Causes of overvoltages

Depending on their nature, surges are classified in two categories:

SURGES DUE TO LIGHTNING STRIKES

Thunderstorms are very common and dangerous. It is estimated that on our planet, 2000 storms and 100 lightning strikes take place simultaneously on earth every second. This represents 4000 storms and 9 million flashes every day.

When lightning strikes, it causes a current impulse that can reach tens of thousands of amperes. This discharge produces an overvoltage in the electrical lines and can cause fires, damages to equipment and even casualties.

SWITCHING OVERVOLTAGES

These surges are generated in electrical lines, mainly due to the following two reasons:

- Electrical switching of large machinery:

Electrical motors are very inductive loads whose connection and disconnection can cause surges. There are other processes capable of producing surges, like the turning on/off of a welding arch and the connection and disconnection of power electronic devices.

- Operation and fault in power supply network:

In the case of short-circuit at any point in the network, the circuit breakers will respond by opening and the following auto-reclosing, in the case of it being a temporary fault. Such faults can generate surges typical in the connection of inductive loads.

Mechanisms of propagation

The prevailing mechanism of switching overvoltages is conduction, because it starts in the very power supply networks. It's in atmospheric discharges where all kinds of different propagation methods can be observed. Therefore, we can differentiate between the following methods:

CONDUCTED OVERVOLTAGES

Lightning can strike aerial lines directly. Surges then propagate and reach the user, finally diverting to ground through the equipment, provoking failures.

A common mistake is to think that hitting discharges in power distribution lines (Medium Voltage) don't reach those of Low Voltage because of the galvanic insulation provided by the existing transformer. However, this is not true due to the fact that the before mentioned insulation is effective for nominal frequencies in the network, while for the wave forms associated with lightning, the transformer produces little attenuation.

INDUCED OVERVOLTAGES

The electromagnetic field produced by electric discharges induces transient current in nearby conductors, entering then the structures and harming the equipment.

CAPACITIVE OVERVOLTAGES

There always exists a capacitive coupling, also called stray capacity, between every pair of conductors.
Overvoltages due to capacitive coupling become more important as the voltage waveform velocity increases.

VOLTAGE RAISES AT THE GROUNDING

This mechanism is a special form of conducted overvoltages (described before) but due to its elevated incidence, it deserves a special mention.

When lightning disperses in the earth, lightning current can raise the ground voltage around the impact point several thousands of volts as a consequence of the passing current.

Any object on the affected ground will acquire the associated voltage during that time, which can produce a dangerous voltage difference to other points on the installation. Take special attention to buried metallic objects such as piping and earth terminals.

	OVERVOLTAGE	INTENSITY
CONDUCTED OVERVOLTAGES	• Up to tens of kV	• Long distance impact: up to 1kA • Close impacts: up to some kA • Direct impacts: up to tens of kA
INDUCED OVERVOLTAGES	• Up to some kV between conductors which are not ground • Up to tens of kV between ground and conductor	• Can reach some kA • Can reach tens of kA
CAPACITIVE OVERVOLTAGES	• Up to some kV between conductors which are not ground • Up to some kV between ground and conductor	• Can reach some kA

The above table represents each mechanism, its transmission value typical for each corresponding overvoltage and its associated current.