Improving Lightning Protection of Power Systems with Externally Gapped Line Arresters (EGLA)

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ArresterWorks
Today's Presentation

1. Real Value of Arresters
2. Improving Distribution Line Protection with EGLA
3. Improving Substation Protection with EGLA
The Real Value of Arresters

• Do we really need to spend our reliability budget on arresters?
• Do they really work?
• How do we justify all this effort?

Very valid questions and ones that every new surge protection engineer should ask......
Montreal 1990’s

In the early 1990’s Hydro Quebec provided great data on the value of an arrester.

For many reasons, they had many distribution transformers without arrester protection.

Then.....1993-1994 Fewest Arresters and More Lightning

Results...... Not good
Montreal 1990's

DISTRIBUTION TRANSFORMER FAILURE CAUSED BY LIGHTNING AND ASSESSMENT OF ARRESTER EFFICIENCY

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Fig 1: Variation of transformers protection

Fig 4: Transformer failure rate from 1988 to 1996
Montreal 1990’s

Study Conclusion

Lightning arresters reduce the rate of transformer failure by about a factor of 10
Example 2 is based on Ground Flash Density and the System Configuration

If the direct strike collection rate of a 4 span section is calculated, then the transformer failure avoidance rate can be determined.
The Real Value of a Distribution Arrester

Assumptions

1. With a Direct Strike and No Arrester will equal a Transformer Failure

2. Direct strike is a function of system and ground flash density
Calculating the Direct Strike Rate on a Distribution Line

\[ N = N_g \left( \frac{28h^{0.6} + b}{10} \right) \]

- \( N_g \) = ground flash density (flashes/km\(^2\))
- \( b \) = width between outside conductors (m) (2m)
- \( h \) = the height of the pole or tower (m) (10m)

Collection Area \( \times \) GFD = Collection Rate
## Results

For 4 spans of a distribution system assuming a distribution transformer cost 1000 USD installed

<table>
<thead>
<tr>
<th>$N_g$</th>
<th>Time between direct Strikes</th>
<th>Number of saves in 20 year life of arrester</th>
<th>Dollars saved over life of the arrester</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>37 years</td>
<td>.54</td>
<td>1851</td>
</tr>
<tr>
<td>4</td>
<td>9 years</td>
<td>2.22</td>
<td>2,200</td>
</tr>
<tr>
<td>8</td>
<td>4.5 years</td>
<td>4.44</td>
<td>4,400</td>
</tr>
<tr>
<td>12</td>
<td>3.1 years</td>
<td>6.45</td>
<td>6,450</td>
</tr>
</tbody>
</table>
The Real Value of a Distribution Arrester

If a 100 dollar investment on an arrester results in cost avoidance of 6000 USD over its life, then the arrester has a value 60 times it cost

Can't beat that as a return on your dollar……
The Real Value of a Station Arrester
The Real Value of a Station Arrester

Assumptions
1. All stations are protected from direct strikes
2. Induced surges are low enough level not to damage equipment
3. Surges to the transformer arrive on the incoming line.
The Real Value of a Station Arrester

Example Parameters
1. 115kV system
2. 1000 meters collection
3. 1% backflash rate
4. Not accounting for Switching Surges
The Real Value of a Station Arrester

For 1000 meters of 110kV transmission line and a transformer worth 100,000 USD

<table>
<thead>
<tr>
<th>$N_g$</th>
<th>Time between direct Strikes</th>
<th>Number of saves in 20 year life of arrester</th>
<th>Dollars saved over life of the arrester</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>27 years</td>
<td>.074</td>
<td>7,400</td>
</tr>
<tr>
<td>4</td>
<td>7.3 years</td>
<td>.27</td>
<td>27,000</td>
</tr>
<tr>
<td>8</td>
<td>3.7 years</td>
<td>.54</td>
<td>54,000</td>
</tr>
<tr>
<td>12</td>
<td>2.5 years</td>
<td>.80</td>
<td>80,000</td>
</tr>
</tbody>
</table>

Lightning Only!!!!
The Real Value of a Transmission Line Arrester
The Real Value of a Transmission Line Arrester

Not Sure

But
The Real Value of a Transmission Line Arrester

It is related to
- Ground Flash density
- Line Geometry

Most Importantly

Effect of Outages on the Users of Power!!!!!!
Improving Protection of Power Systems
Opportunities to Improve the Lightning Performance of Distribution Systems

1. Transformers are already protected very well
2. Line Protection is only real option to improve lightning performance
Opportunities to Improve the Lightning Performance of Distribution Systems

Eliminate the 4/mile practice
• When a surge hits near Pole A, Pole A is well protected...... However most of the time Pole B will then flashover
• The reason for the transfer of the FO is because even though the line arresters save the insulators on Pole A from FO, the pole top voltage rises to significant levels. Several megavolts.

The voltage rise propagates down the line.
With no protection on other poles, the arresters on Pole A are nearly worthless.
A much better alternative to 4/mile is one on top phase of each pole. This configuration can bring your outage rate close to Zero from lightning.
An even better option is to use Externally Gapped Arresters in this application.
Why the EGLA is a Better Alternative for Line Protection

1. Guaranteed to Fail Open
2. No Losses
3. Environmentally more friendly
4. Longer Life
5. Less aging of parts
6. Retrofittable

AND
Soon to be available with a Failure Indicator and with 100% BIL Restoration

Using a standard disconnector but constrained with insulating retainer

Patent Pending
Opportunity to Improve the Lightning Performance of Substations
Opportunity to Improve the Lightning Performance of Substations

Install Line Entrance Arresters at line entrance or first tower
Line Arrester at Sub Entrance
Benefits of Line Entrance Arresters on First tower

1. Eliminates potential of open breaker flashover
2. Reduces stress on transformer mounted arresters
3. Minimal mounting issues compared to mounting in station
Benefits of EGLA as Line Entrance Arresters

1. No Grading Ring
2. No Losses
3. Fail Open
4. Minimal Clearance Issues
5. Failure indicator and 100% BIL Recovery
Summary

• The real value of arrester is vastly underestimated

• There are real opportunities to improve lightning performance of power systems
  – Distribution
  – Substation

• The EGLA Arrester offers even more opportunity for line improvement.