Hendrix Spacer Cable Systems

35 kV, Renewable Application(s)

Hendrix®

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 used for Renewable Application.

2. Performance Requirements

The spacer cable system shall be designed for superior reliability specifically suited for collector circuits used in renewable applications. The spacer cable system provides benefits addressing challenging topography, conductor clashing, improved voltage regulation, minimizing de-rating issues normally associated with URD cable, multiple-circuit construction, use of optical messenger wire (OPGW), space considerations in right-of-way, environmental stewardship, as well as minimizing pole height requirements. The system shall be capable of operating at ambient temperatures of -40° C to 50° C. The cable shall be designed to operate at 75 °C or 90° C under normal conditions and at 100 °C under emergency overload conditions.

1. 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 Cable".

ICEA S-121-733, "Tree Wire and Messenger Supported Spacer Cable".

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4. Covered Conductor

4.1 Conductor

The conductor material shall be 1350-H19 aluminum. Sizes 4/0 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-121-733. 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 gray or 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.

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.

continued

Table 1c, 35kV Cable Dimensions

Note: *Consult factory for sizes not shown.*

Spacer Cable Conductor - 35kV - 3-Layer

Catalog Number	Size	Strands	Type	Conductor Diameter (in)	Finished Cable Diameter (in)	Cable Weight (lbs/1000 ft)
S0040PA35G3-00	4/0 AWG	7	Compact	0.475	1.105	548
S0266PA35G3-00	266.8 kcmil	7	Compact	0.537	1.167	625
S0336PA35G3-00	336.4 kcmil	19	Compact	0.603	1.233	721
S0397PA35G3-00	397.5 kcmil	19	Compact	0.659	1.289	803
S0477PA35G3-00	477.0 kcmil	19	Compact	0.722	1.362	903
S0556PA35G3-00	556.5 kcmil	19	Compact	0.78	1.42	1,004
S0636PA35G3-00	636.0 kcmil	19	Compact	0.835	1.475	1,102
S0795PA35G3-00	795.0 kcmil	19	Compact	0.932	1.572	1,315
S0954PA35G3-00	954.0 kcmil	37	Compact	1.024	1.664	1,469
S1033PA35G3-00	1033.5 kcmil	37	Compact	1.065	1.705	1,557
S1272PA35G3-00	1272.0 kcmil	61	Compact	1.183	1.835	1,841
S1351PA35G3-00	1351.5 kcmil	61	Compact	1.219	1.859	1,922
S1431PA35G3-00	1431.0 kcmil	61	Compact	1.260	1.900	2,016

Table 1d, 35KV Cable Ampacity Ratings

Conductor Size	Ampacity Table 75°C Gray 35kV Cable			
	40°C Ambient Temperature		50°C Ambient Temperature	
	Normal ①	Emergency ②	Normal ①	Emergency ②
4/0 AWG	277	373	220	337
266.8 KCMIL	319	430	253	388
336.4 KCMIL	367	495	290	447
397.5 KCMIL	406	549	321	495
477 KCMIL	452	613	357	553
556.5 KCM	496	674	391	607
636.0 KCM	537	731	423	659
795.0 KCM	614	838	482	755
954.0 KCM	684	937	536	844
1033.5 KCM	717	984	561	886
1272.0 KCM	810	1115	632	1004
1351.5 KCM	839	1156	654	1040
1431.0 KCM	867	1196	675	1076
① Normal Ampacity @ 750C Conductor Temperature, 2 ft/sec Wind, Sun				
② Emergency Ampacity @ 1000C Conductor Temperature, 2 ft/sec Wind, Sun				

Conductor Size	Ampacity Table 90°C Gray 35kV Cable			
	40°C Ambient Temperature		50°C Ambient Temperature	
	Normal①	Emergency②	Normal①	Emergency②
4/0 AWG	340	402	298	370
266.8 KCMIL	391	464	343	426
336.4 KCMIL	450	534	394	491
397.5 KCMIL	499	593	437	545
477 KCMIL	557	662	487	609
556.5 KCM	612	728	535	669
636.0 KCM	664	790	580	726
795.0 KCM	760	906	663	833
954.0 KCM	849	1014	741	932
1033.5 KCM	891	1065	777	978
1272.0 KCM	1008	1208	879	1110
1351.5 KCM	1045	1252	911	1151
1431.0 KCM	1081	1296	942	1191
① Normal Ampacity @ 900C Conductor Temperature, 2 ft/sec Wind, Sun				
② Emergency Ampacity @ 1100C Conductor Temperature, 2 ft/sec Wind, Sun				

4.5 Testing

4.5.1 Qualification Tests

Qualification tests shall consist of all the tests shown 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 Crack Resistance	ASTM D 1693	No Cracking
Weatherometer Test	ASTM G 155, Method A	80% retention of tensile strength & elongation after 720 hrs.
Track Resistance	ASTM D2303	1000 min @ 2500V

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	ICEA S-121-733	Tables 1a -1d above
Concentricity	Finished Cable	ICEA S-121-733	85% min.
Finished Diameter	Finished Cable	ICEA S-121-733	Tables 1a -1d above
DC Resistance*	Conductor	ICEA T-27-581	ASTM B231,B400
Tensile Strength* & Elongation*	Conductor Shield	ICEA T-27-581	1400 PSI, 200%
	Covering	ICEA S-121-733	LDPE: 1800 PSI, 500%
HDPE: 2800 PSI, 400%	795.0 kcmil	19	Compact
Elongation, Aged*	Conductor Shield	ICEA T-27-581	100% after 48 hrs @ 100°C
Tensile Strength & Elongation, Aged*	Covering	ICEA S-121-733	75% retention after
48 hrs @ 100°C	1272.0 kcmil	61	Compact
Heat Deformation*	Covering	ICEA T-27-581	30% max(≤ 266kcm)
10% max(> 266kcm)	1431.0 kcmil	61	Compact
Volume Resistivity*	Conductor Shield	ICEA S-121-733	1000 ohm- m
Spark Test, AC	Finished Cable	ICEA T-27-581	100 VAC/mil

**Test data from raw material supplier is acceptable.*

4.6 Cable Marking

The finished cable shall be marked 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 17,000 lbs. is recommended for 35kv systems.

Table 4: Standard Messenger Wires

Messenger	Equivalent Conductivity	Ampacity (amps)	Overall Diameter	Alumoweld Wires	Aluminum Wires	Weight	Rated Breaking Strength (lbs)
			(inches)	No. x dia (in.)	No. x dia (in.)	(lbs / 1000 ft)	
052 AWA	1/0 AL	253	0.486	5 x 0.1620	2 x 0.1620	346	17,120
7 No. 6 AW	#2 AL	201	0.486	7 x 0.1620	N/A	416	22,730
0052 AWA	2/0 AL	292	0.546	5 x 0.1819	2 x 0.1819	436	20,420
0000127 AWA	4/0 AL	431	0.722	12 x 0.1443	7 x 0.1443	699	32,670
19. No. 8 AW	1/0 AL	283	0.642	19 x 0.1285	N/A	714	43,240

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 11.5 inches for 35KV systems. The leakage distance between any two phases or any phase to messenger shall be no less 17.5 inches for 35KV systems.

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 Crack Resistance	ASTM D 1693	No Cracking
Weatherometer Test	ASTM G 155, Method 1	80% retention of tensile strength & elongation after 720 hrs.
Track Resistance Test	ASTM D 2303	1000 min @ 2500V

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 55-6 for 35 KV. The insulator shall fit on a standard 1-inch insulator pin.

7.1 Testing

7.1.1 Qualification

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 Crack Resistance	ASTM D 1693	No Cracking
Weatherometer Test	ASTM G 155, Method 1	80% retention of tensile strength & elongation after 720 hrs.
Track Resistance Test	ASTM D 2303	1000 min @ 2500V

7. Insulators

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

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 24 inches long for 35KV systems and 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. HDPE insulators shall be used. Vise Top insulators are recommended however, HDPE Line Post insulators are an option for larger conductors.

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.

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. Design Engineering and Field Service Support

The supplier shall have staff engineering personnel to assist in the design of the circuit. Design Engineering Services should include pole by pole material lists, sag & tension calculations, pole strength calculations, clearance checks and electrical calculations.

The supplier shall have field service technicians available for on-site assistance during the installation of the spacer cable circuit. This would include training in installation, operation and post maintenance. Supplier shall perform a final inspection with an inspection report which will include documentation of any deficiencies and recommended solutions.