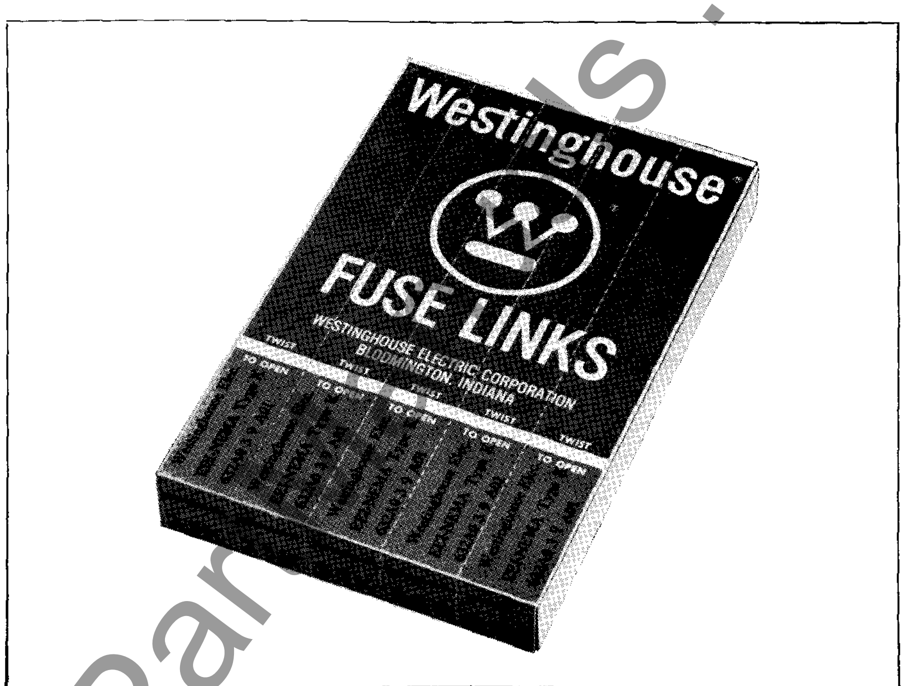
Westinghouse

Fuse Links
Universal Cable Type

UT, Super Surge, K and T
½ to 200 Amperes

The fundamental use of distribution fuse links is in fuse cutouts to provide protection for electrical equipment against faults and overloads, and increased system service continuity through coordinated sectionalizing. Most common specific applications to accomplish this general purpose are:

1. Protection of a distribution transformer.
2. Branch and feeder sectionalizing.
3. Capacitor bank protection and sectionalizing.
4. Substation sectionalizing device.



Fuse Link Designation

There are three types of fuse links described by standards which are in common usage today. The type numbers refer to the relative time-current characteristics of the different fuse links. These fuse links are the "N" rated (Westinghouse types S and UT), "K" rated (fast), and "T" rated (slow).

The "N" rated links are not covered in modern standards; however, rescinded NEMA Standard 49-145 describes the method of obtaining their characteristics. Basically this standard states that an "N" rated link rated 100 amperes and below will melt in 300 seconds at an rms current not to exceed 240 percent of the continuous current rating of the link. For links rated above 100 amperes, the link will melt in 600 seconds at an rms current not to exceed 264 percent of the continuous current rating of the link. The melting time at currents higher than these is left to the manufacturer. Thus, "N" rated links are not required to be electrically interchangeable.

The following ratings are available: 1-S, 2-S, 3-S, 5-S and 7-S; also: 7-N, 10-N, 15-N, 20-N, 25-N, 30-N, 40-N, 50-N, 65-N, 85-N and 100-N.

In 1954 the NEMA Standards were revised to incorporate fuse link requirements which had previously been published as a joint EEI-NEMA Recommendation (EEI Publication TDJ-110: NEMA publication 108-1952.) This joint publication, as well as the current revision of the 1954 NEMA Standards (now published as SG2-1963 and ASA C37-1962, Part 43) describe two types of fuse links whose melting times are specified at three points, thus assuring the user of electrical interchangeability between various manufacturers.

The three points of similarity are (from ASA C37.43-3.1.1):

1. 300 seconds for fuse links rated 100 amperes and below and 600 seconds for fuse links rated 140 and 200 amperes,
2. 10 seconds, and
3. 0.1 seconds.

The maximum and minimum current values for these three points are given in two tables in the standards, thus providing essentially a band curve for the "K" and "T" rated fuses. The following ratings are available (in type "K" and "T") 6, 8, 10, 12, 15, 20, 25, 30, 40, 50, 65, 80, 100, 140, and 200.

There are other minor differences between the "N" rated and the "K" and "T" rated fuses, but they are unimportant from an application standpoint. The Westinghouse type S "N" rated links are dual element, super surge fuses of low ampere ratings. These are recommended for small transformers and loads where standard links will not provide protection. The dual element provides high surge withstand ability, necessary because of the low continuous current rating.

October 1, 1969
Supersedes Application Data 38-665, dated August, 1964
E, D, C/1991/DB

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Time-Current Curves

Applicable standards (ASA C37.43) provide for the presentation of time-current characteristics in the form of log-log curves, on Keuffel & Esser No. 336E paper or equivalent. For each type of link (K, T, UT, and Super-Surge), two curves are provided. The "minimum melting" curves show the minimum value of current which will cause severance of the fusible element in a specified duration of that current. The "total clearing" curves show the maximum duration of a specified current which causes the fusible element to sever and arcing to ensue. The two curves comprise a coordinating band for each link rating.

General Fuse Link Application

Protection with fusible elements falls into two general categories:

1. Overload protection and
2. Short circuit, or fault, protection.

The selection of the type of fused device itself is a function of the interrupting rating of such a device, and is essentially independent of fuse link rating. The selection of the fuse link rating depends upon whether the user is attempting to achieve overload or short circuit protection.

The utility, in applying fuse links to distribution systems, more often selects the rating on the basis of short circuit protection, rather than on overload. Since current responsive devices are applied in series, coordination to assure selective tripping becomes the prime consideration. Generally the procedure is this:

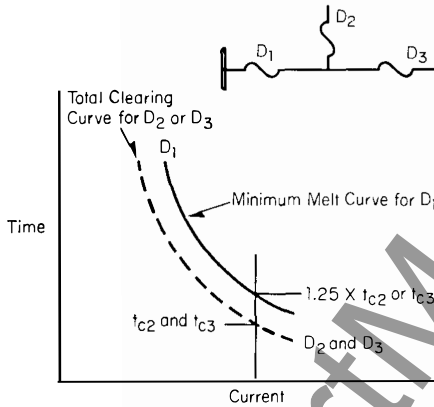
1. Select the lowest possible rating of link for the device at the load extremities of the feeder.

2. Using maximum calculated rms symmetrical short circuit values, determine total clearing time (t_c) for link selected in (1).

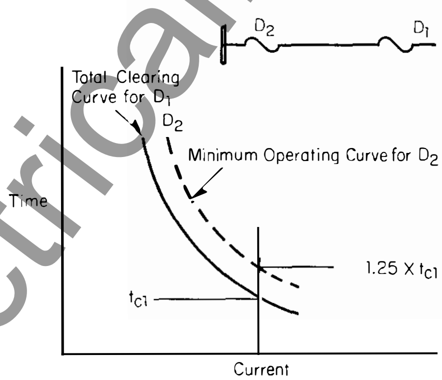
3. To provide an adequate coordinating interval, increase this time (t_c) by 25%, and select back-up device rating with minimum operating time (t_m) equal to 125% of t_c at the same short circuit current as used in (2).

4. To assure coordination at lower fault currents, check at minimum and intermediate current values, or plot both fuse curves on one curve sheet. (This step is generally not necessary unless coordinating links of different types at very high fault currents.)

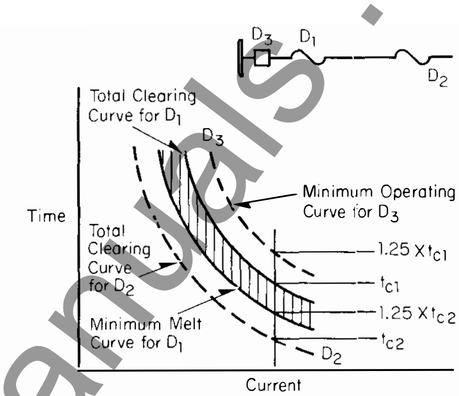
4a. If other current-responsive devices are to open before a praticular fuse link, the minimum melting time (t_m) of the link should be compared to the operating time of the other devices.



4b. If other current-responsive devices are to open after a particular fuse link, the total clearing time (t_c) of the link should be compared to the operating time of the other devices.

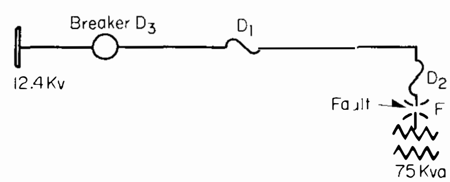


4c. If there are current-responsive devices on both sides of a particular fuse link, use the minimum melting time (t_m) for coordinating with devices on the load side and the total clearing time (t_c) for devices on the source side.



In all cases a multiplier of 1.25 should be applied to the operating time of the protecting device before comparing it with the protected device operating time at any given current.

Example



Short circuit current for fault at F is 500 amperes. Full load current for 75 kva transformer is 6.0 amperes.

If a 10 ampere K-rated link for D_2 is selected

T_{c2}=.02 seconds
1.25 x t_{c2}=.025 seconds

Using K-rated curves (minimum melt), a 15 ampere link will melt in .02 seconds (t_m) and a 20 ampere K-rated link in .03 seconds.

Therefore, D_1 should be a 20 ampere K-rated link or if a preferred link rating is desired, a 25 ampere K-rated link.

Now, using total clearing time curves for 20 ampere K-link

1.25 x t_{c1}=1.25 x .06=.075 seconds.

Thus, for coordination between D_1 and D_3, the protective device at D_3 should not operate in less than .075 seconds at 500 amperes.

This procedure can be used for all selective coordination problems between overcurrent responsive devices such as fuses, reclosers or relayed breakers in any combination or sequence.

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UT, Super Surge, K and T
½ to 200 Amperes

Application Tables

Since fuse cutouts are most commonly used as a sectionalizing device for distribution transformers or capacitor banks, and as such are at the load extremities of the system, tables for determining fuse link rating have been prepared for these applications to facilitate selection. The procedure used in selecting the indicated link size is discussed with each table.

Self Protected Distribution Transformer

Fuse link values in the tables below are based on the full load current of the transformer and a constant multiplier. The multiplier is a compromise based on transformer thermal capability, the fuse speed ratio, and secondary coordination. The values in parentheses are super surge fuse links, type S. There insertion in the table implies that optimum protection cannot be obtained with conventional fuse types because of the low currents involved.

Table 1, Single Phase

Recommended Fuse Link Rating for Fault Protection①

Transformer Kva	Single-Phase Voltage ($E_{L\cdot G}$)					
	2400	4160	4800	7200	7960	14400
5	(3)	(2)	(1)	(1)	(1)	(1)
7.5	6(3)	(3)	(2)	(1)	(1)	(1)
10	6(5)	6(3)	(2)	(2)	(2)	(1)
15	10	6(5)	6(3)	(2)	(2)	(1)
25	20	12	10(7)	6(3)	6(2)	(2)
37.5	25	15	15	10	10(5)	6(3)
50	40	20	20	12	12	8(5)
75	50	30	30	20	15	10(5)
100	80	40	40	25	20	12
167	140	65	65	40	40	20
250	200	100	100	65	65	30
333	...	200	140	80	80	40
500	...	...	200	140	100	80

① Fuse link ratings in parentheses are type S links; others apply to K, T, or UT links.

Table 2, Three Phase

Recommended Fuse Link Rating for Fault Protection②

Transformer Kva	Three Phase Voltage ($E_{L\cdot L}$)						
	2400	4160	4800	7200	12470	13800	24900
9	(5)	(2)	(1)	(1)	(1)	(1)	(1)
15	8(5)	(3)	(2)	(2)	(1)	(1)	(1)
30	12	8(5)	6(5)	(3)	(2)	(2)	(1)
45	20	10	10(7)	6(5)	(2)	(2)	(2)
75	30	20	15	10(7)	6(5)	6(5)	(2)
112.5	50	25	25	15	10(8)	8(5)	(3)
150	65	40	30	20	12	10	6(5)
225	100	50	50	30	20	15	10(7)
300	140	80	65	40	25	20	12
500	...	140	100	65	40	40	20
750	...	...	200	100	65	50	30
1000	...	...	...	200	80	80	40
1500	...	...	...	200	140	140	65

② Fuse link ratings in parentheses are type S links; other refer to K, T, or UT links.

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Application Tables
CSP Transformer Protection

In the case of the completely self-protected transformer, an internal protective link performs the fundamental function of clearing the transformer from the line in the event of an internal fault. Therefore, the fuse cutout performs a back-up service only, and the problem is to find the smallest fuse link which successfully coordinates with the transformer protective link. The protective link characteristic is a function of transformer kva and voltage rating and the number designation can be obtained from table 3. Table 4 lists the minimum size K, T, and UT fuse link which will coordinate with each protective link.

Table 3
Protective Link Curve Designation Number

Transformer Kva	Voltage, $E_{L\cdot G}$ (max)					
	2400	4160	4800	7200	14400	24900
3	5	4	3	2	2	2
5	6	5	5	3A	3	2
10	7	6	5A	5	3	3
15	8	7	7	5A	4	4
25	9	7	7	6	5	5
37.5	10	9	9	8	7	7
50	11	10	10	9	7	7
75	12	11	10	9	8	..
100	13	11	11	10	9	..

Table 4
Coordination of Sectionalizing Fuses and CSP Protective Links

Protective Link Curve Number	Minimum Sectionalizing on Branch Fuse to Coordinate with Protective Link			
	Type UT	Type K	Type T	Type S
2	③(7N)	③(6K)	③(6T)	7S
3	③(7N)	③(6K)	③(6T)	7S
3A	7N	8K	6T	
4	7N	10K	6T	
5	10N	12K	10T	
5A	15N	15K	12T	
6	15N	20K	12T	
7	25N	30K	20T	
8	30N	50K	25T	
9	50N	80K	40T	
10	65N	100K	65T	
11		140K	100T	
12		200K	140T	
13		200K	140T	

③ The super surge 7S gives better coordination for these small ratings.

Fuse Links
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UT, Super Surge, K and T
½ to 200 Amperes

Capacitor Bank Group Fusing

The selection of fuse link ratings to protect the system against consequential damage due to internal capacitor faults is a function of several variables including:

1. Capacitor bank rating (kvar and voltage).
2. Connection of capacitor bank (wye grounded, wye ungrounded, or delta).
3. Rating of individual capacitors.
4. System short circuit capability.
5. Parallel capacitor bank ratings.

In the past, the general procedure has been to use tank rupture time-current characteristics as the limiting curve, and select a fuse link whose total clearing curve lies below with an appropriate margin.

In addition to the above, the following requirements must be met:

1. The link rating must be at least 135% of the capacitor bank rated current (to allow for possible harmonic currents).
2. Transient currents occurring while switching this bank and other parallel banks should not damage the fuse.
3. The system fault current at the point of installation should not exceed: 4,000 amperes (asymmetrical) for 25 kvar units, 5,000 amperes (asymmetrical) for 50 kvar units, and 6,000 amperes (asymmetrical) for 100 kvar units.

Using these criteria, an application table for standard bank sizes can be developed as shown in table 5. The table uses K-rated links since they allow larger bank ratings to be group fused – and this is an economic advantage. Notice this table applies only for grounded wye and delta banks.

The case rupture curves used to compile table 5 are very conservative since they apply to all capacitors regardless of manufacture.

Table 5

Fuse Link Selection for K-Rated Links④ (for Capacitor Group Fusing)

3-Phase Kvar	Voltage-Bank Rating (E_{L-L})					
	2400	4160	4800	7200	12470	13800	24900
150⑤	40	25	20	15	8	8	6
300⑥	80	50	40	30	15	15	10
450⑦	140	80	65	40	25	25	15
600		100	80	65	40	30	20
750		140	100	80	40	40	25
900			140	80	50	50	30
1050				100	65	65	40
1200				140	65	65	40
1350	No			140	80	65	50
1500		group			80	80	50
1800			fusing		100	100	↑ 65⑤
2100					140	100	80
2400				in	140	140	80
2700							100↑
3000					these		100⑥
3300						ratings	140⑦

④ Ground wye and delta banks only.
⑤ Safe zone – rupture probability <10%.
⑥ Zone 1 – rupture probability >10<50.
⑦ Zone 2 – rupture probability >50<90.

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Application Tables, Continued

Westinghouse Capacitor Units

If Westinghouse capacitor units are installed, table 6 can be used for fuse link rating selection. This table is compiled from specific test data using pre-failed Westinghouse capacitor units and K-rated links. It allows larger banks to be group fused and thus provides a more economical application.

The following requirements governed in compiling table 6:

1. The link rating is at least 165% of bank continuous current to minimize fuse damage on transients.

2. The data are applicable for system fault currents up to 5000 amperes rms symmetrical for link ratings 100K and below, and for system fault currents of 4000 amperes rms symmetrical for 140 K-rated links.

3. Tests proving the application consisted of three successful operations of pre-failed Westinghouse capacitors and the appropriate K-rated link at full fault currents as specified in 2.

Ungrounded Wye-connected Capacitor Banks

Connecting a capacitor bank in ungrounded wye results in two special conditions:

1. The fault current is limited to 3 times normal load current.

2. There is no path for harmonic currents, thus the group fuse rating can be sized closer to the maximum load current of the bank.

The choice of link rating is, therefore, governed by these factors:

a. The fuse link must clear in five minutes at a current 285% of the normal load of the capacitor bank.

b. The link rating should be applied according to overload capabilities covered under "repetitive overloads" on page 8.

Table 6

Fuse Link Selection for K-rated Links⑧ for Group Fusing – Westinghouse Capacitors

3 Phase Kvar	Voltage Rating ($E_{L\text{-}L}$)					
	2400	4160	4800	7200	12470	13800
150	50	30	30	20	10	10
300	100	50	50	40	20	20
450	140	80	65	50	30	30
600	...	140	100	65	40	40
750	...	...	100	80	50	50
900	...	...	140	100	65	65
1050	...	...	...	100	65	65↑
1200	...	...	...	140	80	80⑤

⑧ For Westinghouse capacitor units only and delta or wye grounded connected capacitor banks. Less than 10% rupture probability.

Table 7

Fuse Link Selection for K-rated Links⑨ for Group Fusing Capacitor Banks

3 Phase Kvar	Voltage Rating $E_{L\text{-}L}$					
	2400	4160	4800	7200	12470	13800
150	65	20	20	15	8	6
300	80	40	40	25	15	12
450	100	65	50	40	20	20
600	140	80	80	50	30	25
750	...	100	100	65	35	30
900	...	140	100	80	40	35
1050	...	140	140	80	50	40
1200	...	...	140	100	65	50

⑨ For ungrounded WYE-connected banks only.

High System Fault Current Applications

If the system fault current exceeds the values previously recommended for use with given capacitor banks and group fuse sizes, then the following protection scheme may be considered:

1. Use group fuses only per table 5 and take the calculated risk that excessive damage will not be encountered. The following considerations are suggested in evaluating the risk:

   a. The magnitude of the fault current, the group fuse rating, the kvar of the individual capacitor, and the probability of failure.

   b. Recent tests indicate that any violent explosion which results from an internal capacitor failure is due to vaporization of the capacitor leads. Comparison of the vaporization curve of the leads used in Westinghouse capacitors and the 140 K fuse characteristic indicates that at fault currents below 10,000 amperes a satisfactory coordination margin exists. For currents above 10,000, the margin is questionable and some other solution should be employed if 100% protection against case rupture is required.

2. Select smaller size banks and locations chosen to reduce fault current.

3. Add reactor between capacitor neutral and ground to reduce fault current to a value which will give satisfactory fuse coordination.

4. Use capacitors Wye connected with the neutral underground to limit the expected fault current to three times normal capacitor current in the phase to the faulted capacitor.

Fuse Links
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Special Application Considerations

Fuse link rating selection is normally considered as a relatively uncomplicated procedure as evidenced by the selection tables discussed previously. There are, however, some application problems which arise which may modify link rating selection since they are not a function of normal load current. These are discussed in the following paragraphs.

Fuse Link Surge Capability

Because fuse links are in series with the line, they must pass, without damage, high current short duration lightning surges. The low ampere link ratings are naturally most susceptible to melting on these surges. Since the lightning surge is of extremely short duration, it can be assumed that all of the heat generated by the stroke current is dissipated in the fuse element and that none is lost by radiation or convection. With very little error this can also be assumed true for a sinusoidal pulse of one-half cycle duration.

This assumption allows a determination of the surge capability of the link since the one-half cycle current capability can be obtained from the minimum melt characteristic of the fuse link. The surge capability will of course vary with the duration of the surge; however, using a surge with a 40 microsecond duration as a base, the following relationship is obtained:

$$i_{sc} = 17 \times i_o$$

where i_{sc} = crest value of lightning surge current

i_o = minimum melting current at $t = ½$ cycle (.00833 sec.)

Using this relationship and the minimum melting time-current characteristics, the crest impulse current limits for Westinghouse UT, K, and T links can be calculated. Tests made in the past have verified the calculation method as being sufficiently accurate for application on distribution circuits.

Since the current magnitude and wave shape of a lightning stroke is strictly a matter of probability, this value is of no use unless the utility engineer decides on a probability factor he is willing to accept. For this purpose, the historical probability factors for distribution circuits when considering lightning stroke crest current are valuable. These are:

Over 21,000 amperes....... 1%
Over 9,000 amperes....... 5%
Over 3,000 amperes.......20%
Over 1,200 amperes.......50%

From these factors and the related fuse impulse characteristics for a 1½ x 40 microsecond surge, the following application table can be obtained.

Table 8

% Protection Against Fuse Blowing	Minimum Fuse Link Rating Recommended			
	T	UT	K	S
99	15	20	25	...
95	8	7	12	...
90	..	..	..	2-7
80	..	..	..	1

The percent protection refers to all strokes which hit a given distribution system, so this can only be put on an annual basis by correlating it to the isokeraunic level or to strokes per year per unit line length.

Reduced Fuse Melting Time

There are several conditions which may reduce the melting time of a fuse link from that shown on the minimum melting time current curve. These system conditions may co-exist, or affect the melting time independent of one another.

On an application where extremely close coordination is required these conditions should be considered:

1. Fault current asymmetry.
2. Pre-loading.
3. High ambient temperature.
4. Repetitive overloads.

Distribution system applications, where the reduced melting time is important, are generally restricted to a recloser-fuse combination where the fuse is required to hold through one instantaneous operation of the recloser. Where the rms symmetrical fault current through the fuse link exceeds 25 times the link rating, this scheme cannot be used since the fuse link will always melt before the reclosing device clears. The majority of distribution fuse cutout applications require the fuse cutout to clear first, thus reduced melting time will merely increase the coordination margin, providing more consistent sequential clearing.

Individually the effects of the above conditions are discussed below.

Fault Current Asymmetry

The melting time of a given fuse link is, based on the calculated rms symmetrical fault current available at the point of application. Actually, the fault current through the link will contain a d-c component, the magnitude of which is dependent on system x/r ratio and the point of fault initiation with respect to system voltage. The d-c component may, for a few cycles, contribute as much energy to melt the link as the a-c component and a correspondingly decreasing amount as it decays to zero. Thus, for close coordination the melting time should be reduced by some factor to compensate for this increased current.

In lieu of specific data, requiring arduous calculations, the following time reduction factors should be applied.

Table 9

System X/R	Time Reduction Factor (K)		
	Melting Time (t_m) from Curve		
	.01-.03	.03-.1	.1-1
5	.80	.85	.95
10	.70	.80	.93
20	.50	.70	.90

Note: To obtain modified melting time use $t_{mo} = K(t_m)$

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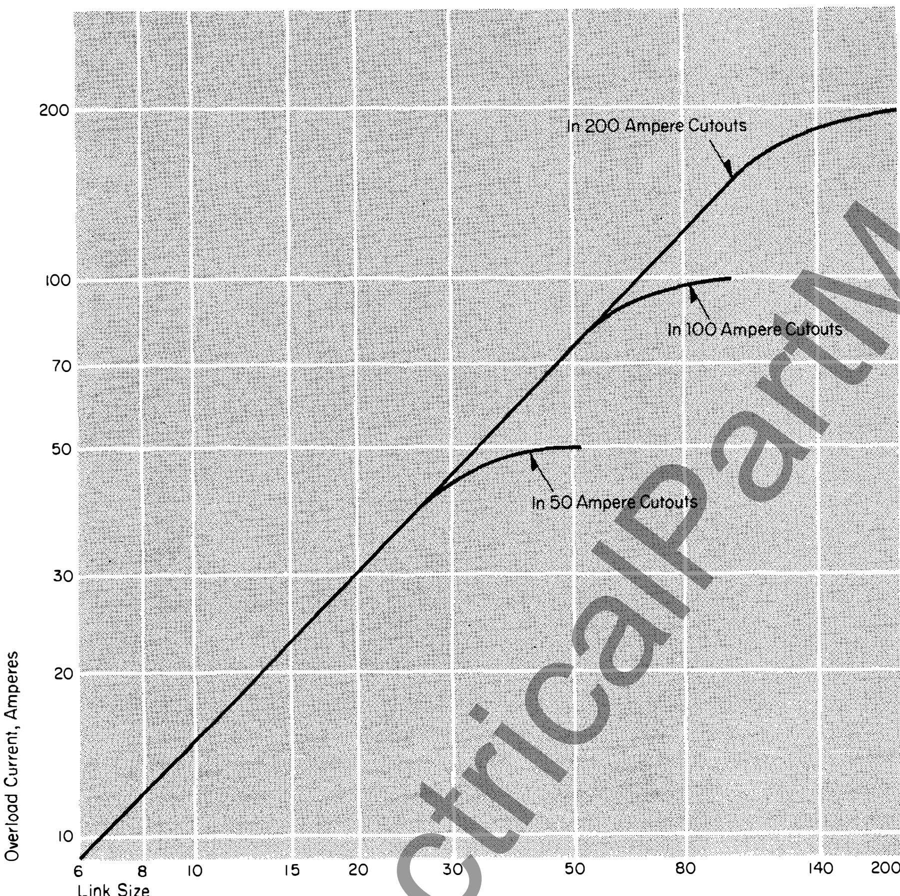
Overload Capacity

Although applicable standards do not specify overload capacities of fuse links, experience has shown that these links have an inherent current-carrying ability of approximately 150% of nominal rating, depending on the thermal capacity of the metallic components of the holder in which the fuse link is installed. For specific link sizes, in Westinghouse cutouts this information is easily presented in graphical form, as shown below.



Preloading

The melting time curves are based on tests conducted with no initial load current through the link. Under actual operating conditions a fuse link will generally be carrying 50 to 90% of rated current continuously. This will raise the link temperature to some fixed value, thus reducing the energy required to melt the link when a fault on overload occurs. Normally no pre-loading compensation is necessary, because this reduction in melting time is small. However, in close coordination applications, the melting time should be reduced ten percent (10%) below the curve value as an additional margin.

If the fuse link is loaded about 100%, this reduction in melting time will become appreciable. Under these conditions the manufacturer should be contacted.

High Ambient Temperature

Standards governing the testing of fuse links require that all published curves be based on an ambient temperature of 25°C. (77°F.) As a result, there is some variation from these curves as the outside temperature changes. As with preloading, the reduction in melting time due to high ambient temperatures is not sufficient to enter into a normal coordination problem. If, however, a really accurate sequential schedule is being considered, the melting time should be reduced by five percent (5%) when the ambient is between 27° and 38°C (80° and 100°F.)

Repetitive Overloads

When a fuse is installed behind a reclosing breaker or automatic circuit recloser, it must be determined if the accumulated heating of the fuse during the close operation will melt the fuse link before the reclosing device clears the fault or locks out. This is not a common application for a distribution fuse cutout since they are usually installed on the load side of the reclosing device.

If an application arises, however, the alternate heating and cooling accumulated affect can be calculated and the application verified. The method for carrying out this study is outlined in detail in Westinghouse catalog section 36-660, application data for power fuses.

Further Information:

Prices: Price List 38-660.

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