

# Fundamental Concepts of Insulation Testing



*Fundamental concepts of insulation testing (on photo Digital Surge/ HiPot / Resistance Tester on site)*

## Introduction

Probably 80% of all testing performed in electrical power systems is related to the **verification of insulation quality**. This technical article briefly describes the fundamental concepts of [insulation testing](#) including – insulation behavior, types of tests, and some test procedures.

## AC or DC?

Most electrical equipment in utility, industrial, and commercial power systems uses either **50Hz** or **60Hz** alternating current. Because of this, the use of an **alternating current** source to test insulation would appear to be the logical choice.

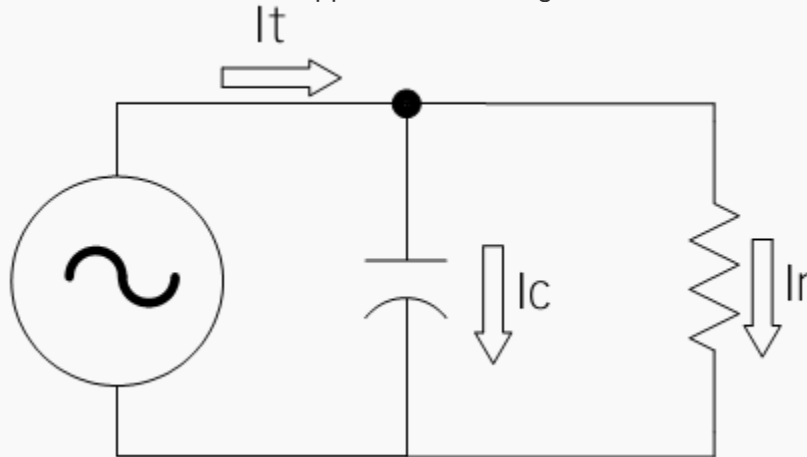


Figure 1 - Insulation with an AC voltage applied

However, insulation systems are extremely capacitive. For this and other reasons, DC has found a large niche in the technology. Before we can really evaluate the value of one system as opposed to the other (e.g. AC vs DC), let us examine how each type of voltage affects insulation.

## Insulation Current Flow (AC)

Insulation may be simply modeled as a **capacitor** in parallel with a resistor as shown in **Figure 1**. The current flow that results will comprise two components: the capacitive current ( $I_c$ ) and the resistive current ( $I_r$ ).

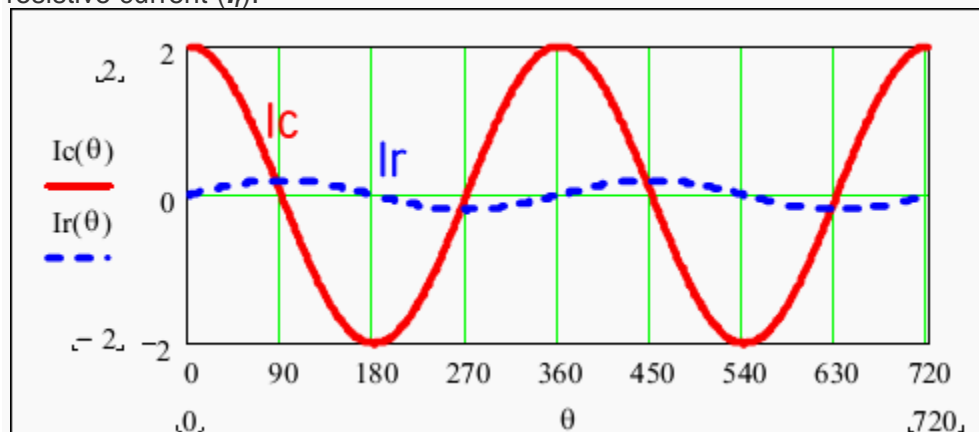


Figure 2 - Insulation current with AC voltage applied

**Figure 2** shows the time domain graph of the two currents. For good insulation:

- $I_c \geq 100 \times I_r$
- $I_c$  leads  $I_r$  by close to  $90^\circ$

## Insulation Current Flow (DC)

When DC current is involved, insulation may be modeled in a slightly different way.

Consider **Figure 3** below:

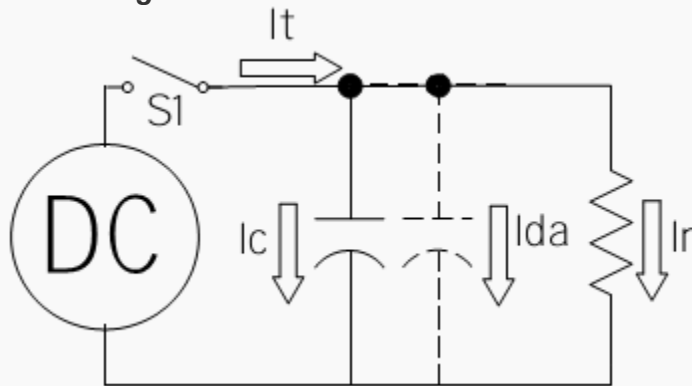


Figure 3 - Insulation with DC voltage applied

When switch **S<sub>1</sub>** is closed, the DC supply is connected to the insulation system. In the DC model an extra capacitor has been added (*dashed lines*). The current that flows through this new capacitor is called the dielectric absorption current ( $I_{da}$ ) and will be explained later.

**Figure 4** show the time relationship for these three currents. The following paragraphs explain each of the three currents.

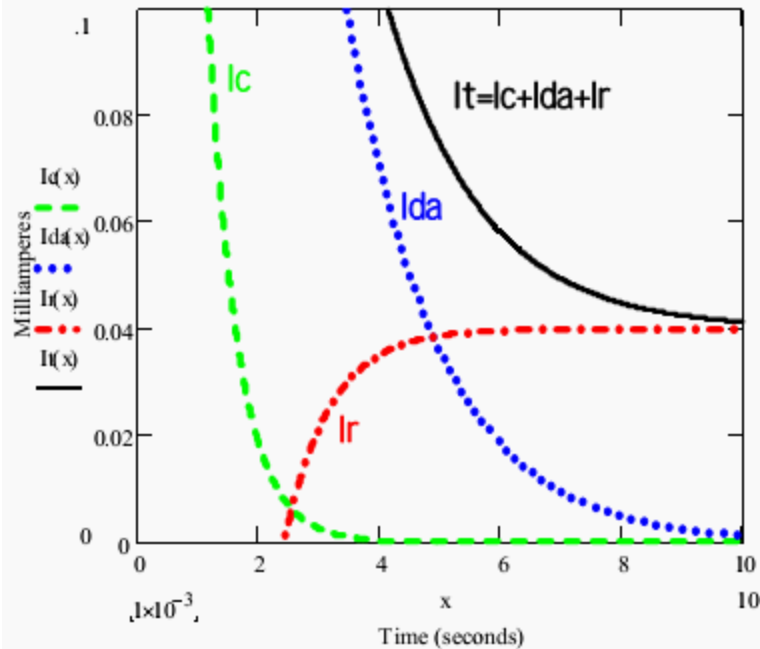


Figure 4 - DC current flow in good insulation

## Capacitive Current ( $I_c$ )

The capacitive current charges the capacitance in the system. It normally stops flowing a few seconds (at most) after the DC voltage is applied. The short burst of capacitive current flow may put a rather substantial stress on any test equipment that is applied to very large insulation systems such as cables or large rotating machines.

## Dielectric Absorption Current ( $I_{da}$ )

The applied insulation voltage puts a stress on the molecules of the insulation. The positive side of the molecules are attracted to the negative conductor and the negative side of the molecules are attracted to the positive conductor.

The result is an energy that is supplied to realign the molecules much like force will realign a network of rubber bands. Like  $I_c$ ,  $I_{da}$  usually dies off fairly quickly as the molecules realign to their maximum extent.

## Resistive (Leakage) Current ( $I_r$ )

This is the electron current flow that actually passes through the insulation. In good insulation the resistive current flow will be relatively small and constant.

In bad insulation the leakage current may be fairly large and it may actually increase with time.

**Resource:** *TECHNICAL BULLETIN — 012a Principles of Insulation Testing by Cadick Corporation*

Source:

<http://electrical-engineering-portal.com/fundamental-concepts-of-insulation-testing>