

Technical Bulletin # 222

CURRENT LIMITING REACTORS (CLR): TECHNICAL OVERVIEW AND MEASUREMENT PROCEDURES

The current limiting reactor (CLR) serves two purposes:

1. It provides protection to the H.V. rectifiers and the controller SCRs by limiting the current flowing during an arc or spark.
2. It provides a means of waveshaping the voltage to provide higher average values.

Functional Description

Once an SCR turns on, it will remain on until the current going through it goes to zero. Thus if an arc occurs in the precipitator, the SCR will continue to conduct the increased fault current for the duration of the half cycle in which it occurs. The CLR limits this fault current by providing additional system impedance.

The CLR design is based on two parameters. The first is the actual inductance of the CLR, expressed in millihenries. The second is the current rating of the reactor. The impedance of the reactor can be calculated by:

$$Z_{clr} = L \times (2 \times \pi \times f) = L \times 377$$

where

$$\begin{aligned} Z &= \text{impedance in ohms} \\ L &= \text{inductance in henries} \\ f &= \text{frequency in hertz} \end{aligned}$$

The amount of protection that a CLR gives a specific T/R set is dependent upon the percent impedance that the reactor provides for the T/R set. The impedance of the T/R set is defined by:

$$Z_{tr} = \frac{\text{Rated Primary Voltage}}{\text{Rated Primary Current}}$$

The percent impedance that the CLR provides is calculated by:

$$\%Z = \frac{Z_{clr}}{Z_{tr}}$$

or

$$\%Z = \frac{L \times 377 \times \text{Amps}}{\text{Volts}} \times 100$$

Working backwards, the inductance can be calculated for a desired percent impedance of a T/R by the following formula:

$$L = \frac{\text{Volts} \times \%Z_{\text{desired}}}{\text{Amps} \times 377 \times 100} \quad (\text{in henries})$$

When an arc occurs the impedance of the T/R set becomes very small (The short is reflected to the primary of the T/R). The primary voltage is across the CLR only. The amount of fault current that will flow through the system is dependent upon the percent impedance that the CLR provides.

$$\text{Fault Current} = \frac{\text{Volts}}{Z_{\text{clr}}}$$

or

$$\text{Fault Current} = \frac{\text{Rated Current} \times 100}{\%Z}$$

The CLR is designed with a core that will handle several times the current rating without saturating. The voltage drop across the CLR will be linear with respect to the current through it. If a CLR were to saturate, excess current would pass through it without any additional voltage drop. At this point it would cease to be linear.

Waveshaping

The CLR can also be used to increase the conduction angle of the SCRs under certain operating conditions. If the conduction angle is low due to sparking within the precipitator, increasing the inductance of the CLR will increase the conduction angle and the average voltage and current levels. Since sparking will occur at a fixed peak voltage that is defined by the precipitator, lowering the peak available output voltage of the T/R will allow the sparkover to occur at a later portion of the half cycle, thereby increasing conduction. Increasing the inductance of the CLR will increase the voltage drop across it, thereby decreasing the voltage available to the T/R set. It should be noted that the voltage drop across the CLR and the primary voltage of the T/R set will not directly add up to the system line voltage. Because the CLR is reactive there is a phase shift between the voltages. The relationship is as follows:

$$(\text{Line Voltage})^2 = (\text{CLR Voltage})^2 + (\text{Primary Voltage})^2$$

METHOD FOR TESTING THE INDUCTANCE OF A CLR

1. Apply power to the system to obtain the maximum attainable primary current without sparkover. Use a true RMS meter for measuring the current.
2. Measure the voltage-across the CLR, at the above current, using a true RMS meter.
3. Calculate inductance - by using the following formula.

$$\text{Inductance} = (\text{Voltage/Current}) \times 377$$