conform closely to the shape of the sleeving particularly at the areas A and R shown on Figure 1. Allow sufficient sleeving area at each end to remain unwrapped so that flashover between the mandrel and the foil will not occur. Wrap two more layers of foil over the first wrap allowing a free end of 0.5 inch (12.7 mm) for connection of the electrode. Two thousand volts shall be applied for 1 minute in accordance with the test procedure of ASTM D149.

5.6.3 Altered Length Sleeve Split Resistance Inspection (Applicable for 3.2.5.3 Only)

- a. Cut sleeve test specimens shall be tested on the restricted shrinkage on mandrel per 5.6.
- b. For altered length of shorter than the length of the mandrel shall be placed in from left to right such that the center of the cut tubing is at the 45-degree transition from B diameter to d diameter.
- c. Altered adhesive lined sleeves shall be tested on a straight mandrel of diameter D with the minimum length of the cut length $+5\%/-0\%$. When testing adhesive lined sleeve, a thin layer of non-stick material may be applied on the mandrel under the sleeve-in-test to allow the re-use of the mandrel with an optional v-groove for easy-removal of the sample and to reuse the mandrel.
- d. All test specimens shall be placed on the mandrel from left to the right, as depicted in Figure 1, and placed such that the right end of the mandrel is not covered by the test specimen.
- e. Sleeves shall be heated per unrestricted shrinkage temperature and time on the detail specification.
- f. Altered length specimens that are significantly longer than the length of the test mandrel may be cut on the right end side of the mandrel after the specimens are inserted into position on the left side.

5.7 Low Temperature Properties

Low temperature properties of heat shrinkable sleeving shall be determined as specified in the applicable detail specification using one of the methods specified below.

5.7.1 Low Temperature Flexibility

For sleeving sizes less than 0.375 inch (9.5 mm) (maximum ID nominal after unrestricted shrinkage), the sleeving shall be shrunk and conditioned as specified in 5.5 onto a stranded AWG wire (nearest AWG which is larger than the sleeving max ID nominal after unrestricted shrinkage). For sleeving sizes 0.375 inch (9.5 mm) and larger, a 6 x 0.25 inch (15.2 x 0.64 cm) longitudinal strip shall be cut from sleeving that has been shrunk and conditioned as specified in 5.5. The specimen (strip or sleeving) and a steel mandrel of the size specified in Table 11 shall be conditioned in a cold chamber for 4 hours at the temperature specified in the applicable detail specification. After completion of the conditioning period and while still in the cold chamber at the specified temperature, the specimen shall be bent around the mandrel through not less than 360 degrees. Unless otherwise specified in the detail specification, the time to complete the bend shall be 10 seconds \pm 2 seconds. Visually examine the sleeving for cracks.

Table 11 - Mandrel sizes for bend tests

Nominal Sleeving ID (Max, After Unrestricted Shrinkage) Inches (mm)	Mandrel Diameter ^{1/} Inches (mm)
0.023 to 0.125 (0.60 to 3.18)	0.313 \pm 0.002 (7.94 \pm 0.05)
0.126 to 0.250 (>3.18 to 6.35)	0.375 \pm 0.003 (9.53 \pm 0.08)
0.251 to 1.000 (>6.35 to 25.40)	0.438 \pm 0.004 (11.11 \pm 0.10)
1.001 to 2.000 (>25.40 to 50.80)	0.875 \pm 0.005 (22.23 \pm 0.13)
2.001 to 3.000 (>50.80 to 76.20)	1.000 \pm 0.005 (25.40 \pm 0.13)
3.001 to 4.000 (>76.20 to 101.60)	1.125 \pm 0.005 (28.58 \pm 0.13)

^{1/} Unless otherwise specified in the detail specification.

5.7.2 Cold Impact

Impact testing shall be conducted in accordance with ASTM D746 Procedure A, using a longitudinal strip cut from sleeving and prepared as specified in 5.7.1. Temperature shall be as specified in the applicable detail specification.

5.8 Heat Shock (As Supplied)

A 6-inch (15.2 cm) length of the sleeving or a 6 x 0.5 inch (15.2 x 1.3 cm) strip cut longitudinally from sleeving that has a nominal ID greater than 0.5 inch (12.7 mm) (as supplied) shall be placed in an oven for 4 hours at the temperature specified in the detail specification. The specimen shall be suspended vertically in the oven by means of a piece of wire attached to a hole in the specimen. While in the oven and after removal from the oven, the specimen shall be examined for evidence of cracking, flowing, or dripping. The specimen shall then be conditioned as specified in 5.1 and bent through 360 degrees in 2 to 4 seconds over the steel mandrel specified in Table 11. The specimen shall then be visually examined for conformance to 3.3.1.1.

5.9 Heat Resistance

Heat resistance shall be determined in accordance with ASTM D2671 and the following: after removal from the oven, the sleeving shall be conditioned as specified in 5.1 prior to initiating the tests specified in the detail specification.

5.10 Corrosion

Prior to corrosion testing, the sleeving sample shall be heat shrunk and conditioned as specified in 5.1. The corrosion test procedure(s) specified in the applicable detail specification shall be followed.

5.10.1 Corrosion in Contact with Copper

A 6-inch (15.2 cm) length of shrunk sleeving shall be slid over a straight, clean, bare copper conductor. For sleeving of 0.25 inch (6.4 mm) inside diameter and smaller (maximum ID after unrestricted shrinkage), a single conductor shall be used; for larger sleeving, a twisted bundle of several conductors shall be used, each AWG 18 or smaller. The specimens on the conductor shall be heated in an air-circulating oven for the time and at the temperature specified in the applicable detail specification. The specimens shall then be removed from the oven, cooled, and conditioned in accordance with 5.1. The sleeving shall be slit open and the copper conductor shall be examined for pitting and blackening. The sleeving shall be considered noncorrosive only if the copper conductor is not pitted or blackened. Darkening of the copper conductor due to normal air oxidation shall not be cause for rejection.

5.10.2 Copper Mirror Corrosion

For sizes 0.400 inch (10.2 mm) or larger (maximum ID nominal after unrestricted shrinkage), a 0.25 x 1 inch (6.4 x 25.4 mm) strip shall be cut longitudinally from the shrunk sleeving. For sizes smaller than 0.400 inch (10.2 mm) (maximum ID nominal after unrestricted shrinkage), a number of pieces of shrunk sleeving having an area of approximately 0.25 in² (161 mm²) shall be used. The strip or pieces of sleeving shall be placed in the bottom of a clean, dry 0.5 x 12 inch (1.3 x 30.5 cm) test tube. A copper glass mirror about 0.25 x 1 inch (6.4 x 25.4 mm) and a calibrated thermometer shall be suspended 6 to 7 inches (15.2 to 17.8 cm) above the bottom of the test tube by means of a fine, clean copper wire attached to a cork that has been wrapped in clean aluminum foil. A second clean test tube containing only the mirror and thermometer shall be used as a control. The lower 2 inches (5.1 cm) of the test tube shall be immersed in an oil bath at the temperature and for the time specified in the applicable detail specification. The temperature of that portion of the test tube containing the copper mirror shall be below 140 °F (60 °C). After removal from the oil bath and cooling to room temperature, visually examine the mirror for corrosion by placing it on a white background in good light. Evidence of corrosion shall be the removal of the copper film from any part of the mirror as evidenced by the white background showing through. Disregard removal of copper from the bottom 0.063 inch (1.6 mm) of the mirror. Discoloration of the copper film or reduction of its thickness should not be considered corrosion. The mirrors shall be vacuum deposited copper with a thickness equal to 10% ± 5% transmission of normal light of 5000 Angstroms. They shall be stored in a vacuum and shall be used only if no oxide film is present and the copper is not visually damaged or contaminated.

5.11 Fluid Resistance

The sleeving shall be heat shrunk and conditioned as specified in 5.1. A suitable number of 6-inch (15.2 cm) lengths of sleeving shall be totally immersed in each of the six fluids specified in Table 12. The volume of the fluid shall be not less than 20 times that of the sleeving. After 24 hours immersion at 75 °F ± 5 °F (24 °C ± 3 °C), the sleeving shall be lightly wiped and then conditioned for 45 minutes ± 15 minutes at room temperature. The sleeving from each of the test fluids shall then be tested for conformance to the tensile strength (see 5.13, using the dimensions obtained on specimens prior to fluid immersion as the basis for calculating tensile strength), ultimate elongation, and dielectric strength (as applicable) of the detail specification.

Table 12 - Test fluids

Fluid	Conforming to
Hydraulic fluid, petroleum base	MIL-PRF-5606
JP-8	MIL-DTL-83133
Lubricating oil	MIL-PRF-7808
Lubricating oil	MIL-PRF-23699
5% NaCl	A-A-694
Deicing fluid	AMS1424