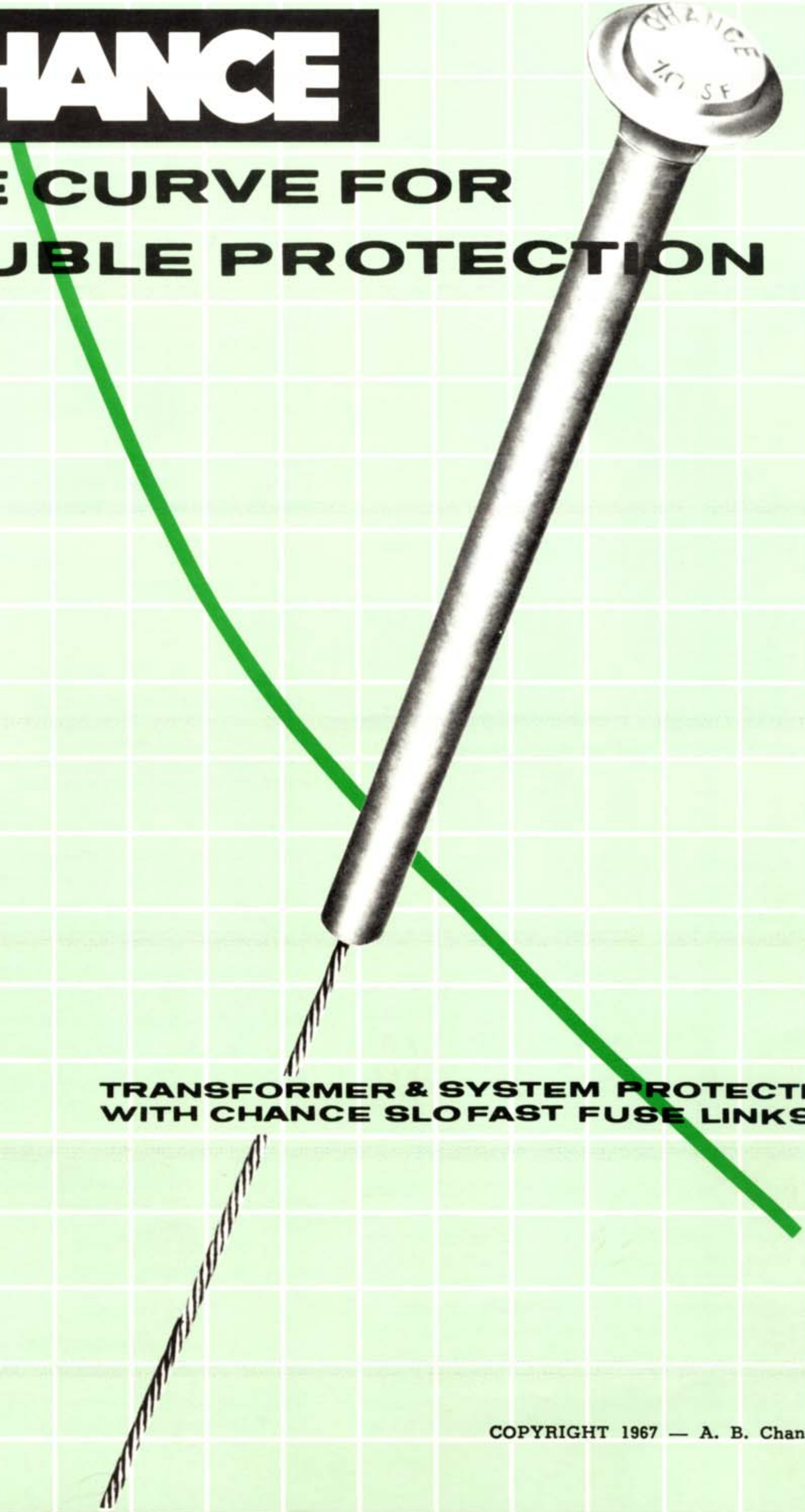
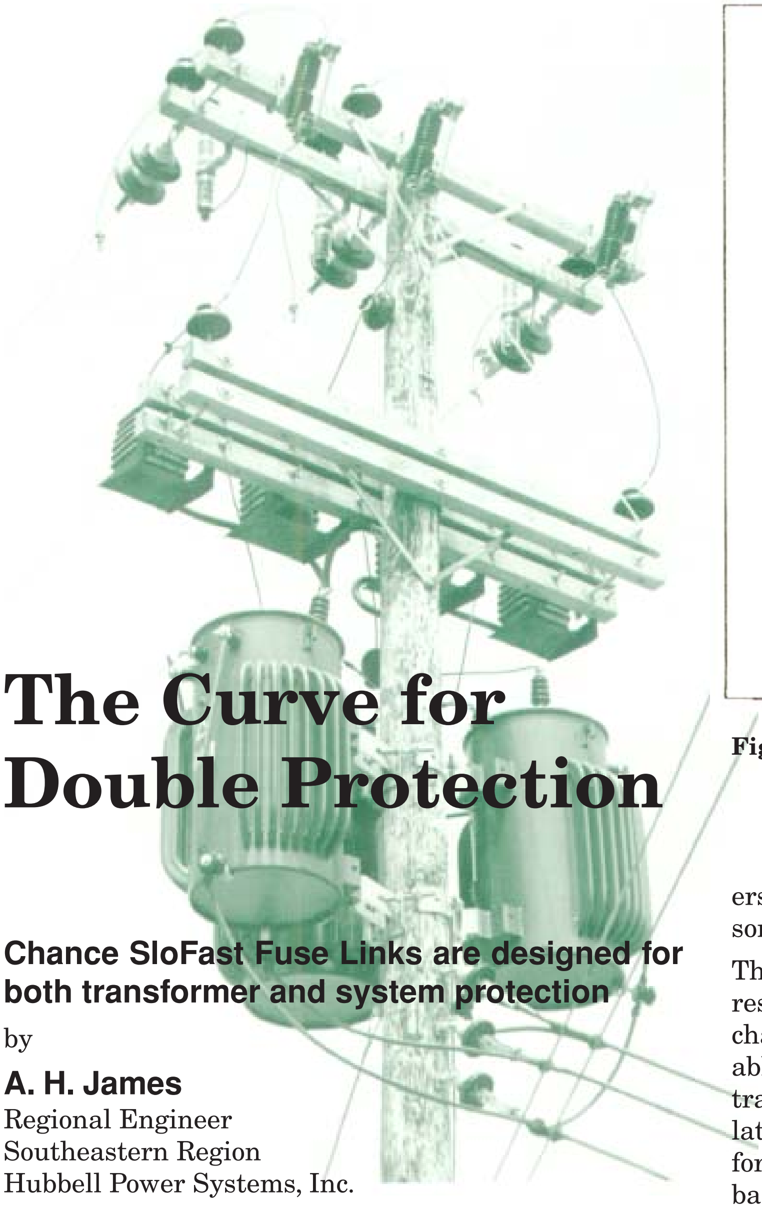
CHANCE

THE CURVE FOR DOUBLE PROTECTION



TRANSFORMER & SYSTEM PROTECTION WITH CHANCE SLOFAST FUSE LINKS



The Curve for Double Protection

Chance SloFast Fuse Links are designed for both transformer and system protection

by

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For many years in the electric utility industry, the application of distribution transformers was made from estimates, rule-of-thumb, and often by guess. Transformer losses from burnout, lightning damage and other causes have long been a curse of the distribution engineer's existence . . . trying to second guess load growth and yet hold transformer investment in line.

Within recent years the growing use of electronic record keeping has allowed the utility industry to devote the same load management attention to distribution transformers as previously given to station transformers. By "load management" we mean initial load, daily peaks, allowable overload and so forth. This is all in an effort to improve service continuity, reduce losses and provide the greatest amount of utilization of an overall large investment. One of the primary problems continues to be overload capability and protection of distribution transformers. This is the area explored in the following comparisons and philosophy.

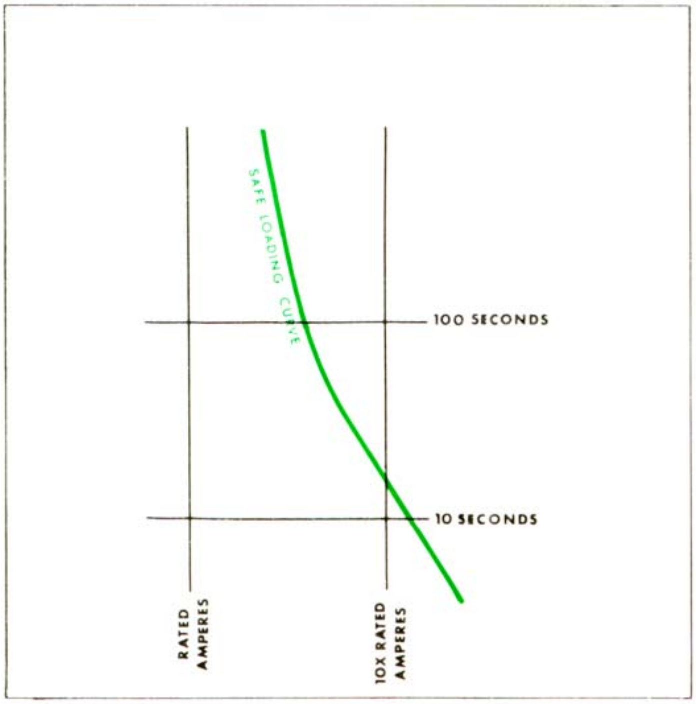


Figure 1 — Safe Loading Curve for oil immersed self-cooled transformers.

The curve in Figure 1 was drawn on a log-log scale corresponding to the scale used for fuse link time-current characteristic curves. This curve represents the allowable short-time overload that an oil immersed self-cooled transformer can withstand without damage to the insulation, and is used as a guide for application of transformer overload protection. This **safe loading curve** is based on over ten years of experience with the Chance SloFast fuse link in protecting distribution transformers of various makes and service lives. It allows slightly heavier loading of the transformer than does the standard ASA curve, hence a higher degree of utilization.

The allowable overload represented here is overload following 100% load. In tabular form it is:

TIME	TIMES RATED KVA
4.0 Seconds	25.00
10.0 Seconds	13.70
30.0 Seconds	6.70
60.0 Seconds	4.75
5 Minutes	3.00

This safe loading curve will be used with several of the following illustrations.

FUSING TO PROTECT THE TRANSFORMER

For simplification, our example will consider only one transformer, a 25 kVA 7620/120-240V, oil immersed self-cooled.

Fuse links, as known today, are essentially designed for circuit protection and developed to closely follow the time-current characteristics of most over-current relays used in oil circuit breakers.

However, our problem here is transformer and circuit protection. Our 25 kVA 7620V transformer has a full load primary current of 3.28 amperes. On the basis that a 3 ampere NEMA type "K" fuse link requires approximately 6 amperes to melt in 300 seconds, this seems to be the natural choice fuse to use for this transformer.

When the safe loading curve is plotted over this curve, Figure 2, it becomes obvious that although the fuse link will do an excellent job of protecting the transformer, it leaves a large amount of overload capability unusable. This is represented by the colored cross-hatched area.

Use of a fuse link of this size would materially increase the outage time on the transformer due to transient overloads, lightning surges and similar occurrences.

Although it protects the transformer very well, one would probably not use this link, since a good portion of capability is unavailable and service calls for re-fusing, and customer irritation would probably be at a high level.

This fuse does protect the transformer.

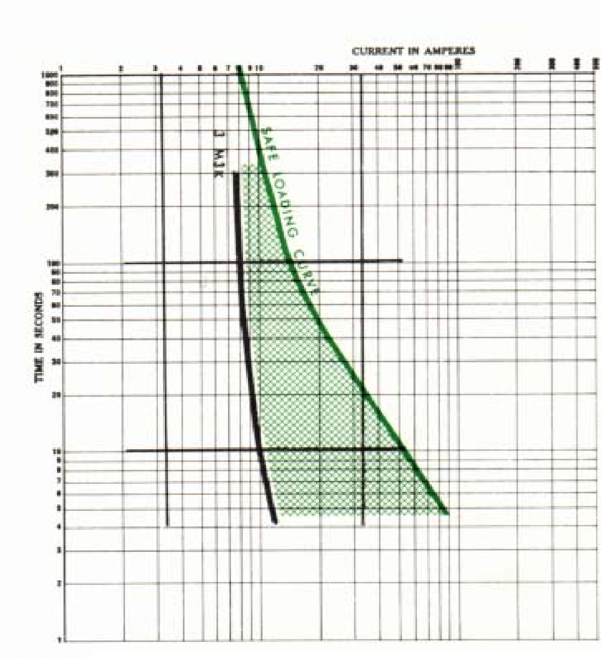


Figure 2 — Total Clearing Curve for NEMA 3 ampere "K" Fuse Link. Chance Catalog No. M3K26.

FUSING TO PROTECT THE SYSTEM

In Figure 2 we had an illustration showing extreme transformer protection. Let us now consider the other end of the scale. Following an old rule-of-thumb for 2400 volt systems, we will fuse the transformer one ampere per kVA, and install a 25 ampere NEMA "K" link.

By using the safe loading curve in this example, Figure 3, we can see that the transformer has departed for its "happy hunting ground" long before the fuse link melts. This fuse link gives absolutely no transformer protection, but does afford good system protection provided the 25 ampere "K" link coordinates with other back-up fuses, reclosers or breakers.

Transformer fusing in this manner would be advisable only if transformer losses are unimportant or secondary.

This is a good example of system protection.

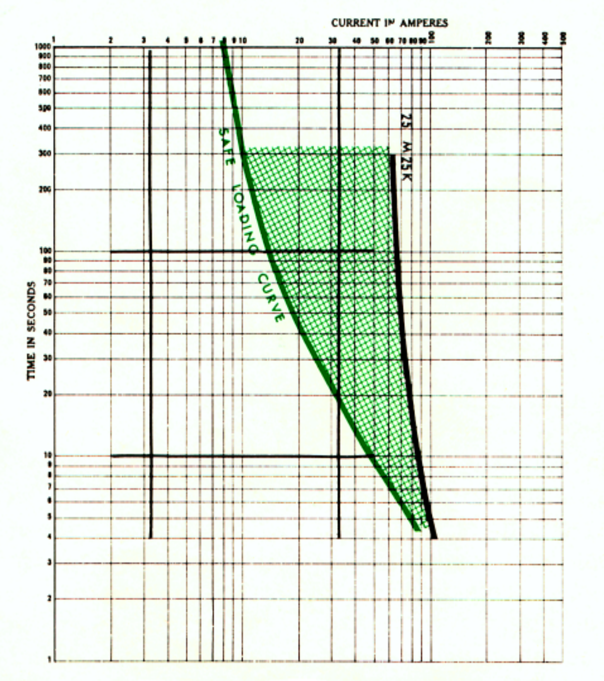


Figure 3 — Total Clearing Curve for NEMA 25 ampere "K" Fuse Link. Chance Catalog No. M25K26.

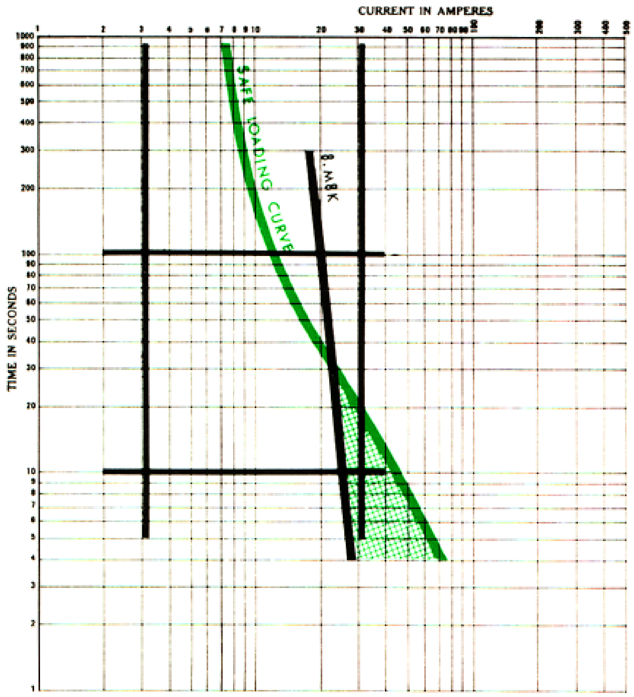


Figure 4 — Total Clearing Curve for NEMA 8 ampere "K" Fuse Link. Chance Catalog No. M8K26.

CROSSING THE SAFE LOADING CURVE

From the preceding illustrations, it is obvious that some sort of compromise is necessary. Let's consider the old rule-of-thumb for fusing 2400 volt transformers of one ampere per kVA. Simple arithmetic reveals that one ampere per kVA at 2400 volts uses a fuse link that has a rating of approximately 2½ times the full load primary current of the transformer. There remains some debate as to whether this value was derived scientifically, or used because it was easy to remember. However, it is a fair compromise and is widely used today.

Our 25kVA 7620V transformer has a full load primary current of 3.28 amperes, 3.28 x 2.5 = 8.20 amperes. The nearest NEMA "K" link is the 8 ampere, as shown in Figure 4. By using the safe loading curve here, it is clear that the fuse link curve crosses the safe loading curve at approximately midpoint. The segment to the right, or above the safe loading curve, is system protection; that is, it removes the transformer from the circuit after burnout. The segment to the left, or below the curve, is transformer protection. Although it will remove the transformer from the line before damage occurs, the fuse link still prevents use of a considerable amount of overload capability as represented by the colored cross-hatched area.

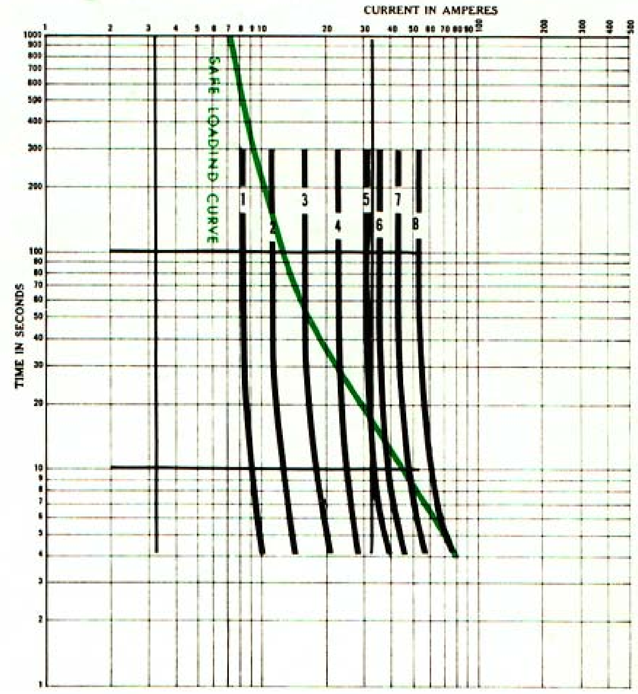


Figure 5 — Eight curves for fuses used as high-side internal fuses in self-protected transformers by one manufacturer. (The number designations are arbitrary and are not to be used as ampere ratings.)

SYSTEM PROTECTION

For a number of years, transformer manufacturers have attempted to improve service continuity, provide both circuit protection and transformer protection by the addition of accessories to the transformer. These accessories are a thermal breaker ahead of the low voltage terminals and a high-side internal fuse link (with or without current limiting) between the high-side bushing and the high-side winding.

The eight curves in Figure 5 are part of a family of curves for internal high-side fuses by one transformer manufacturer. Comparison of these curves with the NEMA "K" curves in Figures 1 through 4 show they have very much the same slope. Our safe loading curve in Figure 5 points out that curve No. 8 is the smallest size that will insure transformer failure before taking the transformer off the line. The intent of the use of this type link is solely to remove the transformer from the circuit after failure.

There are two disadvantages to this high-side fuse link. Being internal, that is, the fuse is inside the transformer, the transformer tap from the feeder *must* be considered as an unfused lateral. The other disadvantage is rather remote, but nevertheless present: should the internal high-side link melt for any reason other than transformer failure, the transformer would have to be removed from the pole for replacement.

This is system protection.

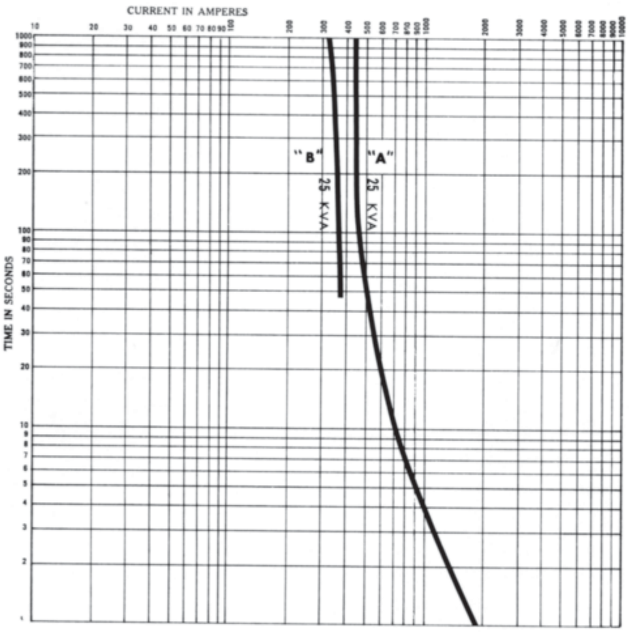


Figure 6 (left) —Curve "A" 240V secondary breaker for 25 kVA, 7620V transformer. Curve derived from tests at 240V, 25°C ambient, no pre-loading. Curve "B" 240V secondary breaker for 25 kVA, 7200V transformer. Curve derived from tests, 70% pre-load, 35°C ambient, curve shown for 65°C transformer.

TRANSFORMER PROTECTION

The thermal breaker used in the secondary side of the self-protected transformer is submerged in the coolant and is responsive not only to the load current but also to the temperature of the coolant. A disadvantage of the thermal breaker in the earlier transformer models was that if "tripping" occurred under high ambient conditions, a period of several hours was often required to allow the coolant temperature to go down enough for the thermal breaker to be successfully closed. In later models, however, an emergency overload reset has been employed which extends the range of the breaker approximately 10%, allowing immediate reset after a trip on normal setting. Theoretically, this allows load rearrangement or transformer replacement under planned conditions. However, if the transformer is allowed to remain until the emergency setting trips the breaker, then the transformer must be replaced, or time lapse allowed for the coolant temperature to go down enough for breaker to reset.

The two breaker curves in Figure 6 are from two different transformer manufacturers. Curve "A" is a trip curve with no preloading of the breaker. Curve "B" is trip following 70% preload and is of different manufacture than Curve "A."

Since our safe loading curve is allowable overload following 100% load, we cannot get a true comparison between Curves "A" and "B" and the safe loading curve. However, Curves "A" and "B" as shown, leave some transformer capacity in the shorter time ranges. If the two breakers were preloaded to 100% of transformer rated secondary load, these two curves would move to the left which would further decrease the amount of short time overload capability that is available in the transformer.

It is also apparent that the slope of these curves more nearly approaches the fuse link curves previously discussed including the internal high-side link.

This is transformer protection but does not allow full use of the transformer overload capacity.

THE DUAL SLOFAST

Chance has not been satisfied with the arbitrary compromise used for fusing transformers. As a result of this dissatisfaction, a Chance fuse link designed especially for use with transformers was developed. This is a dual-element link using a solder joint plus a standard copper or copper alloy element in series. These two fusible elements combined provide a time-current characteristic as shown in Figure 7. The solder joint has a relatively flat or slow curve, the standard fusible element has a steep or fast curve. As an appropriate sequence, this fuse link has been designated as the Chance "SloFast" link.

Because of the many distribution voltages throughout the industry, it is rather impractical to apply a kVA rating to these fuse links as a rating of this nature also involves a specific voltage. Since different transformers of various voltage ratings have the same full load high-side current, the fuse links are designated as such so they may be applied solely on a current basis without regard to primary voltage. For instance, the 25 kVA 7620V transformer has a full load high-side current of 3.28 amperes for which we would use a 3.5 ampere Chance SloFast link. This same link is applicable to a 15 kVA 4160V, a 50 kVA 13,200V, or any transformer with a high-side full load current close to 3.5 amperes.

By comparing this SloFast curve with the safe loading curve, we see that it follows the safe loading curve to its full length. This allows maximum use of transformer short time overload capacity, plus the lower, or fast, segment of the curve provides immediate removal from the circuit in the event of transformer failure or other fault conditions.

The Chance SloFast link thereby provides protection for the transformer and the circuit with a bonus benefit of obtaining the full overload capability of the transformer.

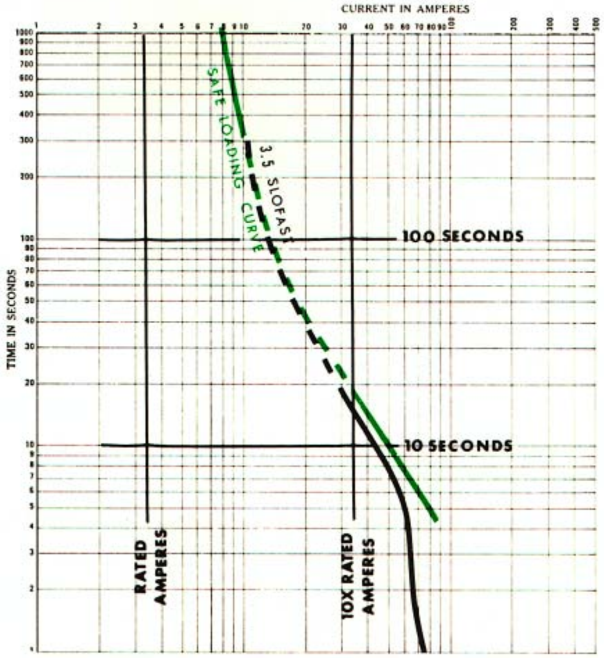
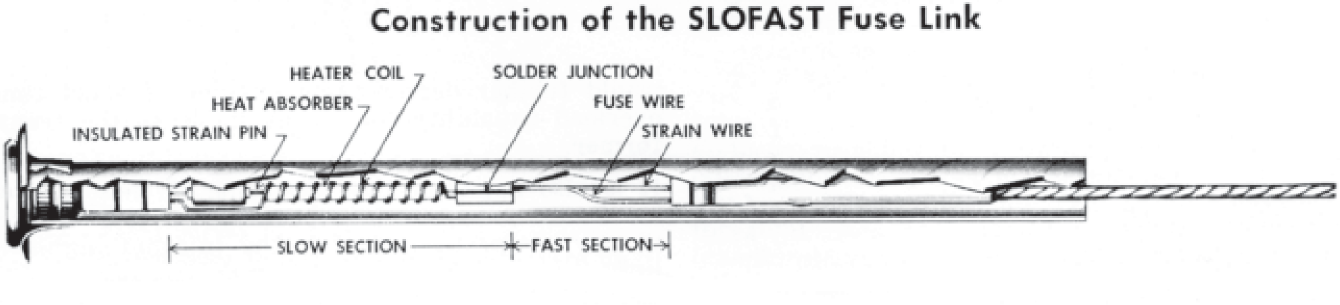
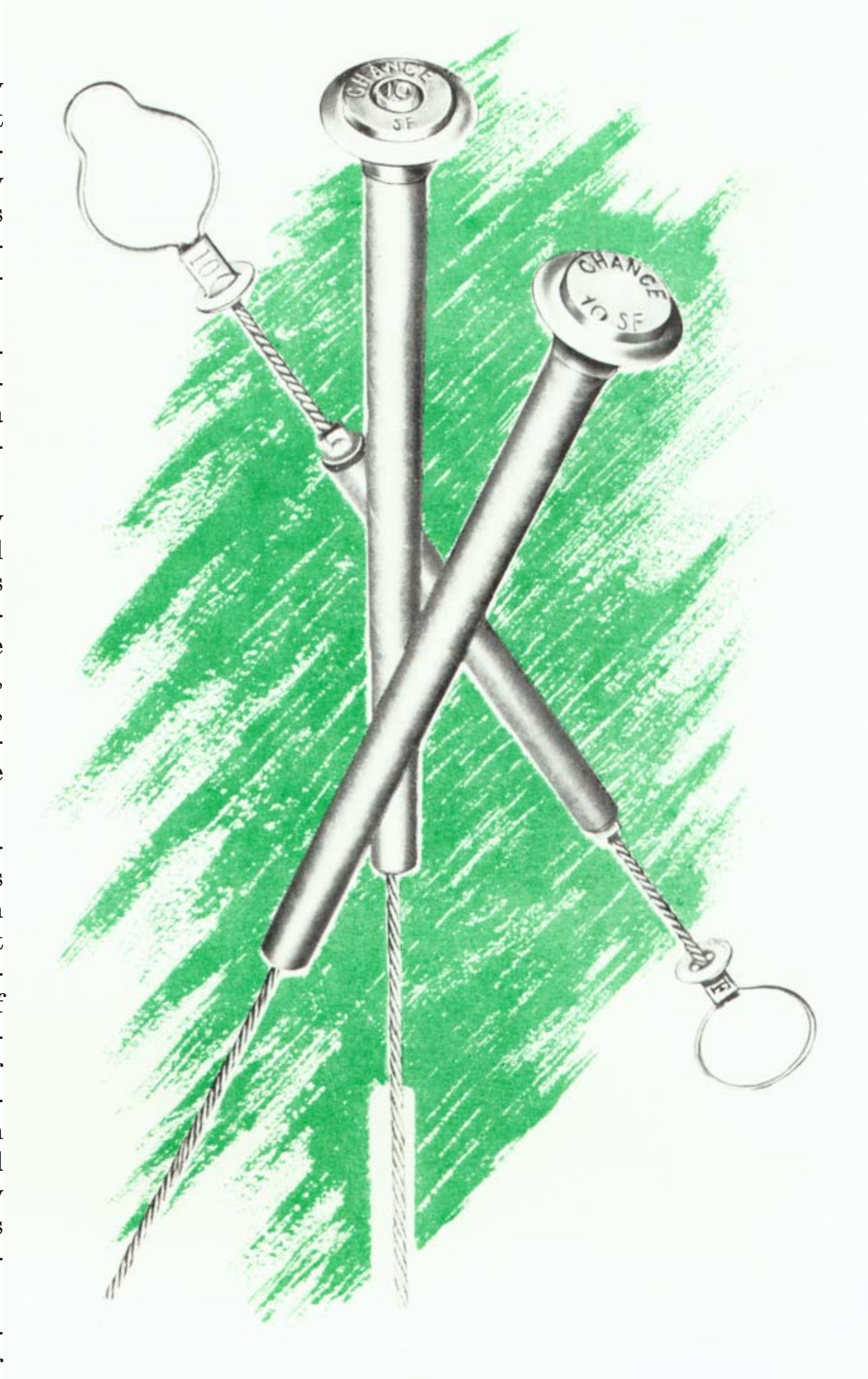


Figure 7 — Minimum Melting time curve of Chance SloFast Fuse Link. Chance Catalog No. M3.5SF.



RELIABLE AND ECONOMICAL PROTECTION



Although the cost per individual unit may seem relatively small, the total investment in distribution transformers by any one utility is a considerable expenditure. If for any reason the full capability of a transformer is not available for use, then this unusable portion is investment that cannot produce a return.

The time honored practice of fusing transformers approached a balance between transformer losses from overloads and that of a service discontinuity from unusable transformer capability.

The primary operating objective of a utility is to maintain the best service possible to all customers within economical limits. Towards accomplishing this objective, many expenditures are continuing to be directed to improve lightning performance of distribution circuits, improve mechanical strength of structures, and within the last few years various approaches to improve the aesthetic appearance of overhead lines.

With the increasing popularity of central air-conditioning and other load growth elements in residential areas particularly, distribution engineers may soon begin to dread the hot summer weather along with the related emergency transformer changeouts. A method of relating kWH consumption on any transformer to the kVA demand on the transformer was developed, and is used with varying degrees of satisfaction in checking load growth on individual transformers. This has helped to prevent some failures but there are many transformers lost from overloads and fuses blown from short time loads that the transformer could easily withstand.

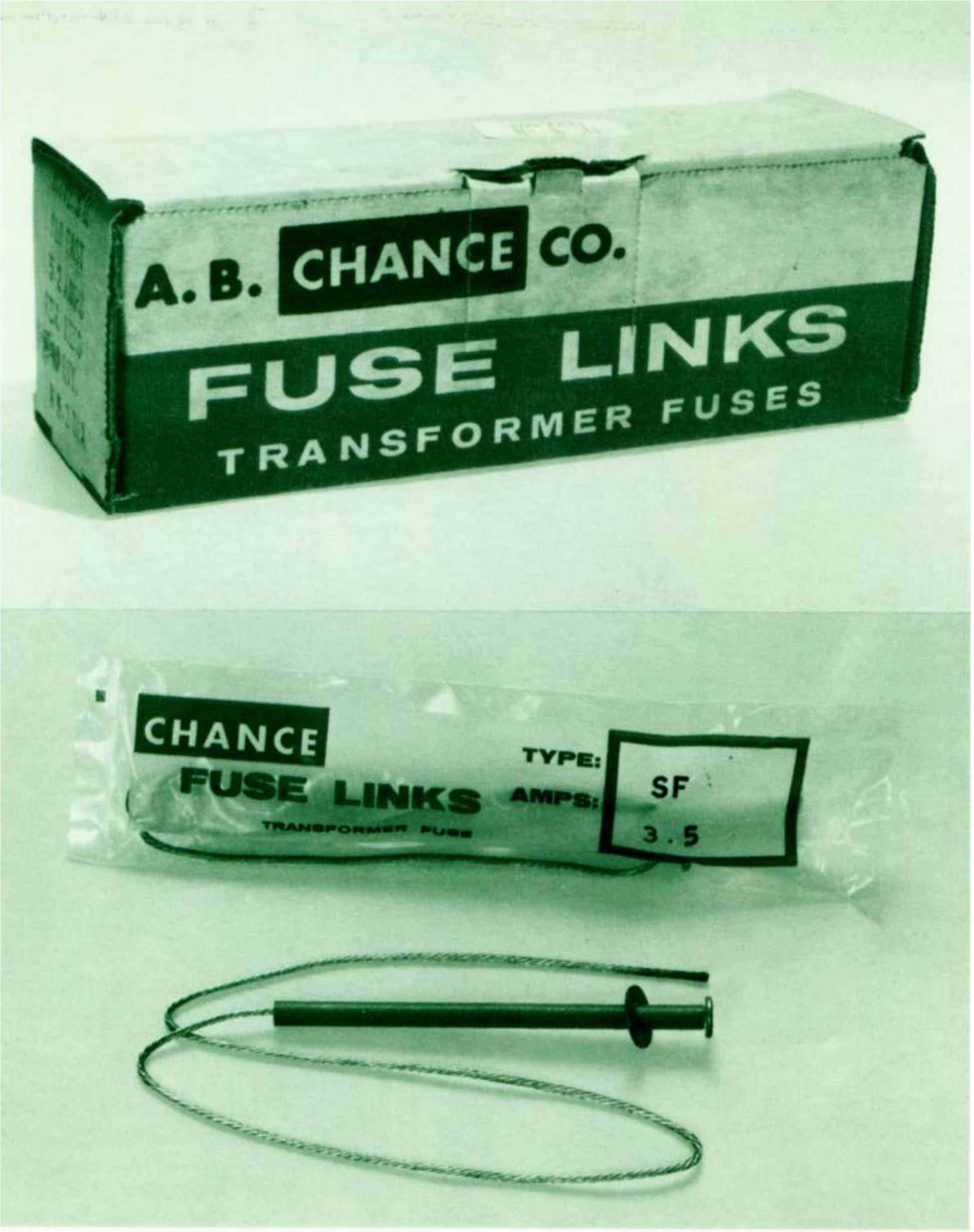
Some utilities are using self-protected transformers to serve the total electric home for the advantage of the emergency overload feature to reduce service outage in event the secondary breaker trips. This service improvement is somewhat doubtful in view of the previous comparison with the transformer safe loading curve. The question would seem to remain as to whether the trip-out of the breaker was due to genuine overload or a short time load within the capacity of the transformer, but beyond the limits of the breaker.

The best place to protect a feeder circuit from lateral circuits or equipment connected to the feeder is at the point of attachment. The most reliable device for doing this is a fuse link of the correct size in a properly designed cutout.

The least expensive and most reliable device for utilizing the full capacity of a transformer which also makes full use of the investment in the transformer, is a Chance SloFast fuse link in a cutout at the tap point on the feeder circuit.

As illustrated, the SloFast fuse link has a time-current characteristic that follows this safe loading curve. This characteristic protects the transformer. The SloFast link also has a fast operating element to remove the transformer quickly if necessary. This characteristic protects the system.

Add these two characteristics together — transformer protection plus system protection — and the tangible results are better service, reduced losses and greater utilization of transformer investment dollars.



For easier identification of Chance primary fuse links by line truck crews, the plastic container bag has size and type of the fuse link printed on the outside over a white background. Each link is in a separate bag for all-weather protection and keeps them from becoming tangled.

Chance SloFast fuse links conform to all applicable EEI-NEMA specifications and are available in a range of ratings for protection of distribution transformers up to 500 kVA. Three different fuse link types are available: (1) universal solid buttonhead, (2) universal removable buttonhead, and (3) an open-link type. Overall length of the universal type is 23 inches, button-to-button length of the open-link is 8½ inches. For more information on Chance SloFast fuse links and their application for single- and three-phase transformer protection, see your Chance representative or write Hubbell Power Systems, Inc.

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serves power

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