



**THE
OKONITE
COMPANY**

PIPE-TYPE CABLES



Setting the Standard

PIPE TYPE CABLE SYSTEMS

BACKGROUND

Pipe Type Cables, for over 80 years, continue to be the backbone of underground transmission systems throughout North America. For generations, Pipe Type Cable systems have been the design choice for engineers selecting the maximum long-term reliability and overall cost effectiveness.

Okonite has been producing paper insulated cables from 15kV to 345kV at our Paterson, NJ plant since the early 1930's. Throughout the years, many innovations in design, processing and equipment have been developed to provide our customers with the highest quality cable at the most competitive cost.

With the advent of Okonite's innovative Laminated Paper-Polypropylene (LPP) insulation, thicknesses were able to be reduced, thereby decreasing the required pipe diameter. The designer also has the option of increasing the conductor size or upgrading to a higher voltage level within a given pipe diameter.

Solid dielectric cables with XLPE insulations entered the underground transmission arena in the 1980's. Despite a lack of proven field service history, they apparently appealed to those looking for a less sophisticated design. However, these XLPE systems demonstrated intolerance for contamination and installation workmanship errors not exhibited with Pipe Type Cables. With longer installation lengths, experience has shown that Pipe Type Cables can lower significantly installation costs and provide unequalled service performance.

Pipe Type Cables have an outstanding and a proven track record of over 80 years. Modern extra-high voltage solid dielectric cables have only limited service years and rely upon statistical analysis of accelerated testing to attempt attain a 40 year plus life cycle.



One of two EHV voltage tapping head machines.



On right reel - Large 188" reel in the paper tapping machine.

PIPE TYPE CABLE SYSTEMS

WHY PIPE TYPE CABLES?

- **Reliability:** To date, over 53,000,000 feet of Pipe Type Cable have been installed. The superiority and reliability of these systems is unparalleled when compared to any other type of extra-high voltage underground transmission alternatives.
- **Performance:** High overload ratings and reliability can be achieved with the cooling effects provided by the continuous dielectric medium of 200 psi in a welded steel pipe. Because of the close spacing of the three cables inside a single steel pipe, EMF is negligible in comparison to other systems.
- **Total Owning Cost:** Because of the compact design and minimized trench sizes, the security provided by the steel pipe with the much longer manufacturing installation lengths result in fewer manholes, splices and, as a result, capital installation costs can be much lower than solid dielectric alternatives.
- **Made in the USA:** Like all other Okonite products, Pipe Type Cables are made entirely in the USA. Employees, under Okonite's ESOP form of ownership, have a vested and very special interest in the company and take extra care in assuring a quality product. Recent upgrades and expansions to our Paterson, NJ manufacturing facility have increased capacity by over 50%.
- **Quality Engineering:** Experienced manufacturing and design engineers, technical specialists, and installation engineers are always ready to assist and support customers with their system requirements and installation procedures.



Horizontal Tank capable of impregnating up to 345 kv HPFF cables in lengths of 6,500 to 12,000 feet on 188" diameter reel.

PIPE TYPE CABLE SYSTEMS

RE-CABLING WITH LPP INSULATION

Excavation, restoration and manhole and duct systems are responsible for over 70% of the costs of adding new underground transmission capacity. Controlling and reducing these sizeable costs, while keeping EMF close to zero and increasing the capacity of your existing cable system are unique to Pipe Type cable designs. Your options include increasing the operating voltage and ampacity within the same pipe, while decreasing the amount of dielectric medium required, or if desired, providing a Gas Filled medium using nitrogen gas. So, before you decide, let our Okonite engineers determine the sizeable economics of re-cabling with LPP Pipe Type insulation.

Pipe Type Cable systems were invented by Okonite in 1932 and have continually provided exceptional and excellent transmission reliability for our utility customers for over 80 years, without system interruptions.



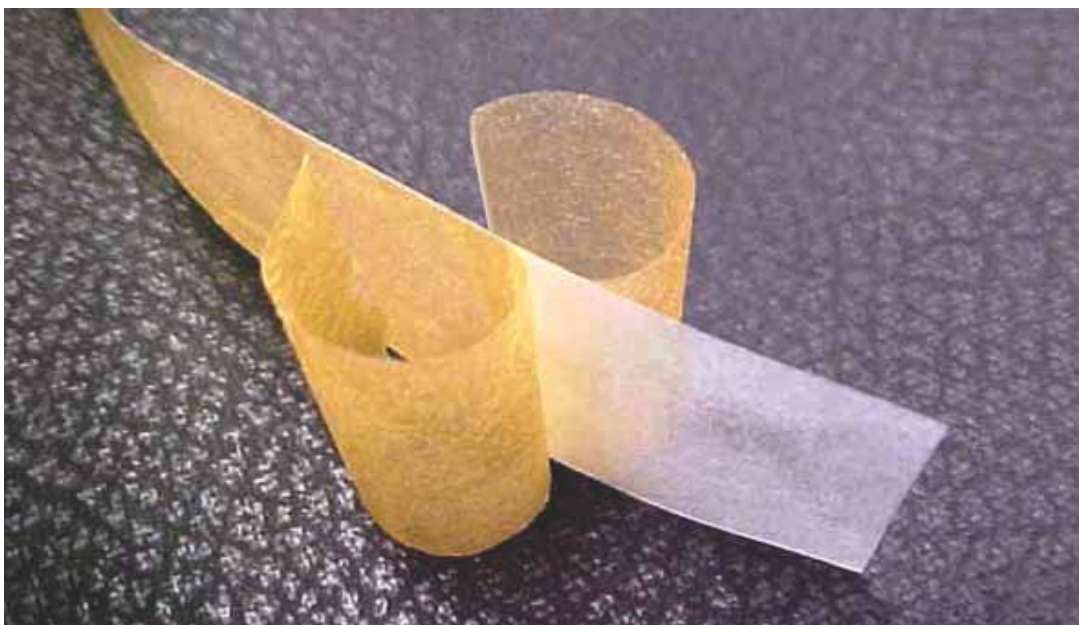
BEFORE

138kV, 1500 kcmil copper conductor
with 505 mil Kraft paper insulation in an 8" pipe.



AFTER

345kV, 2500 kcmil copper conductor
with 600 mil LPP insulation in an 8" pipe.



By using our Laminated Paper Polypropylene (LPP) insulation (shown in picture at left) in existing pipe systems, cables can be produced with significantly thinner walls than that of traditional kraft paper. That allows for the use of larger conductors, and/or operations at much higher voltages, to increase system capacity considerably.

PIPE TYPE CABLE SYSTEMS

RE-CABLING WITH LPP INSULATION



Installation during one of the recent re-cabling projects. Pacific Gas & Electric, Public Service Electric & Gas, and Potomac Electric Power Company are among those utilities that have re-cabled circuits.

Increases in customer demand and the need for reliable electric service delivery is prompting utilities to redesign their systems in order to meet customer needs. Pipe Type Cable systems have provided the most reliable transmission cables for over 80 years. Manufactured to Okonite standards, in conjunction with the evolution of LPP insulation has created the opportunity to upgrade at minimum capital cost, within the same pipe size infrastructure, and without excavation of streets and disturbing surrounding surface conditions. Permit and approval processes for new transmission add undue costs and can mean significant scheduling delays. Therefore, reusing and up-grading the pipe-type system is a distinctive characteristic of Okonite's extra high voltage cable innovations.

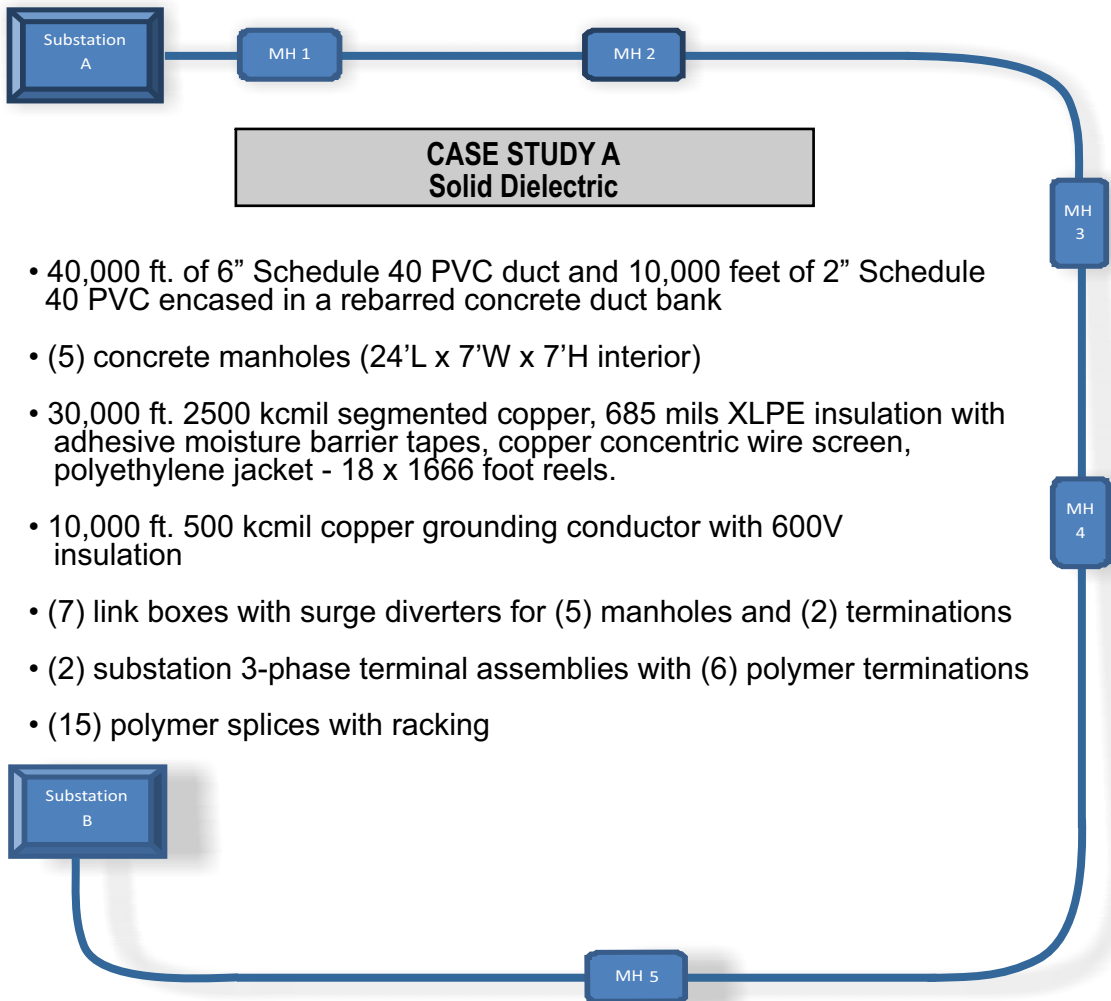
SYSTEM CAPACITY INCREASE EXAMPLES AS A RESULT OF RE-CABLING

	CABLE	AMPERES	MVA	MVA% INCREASE
Original Installed Cable	HPFF 345kV/2000 kcmil Cu 1.020" paper	832	497	—
Replaced With	HPFF 345kV/3500kcmil Cu 0.650" LPP	1185	707	42%
Assumptions: 1 Circuit, 85°C operating temp. 25°C earth ambient, 100% LF, 90 rho, 36" depth, Nominal 10" Pipe				
Original Installed Cable	HPFF 69kV/1500kcmil CU 0.270" paper	792	94.7	—
Replaced With	HPFF 138kV/3000kcmil Cu 0.350" LPP	928	221	233%
Assumptions: 1 Circuit, 85°C operating temp. 25°C earth ambient, 100% LF, 90 rho, 36" depth, Nominal 8" Pipe				
Original Installed Cable	HPGF 115kV/1000kcmil Cu 0.500" paper	713	142	—
Replaced With	HPGF 115kV/2000 kcmil Cu 0.385" LPP	968	193	36%
Assumptions: 1 Circuit, 85°C operating temp. 25°C earth ambient, 100% LF, 90 rho, 36" depth, Nominal 6" Pipe				

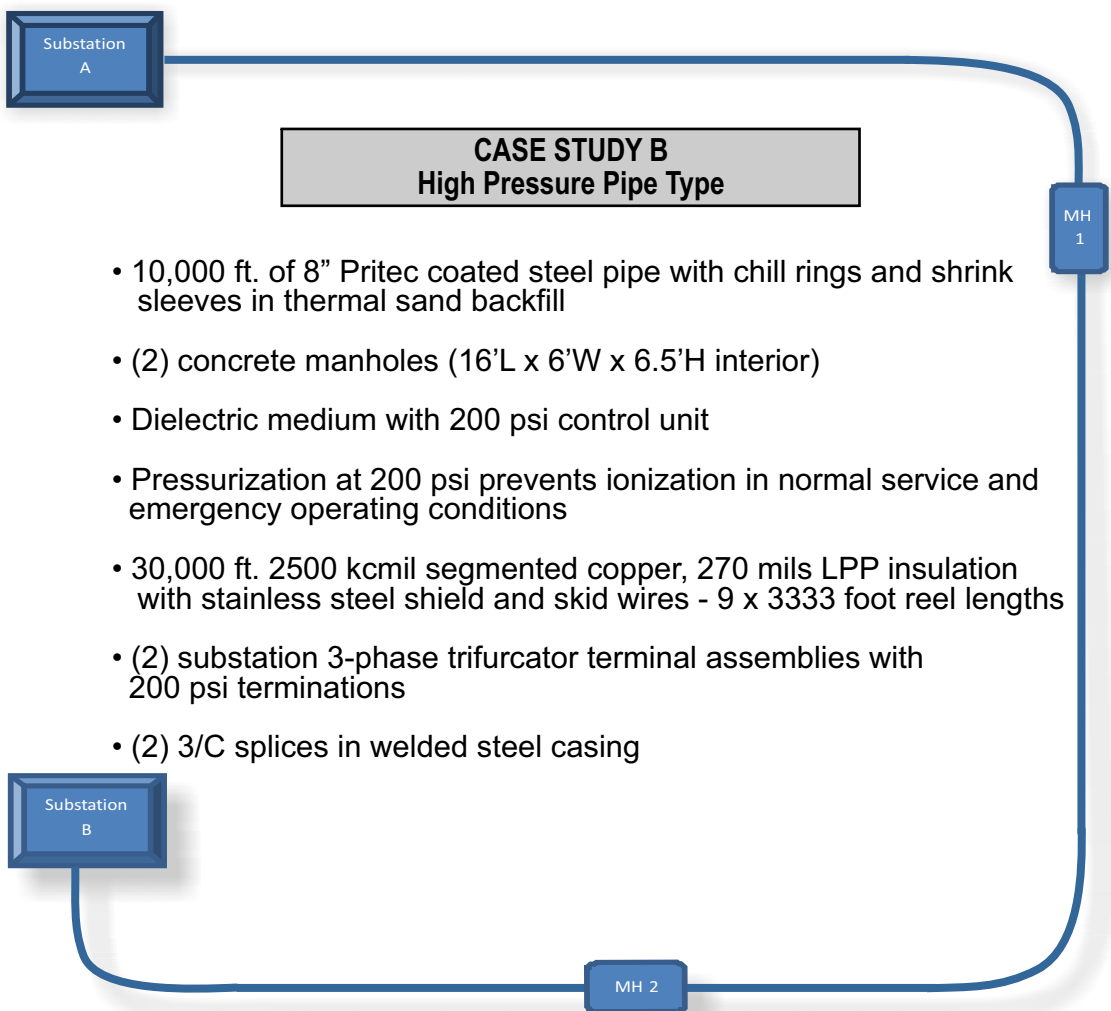
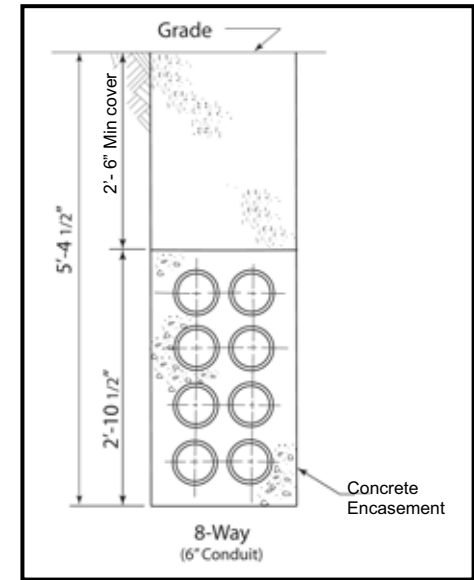
*Re-cabling designs are also applicable to 230kV and 345kV HPFF systems. Contact Okonite's Applications Engineering Department with specific design goals.

TYPICAL 138kV SINGLE UNDERGROUND TRANSMISSION CIRCUIT - 10,000 FEET

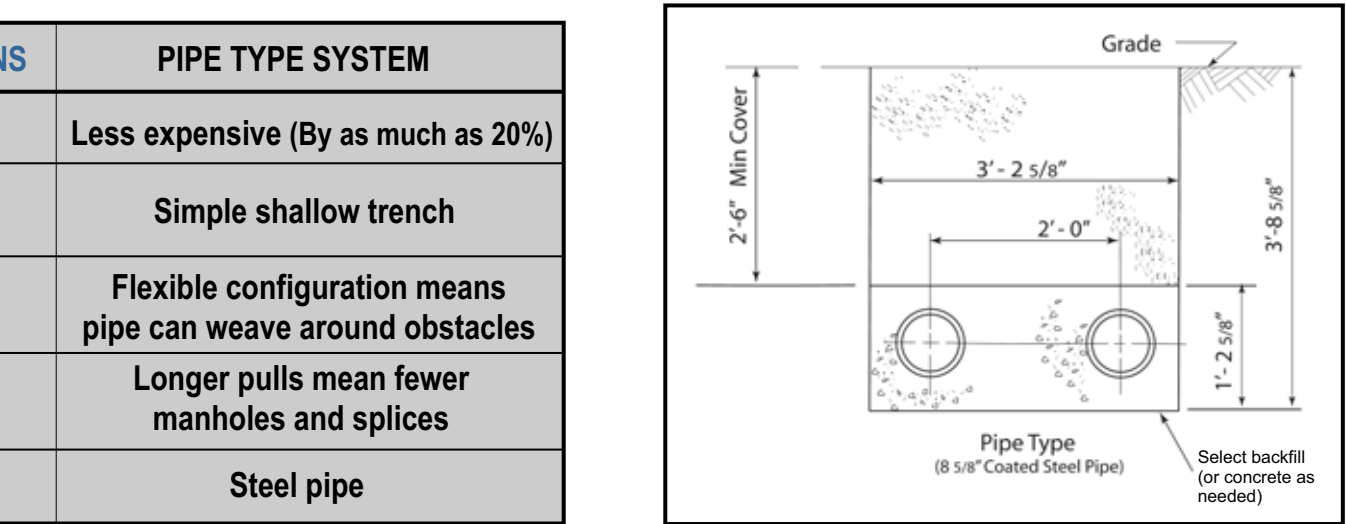
TOTAL INSTALLED COST COMPARISON The following examples show some simple comparisons between a typical solid dielectric (XLPE) system vs. a Pipe Type Cable system. Pipe Type Cable systems offer many advantages for route configuration flexibility due to their compact design and smaller trench dimensions. This means lower excavation costs, longer pulling lengths, fewer manholes and splices, which in turn can mean fewer possible joint issues.



- 40,000 ft. of 6" Schedule 40 PVC duct and 10,000 feet of 2" Schedule 40 PVC encased in a rebarred concrete duct bank
- (5) concrete manholes (24'L x 7'W x 7'H interior)
- 30,000 ft. 2500 kcmil segmented copper, 685 mils XLPE insulation with adhesive moisture barrier tapes, copper concentric wire screen, polyethylene jacket - 18 x 1666 foot reels.
- 10,000 ft. 500 kcmil copper grounding conductor with 600V insulation
- (7) link boxes with surge diverters for (5) manholes and (2) terminations
- (2) substation 3-phase terminal assemblies with (6) polymer terminations
- (15) polymer splices with racking



- 10,000 ft. of 8" Pritec coated steel pipe with chill rings and shrink sleeves in thermal sand backfill
- (2) concrete manholes (16'L x 6'W x 6.5'H interior)
- Dielectric medium with 200 psi control unit
- Pressurization at 200 psi prevents ionization in normal service and emergency operating conditions
- 30,000 ft. 2500 kcmil segmented copper, 270 mils LPP insulation with stainless steel shield and skid wires - 9 x 3333 foot reel lengths
- (2) substation 3-phase trifurcator terminal assemblies with 200 psi terminations
- (2) 3/C splices in welded steel casing



SOLID DIELECTRIC	DESIGN CONSIDERATIONS	PIPE TYPE SYSTEM
More expensive	Total Installed Cost	Less expensive (By as much as 20%)
May require complicated trenching to meet safety requirements	Excavation	Simple shallow trench
Existing underground facilities/structures may need to be relocated	Versatility	Flexible configuration means pipe can weave around obstacles
Shorter pulls mean more manholes and splices which could impact reliability	Cable Installation	Longer pulls mean fewer manholes and splices
Plastic conduit/concrete encasement	Mechanical Protection	Steel pipe

* Comparisons above reflect single circuit design, with drawings representing installations which provide for future double circuit capabilities

FEATURES & ADVANTAGES

The Pipe Type Cable system in both HPFF and HPGF versions has many desirable features and advantages as follows:

1. Provides a highly reliable, simple, trouble-free system with a proven long term track record for new bulk power transmission circuits in the 69kV to 500kV range, as an alternative to solid dielectric cables.
2. Impregnated paper insulated Pipe Type Cables have proven to be most reliable in service life. No Pipe Type Cable systems have been decommissioned due to age or problems with the impregnated paper or LPP dielectric. All systems are still in service.
3. There are approximately 4100 circuit miles of underground high voltage transmission cable in service in the U.S.A. Over 80% of this total is Pipe Type Cables.
4. Multiple layers of insulating tapes produce a uniform laminated insulation wall, minimizing effects of any abnormalities throughout the insulation, as compared to the prospects of deficiencies in extra-high voltage solid type dielectric cables.
5. Cable can be manufactured and installed in long lengths of 6500 feet, and even longer, which minimizes the number of manholes, splices and installation costs.
6. Cable insulation materials and manufacturing processes have been refined to a high degree of quality and reliability for over eight (8) decades.
7. Pipe Type Cable splices and terminations have proven over many years of service to be exceptionally reliable and trouble-free, as compared to the more volatile track record of alternate type cable systems at extra-high voltage levels.
8. Built in design for voltage and MVA uprating by reconductoring the existing pipe.
9. Pipe system is totally welded from end to end including the splice joint casings in the manholes, and provides an exceptionally rugged, damage free and very low maintenance system. The system is subjected to a simple, and fool-proof series of vacuum and pressure tests during the original installation, and is also designed for uncomplicated maintenance programs.
10. Only a single pipe is required for the 3 phase circuit instead of four individual 5" or 6" ducts in a bulky concrete encased bank. This smaller trench requirement with Pipe Type Cables is particularly significant when threading new circuits through congested urban streets, as compared to a solid type extra high voltage dielectric.
11. Pipe Type Cable systems are less costly, on an installed cost basis, with extra high-voltage solid dielectric cable systems in concrete encased duct banks.
12. Pressurization at 200 psig of the dielectric fluid or nitrogen gas in Pipe Type systems prevents ionization in service under normal and emergency operating conditions.
13. Real time monitoring of the cathodic protection system has recently been developed which even further enhances the reliability and minimizes the already low maintenance of these systems.
14. Manufacture and testing is tightly governed by the longstanding industry standard AEIC CS2-97 "Specification for Impregnated Paper and Laminated Paper Polypropylene Insulated Cable High-Pressure Pipe-Type", 6th edition dated March, 1997.
15. The laminated paper polypropylene (LPP) cables were innovated and proven by extensive Okonite testing to have exceptional reliability under extreme operating conditions that are far beyond the AEIC CS2-97 requirements. The results of these unique extended tests were presented at industry IEEE Insulated Conductor Committee meetings and are published in the Spring and Fall 1992 Minutes of the ICC.
16. If required, these cables can be overinsulated to allow conversion in the future for operation at higher system voltages. A number of circuits have been installed in this fashion and initially operated at a lower voltage and then later switched to the higher operating voltage when greater MVA system capacity was required in the cable system. The conversion is achieved with minimal expenditures.
17. Manufactured in the U.S.A. in the largest capacity, most modern paper cable plant in Paterson, New Jersey. Engineering, installation and technical assistance are always readily available.
18. To date, over 27 Pipe Type Cable circuits have been re-cabled representing over 100 circuit miles, and have saved hundreds of millions in installation costs.

EXPERIENCE RECORDS & CUSTOMERS

OKONITE 345kV OILOSTATIC[®] AND OILOSTATIC LPP[®] SYSTEM EXPERIENCE RECORD

Okonite has been the predominant supplier of the highly reliable HPFF and HPGF pipe type underground transmission cables. Numerous circuits are in service at many utilities throughout the United States totaling thousands of conductor miles at all voltage levels from 69kV through 345kV inclusive. Records of all these various installations were kept for many years through the 1960s but they became so common and voluminous at the lower voltage levels that the listing of installations was only continued for the higher voltage 230kV and 345kV systems. **The Okonite record of 345kV installations follows, but other history on Pipe Type Cable systems at 69kV to 230kV is available.**

Customer	Linear Footage	Conductor Size kcmil	Insulation Thickness	Year
Consolidated Edison Co. of New York, Inc.	634,000	2000	1.025"	1964 to Present
Consolidated Edison Co. of New York, Inc.	63,000	2500	1.025"	1964 to Present
Duquesne Light Company, Pittsburgh, PA (Note 1)	282,000	2500	.920"	1979
Niagara Mohawk, Syracuse, NY (Note 2)	13,000	2500	.920"	1980
U. S. Department of Energy, Piketon, OH (Note 3)	50,688	1000 (Aluminum)	1.035"	1981
Public Service Electric & Gas Co., Newark, NJ	90,288	2500	.920"	1982
Public Service Electric & Gas Co., Newark, NJ	47,520	2000	.920"	1982
Long Island Lighting Company, Mineola, NY	60,192	2500	1.035"	1983
Boston Edison Company, Boston, MA	4,752	2500	.920"	1983
Boston Edison Company, Boston, MA	101,376	2000	.650" (LPP)	1988
Boston Edison Company, Boston, MA	71,280	2250	.600" (LPP)	1989
New York Power Authority, Long Island, NY	161,568	2500	.600" (LPP)	1990
Ebasco (Cogen Technologies), Linden, NJ	23,760	2500	.600" (LPP)	1992
Narragansett Electric Company, Providence, RI	218,592	2750	.600" (LPP)	1994
Consolidated Edison Co., of New York, Inc.	9,504	2000	.905"	1994
Commonwealth Edison Company, Chicago, IL	120,384	2500	.600" (LPP)	1995
Consolidated Edison Co., of New York, Inc.	10,020	2500	.600" (LPP)	2000
Boston Edison Company, Boston, MA	63,726	2250	.600" (LPP)	2000
Boston Edison Company, Boston, MA	82,253	2500	.600" (LPP)	2001
KeySpan Energy, Hicksville, NY	127,065	2500	.600" (LPP)	2001/2002
Public Service Electric & Gas Co., Newark, NJ	36,399	2500	.600" (LPP)	2002
Consolidated Edison Co. of New York, Inc. NY	75,960	2500	.600" (LPP)	2002/2003
Detroit Edison, Detroit, MI	2,299	2500	.600" (LPP)	2003
Commonwealth Edison Company, Chicago, IL	101,070	2500	.600" (LPP)	2003/2004
International Transmission Company/ Black & Veatch, Detroit, MI	124,560	2500	.600" (LPP)	2004/2005

EXPERIENCE RECORDS & CUSTOMERS

New York Port Authority, White Plains, NY	7,800	1000	.680" (LPP)	2004
Consolidated Edison Co. of New York, Inc., NY	6,000	2500	.600" (LPP)	2005
Northeast Utilities/W. A. Chester Bethel-Norwalk, CT	309,342	2500	.600" (LPP)	2005/2006
Consolidated Edison Co. of New York, Inc., NY	50,551	2500	.600" (LPP)	2006
Duquesne Light Company, Pittsburgh, PA	2,628	2500	.600" (LPP)	2006
Consolidated Edison Co. of New York, Inc., NY	18,525	2500	.600" (LPP)	2007
Duquesne Light Company, Pittsburgh, PA	685	2500	.600" (LPP)	2007
Duquesne Light Company, Pittsburgh, PA	60,886	2500	.600" (LPP)	2007
Duquesne Light Company, Pittsburgh, PA	6,019	2500	.600" (LPP)	2007
W.A. Chester/Northeast Utilities Bethel-Norwalk, CT	930	2500	.600" (LPP)	2007
Consolidated Edison Co. of New York, Inc., NY	23,556	2500	.600" (LPP)	2008
New York Power Authority White Plains, NY	7,300	1000	.680" (LPP)	2008
W. A. Chester/NSTAR Boston, MA	278,556	2500	.680" (LPP)	2008
Consolidated Edison Co. of New York, Inc., NY	122,085	2500	.600" (LPP)	2009
Consolidated Edison Co. of New York, Inc., NY	29,151	2500	.600" (LPP)	2009
Public Service Electric & Gas Co. New York, Inc., NY	29,151	2500	.600" (LPP)	2009
Prysmian Cables & Systems	16,625	3500	.600" (LPP)	2010
Astoria Energy II, LLC/Con Edison	10,321	2500	.600" (LPP)	2010
Con Edison	2,031	2500	.600" (LPP)	2010
Astoria Energy II, LLC/Con Edison	10,321	2500	.600" (LPP)	2010
Con Edison	3,639	2500	.600" (LPP)	2010
Public Service Electric & Gas Co.	93,914	3500	.650" (LPP)	2010
Public Service Electric & Gas Co.	62,220	3500	.600" (LPP)	2010
NSTAR Services Co.	21,600	2500	.600" (LPP)	2011
Prysmian Cables & Systems	2,165	3500	.650" (LPP)	2011
Prysmian Cables & Systems	25,369	3500	.650" (LPP)	2011
Public Service Electric & Gas Co.	173,425	3500	.650" (LPP)	2011
Public Service Electric & Gas Co.	28,473	3500	.650" (LPP)	2011
Public Service Electric & Gas Co.	150,055	3500	.650" (LPP)	2012
Genon Bowline/Con Edison	1,100	2500	.600" (LPP)	2012
NSTAR/W.A. Chester	11,403	2500	.600" (LPP)	2012
Public Service Electric & Gas Co.	8,130	3500	.650" (LPP)	2012
Con Edison	20,130	2500	.600" (LPP)	2013
COMED Energy	1,260	2500	.600" (LPP)	2013
Public Service Electric & Gas Co.	51,603	3500	.650" (LPP)	2013
Public Service Electric & Gas Co.	21,567	3500	.650" (LPP)	2013
NSTAR Services Company	9,846	2500	.600" (LPP)	2013

TOTAL CABLE FOOTAGE ALL: 4,247,880 TOTAL CABLE FOOTAGE (LPP ONLY): 2,992,946

1970 to Present 3,530,890
 1980 to Present 3,268,890
 1990 to Present 2,829,794
 2000 to Present 2,295,986

Note 1: Okonite furnished: Joints, SS riser pipe and pipe filling fluid

Note 2: Okonite furnished: Steel Pipe, Ss riser pipe, potheads, joints, pumping plant & pipe filling fluid

Note 3: Okonite furnished: Steel Pipe, SS riser pipe, potheads, joints, pumping plant & pipe filling fluid

PIPE TYPE CABLE SYSTEMS

OKONITE HISTORY AND VISION

Since 1878, Okonite has been dedicated to the design and production of the highest quality electrical cables available. What began as a single plant in Passaic, NJ has grown to six manufacturing plants across the U.S. producing cables ranging from 300V to 345kV. We serve various markets including: Electric Utility (Generation, Transmission, Distribution and Substation), Oil & Gas, Industrial, Railroads and Transportation, Renewable Energy.

As part of our continuous modernization program and to assure Okonite customers that we will continue to serve their paper insulated cable needs. In 2011 we embarked on a major \$40 million expansion of the Paterson, NJ plant. This program included:

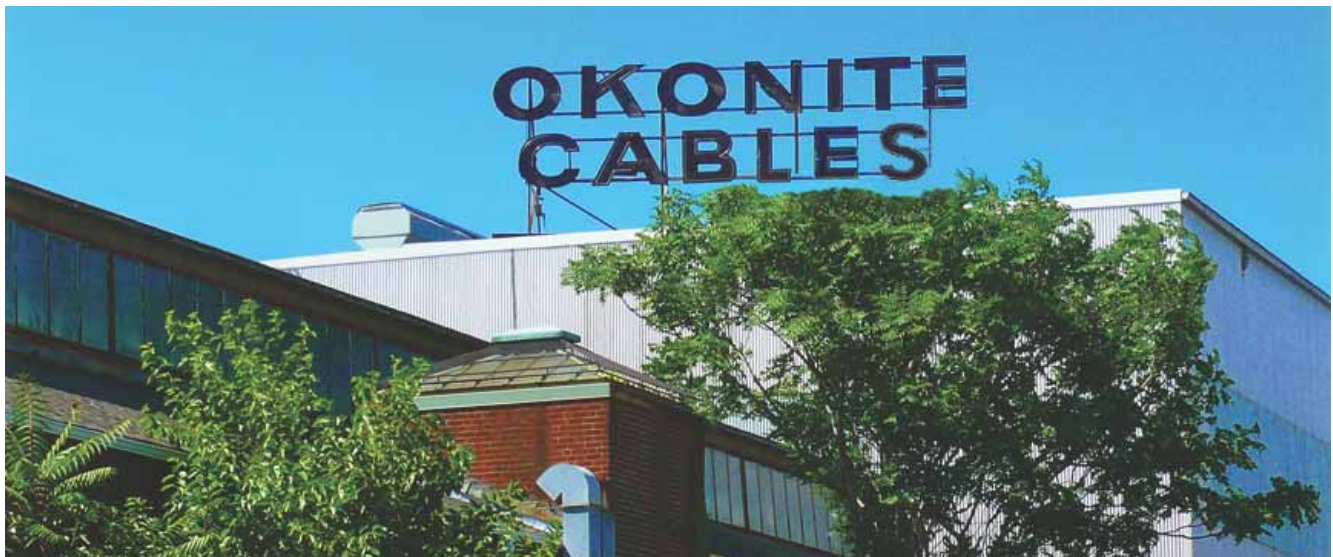
- New and larger impregnation tanks to increase manufacturing capability and provide for longer lengths between manholes.
- Major upgrades to the "D" wire armoring line.
- Additional EHV taping heads to increase 230kV and 345kV capability.
- Taping and cabling machine upgrades.
- Major test equipment department upgrades.

These upgrades have resulted in a state of the art facility with an increase in capacity of over 50%. This also allows Okonite additional flexibility to meet customer's emergency paper cable needs.

Let Okonite help you design and manufacture the most reliable UG Transmission system with Pipe Type Cables having over an 82 year incomparable and highly reliable service record.



Four Vertical tanks for impregnating up to 345 kv HPFF cables in Lengths of 8,000 to 10,000 feet on 174" diameter reels.



Paterson New Jersey Plant.

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