Fusing Equipment

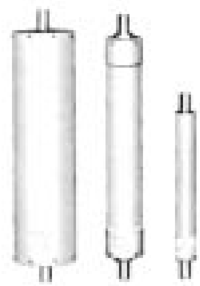
COOPER Power Systems

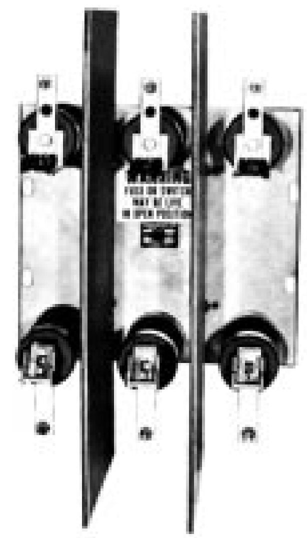
Electrical Apparatus

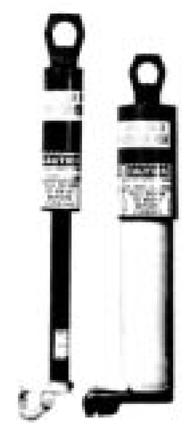
NX® Indoor Current-Limiting Fuses

240-60

CONTENTS







GENERAL

Type NX current-limiting fuses and mountings provide overload protection for all indoor and underground cable distribution system 2.4 through 38 kV. NX fuses are noiseless and expel no hot gases or burning particles while interrupting currents from minimum melt to maximum fuse rating (50,000 amps through 23 kV; 35,000 amps through 27 and 38 kV). Their current-limiting capability greatly reduces the momentary duty on protected equipment, extending the life and, in some cases, reducing the original cost of that equipment.

The ability of an NX fuse to interrupt low-current faults eliminates the need for auxiliary devices to handle these troublesome current levels. An NX fuse extends system coordination because it is fast clearing and current limiting— conductor and equipment damage caused by high currents is virtually eliminated.

Clip-Style NX Fuses

The basic NX fuse unit is designed to mount in a Cooper Power Systems® clip-style mounting. Basic clip-style NX fuses are available in 4.3, 5.5, 8.3,15.5, 23, 27, and 38 kV ratings.

Arc-Strangler Loadbreaking Device

An NX fuse with an Arc-Strangler loadbreaking device that mounts in a hinge-style mounting is available on 4.3, 5.5, 8.3, and 15.5 kV fuses. All current magnitudes from excitation current through 200 amps can be interrupted positively and safely by opening the fuse with a switchstick.

Arc-Strangler Switchblade

Switchblades with the Arc-Strangler loadbreaking device are available in 8.3 and 15.5 kV, 200 amp continuous-current ratings.

Mounting and Enclosures

NX fuse characteristics make possible a wide variety of sectionalizing, switching and protective schemes—with compactness and safety unattainable with other fusing equipment. (Mounting arrangements other than those cataloged are available.)

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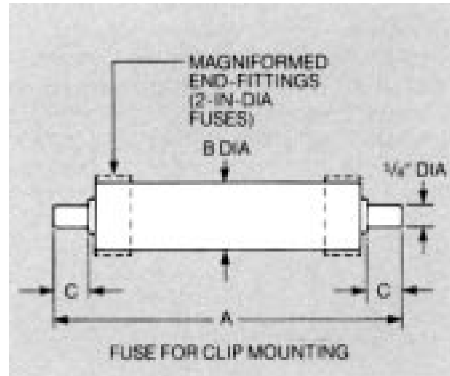
ORDERING AND DIMENSIONAL INFORMATION
NX Current-Limiting Fuses-Clip Style

TABLE 1
Ratings

Rating*		Mounting Code Number**	Fuse Diameter (in.)†	Catalog Number
Voltage (kV	Continuous Current (amp)			
4.3	18	4	1-1/8	FA1H18
	25	4	1-1/8	FA1H25
	35	4	1-1/8	FA1H35
	45	4	2	FA1H45
	50	4	2	FA1H50
	65	4	2	FA1H65
	75	4	2	FAl H75
	105	4	2	FA1H100
5.5	6	4	1-1/8	FA2H6
	8	4	1-1/8	FA2H8
	10	4	1-1/8	FA2H10
	12	4	1-1/8	FA2H12
	18	4	1-1/8	FA2H18
	20	4	2	FA2H20
	25	4	2	FA2H25
	30	4	2	FA2H30
	40	4	2	FA2H40
	50	4	2	FA2H50
	65	4	2	FA2H65
	75	4	2	FA2H75
8.3	1.5	4	1-1/8	FA3H1
	3	4	1-1/8	FA3H3
	4.5	4	1-1/8	FA3H4
	6	4	1-1/8	FA3H6
	8	4	1-1/8	FA3H8
	10	4	1-1/8	FA3H10
	12	4	1-1/8	FA3H12
	18	4	2	FA3H18
	20	4	2	FA3H20
	25	4	2	FA3H25
	30	4	2	FA3H30
	40	4	2	FA3H40
	50	5	3-7/16	FA3H50
	65	5	3-7/16	FA3H65
	80	5	3-7/16	FA3H80
	100	5	3-7/16	FA3H100
15.5	1.5	5	1-1/8	FA4H1
	3	5	1-1/8	FA4H3
	4.5	5	1-1/8	FA4H4
	6	5	2	FA4H6
	8	5	2	FA4H8
	10	5	2	FA4H10
	12	5	2	FA4H12
	18	5	2	FA4H18
	20	5	2	FA4H20
	25	5	2	FA4H25
	30	5	2	FA4H30
	40	5	2	FA4H40
	50	6	3-7/16	FA4H50
	65	6	3-7/16	FA4H65
	80	6	3-7/16	FA4H80
	100††	6	3-7/16	FA4H100†
23	6	6	2	FA5H6
	8	6	2	FA5H8
	10	6	2	FA5H10
	12	6	2	FA5H12
	18	6	2	FA5H18
	20	6	2	FA5H20
	25	6	2	FA5H25
	30	6	2	FA5H30
	40	6	2	FA5H40

TABLE 1
Ratings (continued)

Rating*		Mounting Code Number**	Fuse Diameter (in.)†	Catalog Number
Voltage (kV)	Continuous Current (amp)			
27	6	9	3-7/16	FA9H6
	8	9	3-7/16	FA9H8
	10	9	3-7/16	FA9H10
	12	9	3-7/16	FA9H12
	15	9	3-7/16	FA9H15
	18	9	3-7/16	FA9H18
	20	9	3-7/16	FA9H20
	25	9	3-7/16	FA9H25
	30	9	3-7/16	FA9H30
	40	9	3-7/16	FA9H40
	50	9	3-7/16	FA9H50
38	6	10	3-7/16	FA10H6
	8	10	3-7/16	FA10H8
	10	10	3-7/16	FA10H10
	12	10	3-7/16	FA10H12
	15	10	3-7/16	FA10H15
	18	10	3-7/16	FA10H18
	20	10	3-7/16	FA10H20
	25	10	3-7/16	FA10H25
	30	10	3-7/16	FA10H30
	40	10	3-7/16	FA10H40
	50	10	3-7/16	FA10H50



*4.3, 5.5, 8.3, 15.5, 23 kV have 50,000 amp symmetrical rating; 27 and 38 kV have 35,000 amp symmetrical rating.
**Code number of mounting must match code number of fuse or switchblade.
† All 2-in. diameter fuses have magniformed end fittings.
†† At present, 100 amp, 15.5 kV fuse is suitable for systems up to 13.5 kV maximum voltage rating.

TABLE 2
Dimensions

Description	Mounting Code Number*	A (in.)	B (in.)	C (in.)
1 -1/8-in.-diameter fuse for clip mounting	4	10	1-1/8	1
2-in -diameter fuse for clip mounting	4	10	2	1
	5	14-5/16	2	1
	6	17-1/8	2	1
3-7/16-in.-diameter fuse for clip mounting	5	14-11/16	3-7/16	1-3/16
	6	17-1/2	3-7/16	1-3/16
	9	27-3/8	3-7/16	1-3/16
	10	35-3/8	3-7/16	1-3/16

*Code number of mounting must match code number of fuse.

NX Hinge-Style Arc-Strangler Loadbreaking Device

RATINGS

The Arc-Strangler loadbreaking device used on NX current-limiting fuses meets all the requirements of ANSI Std. C37.47. Its loadbreaking duty cycle rating is five operations at rated continuous current at rated voltage.

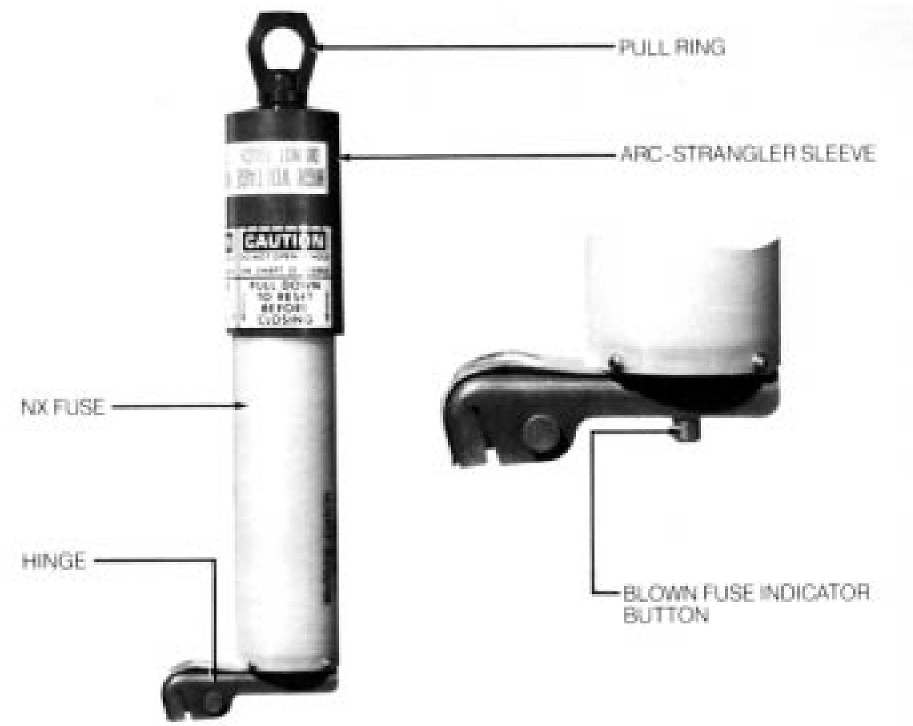
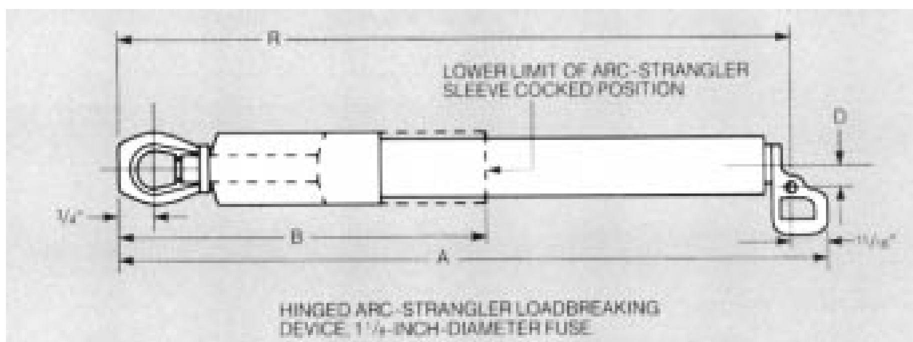


Figure 1.
Cooper Power Systems Type NX current-limiting fuse with Arc-Strangler loadbreaking device.



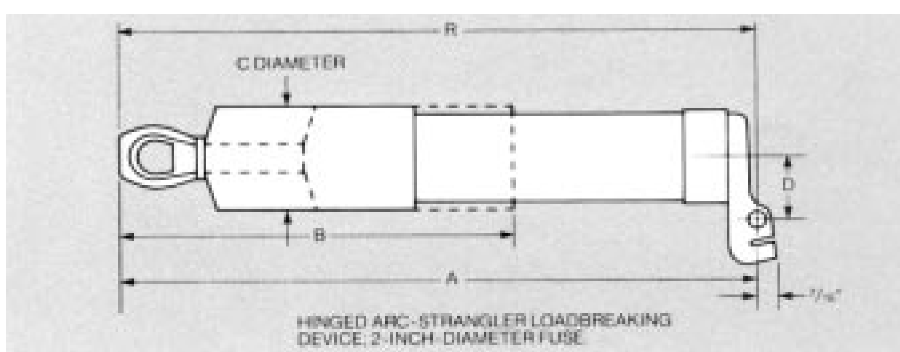


TABLE 3
Ratings
50,000 amps Symmetrical Interrupting Rating

Rating Voltage (kV)	Continuous Current (amp)	Mounting Code Number*	Fuse Diameter (in.)**	Catalog Number
For Single- and Parallel-Unit Hinge-Style Mountings				
4.3	18	1	1-1/8	FA1A18
	25	1	1-1/8	FA1A25
	35	1	1-1/8	FA1A35
	45	1	2	FA1A45
	50	1	2	FA1A50
	65	1	2	FA1A65
	75	1	2	FA1A75
	100	1	2	FA1A100
5.5	6	1	1-1/8	FA2A6
	8	1	1-1/8	FA2A8
	10	1	1-1/8	FA2A10
	12	1	1-1/8	FA2A12
	18	1	1-1/8	FA2A18
	20	1	2	FA2A20
	25	1	2	FA2A25
	30	1	2	FA2A30
	40	1	2	FA2A40
	50	1	2	FA2A50
	65	1	2	FA2A65
	75	1	2	FA2A75
8.3	1.5	1	1-1/8	FA3A1
	3	1	1-1/8	FA3A3
	4.5	1	1-1/8	FA3A4
	6	1	1-1/8	FA3A6
	8	1	1-1/8	FA3A8
	10	1	1-1/8	FA3A10
	12	1	1-1/8	FA3A12
	18	1	2	FA3A18
	20	1	2	FA3A20
	25	1	2	FA3A25
	30	1	2	FA3A30
	40	1	2	FA3A40
15.5	1.5	2	1-1/8	FA4A1
	3	2	1-1/8	FA4A3
	4.5	2	1-1/8	FA4A4
	6	2	2	FA4A6
	8	2	2	FA4A8
	10	2	2	FA4A10
	12	2	2	FA4A12
	18	2	2	FA4A18
	20	2	2	FA4A20
	25	2	2	FA4A25
	30	2	2	FA4A30
	40	2	2	FA4A40

*Code number of mounting must match code number of fuse or switchblade.
** All 2-in.-diameter fuses have magniformed end fittingswith stamped hinge.

TABLE 4
Dimensions

Description	Voltage Rating (kV)	Mounting Code Number*	A (in.)	B (in.)	C (in.)	D (in.)	R (in.)
1-1/8-in.-diameter hinged fuse	4.3, 5 5, and 8.3	1	14	8-7/8	1-3/8	3/8	13-5/16
	15.5	2	18-1/2	8-7/8	1-3/8	3/8	17-13/16
2-in.-diameter hinged fuse	4.3, 5.5, and 8.3	1	13-3/4	8-15/16	2-7/l6	1-7/16	13-5/16
	15.5	2	18-7/8	9-1/8	2-7/16	1-7/16	18

*Code number of mounting must match code number of fuse.

NX Hinge-Style Arc-Strangler Switchblade

RATINGS

The Arc-Strangler loadbreaking device used on NX switchblades meets all the requirements of ANSI Std. C37.47. It has a continuous-current rating of 200 amps, its momentary and closing-in rating is 18,000 amps, and its loadbreaking ability is five operations at 200 amps at 80% power factor. At smaller current levels, more operations are possible.

TABLE 5
Ratings and Dimensions

Rating		Description	Mounting Code Number*	Dimension A (in.)	Catalog Number
Voltage (kV)	Continuous and Loadbreak Current (amp)				
8.3	200	Blade	1	14	FA1B1
15.5	200	Short 15 kV blade	1	14	FA4B1
15.5	200	Long 15 kV blade	2	18-1/2	FA3B1

*Code number of mounting must match code number of fuse.

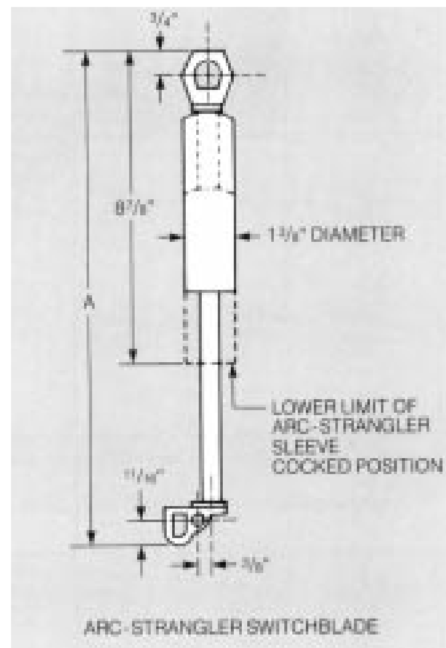


Figure 2.
Arc-Strangler switchblade.

NX Mountings-Clip Style

TABLE 6
Ratings and Dimensions of Channel-Based Mountings for Clip_Style NX Fuses (See drawings on page 8.)

Mounting Type	Maximum Voltage Rating (kV)	BIL (kV)	Mounting Code Number*	Catalog Number	Dimensions (in.)							
					A	B	C	D	E	F	G	H
Single Fuse, Single Pole	8.33	95	4	FAB1D1	17-1/2	11	9-3/4	14	4	–	3-7/8	1-1/4
	15.5	95	5	FAB1D2	21-7/8	15-3/8	9-3/4	18-3/8	9-3/4	–	3-7/8	1-1/4
	15.5	125	5	FAB1D4	21-7/8	15-3/8	11-1/8	18-3/8	9-3/4	–	3-7/8	1-1/4
	15.5	95	6	FAB1D5	24-3/4	18-3/16	9-3/4	21-3/16	12-5/8	–	3-7/8	1-1/4
	15.5	125	6	FAB1D8	24-3/4	18-3/16	11-1/8	21-3/16	12-5/8	–	3-7/8	1-1/4
	23	150	6	FAB1D3	24-3/4	18-3/16	12-1/2	21-3/16	12-5/8	–	3-7/8	1-1/4
	27	150	9	FAB1D6	34-9/16	28-1/16	13-1/16	32-1/16	17-1/2	–	7-1/4	1-1/4
	38	150	10	FAB1D7	42-9/16	36-1/16	13-1/16	40-1/16	25	–	7-1/2	1-1/4
Parallel Fuse, Single Pole	8.3	95	4	FAB1K1	20-3/4	11	9-3/8	14	4-1/4	6-1/4	4-7/8	2
	15.5	95	5	FAB1K2	25-1/8	15-3/8	9-3/8	18-3/8	8-5/8	6-1/4	4-7/8	2
	15.5	125	5	FAB1K3	25-1/8	15-3/8	11-1/4	18-3/8	8-5/8	6-1/4	4-7/8	2
	15.5	95	6	FAB1K4	27-15/16	18-3/8	9-3/8	21-3/8	11-7/16	7-11/16	4-7/8	2
	23	125	6	FAB1K5	27-15/16	18-3/16	11-1/4	21-3/8	11-7/16	7-11/16	4-7/8	2
	27	150	9	FAB3K1	37-13/16	28-1/16	13-7/8	32-1/16	17-1/2	7-11/16	7-1/4	2
	38	150	10	FAB3K2	45-13/16	36-1/16	13-7/8	40-1/16	25	7-11/16	7-1/2	2
	23	150	6	FAB3K3	27-15/16	18-3/16	13-7/8	22-3/16	11-7/16	7-11/16	5-1/4	2

*Code number of mounting must match code number of fuse.

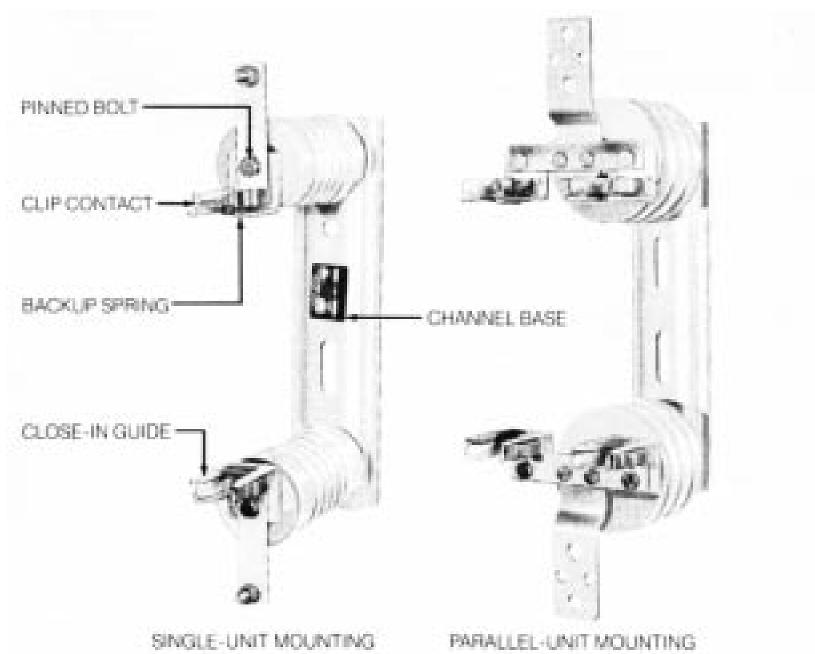
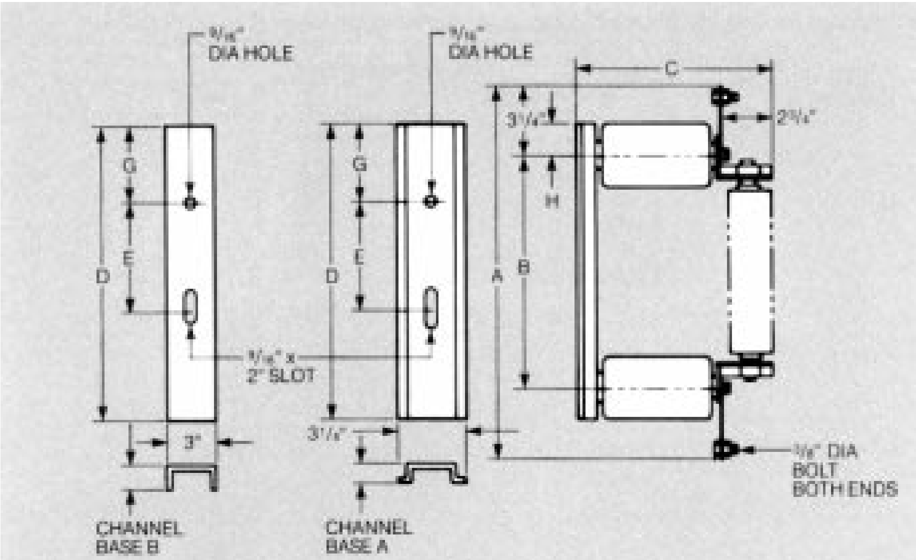


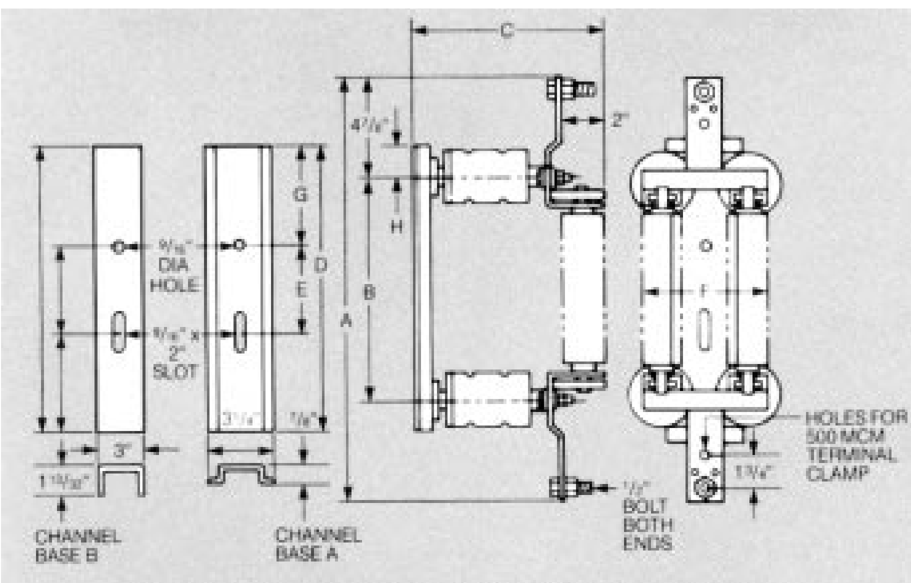
Figure 3.
Open channel-based mountings for clip-style fuses.

NX Mountings-Clip Style



SINGLE-POLE MOUNTING FOR CLIP-MOUNTED FUSES (FAB1D SERIES).

NOTE: Channel Base B is used on FAB1D6 and FAB1D7; all other FAB1D series employ Channel Base A.



SINGLE-POLE PARALLEL MOUNTING FOR FAB1K SERIES IS THE SAME EXCEPT THAT CLIP-MOUNTED FUSES (FAB3K SERIES). (HAD TWO INSULATORS.)

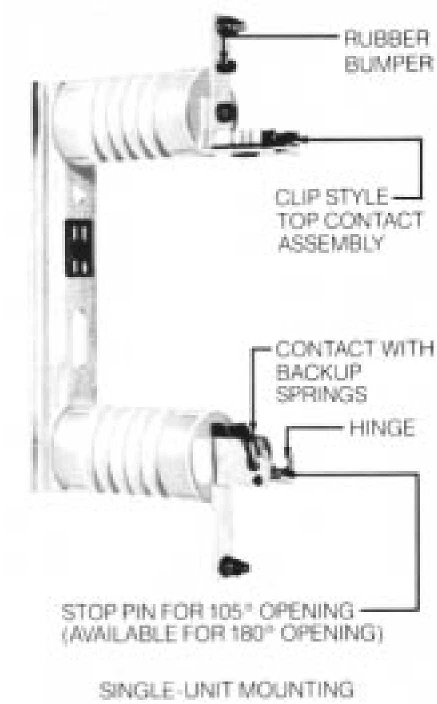
NOTE: Channel Base A is used on the FAB1K series. Channel Base B is used on the FAB3K series.

NX Mountings-Hinge Style

TABLE 7
Ratings and Dimensions of Channel-Based Mountings for Hinge-Style NX Fuses (Arc-Strangler Loadbreaking Device Arc-Strangler Switchblade)

Maximum Voltage (kV)	BIL (kV)	Description	Mounting Code Number*	Catalog No. 105° Open	Catalog No. 180° Open	Dimensions (in.) A	B	C	D	E	F	G
8.3	95	Single-pole mounting	1	FA1D1	FAA1D1	18-1/4	11-1/8	13-5/16	14	5	9-3/4	8-11/16
15.5	95		2	FA1D2	FAA1D2	22-5/8	15-1/2	17-13/16	18-3/8	9-3/4	9-3/4	8-11/16
15.5	125		2	FA1D4		22-5/8	15-1/2	17-13/16	18-3/8	9-3/4	11-1/8	10-1/16

*Code number of mounting must match code number of fuse.



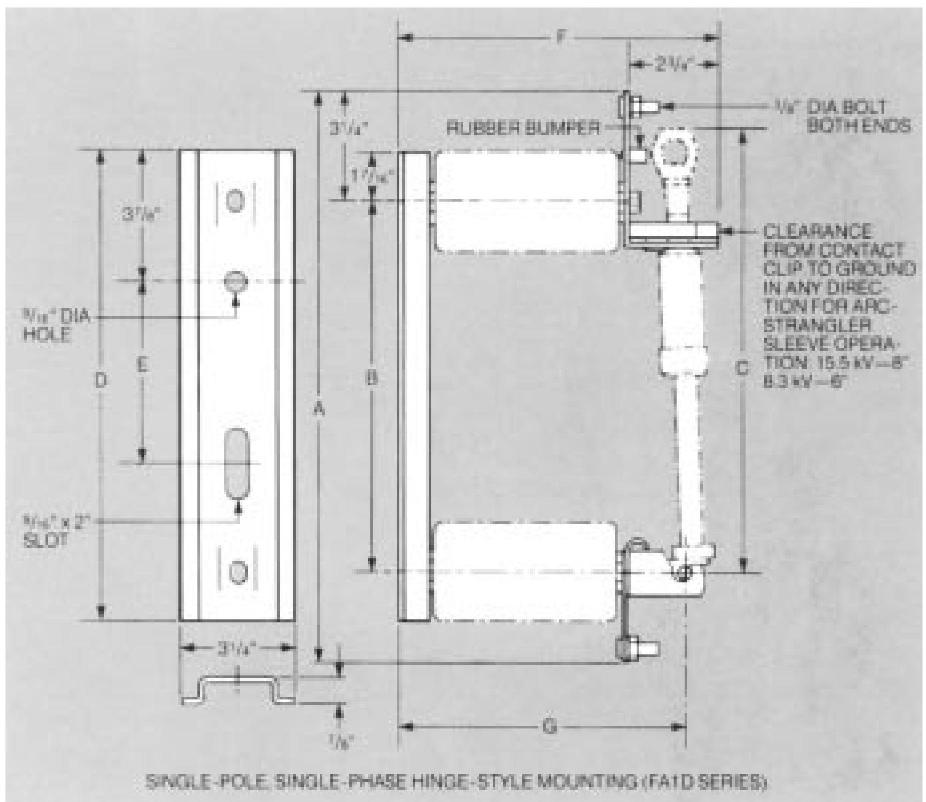


Figure 4.
Open channel-based mountings for NX fuses with Arc-Strangler loadbreaking device and for Arc-Strangler switchblade.

NX Mountings-Channel Based Tandem

TABLE 8
Ratings and Dimensions of Channel-Based Tandem Mountings (See drawings on page 11.)

Mounting Type	Voltage Rating (kV)	BIL (kV)	Mounting Code Number*		Catalog Number	Dimensions(in.)**			
			Switch	Fuse		A	B	C	D
With Switch Mounted Above Fuse									
Single	8.3	95	1	5	FAJ1D1	31-11/16	15-15/16	30-1/16	17-1/4
Fuse	15.5	95	1	6	FAJ1D2	34-5/8	18-3/4	32-7/8	20
	8.3	95	1	4	FAJ1K3	29-5/16	11	27-9/16	12-3/4
Parallel	8.3	95	1	5	FAJ1K1	33-5/8	15-5/16	31-7/8	17-1/16
Fuse	15.5	95	1	6	FAJ1K2	36-1/2	18-1/8	34-11/16	19-7/8
With Fuse Mounted Above Switch									
Single	8.3	95	1	5	FAJ3D1	36-7/8	17-7/8	33-3/8	17-1/2
Fuse	15.5	95	1	6	FAJ3D2	39-11/16	20-11/16	36-3/16	20
	8.3	95	1	4	FAJ3K3	32-1/8	13-1/2	29	15
Parallel	8.3	95	1	5	FAJ3K1	36-1/2	17-7/8	33-3/8	17-1/2
Fuse	15.5	95	1	6	FAJ3K2	39-5/16	20-11/16	36-3/16	20

*Code number of mounting must match code number of fuse.
** See page 11 for dimensional drawings.

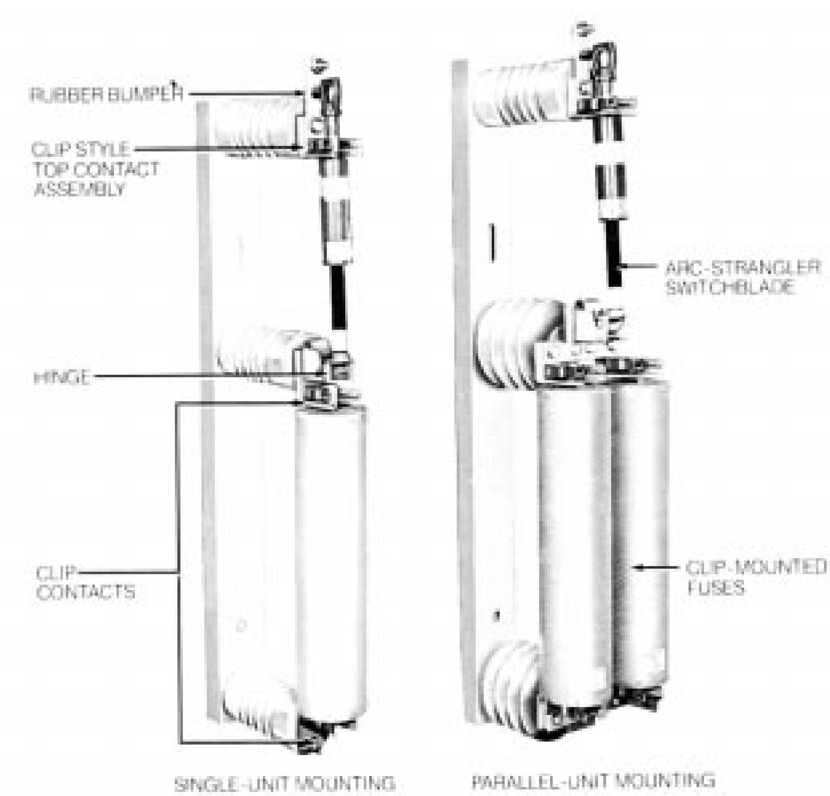
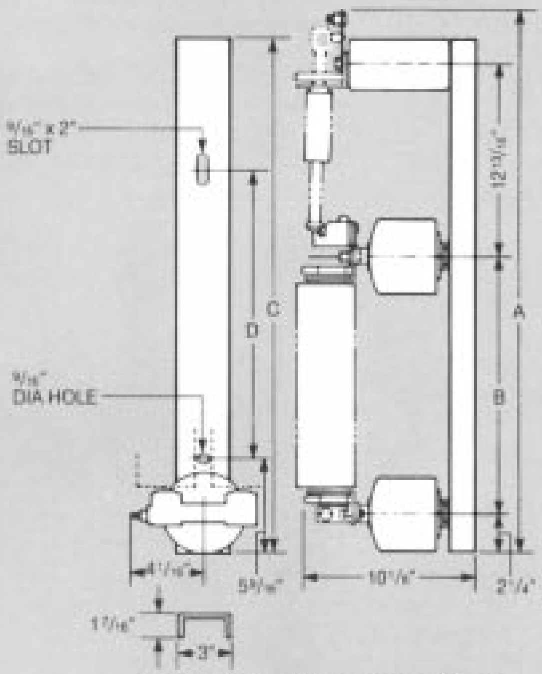
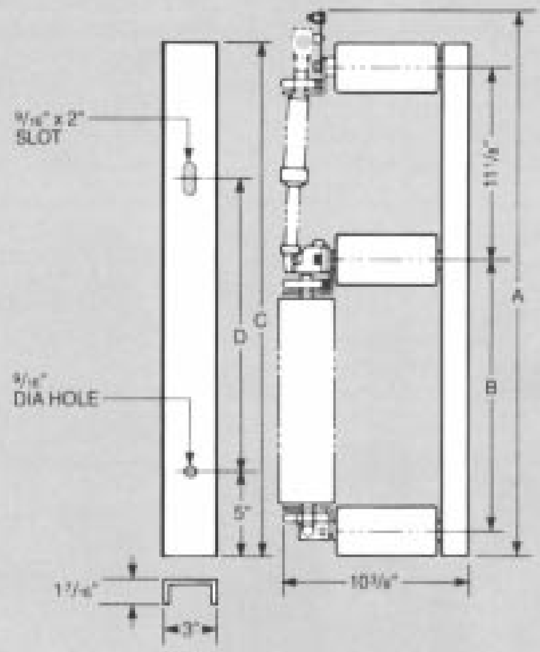


Figure 5.
Tandem-unit mountings for clip-mounted fuses and Arc-Strangler switchblades.

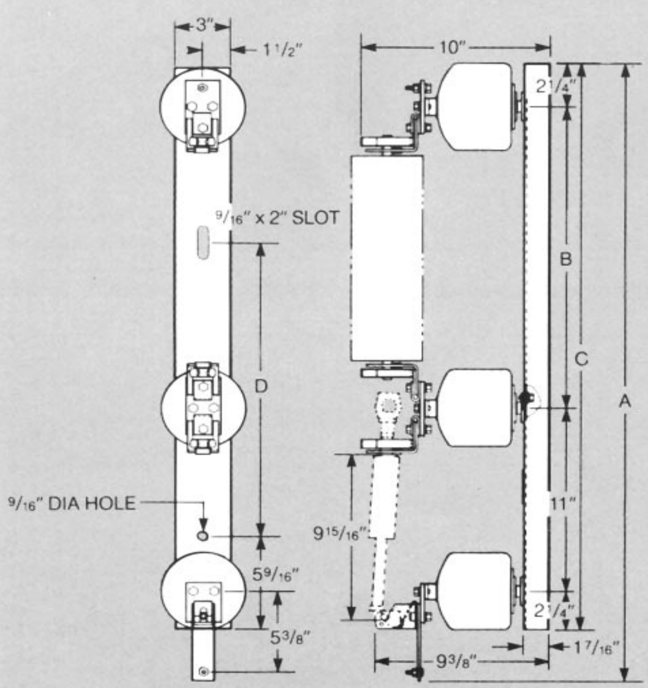
DIMENSIONS OF CHANNEL-BASED TANDEM MOUNTINGS



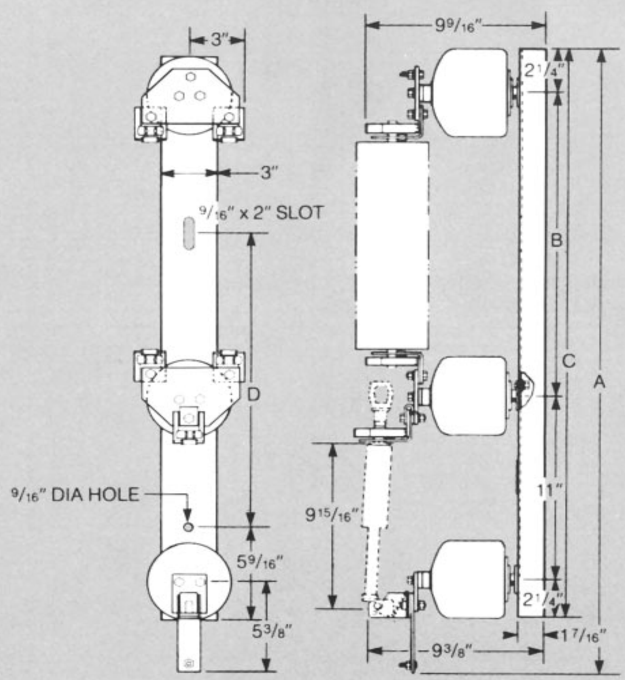
MOUNTING FOR TANDEM SWITCH AND
PARALLEL FUSES (FAJ1K SERIES).



MOUNTING FOR TANDEM SWITCH AND
SINGLE FUSE (FAJ1D SERIES).



MOUNTING FOR TANDEM SWITCH AND
SINGLE FUSE (FAJ3D SERIES).



MOUNTING FOR TANDEM SWITCH AND
PARALLEL FUSES (FAJ3K SERIES).

NX Mountings—Frame

Cooper Power Systems offers a selection of frame mountings that provides convenience in application and compactness and safety in use. These mountings have the same hinge and clip contact assemblies and terminal pads as described in the section on open channel-based mountings.

The frame mountings consist of a flat backing plate, Benelex* insulating barriers, and porcelain support insulators with hinge and clip contact assemblies. Both single- and three-phase styles are available.

Fuses and switchblades can be inserted, opened, and removed easily and safely in either the frame mountings with a standard hookstick or Cooper Power Systems' universal switchstick head.

A 3- x 4-1/2-in. label with the following wording accompanies all frame and box mounting assemblies: *"Warning: Fuse* or *switch may be live in open position."*

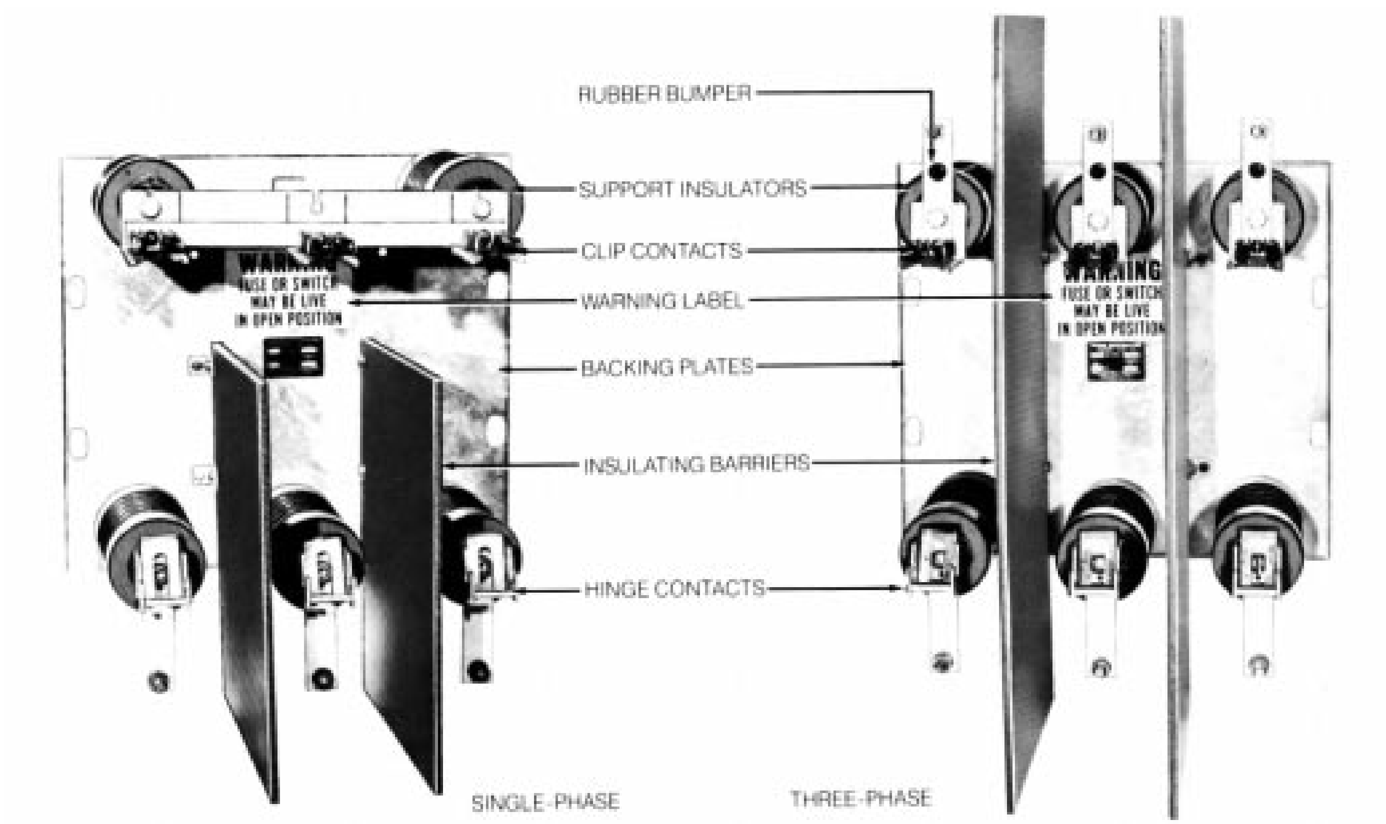


Figure 6.
Typical feed-through (left and three-phase frame mountings. Installation is simple: Fasten the backing plate to a wall and clip on the insulating barriers and the leads.

* Registered trademark of Masonite Corporation.

TABLE 9
Ratings of Frame Mountings*

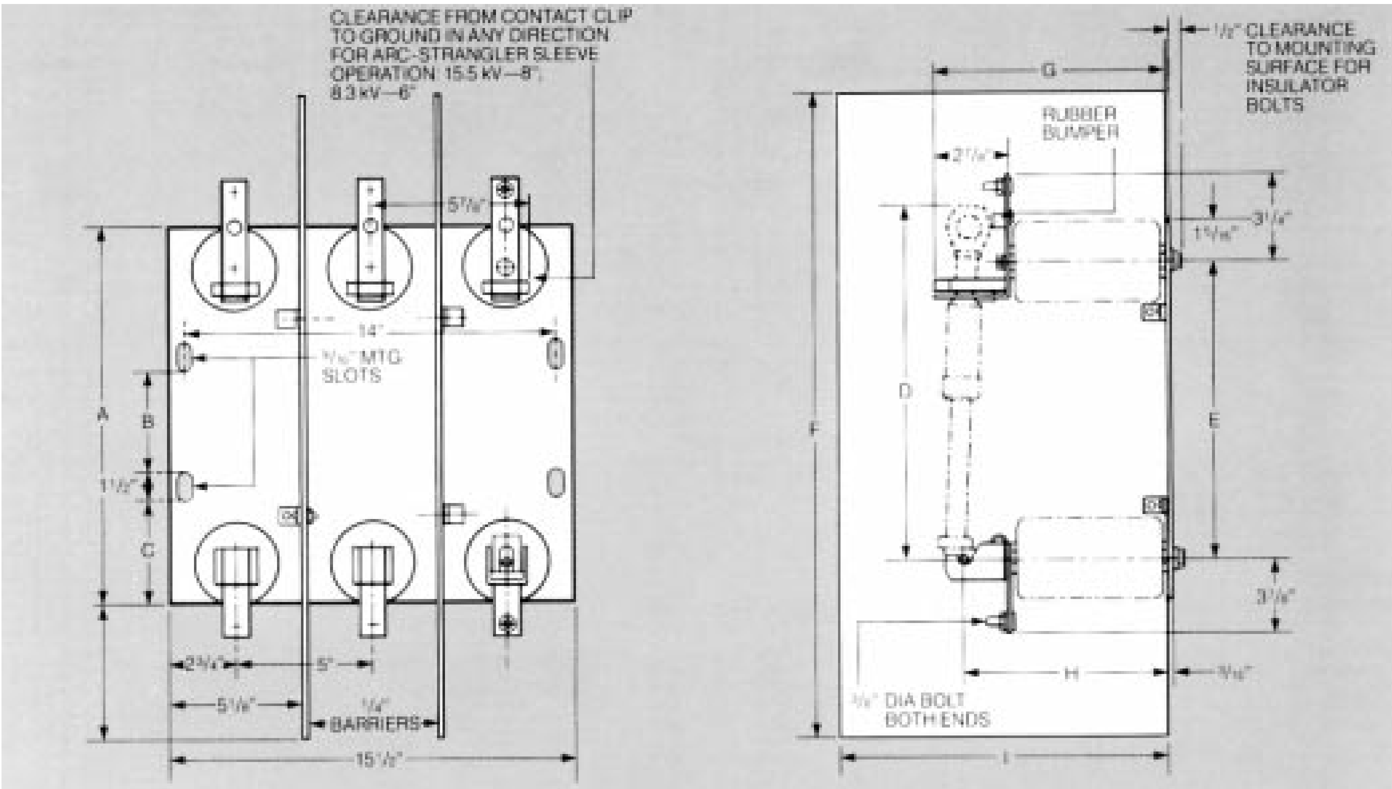
Maximum Design Voltage (kV)	BIL (kV)	Description	Mounting Code Number**	Catalog Number 110°† Opening	Catalog Number 180°† Opening
8.3	95	Three-phase, frame mounting	1	FA1F1	FAA1 F1
15.5	95		2	FA1F2	FAA1 F2
15.5	125		2	FA1F3	–
8.3	95	Single-phase feed-through common-latch frame mounting with five insulators		FA1E1	FAA1E1
15.5	95		2	FA1E2	FAA1F2
15.5	15		2	FA1E3	–
8.3 or 15.5	95	Single-phase, feed-through, common-latch frame mounting with four insulators††	1	FA2E1	–
	125		1	FA2E2	–
15.5	125	Single-phase, feed-through, common-latch frame mounting with four insulators††	2	FA2E3	–
8.3	95	Single-phase, feed-through, common-hinge frame mounting with three insulators (Vl style)††	1	FA5E1	–
8.3	95	Single-phase, feed-through, common-hinge frame mounting with four insulators (Vl style)††	1	FA7E1	–

* Fuses or switchblades are not included in mountings and must be ordered separately.
** Code Number of mounting must match code number of fuse or switchblade.
† Refer to dimensional drawings for exact opening dimensions.
†† Uses transformer bushing as remaining insulator required for center fuse support.

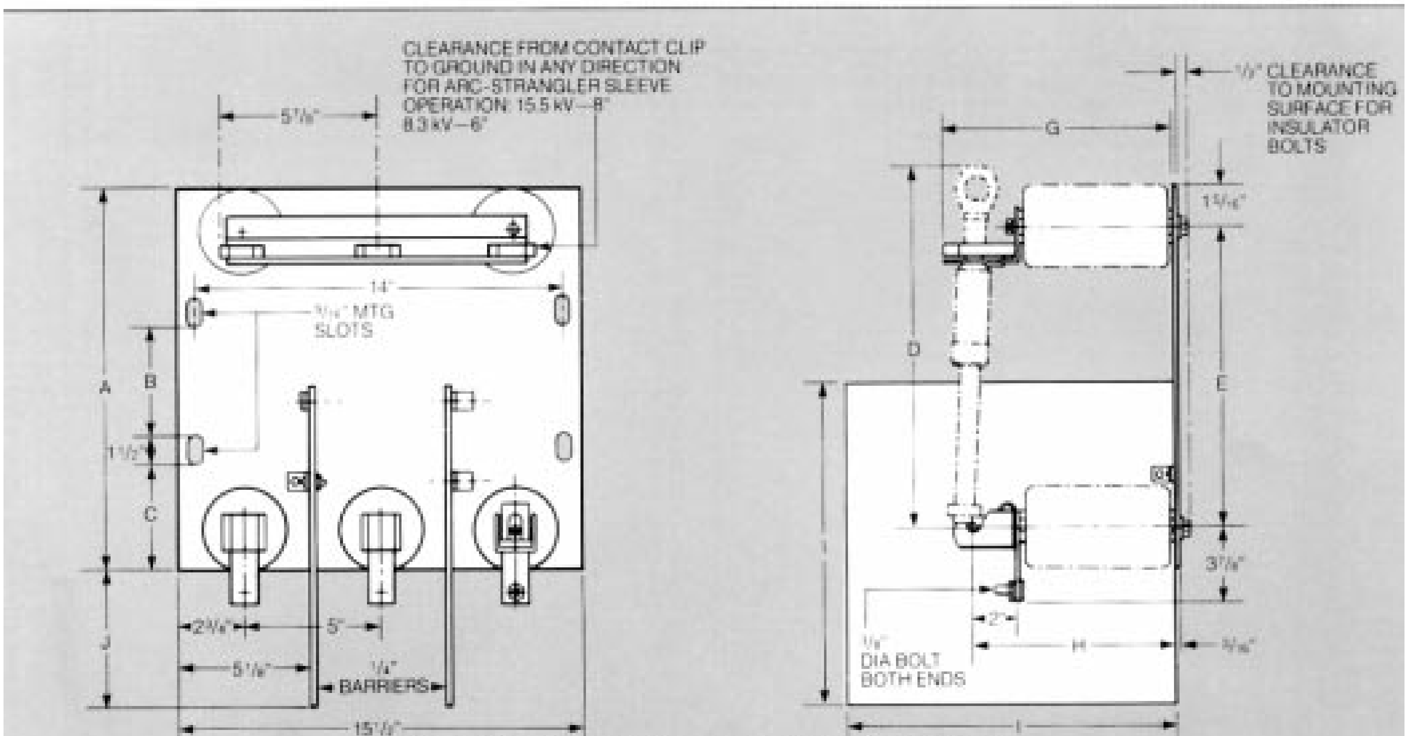
TABLE 10
Dimensions of Frame Mountings (See drawings on pages 14 and 15.)

Catalog Number	Dimensions (in.) A	B	C	D	E	F	G	H	I	J
FA1F1	13-3/4	3-1/2	3-5/8	13-5/16	11-1/8	24	8-15/16	7-13/16	12	5-1/8
FA1F2	18-1/8	8-1/2	3-5/16	17-13/16	15-1/2	28	8-15/16	7-13/16	12	5-1/8
FA1E1	13-3/4	3-1/2	3-5/8	13-5/16	11-1/8	12	8-15/16	7-13/16	12	4-7/16
FA1E2	18-1/8	8-1/2	3-5/16	17-13/16	15-1/2	12	8-15/16	7-13/16	12	4-7/16
FA1E3	18-1/8	8-1/2	3-5/16	17-13/16	15-1/2	14	10-5/16	9-1/16	14	6-7/16
FA2E1	13-3/4	3-1/2	3-5/8	13-5/16	11-1/8	12	8-15/16	7-13/16	4-7/16	–
FA2E2	13-3/4	3-1/2	3-5/8	13-5/16	11-1/8	14	10-1/8	9	6-7/16	–
FA2E3	18-1/8	8-1/2	3-5/16	17-13/16	15-1/2	14	10-1/8	9	6-7/16	–
FA5E1	See dimensional drawing on page 15.									
FA7E1	See dimensional drawing on page 15.									

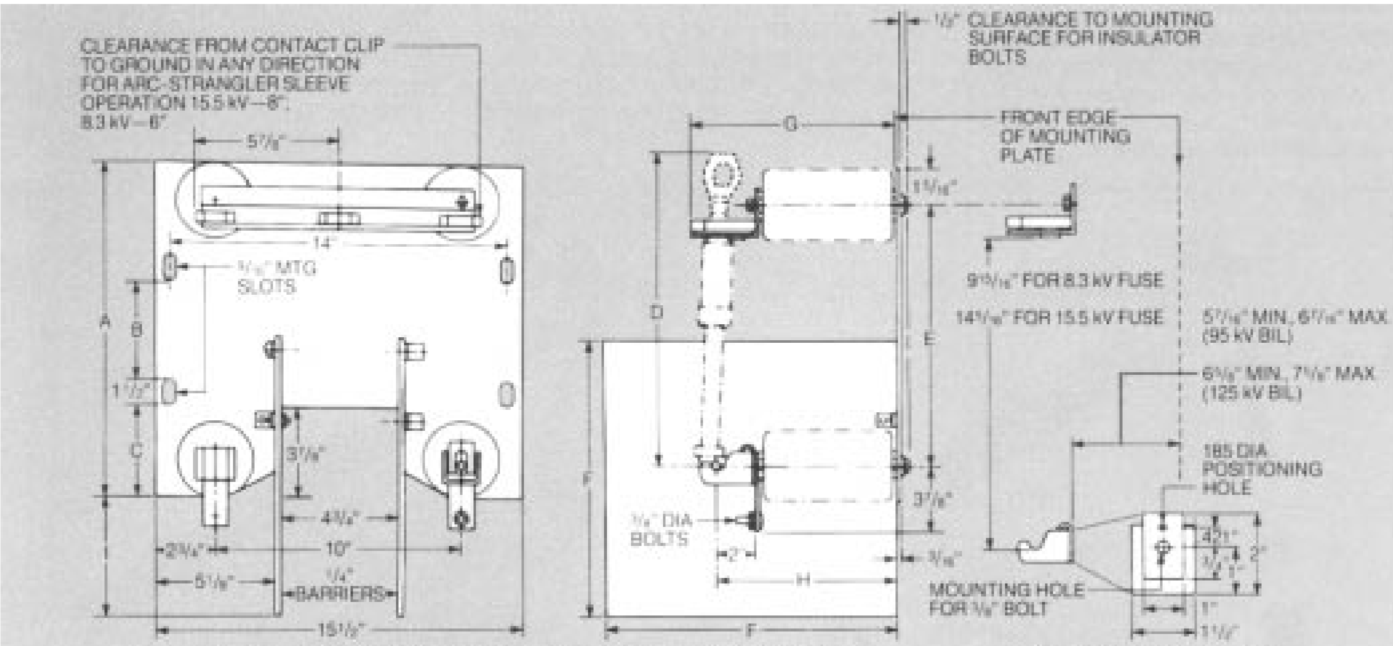
DIMENSIONS OF FRAME AND BOX MOUNTINGS



THREE-PHASE FRAME MOUNTING (FA1F SERIES).



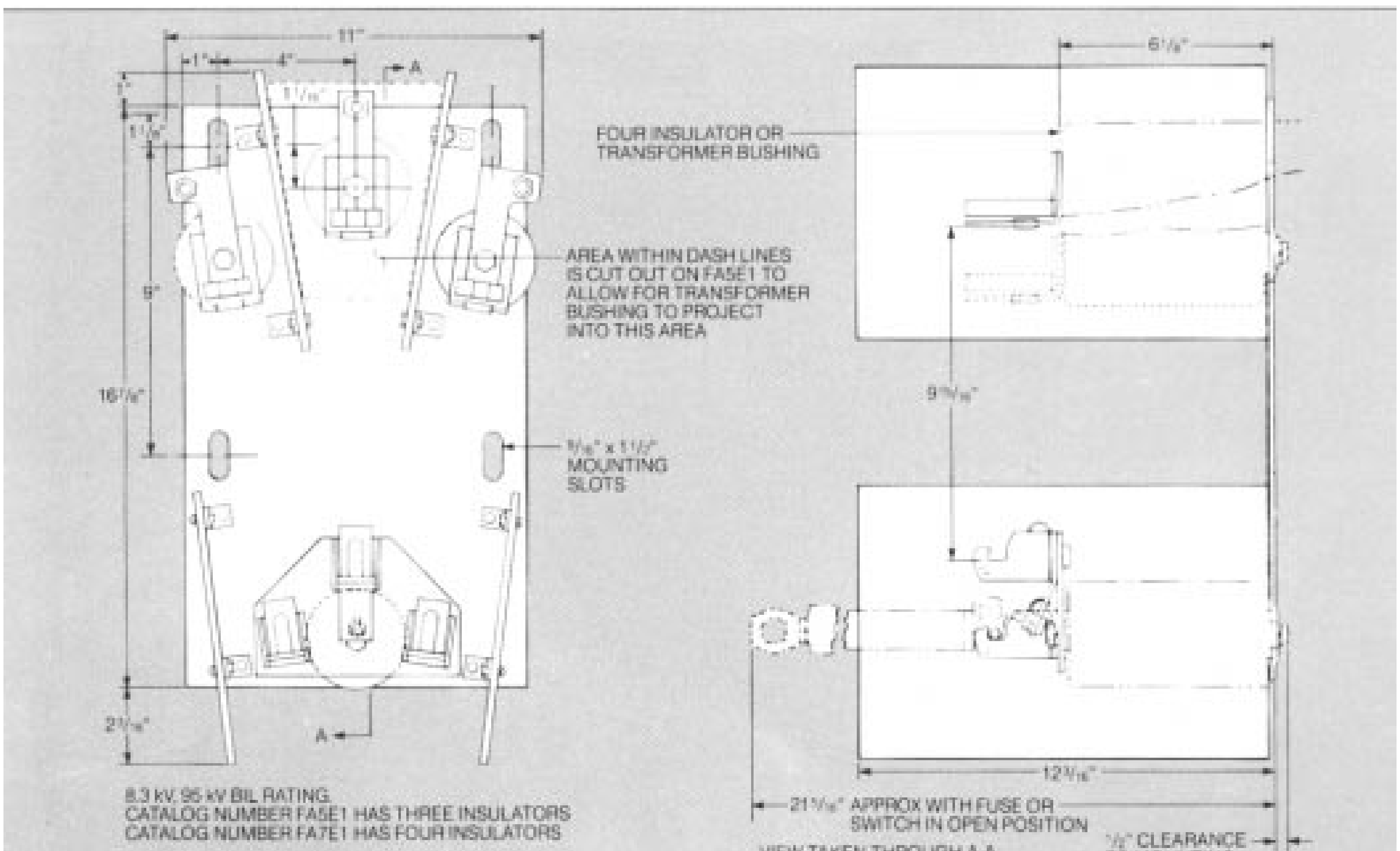
SINGLE-PHASE, COMMON-LATCH, FEED-THROUGH FRAME MOUNTING WITH FIVE INSULATORS (FA1E SERIES).



SINGLE-PHASE, COMMON-LATCH, FEED-THROUGH FRAME MOUNTING WITH FOUR INSULATORS (FA2E SERIES).

LOCATING AND MOUNTING DIMENSIONS FOR CENTER HINGE

NOTE: Fuses rated through 15.5 kV (Codes 1 and 2) can be used in center position; either 8.3 kV or short 15.5 kV switchblades (Code 1) can be used in the outer positions on Catalog Numbers FA2E1 and 2. Only long 15.5 kV switchblades (Code 2) can be used in the outer positions on Catalog Number FA2E3. When mounting center hinge to through bushing, maintain dimensions shown for proper Arc-Strangler loadbreaking operation.



SINGLE-PHASE, COMMON-HINGE, FEED-THROUGH, VI-STYLE FRAME MOUNTING (FA5E1 AND FA7E1).

ACCESSORIES

Universal Switchstick Head

A hook is available for universal switchsticks to simplify the handling of NX fuses and switchblades. For fuses and switchblades with cast hinges, a square-ended projection on the end of the hook prevents the fuse from rotating on the switchstick as it is being placed in its mounting hinge. For fuses with stamped hinges, the notched design of the main shaft provides easy installation and removal. The serrated connection end permits attaching the head to any universal switchstick. It is simple to attach and needs no special instruction or tools.

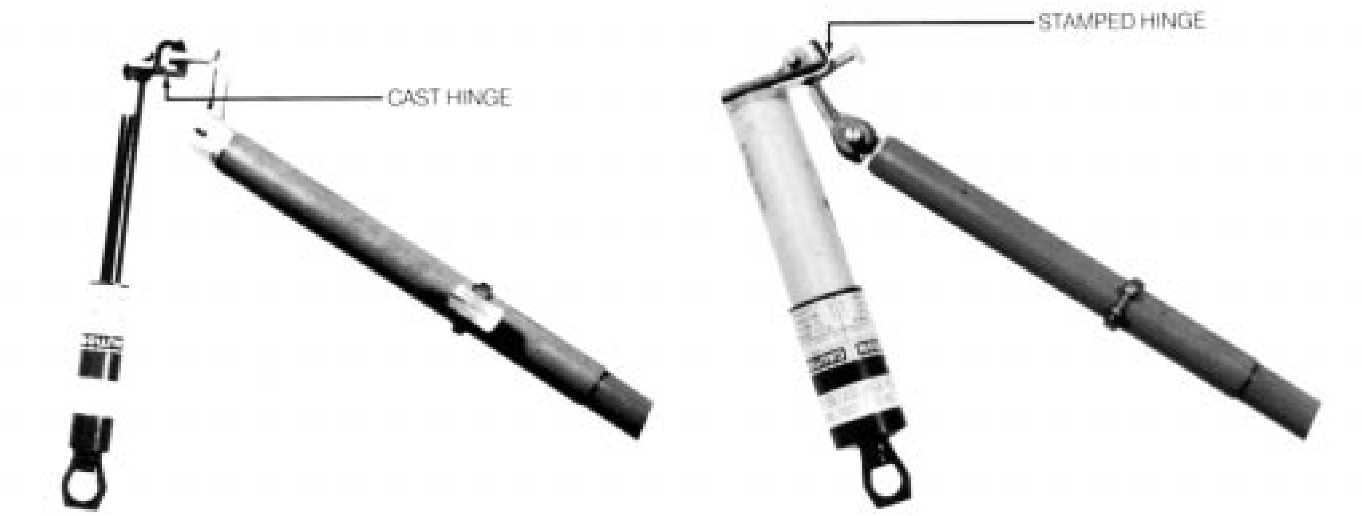


Figure 7.
Universal switchstick head.

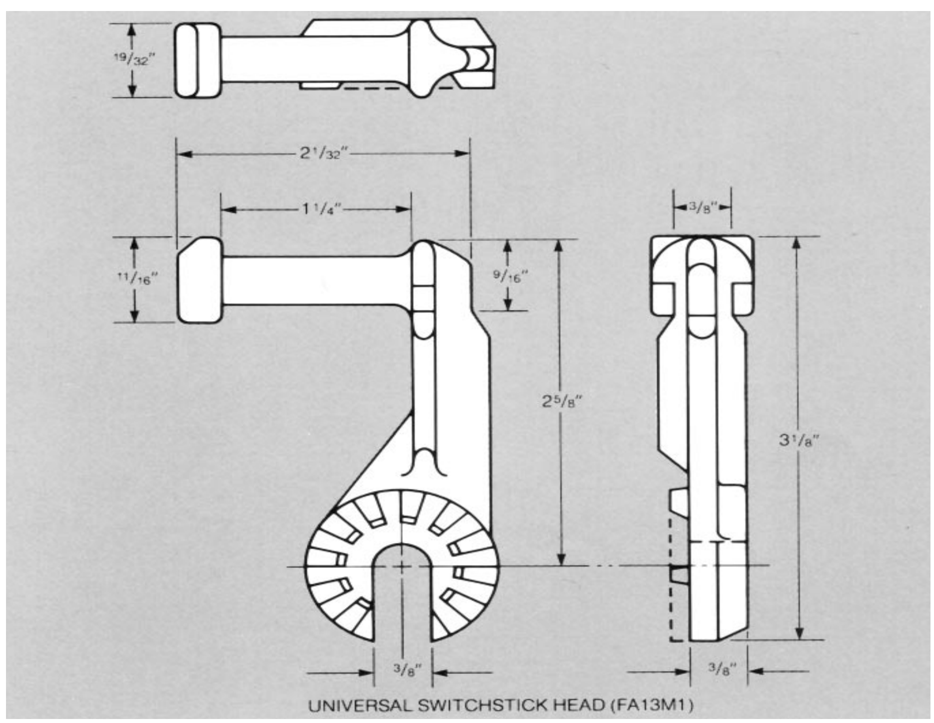


Figure 8.

Clip-Style Current-Limiting Fuse

FEATURES

Silent. No gases are expelled because the arc is confined and cooled and the vapor quickly condensed by a sand filler.

Safe. No explosion or strong mechanical force is produced to damage surrounding equipment; no burning particles that might be a fire hazard.

Current-limiting. Fault current is held to a low value by a fulqurite produced by the fault current itself.

Compact. NX fuses require less operating clearance than expulsion fuses. A variety of space-saving schemes are available with Cooper Power Systems mountings.

Fast, full-range clearing from minimum melt to maximum fuse rating. NX fuses clear faults in one-half cycle or less at high-fault currents.

Positive, accurate time-current coordination with other protective devices in the line.

Blown-fuse indication, A red button in the end of the lower contact projects and is visible after the fuse has operated.

Two NX fuses can be paralleled for higher capacity. Design enables fuses to handle high energy when clearing faults in parallel.

OPERATING PRINCIPLES

A basic current-limiting fuse consists of one or more silver wire or perforated ribbon elements suspended in an envelope filled with sand. To make the fuse as short as possible it is normally spirally wound on a high-temperature-resistant, non-tracking form called a spider. The assembly (the fusible element, spider, and end contacts) is placed in a tube (also of high-temperature-resistant material), and the fuse is then filled with high-purity silica sand and sealed at both ends.

When operating against a high-fault current, the fusible element melts almost instantaneously over its full length. The resulting arc rapidly loses its heat energy to the surrounding sand. This energy melts or fuses the sand surrounding the element into a glass-like tunnel structure

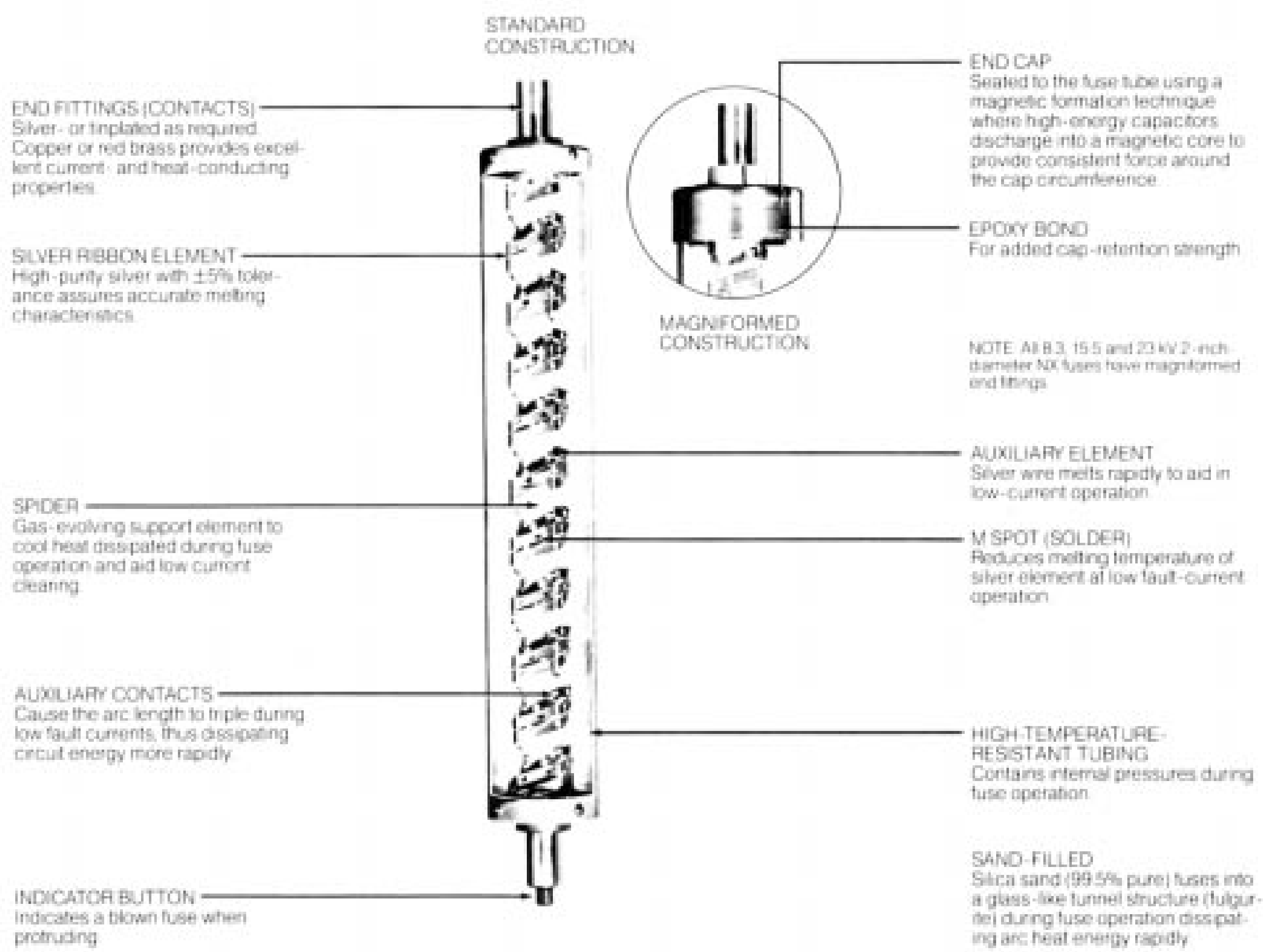


Figure 9.
Basic components of the Cooper Power Systems NX current-limiting fuse.

called a fulgurite. Figure 10 illustrates the fulqurite formed by a high-fault current.

The rapid loss of heat energy and the confinement of the arc by the molten glass fulqurite literally chokes off the current at a relatively small value known as the let-through current. Current interruption takes place in about one-quarter cycle (Figure 11).

On low currents—such as those that might occur on high-impedance faults, sustained overloads, or secondary faults—an entirely different phenomenon occurs. The following three features all have an integral part in the proper interruption at these low current faults:

First, since silver has a melting point of 960°C and overloads or low-fault currents can flow for minutes to hours in order to reach the element-melting temperature excessive pre-heating of the fuse itself complicates low-current clearing. Initial melting temperature can be reduced by the use of an M spot, a bit of metal attached to the main element. An M spot (such as a tin-lead alloy with a melting temperature of about 180 to 250°C) has a melting temperature lower than that of the silver element. In operation, as the silver elements are heated, the M spot amalgamates with the silver element, lowering the melting temperature at that point.

Second, one of the most important developments in the art of low-current operation is the use of a gas-evolving spider to support the silver elements. Its contribution is simple, but most effective. During the initial arc period, enough heat is generated to decompose portions of the supporting spider immediately adjacent to the fulgurite, allowing a gas-blast phenomenon to occur which cools the fulgurite in that area and minimizes the length of fulqurite required for current interruption.

Third, a novel feature that forces additional arcs is needed to provide low-current clearing. A small silver trigger or auxiliary element is wound adjacent to the main element and gapped to the main element about one-quarter the distance from both ends (Figure 12).

When the main element melts at the centrally located M spot, a voltage gradient appears across the arc and across both auxiliary element gaps. The gaps break down, the current temporarily transfers to the auxiliary element, and the arcing cuts additional openings in the main element. Since the current is many times the rated value of the auxiliary element, it melts over its whole length. A small fulgurite is formed and it clears easily and rapidly. If the main element continues to arc, it must now do so at three regions: the two electrode points and the M spot section, tripling the arc length and the area available to dissipate circuit energy. Figure 13 illustrates the fulgurite formed by a low-fault current causing arcing at the three locations.

Cooper Power Systems NX current-limiting fuses of all ratings (except for 27 and 38 kV fuses which are rated at 35,000 symmetrical amps) are capable of interrupting and clearing overcurrent values from any continuous current that melts the element to an available 50,000 symmetrical amps. Actual let-through current is considerably less than the maximum available value. Interruption is noiseless and non-gas-producing.

Cooper Power Systems NX fuses meet or exceed ANSI standards for general-purpose distribution current-limiting fuses (ANSI C37.41-69, C37.47-69, and C37.48-69). They also conform to the electrical interchangeability requirements of ANSI C37.47-1969 and are so identified by the letter *C* following the current rating on the fuse label.

Figure 10.
Fulgurite information caused by a high-fault current.

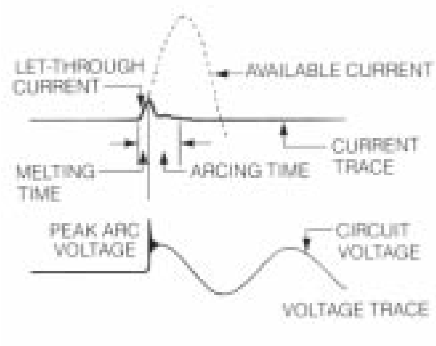


Figure 11.
Oscillogram illustrating operation at high currents.

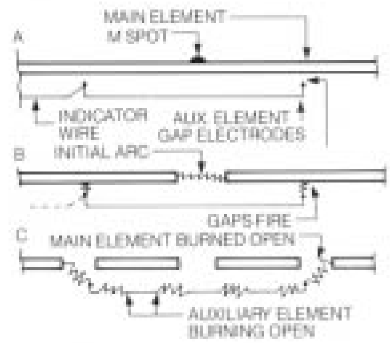


Figure 12.
NX fuse low-current operation.

Figure 13.
Fulgurite formation caused by a low fault current.

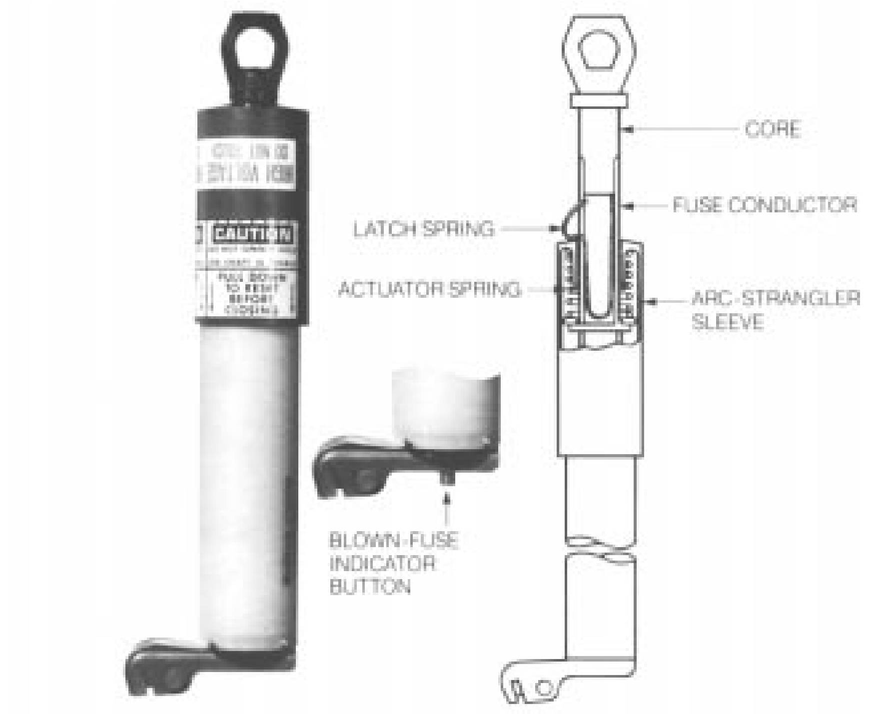


Figure 14.
Basic parts of the Cooper Power Systems NX current-limiting fuse with Arc-Strangler loadbreaking device.

Figure 15.
Arc-Strangler loadbreaking devise with optional accessory latch.

NX Fuses With Arc-Strangler Loadbreaking Device

NX current-limiting fuses up to 15.5 kV can be ordered with an integral Arc-Strangler loadbreaking device. These units have the same operating characteristics as the basic clip-style fuse along with loadbreaking capabilities.

FEATURES

Cooper Power Systems NX fuses with the ArcStrangler loadbreaking device offer:

Safe loadbreaking. The Arc-Strangler loadbreak quickly extinguishes loadcurrent arcs drawn between the mounting contacts and the fuse conductor during loadbreaking operation.

Rugged construction. The Arc-Strangler sleeve and all other components are made from high-strength materials and designed for a long inservice life.

Prevention from accidental closing. The Arc-Strangler loadbreaking device must be cocked before the fuse can be closed into the mounting.

NEMA standard hook,stick operation. Both the pullring and the hinge accept the standard distribution-class hookstick. The hinge is made with a slot for the hookstick, making fuse removal from—and replacement in—the mounting easy.

Blown-fuse indication. A red button is clearly visible after the fuse has operated.

High-voltage warning. The big warning label (readable when the fuse is hanging open) warns personnel of possible danger.

Optional latch. A plastic latch that gives a positive indication that the device is armed is available as an accessory (Figure 15). (Contact your local Cooper Power Systems representative for ordering and additional information concerning this accessory.)

OPERATING PRINCIPLES

The Arc-Strangler loadbreaking device is a springloaded sliding sleeve that cuts off the arc drawn between the mounting contacts and the fuse conductor when the fuse is opened while load current is flowing. A pullring at the top of the fuse (for hookstick operation) and a hinge at the bottom complete the loadbreak device. The Arc-Strangler loadbreak is complete in itself—no auxiliary loadbreaking tool is required and no additional loadbreaking switch in series is necessary. All current magnitudes through the continuous-current rating of the fuse can be interrupted positively and safely under proper conditions.

The loadbreaking assembly includes a stationary core and a sliding molded sleeve that covers the contacts on opening the hinged assembly. The sleeve is made of high-quality material that gives off small quantities of arc-quenching gases under the heat of the arc.

ARC - STRANGLER SWITCHBLADES

Two-hundred amp switchblades with integral Arc-Strangler loadbreaking devices are available for use in NX fuse mountings. They are completely interchangeable with NX fuses of the same code number so that, as system needs change, switches can be substituted for fuses and vice versa without any alteration to the mounting.

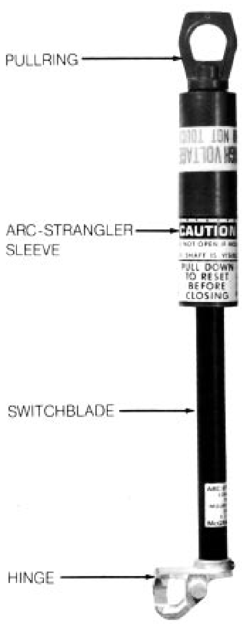


Figure 16.
The Cooper Power Systems Arc-Strangler switchblade. (The Arc-Strangler sleeve quickly extinguishes the arc in exactly the same manner as when used on NX fuses.)

Channel-Based Mountings

Channel-based mountings are available in several styles to accommodate a variety of switching and fusing system designs. For applications requiring no switching or loadbreaking capability the basic clip-style mounting is available for either single or parallel fuses. A mounting with a hinge at the bottom to provide the switching or loadbreaking capability required is available for NX fuses with Arc-Strangler loadbreaking devices or switchblades.

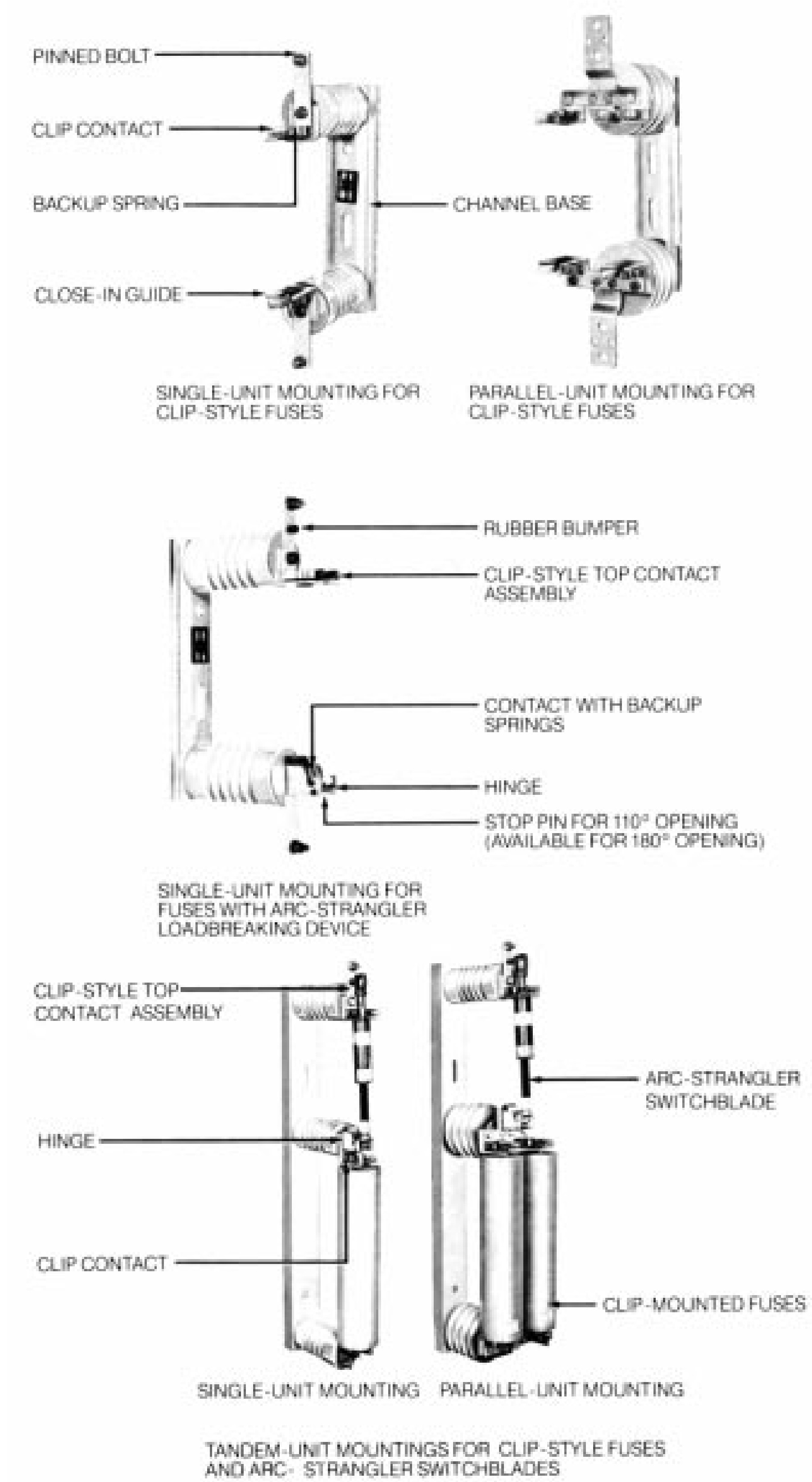


Figure 17.
Open channel-based mountings for clip-style NC fuses, NX fuses with Arc-Strangler loadbreaking devices, and Arc-Strangler switchblades.

A tandem unit that holds an Arc-Strangler switch and a clipmounted fuse is also available in some ratings.

FEATURES—CLIP- AND HINGESTYLE MOUNTINGS

Silverplated copper contacts with stainless steel backup springs assure cool operation.

Detent on the clip contacts holds the fuse firmly closed.

Rugged, close-in guide prevents deformation of the mounting contacts when the fuse is closed or opened and prevents closing if the operator forgets to recock the Arc-Strangler sleeve.

Pinned bolt securely fastens the contact to insulator support and prevents the contacts from rotating.

Tinplated copper terminal pad on single-unit mountings is furnished with a 3/8-inch bronze bolt to accommodate spade terminals.

Copper or tinplated terminal pad on parallel mountings accommodates NEMA standard two-bolt connectors or accessory clamp-type connectors.

Choice of opening angle. Hinge-style mountings can be ordered for either a 110-degree or a 180-degree opening. (A 110-degree opening is recommended for mountings to be installed at shoulder height or lower.)

Strong, easily installed channel base. Mounting holes and slots accommodate 1/2-inch bolts. The base conforms to the vertical mounting centers for rails in Transclosure® housings and other enclosures.

Galvanized, formed *steel hinges* firmly support the fuse and permit the easy removal of the fuse from the mounting with either a standard hookstick or with a Cooper Power Systems universal switchstick head (see Parts and Accessories).

Rubber bumper prevents pullring breakage caused by excessive close-in pressure with switchstick.

OPERATING PRINCIPLES

All channel-based—and most frame— mountings for hinged fuses or switchblades are available with one of two hinge constructions: One allows 110 degree swingdown on opening; the other, a 180-degree swingdown. Exact swingdown dimensions can be determined from the Dimensional Information section. operator position, as well as clearances, are essential when considering which hinge style is suitable.

Units providing a 110-degree opening are recommended for most installations. Mountings that allow fuses or switchblades to swing down 180-degrees are recommended where the hinge level will be above the shoulder height of the operator. This enables easy removal of an opened switch or fuse with a standard-head hookstick. The use of mountings with 180-degree hinges below this height prevents the removal of a fuse or a switchblade with a hookstick.

All channel-based and frame mountings for hinge-style NX fuses and switchblades are available in two hinge-to-upper-contact spacings. Mountings with the longer spacing (Code No. 2) available with BIL ratings of 95 or 125 kV, accommodates 15.5 kV fuses and the long 15.5 kV switchblades. Mountings with the shorter spacing (Code No. 1), rated 95 kV BIL, accommodate 4.3 5.5, or 8.3 kV fuses and 8.3 kV or short 15.5 kV switchblades.

For normal 15 kV switch application, the short 15.5 kV switchblade in a mounting with the shorter hinge-toupper-contact spacing is recommended. Long 15.5 kV switchblades in mountings with the mountings with the longer spacing can be used when interchangeability with 15.5 kV fuses is desired. Mountings for clip-style fuses are available in five clipto-clip spacings.

Table 11 shows the code numbers for NX fuses and switchblades to simplify ordering and application, assuring the correct fuses or switchblades to fit the mounting selected. These codes are governed by two factors: style of mounting and size.

Manufacturing NX Fuses

All the components of a current-limiting fuse must be of high-quality material and positioned precisely in the fuse to perform their designed function. Since all the interrupting action takes place within the fuse, resulting in substantial heat release, each fuse must be of top quality. Materials used in NX fuses are carefully selected and held to detailed specifications. Inspection of the materials prior to assembly is essential. The fusible element is made of fine silver and the filler material is a high-purity silica sand of a precise grain size. The special gas-evolving spider and the tubing are selected to have high-temperature-operating capability as required in a current-limiting fuse.

Fuses are carefully inspected at various stages of assembly. Assembly personnel are taught to watch for—and to report—any component defects that have escaped earlier inspection. This is extremely important since the internal structure is completely hidden from visual inspection after the assembly is completed.

TABLE 11
Coding System—Mountings for NX Fuses and Arc-Stranglers

Rating Group	Features	Code
Hinged mounting		
8.3 kV and below	110- or 180-degree opening	1
15.5 kV	110- or 180-degree opening	2
Clip mounting		
All 4.3 and 5.5 kV 8.3 kV: through 40-amp fuse units	–	4
8.3 kV: 50-, 65-, 80-, and 100-amp fuse units 15.5 kV: through 40-amp fuse units	–	5
15.5 kV: 50-, 65-, 80-, and 100-amp fuse units 23 kV: through 40-amp fuse units	–	6
Clip mounting (high voltage)		
27 kV: 6 through 50-amp fuse units	–	9
38 kV: 6 through 50-amp fuse units	–	10

NOTE: Parallel mountings—and the fuses used in them—have the same code number as single units.

I^2t Testing

After a current-limiting fuse has been completely assembled, it is industry practice to measure the resistance of the fuse either directly with a sensitive bridge or by using a test setup that measures a millivolt drop across the fuse with a set amount of current flow. Although this resistance measurement is quite sensitive, a small flaw in the element capable of reducing the melting I^2t of the fuse can be—and often is— masked by production tolerances. Such flaws can cause premature blowing of the fuse on inrush conditions or disrupt its coordination characteristics. Because this resistance measurement alone is not sufficient to guarantee flawless operation of current-limiting fuses, all Cooper Power Systems current-limiting fuses are subjected to a special test to seek out any fuse with a damaged element that would not be detected in a millivolt test. This test—which consists of two separate 60 Hz pulses four seconds apart, each producing the minimum melt I^2t—is made on every production fuse. Good element construction is not damaged by this test; however, a defective element will be opened completely by the I^2t pulses and, thus, can be easily detected in a subsequent bridge test. To verify that a good element is not being damaged by the I^2t test, Cooper Power Systems has periodically random-selected fuses that have successfully passed the I^2t test and has run a total of 1000 I^2t pulses without any damage to the element and then placed the fuse through a high-current test to determine if it would function exactly in accordance with its characteristics. This has happened in all cases.

Protective Characteristics

LET-THROUGH CURRENTS

Type NX fuses have the ability to limit system fault currents, frequently to a fraction of system fault capability. This greatly reduced value is referred to as let-through current.

The operating advantages, along with fast clearing, include greatly reduced burning at the point of fault and minimal line damage. In addition, there is less chance of damage—both electrical and mechanical (by magnetic forces)—to other equipment in the faulted circuit. Figures 18,19, and 20 show maximum let-through current values.

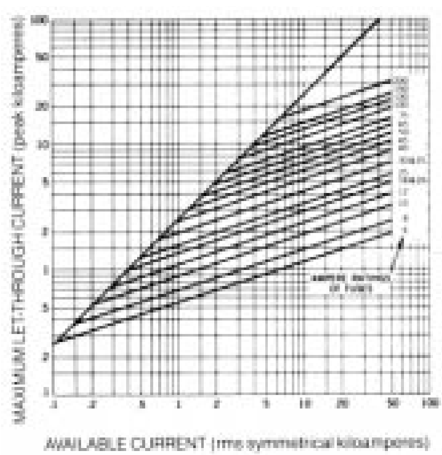


Figure 18.
Maximum let-through current for NX current-limiting fuses—4.3 and 5.5 kV.

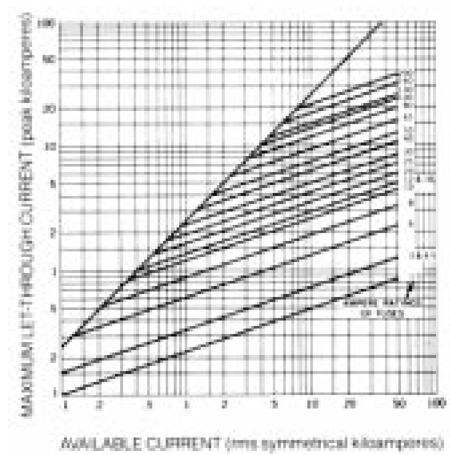


Figure 19.
Maximum let-through current for NX current-limiting fuses—8.3, 15.5, and 23 kV.

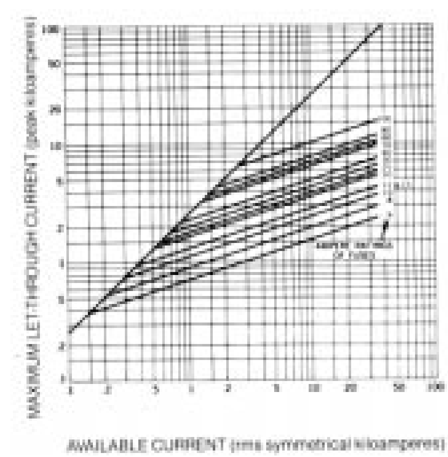


Figure 20.
Maximum let-through current for NX current-limiting fuses—27 and 38 kV.

The maximum let-through curves provide an indication of the amount of current-limiting action provided by NX fuses: Assume an 8.3 kV circuit has a 20,000 rms amp fault current available. Extend a line upward on the curve in Figure 19 and note that there would be an unlimited maximum fault current of 48,000 peak amps. Protecting this circuit with a 40 amp NX fuse allows a maximum let-through current of 7800 peak amps. This is equivalent to an unprotected circuit having a maximum fault available of 3200 rms amps.

LET-THROUGH ENERGY

Examining the amount of possible energy gives an even more dynamic view of the benefits of current limiting. Figure 21 shows a plot of current squared vs time for our 8.3 kV 20,000 circuit. The area under the curves is the I^2t or total available energy in a unit resistance. During an asymmetric fault, an unlimited circuit would have an I^2t of 13,300,000—approximately the energy that would be released if our circuit was protected with any non-limiting interrupter such as an expulsion fuse. Protecting apparatus with a 40 amp NX current-limiting fuse allows a maximum let-through current of 7800 peak amps and an I^2t of only 50,000. From a peakamp standpoint, this is equivalent to an unprotected circuit having 3200 amps rms available. However, in viewing the I^2t curves, it is evident that under maximum conditions, an asymmetric fault, the equivalent circuit will release 352,000 I^2t. The reduced momentary duty and heating effect on all equipment protected by an NX current limiting fuse can be readily seen.

Applications

VOLTAGE RATING SELECTION

To determine the correct voltage rating for a current-limiting fuse, proper consideration must be given to the type of distribution system, the system voltage the transformer winding connection, and neutral grounding. In general, single-phase fusing permits the use of a fuse with phase-to-neutral voltage rating; whereas, three-phase fusing usually requires a fuse with phase-to-phase voltage rating. However, where it is desirable (because of economics, standardization, oil space, etc.) NX fuses with phase-to-neutral voltage ratings may be used on three-phase applications provided certain parameters are met. See three-phase applications. Allowance is normally given for voltages slightly exceeding the normal system voltage. (Standards consider the maximum service voltage as 5 to 6% over normal.) Since each current-limiting fuse has a maximum design voltage, application must be such that the post-interruption voltage impressed across the fuse does not exceed that maximum design voltage.

Table 12 lists the recommended voltage ratings for current-limiting fuses applied on the most commonly encountered distribution systems.

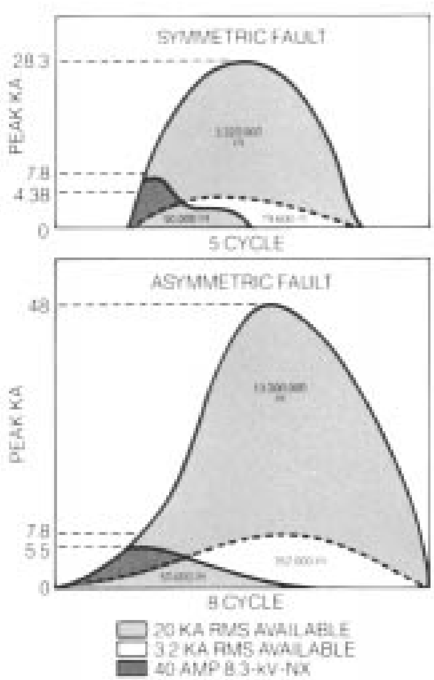


Figure 21.
Circuit let-through energy levels with—and without—current-limiting fuse protection.

TABLE 12
Recommended Current-Limiting Fuse Voltage Ratings

System Voltage (kV)		Recommended NX Fuse Rating (kV)			
		Four-Wire Multi-Grounded Neutral		Delta	
Nominal	Maximum	Single-Phase	Three-Phase	Single-Phase	Three-Phase
2.4	2.54	–	–	4.3	4.3
2.4/4.16	2.54/4.4	4.3	5.5*	–	–
4.16	4.4	–	–	4.3	4.3
4.8	5.1	–	–	5.5	5.5
4.8/8.32	5.1/8.8	5.5	8.3*	–	–
6.9	7.26	–	–	8.3	8.3
6.93/12	7.3/12.7	8.3	15.5*	–	–
7.2	7.62	–	–	8.3	8.3
7.2/12.47	7.62/ 13.2	8.3	15.5*	–	–
7.97	8.4	–	–	8.3	8.3
7.97/13.8	8.4/14.5	8.3	15.5*	–	–
8.32	8.8	–	–	8.3	8.3
8.32/ 14.4	8.8/ 15.2	8.3	15.5*	–	–
12/20.8	12.7/22	15.5	23*	–	–
12.47	13.2	–	–	15.5	15.5
13.2/22.9	14/24.2	15.5	23*	–	–
13.2	14.5	_	_	15.5	15.5
14.4/24.9	15.2/26.4	15.5	27*	–	–
14.4	15.2	–	–	15.5	15.5
19.9/34.5	21.1/36.5	23	38*	–	–
34.5	36.5	–	–	38	38

*A line-to-line rating may be used if certain parameters are met; see three-phase applications.

THREE-PHASE-APPLICATIONS
On three-phase applications, special attention must be given to the transformer connections for proper selection of voltage ratings. Table 13 illustrates the majority of the connections found on distribution systems and the recommended fuse voltage rating for each.

PEAK ARC VOLTAGE
When a current-limiting fuse operates, it generates a peak arc voltage that must be taken into consideration because certain applications could cause surge arrester operation. This voltage depends on the time of fault initiation on the system voltage as well as the fuse element design and size. For wire-element fuses (uniform elements used below 15 amps), available fault current is also a factor. The peak arc voltage of a wire-element fuse has no definite relationship to the circuit voltage because the transient depends primarily on the current at the time of the element breakdown. Thus, for low-amp-rated fuses (below 15 amps), the maximum peak arc voltages can be shown vs. available current (Figure 22).

For ribbon-element fuses (non-uniform elements 15 amps and above), the generated peak arc voltage during interruption depends primarily on the system voltage and thus can be shown vs. circuit voltage (Figure 23).

The time-to-peak voltage at high-fault currents varies from 10 to 20 microseconds for small-sized wire-element fuses and from 200 to 500 microseconds for larger-sized ribbon-element fuses. This time increases at lower fault currents.

To determine the peak arc voltage for a ribbon-element (15 amps and above) current-limiting fuse application, refer to Figure 23 and follow these steps:

1. Choose the coordinate of the system voltage on the horizontal axis (phase-to-neutral on grounded-wye systems; phase-to-phase on other systems).
2. Extend a vertical line upward until it intersects the arc-voltage curve.
3. Extend a horizontal line from the intersection point to the vertical axis.
4. Read the maximum peak arc voltage directly.

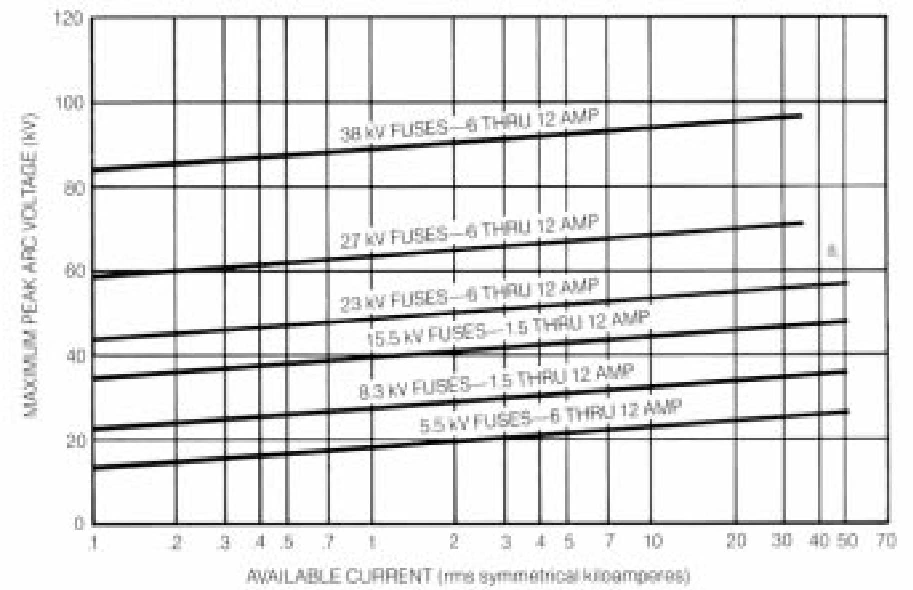


Figure 22.
Maximum peak arc voltages for low-amp-rated fuses (12 amps or less) with wire elements.

To determine the peak arc voltage for a wire element (below 15 amps) fuse application, refer to Figure 22 and follow these steps:

1. Choose the coordinate of the available fault current on the horizontal axis.
2. Extend a vertical line upward until it intersects the arc-voltage curve with the proper voltage rating of the NX fuse.
3. Extend a horizontal line from the intersection point to the vertical axis.
4. Read the maximum peak arc voltage directly.

This maximum generated peak arc voltage can now be compared with the arrester sparkover level for units on the applied system. To do this, take the 60 Hz minimum sparkover level (given as an rms value) of the arrester and multiply by $\sqrt{2}$ to obtain a peak voltage. This value should be larger than the maximum generated peak arc voltage of the fuse thus assuring that the arrester will not be sparked over by an interruption. Wire-element fuses (those below 15 amps) should be applied only on the voltage for which they are rated. However, since arc voltage on ribbon-element fuses (15 amps and above) depends on actual system voltage, higher voltage fuses can be applied on lower voltage systems, allowing standardization of fuse voltage rating.

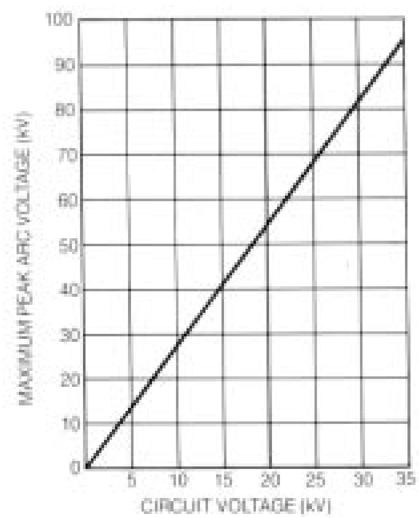
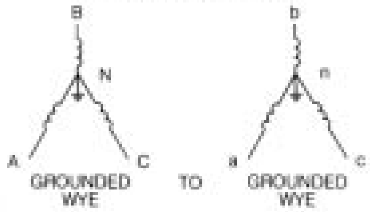
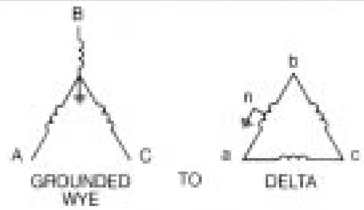
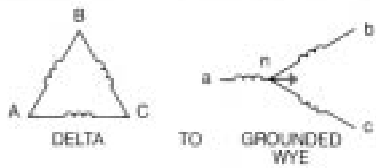
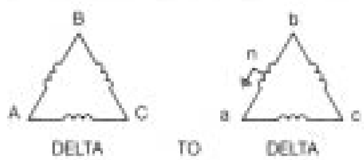
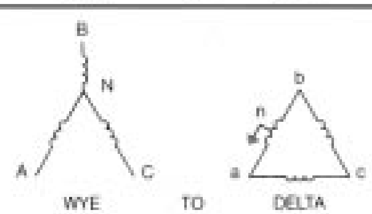
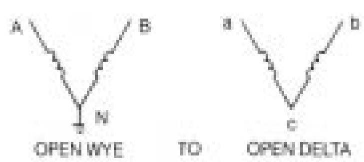
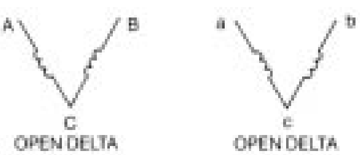
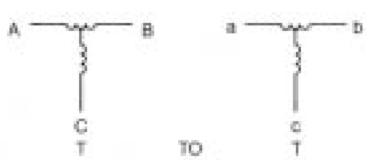


Figure 23.
Maximum peak arc voltage for high-amp-rated fuses (15 amps and above) with ribbon elements.

TABLE 13
Recommended Three-Phase NX Voltage Ratings

Transformer Connection	Recommended Voltage Rating
	Line-to-line except line-to-neutral if any of the following conditions exist: 1. If the probability of a line-to-line or three-phase ungrounded fault is very low. 2. If the fault current is high enough to assure two fuses operating simultaneously by melting at 0.2 seconds maximum. 3. If the load is predominately grounded. 4. If a secondary breaker is employed to interrupt overloads.
	Line-to-line except line-to-neutral if the following conditions exist: 1. If the probability of a primary line-to-line or three-phase ungrounded fault is very low. 2. If the fault current is high enough to assure two fuses operating simultaneously by melting at 0.2 seconds maximum. 3. If the delta winding does not have a neutral.
	Line-to-line. No exceptions for line-to-neutral ratings.
	Line-to-line. No exceptions for line-to-neutral ratings.
	Line-to-line. No exceptions for line-to-neutral ratings.
	Line-to-line except line-to-neutral if any of the following conditions exist: 1. The probability of a primary line-to-line or three-phase ungrounded fault is very low. 2. If the fault current is high enough to assure two fuses operating simultaneously by melting at 0.2 seconds maximum.
	Line-to-line. No exceptions for line-to-neutral ratings.
	Line-to-line. No exceptions for line-to-neutral ratings.

AMPERE RATING SELECTION

Another consideration in the selection of a current-limiting fuse is the ampere rating which must be such that the inrush currents that can occur in a transformer will not cause the fuse to operate.

Two rules of thumb should be used for this consideration:

1. A fuse should be able to withstand 12 times the transformer-rated current for 0.1-second without element damage.
2. The element must be able to withstand twenty-five (25) times the transformer-rated current for one-half cycle.

This second rule was established because of the magnitude of the first loop of inrush current which can far exceed 12 times the transformer rated current and thus cause element damage and the steep slope in the melting characteristics of the current-limiting fuse. Because tcc curves only extend down to the 0.01-second melt time, it is satisfactory to compare the 25 x rated current to the 0.01-second minimum melt of a fuse. This will provide only a slightly more conservative comparison than using the 0.0083-second value. Although, theoretically, higher values of inrush current are possible, test data and field experience indicate that they are quite unlikely to exceed this value.

The second consideration for selecting the fuse amperage rating is the maximum load current that the

TABLE 14
Overload Protection of Oil-Insulated—Self-Cooled, and Dry-Type Transformers [1]
Single-Phase Application

Transformer (kVA)	Nominal Single-Phase Voltage Across Transformer Terminals (kV): 2.4		4.16				4.8		7.2-7.96		12-12.47		13.2-14.4		19.9		24.9		34.5	
Recommended Fuse Voltage (kV)	4.3		4.3		5.5		5.5		8.3		15.5		15.5		23		27		38	
Recommended Fuse-Current Ratings (amperes) [2] [5]; Column A—140-200% Transformer Rating; Column B—200-300% Transformer Rating	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
1½		18		18		6		6		1½		1½		1½		6		6		6
3		18		18		6		6		1½		1½		1½		6		6		6
5	3	18		18	3	6	3	6	3	1½	3	1½	3	1½		6		6		6
7½		18		18		6		6		1½		1½		1½		6		6		6
10		18	3	18		6		6		3		1½		1½	3	6	3	6		6
15		18		18		6		6		3		3		1½		6		6	3	6
25		18		18		10		8		6		3		3		6		6		6
37½		25		18		18		12		10		6		6		6		6		6
50	25	45	18	25		20		18		12		8		6		6		6		6
75	45	75	25	35	25	30		25		18		10		10		8		6		6
100	50	100	35	50	30	50	25	40		25		12		12		10		8		6
150	100	150	45	100	50	75	40	65	25	40	18	25	18	20		12		10		8
167	100	150	50	100	50	75	50	75	30	50	20	30	18	25	12	18		12		10
200	130	200	65	130	75	100	50	75	30	65	25	40	20	30	12	20	12	15		12
250	150	200	75	150	75	130	65	100	40	80	30	50	25	40	18	25	15	20		12
333	200		130	200	100	150	100	150	65	100	30	65	30	50	25	40	20	30		15
500			150		150		130		100	160	50	100	50	80	30		30	50	20	30
750			200 [4]						130	200	80	130	80	130	40 [4]		40	60	30	50
1000									200		100	200	100	160			60	100	40	60
1250									200 [4]		130	200	130	160			80	100	50	80
1500											200		160				80		60	100
1667											200		160				100		60	100
2000											200		160 [4]				100 [4]		80	100
2500																			100	
3000																			100 [4]	

1 Recommendations are based on fuse-melting characteristics at an ambient temperature of 40°C (See R240-60-2).
2 To prevent fuse blowing on transformer inrush, DO NOT USE FUSES SMALLER THAN RECOMMENDED without specific approval of the manufacturer.
3 Fuses allow in excess of 300% of load
4 Fuses allow less than 140% of load
5 Ratings in shaded area are for parallel-fuse combinations

fuse is expected to carry without fuse damage. This includes the allowable transformer overloading for certain periods of time. Transformer fusing tables normally list the ranges of overload provided. If the long-time minimum-melt current is known for the fuse size in question, it can be compared to the transformer-rated current to determine the exact percentage of overload permitted. Since fuse heating plus transformer heating would probably raise the ambient temperature for the fuse, the long-time minimum-melt current should be reduced accordingly. An ambient of 40°C is often assumed for this condition. of course, the proposed current-limiting fuse must be capable of carrying such currents without damage, and it must interrupt minimum-melt currents and all higher values.

Transformer primary fuses are not usually applied to coordinate with the ANSI transformer safe-loading requirement; namely, melting at 300% kVA rating in 5 minutes and sensing 200% kVA in about 30 minutes. This duty would require a fuse size that would be subject to inrush-current damage. In addition, it would respond too rapidly to short-time high overloads. Common practice is to fuse to interrupt overload currents in the 200 to 300% range after several hours' duration. Specification recommendations are shown in Tables 14 and 15.

TABLE 15
Overload Protection of Oil-Insulated —Self-Cooled, and Dry-Type Transformers 1
Three-Phase Application

Transformer (kVA)	Nominal Three-Phase Voltage Across Transformer Terminals (kV)																					
	2.4		4.16				4.8		7.2-7.96		8.32		12.47		13.2-14.4		20.8		22.9-24.9		34.5	
	Recommended Fuse Voltage (kV)																					
	4.3		4.3		5.5		5.5		8.3		15.5		15.5		15.5		23		27		38	
	Recommended Fuse-Current Ratings (amperes) 2 5 Column A—140-200% Transformer Rating Column B—200-300% Transformer Rating																					
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
15		18		18		6		6		1½		1½		3 1½		3 1½		6		6		6
22½	3	18		18	3	6	3	6		3		3		1½		1½		6		6		6
30		18	3	18		8		6		4½		4½		3		3 3	3	6		6		6
45		18		18		10		10		6		6		3		3		6	3	6		6
75	25	35		18	12	20	12	18		10		10		6		6		6		6	3	6
100	35	50		25	20	25	18	25	12	18		12		10		8		6		6		6
112½	45	65		25	25	30	18	30	12	18		12		10		10		6		6		6
150	50	100	25	45	25	40	25	40	18	25		18		12		12		8		8		6
200	65	100	45	65	40	65	30	50	20	30	18	25		18	12	18		10		10		8
225	75	130	45	75	40	75	40	65	25	40	20	30		18	12	20		10		10		8
300	100	200	50	100	50	75	50	75	30	50	25	50	20	25	18	25		12		12		10
500	200		100	150	100	150	75	130	50	100	50	80	30	50	30	50	20	25	18	25		15
750	200C 4		130	200	130		130		80	130	65	130	40	80	40	80	25	40	25	40	18	25
1000			200		150 4		150		100	160	100	160	65	100	65	100	30		30	50	25	30
1500									160	200	130	200	100	160	80	160	40 4		50	80	30	50
2000									200		200		130	200	130	160			60	100	40	60
2500											200 4		160	200	160				80		50	100
3000													200		160				100		60	100
3500													200		160 4				100 4		80	100
3750													200 4						100 4		80	
4000													200 4								80	
5000																					100	

1 Recommendations are based on fuse-melting characteristics at an ambient temperature of 40°C (See R240-60-2).
2 To prevent fuse blowing on transformer inrush, DO NOT USE FUSES SMALLER THAN RECOMMENDED without specific approval of the manufacturer.
3 Fuses allow in excess of 300% of load.
4 Fuses allow less than 140% of load.
5 Ratings in shaded area are for parallel-fuse combinations.

Derating NX Fuses—Raised Ambient Temperatures

To determine the proper NX fuse size for carrying desired current and percent overload available at raised ambient temperatures, the minimum-melt current must be aerated. The curves in Figure 24 show the aerating factors for NX fuse applications at raised ambient temperatures in air, in canisters suspended in oil, and in transformer bushings. (These curves are based on a six-hour melting time' not the maximum pre-melt current.)

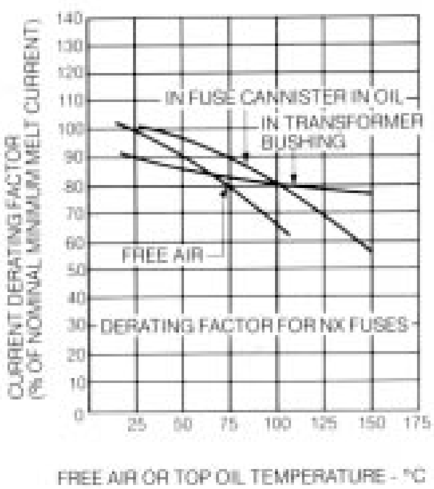


Figure 24.
Derating curves for NX fuse application at raised ambient temperatures.

By using these curves in conjunction with minimum-melt current values from the minimum-melting characteristic table for NX fuses, Table 16, which is based on a 25°C ambient temperature and a six-hour melting time, the proper fuse size can be determined.

Example

To aerate the minimum-melt current of a 5.5 kV, 20 amp NX fuse mounted in free air at a raised ambient temperature of 75°C:

1. On Figure 24, draw a vertical line at 75°C to intersect the free-air curve.
2. From the intersection point, draw a horizontal line to the vertical axis to determine the aerating factor which in this case, is 80%.
3. From Table 16, find the minimum-melt current for the 5.5 kV, 20 amp fuse which, in this case, is 28 amps.
4. Multiply this value by the aerating factor to determine the aerated minimum-melt current: 28 amps x .80 = 27 amps.

TABLE 16
Minimum-Melting Characteristic for NX Current-Limiting Fuses Based on a 25°C Ambient Temperature and a Six-Hour Melting Time

Voltage Rating (kV)	Continuous Current Rating (amp)	Minimum Melt Current (amp)
4.3	18	27
	25	27
	35	50
	45	64
	50	68
	65	78
	75	90
	100	110
	130*	156
	150*	180
	200*	220
5.5	6	9
	8	12
	10	14
	12	17
	18	27
	20	28
	25	37
	30	42
	40	55
	50	68
	65	78
	75	90
	100*	136
	130*	156
	150*	180
8.3	1.5	2.3
	3	4.5
	4.5	6.7
	6	9
	8	12
	10	14
	12	17
	18	26
	20	28
	25	35
	30	41
	40	52
	50	63
	50*	70
	60*	82
	65	80
	80	96
	80*	104
	100	120
	100*	126
	130*	160
	160*	192
	200*	240

Voltage Rating (kV)	Continuous Current Rating (amp)	Minimum Melt Current (amp)
15.5	1.5	2.3
	3	4.5
	4.5	6.7
	6	9
	8	12
	10	15
	12	18
	18	26
	20	28
	25	35
	30	41
	40	52
	50	63
	50*	70
	60*	82
	65	80
	80	96
	80*	104
	100	120
	100*	126
	130*	160
	160*	192
	200*	240
23	6	9
	8	12
	10	15
	12	18
	18	26
	20	28
	25	35
	30	41
	40	52
	6	9
27 and 38	8	12
	10	15
	12	18
	15	22
	18	26
	20	28
	25	35
	30	41
	40	52
	50	63
	60*	82
	80*	104
	100*	126

*Indicates two smaller fuses in parallel.

Coordination of Fuses in Series—TCC Comparison

After fuse sizes have been selected to satisfy the inrush and load current requirements, various fusing steps in the system can be checked for coordination. For successful coordination, the protecting fuse (load-side) should blow and clear the circuit before the protected fuse (source side) operates or is damaged.

In general, the comparison of the minimum-melt current of the source-side fuse to the maximum-clearing current of the load-side fuse can be used to determine whether the load-side fuse will protect the source-side fuse. To assure that no damage will occur to the source fuse, it is customary to keep the maximum-clearing time below 75% of the minimum-melt time. If tcc transparencies are being used, this comparison can be made easily by overlaying the maximum-clearing-curve sheet on top of the minimum-melt sheet, but shifting it in a vertical direction sufficiently to allow the 75% factor, placing the maximum-clearing three-second line on the minimum-melt four-second line. This factor is used to allow for possible preheating of the source fuse due to load conditions and also for variations in the ambient temperatures of the fuses. Because typical fuse performance usually follows average tcc characteristics, both melting and clearing, an additional coordination safety factor exists with the use of minimum and maximum tcc's.

CURRENT-LIMITING LOAD-FUSE To EXPULSION SOURCE-FUSE

Figure 25 compares the maximum-clearing tcc of a 12C amp NX current-limiting fuse with the minimum-melt tcc of a 30K expulsion fuse. It can be seen that, at any fault current, the clearing time of the load fuse is less than 75% of the minimum melt of the source fuse. If tcc comparison shows the proper coordination the fuses will coordinate properly at all fault currents to the maximum interrupting rating of the current-limiting fuse. This can be verified by comparing the maximum let-through I^2t current-limiting fuse with the minimum melt I^2t of the expulsion fuse.

EXPULSION LOAD FUSE TO CURRENT-LIMITING SOURCE FUSE

Using an expulsion fuse as the load fuse and a current-limiting fuse as the source fuse provides a limited coordination condition possible only at low-fault currents. Figure 26 shows this relationship. Expulsion fuses do not have any significant

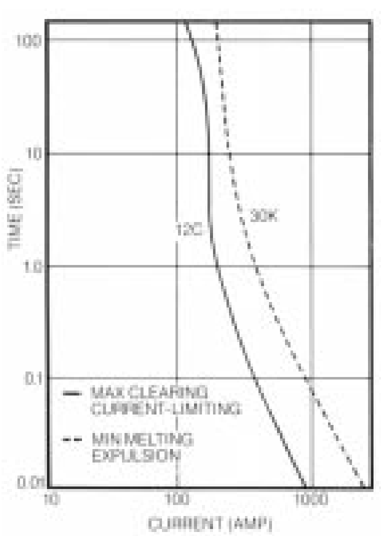


Figure 25.
Fuse coordination—current-limiting load fuse to expulsion source fuse.

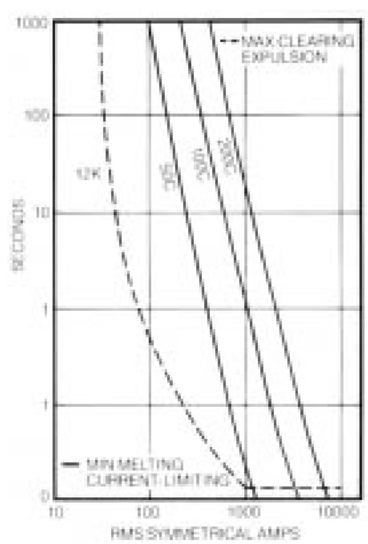


Figure 26.
Fuse coordination—expulsion load fuse to current-limiting source fuse.

current-limiting ability nor can they force an early current zero. Thus, an asymmetrical fault current may flow for 0.13 second, allowing for typical transient decay decrements. For this reason, the maximum total tcc for expulsion fuses extends parallel to the current axis at 0.013 second. Thus, for the example shown, coordination would appear possible through 1000 amps with the source fuse a 50 amp unit, 3000 amps with the source fuse a 100 amp unit, and 6000 amps with the source fuse a 200 amp unit.

Table 17 simplifies the selection of NX fuses for coordination with expulsion fuses. It lists the smallest size K or T fuse link that will coordinate with NX fuses regardless of fault-current magnitude.

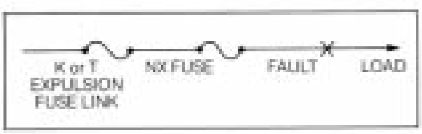


TABLE 17

NX NX Voltage (kV	NX Fuse Continuous Current (amp)	Minimum Size Backup Fuse Link for Coordinalion (amp)	
		K	T
4.3	18	30	30
	25	50	50
	35	65	65
	45	100	80
	50	100	80
	65	140†	100
	75	140†	140†
	100	200	140
	130*	200	200
	150*	200	200
	200*	–	200
5.5	6	10	10
	8	15	15
	10	20	20
	12	25	25
	18	30	30
	20	40	30
	25	50	40
	30	65	50
	40	80	80
	50	100	80
	65	140†	100
	75	140†	140†
	100*	200	140
	130*	200	200
	150*	200	200
8.3	6	6	6
	3	6	6
	4.5	8	8
	6	10	10
	8	15	15
	10	20	20
	12	25	25
	18	40	30
	20	40	40
	25	50	50
	30	80	65
	40	100	80
	50*	100	100
	50	140†	100
	60*	140†	140†
	65	140†	140†
	80*	140†	140†
	80	200†	140†
	100*	200	140
	100	200	200
	130*	–	200
	160*	–	200
	200*	–	–

* Parallel fuse combination.
† The Cooper Power Systems Type C expulsion fuse Link (Catalog No. FL1C101), rated at 140 amps for coordination purposes, is also satisfactory for ratings through 27 kV.

NX Voltage (kV)	NX Fuse Continuous Current (amp)	Minimum Size Backup Fuse Link for Coordination (amp)	
		K	T
15.5	1.5	6	6
	3	6	6
	4.5	8	8
	6	12	10
	8	15	15
	10	25	20
	12	30	25
	18	40	30
	20	40	40
	25	50	50
	30	80	65
	40	100	80
	50*	100	100
	50	140†	100
	60*	140†	140†
	65	140†	140
	80*	140†	140†
	80	200†	140†
	100*	200	140
	100	200	200
	130*	–	200
	160*	–	200
	200*	–	–
23	6	12	10
	8	15	15
	10	25	20
	12	30	25
	18	40	30
	20	50	40
	25	50	50
	30	80	65
	40	100	80
27	6	12	10
	8	15	–
	12	25	15
	15	30	25
	18	30	30
	20	40	30
	25	40	40
	30	50	50
	40	80	80
	50	140†	100
	60*	140†	100
	80†	140†	140†
	100†	200	140
38	6	15	10
	8	20	12
	10	25	15
	12	25	15
	15	30	25
	18	30	30
	20	30	30
	25	40	40
	30	50	50
	40	80	80
	50	140†	100
	60*	140†	100
	80*	140†	140†
	100*	200	140

TABLE 18
Minimum-Melt and Maximum Let-Through I^2t Values for NX Current-Limiting Fuses

Voltage Rating (kV)	Continuous Current Rating (kV)	Min. Melt I^2t (amps^2 x sec) x 10^3	Max. Let-Through I^2t (amps^2 x sec) x 10^3
4.3	18	1.5	7.9
	25	2.9	12.5
	35	2.9	25.0
	45	6.6	69.0
	50	9.0	75.0
	65	18.2	100.0
	75	26.5	150.0
	100	45.5	240.0
	130*	73.0	400.0
	150*	106.0	620.0
	200*	185.0	960.0
5.5	6	0.13	0.60
	8	0.35	1.05
	10	0.52	2.0
	12	1.15	4.0
	18	1.25	10.0
	20	1.65	14.0
	25	3.0	38.0
	30	3.0	46.0
	40	5.3	67.0
	50	9.0	98.0
	65	18.2	167.0
	75	26.5	244.0
	100*	36.0	380.0
	130*	73.0	790.0
	150*	105.0	980.0
8.3	1.5	0.01	0.15
	3	0.05	0.30
	4.5	0.05	0.30
	6	0.13	0.76
	8	0.34	1.5
	10	0.52	3.6
	12	1.15	6.3
	18	1.25	11.0
	20	1.65	13.0
	25	2.0	24.0
	30	4.0	31.0
	40	8.0	50.0
	50	11.6	72.0
	60*	15.8	125.0
	65	26.5	130.0
	80*	32.5	200.0
	80	47.0	220.0
	100	100.0	450.0
	130*	102.0	520.0
	160*	187.0	800.0
	200*	400.0	1800.0
15.5	1.5	0.01	0.15
	3	0.05	0.59
	4.5	0.05	0.59
	6	0.13	1.44
	8	0.21	2.90
	10	0.52	6.65
	12	1.15	10.4
	18	1.25	10.5
	20	1.65	16.5
	25	2.0	27.0
	30	4.0	34.0
	40	8.0	57.0
	50	11.6	90.0
	60*	16.0	132.0
	65	26.5	200.0
	80*	32.5	225.0
	80	46.5	340.0
	100*	47.0	370.0
	100	100.0	580.0
	130*	102.0	790.0
	160*	187.0	1380.0
	200*	400.0	2350.0
23	6	0.13	1.8
	8	0.21	3.5
	10	0.52	7.8
	12	1.15	13.5
	18	1.25	16.2
	20	1.65	18.0
	25	2.0	28.0
	30	4.0	36.0
	40	8.0	62.0
27	6	0.08	1.6
	8	0.21	2.5
	10	0.53	3.8
	12	0.72	6.0
	15	0.74	6.0
	18	1.30	7.0
	20	1.65	9.4
	25	2.95	16.0
	30	4.60	26.0
	40	5.25	29.5
	50	11.30	65.0
	60*	18.40	104.0
	80*	20.10	118.0
	100*	26.00	260.0
38	6	0.08	3.5
	8	0.21	4.7
	10	0.53	5.6
	12	0.72	9.0
	15	0.74	10.5
	18	1.15	10.5
	20	1.65	13.8
	25	3.00	19.5
	30	4.60	29.0
	40	5.13	35.0
	50	11.60	80.0
	60*	18.50	117.0
	80*	21.20	140.0
	100*	47.00	320.0

*Indicates two smaller fuses in parallel

Coordination NX and NX in Series

For coordination between current-limiting fuses, the tcc comparisons are satisfactory for clearing times greater than 0.01 second. But, for the shorter times where current-limiting fuses are primarily involved, some additional means must be provided for checking fuse coordination. The minimum melt and maximum let-through I^2t values for NX fuses provide a simple means for checking this coordination at high fault currents. Table 18 lists these minimum melt and maximum let-through I^2t values for each of the various NX current-limiting fuses. To properly coordinate one NX fuse in series with another, the maximum let-through I^2t of the protecting fuse (loadside) must be lower than the minimum melt I^2t of the protected fuse (source side). If this parameter is met coordination will be satisfactory.

PARALLEL OPERATION OF NX CURRENT-LIMITING FUSES

Maximum peak let-through current for two parallel fuses will not exceed twice the let-through current of one fuse operated at half the available fault current.

Parallel fuse operation has no effect on the maximum arc voltage generated. Maximum arc voltage will not exceed approximately twice the peak design voltage.

Applications where the circuit is energized by closing the first of two paralleled fuses require proper fuse selection to prevent fuse blowing by transient inrush currents. Normal criterion for this condition is to have the 0.1-second minimum melting current equal to—or greater than—12 times the transformer rated current and the 0.01-second minimum melting current equal to—or greater than—25 times the transformer rated current.

Because of precise fuse-cartridge manufacture, proper mounting design, and the inherent resistance characteristics of the fusible elements, smaller NX fuses can be used in parallel to fulfill application requirements for larger capacity fuses. Protection of transformers through 2000 kVA, singlephase and 4000-kVA, three-phase is possible with NX fuses, offering fullrange fault-clearing ability and safe, silent operation.

For a detailed discussion of parallel operation of NX fuses, see R240-60-7, (NX Current-Limiting Fuses Parallel operation), available from your local Cooper Power Systems representative.

ADDITIONAL LITERATURE

Cooper Power Systems has additional reference information available on NX fuses. For copies of any of the following bulletins, contact your local Cooper Power Systems representative.

R240-60-2 NX Current-Limiting Fuses—Minimum Melting Characteristics.
R240-60-5 MaximumTotal and Minimum Melt Comparison of NX Fuses.
R240-60-6 Mounting Clearances—Type NX Fuses.
R240-60-7 Parallel operation of NX Fuses.
R240-60-8 A Guide to Secondary Cable Fault Clearing With NX Fuses.
R240-60-9 Properties of Molded Box for NX Fuses With Arc-Strangler Switch.
R240-60-11 Specifications—NX Fuses With Arc-Strangler Switch.
R240-60-13 NX Fuse Recommended Transformer Applications.
Bulletin 71007 Coordination with Current-Limiting Fuses.
Bulletin 73018 Current-Limiting Fuses Prevent Catastrophic Transformer Failures.
Bulletin 74011 Protection of Distribution Circuits Using CurrentLimiting Fuses.
Bulletin 76039 Overcurrent Protection of Overhead Distribution Circuits.
Bulletin 76051 Production I^2t Testing of Current-Limiting Fuses.

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