Polymer Arresters as an Alternative to Shield Wire

This article is taken from a paper presented at the 24th Annual Transmission & Substation Design and Operation Symposium.

by Jim Sanders and Kevin Newman

ABOUT THE AUTHORS:

Jim Sanders received a Bachelor of Science in Electrical Engineering in 1988 from the University of Texas at Austin. He is currently a staff engineer at TU Electric's Transmission Engineering Department.

Kevin Newman received a Bachelor of Science in Civil Engineering in 1989 and a Master of Engineering in Civil Engineering in 1990, both from Texas A&M University. He joined TU Electric in 1990 and is currently an engineer in the Transmission Engineering Department.

Introduction

Electric utilities continue to explore ways to improve the quality of service provided to their customers. One way to improve the quality of service is to reduce the number of transmission line interruptions. A high percentage of these interruptions are due to lightning. The traditional method of lightning protection for transmission lines has been overhead ground or shield wires. TU Electric has installed Ohio Brass Protecta*Lite lightning arresters as an alternative method of providing lightning protection on previously unprotected transmission lines to improve performance.

In 1989, TU Electric identified approximately 450 miles of unshielded transmission lines within the service area which were to be evaluated for improved lightning performance. The majority of these lines are older 69 kV lines which were constructed during the 1920's. While these lines represent less than 10 percent of the lines in the service area, they are responsible for about 40 percent of the interruptions.

These transmission lines were reviewed and prioritized by a number of factors including customer impact. The lines with the highest priorities were then studied in greater detail. Various methods of adding lightning protection to these lines were examined. Preliminary cost estimates were prepared for each method. The initial estimates showed lightning arrester installations to be considerably less expensive than shield wire installations.

Shield Wires

Typically, transmission lines are protected by ground or shield wires located above the phase conductors. These wires are placed above the phase conductors in a position to "shield" the phase conductors from direct lightning strokes. Virtually all transmission lines constructed by TU Electric since 1930 have used this type of protection.

There are a number of problems with adding a shield wire to unshielded lines. A bayonet must be added to the top of each pole to install the shield wire in a position to provide an adequate shield for the phase conductors. The shield wire must be five to six feet above the pole top to provide a shield angle of 30 degrees which is the industry standard. The shield wire and bayonets add significant loading to the transmission structures. Many of the poles in these lines will not handle the added loads.

Arresters

Within the last few years, polymer housed MOV arresters have been used on TU Electric's distribution system. These arresters are now available for transmission operating voltages. The arresters for 69 kV applications weigh approximately 20 pounds and can be easily mounted on transmission structures. They can be used to eliminate the need for shield wires or as a supplement to shield wires for additional protection. Arresters for 138 kV and 230 kV applications are also available.

Arresters can be installed on the top phase only on single pole construction allowing the top phase to shield the outside phases from lightning. Arresters can also be installed on all phases to provide even greater protection. Different levels of protection can be obtained by adjusting the spacing between sets of arresters. Theoretically, all lightning flashovers could be eliminated by installing arresters on all phases of every structure. A more thorough review is necessary to decide how many arresters should be installed.

(CONTINUED)

Hi-Tension News
Reprinted from Spring/Summer 1992
Volume 63, No. 2

Review Process

Any lightning arrester installation would have to perform at least as well as a shield wire installation to be acceptable to TU Electric. TU Electric investigated in detail the two lines on the system with the highest priority. These two lines were of different types of construction, one was H-Frame construction and the other was single pole construction with pin-type insulators.

The two lines were modeled using the following information:

- Existing line performance (outages per year)
- Targeted line performance (outages per year)
- Voltage of line
- Length of line
- Location of line
- Proposed arrester MCOV
- Time in which faults will be cleared
- Typical ground resistance
- Typical spacing between grounds
- Type terrain
- Structure type
- Span length
- Conductor type
- Insulator type
- Negative impulse capability of insulation
- Isokeraunic level (thunderstorm days per year)
- Type of bonding of insulators (if any)
- Type of fireproofing (if any)
- Width of spark gap (if any)

The proprietary OB TLP Program was used for the modeling. Four basic configurations were used for each structure type. The basic configurations which include unshielded structures, shielded structures, and structures with arresters are shown in Figure 1 and Figure 2.

These configurations were used to provide reference data to compare the performance of the different installations on each construction type. The data was compared to the existing performance data for the two individual lines. A comparison of the data for two of the possible causes is shown in Table 1.

The data shown for single pole construction assumes 50 ohm ground resistance, 600 ft. spacing (every other structure) for the arrester on the top phase only configuration, and 1500 ft. spacing (every fifth structure) for the arrester on all three phase configuration. The data shown for H-Frame construction assumes 10 ohm ground resistance and 1650 ft. spacing (every third structure) for the arrester on all three phase configuration. Table 1 represents only a portion of the information used in the study. The

Figure 1
Single Pole Configurations

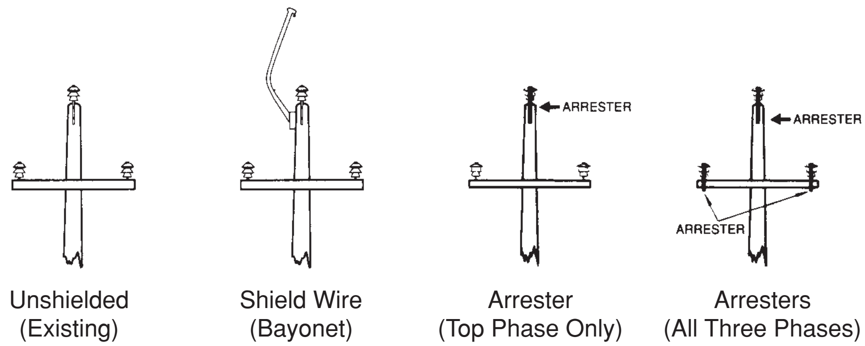
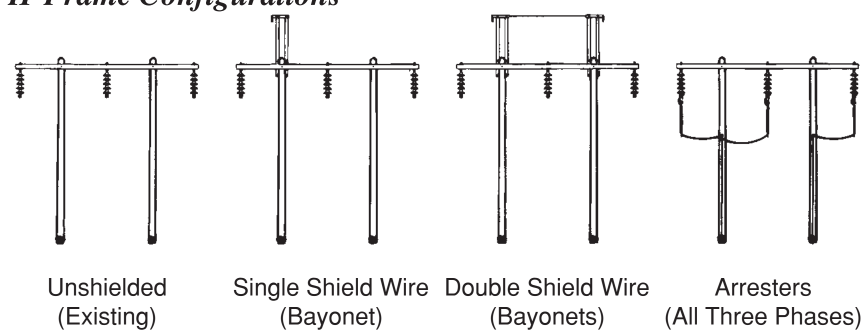


Figure 2
H-Frame Configurations



calculated number of flashovers per year depends upon several factors. The following is a list of a few of the more important variables and a brief explanation of how they can affect the installations.

• Ground Resistance

This is a very important factor in determining the performance of shield wires and lines with arresters on the top phase only. These two configurations are very dependent on ground resistance with lower ground resistances providing better performance. Outages are due primarily to backflash which is a flash across the insulator due to increased ground potential.

The dependence on ground resistance can be reduced significantly by installing arresters on all three phases. This eliminates the backflash problem on structures where the arresters are installed.

• Spacing

The distance between arresters or sets of arresters controls the performance of an installation and the economics of a project. The arrester spacing can be adjusted to provide the level of performance needed or adjusted to meet the available budget. TU Electric chose a spacing to provide equal or better performance than a shield wire installation for the initial projects. Performance experience will be used to determine the spacing on future projects.

Table 1
Calculated Performance Comparison

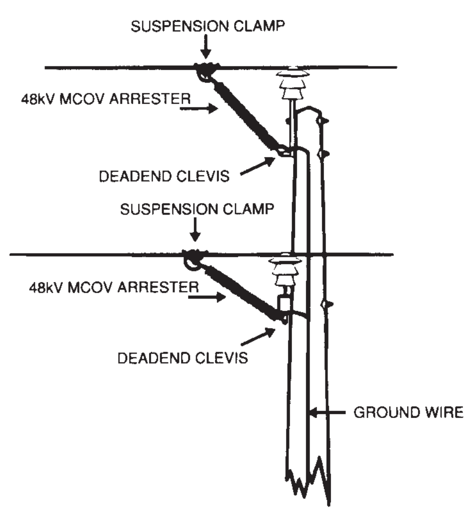
Construction Type	Line Length (miles)	Flashovers (per year)
Single Pole Unshielded	20	19
Single Pole—Shield wire	20	8
Single Pole—Arrester on top phase only	20	10
Single Pole—Arresters on all three phases	20	4
H-Frame—Unshielded	36	53
H-Frame—Single shield wire	36	15
H-Frame—Double shield wire	36	8
H-Frame—Arresters on all three phases	36	8

• Bonding

The structures TU Electric investigated all had some type of bonding. The insulator hardware was attached to the pole grounds. This bonding reduces the BIL of the structure and will lower the lightning performance level of the lines with arresters. TU Electric chose to leave all of the bonding on the structures. The bonding of the structures may be removed at a later date if the line does not perform to expectations.

(CONTINUED)

Figure 3
Typical Arrester Installation - 69 kV Single Pole



TU Electric decided to install arresters on all three phases for both the single pole and H-Frame lines. This method provides the best performance, is the most economical, and eliminates concerns about high ground resistance.

Table 2
Cost Comparison

Construction Type	Shield Wire (cost per mile)	Arrester (cost per mile)
H-Frame	$21,000*	$7,500
Single Pole	$17,000*	$7,500

*These costs can increase considerably if the poles are not able to handle the added load.

Installation

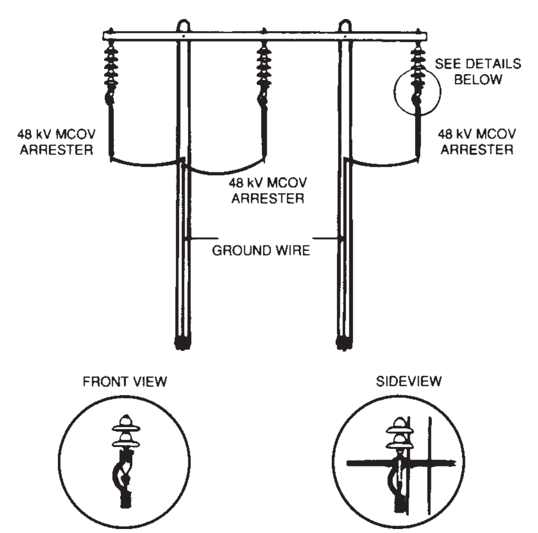
A number of different installation methods were investigated. The method chosen for pin type construction is shown in Figure 3. The three arresters are attached to the conductor with an eye connected to a suspension clamp. This connection is bonded with a copper lead to prevent any radio interference. The ground side of the arrester is connected with an eye to a deadened clevis which was connected to existing bolts on the pin insulator or ridge pin assembly depending on which phase is receiving the arrester. This connection is also bonded with a copper lead connected to the ground wire which is taken down the pole to a driven ground at each structure.

The arresters are equipped with an isolator which separates if the arrester fails. The isolator was placed on the conductor side of the arresters, so the arresters will fall away from the conductor down to the pole or crossarm if the arrester should fail. An arrester failure will not cause an immediate maintenance problem. The failed arrester can be spotted from a distance during routine inspection and replaced when convenient.

Two other installation methods were investigated for single pole construction. One included suspending the arresters from the conductors with a suspension clamp with no connection at the ground except for the ground lead itself. This method was eliminated because of clearance concerns if the top arrester were to fail. The isolator or arrester itself could fall into one of the lower phase conductors. Another method was mounting the arresters in a fixed position with a bracket attached to the pole or crossarm similar to a distribution arrester. This method was eliminated because of problems finding a satisfactory bracket.

The installation method for H-Frame construction is shown in Figure 4. The arresters are attached directly below the suspension clamp using a bracket designed specifically for this purpose. The bracket uses a pin to replace the existing pin in the suspension clamp and another pin at the bottom to connect to the eye on the arrester. The connection is bonded with a copper ground lead. By attaching the arrester directly below the suspension clamp, concerns about the affects of conductor galloping are eliminated. The ground side of the arrester is connected to the pole ground with a copper lead. The isolator is located on the ground side of the arrester and will fall away if the arrester fails.

Figure 4
Typical Arrester Installation - 69 kV H-Frame



Two other installation methods were investigated for H-Frame construction. One was to suspend the arresters from a separate suspension clamp a few inches from the existing suspension clamp. This method was not used because of potential problems during conductor galloping. Another method was to connect the ground side of the arrester directly to the pole and mounting the arrester horizontally between the pole and conductor similar to a strut insulator. This method was not used because of problems associated with a crimp connector or clamp on the conductor itself.

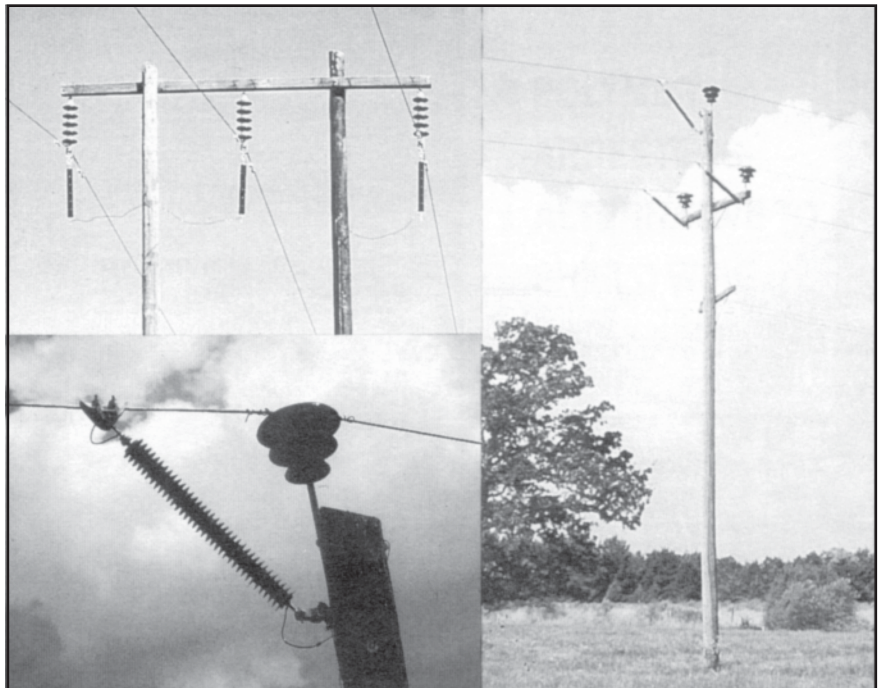


Figure 5: Construction Photographs

Construction

The arresters were relatively easy to install, especially when compared to adding shield wires. The construction crew was able to set up at the structure and complete their work with minimal damage to the right-of-way. They were also able to work on the project whenever their schedule permitted. Crew sizes varied on the different projects, but only a few workers were required at each structure location. After a learning period at the beginning of the project, the crews were able to install the three arresters at each structure in less than one hour. Photographs of the installations are shown in Figure 5.

Conclusion

TU Electric has now installed arresters or shield wires on 155 of the 450 miles of unshielded lines. Shield wires and bayonets were added to two H-Frame lines covering 30 miles. Arresters were added to five lines covering 125 miles. Table 2 shows a comparison of the installation costs on the two different construction types.

In the future, TU Electric will investigate other applications for arresters. Potential applications include arresters for new construction, line rebuilds or reconductors, and as additional protection for critical or problem lines. Arresters on new construction would reduce the required structure height and could provide better lightning protection than shield wires. Arresters on line rebuilds could allow the existing structures to remain with larger conductor by eliminating the shield wires.

Although the arresters have not been in service for enough time to establish definite conclusions, operation records indicate significant reductions in outages during storm conditions. TU Electric continues to evaluate performance and will make determinations of future arrester installations after adequate performance data has been evaluated.

Web: http://www.hubbellpowersystems.com
E-mail: hpsliterature@hps.hubbell.com

UNITED STATES

HUBBELL POWER SYSTEMS, INC.
210 N. Allen
Centralia, Mo 65240-1395
Phone: 573-682-5521
Fax: 573-682-8714
e-mail: hpsliterature@hps.hubbell.com

CANADA

HUBBELL CANADA, INC.
870 Brock Road South
Pickering, Ontario L1W 1Z8
Phone: 905-839-1138
Fax: 905-831-6353
e-mail: infohps@hubbellonline.com

MEXICO

HUBBELL DE MEXICO, S.A. DE. CV
Av. Coyoacan No. 1051
Col. Del Valle
03100 Mexico, D.F.
Phone: 52-55-9151-9999
Fax: 52-55-9151-9988
e-mail: vtasdf@hubbell.com.mx

ASIA

HUBBELL S.E. ASIA PTE. LTD.
23 Tagore Lane #03-16
Tagore 23 Warehouse
Singapore 787601
Phone: 65-6454-4772
Fax: 65-6454-4775
e-mail: hpsliterature@hps.hubbell.com

ANDERSON™ CHANCE® FARGO® HUBBELL® OHIO/BRASS®

EU1413-H