Fuses

Fuse Curves

The figure to the right illustrates the time-current characteristic curves for two sizes of time-delay, dual-element fuses in series, as depicted in the one-line diagram. The horizontal axis of the graph represents the RMS symmetrical current in amps. The vertical axis represents the time, in seconds.

For example: Assume an available fault current level of 1000A RMS symmetrical on the load side of the 100A fuse. To determine the time it would take this fault current to open the two fuses, first find 1000A on the horizontal axis (Point A), follow the dotted line vertically to the intersection of the total clear curve of the 100A time-delay dual-element fuse (Point B) and the minimum melt curve of the 400A time-delay dual-element fuse (Point C). Then, horizontally from both intersection points, follow the dotted lines to Points D and E. At 1.75 seconds, Point D represents the maximum time the 100A time-delay dual-element fuse will take to open the 1000A fault. At 90 seconds, Point E represents the minimum time at which the 400A time-delay dual-element fuse could open this available fault current. Thus, coordination operation is assured at this current level.

The two fuse curves can be examined by the same procedure at various current levels along the horizontal axis (for example, see Points F and G at the 2000A fault level). It can be determined that the two fuses are coordinated, for the overcurrents corresponding to the fuse curves on the graph. The 100A time-delay dual-element fuse will open before the 400A time-delay dual-element fuse can melt. However, it is necessary to assess coordination for the full range of overloads and fault currents that are possible.

For analyzing fuse selective coordination for higher level fault currents see the next page, "Medium to High Level Fault Currents–Fuse Coordination." When using the published Fuse Selectivity Ratios, drawing time current curves is not necessary for any level of overcurrent.

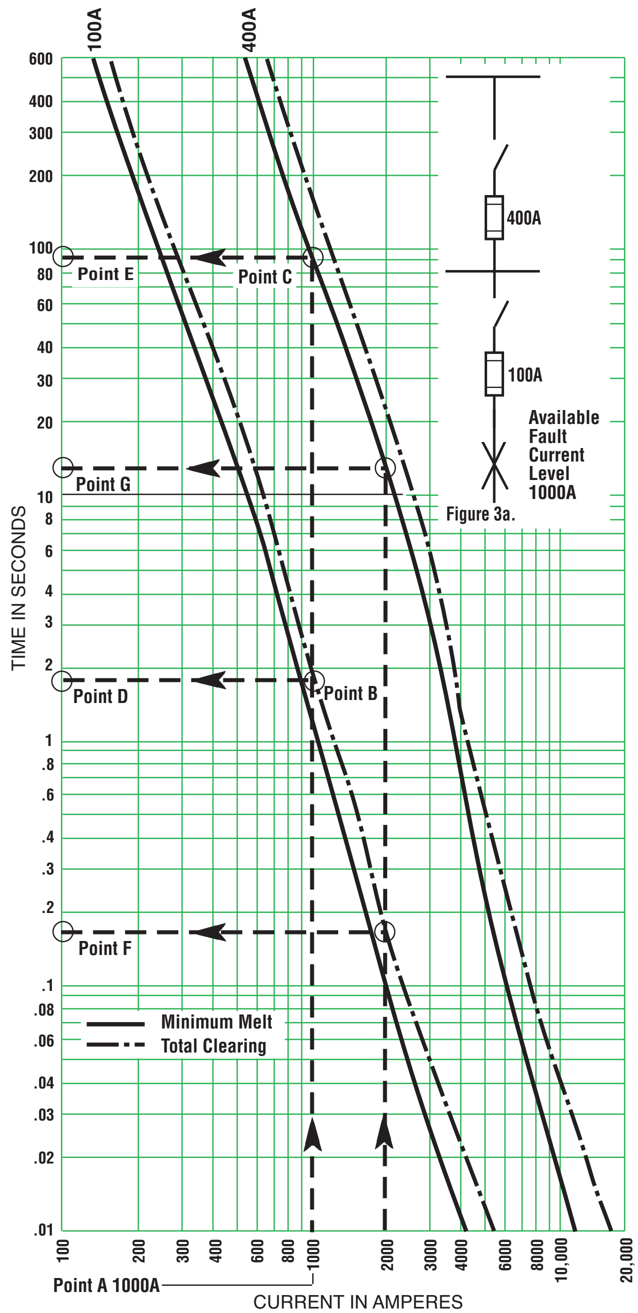


Figure 3a.

Fuses: Selectivity Ratio Guide

Medium to High Level Fault Currents – Fuse Coordination

The illustrations on the next page shows the principles of selective coordination when fuses are properly applied. The available short-circuit current will reach a peak value of I_p during the first half cycle unless a protective device limits the peak fault current to a value less than I_p. A current-limiting fuse will reduce the available peak current to less than I_p, namely I'_p, and will clear the fault in approximately one-half cycle or less. Note that t_c is the total clearing time of the fuse, tm the melting time and ta the arcing time of the fuse. Where high values of fault current are available, the sub-cycle region becomes the most critical region for selective operation of current-limiting fuses.

The area under the current curves is indicative of the energy let-through. If no protective device were present, or if mechanical type overcurrent devices with opening times of one-half cycle or longer were present, the full available short circuit energy would be delivered to the system. The amount of energy delivered is directly proportionate to the square of the current. So we can see how important it is to have fuses which can limit the current being delivered to the system to a value less than the available current. The amount of energy being produced in the circuit while the fuse is clearing is called the total clearing energy and is equal to the melting energy plus the arcing energy.

Selectivity between two fuses operating under short circuit conditions exists when the total clearing energy of the load side fuse is less than the melting energy of the line side fuse.

An engineering tool has been developed to aid in the proper selection of Cooper Bussmann fuses for selective coordination. This Selectivity Ratio Guide (SRG) is shown below.

***Selectivity Ratio Guide for Blackout Prevention (Line-Side to Load-Side)**

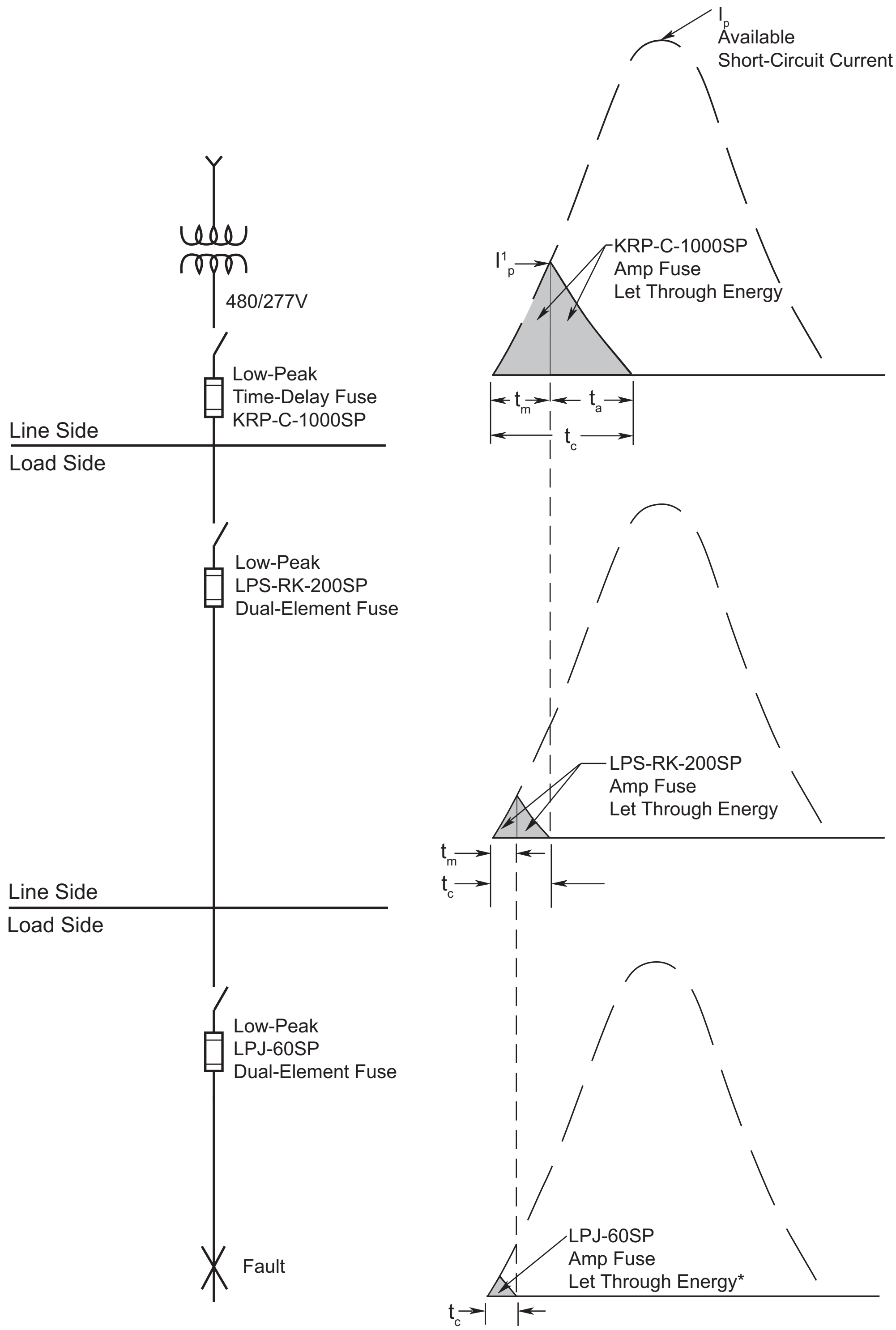
Circuit					Load-Side Fuse									
	Current Rating				601-6000A	601-4000A	0-600A			601-6000A	0-600A	0-1200A	0-600A	0-60A
	Type				Time-Delay	Time-Delay	Dual-Element Time-Delay			Fast-Acting	Fast-Acting	Fast-Acting	Fast-Acting	Time-Delay
			Trade Name		Low-Peak	Limitron	Low-Peak		Fusetron	Limitron	Limitron	T-Tron	Limitron	SC
			Class		(L)	(L)	(RK1)	(J)	(RK5)	(L)	(RK1)	(T)	(J)	(G)
			Cooper Bussmann Symbol		**KRP-C_SP**	**KLU**	**LPN-RK_SP LPS-RK_SP**	**LPJ-SP TCF†**	**FRN-R FRS-R**	**KTU**	**KTN-R KTS-R**	**JJN JJS**	**JKS**	**SC**
Line-Side Fuse	601 to 6000A	Time-Delay	Low-Peak® (L)	**KRP-C_SP**	2:1	2.5:1	2:1	2:1	4:1	2:1	2:1	2:1	2:1	N/A
	601 to 4000A	Time-Delay	Limitron® (L)	**KLU**	2:1	2:1	2:1	2:1	4:1	2:1	2:1	2:1	2:1	N/A
	0 to 600A	Dual-Element	Low-Peak (RK1)	**LPN-RK_SP LPS-RK_SP**	–	–	2:1	2:1	8:1	–	3:1	3:1	3:1	4:1
			(J)	**LPJ-SP**	–	–	2:1	2:1	8:1	–	3:1	3:1	3:1	4:1
			Fusetron® (RK5)	**FRN-R FRS-R**	–	–	1.5:1	1.5:1	2:1	–	1.5:1	1.5:1	1.5:1	1.5:1
	601 to 6000A		Limitron (L)	**KTU**	2:1	2.5:1	2:1	2:1	6:1	2:1	2:1	2:1	2:1	N/A
	0 to 600A	Fast-Acting	Limitron (RK1)	**KTN-R KTS-R**	–	–	3:1	3:1	8:1	–	3:1	3:1	3:1	4:1
	0 to 1200A		T-Tron® (T)	**JJN JJS**	–	–	3:1	3:1	8:1	–	3:1	3:1	3:1	4:1
	0 to 600A		Limitron (J)	**JKS**	–	–	2:1	2:1	8:1	–	3:1	3:1	3:1	4:1
	0 to 60A	Time-Delay	SC (G)	**SC**	–	–	3:1	3:1	4:1	–	2:1	2:1	2:1	2:1

***Note:** At some values of fault current, specified ratios may be lowered to permit closer fuse sizing. Plot fuse curves or consult with Cooper Bussmann.
General Notes: Ratios given in this Table apply only to Cooper Bussmann fuses. When fuses are within the same case size, consult Cooper Bussmann.
† TCF (CUBEFuse) is 1 to 100A Class J performance; dimensions and construction are unique, finger-safe IP-20 design.

COOPER Bussmann

Fuses

For the next example, the Selectivity Ratio Guide suggests that the minimum ratio between line side and load side fuse should be at least 2:1. The one-line shows Low-Peak® fuses KRP-C-1000SP feeding a LPS-RK-200SP. The ratio of amp ratings is 5:1 (1000:200) which indicates coordination between these fuses. Continuing further into the system the LPS-RK-200SP feeds a LPJ-60SP. This ratio of amp ratings is 3.33:1 (200:60), which also indicates a selectively coordinated system.



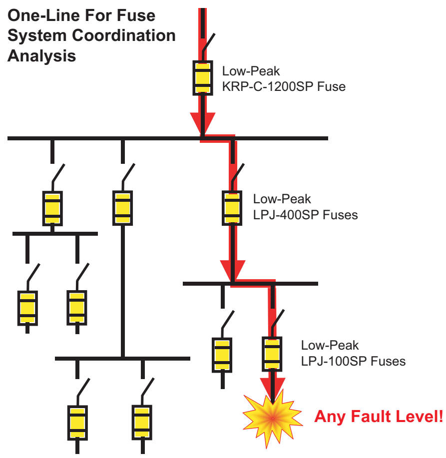
Requirements for selectivity—Total clearing energy of load side fuse is less than melting energy of line side fuse.

*Area under the curves is not actual energy but is indicative of let-through energy. Actual let-through energy is I^2rt.

Fuses

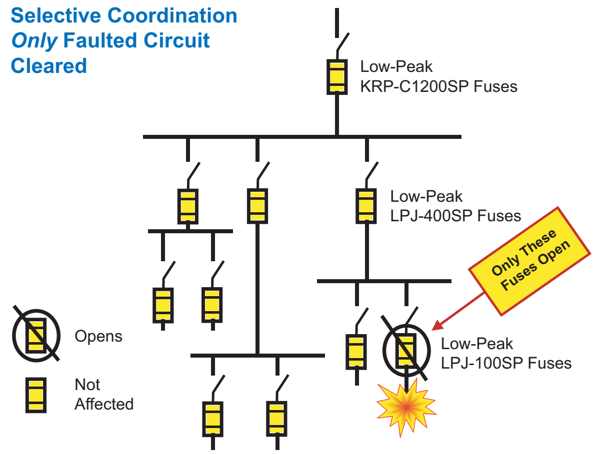
Example — Fuse Selective Coordination

Review the one-line diagram of the fusible system. All the fuses are Low-Peak Fuses. The Selectivity Ratio Guide provides the minimum amp ratio that must be observed between a line-side fuse and a load-side fuse in order to achieve selective coordination between the two fuses. If the entire electrical system maintains at least these minimum fuse amp rating ratios throughout the system, the entire electrical system will be selectively coordinated for all levels of overcurrent. Notice, time current curves do not even need to be plotted.



Check the LPJ 100SP fuse coordination with the LPJ-400SP fuse. The amp rating ratio of these fuses is 400:100 which equals 4:1 ratio. Checking the Selectivity Ratio Guide, line-side LPJ (vertical left column) to load-side LPJ (horizontal), yields a ratio of 2:1. This indicates selective coordination for these two sets of fuses. This means for any overcurrent on the load-side of the LPJ-100SP fuse, only the LPJ-100SP fuses open. The LPJ-400SP fuses remain in operation as well as the remainder of the system.

Check the LPJ-400SP fuse coordination with the KRP-C-1200SP fuse. Use the same steps as in the previous paragraph. The amp rating ratio of the two fuses in the system is 1200:400, which yields an amp rating ratio of 3:1. The Selectivity Ratio Guide shows that the amp rating ratio must be maintained at 2:1 or more to achieve selective coordination. Since the fuses used have a 3:1 ratio, and all that is needed is to maintain a 2:1 ratio, these two fuses are selectively coordinated. See the following diagram.



Summary — Fuse Coordination

Selective coordination is an important system criteria that is often overlooked or improperly analyzed. With modern current-limiting fuses, all that the design engineer, contractor, plan reviewer, electrical inspector or user needs to do is adhere to these ratios. It is not necessary to plot the time current curves. Just maintain at least the minimum amp rating ratios provided in the Cooper Bussmann Selectivity Ratio Guide and the system will be selectively coordinated. This simple method is easy and quick.