# Insulation Coordination FAQ

**Jonathan Woodworth ArresterWorks**



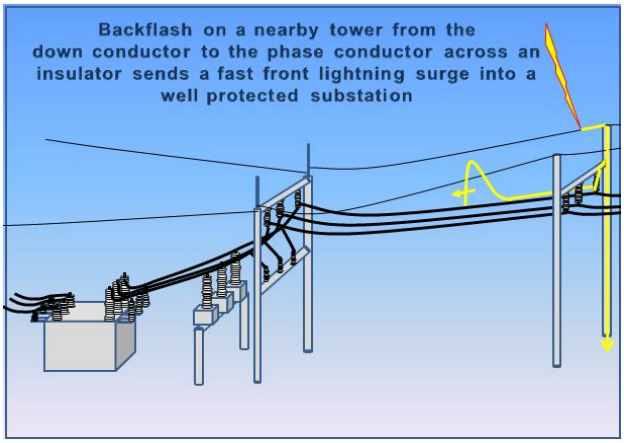
**What is Insulation Coordination?**

In its simplest form, Insulation Coordination is "the selection of insulation strength".

In a few more words, Insulation Coordination is a series of steps used to select the dielectric strength of equipment in relation to the operating voltages and transient overvoltages which can appear on the system for which the equipment is intended.

Many factors are taken into account during the selection process including the service environment, insulation withstand characteristics, arrester characteristics and in some cases, the probability of potential surges.

**What are some Examples of Insulation Coordination Studies?**




**High Voltage Substations** Typical studies include the analysis of a substation to determine the probability of post insulator flashovers. This is generally measured in flashovers per hundred years. Another important analysis is to determine that the insulation contained within transformers has an acceptable margin of protection. Since the internal insulation is not self-restoring a failure is completely unacceptable. An insulation coordination study of a substation will present all the probabilities and margins for all potential transients entering the station. The studies include both switching surge analysis and lightning surge analysis. Even though stations are usually shielded, the lightning surge finds its way into a substation when there is a backflash on any incoming line. The resulting current levels in the station are quite low relative to direct strikes, but all that is needed to fail insulation is voltage and not current. (Index)

**Transmission Lines:** In this type of study, switching surges and lightning surges are modeled using time domain software. The magnitude of the surges are compared to the insulator withstand capabilities to determine the potential outage rate based on the lightning density and expected switching surge activity. OHGW locations and ground resistances are very important in this type of study. If the study purpose is to determine locations for arresters for mitigation the process is quite iterative checking various installation cases. (Index)

**Small Power Plants:** This type of study analyzes the insulation from the generator terminals to the outgoing transmission or distribution lines. Incoming and internal surge sources are considered in this type of analysis. If the power plant is connecting to a distribution system that is unshielded, special consideration needs to be given to grounding on the incoming pole or tower. (Index)

**Industrial Complexes:** This type of study compares the expected transients on the power system and the insulation withstand of the system. For industrial environments, transients from arc furnaces, switching power supplies and other various electronics need special considerations. (Index)

**Windfarms and Solar farms:** These devices are treated in a similar fashion to small power plants. Grounding and internal switching surges need consideration. (Index)

**Are there any Insulation Coordination Standards?**

**The IEEE standards** that describe insulation coordination methods and definitions are C62.82.1 and C62.82.2. Prior to 2010 these standards were referred to as IEEE 1313.1 and 1313.2.

**The IEC standards** that describe insulation coordination methods and definitions are IEC60071-1, 60071-2 and 60071-4. (Index)

**Are there any standards that require Insulation Coordination studies to be completed?**

There are no standards that require studies be completed. Studies are risk reduction actions, and not mandated by standards but instead are the option of the owner as part of risk management. (Index)

**Who typically request Insulation Coordination Studies?**

Since there are so many types of studies, many different organizations request studies. Large utilities with large substations or transmission lines are typical study users. Small organizations that are having higher than desired outages will request lightning studies to mitigate the causes of the outage. Small power plants where uptime is so critical are common users and requesters of studies to improve their reliability. If your organization is responsible for power system reliability of an existing or future operation, then you are likely to be interested in an insulation coordination study. (Index)

**What are the Steps in an Insulation Coordination Study?**

In all types of studies, the basic steps are similar.

1. Clearly define the purpose of the study. Lightning, switching, both, etc.
2. Gather all relative data.
3. Model the system in time domain software such as EMTP, ATP, etc. Some non time domain software is available for transmission line studies similar to IEEE Flash.
4. Validate the model for proper response to various surge types.
5. Plan and develop potential transient cases.
6. Re run cases with mitigation options if that is part of the purpose.
7. Summarize flashover rates, margins of protection, clearances etc in table form
8. List Conclusions
9. Make recommendations (Index)

**What Types of Data Required for Insulation Coordination Study?**

The data collected for a study is dependent on the purpose of the study, but the following are examples of required data.

1. Collect BIL, CFO data of all insulation
2. Collect Arrester characteristics and installed locations if applicable.
3. Obtain one line diagram of system with distances between all insulators and arresters.
4. Insulator counts and locations in particular if a switching study is the goal.
5. Region of the country
6. Lightning data for area of analyses.
7. Ground resistances where possible. (Index)

**Is there any Importance in Geographic Location relative to studies?**

Insulation Coordination studies are done for all geographic locations. If the lightning density is low, that will be reflected in the study results. If a switching surge study is part of the analysis, geographic location is not a factor. If the location is in a high elevation, the results will definitely be affected and mitigation recommendations will also be different. (Index)

**How long does it take to run a study?**

Very simple studies can take as little as a few days if all relative data is available. Most studies require 30-50 hours of effort. Large studies of large substations or long lines with many tower types can take a several weeks to complete. (Index)

**What are typical recommendations from an Insulation Coordination Study?**

For substation the minimum insulation withstand capability is given based on the desired reliability. The reliability for substations is generally given in Mean Time between Flashovers (MTBF).

For transmission lines and distribution lines, the minimum insulation strength can be specified for the desired reliability often given in lightning flashover rate. However often times it is the reverse where the reliability rate is determined from the given in insulation. If the purpose of the study is to improve the reliability, the recommendation is to where to install arresters and what the associated flashover rate or back flashover rate will be. (FOR or BFOR) (Index)

**What are some of the Important Definitions used in Insulation Coordination?**

**Self-restoring Insulation:** Insulation which, after a short time, completely recovers its insulating properties after a disruptive discharge during test.

**Non self-restoring insulation**

Insulation which loses its insulating properties, or does not recover them completely, after a disruptive discharge during test.

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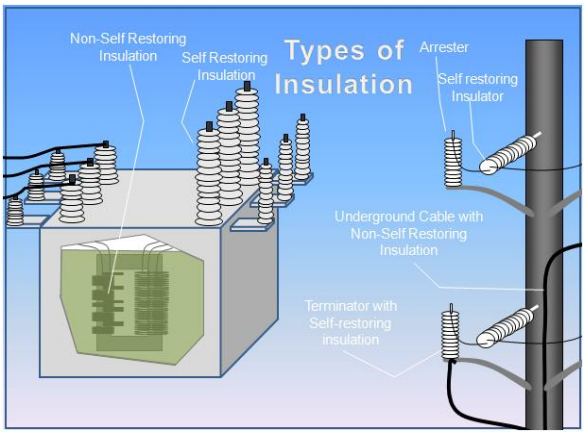

**Flashover Rate**

The rate at which an insulator flashes over on a system from lightning or switching. For a line study, this rate along with the BFR determine the outage rate of a line.

**Shielding Failure Rate (SFR)**

The shielding failure rate is the number of strikes that terminate on the phase conductors. If the voltage produced by a strike to the phase conductors exceeds the line CFO (critical flashover voltage), flashover occurs.

**Back Flashover Rate (BFR)**

The back flashover rate is the number of lightning strikes that terminate on towers or shield wires and result in insulator flashover The current impulse raises the tower voltage, in turn this generates a voltage across the line insulation. If the voltage across the line insulators exceeds the insulation strength, a back flashover can be expected from the tower onto the phase conductor.

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**Can I read Examples of Insulation Coordination Studies?**

Absolutely, below are links to three studies that can be read and downloaded.

Small Power Plant

High Voltage Substation

Transmission Line Lightning Study

**Where Can I find more information on Insulation Coordination Studies?**

1. ArresterFacts 037 " Insulation Coordination Fundamentals" by ArresterWorks
2. Insulation Coordination for Power Systems by Andrew Hileman 1999 Marcel Decker

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