ArresterFacts 017

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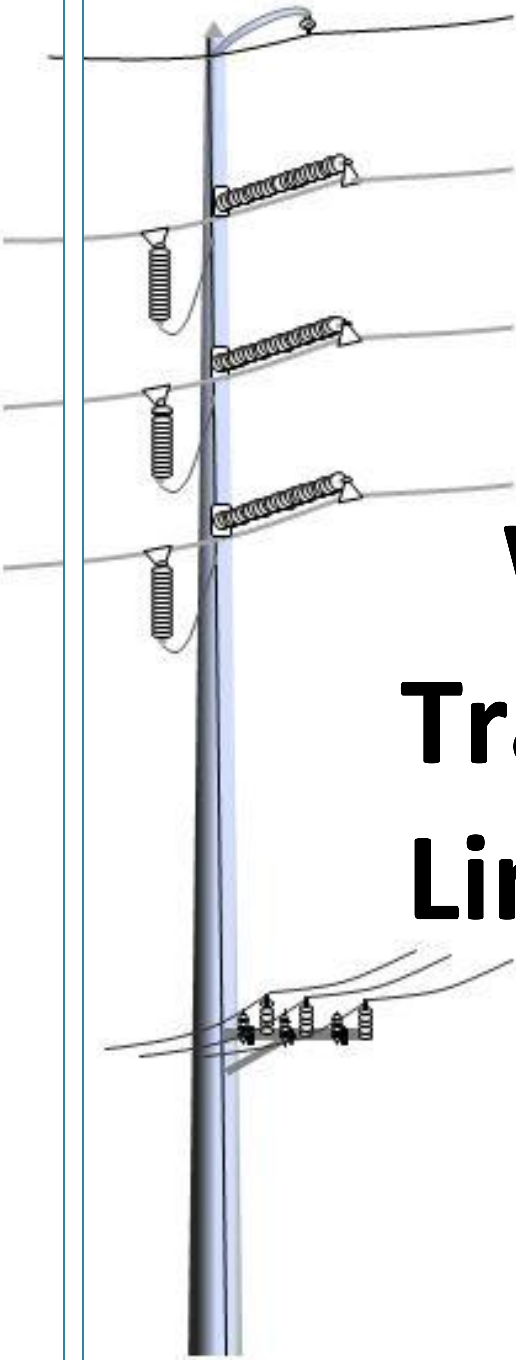

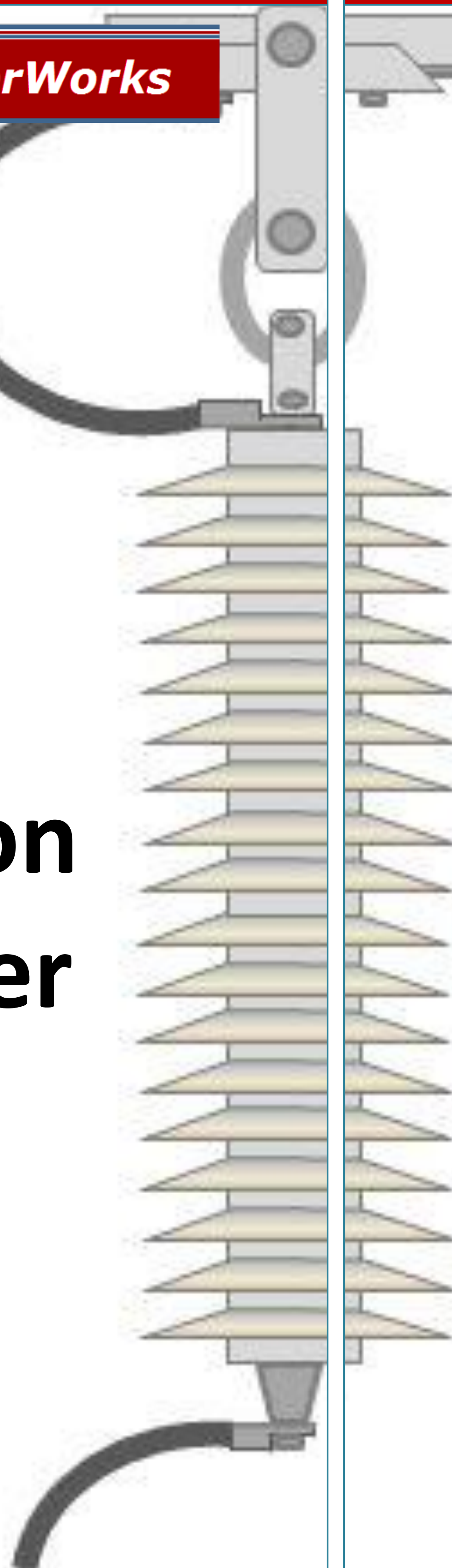

What is a Transmission Line Arrester

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Introduction

Power system reliability demands continue to grow in priority and because of this; electrical service providers are seeking means to provide this desired improvement. An effective method of reducing lightning related outages on transmission lines is by the strategic application of arresters. Since the early 1990's cost effective and light weight arresters have been available for installation on transmission lines. Arresters can also be an effective means for transmission line cost control as when they are used in switching surge control, voltage uprating projects and compact line construction. This ArresterFacts covers the fundamentals of Transmission Line Arresters (TLAs).

Definitions

The definition of Transmission Line Arrester does not appear in any IEEE standard or IEC standard associated with arresters. The term Line Arrester does appear in the text of IEEE C62.22-1997 but it is not found in any existing IEC standard.

Line Arrester

Any arrester that is applied on the lines of a power system to reduce the risk of insulator flashover during surge events. A line arrester is not generally used to protect equipment. Substation type arresters as well as distribution type arrester can be used for line protection and in this case are then considered line arresters.

Transmission Line Arrester is a line arrester applied on a transmission line.

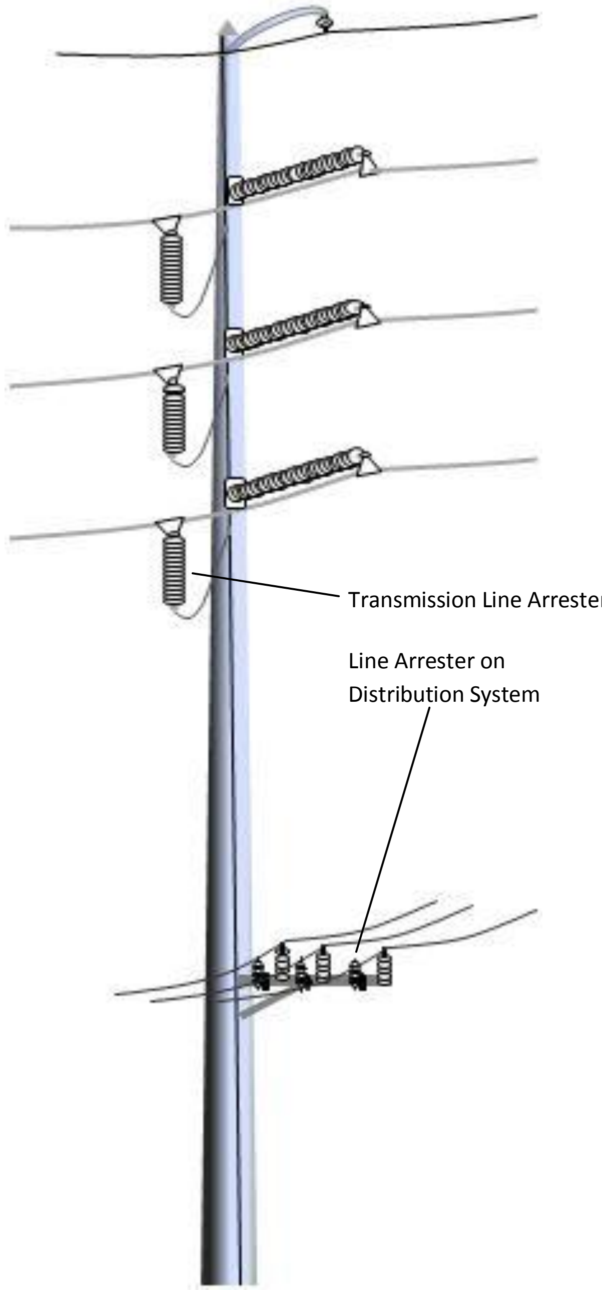

Figure 1: Two forms of Line Arresters - Transmission Line and Distribution Line Arresters

Externally Gapped Line Arrester (EGLA)
A line surge arrester designed with an external spark gap in series with a SVU part to protect the insulator assembly from lightning caused fast front overvoltages only; this is accomplished by raising the spark over level of the external series gap to a level that isolates the arrester from power frequency overvoltages and from the worst case slow front overvoltages due to switching and fault events expected on the line to which it is applied. (This is an IEC term, not yet recognized by IEEE users and market)

Backflash
A backflash is a flashover originating from the pole or tower ground across the insulator onto the phase conductor as shown in Fig. 2. This can occur during a lightning strike to the overhead shield wire

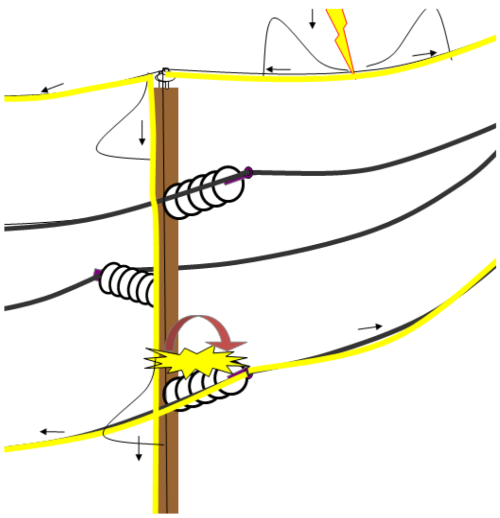

Figure 2: The Backflash

and where the ground impedance is high. It is referred to as a back flashover since it is in the opposite direction of flashovers produced in laboratory tests. The backflash is usually followed by a standard flashover of the insulator with power frequency current that requires a breaker operation to terminate.

Ground Lead Disconnector (GLD)
A device attached to the ground end of an arrester to disconnect it from the ground in the event of a faulted arrester. Sometimes this device is attached to the line end of the arrester however it is still referred to as a GLD. (more info in ArresterFacts 005 Arrester Disconnector)

Purpose of a Transmission Line Arrester

There are two basic reasons to install transmission line arresters on a system. The most common purpose is to reduce or eliminate lightning induced outages due to flashover of insulators. The second and less common purpose of this type of arrester is to eliminate insulator flashover due to switching surges. In both cases, the objective is to reduce or eliminate flashover of system insulators. In both cases, a study of the system is generally carried out to determine the best location for the arresters to fulfill the desired results.

For switching surge control, the arresters need only be located where the switching surges reach an amplitude that exceeds the insulator string switching surge withstand levels. This could be just a few locations along the entire transmission line.

For lightning surge control, the zone of protection is seldom more than one span from the arrester therefore arresters need to be located at nearly every tower and sometimes on each phase.

Theory of Operation

The transmission line arrester applied to shielded lines operates differently than any other arrester application. The surge current is conducted onto the phase conductor instead of away from it as in all other cases of lightning protection.

If no arresters are in service, and a shield experiences a direct strike, the surge current travels down the shield line and down the nearest pole down conductor. If the voltage along this down conductor increases to a level that exceeds the withstand level of the line insulator (approximately 85% of CFO), the insulator may backflash. Immediately following the backflash is a power frequency forward flash created along the ionized surge current arc path as shown in Fig. 3 This power frequency arc is the undesirable event because it can only be terminated with an overcurrent device that causes a blink on the system.

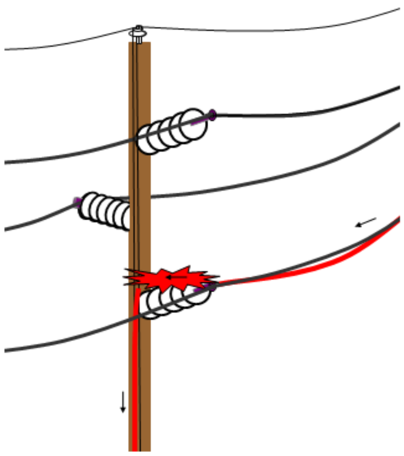

Figure 3: Power Frequency Forward Arc Flash

With an arrester installed on this phase, the surge current is uneventfully transferred onto the phase conductor as shown in Figure 4. No ionizing arc is produced so there is no power frequency fault and no blink or momentary outage. In all cases, transmission line arrester applications inhibit insulator flashovers which in turn eliminate system momentary outages.

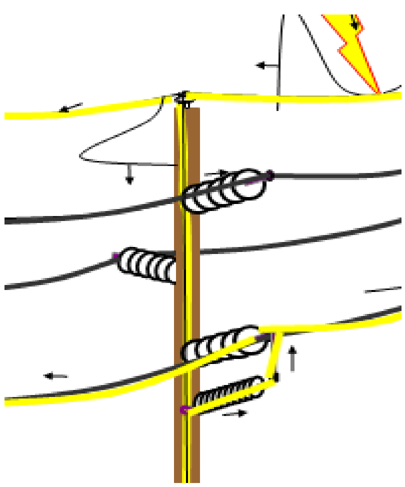

Figure 4: TLA Conduction path on a shielded system

Specifying Transmission Line Arresters

There are many factors involved in the selection of a transmission line arrester. These factors are as follows.

1. Purpose of the arrester. Switching mitigation, lightning mitigation, or both.
2. Nominal system voltage and temporary overvoltage potential
3. System shielding. For unshielded systems, where the top phase is used as a shield, the top arrester may be different than the others.
4. Lightning flash density and or historical insulator flashover rate.
5. Quality of the tower ground.
6. Desired flashover rate.
7. Available fault current on the system.

For details on TLA selection, see ArresterFacts 017a TLA Selection Guide

TLA Components

It is important to note that there are some basic components of a TLA that are common to all units, but nearly each TLA configuration is different and must be designed for that particular application. Even in one project there may be several configurations needed to match the numerous tower or pole configurations. Connecting hardware and arrester orientation must be designed for each installation.

Saddle Clamp: This component is often times the same component that is used to connect the conductor to the insulators.
Flex Joint: The flex joint is essential for the longevity of the arrester. This joint

eliminates mechanical stress on the arrester due to the motion of the conductor.
Shunt: This component eliminates the need of the flex joint to also be a current carrying component.

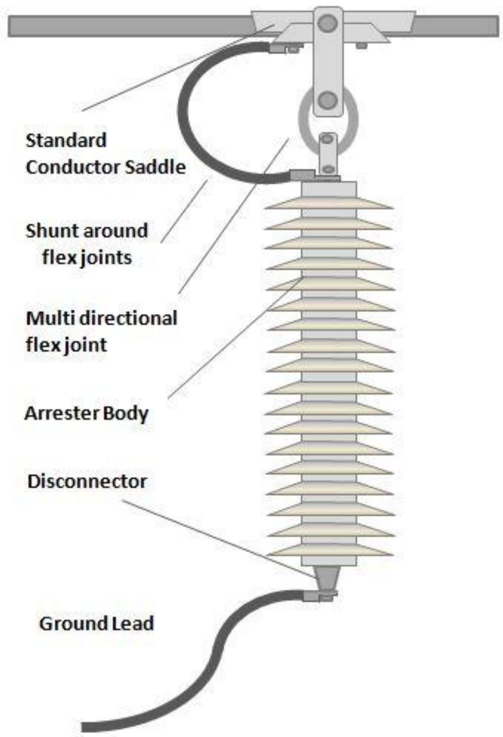

Figure 5: Typical Suspension Arrester

Arrester Body: This component is very similar from configuration to configuration. It is electrically specified to conduct for either lightning only or for lightning and switching surges.
Disconnector: The disconnector separates only in the event of an arrester failure. Should the arrester become a short circuit to the system, the disconnector operates and isolates the arrester from earth.
Ground Lead: The ground lead connects the arrester to the tower ground. Lead management is important here to insure that the ground lead never makes contact with other phase

Arrester Locations

Determining the optimum locations for transmission line arresters to achieve your desired outage rate is not a simple task. If no arresters are installed on a line, it is a well known fact that with a direct strike to a phase conductor, there is a 100% probability of an insulator flashover. It is also a fact that if arresters are installed on every phase of every tower, a direct strike to the shield or phase conductor will result in 0% probability of an insulator flashover.

Any arrester locations other than these two above will result in lowering the probability of flashover, but without a lightning mitigation study the probability will be unknown. Most manufacturers of transmission line arresters can calculate the probability of flashover if a few system characteristics are provided to them.

Lightning mitigation studies can also ran by using EMTP/ATP type software. Numerous engineering consultants can supply this data service. As usual overvoltage protection is as much an economic decision as a technical decision.

The following table shows typical results of a lightning mitigation study for various arrester locations.

Flashover Probability for a 230kV Vertical Structure Configuration and a 50 ohm ground when struck by lightning	
Arrester Location	**Probability of Flashover**
No Shield and No Arresters	100%
Arrester on top phase only on every other structure	88%
Arresters on all phases on every other structure	87%
No Arresters, only a Shield wire	21%
Arresters on top phase of every structure	18%
Arresters on all phases of every structure	0.00%

Figure 6: Example Flashover Probabilities

Grounding Considerations

When shield lines are initially installed, a great deal of effort is made to insure that the tower ground impedance is as low as possible. High impedance grounds can cause significant voltage levels to appear along the tower down conductor during a lightning event. The general rule of thumb here is “The higher the ground impedance, the higher the risk of backflash on the insulators”.

When transmission line arresters are installed on a tower, the importance of the ground is reduced and can be virtually eliminated. If arresters are installed on all three phases, the value of the ground becomes insignificant. With higher ground impedance more surge current is diverted onto the phase conductor which may seem like an issue, but has no negative impact on the phase conductor performance.

Unshielded Configuration

Another popular TLA configuration is when the arrester is connected to the top phase of an unshielded system. This is popular for shorter compact line applications. In this configuration the two lower phases can backflash if arresters are not installed. Also in this configuration the top arrester may require a higher energy rating or current carrying capability since 100 percent of the stroke current conducts through the arrester before it is shunted to earth.

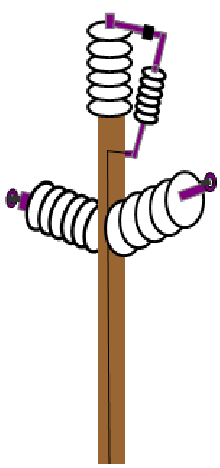

Figure 7: Unshielded Configuration

Externally Gapped Line Arrester (EGLA)

The EGLA is a transmission line arrester that is growing in popularity in most of the world except North America. Currently this arrester is installed for lightning mitigation of shielded lines. The theory of operation is the same as an ungapped arrester, however the series gap requires a sparkover before the arrester will begin to conduct the surge. If the gap is set sufficiently high, the arrester will not conduct during a switching surge. There is no real technical reason why this arrester design could not be used for switching surge mitigation, however that application has not been utilized yet. For more see ArresterFacts 004a.

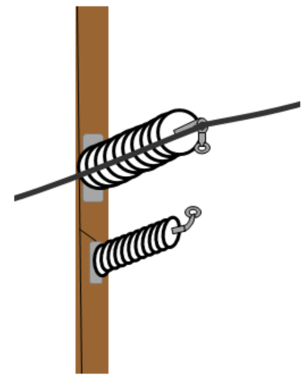

Figure 8: Externally Gapped Line Arrester (EGLA)

Standards

Currently there are no standards specifically written for transmission line arresters. There are only a few references to line arrester applications in existing guides.

The standards that this type of arrester must comply with at the present time are

1. C62.11 IEEE MOV Arrester Test Standard
2. C62.22 IEEE MOV Arrester Application Guide
3. IEEE 1243. Guide on Lightning Improvement of Transmission Lines
4. IEC 60099-4 Gapless MOV Test Standard

5. IEC 60099-5 Gapless MOV Application guide. (Soon to cover all designs)
6. IEC 60099-8 EGLA (In draft state)

Future

Using transmission line arresters on compact line and voltage upgrading projects hold significant opportunity for the industry. However both of these applications require that engineers to specify clearance limits lower than those used for the past 100 years. Due to the conservative nature of this industry these two applications remain underutilized.

Summary

The application of transmission line arresters continues to be the area of most activity in the high voltage arrester industry. The reason for this popularity is due to the fact that TLA's can and do improve lightning induced outages. However even with this increased popularity, this device is still misunderstood and not fully utilized. This ArresterFacts was written to improve this lack of understanding. For a more extensive guide on how to select the right TLA sees ArresterFacts 017a.

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Other ArresterFacts Available

Thank you for using www.ArresterWorks.com as a source of information on high voltage surge arresters.

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