Hendrix Spacer Cable Systems, 15kV to 46 kV

1. Scope

This specification covers the minimum requirements for the design, manufacturing, testing and performance of cable, messenger and hardware components used in solidly grounded aerial spacer cable systems.

2. Performance requirements

The spacer cable system shall be designed for superior reliability compared to bare open wire systems. This includes the ability to support moderate size tree limbs or to support itself when a pole has been broken. The system shall be designed to withstand short term phase to phase contact or phase to ground contact without causing an outage. The system shall be capable of operating at ambient temperatures of -40° F to 120° F. The cable shall be designed to operate at 75 °C under normal conditions and at 95 °C under emergency overload conditions.

3. Reference Standards

The cable, messenger and hardware shall conform to the following specifications except where modified by this specification.

ANSI C2, “National Electrical Safety Code”

ASTM B 231, “Concentric Lay Stranded, Aluminum 1350 Conductors”.

ASTM B 400, “Compact Round Concentric Lay Stranded Aluminum 1350 Conductors”.

ASTM B 416, “Concentric Lay Stranded Aluminum Clad Steel Conductors”.

ASTM B 502, “Aluminum Clad Steel Core Wire for Aluminum Conductors, Aluminum Clad Steel Reinforced”

ASTM B 549, “Concentric Lay Stranded Aluminum Conductors, Aluminum Clad Steel Reinforced”.

ASTM D 1248, “Polyethylene Plastics Molding and Extrusion Materials”.

ICEA T-27-581, “Standard Test Methods for Extruded Dielectric Power Cables…”.

ICEA S-70-547, “Weather Resistant Polyolefin Covered Wire & Cable”.

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4. Covered Conductor

4.1 Conductor

The conductor material shall be 1350-H19 aluminum. Sizes #2 AWG and smaller shall be concentric round regular strand in accordance with ASTM B 231. Sizes 1/0 AWG and larger shall be compact concentric strand in accordance with ASTM B 400. The lay direction for all conductors shall be right hand lay. The stranding shall be class A or class AA. The center strand shall be indent marked with the manufacturers name and year of manufacture at 12 inch intervals. Standard conductor sizes are shown in tables 1a through 1d.

4.2 Conductor Shield

The conductor shield shall be an extruded black semiconducting polymer meeting the physical requirements of ICEA S-61-402. The nominal thickness is shown in tables 1a through 1d. The minimum thickness at any point shall not be less than 0.010”.

4.3 Covering

The covering shall consist of two layers which are thermally bonded to each other and to the conductor shield. The first layer shall be an extruded natural (clear) low density polyethylene which shall comply with ASTM 1248 for Type I, Class A, Category 5, Grade E3 material. The outer layer shall be an extruded black track resistant high density polyethylene which shall comply with ASTM 1248 for Type III, Class B, Category 4, Grade E9 or J4 material. The nominal thickness is shown in tables 1a through 1d. The minimum thickness of the two layers combined shall not be less than 90% of the nominal thickness.

Option: A gray outer layer is available upon request.

4.4 Manufacturing

The three layers shall be extruded in one pass. The overall diameter shall have a tolerance of + 0.020”/-0.010” from the nominal diameter shown in tables 1a through 1d. The concentricity of the three layers combined shall not be less than 85% for individual measurements and no less than 90% when averaged over the entire production run.

Table 1a, 15KV Cable Dimensions

Conductor Size	Type	Strands	Conductor Diameter	Conductor Shield Thickness (Nominal)	Insulation Thickness (Nominal)		Finished Diameter (Nominal)
					Inner	Outer	
#4 AWG	Round	7	0.232”	0.015”	0.075”	0.075”	0.562”
#2 AWG	Round	7	0.292”	0.015”	0.075”	0.075”	0.622”
1/0 AWG	Compact	7	0.336”	0.015”	0.075”	0.075”	0.666”
2/0 AWG	Compact	7	0.376”	0.015”	0.075”	0.075”	0.706”
3/0 AWG	Compact	7	0.423”	0.015”	0.075”	0.075”	0.753”
4/0 AWG	Compact	7	0.475”	0.015”	0.075”	0.075”	0.805”
266.8 KCM	Compact	7	0.537”	0.015”	0.075”	0.075”	0.867”
336.4 KCM	Compact	19	0.603”	0.015”	0.075”	0.075”	0.933”
397.5 KCM	Compact	19	0.659	0.015”	0.075”	0.075”	0.989”
477.0 KCM	Compact	19	0.722”	0.020”	0.075”	0.075”	1.062”
556.5 KCM	Compact	19	0.780”	0.020”	0.075”	0.075”	1.120”
636.0 KCM	Compact	19	0.835”	0.020”	0.075”	0.075”	1.175”
795.0 KCM	Compact	19	0.932”	0.020”	0.080”	0.080”	1.292”

Table 1b, 25KV Cable Dimensions

Conductor Size	Type	Strands	Conductor Diameter	Conductor Shield Thickness (Nominal)	Insulation Thickness (Nominal)		Finished Diameter (Nominal)
					Inner	Outer	
#2 AWG	Round	7	0.292”	0.015”	0.125”	0.125”	0.822”
1/0 AWG	Compact	7	0.336”	0.015”	0.125”	0.125”	0.866”
2/0 AWG	Compact	7	0.376”	0.015”	0.125”	0.125”	0.906”
3/0 AWG	Compact	7	0.423”	0.015”	0.125”	0.125”	0.953”
4/0 AWG	Compact	7	0.475”	0.015”	0.125”	0.125”	1.005”
266.8 KCM	Compact	7	0.537”	0.015”	0.125”	0.125”	1.067”
336.4 KCM	Compact	19	0.603”	0.015”	0.125”	0.125”	1.133”
397.5 KCM	Compact	19	0.659	0.015”	0.125”	0.125”	1.189”
477.0 KCM	Compact	19	0.722”	0.020”	0.125”	0.125”	1.262”
556.5 KCM	Compact	19	0.780”	0.020”	0.125”	0.125”	1.320”
636.0 KCM	Compact	19	0.835”	0.020”	0.125”	0.125”	1.375”
795.0 KCM	Compact	19	0.932”	0.020”	0.125”	0.125”	1.472”

Table 1c, 35KV Cable Dimensions

Conductor Size	Type	Strands	Conductor Diameter	Conductor Shield Thickness (Nominal)	Insulation Thickness (Nominal)		Finished Diameter (Nominal)
					Inner	Outer	
1/0 AWG	Compact	7	0.336”	0.015”	0.175”	0.125”	0.966”
2/0 AWG	Compact	7	0.376”	0.015”	0.175”	0.125”	1.006”
3/0 AWG	Compact	7	0.423”	0.015”	0.175”	0.125”	1.053”
4/0 AWG	Compact	7	0.475”	0.015”	0.175”	0.125”	1.105”
266.8 KCM	Compact	7	0.537”	0.015”	0.175”	0.125”	1.167”
336.4 KCM	Compact	19	0.603”	0.015”	0.175”	0.125”	1.233”
397.5 KCM	Compact	19	0.659	0.015”	0.175”	0.125”	1.289”
477.0 KCM	Compact	19	0.722”	0.020”	0.175”	0.125”	1.362”
556.5 KCM	Compact	19	0.780”	0.020”	0.175”	0.125”	1.420”
636.0 KCM	Compact	19	0.835”	0.020”	0.175”	0.125”	1.475”
795.0 KCM	Compact	19	0.932”	0.020”	0.175”	0.125”	1.572”

Note: Consult factory for sizes not shown.

Table 1d.
Dimensions, 46KV

Conductor Size	Type	Strands	Conductor Diameter	Conductor Shield Thickness (Nominal)	Insulation Thickness (Nominal)		Finished Diameter (Nominal)
					Inner	Outer	
1/0 AWG	Compact	7	0.336”	0.015”	0.225”	0.175”	1.166”
2/0 AWG	Compact	7	0.376”	0.015”	0.225”	0.175”	1.206”
3/0 AWG	Compact	7	0.423”	0.015”	0.225”	0.175”	1.253”
4/0 AWG	Compact	7	0.475”	0.015”	0.225”	0.175”	1.305”
266.8 KCM	Compact	7	0.537”	0.015”	0.225”	0.175”	1.367”
336.4 KCM	Compact	19	0.603”	0.015”	0.225”	0.175”	1.433”
397.5 KCM	Compact	19	0.659	0.015”	0.225”	0.175”	1.489”
477.0 KCM	Compact	19	0.722”	0.020”	0.225”	0.175”	1.562”
556.5 KCM	Compact	19	0.780”	0.020”	0.225”	0.175”	1.620”
636.0 KCM	Compact	19	0.835”	0.020”	0.225”	0.175”	1.675”
795.0 KCM	Compact	19	0.932”	0.020”	0.225”	0.175”	1.772”

Note: Consult factory for sizes not shown.

4.5 Testing

4.5.1 Qualification Tests

Qualification tests shall consist of all the production tests required in section 4.5.2. In addition, the outer layer shall meet the requirements in table 2 below. Qualification data shall be submitted upon request of the purchaser.

Table 2
Qualification Tests for Covered Conductors

Test	Reference Standard	Requirement
Environmental Stress Cracking	ASTM D 1693	No Cracking
Weatherometer Test	ASTM G 155, Method A	ICEA S-70-547

4.5.2 Production Tests

Production tests are shown in table 3. Tests that apply to raw materials shall be performed on a sampling basis. Tests that apply to finished cable shall be performed on each reel. Tests reports shall be furnished upon request.

The AC spark test shall be performed continuously as the cable is extruded. The applied voltage shall be the voltage shown in table 3 multiplied by the thickness in mils of both insulating layers combined.

Table 3
Production Tests for Covered Conductors

Test	Component	Reference Standard	Requirement
Conductor Diameter	Conductor	ASTM B231, ASTM B400	Tables 1a -1d above
Wall Thickness	Finished Cable	---	Tables 1a -1d above
Concentricity	Finished Cable	---	85% min.
Finished Diameter	Finished Cable	---	Tables 1a -1d above
DC Resistance*	Conductor	ICEA T-27-581	ASTM B231,B400
Track Resistance	Outer Covering	ASTM D 2303	1000 minutes minimum time to track at 2500 volts.
Tensile Strength* & Elongation*	Conductor Shield	ICEA T-27-581	1400 PSI, 200%
	Covering	ICEA S-70-547	LDPE: 1800 PSI, 500% HDPE: 2800 PSI, 400%
Volume Resistivity*	Conductor Shield	ICEA T-27-581	500 Ω•cm
Spark Test, AC	Finished Cable	ICEA T-27-581	100 Volts AC/mil

* Test data from raw material supplier is acceptable.

4.6 Cable Marking

The finished cable shall be marking with sequential footage numbers at an interval of two feet.
Note: Standard marking is in feet. Meter marking is available upon request.

4.7 Packaging

Completed conductor shall be packaged in continuous lengths on non-returnable wooden reels. Reels shall meet the requirements of NEMA WC-26. The actual length shall have a tolerance of -0/+5% from the nominal length.

4.7.1 Reel Tags

A weather resistant reel tag shall be attached to the outside of the flange. The tag shall include the ship to location, length of cable, gross, net and tare weight, purchase order #, manufacturers name, date of manufacture, conductor size and stranding, conductor material, covering material and thickness, manufacturers production order number and reel serial number.

5. Messenger Wire

The messenger shall be an alumoweld or alumoweld-aluminum stranded wire. Alumoweld strands shall be hard drawn aluminum clad steel and aluminum wires shall be hard drawn 1350-H19 temper. The messenger shall not be stressed beyond 60 % of its ultimate strength when loaded with cables, spacers and the ice and wind loads given in rule 251 in the NESC code (ANSI C2). A messenger with a breaking strength of at least 10,000 lbs. is recommended for systems through 15 KV and at least 17,000 lbs for systems 25 KV through 46 KV.

Table 4
Standard Messenger Wires

Messenger	Diameter	Aluminum Strands	Alumoweld Strands	Breaking Strength	Weight
252 AWA	.386”	2 x .1285”	5 x .1285”	11,960 lbs.	218 lbs/1000 ft.
052 AWA	.486”	2 x .1620”	5 x .1620”	17,120 lbs.	346 lbs/1000 ft.
7#6 AW	.486”	N/A	7 x .1620”	22,730 lbs.	416 lbs/1000 ft.

Option: Higher strength messengers, higher conductivity messengers, copperweld messengers or fiberoptic messengers are available upon request.

6. Spacers

6.1 Design

The spacers shall be designed with sufficient mechanical strength to support the phase conductors at 30 foot intervals. The spacers shall hold the conductors in a diamond configuration with phase to phase spacing of at least 7 inches for systems through 15 KV and at least 10 3/4 inches for systems 25 KV through 46 KV. The leakage distance between any two phases or any phase to messenger shall be no less than 10 1/2 inches for systems through 15 KV and at least 17 3/4 inches for systems 25 KV through 46 KV.

6.2 Material

The spacer shall be molded of gray track resistant high density polyethylene which shall comply with ASTM 1248 for Type III, Class B, Category 4, Grade E9 or J4 material. The dielectric constant of the spacer shall be equal to that of the cable insulation.

6.3 Testing

6.3.1 Qualification Tests

Qualification tests shall consist of the requirements in table 5 below. Qualification data shall be submitted upon request of the purchaser.

Table 5
Qualification Tests for Polyethylene Spacers

Test	Reference Standard	Requirement
Environmental Stress Cracking	ASTM D 1693	No Cracking
Weatherometer Test	ASTM G 155, Method 1	ICEA S-70-547
Track Resistance Test	ASTM D 2303	1500 minutes minimum time to track at 2500 volts.

6.4 Ring Ties

The spacers shall be furnished with four ring ties to secure the messenger and conductors. The ring ties shall be designed so that they may be applied with a hot stick. The material shall be gray ultraviolet resistant EPR rubber.

Option: Spacer with an integral fastening mechanism for conductors and messenger may be specified in lieu of the spacer with rubber ring ties.

7. Insulators

Pin type insulators shall be molded from gray track resistance high density polyethylene which shall comply with ASTM 1248 for Type III, Class B, Category 4, Grade E9 or J4 material. The dielectric constant shall be equal to that of the cable insulation. The insulator shall have an insulating capacity equal to or greater than that of ANSI class 55-4 for 15 kV systems, ANSI class 55-5 for 25 KV systems and ANSI class 55-6 for 35 KV and 46 KV systems. The insulator shall fit on a standard 1 inch insulator pin.

7.1 Testing

7.1.1 Qualification Tests

Qualification tests shall consist of the requirements in table 6 below. Qualification data shall be submitted upon request of the purchaser.

Table 6
Qualification Tests for Polyethylene Insulators

Test	Reference Standard	Requirement
Environmental Stress Cracking	ASTM D 1693	No Cracking
Weatherometer Test	ASTM G 155, Method 1	ICEA S-70-547
Track Resistance Test	ASTM D 2303	1500 minutes minimum time to track at 2500 volts.

7.1.2 Production Tests

The Production test shown in table 7 shall be performed on a sampling basis to insure consistency of the product. Test reports shall be furnished upon request.

Table 7
Production Tests for Polyethylene Insulators

Test	Component	Reference Standard	Requirement
X-ray Examination	Insulators	N/A	No Voids

8. Pole Hardware & Brackets

All brackets must be designed for use with spacer cable so that the recommended conductor spacing is maintained. The spacer cable system shall be designed so that the brackets are not stressed beyond 50 % of their ultimate strength when subjected to the NESC ice and wind loading conditions. In addition, the hardware must be compatible with installation equipment provided by the manufacturer.

8.1 Tangent Brackets

Tangent brackets shall be fabricated from ductile iron galvanized to ASTM A-153. Tangent brackets shall be a minimum of 14 inches long for systems through 15 KV and 24 inches long for systems 25 KV to 46 KV. 14 inch brackets shall have a minimum vertical yield strength of 3200 lbs and 24 inch brackets shall have a minimum vertical yield strength of 4000 lbs. The mounting holes shall be 13/16 inch diameter and separation shall be 8 inches center to center.

8.2 Angle Brackets

Angle brackets shall be fabricated from galvanized steel channel iron. The bracket should be designed to support the conductors in a compact triangular configuration on polyethylene pin type insulators. The bracket should have a minimum vertical yield strength of 500 lbs. at each conductor position.

8.3 Deadend Brackets

Deadend brackets shall be fabricated from galvanized steel channel/angle iron. The bracket should be designed to support the conductors in a compact triangular configuration. The bracket should have a minimum vertical yield strength of 500 lbs. at each conductor position.

8.4 **Miscellaneous Hardware**

The supplier shall have available all the miscellaneous hardware required for the proper installation and operation of an aerial spacer cable circuit. This includes covered tie wire, transformer tap wire, wildlife guards, deadend insulators, deadend grips, shackles, clevises, angle clamps and insulator pins.

9. Installation Equipment

The manufacturer shall have available the stringing equipment for the installation of spacer cable. Single and three sheave blocks shall be available for installing the messenger and conductors at tangent poles and angle poles.

10. Engineering Assistance

The supplier shall have on staff engineering personnel to assist in the design of the circuit. This includes pole by pole material lists, sag & tension calculations, pole strength calculations and electrical calculations. The supplier shall have field service engineers available for on-site assistance during the installation of the spacer cable circuit.