INCH-POUND

MIL-DTL-55668D
February 20, 2009
SUPERSEDING
MIL-DTL-55668C
9 September 2005

DETAIL SPECIFICATION

CORD, ELECTRICAL; AUDIO, SUBMINIATURE (RETRACTILE AND STRAIGHT)

Reactivated after 10 September 1993 and may be used for new and existing designs and acquisitions

This specification is approved for use by all Departments and Agencies of the Department of Defense

1. SCOPE

1.1 Scope. This specification covers subminiature audio helical retractile cords and straight cords with either stranded wire or tinsel wire conductors, for accessories associated in for the use with microphone, telephone, switchboard, and associated communication equipment. These cords are intended for operations at audio frequencies and temperatures from -55 °C to +85 °C with a high degree of flexibility. Each retractile cord is designed for extension in normal service up to 6 times its nominal retracted helical length.

1.2 Classification. The types of cords covered by this specification are classified as follows:

Type I	-	Retractile cords with stranded wire conductors.
Type II	-	Retractile cords with tinsel wire conductors.
Type III	-	Straight cords with stranded wire conductors.
Type IV	-	Straight cords with tinsel wire conductors.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are cited in sections 3, 4 or 5 of this specification. These lists do not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of these lists, document users are cautioned that they must meet the requirements specified in the documents cited in sections 3, 4 or 5 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards and handbooks. The following specifications, standards and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

Beneficial comments, recommendations, addtions, deletions, clarifications, etc., and any data that may improve this document should be sent to: Defense Supply Center, Columbus, ATTN: DSCC-VAI, P.O. Box 3990, Columbus, Ohio 43218-3990, or email to WireCable@dscc.dla.mil. Since contact information can change you may want to verify the currency of this address informaiton using the ASSIST Online database at http://assist.daps.dla.mil.

FEDERAL STANDARD

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

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-C-572	-	Cords, Yarns, and Monofilaments, Organic Synthetic Fiber.
MIL-I-631	-	Insulation, Electrical, Synthetic Resin Composition Non-Rigid.

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-104	-	Limits for Electrical Insulation Color.
MIL-STD-202	-	Test Methods for Electronic and Electrical Component Parts.

(Copies of these documents are available online at http://assist.daps.dla.mil/quicksearch/ or from the Standardization Document Order 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

ASTM INTERNATIONAL

ASTM D1248	-	Standard Specification for Polyethylene Plastics Molding and Extrusion Materials.
ASTM D4101	-	Standard Specification for Propylene Plastic Injection and Extrusion Materials.
ASTM B33	-	Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes.

(Copies of these documents are available online from http://www.astm.org or ASTM International, P.O. Box C700, 100 Barr Harbor, West Conshohocken, PA 19428-2959.)

NATIONAL CONFERENCE STANDARDS LABORATORIES (NCSL)

NCSL Z540.3 - General Requirements for Calibration of Measuring and Test Equipment

(Copies of this document are available from http://www.ncsli.org or from the National Conference of Standards Laboratories (NCSL), 2995 Wilderness Place, Suite 107, Boulder, CO 80301-5404.)

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 10012-1 -Quality Assurance Requirements forMeasurement Equipment / Metrological Confirmation System for Measuring Equipment.

(Copies of these documents are available online at http://www.iso.ch or from the International Organization for Standardization American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036.)

2.4 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the 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.

3. REQUIREMENTS

3.1 First article. The cords furnished under this specification shall be products which have been tested to and have passed the first article inspection. First article approval is valid only on the contract under which it is granted, unless extended by the government to another contract (see 6.4).

3.2 Conductors.

3.2.1 Stranded wire. Each stranded wire shall be the equivalent of No. 26 American Wire Gauge (AWG) and shall consist of 26 strands of No. 40 AWG wire having a cross-sectional area of 9.9 circular mils and stranded with a .25 inch (6.35 mm) nominal, .38 inch (9.65 mm) maximum, unidirectional left-hand lay. The diameter of the stranded conductor shall be approximately .019 inch (.483 mm). Each strand shall be tinned, soft or drawn and annealed cadmium-copper alloy having a 1 percent, nominal, cadmium content and a minimum conductivity of 85 percent.

3.2.1.1 Tin-coating. Each strand shall be tin-coated with commercially pure tin. The tin-coating, continuity, adherence, and finish shall meet the requirements of ASTM B33 (see 4.7.2.1).

3.2.1.2 Stranded wire tensile strength and elongation. When tested as specified in 4.7.2.2, the tensile strength and elongation of the coated strands, removed from the wires of insulated conductors prior to cabling, shall be as follows:

Tensile strength	Elongation in 10 inches (254 mm)
40,000 psi (min.)	13 percent (min.)

3.2.1.3 Stranded wire resistance. Each strand shall have a direct current (dc) resistance of not more than 1.27 ohms per foot. The dc resistance of the No. 26 stranded conductor shall be not more than .0556 ohms per foot. Resistance values should be measured at or corrected to 20 ºC when tested in accordance with 4.7.2.3 (see 6.3).

3.2.2 Tinsel wire. Tinsel wire shall meet the requirements type IV tinsel electrical wire, having an overall dimension of 0.022 inch (.56 mm) ± 0.002 inch (.05 mm) and a breaking load minimum of 10 pounds (see 6.3).

3.3 Insulation. The insulation for both stranded and tinsel wire conductors shall be a crystalline ethylene-propylene copolymer thermoplastic meeting the requirements of ASTM D4101. Insulation removed from insulated conductors of finished cords shall meet the requirements of ASTM D1248 with the following exceptions:

a. Cold bend shall be performed at -55 °C.

b. For insulation removed from tinsel conductors, the ultimate elongation shall be 250% minimum, and the tensile strength shall be 2,500 PSI minimum.

When tested for heat shock; there shall be no evidence of cracking.

3.3.1 Insulation wall thickness. Wall thickness at any section of insulation shall be nominal .007 inch (.178 mm); minimum .004 inch (.102 mm).

3.3.2 Dimensions of insulated conductors. The diameter of the insulated stranded and tinsel conductors shall be .035 inch (.889 mm), +.004, -.002 inch (+.102 mm, -.051 mm).

3.3.3 Insulation colors. Color of insulation shall conform to MIL-STD-104, class 1. The colors of individual insulated conductors in a core complement shall be in the following sequence:

1. Black
2. White
3. Red
4. Green
5. Orange
6. Yellow
7. Blue
8. Purple
9. Brown
10. Gray

3.4 Fibers and yarns. All synthetic yarns and fibers employed as servings, binders, fillers, cores for tinsel strands and wires, and staycords shall be as specified herein.

3.4.1 Fillers. Filler yarn shall be used between insulated conductors to form an essentially circular cross-section core and provide a slippage between the insulated wires. Fillers shall be a yarn conforming to MIL-C-572 type PSTR (polyester) or type CTA (cellulose triacetate), or a polypropylene yarn or twisted polypropylene film.

3.4.2 Staycord. Staycord shall consist of a polyaryl-amide fiber conforming to MIL-C-572 type PAA. The cord shall have a minimum breaking strength of 20 pounds for cords of 2, 3, and 4 conductors, and 30 pounds for cords of 5 to 10 conductors. The filaments of the staycord shall be bonded together with a fungus-inert adhesive in order to facilitate knotting during termination of the finished cord.

3.4.2.1 Center core. If necessary to provide a center core larger in diameter than the staycord, a filler material as specified in 3.4.1 shall be served around the staycord.

3.5 Shield. Shielding shall be served tinsel strands. The ribbon comprising the strands shall be silver or tin-coated cadmium-copper of .0095 inch (.241 mm) nominal width and .0009 inch (.023 mm) nominal thickness. A strand shall consist of a single ribbon, spiral-wrapped 54 turns per inch, nominal, around a cotton thread, or a polyaryl-amide thread conforming to MIL-C-572, type PAA. The shield shall consist of 10 tinsel strands laid adjacent to each other, and spiral-wrapped around the insulated conductor in an even, helical, right-hand lay, with a minimum of 60 turns per foot. At no cross-section should there be less than eight strands in a turn. Shield coverage shall be 80 percent minimum, as calculated in 4.7.5. An overlapping spiral-wrap of .0005 inch (.013 mm) nominal thickness polyester tape in accordance with MIL-I-631, type G, shall be applied in a right-hand lay over the shield. Another tape may be placed between the insulation and the shield. The diameter of the taped, shielded insulated wire shall be approximately .052 inch (1.32 mm).

3.5.1 Shield resistance. The dc resistance of a shield strand prior to application on the insulated conductor shall be 2.50 Ω per foot maximum, measured at, or corrected to, 20 °C (see 6.3).

3.6 Jacket. The jacket shall be a smooth, dense, uniform black elastomer free of surface irregularities. Jacket dimensions shall be as specified in table . The wall thickness shall be measured on the straight ends. The jacket material shall be a black vulcanized rubber compound based on one of the following:

a. Styrene butadiene rubber (SBR) or blend of SBR and polyisoprene rubber, not exceeding 35 percent natural or synthetic polyisoprene by weight.

b. A blend of SBR and ethylene-propylene terpolymer (EPDM), with 25 percent EPDM by weight, minimum.

c. EPM rubber or EPDM rubber.

3.6.1 Jacket material properties. Vulcanized rubber jacket materials shall meet the requirements of jacketing compound, type JS-L low temperature, heat resistant, styrene butadiene rubber, except as specified in table II. The actual values shall be recorded and forwarded with first article sample test data (see 3.1). Unless otherwise indicated, specimens shall be taken from the straight section of finished cord; for first article inspection testing, cords may be made up with extra-long straight sections.

3.6.2 Anti-deterioration agents. The rubber compound shall contain anti-oxidants, anti-ozonants, and sunproofing waxes of the types and amounts necessary to provide long-term protection, yet not interfere with adhesion to subsequent rubber strain-reliefs, seals, or crotch-splices.

3.7 Cord construction.

3.7.1 Cord construction parameters. The core shall consist of a staycord in the center around which the insulated conductors and fillers are twisted in a right-hand lay. Powdered soapstone (lubricant) shall be applied to the completed core just prior to jacketing the cord. For a retractile cord, the helical portion shall have a left-hand lay with adjacent turns contiguous and a straight length of cord at each end tangent to the coil. The cord construction parameters consisting of the number of conductors, number of shielded conductors, core diameter, core lay, jacket wall thickness, jacket diameter, and, for retractile cords, the helix outside diameter shall be specified in table I.

TABLE I. Construction dimensions (*) for straight and retractile cords.

Total number of conductors	Number of unshielded conductors	Number of shielded conductors	Core dia. Nom/(mm)	Core lay Nom/(mm)	Core lay Max./(mm)	Jacket wall thickness Nom/(mm)	Jacket wall thickness Min/(mm)
2	2	0	.083/(2.11)	.4735/(11.1)	.5625/(14.3)	.026/(.66)	.016/(.406)
3	3	0	.085/(2.24)	.625/(15.9)	.75/(19)	.040/(1.02)	.024/(.024)
3	2	1	.095/(2.41)	.4375/(14.3)	.5625/(14.3)	.035/(.889)	.021/(.533)
4	4	0	.090/(2.29)	.625/(15.9)	.75/(19)	.037/(.94)	.022/(.559)
4	3	1	.095/(2.41)	.625/(15.9)	.75/(19)	.035/(.889)	.021/(.533)
5	5	0	.102/(2.59)	.625/(15.9)	.75/(19)	.031/(.787)	.019/(.483)
5	4	1	.098/(2.49)	.625/(15.9)	.75/(19)	.033/(.838)	.020/(.508)
6	5	1	.110(2.79)	.625/(15.9)	.75/(19)	.027/(.686)	.016/(.406)
7**	7	0	.116/(2.95)	.75/(19)	.875(22.2)	.037/(.94)	.022/(.559)
8**	7	1	.125/(3.17)	.75/(19)	.875(22.2)	.032/(.813)	.019/(.483)
9**	7	2	.130/(3.30)	.75/(19)	.875(22.2)	.303/(.762)	.018(.457)

TABLE I. Construction dimensions (*) for straight and retractile cords - Continued.

Total number of conductors	Number of unshielded conductors	Number of shielded conductors	Jacket diameter Nom/(mm)	Jacket dia. tolerance ±/(mm)	Helix OD for retractile cords Nom/(mm)	Helix OD for retractile cords Max/(mm)
2	2	0	.135/(3.43)	.006/(.152)	.5000/(12.7)	.6250/(15.9)
3	3	0	.165/(4.19)	.007/(.178)	.5625/(14.3)	.71825/(18.2)
3	2	1	.165/(4.19)	.007/(.178)	.5625/(14.3)	.71825/(18.2)
4	4	0	.165/(4.19)	.007/(.178)	.5625/(14.3)	.71825/(18.2)
4	3	1	.165/(4.19)	.007/(.178)	.5625/(14.3)	.71825/(18.2)
5	5	0	.165/(4.19)	.007/(.178)	.5625/(14.3)	.71825/(18.2)
5	4	1	.165/(4.19)	.007/(.178)	.5625/(14.3)	.71825/(18.2)
6	5	1	.165/(4.19)	.007/(.178)	.5625/(14.3)	.71825/(18.2)
7**	7	0	.190/(4.83)	.008/(.203)	.6563/(16.7)	.71825(19.8)
8**	7	1	.190/(4.83)	.008/(.203)	6563/(16.7)	.71825(19.8)
9**	7	2	.190/(4.83)	.008/(.203)	6563/(16.7)	.71825(19.8)

* - All dimensions are in inches

** - Fillers in valleys are not required

TABLE II. Properties of jacket material.

Property	Value
Unaged	
Ultimate elongation, minimum average percent	175
with no value less than, percent	150
Tear resistance, minimum lb./in.	15
Cold tension recovery at -55 °C, minimum percent	20
Hot tension recovery at 85 °C, minimum percent	75
Free sulfur, maximum percent	.25
Tensile strength, minimum psi	1500
Set, maximum inch	.375
Tensile stress, (200 percent elongation, minimum psi)	300
Brittleness temperature, unaged, max, °C	-55
Aged	
Oxygen bomb, 95 ±1 hour at 70 °C	
Change in tensile strength, maximum percent	25
Change in elongation, maximum percent	35
Air oven, 168 ±1 hour at 100 °C	
Change in tensile strength, maximum percent	20
Change in elongation, maximum percent	60
Ozone resistance after oven-aging	No cracks
Brittleness temperature, after aging, max. °C	-55
Torsional stiffness ratio, max	10

3.8 Requirements of the completed cord. The completed cord shall meet the requirements specified in table III when tested under the applicable test paragraph, except that the extension or retraction requirements and tests of 4.7.7, 4.7.7.2, 4.7.7.3, 4.7.7.4, 4.7.9, 4.7.11 and 4.7.12 do not apply to straight cords.

TABLE III. Cord requirements.

Test paragraph	Property	Value
4.7.7	Cord retractility	Contiguous
4.7.7.1	Breaking load, minimum pounds 2-conductor cords only	70 60
4.7.7.2	Cord extension (7:1) force, maximum ounces	32
4.7.7.3	Retraction after static vertical loading, percent of original length:	
	Stranded wire cord, maximum percent	120
	Tinsel wire cord, maximum percent	110
4.7.11	Stretch cycling (6:1) extension):	
	Variation in resistance during cycling, maximum percent	5
	Increase in resistance during or after cycling, maximum percent	10
	Retraction after cycling, maximum percent of original length	120
4.7.10	Bending flex (180°):	
	Stranded wire cord, minimum number of cycles	5,000
	Tinsel wire cord, minimum number of cycles	15,000
4.7.7.4	Low temperature (-55 °C) extension and retraction:	
	Cord extension (4:1) force, maximum ounces	35
	Retraction, percent of original length: Stranded wire cord, maximum percent Tinsel wire cord, maximum percent	 160 125
4.7.8	Cold bend (-55 °C)	No cracks
4.7.9	Low temperature (-55 °C) rapid extension	No cracks
4.7.12	Retraction at 85 °C, maximum percent of original length	275
4.7.13	Voltage withstand, as received, test volts	1,000 without breakdown
4.7.14	Insulation resistance, as received minimum megohms	1,000
4.7.15	Continuity	No opens
4.7.16	Humidity cycling	
4.7.13	Voltage withstand, test volts	1,000 without breakdown
4.7.14	Insulation resistance per finished cord length, minimum megohms	1,000
4.7.15	Continuity	No opens
4.7.17	Simulated storage, 336 ±2 hrs & 85 ±1 °C	
4.7.13	Voltage withstand, test volts	1,000 without breakdown
4.7.14	Insulation resistance, per finished cord length, minimum megohms	1,000
4.7.9	Low temperature (-55 °C) rapid extension	No cracks

3.9 Workmanship. The cords shall be a uniform and consistent product and shall be free from any defects which will adversely affect the serviceability of the product, such as lumps, kinks, splits, abrasions, scrapes, corroded surfaces, skin impurities and faulty extruded surfaces.

3.10 Recycled, recovered, or environmentally referable materials. Recycled, recovered, or environmentally preferable materials should be used to the maximum extent possible, provided that the material meets or exceeds the operational and maintenance requirements, and promotes economically advantageous life cycle costs.

3.11 Pure tin. The use of pure tin is prohibited both internally and externally. Tin content of cable components and solder shall not exceed 97 percent. Tin shall be alloyed with a minimum of 3 percent lead by mass (see 6.9).

4. VERIFICATION

4.1 Classification of inspections. The inspection requirements specified herein are classified as follows:

a. First article inspection (see 4.5).
b. Conformance inspection (see 4.6).

4.2 Requirements cross-reference matrix. Table IV provides a cross-reference matrix of the section 3 requirements tested or verified in the paragraphs below.

TABLE IV. Requirements cross-reference matrix.

Requirement paragrah	Verification paragraph	Requirement paragraph	Verification paragraph
3.1	4.5	3.4.2	4.7.1
3.2.1	4.7.1	3.4.2.1	4.7.1
3.2.1.1	4.7.2.1	3.5	4.7.1
3.2.1.2	4.7.2.2	3.5.1	4.7.14
3.2.1.3	4.7.2.3	3.6	4.7.1, 4.7.3, 4.7.3.1, 4.7.3.2
3.2.2	4.7.1	3.6.1	4.7.1, 4.7.6
3.3	4.7.1, 4.7.3, 4.7.3.1, 4.7.4	3.6.2	4.7.1, 4.7.6, 4.7.6.1
3.3.1	4.7.1, 4.7.4, 4.7.4.1, 4.7.4.2		4.7.1
3.3.2	4.7.1, 4.7.4, 4.7.4.1, 4.7.4.2		
3.3.3	4.7.1, 4.7.3, 4.7.3.1, 4.7.3.2, 4.7.4, 4.7.4.1, 4.7.4.2	3.8	4.7.1, 4.7.7, 4.7.7.1, 4.7.7.2, 4.7.7.3, 4.7.7.4, 4.7.8, 4.7.10, 4.7.11, 4.7.12, 4.7.13, 4.7.13.1, 4.7.13.2, 4.7.13.3, 4.7.14, 4.7.15, 4.7.16, 4.7.17
3.4	4.7.1	3.9	4.7.1
3.4.1	4.7.1		

4.3 Inspection equipment and facilities. Inspection equipment and facilities shall be established and maintained. ISO 10012-1 and NCSL Z540.3 or comparable standards are available as guidance.

4.4 Materials inspection. Materials inspection shall consist of certification supported by verifying data that the materials specified in table V, used in fabricating subminiature cords, are in accordance with the applicable referenced specification or requirements prior to such fabrication.

TABLE V. Materials inspection.

Material	Requirement paragraph	Applicable specification
Tinsel wire	3.2.2	N/A
Insulation	3.3	ASTM D1248 and ASTM D4101
Fillers, Center core	3.4.1	- - - - - - -
Cellulose triacetate		MIL-C-572, type CTA
Polyester		MIL-C-572, type PSTR
Polypropylene		- - - - - - -
Staycords	3.4.2	MIL-C-572, type PAA
Polyester tape	3.5	MIL-I-631, type G
Jacket material	3.6.1 and table I	Table II

4.5 First article inspection. First article inspection shall be performed by the supplier after award of contract and prior to production, at a location acceptable to the government (see 6.4). First article inspection shall be performed on sample units which have been produced with equipment and procedures normally used in production (see 3.1).

4.5.1 Sample size and test routine. Twenty-five sample units shall be subjected to the tests specified in table VI. These sample units shall be of sufficient length to perform the tests specified.

TABLE VI. First article inspection tests.

Requirement	Property
3.2.1	Stranded wire construction, coating; tensile strength and elongation of stranded conductor.
3.2.1.3	Stranded wire conductor resistance.
3.2	Tinsel wire construction, properties.
3.3	Insulation properties.
3.3.1	Insulation wall thickness.
3.3.2	Dimensions of insulated conductors.
3.3.3	Insulation colors.
3.4	Fibers and yarns.
3.4.1	Fillers.
3.4.2	Staycord.
3.5	Shield wire; construction, coverage, outside diameter.
3.5.1	Shield resistance.
3.6	Jacket wall thickness and outside diameter.
3.6.1	Jacket material properties.
3.7	Cord construction.
3.8	Cord properties: Retractility, breaking load, cord extension (7:1) force, retraction after static vertical loading, low temperature extension and retraction, cold bend, retraction at 85 °C, voltage withstand, insulation resistance, continuity, stretch cycling, bending flex, humidity cycling and simulated storage.

4.5.2 Failures. No failures of the tests specified in table VI are permitted.

4.6 Conformance inspection.

4.6.1 Inspection lot. An inspection lot shall consist of all cords of the same type (see 3.7) processed under essentially the same conditions and submitted for inspection at the same time.

4.6.1.1 Unit of product. The unit of product, for purposes of sampling, shall be each continuous length of cord as specified in the contract or order.

4.6.1.2 Inspection sample. The inspection sample shall be product selected at random and shall be of the size specified in table VII.

TABLE VII. Inspection sample.

Production lot size 1/	Sample size
2 to 8	2
9 to 15	3
16 to 25	5
26 to 50	8
51 to 90	13
91 to 150	20
151 to 280	32
281 to 500	50
501 to 1200	80
1201 to 3200	125
3201 to 10000	200
10001 to 35000	315

NOTE: 1/ Lot size will be based on number of reels, spools, or coils of product

4.6.1.3 Selection of test specimens. Test specimens for inspection shall be taken from each unit of product which forms part of the sample.

4.6.1.4 Nonconforming inspection lots. Lots found unacceptable shall be resubmitted for reinspection only after all units are re-examined or re-tested and all nonconforming units are removed or nonconformities corrected. The responsible authority shall determine whether normal or tightened inspection shall be used on reinspection and whether reinspection shall include all types or classes of nonconformities or only the particular types or classes of nonconformities which caused the initial rejection.

4.6.1.5 Finished cords. A finished (or completed) cord is one of a definite length, or a continuous length of straight cord on a reel, spool or coiled as specified in the contract or order, with all manufacturing operations completed.

4.6.2 Group A inspection. Group A inspection shall include the examinations and tests of table VIII, subgroups I and II.

4.6.2.1 Subgroup I and II acceptance. Each sample selected in accordance with 4.6.2 shall be examined to determine conformance with the requirements of table VIII. If one or more defects are found in the inspection sample, then the production lot shall be inspected for that particular defect and defects removed. A second inspection sample shall be selected from the production lot and all sampling tests performed again. If one or more defective items are found in the second inspection sample, the production lot shall be rejected and shall not be supplied to this specification. Tests for subgroup I may be performed in any order. Tests for subgroup II shall be performed in the order specified in table VIII.

TABLE VIII. Group A inspection.[1/]

Examination or test	Requirement paragraph	Test method paragraph
Subgroup I	3.2 through 3.7 and 3.9	
Visual and mechanical		
Material and construction		
Workmanship		4.7.1 4.7.1
Subgroup II	Table III	
Electrical		
Voltage withstand		4.7.13
Insulation resistance		4.7.14
Continuity		4.7.15

1/ All electrical defects are considered major.

4.6.2.2 Rejected lots. If an inspection lot is rejected, the supplier may withdraw the lot from further inspection. The supplier may also rework a rejected lot to correct the defects or screen out the defective units and reinspect the lot in accordance with 4.6. Rejected lots shall be kept separate from new lots and shall not lose their identity.

4.6.3 Group B inspection. This inspection, including sampling, as specified in table IX. Group B inspection shall be performed on inspection lots that have passed group A inspection and on specimens selected from units of product that have been subjected to and met the group A inspection. Sample size selection shall be in accordance with table X.

4.6.3.1 Group B acceptance. Each sample selected in accordance with 4.6.3 shall be examined to determine conformance with the requirements in table IX. If one or more defects are found in the inspection sample, then the production lot shall be inspected for that particular defect and defects removed. A second inspection sample shall be selected from the production lot and all inspections performed again. If one or more defective items are found in the second inspection sample, the production lot shall be rejected and shall not be supplied to this specification. Group B inspection shall be performed in any order which is satisfactory to the government.

4.6.3.2 Disposition of samples. Samples subjected to group B tests shall not be delivered on contract or order.

TABLE IX. Group B inspection.

Examination or test	Requirement paragraph	Test method paragraph
Subgroup I	3.2.1.1, 3.2.1.2 3.2.1.3	
Stranded wire		
Tin-coating		4.7.2.1
Tensile strength and elongation		4.7.2.2
Resistance		4.7.2.3
Subgroup II	Table III, except as modified by 3.8 requirement paragraph	
Cord		
Retractility		4.7.7
Breaking load		4.7.7.1
Extension force		4.7.7.2
Retraction after static vertical loading		4.7.7.3
Bending flex		4.7.10
Stretch cycling		4.7.11
Examination or test		
Low temperature (-55 °C)		
extension and retraction		4.7.7.4
Cold bend		4.7.8
Retraction at 85 °C		4.7.12

TABLE X. Small sample inspection.

Lot size (passed group A inspection)	Sample size
2 to 8	2
9 to 15	2
16 to 25	2
26 to 50	3
51 to 90	3
91 to 150	3
151 to 280	5
281 to 500	5

4.6.4 Group C inspection. This inspection shall consist of the tests specified in table XI and shall be performed periodically as indicated in 4.6.4.1. Samples shall be selected from lots that have passed group A and B inspection.

TABLE XI. Group C inspection.

Examination or test	Requirement paragraph	Test method paragraph
Low temperature rapid extension	Table III, except as modified by 3.8	4.7.9
Humidity cycling		4.7.16
Simulated storage		4.7.17

4.6.4.1 Inspection sample. One sample shall be selected per each 5,000 feet of cord or fraction thereof, not to exceed a total of five samples per order. Samples shall be selected periodically through the life of the contract to assure representative results.

4.6.4.2 Noncompliance. No failures shall be allowed in group C inspection. If a sample unit fails to pass group C inspection, acceptance of the product shall be discontinued until corrective action, acceptable to the government, has been taken. After the corrective action has been taken, group C inspection shall be repeated on additional sample units (all inspections or the inspection that the original sample failed, at the option of the government). Groups A and B inspection may be reinstituted; however, final acceptance shall be withheld until the group C reinspection has shown that the corrective action was successful. In the event of failure after reinspection, information concerning the failure and the corrective action taken shall be furnished to the cognizant inspection activity and the qualifying activity.

4.7 Test methods.

4.7.1 Visual and mechanical inspection. The finished cords shall be given a visual and mechanical inspection for conformance to the applicable requirements of table VIII.

4.7.2 Stranded wire.

4.7.2.1 Tin-coating. The tin-coating on the conductor strands and the continuity, adherence, and finish shall pass the applicable tests specified in ASTM B33.

4.7.2.2 Tensile strength and elongation. This test shall be performed in accordance with FED-STD-228, method 3211.

4.7.2.3 Stranded wire resistance. The direct current resistance of conductors shall be measured after being insulated, but prior to cabling, in accordance with FED-STD-228, method 6021.

4.7.3 Insulation and jacket tension recovery. The apparatus and procedure for tension recovery of insulation and jacket shall be in accordance with table II, Cold tension recovery, except as specified below.

4.7.3.1 Specimens. Specimens for tension recovery shall be tubular, taken from straight sections of the finished cord.

4.7.3.2 Procedure. The specimen shall be stretched at room temperature to 50 percent elongation and conditioned for 23±1 hours at the specified test temperature. At the end of the conditioning period, the specimen shall be released and the percent recovery shall be measured at the end of one minute.

4.7.4 Testing of insulation. Properties of the insulation, as removed from finished cord, shall be determined in accordance with ASTM D1248, except as specified below.

4.7.4.1 Tensile strength and elongation. The speed of jaw separation shall be two inches per minute.

4.7.4.2 Tubing requirements of insulation. To determine whether the extrusion process has caused strains in the insulation, a specimen of each insulated conductor, taken from the straight section of a finished cord, shall be looped back and then wound tightly on itself for 5 close turns, the ends securely taped, and the specimen placed in a circulating air oven maintained at 121±1 °C for a period of 60±2 minutes. After removal from the oven, the specimen shall show no evidence of cracking of the insulation when examined under 3X magnification.

4.7.5 Shield coverage. Shield coverage shall be calculated as follows:

$$K = \frac{NPd}{\sin a} * 100$$

where:

K = Percent coverage
N = number of tinsel strands per carrier
P = picks per inch of cable length
d = diameter of tinsel strand in inches
a = angle of serving with axis of conductor

$$\text{Tan } a = 2\pi(D + d) * \frac{P}{C}$$

where:

D = diameter under served shield, in inches
C = number of carriers

4.7.6 Testing of jacket material. Properties of the jacket material shall be specified in table II, except as indicated herein.

4.7.6.1 Ozone resistance test. The specimen shall be a completed cord or helical section thereof. The specimen shall be air-oven aged at 70±1 °C for a period of 168±1 hours in an unstressed condition and allowed to cool to room temperature prior to placement in the ozone chamber. A 2 inch (50.8 mm) (minimum) section of the helical section shall be stretched 5:1 and maintained in this elongated condition while in the ozone chamber and during examination for cracks at room temperature.

4.7.7 Cord retractility. Prior to meeting any extensile and retractile requirements, the completed cord shall be conditioned by extending the coiled portion to five times its retracted length and allowing it to retract freely for a total of 6 cycles. After this conditioning, the cord shall be placed on a horizontal surface and the coils examined for contiguity (see table IV).

4.7.7.1 Breaking load. The test specimen shall be a straight cord or a retractile cord, as applicable. The straight cord shall be approximately 1 foot long; the retractile cord (or section thereof) shall contain at least five helical turns and shall be approximately 1 foot long in extended length including a straight section. For retractile cords with less than five turns, the entire cord shall be used. The breaking load shall be determined on a power driven tensile testing machine. The test shall be made at the rate of 12 inches (305 millimeters) per minute. The conductors of the cord may be connected in series to an indicating or signaling device or automatic stop, or both. The arrangement shall be such that an indication will be given when there is a disruption of electrical continuity due to the breaking of the conductors of the cord under test. The minimum load shall be as specified in table IV.

4.7.7.2 Cord extension force. The finished cord, or helical portion thereof, in a horizontal position shall be fastened at one end, with all coils contiguous. The length of the helical portion shall be measured and a tensile force applied to the free end of the cord, sufficient to extend the helical portion seven times its retracted length. The maximum force required for this extension shall be as specified in table IV.

4.7.7.3 Retraction after static vertical loading. At room temperature, the finished cord shall be secured at one end and hung vertically with a weight attached to the lower end, sufficient to extend the helical portion of cord to 250±1 percent of its original horizontal retracted length. After 48 hours, the weight shall be removed and the cord placed on a horizontal surface. This surface shall be tapped to reduce frictional restraint. Thirty minutes after being placed on the horizontal surface, the helical portion of the cord shall be measured to determine percent retraction of original length (see table IV). Percent retraction shall be calculated as follows:

$$\text{Percent Retraction} = \frac{\text{Retracted length after extension}}{\text{Original retracted length}} * 100$$

4.7.7.4 Low temperature (-55 °C) extension and retraction. A 6-inch (152 millimeter) helical portion of a completed cord with all coils contiguous shall be placed in a horizontal position within an environmental test chamber maintained at -55±1 °C, fastened at one end, and conditioned for not less than 20 hours prior to testing. If the helical portion of the finished cord is less than 6 inches (152 millimeters) long, the complete cord shall be used and measurements made of the helical portion. At the conditioning temperature, a force shall be applied to the free end of the cord sufficient to extend the helical portion four times its retracted length within 5 seconds. The maximum force shall be as specified in table IV. Upon release of the force and while still at -55 °C, within 30 seconds after release, the helical portion of the specimen shall retract to not more than the percent of its original length as specified in table IV. Frictional restraint shall be minimized by tapping the surface on which the cord rests. Upon visual examination at room temperature, the jacket, insulation, and conductors in both extended and retracted states shall be free of cracks and other defects.

4.7.8 Cold bend. Specimens shall be taken from the straight portions of the cords. The specimens from any one cord shall be divided, one part for checking the finished cord as a whole (jacketed cord) and the other for checking insulation, as specified in table IV. The part selected for checking insulation shall have the insulated conductors removed for test; shielding, if any, shall be removed. Each insulated conductor shall be tested. The test specimens shall be attached to mandrels of diameters equal to the diameters of the specimens, and shall be suspended vertically with lower ends weighted sufficiently to keep the specimens taut and to permit bending them without handling. The mandrels and specimens shall be placed for at least 24 hours in a cold chamber maintained at -55±1 °C. While at this temperature, the specimens shall be bent for five close turns around the mandrels at the rate of one turn per second. After removal from the cold chamber, the specimens shall be examined under 3X magnification for cracks, breaks, or other faults. Jacketed specimens shall be stripped and the insulation of the conductors examined.

4.7.9 Low temperature rapid extension. The test specimen shall be a completed cord if the helix is not greater than 9-inches long, or portion thereof including one straight end and at least 8 inches of the helical section. The specimen, with all coils contiguous, shall be placed in a horizontal position within a cold chamber and conditioned for 7 days at -55±1 °C. While at -55 °C, the specimen shall be secured at one end so that the cord hangs vertically, with a straight section at the bottom. A 1-pound (minimum) weight shall be attached to the free straight end and then allowed to fall. The distance of fall shall be sufficient to extend the helical portion of the cord to four times its retracted length. After removal from the test chamber, the cord shall be examined under 3X magnification for cracks or other defects in the jacket and conductor insulation (see table IV).

4.7.10 Bending flex. The test specimen shall be a finished straight cord (or convenient length thereof), or a finished retractile cord, as applicable. The cord-flexing machine shall contain a rotating actuating arm whose normal zero position is vertical. The arm shall rotate about a horizontal axis, the outer end traversing a circular arc in a vertical plane. The arm shall rotate 90 degrees from the zero position to a position 90 degrees from the zero position in the opposite direction and then reverse its direction and rotate back to zero position, thus completing a cycle. The arm shall be rotated at approximately 14±1 cycles per minute. Two adjustable-position mandrels, each approximately .300 inches (7.62 millimeters) in diameter, shall be mounted in the machine with their axes perpendicular to the plane of rotation of the actuating arm. The plane through the axes of the two mandrels shall be horizontal and shall pass through the axis of rotation of the actuating arm. The mandrels shall be placed so that the axis of rotation lies midway between the mandrels. With the fixture positioned vertically, the specimen shall be clamped 2 inches above the helix, so that the straight end protrudes above the clamping device and passes between the mandrels with some slight clearance. The conductors and shields shall be wired in series and connected to the electrical test apparatus as indicated by the schematic on figure 1. (A cord identical to the one being tested is also wired in series, and connected as the reference leg of the Wheatstone Bridge). A 5-pound weight shall be attached to the 10th convolution of the helix (counting from the clamped end down). If the helix has less than 10 turns, the weight shall be clamped to the lower straight end, as near as possible to the helix. The test weight shall be restricted from twisting (to simulate service conditions) by a slack anchor attached to the weight. The electrical test circuit is energized and meter null adjustments made with the variable resistor. A mechanical counter shall be used to record the number of cycles. The meter relay shall be set to trip at a fluctuation of 50 milliohms (±25 milliohms from the null point) in the resistance of the specimen, terminating the test. Tests on tinsel wire conductors shall be discontinued, if no failure occurs, at the number of cycles specified in table IV. Tests on stranded wire conductors shall be run until failure, and the number of cycles recorded for comparison with the requirements in table IV.

4.7.11 Stretch cycling. The test specimen shall be the finished cord, or, for very long cords, at least an 8 inch helical section. The resistance (R_i) of each conductor shall be measured prior to cycling. The helix shall then be extended to 6 times its retracted length and allowed to retract. This stretch cycle shall be repeated 60,000 times at a rate of not more than 40 cycles per minute. At the completion of 60,000 cycles, twenty five (25) additional cycles shall be run; during this period, the conductor resistance shall be monitored continuously and recorded.

(a) The percent variation in resistance during these cycles shall be calculated as follows:

$$\text{Percent variation} = \frac{R_v}{R} * 100$$

Where R = The conductor resistance in ohms at the start of the final cycling.

R_v = Difference between highest and lowest resistance values of the conductor during the cycling.

(b) The percent increase in conductor resistance due to cycling shall be calculated as follows:

$$\text{Percent increase} = \frac{R_m - R_i}{R_i} * 100$$

Where R_i = The conductor resistance in ohms before cycling,

R_m = Maximum resistance of the conductor during cycling or at completion of cycling, whichever is higher.

The maximum percent variation in the resistance of any conductor shall be as specified in table IV. At the completion of the cycling test, the maximum percent increase in resistance of any conductor over the resistance before cycling shall be as specified in table IV. All resistance measurements shall be at or corrected to 20 °C. The helical portion of the test specimen shall be measured for percent retraction within 1 hour after completion of the cycling. Measurements shall be made on a horizontal surface as specified in 4.7.7.3. The maximum percent retraction shall be as specified in table IV.

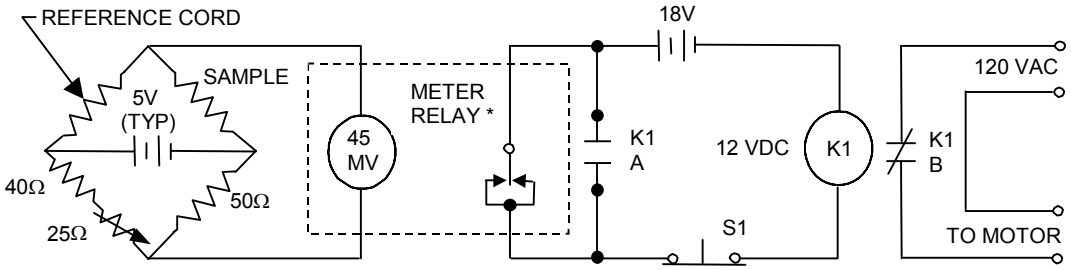

FIG. A FIG. B FIG. C

NOTES:

1. * Zero center, approximate full scale sensitivity 45 mv, or equal (see 6.).

2. Figure A shows the sample cord connected as one arm in a Wheatstone Bridge. The opposite leg (reference cord) is an identical cord used to balance out temperature fluctuations in the sample. The meter relay is set to trip at a fluctuation of ±25 milliohms.

3. Upon tripping, the control relay K1 is pulled in, normally open contacts K1A are closed, and K1 latches in the energized position until release switch S1 is depressed as shown on figure B.

4. Figure C shows the second pole of relay K1 as it is used to control the flex tester motor.

5. The power supply is shown as a battery for simplicity.

FIGURE 1. Basic circuit used for 180 degree bending flex control.

4.7.12 Retraction at 85 °C. The test specimen shall be a completed cord. With the helical section extended to three times its retracted length, the cord shall be conditioned in a circulating air oven maintained at 85±1 °C for 20 hours. At the end of this period and while in the oven at 85 °C, the helical section shall be extended further, to five times its retracted length, and returned to its original retracted length. The extension and retraction shall be repeated for a total of three cycles. The cord shall then be suspended vertically and measured for retraction at the end of 15 seconds the percent retraction (calculated based on original horizontal retracted length) shall meet the requirements specified in table III.

4.7.13 Voltage withstand. The finished retractile cord, or convenient length of straight cord, as applicable, shall be immersed in tap water, at room temperature, for at least 9 hours prior to testing. During the test, neither the extreme ends of the cord nor the bared conductor wires shall be immersed in water. Cord shall meet the requirements of table IV.

4.7.13.1 High-voltage source. The voltage withstand test shall be made with an alternating potential of commercial power frequency, having a wave form as nearly sinusoidal as practicable. The testing transformer and power source shall be capable of supplying no less than 3.0 kVA.

4.7.13.2 Voltage measurements. The testing voltage may be measured by any approved method which gives a root-mean-square value, preferably by means of a voltmeter connected to a special voltmeter coil in the high-voltage winding of the testing transformer or to a separate step-down transformer. A voltmeter on the low-voltage side of the transformer is satisfactory, provided the ratio of transformation does not change under any test condition.

4.7.13.3 Procedure. An alternating potential as specified in table IV shall be applied between two terminals, one being each conductor in turn, and the other being all the remaining conductors tied together in electrical contact with the water. The initially applied voltage shall be no greater than 600 volts, and the rate of increase shall be approximately uniform and not over 100 percent in 10 seconds, nor less than 100 percent in 60 seconds. The specified test voltage shall be applied for not less than one minute unless breakdown occurs prior to that.

4.7.14 Insulation resistance. The insulation-resistance measurements shall be made on sample units which have successfully passed the voltage withstand test (see 4.7.13). The apparent insulation resistance shall be measured as soon as practicable after the voltage withstand test. The leakage current shall be measured after a 1-minute electrification with a direct-current potential of not less than 100V or more than 500V. The polarity of the conductor wire shall be maintained negative with respect to the water. The insulation resistance of each cord shall be measured as follows: A direct current potential shall be applied between two terminals: (1) one terminal shall be all the conductors and shield wires tied together, and the other shall be the jacket surface which is in electrical contact with the water; (2) one terminal shall be each conductor wire in turn, and the other shall be all the remaining conductors plus all shield wires tied together in electrical contact with the water. If measurements are made at lower than 20 °C, the measured value of each resistance shall be corrected to 20 °C. The minimum resistance value per cord shall be as specified in table IV.

4.7.15 Continuity. Each conductor and shield of each length of finished cord or cord on reel, as applicable, shall be tested for continuity. The maximum test voltage shall be 10 volts (see table IV).

4.7.16 Humidity cycling. The test specimen shall be a finished cord which has passed the voltage withstand and insulation resistance tests as specified in table IV. The cord shall be placed in a humidity chamber, and the ends of the cord brought out through the walls of the chamber for electrical measurements. The humidity cycle shall be in accordance with MIL-STD-202, method 106, except step 7. Voltage withstand and insulation resistance shall be measured before start of the environmental cycle and during the 10th cycle, after step 6, at room temperature and 90-100 percent relative humidity (RH), with the specimen in the chamber, in accordance with 4.7.13 and 4.7.14, and shall meet the requirements in table IV. The specimen shall then be removed from the chamber and subjected to the bending flex test of 4.7.10 as specified in table IV.

4.7.16.1 Alternate humidity cycle. An alternate method of humidity cycling is as follows:

Step A: 16 ±1/2 hours at 65 °C at 90-100 percent RH
Step B: 8 ±1/2 hours at room temperature at 90-100 percent RH

Voltage withstand and insulation resistance measurements shall be made before start of the environmental cycle and after 4 but not more than 6 hours have elapsed in step A of the 10th cycle, with the specimen still in the chamber.

4.7.17 Simulated storage. The test specimen shall be a completed cord. The cord shall be aged in a circulating air oven for 336±2 hours at 85±1 °C, then cooled at room temperature for a minimum of 24 hours. Effects of plasticizer migration or loss shall be determined by testing voltage withstand, insulation resistance, and low temperature rapid extension as specified in 4.7.13, 4.7.14, and 4.7.9, and comparing with the requirements in table IV.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order. When packaging of materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the military service's system commands. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The basic cord covered by this specification is intended for use in subminiature audio helical retractile cords and straight cords for accessories such as microphone, telephone, switchboard, and associated communication equipment operating at audio frequencies and temperatures from -55 °C to +85 °C.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of this specification.
b. Type required (see 1.2).
c. Length and quantity of finished cords to be delivered.
d. Level of packaging and level of packing required (see 5.1).

6.2.1 Cord procurement data. The contract or order should specify the type of cord (see 1.2), number of insulated conductors (shielded and unshielded), and total length of cord. For retractile cords, the length of helix or number of turns, length of straight ends, and overall length of cord should be specified. In the event of any conflict between requirements of this specification and the contract or order, the latter will govern.

6.2.2 Indirect shipments. The preservation, packaging, packing and marking specified in section 5 apply only to direct purchases by or direct shipments to the government, and are not intended to apply to contracts or orders between the supplier and prime contractor.

6.3 Resistance values. Typical approximate resistance values for conductors and shields (corrected to 20 ºC) in a finished straight cord 120 inches long, or a finished retractile cord with a 12.5 inch (305.5 mm) length of helix (rated for extension to 75 inches) and 6 inch (152 millimeter) long straight ends, are:

Stranded wire cord:	Conductor	-	0.44 Ω
	Shield	-	2.5 Ω
Tinsel wire cord:	Conductor	-	2.3 Ω
	Shield	-	2.5 Ω

6.4 First article inspection. Information pertaining to first article inspection of cords covered by this specification should be obtained from the procuring activity for the specific contracts involved (see 3.1).

6.4.1 First article inspection on repeat orders. First article inspection will not be required from a supplier who has manufactured the same type cord (same type of wire, number of conductors, number of shielded conductors, same materials, etc.) on a previous order or contract within 2 years of the current order or contract, and which passed first article inspection at that time. A supplier who has passed first article inspection on a cord of a type classification as specified in 1.2 will be considered qualified on cords of the same type classification providing these cords contain the same total number of conductors and shielded conductors as, or a lesser total number of conductors or shielded conductors than the cords previously qualified and satisfactorily manufactured.

6.5 Meter relay. The meter relay called out in the basic circuit was Nalder Bros. & Thompson Ltd., London, Eng. Model SR6W5, zero center, approximate full-scale sensitivity 45 mv, or equal.

6.6 Control relay. The control relay used was a Potter & Brumfield (P&B) KRP II, or equal.

6.7 Subject term (key word) listing.

Bending
Elongation
Force
Shield
Staycord
Strength
Stretch
Stranded
Tinsel

6.8 Environmental. Environmental pollution prevention measures are contained in the packaging material specifications referenced herein. Refer to material specifications or preparing activity for recommended disposability methods.

6.9 Tin whisker growth. The use of alloys with tin content greater than 97 percent, by mass, may exhibit tin whisker growth problems after manufacture. Tin whiskers may occur anytime from a day to years after manufacture and can develop under typical operating conditions, on products that use such materials. Conformal coatings applied over top of a whisker-prone surface will not prevent the formation of tin whiskers. Alloys of 3 percent lead, by mass, have shown to inhibit the growth of tin whiskers. For additional information on this matter, refer to ASTM-B545 (Standard Specification for Electrodeposited Coatings of Tin).

6.10 Environmentally preferable material. Environmentally preferable materials should be used to the maximum extent possible to meet the requirements of this specification. As of the dating of this document, the U.S. Environmental Protection Agency (EPA) is focusing efforts on reducing 31 priority chemicals. The list of chemicals and additional information is available on their website http://www.epa.gov/osw/hazard/wastemin/priority.htm. Use of these materials should be minimized or eliminated unless needed to meet the requirements specified herein (see section 3).

6.11 Changes from previous issue. The margins of this specification are marked with vertical lines to indicate where changes from the previous issue were made. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship to the last previous issue.

CONCLUDING MATERIAL

Custodians:
Army – CR
DLA - CC

Preparing activity:
DLA - CC

(Project 6145-2008-126)

NOTE: The activities listed above were interested in this document as of the date of this document. Since organization and responsibilities can change, please verify the currency of the information above using the ASSIST Online database at http://assist.daps.dla.mil.