ArresterFacts-001
Arrester Lead Length

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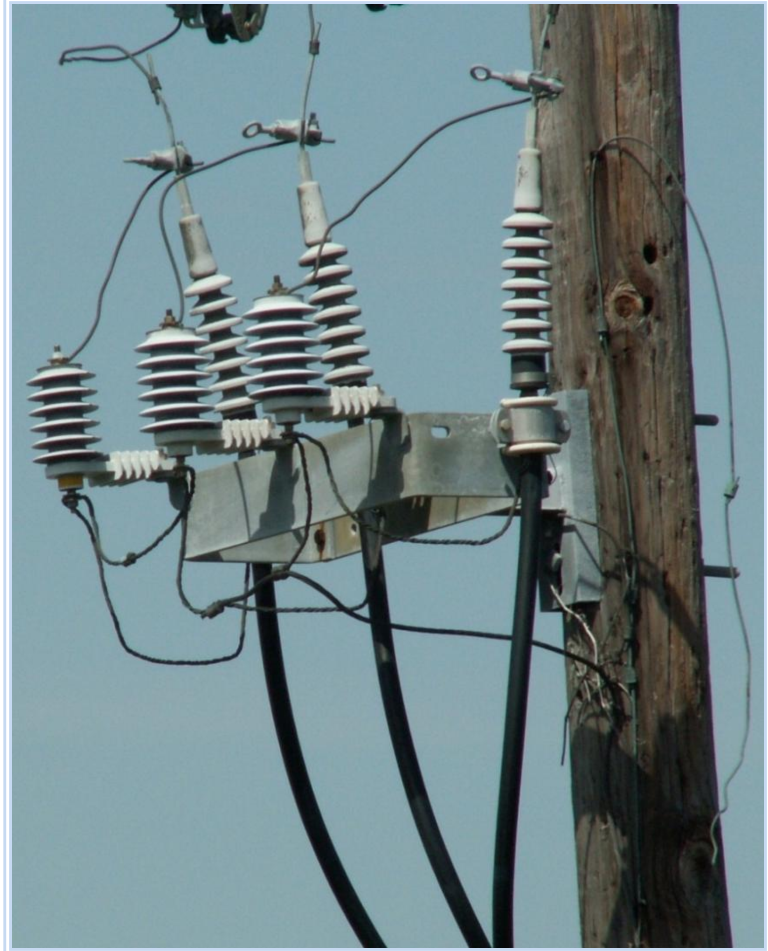
The arrester lead length issue is not a new one, but is still routinely misunderstood. If a stakeholder wants the highest return on their arrester investment, then the leads connecting the device should be as short as possible.

This ArresterFacts will show you why!

Note: This is an excellent example of short lead lengths.

This ArresterFacts applies to distribution arrester and medium voltage arresters. For a similar effect on substation arresters, see ArresterFacts: Separation Distance

Contents



Arrester lead length is of the utmost importance when protecting underground circuits also.

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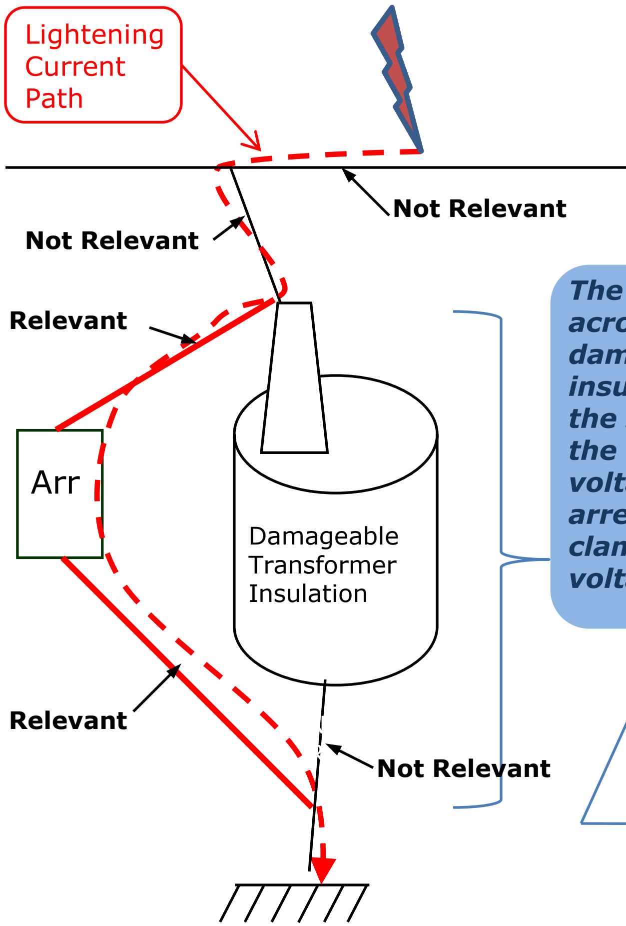
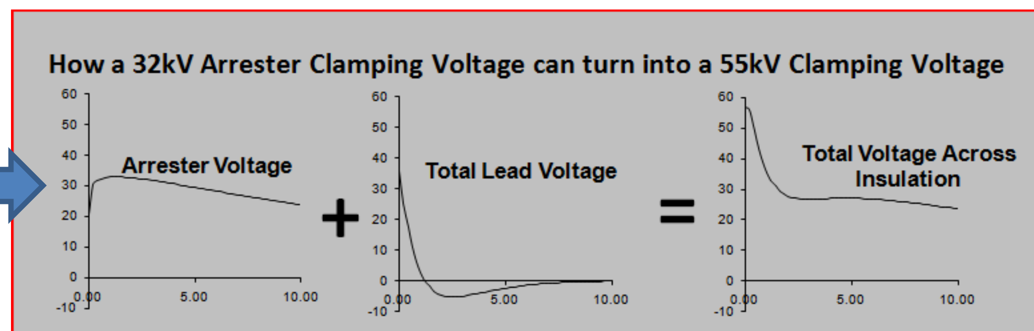


The voltage across the damageable insulation is the sum of the lead voltages and arrester clamping voltage

Definition of Relevant Arrester Lead Length

Any section of the arrester leads that are electrically in parallel with the protected insulation and conduct impulse current during the lightning strike

- *Only relevant at impulse frequencies*
- *Only important for damageable insulation*
- *Can be inside or outside the tank*
- *The arrester rating has no effect on the lead length effect*
- *Can be a ground lead or line lead*



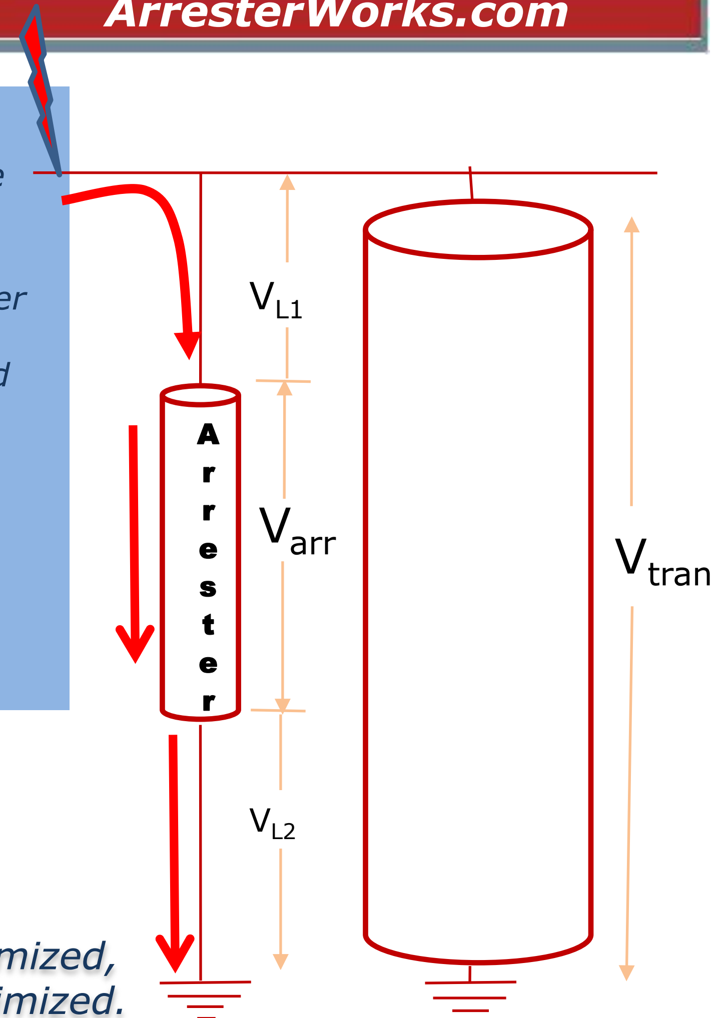
Why Does it Matter

The purpose of an arrester is to limit the voltage stress on the insulation electrically in parallel with it during a surge event.

The voltage stress on the insulation in parallel with the arrester is the sum of the arrester residual voltage and the inductive voltage of the leads that are also in parallel with the protected insulation.

The longer the leads, the higher the voltage created by the leads during the surge.

The higher the stress on the insulation, the higher the probability of equipment failure.



During a surge, the voltage stress on the transformer insulation is

$$V_{tran} = V_{L1} + V_{arr} + V_{L2}$$

It should be obvious then that if V_{L1} and V_{L2} can be minimized, then the stress on the transformer insulation will be minimized.

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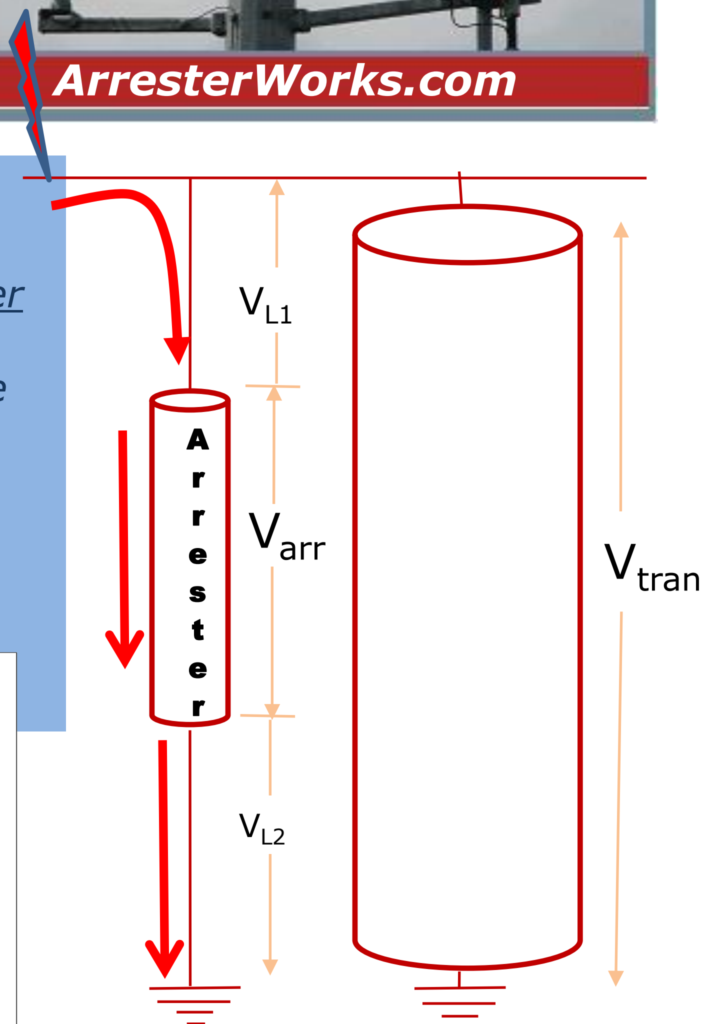
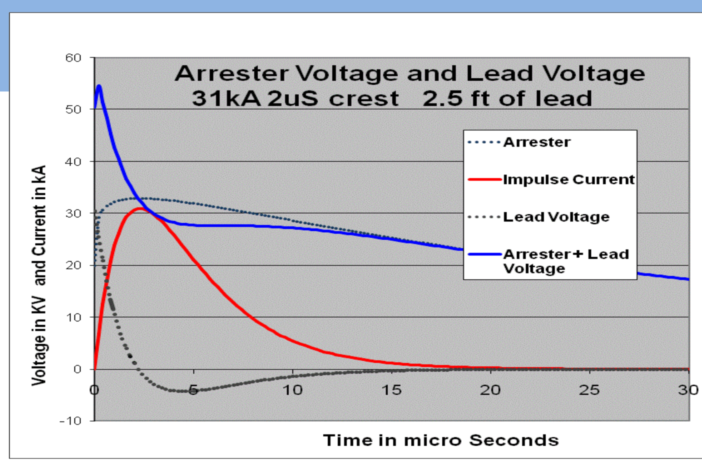
How to Calculate the Effect

V_{arr} is a function of the surge current magnitude, surge current wave shape and VI characteristics of the arrester

V_{L1} and V_{L2} are a function of the rate of rise of the surge current, and the inductance of the lead.

For an accurate value, the total voltages is not an arithmetic sum since the max values of each voltage do not occur at the same time.





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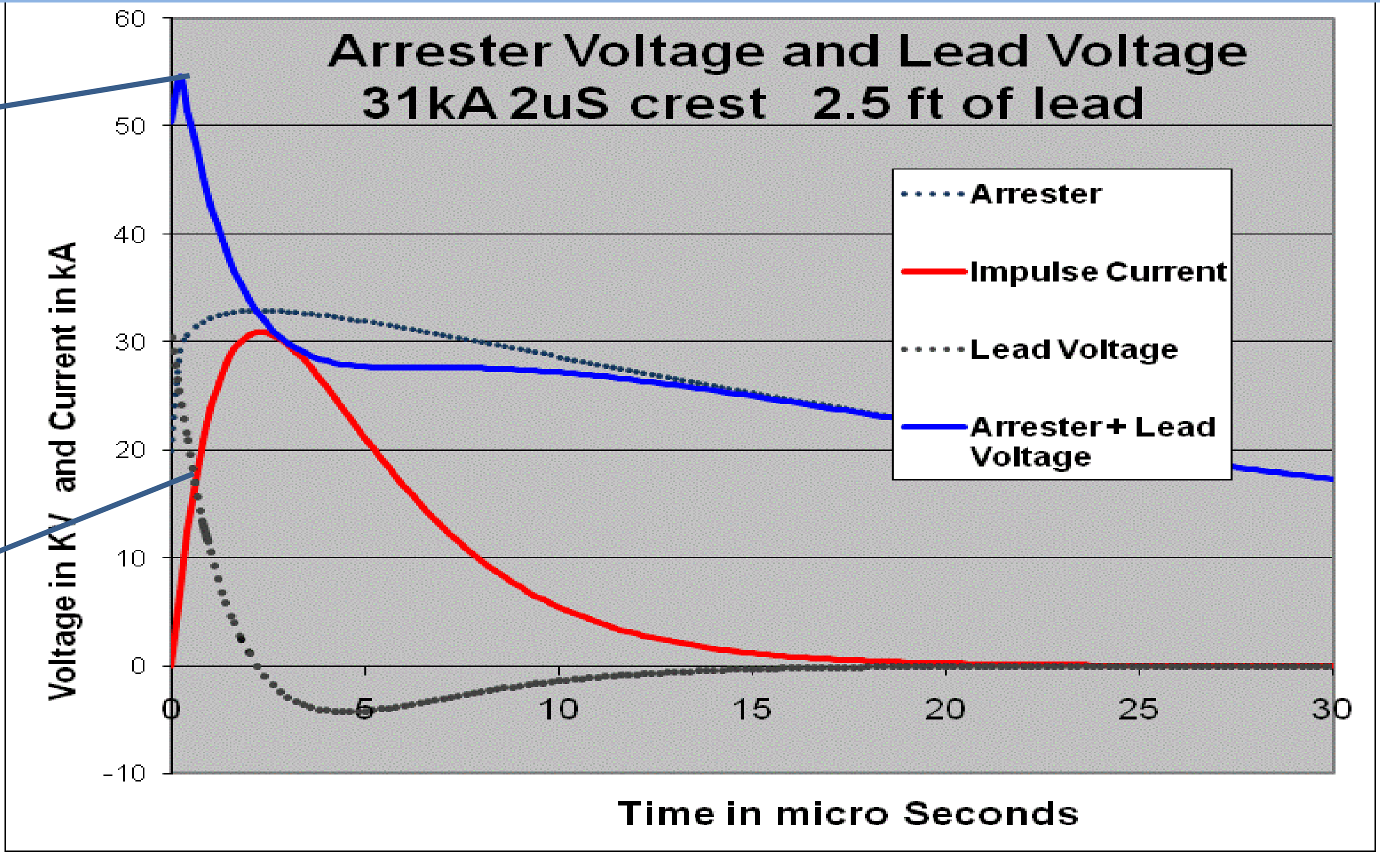
Example: *In this example, the line leads generate 29kV crest voltage and the arrester generates 32kV crest and the total voltage across the protected device is 54kV.*

Note that since the crest voltages are at different times, the total voltage is not a simple sum.



Note that the inductive voltage of the lead is maximum where the rate of rise of the current is the highest

Approximate Calculation for the Lead only

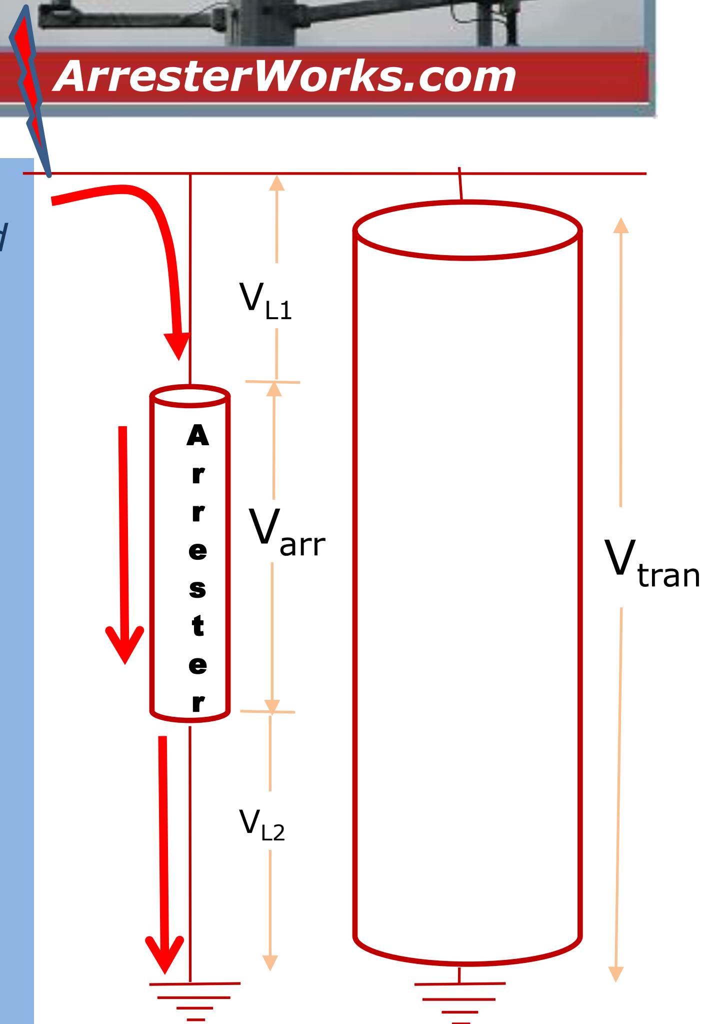
The approximate lead voltage (kVp) that can be added to the arrester residual voltage is

*V_{Lead} = L/unit * Length * (di/dt) * K*
V_{Lead} = kV crest
L/unit = .34uh/ft or .94uh/m (typical)
Length = feet or meters (total length of lead)
di/dt = crest surge current kA/ time to crest in μs
K =2.0 = compensation for inaccurate di/dt

Example
2.5 feet of lead , 31kA surge that crests in 2.5 μs

*V_{Lead} =.34 * 2.5* (31/2.5) * 2.0*
V_{lead} = 21.08 kV

The arrester voltage (V_{arr})for the rating of arrester used and the current level used comes directly from the catalog section of the arrester supplier.



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A more accurate calculation

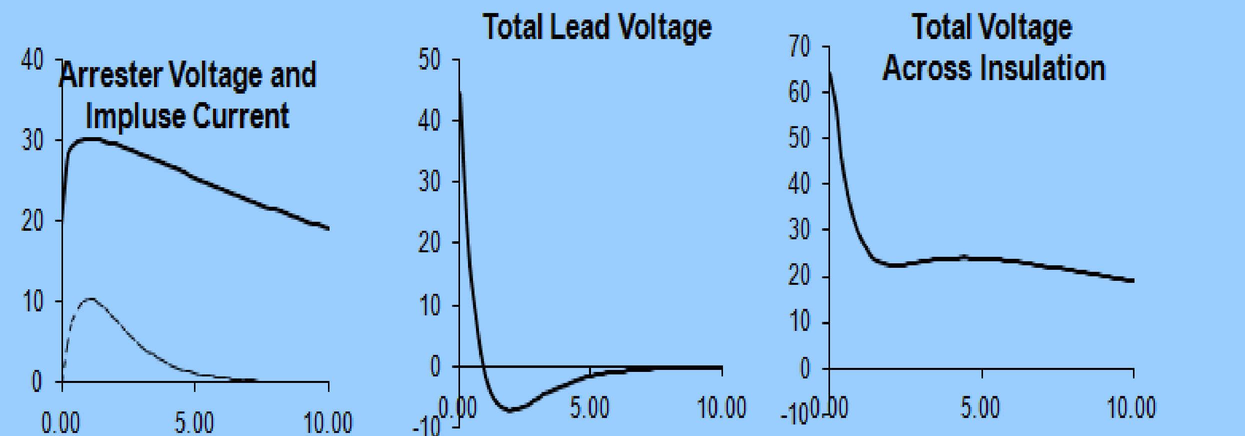
By downloading the Interactive Lead Length Effect Calculator from ArresterWorks, one can generate a graphic output similar to the one seen here. This excel based calculator uses the exact di/dt.

Interactive Accurate Lead Length Effect Calculator

Enter Peak Crest Time (us)	1
Enter Peak Current (kA)	10
Enter Lead Length (ft)	6

Enter Inductance (uH/ft)	0.32
Enter Arrester Rating (kV)	10

Max Combined V (kV)	64



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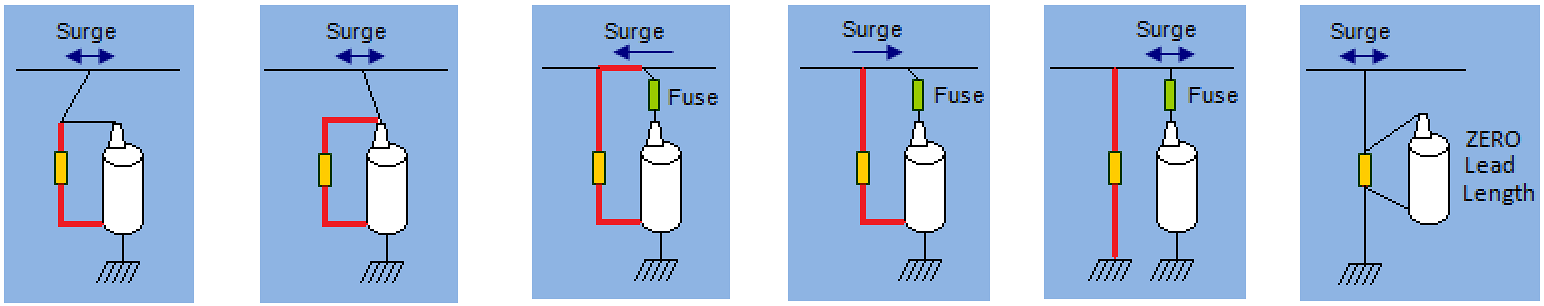
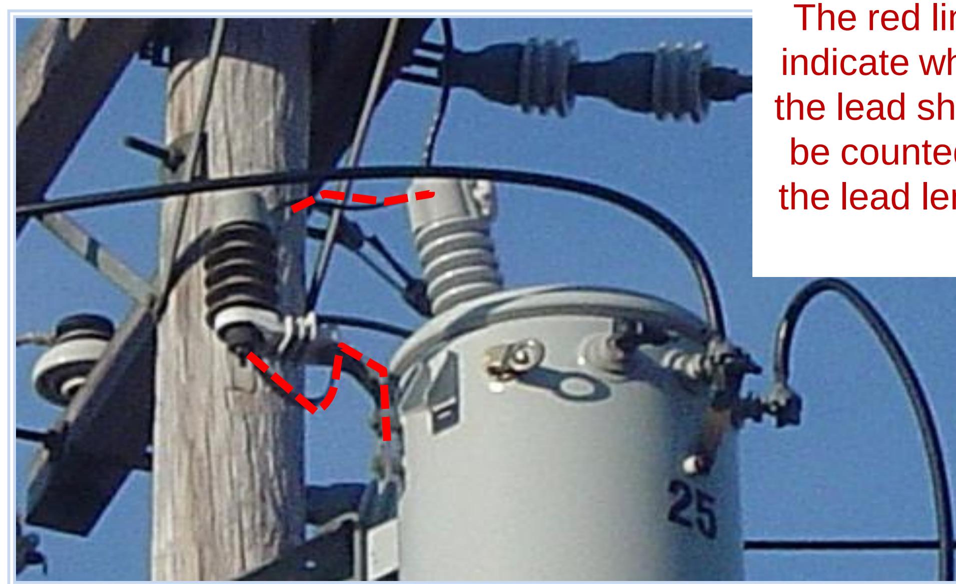


Basic Rule to Follow

The lead length that is in parallel with the protected insulation and conducts the surge current during a strike will be the relevant lead length.

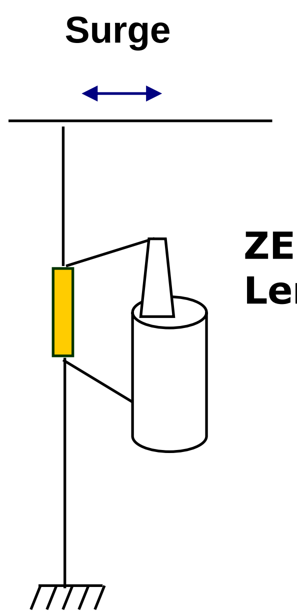


The red lines indicate where the lead should be counted in the lead length

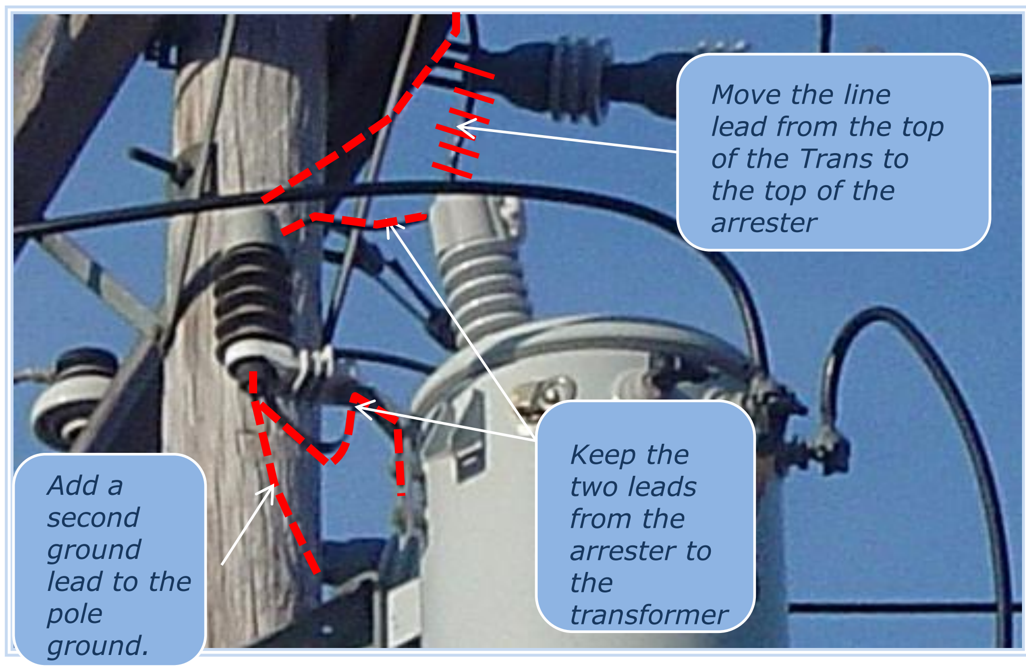
Zero Lead Length Configuration

In the configuration below, two changes will turn this into a Zero Lead Length Configuration.

1. *Move the line lead from the top of the transformer to the top of the arrester.*
2. *Add one more lead from the bottom of the arrester to the pole ground. (Do not remove the lead between the arrester base and the transformer ground.*



ZERO Lead Length



Thank you for using ArresterFacts

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Thank you for using ArresterWorks as your source of information on Arresters.

Jon Woodworth