

## ***Insulation Coordination***

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Insulation coordination was not given serious consideration until after the first World War, primarily due to a lack of information on the nature of lightning and the characteristics of available insulation and protective equipment. In the absence of that information, early coordination was rule of thumb based on experience and personal ideas. This resulted in parts of the system being over insulated while other parts were under insulated in many cases.<sup>1</sup>

Today, there are many industry standards, technical papers, design manuals, programs and other tools devoted to insulation coordination but it essentially comes down to four elements.

- The electrical and environmental stresses to which the insulation or equipment will be subjected.
- The dielectric withstand characteristics of the insulation throughout its design life.
- Comparison of the two in conjunction with appropriate protective devices to ensure adequate protective margins.
- Cost and consequences of insulation failure.

Following are a few definitions and characteristics that are important in insulation coordination:

**BIL:** Basic Impulse Insulation Level defines the maximum crest impulse voltage that insulation will withstand repeatedly and without damage.

**SIL:** Switching Impulse Level, same as BIL except with a longer switching surge, typically 200 – 2,000 microseconds.

**Impulse:** A surge of unidirectional polarity; either positive or negative with that surge being a transient wave of voltage, current or power.

**Power frequency:** AC system frequency; normally 50 or 60 Hz.

**Critical flashover:** A voltage that results in a 50% probability of insulation flashover.

**Insulation withstand voltage:** A voltage that the insulation will repeatedly withstand without flashover.

**Self-Restoring Insulation:** Such as air, which will recover its full dielectric strength without damage following flashover or fault clearing.

**Non-Self Restoring Insulation:** Such as solid dielectrics, oil paper, oils or gases which may be damaged by overvoltages.

Insulation coordination will generally begin by establishing a common insulation level for all the station insulation then coordinating that level with the line insulation. Since the line insulation typically consists of self-restoring insulation while the station insulation is more likely to include non-self restoring, it is generally better if the line insulation level is lower than that of the station insulation. Satisfactory line insulation is generally achieved with insulators that have a dry 60 Hz flashover of three to five times the system phase to ground voltage and a leakage distance of about twice the shortest air gap (strike) distance. Other environmental factors, such as contamination and altitude, must also be considered because they affect all insulation performance.

The final coordination consideration is application of suitable overvoltage surge protection.

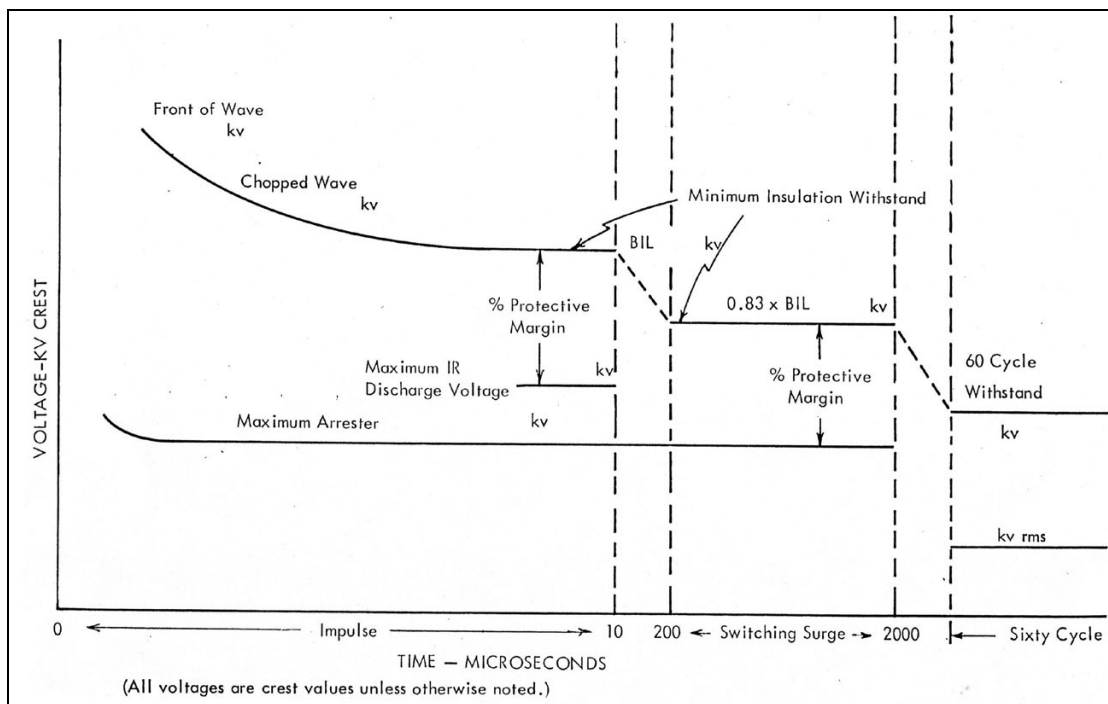
Table 1 lists standard equipment BILs in North America.



Table 1

<u>Ref Class, kV</u>	<u>BIL, kV Withstand</u>
1.2	30/45
2.5	45/60
5.0	60/75
7.5	95
8.7	75/95
15	95/110
23	150
34.5	200
46	250
69	350
115	550
138	650
161	750
230	825/900/1050/1175
345	1050/1300
500	1550/1800
765	2050

Virtually all insulation has a volt-time dielectric strength characteristic. That is the shorter the time, the higher the dielectric strength and withstand. Following is a typical volt-time coordination curve with the insulation withstand voltages on the upper curve at the respective times and the lower curve representing corresponding surge arrester characteristics. The difference in the two curves is the protective margin which, in this case is based on an 83% arrester. The time scale is logarithmic with the time to 60 Hz half cycle crest of 4,167 microseconds.



1. Electrical Transmission and Distribution Reference Book, Copyright 1964 by Westinghouse Electric Corporation, East Pittsburgh, PA.

