Current limitation is one of the important benefits provided by modern fuses. Current-limiting fuses are capable of isolating a faulted circuit before the fault current has sufficient time to reach its maximum value. This current-limiting action provides several benefits:

- It limits thermal and mechanical stresses created by the fault currents.
- It reduces the magnitude and duration of the system voltage drop caused by fault currents.
- Current-limiting fuses can be precisely and easily coordinated under even short circuit conditions to minimize unnecessary service interruption.

Peak let-thru current (I_p) and I²t are two measures of the degree of current limitation provided by a fuse. Maximum allowable Ip and I²t values are specified in UL standards for all UL listed current-limiting fuses, and are available on all semiconductor fuses.
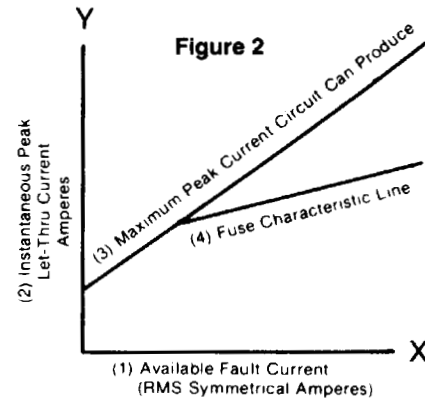
LET-THRU CURRENT

Let-thru current is that current passed by a fuse while the fuse is interrupting a fault within the fuse's current-limiting range. Figure 1 illustrates this. Let-thru current is expressed as a peak instantaneous value (Ip).
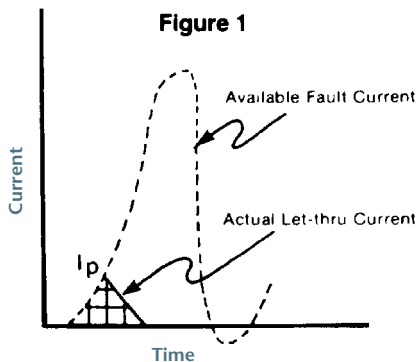
Figure 1

I$_P$

I_p data is generally presented in the form of a graph. Let's review the key information provided by a peak let-thru graph. Figure 2 shows the important components.

(1) The X-axis is labeled "Available Fault Current" in RMS symmetrical amperes.

(2) The Y-axis is labeled as "Instantaneous Peak Let-Thru Current" in amperes.

Figure 2

(3) The line labeled "Maximum Peak Current Circuit Can Produce" gives the worst case peak current possible with no fuse in the circuit.

(4) The fuse characteristic line is a plot of the peak let-thru currents which are passed by a given fuse at various available fault currents.
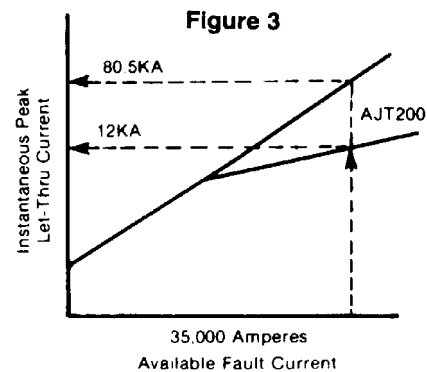

Figure 3

Figure 3 illustrates the use of the peak let-thru current graph. Assume that a 200 ampere Class J fuse (#AJT200) is to be applied where the available fault current is 35,000 amperes RMS. The graph shows that with 35,000 amperes RMS available, the peak available current is 80,500 amperes (35,000 x 2.3) and that the fuse will limit the peak let-thru current to 12,000 amperes.

Why is the peak available current 2.3 times greater than the RMS available current? In theory, the peak available fault current can be anywhere from 1.414 x (RMS available) to 2.828 x (RMS available) in a circuit where the impedance is all reactance with no resistance. In reality all circuits include some resistance and the 2.3 multiplier has been chosen as a practical limit.

I_P VERSUS I²T

I_p has a rather limited application usefulness. Two fuses can have the same I_p but different total clearing times. See Figure 4.

Figure 4
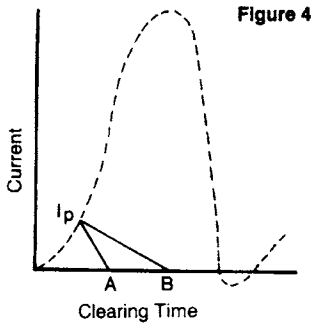
The fuse that clears in time A will provide better component protection than will the fuse that clears in time B.

Fuse clearing I²t takes into account Ip and total clearing time. Fuse clearing I²t values are derived from oscillograms of fuses tested within their current-limiting range and are calculated as follows:

The "t" in the equation is the total clearing time for the fuse. To be proper, I²t should be written as $(I_{RMS})^2 t$. It is generally understood that the "I" in I²t is really I_{RMS}, and the RMS is dropped for the sake of brevity.

$$I^2 t = \int_0^t I^2 dt$$

Note, from Figure 4, since clearing time "B" is approximately twice clearing time "A", the resultant I²t for that fuse will be at least twice the I²t for the fuse with clearing time "A" and its level of protection will be correspondingly lower.

The I²t passed by a given fuse is dependent upon the characteristics of the fuse and also upon the applied voltage. The I²t passed by a given fuse will decrease as the application voltage decreases. Unless stated otherwise, published I²t values are based on AC testing. The I²t passed by a fuse in a DC application may be higher or lower than in an AC application. The voltage, available fault current and time constant of the DC circuit are the determining factors.

Fuse I²t value can be used to determine the level of protection provided to circuit components under fault current conditions. Manufacturers of diodes, thyristors, triacs, and cable publish I²t withstand ratings for their products. The fuse chosen to protect these products should have a clearing I²t that is lower than the withstand I²t of the device being protected.

FUSE LET-THRU TABLES

APPARENT RMS SYMMETRICAL LET-THRU CURRENT

Although the current-limiting characteristics of current-limiting fuses are represented in Peak Let-Thru charts, an increasingly easy to use method of presenting this data uses Peak Let-Thru tables. The tables are based on Peak Let-Thru charts and reflect fuse tests at 15% power factor at rated voltage with prospective fault currents as high as 200,000 amperes. At each prospective fault current, let-thru data is given in two forms for an individual fuse - I_{rms} and Ip. Where Irms is the "Apparent RMS Symmetrical Current" and Ip is the maximum peak instantaneous current passed by the fuse, the Ip let-thru current is 2.3 times Irms. This relationship exists between peak current and RMS available current under worst-case test conditions (i.e. closing angle of 0° at 15% power factor).

Let-thru tables are easier to read than let-thru charts. Presenting let-thru data in table versus chart format reduces the possibility of misreading the information and saves time. These tables are also helpful when comparing the current-limiting capability of various fuses.

A
P