

For top protection, each breaker should have enough interrupting capacity to handle available short-circuit currents at its point in the circuit. Also, breakers in series should have time discrimination so any fault at far end of string will be isolated by nearest breaker and service maintained to remaining loads. When you specify both adequate interrupting capacity and time discrimination, you have the recommended selective tripping scheme.

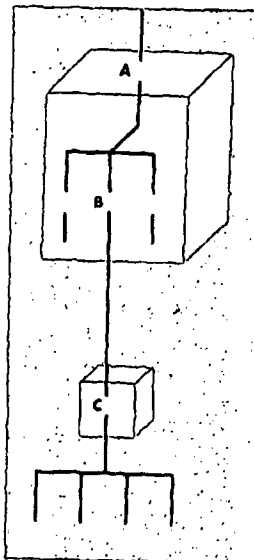
selective

In sketch, right, C would be, perhaps, a motor feeder breaker with tripping elements having both long time-delay (for motor-starting duty and overload protection) and instantaneous characteristics (for short circuits). Breakers B and A would have tripping elements with both long and short time-delay characteristics, time delay for A being longer than B.

Time-delay feature provides needed time for short-circuit current to trip breaker farther down the line first. Thus, breaker A would trip only for a fault between A and B. Breaker B would operate only for a fault between B and C.

For a selective tripping system, each breaker must have an interrupting rating equal to or, better still, greater than available short-circuit current at point of application. Also, all breakers, except those with instantaneous tripping elements, such as those farthest from power source, have a short-time (30 cycle) rating equal to or greater than available fault current. Then, so current-time characteristics will not overlap for adjacent breakers, current ratings must be selected with a ratio of at least 2:1 to prevent false tripping.

Selective tripping has become a must for essential circuits—such as those supplying power-station auxiliaries.



But many engineers find it hard to justify cost of selective tripping on some low-voltage circuits. So they specify breakers in cascade. Then only breaker closest to source has adequate interrupting capacity; those down the series string are applied beyond that breaker. If a heavy short occurs, even beyond last breaker, main breaker may trip out, killing all service. Where properly applied (below), cascading is practical but not generally recommended.

cascade

Breakers are connected in cascade simply as a way of cutting first cost. It's possible for two or all three breakers in cascade to open if fault current is severe. Since smaller breakers are backed by those with higher interrupting rating, their life depends on backup breakers coming to the rescue. But where two or more breakers operate at same time, in series, individual stresses are less than if each opened alone. This is considered in cascading breakers. Motors recommend electrical operation for cascaded breakers.

Where cascading is adopted, power engineers have each breaker in setup inspected after tripping on a heavy fault, before reclosing. Heavy fault current may have damaged breaker so even normal current couldn't be carried safely.

Cascading is usually limited to three steps of interrupting rating. Breaker nearest power source, A, must have adequate capacity. Breaker next lower in cascade, B, may have $\frac{1}{2}$ interrupting rating required by maximum available fault current, one farthest from source, C, may have $\frac{1}{4}$ maximum rating.

Before adopting cascading, weigh carefully the disadvantages of reduced selectivity, restricted interrupting-duty cycle, and some additional maintenance.

Weigh cascading's many disadvantages; don't let price tag alone rule your decision

Cascading is far from ideal in breaker application. But seeing that it's with us, and widely used today in industry, make sure you know all the facts, before you choose.

In a cascade hookup, total kva of connected synchronous motors should not exceed 25% of supply transformer or generator kva. Main breaker A should be set to trip when current through breaker B reaches 80% of its interrupting rating. This insures that main breaker will operate whenever short-circuit duty exceeds interrupting rating of breaker B.

Another general practice of power engineers using the cascade scheme is to select breakers from the same maker, to be sure they have similar characteristics.

Molded-Case Breakers. Is it wise to cascade them? Tests have been made by various manufacturers to answer just that question. Tests were independent but results were in substantial agreement. Conclusion: Molded-case breakers shouldn't be used in cascade arrangement. Here's why:

Various types and sizes of molded-case units were tested

and nearly all those cascaded were damaged—covers broken, contacts and operating mechanism destroyed, etc. So there's general agreement that molded-case breakers should be used within their interrupting capacity limits, not cascaded.

Cascading Disadvantages. Forgetting initial cost for a moment, look into major limitations of cascaded arrangement. Realize that, although you had reliability and service continuity upmost in mind when you selected a circuit arrangement (pp 88-91), these values can be cancelled quickly with cascading. Unlike the selective-tripping scheme, whenever a leader fault draws current greater than 80% of interrupting rating of leader breaker, main breaker will trip. Then service to all leaders served by main breaker is lost and will stay lost until main breaker is reclosed.

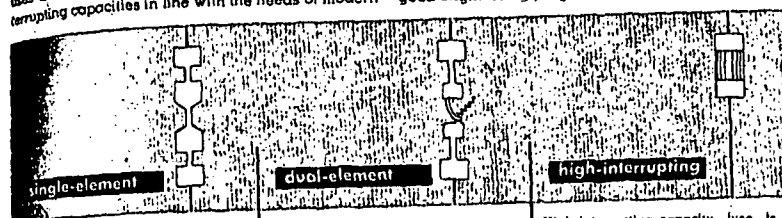
In brief, cascading is being used and proving satisfactory in many industries. Your job is to weigh its disadvantages against its lower initial cost and determine which of the two tripping arrangements fits your overall needs best.

A generation or so back, the fuse vs circuit breaker question was often discussed. But the breaker has since been developed to a point where few engineers will question its place in circuit protection.

In recent years, however, the fuse has moved into the major league in the low-voltage field. Back of this move is the high-interrupting-capacity fuse. It uses a silver element surrounded by silica, has interrupting capacities in line with the needs of modern

plants. Its chief boast is that it will interrupt a short circuit before current reaches the dangerous values possible. Some fuse manufacturers look on it as an "anticipator".

On this page and next, you'll find information to help you seek proper spots in your plant for this fuse type. Since there is far from firm agreement on where it fits best, final decision, as always, rests on your good engineering judgment.

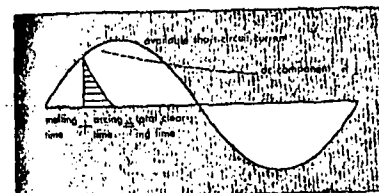


Simplest of fuses has but a single element. On a heavy overload or short circuit, weak spots in the link are suddenly heated to a high temperature and vaporize. Because length of these weak spots is relatively short, any arc formed would continue. But arcs are low in voltage across each is low, so arc is stopped and circuit opened. Only one weak spot may open on minor overload.

Here fuse link copes with heavy overloads and short circuits, while a thermal cutout takes care of sustained overloads. Current flow generates heat in link. With minor overloads, where there is ample time for thermal conduction, heat is carried into thermal cutout in fuse center. Fusible alloy melts at proper point, permitting interrupter to move under spring tension and open circuit.

High-interrupting-capacity fuse is a tube with silver elements in silica filler. Silver is used because: (1) Conductivity is not impaired by continuous operation or current surges yielding temperatures just under melting point. (2) Having low specific heat, silver can be raised to vaporization faster. (3) Its vaporization temperature is much below temperature at which the vapor readily ionizes.

High-interrupting-capacity fuses offer sound low-cost protection



A high-interrupting-capacity current-limiting fuse is designed to open a short within the first quarter cycle, before serious damage can be done. This fast microsecond action in face of high available short-circuit currents (up to infinity) finds new spots in industry for this fuse type.

Magnetic stresses circuit equipment must stand are a function of actual "let-through" current squared. Thermal stress, or equipment heating, depends on let-through current squared multiplied by clearing time. Tie these thoughts to the sketch above and you'll see how current-limiting action of this fuse holds in check the dangerous effects of a heavy short.

A symmetrical short-circuit is sketched above. But if the short hit at time zero, dc component would give an asymmetrical wave about a displaced higher-value axis.

Curve to right is plotted for available fully displaced rms amperes (asymmetrical or total rms amp). This is on the basis that maximum offset rms amp equal symmetrical amp multiplied by 1.4. Curves are peak let-through values.

