

EmPowr® Link CL™ UL Type MV-105* Eco-nomical, Eco-efficient, Eco-friendly

EmPowr® Link CL™ — the next generation in renewable energy collection systems. It's the only medium-voltage cable that costs less now and pays more later.

- **Reduced upfront cost**
- **Environmentally friendly**
- **Better long-term efficiency**
- **Greater return on investment**

Our Non-stop Commitment

When specifying cables that effectively and efficiently operate under complex conditions, your options have changed. There's now something better. General Cable's team of experts has once again applied extensive R&D experience to re-engineer our medium-voltage cable, improving the performance of collection systems and making renewable energy more **eco-nomical, eco-efficient and eco-friendly** than ever before.

EmPowr Link CL — Eco-nomical

Through an innovative redesign of the cable's concentric neutrals, General Cable has succeeded in reducing the amount of high-cost copper to cut initial material costs.

EmPowr Link CL — Eco-efficient

This exciting breakthrough features the latest in Cross-linked Polyethylene (XLPE) cable jacketing coupled with reduced concentric neutrals, providing better efficiency over the life of the cable through cooler operation, lower line loss and greater resistance to deformation.

EmPowr Link CL — Eco-friendly

General Cable's EmPowr Link medium-voltage cables are already the greenest choice for wind farm construction. EmPowr Link offers high dielectric strength with the lowest dielectric loss characteristics of any medium-voltage cable type. With its built-in cost benefits and long-term efficiencies, CL is the total green solution — allowing you to go green and save green for an overall better return on investment.

- Reduced Copper in Concentric Neutrals
- Cooler Operation
- Enhanced Thermomechanical Properties
- Optimal Efficiency with Lower Line Loss
- Environmentally Friendly with Lead-Free Compounds
- Returnable Reels and Carbon Credit Value



Through extensive industry-recognized testing, this next-generation cable has proven its ability to meet the needs of today's wind farm collection systems while maintaining the reliability and performance of General Cable's existing EmPowr Link 35 kV TRXLPE insulated cable. Look at the test data on every purchase of medium-voltage cable to ensure that you're getting the performance you expect.

* See next page



 **General Cable**

Industry-Leading Reliability and Performance

EmPowr® Link CL™ UL Type MV-105*— Your Best Choice

Utilities have historically used Linear Low Density Polyethylene (LLDPE) thermoplastic jackets for the beneficial balance of cost and physical protection they provide. The future of utility power cable jacketing is thermoset XLPE jackets that provide a lower-total-cost solution.

Advantages of this new generation of cable construction include:

Approximately 25% reduction in copper in the concentric neutrals:

Using the ICEA P-45-482-2007 calculations to determine the shield cross-sectional area required for a given fault current, LLDPE jackets are limited to a maximum transient temperature of 200°C; XLPE jackets allow 350°C. The higher temperature allowance provides a greater amount of fault current capability for a given cross-sectional area, reducing the required copper in the neutrals. A smaller circulating current provides a reduced operating temperature, resulting in higher cable ampacities.

Further savings can be realized through the EPRI Short2 Program. General Cable's engineering team will gladly assist you in optimizing your cable design.

Reduced shield losses equate to lower line loss: With reduced copper concentric neutrals, the shield resistance will increase, with lower losses due to circulating currents. This effect is most easily seen in the larger kcmil sizes but is applicable to all conductor sizes.

Equivalent physical properties to existing LLDPE jacketed construction:

Test data has shown that EmPowr® Link CL™ maintains the physical properties, jacket stripping, coefficient of friction and installation characteristics of traditional EmPowr Link LLDPE jacket constructions.

Enhanced thermomechanical performance provides excellent resistance to deformation:

To simulate three-conductor installed performance, General Cable conducted AEIC/ICEA thermomechanical testing on traditional EmPowr Link LLDPE jacketed cables and EmPowr Link CL XLPE jacketed cables.

Photos and results of the testing are shown below:

EmPowr® Link LLDPE jacketed cables:

The results of the testing showed that the LLDPE failed 3 x 1/C Cable/Conduit 140°C testing. It clearly melted and fused together, causing exposed concentric neutrals at some locations.



EmPowr Link CL XLPE jacketed cables:

These cables passed 3 x 1/C Cable/Conduit 140°C testing with no problem areas.



Comparative Study: EmPowr Link Versus EmPowr Link CL

PRODUCT DESIGN	DESCRIPTION - 1000 kcmil Aluminum, TRXLPE, 1/3 CN, 35 kV			
	EMPOWR LINK LLDPE JACKET		EMPOWR LINK CL XLPE JACKET	
Concentric Neutrals	No. of Wires: 20	10 AWG	No. of Wires: 23	12 AWG
Concentric Neutrals - CU WT.	673 lbs/kft (1002 kg/km)		487 lbs/kft (725 kg/km)	
Shield Fault Capacity – Currents @ 6 Cycles (AMPS)	42645 A		42695 A	
Ampacity ⁽¹⁾ Direct Buried @ 90°C – Flat	645 A		660 A	
Cost of Shield Losses ⁽²⁾	\$82,700		\$75,300	
Calculated Savings ⁽³⁾			\$976,800	

(1) Based on cables with 90°C normal operation.

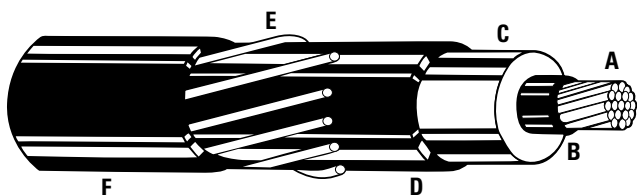
(2) Based on 3 conductor, flat, 7.5" spacing, 36" burial depth, 20°C ambient, 75% load factor, soil Rho 0.9°C-m/W.

(3) Based on 3 conductor, flat, 7.5" spacing, 645 A, avg. energy cost \$0.06/kWh, 1 circuit mile, 1-year time frame.

(4) Based on 3 conductor, flat, 7.5" spacing, 645 A, avg. energy cost \$0.06/kWh, 20 circuit miles, 20-year life of a wind farm, 1/3 production time.

*UL Type MV-105 EmPowr Link CL is rated MV-105 in accordance with the UL 1072 standard. It should be noted that utilizing a 105°C normal operating conductor temperature will increase cable ampacity rating but will reduce the shield fault capability slightly. If the user plans on operating these cables at 105°C conductor temperature for normal operation and 140°C for emergency overload, please contact General Cable for the applicable cable ampacity and shield fault capability ratings. Another important consideration is that the migration of soil moisture away from the cable is more likely at the higher operating conductor temperature and can result in an increase in soil thermal resistivity, resulting in an increase in conductor and soil temperature.

U.S. Specification for TRXLPE Medium-Voltage Underground Distribution Cable with XLPE Jacket



1.0 SCOPE

This specification covers single conductor tree-retardant cross-linked polyethylene insulated, concentric neutral cables rated from 5 kV to 46 kV. The cable shall be suitable for both single- and three-phase primary underground distribution (UD) for installation in underground ducts, conduit and direct burial in wet or dry locations. It shall also be suitable for on-grade and aerial installations. The cable shall be rated 90°C for normal operation, 130°C for emergency overload, and 250°C for short-circuit conditions in accordance with the latest revision of ANSI/ICEA S-94-649, AEIC CS8 and UL 1072 as applicable.

2.0 GENERAL

Cable shall meet or exceed the latest requirements of the following industry specifications and standards. The order of precedent is as follows: 1) Customer Specification, 2) AEIC CS8, 3) ANSI/ICEA S-94-649, 4) UL 1072. Where a particular product requirement or characteristic is specified in more than one document, the most stringent requirement will apply. Wherever reference is made to an industry specification or standard, it shall be understood to be the latest edition of that document.

3.0 QUALITY ASSURANCE

The cable shall be produced with the conductor shield, insulation and insulation shield applied in the same extrusion operation. All three extruded layers shall be applied in a common extruder head. A dry-cure process shall be used. Compound pellets used for strand shield, insulation and insulation shield shall be received and unloaded using an ultra-clean bulk handling system and/or an ultra-clean box handling system. The bulk handling system shall be a closed system. The material transfer/storage system shall use filtered air. The box handling system shall incorporate a dedicated material transfer system with filtered air involving at least the following: a Class 10,000 clean room per FED-STD-209E to hold the bag of compound as it is unloaded into the transfer system or a Class 10,000 clean compartment per FED-STD-209E surrounding the transfer point.

4.0 CONDUCTORS (A)

The central conductor shall be either solid or stranded. If stranded, it shall be filled with a material compatible with the conductor and the conductor shield to prevent the longitudinal penetration of water into the conductor. Solid aluminum shall meet the requirements of ANSI/ICEA S-94-649 Part 2. Stranded aluminum conductor shall be Class B, compressed per ANSI/ICEA S-94-649 Part 2. Conductor temper shall be H-16 to H-19 (3/4 to hard drawn) for stranded conductors and H-14 to H-16 (1/2 to 3/4 hard) for solid conductors.

5.0 CONDUCTOR SHIELD (B)

The conductor shield shall be an extruded thermosetting semi-conductive material complying with the applicable requirements of AEIC CS8 and ANSI/ICEA S-94-649 Part 3. The extruded shield shall be easily removable from the conductor and shall be firmly bonded to the overlying insulation.

6.0 INSULATION (C)

The insulation shall be a tree-retardant cross-linked polyethylene and shall comply with AEIC CS8 and ANSI/ICEA S-94-649 Part 4. The thickness shall be as required by ANSI/ICEA S-94-649 Table 4-4. An insulation pellet inspection system capable of examining 100% of the insulation pellets and rejecting contaminants shall be used. The manufacturer shall state the method used to examine and reject contaminated pellets.

7.0 INSULATION SHIELDING (D)

The insulation shield shall be a thermosetting semi-conductive material complying with the applicable requirements of ANSI/ICEA S-94-649 Part 5.

8.0 CONCENTRIC NEUTRAL (E)

The concentric neutral conductor shall consist of bare annealed copper wires per ANSI/ICEA S-94-649 Part 6, applied helically and essentially equally spaced over the outer semi-conducting shield, with a lay length of not less than six nor more than ten times the diameter over the concentric neutral conductor. The neutral indents in the insulation shield shall be within the requirements of ANSI/ICEA S-94-649 Part 5.2. The cable shall contain water-blocking components for the concentric neutral, and the completed cable longitudinal water penetration resistance shall comply with the requirements of ANSI/ICEA S-94-649 Part 6 and ANSI/ICEA T-34-664.

9.0 OVERALL OUTER JACKET (F)

The outer jacket is an extruded-to-fill black non-conducting cross-linked polyethylene jacket, meeting the physical requirements of Table 1 when tested by the methods specified in ANSI/ICEA S-94-649. The jacket shall be free stripping and not interfere with an intimate contact between the neutral wires and the underlying extruded insulation shield. The jacket shall contain a print legend marking, sequential length marking and three longitudinal extruded red stripes.

Table 1: Physical Properties of Extruded-to-Fill XLPE Jacket

PHYSICAL REQUIREMENTS	VALUES
Unaged Tensile Strength, Min. (psi)	1500
Aged* Tensile Strength, Min. Ret. (%)	70
Unaged Elongated, Min. (%)	150
Aged* Elongated, Min. Ret. (%)	70
Heat Distortion 1 hr at 131°C, Max. (%)	30

*Aged for 168 hrs at 121°C.

10.0 TESTS

All tests required by the referenced specifications shall be performed and passed prior to shipment, and a certified copy of the results of the tests shall be sent to the customer, if so requested. The manufacturer shall either submit with the quotation, or have on file with the customer, certified support data for the qualification tests required by ANSI/ICEA S-94-649 Part 10 as applicable.

11.0 EXCEPTIONS

All exceptions to these specifications are to be clearly stated in the bid proposal and will require the review and approval of the customer.

EmPowr® Link CL™ Underground Distribution Cable 35 kV

Al Conductor TRXLPE Insulation Concentric Neutral XLPE Jacket, UL Type MV-105



UNDERGROUND DISTRIBUTION CABLE – 35 kV – TYPE UD – CONCENTRIC NEUTRAL													
COMPRESSED CONDUCTOR		COPPER NEUTRAL			DIAMETER (2) INCHES			NOMINAL JACKET THKN. INCHES (2)	APPROXIMATE WEIGHT (2) LB/1000 FT			AMPACITY (3)	
AL AWG or kcmil	NO. OF WIRES	NO. OF WIRES	WIRE SIZE AWG	FAULT CURRENT EQUIV. LLDPE CN DESIG. (1)	INSULATION		ENCAP XLPE JACKET		AL COND.	CU NEUT. WIRES	TOTAL	DIRECT BURIED	
					MIN.	MAX.		FLAT				TREFOIL	

345 mils NOMINAL TRXLPE INSULATION – 100% INSULATION LEVEL

1/0	19	19	16	Full	1.045	1.145	1.404	0.055	99	160	831	245	230
		13	16	2/3			1.377			109	786	245	230
		10	16	1/2			1.377			84	763	250	230
		7	16	1/3			1.377			59	740	250	230
3/0	19	18	14	Full	1.140	1.240	1.498	0.055	158	240	1053	315	300
		20	16	2/3			1.498			168	964	315	300
		15	16	1/2			1.471			126	927	320	300
		10	16	1/3			1.471			84	889	320	300
4/0	19	23	14	Full	1.195	1.295	1.544	0.055	199	307	1196	350	340
		16	14	2/3			1.554			214	1112	355	340
		19	16	1/2			1.554			159	1038	360	340
		13	16	1/3			1.554			109	993	365	340
350	37	26	14	2/3	1.355	1.455	1.797	0.080	329	347	1542	445	445
		19	14	1/2			1.763			254	1458	455	445
		20	16	1/3			1.736			168	1353	465	450
		10	16	1/6			1.736			84	1278	475	450
500	37	23	12	2/3	1.480	1.580	1.925	0.080	468	487	1952	510	540
		17	12	1/2			1.925			360	1838	520	540
		18	14	1/3			1.925			240	1690	540	545
		15	16	1/6			1.891			126	1557	570	550
750	61	26	12	1/2	1.670	1.770	2.184	0.080	703	551	2461	590	660
		17	12	1/3			2.142			360	2290	615	670
		22	16	1/6			2.108			185	2053	670	680
1000	61	22	10	1/2	1.815	1.920	2.333	0.080	937	741	3690	650	760
		23	12	1/3			2.291			487	2774	660	765
		18	14	1/6			2.291			241	2504	725	785
1250	61	18	10	1/3	1.960	2.065	2.481	0.080	1172	606	3328	700	845
		23	14	1/6			2.439			307	3943	765	870
		18	16	1/12			2.405			151	2764	850	885

(1) The concentric neutral (CN) cable designs for the XLPE jacket, when operated at 90°C, are equivalent in fault current carrying capability (but with reduced cross-sectional area) to concentric neutral cable designs with LLDPE jackets and the indicated concentric neutral designation. For single phase full neutral applications, a neutral equivalent in cross-sectional area to the LLDPE jacket designs must be used. Three phase designs may use the configurations with reduced cross-sectional area (but equivalent fault current capability) as shown in the table.

(2) Extruded layer thicknesses and insulation and insulation shield diameters are in accordance with ANSI/ICEA S-94-649 for Concentric Neutral Cables Rated 5 Through 46 kV and also meet the requirements of the latest revisions of AIEC CS8.

(3) Ampacity based on earth thermal resistivity of 90°C-cm/watt, 90°C conductor temperature, 20°C earth ambient temperature, 75% load factor and 36" depth of burial. Values are based on one three-phase circuit, one conductor per phase, with neutral wires bonded at each end. Flat configuration based on 7.5" on center spacing between cables. For specific ampacities, contact your General Cable sales representative. Dimensions and weights not designated minimum or maximum are nominal values and subject to manufacturing tolerances. In this context, weight means mass.

