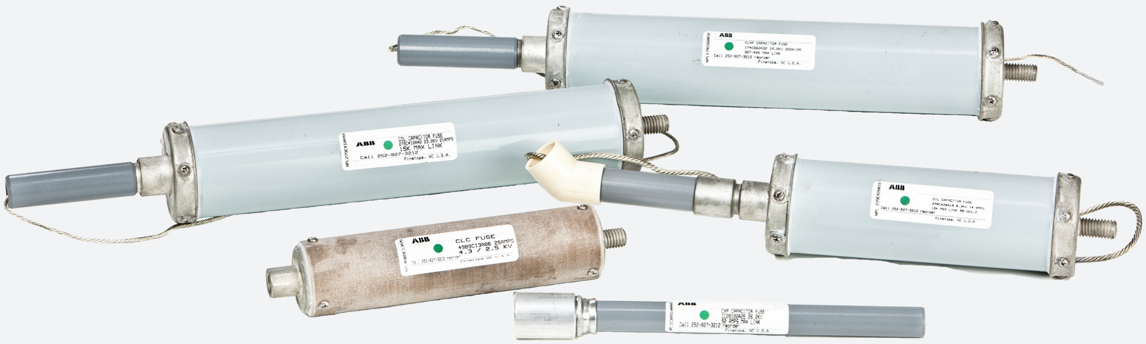
DISTRIBUTION SOLUTIONS

Capacitor fuses

Technical selection guide



ABB's portfolio of capacitor fuses includes current-limiting, expulsion and combination fuses for both indoor and outdoor applications up to 26.2 kV and 100 A ratings.

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Capacitor fuse ratings

Fuse name	Voltage rating (kV)	Rated current (A)	Interrupting capability Iind (kA)	Interrupting capability Icap (kA)	Discharge capability (kilojoules)	Fuse type	Application
CLC	1.2	25–175	115	1.25	50	Current limiting	Indoor
	1.8	25–175	40	1.25	80	Current limiting	Indoor
	2.5	25–75	35	1.25	80	Current limiting	Indoor
	3.0	25–130	35	1.25	100	Current limiting	Indoor
	4.3/2.5	25–75	60	1.25	80	Current limiting	Indoor
CIL	5.5	15–65	40	2.9	77	Combination	Indoor
	8.3	8–40	60	2.9	75	Combination	Indoor
	15.5	6–25	90	0.8	88	Combination	Indoor
	23	21	60	0.8	50	Combination	Indoor
CXP	9.7	6–100	10	1.9	30	Expulsion	Outdoor
	16.6	6–50	5	2.1	30	Expulsion	Outdoor
	26.2	6–50	2.5	0.8	30	Expulsion	Outdoor
COL	2.8	25–80	40	2.9	85	Combination	Outdoor
	5.5	15– 65	40	2.9	77	Combination	Outdoor
	8.3	8–40	60	2.9	75	Combination	Outdoor
	15.5	6–25	90	2.3	88	Combination	Outdoor
	23.0	6–15	60	0.8	50	Combination	Outdoor
CLXP	2.5	15–33	0	> 1.4	No limit	Combination	Outdoor
	5.0	8–33	0	> 1.4	No limit	Combination	Outdoor
	8.0	6–33	0	> 1.4	No limit	Combination	Outdoor
	10.0	15–33	0	> 1.4	No limit	Combination	Outdoor
	15.0	10–33	0	> 1.4	No limit	Combination	Outdoor
	20.0	8–33	0	> 1.4	No limit	Combination	Outdoor
	25.0	8–33	0	> 1.4	No limit	Combination	Outdoor

Useful capacitor formulae

Nomenclature:
C = Capacitance (microfarads)
V = Voltage
A = Current
K = 1000

A. Capacitors connected in parallel:

$$C_{total} = C_1 + C_2 + C_3 + \text{----}$$

B. Capacitors connected in series:

For two units:

$$C_{total} = \frac{C_1 \times C_2}{C_1 + C_2}$$

For more than two units:

$$C_{total} = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \text{----}}$$

C. Reactance — X_C (capacitive)

1) $X_c = \frac{10^6}{(2\pi f)C}$

2) $X_c = \frac{kV^2 \times 10^3}{kVAR}$

3) $X_c = \frac{2653}{C}$ @ 60 Hz (1µF = 2653)

D. Capacitance - C

1) $C = \frac{10^6}{(2\pi f)X_C}$

2) $C = \frac{kVAR \times 10^3}{(2\pi f)(kV)^2}$

E. Capacitive kiloVARs

1) $kVAR = \frac{(2\pi f)C \times (kV)^2}{10^3}$

2) $kVAR = \frac{10^3 \times (kV)^2}{X_C}$

F. Miscellaneous

1) Power factor = Cos Θ = kW/kVA

		Single Phase	Three Phase
2)	kW =	$\frac{V \times A \times PF}{10^3}$	$\frac{\sqrt{3} \times V \times A \times PF}{10^3}$
3)	kVA =	$\frac{V \times A}{10^3}$	$\frac{\sqrt{3} \times V \times A}{10^3}$
4)	Line = current	$\frac{kVA \times 10^3}{V}$	$\frac{kVA \times 10^3}{\sqrt{3}\,V}$

5) Capacitor current = (2 π f)CV x 10-6

Also: $\frac{kVAR \times 10^3}{V}$ $\frac{kVAR \times 10^3}{\sqrt{3}\,V}$

6) kVA = KW/PF: (kW motor input)

7) kW (motor input) = $\frac{hp \times 0.746}{efficiency}$

8) Approximate motor kVA = motor HP (at full load)

G. Additional

1) Improved voltage at transformer due to capacitor addition

$$\% V.R. = \frac{kVAR\ (cap.) \times \%\ transformer\ reactance}{kVA\ (transformer)}$$

2. Losses reduction:

$$\% L.R. = 100 - 100 \left(\frac{original\ PF}{improved\ PF}\right)^2$$

3) Operation at other than rated voltage and frequency:

Reduced voltage:

Actual kVAR (output) = rated kVAR $\left(\frac{actual\ voltage}{rated\ voltage}\right)^2$

Reduced frequency

Actual kVAR (output) = rated kVAR $\frac{actual\ frequency}{rated\ frequency}$

H. Back-to-back switching

$I_r = 1.333 \sqrt{kVAR_{eff} / L}$

I_r = peak inrush current in kilo amps

L = 10µH (assumed)

$$kVAR_{eff} = \frac{kVAR_1 \times kVAR_2}{kVAR_1 + kVAR_2}$$

Capacitor fuse overview

Capacitor fuse terminology

An ideal fuse could be defined as a lossless smart switch that can thermally carry infinite continuous current, detect a preset change in the continuous current and open automatically (instantly) to interrupt infinite fault currents at infinite voltages without generating transients. Unfortunately, such a device with real world materials does not exist. Over the years, a set of terms has been developed to apply capacitor fuses. The concept of applying fuses should be a simple engineering task; however, fuse operation is a non-linear function. The resistance of fuse elements changes non-linearly as they melt and clear. This means that fuse development requires many laboratory experiments to empirically derive and plot the relationships. Below is a brief list and definition of the key terms used in the development and application of capacitor fuses.

Application ratings

Maximum continuous current rating
The maximum current that the fuse can carry continuously without deterioration (including harmonics). This rating is determined by temperature rise tests and is valid for some maximum ambient temperature.

Maximum rated voltage
The maximum power system voltage that the fuse can clear against. For high voltage capacitor fuses, this is generally defined as 8.3, 15.5 or 23 kV, the distribution system maximum voltages. Other voltage ratings may be available for special applications.

Maximum parallel energy
When a capacitor fails, the energy stored in its series group of capacitors is available to dump into the combination of the failed capacitor and fuse. The failed capacitor and fuse must be able to absorb or hold off this energy with a low probability of case rupture of the capacitor unit. The available energy is calculated by assuming that the parallel capacitance is charged to 1.1 times the crest of the AC rated voltage (kV AC) (j = ½ CV2). For shunt capacitor applications, the energy is equal to 3.19 joules per kVar. The available energy is then compared to the rating of the fuse and capacitor unit. This is one criteria for selecting either expulsion or current-limiting fuses for a given application. If the parallel energy is above 20 kJ or 6000 kVar, we apply current-limiting fuses. If the parallel energy is less than 20 kJ and the available fault current is within the rating of our expulsion fuse, we apply our CXP expulsion fuse.

Maximum interrupting current
Most capacitor fuses have a maximum power frequency fault current that they can interrupt. These currents may be different for inductive and capacitively limited faults. For ungrounded or multi-series group banks, the faults are capacitive limited. Typically, the available fault current for these banks is very low (less than two or three times the actual capacitor bank load current).Typically, we provide CXP expulsion fuses if the parallel energy available is less then 20 kJ. For cases where the energy exceeds 20 kJ, we apply CLXP current-limiting fuses.

On single series group grounded wye or delta banks, the faults are inductively limited. The fault current is limited only by the available system fault current. If the available energy is less than 20 kJ and the available fault current is low, we apply CXP expulsion fuses. If the fault current is higher, we apply COL current-limiting fuses.

Amp-squared seconds (I^2t)
Fuse operation is caused by raising the temperature of the fuse element above its melting point. Fuse melting is an energy function. The heat generated by passing the fault current and the current from the parallel charged capacitors must melt the fuse element. The term “energy” is not generally used because it is very difficult to calculate. The resistance of the fuse element when the fuse is cool or operating at rated current is typically 10 to 50 milliohms. During a fuse operation, the element temperature increases and causes the element resistance to increase. When the element melts and vaporizes, the resistance increases at a more rapid rate until the fuse clears and the resistance becomes infinite. To calculate the energy in the fuse, we have to dynamically calculate the resistance of the fuse and integrate the square of the current times its dynamic resistance over the time period of the fuse operation. The term “I^2t” or “amp-squared seconds” was devised to avoid this calculation problem. I^2t is proportional to energy ($J = I^2t \times P$). The proportionality constant is the resistance of the element ($R = J/(I^2t)$). The argument is as follows: If we pass a certain current through a fuse element, it takes a certain amount of time for the fuse to melt. If we test many different elements at many different currents, we can determine the I^2t for the elements. For fast rates of energy input into the fuse, the I^2t to melt is very consistent.

For long low current exposures, the fuse element tends to transfer a portion of the heat to the fuse housing and the I^2t to melt will, therefore, be much higher. For this reason, the term is used only for fuse operations that occur faster than about 0.1 or 0.01 seconds.

I^2t withstand
Each time the temperature of a fuse element is raised near its melting point, the fuse deteriorates slightly. A curve can be plotted that shows the expected number of operations a fuse can survive for a given percent of its one-shot I^2t to melt. This information is valuable if the fuse is to be exposed to many switching operations or discharges. For applications with many such exposures, we tend to supply fuse elements with a higher I^2t to melt capability (larger diameter element).

I^2t let-through
The I^2t required for the fuse to clear is always greater than the I^2t to melt. Some additional time is always required for the fuse element to change its impedance from a finite number (resistance of the element at the time of melting) to an infinite value (the fuse element has opened and interrupted). The total I^2t to clear is also the I^2t let-through. This is the I^2t that the failed capacitor sees as the fuse is operating. The capacitor must be able to absorb this energy with a low probability of case rupture.

Fusing factor
Fuses are usually applied with some continuous current margin. The margin is typically in the range of 1.3 to 1.65 per unit. This margin is called the fusing factor. On a typical power system, the fuses may be exposed to higher steady state currents in the following ways: (1) The rated kVar of a capacitor unit for shunt applications is a minimum (kVar tolerance = 0/+ 15%); (2) if harmonics are available on the system, the capacitors will provide a low impedance path and more current will flow through the fuse; and (3) capacitor units by standards must be able to operate at 1.1 times rated voltage or 1.35 times rated kVar continuously. The fusing factor allows for these conditions. If the application is known to have a large harmonic content, the increase in current should be included in the fuse selection process.

Expulsion vs. current-limiting fuses

Fuse operation
In general, fuses operate by melting a fusible element or link. As the element melts, an arc is developed. Three things must be present to extinguish the arc: pressure, cooling and stretching.

Expulsion fuses
The CXP expulsion fuse provides a means of disconnecting a failed capacitor from the circuit by melting a tin-lead low current link. The shorted capacitor unit causes a large increase in the current through the fuse. The current is limited only by the power system reactance and the other capacitor units in series with the failed capacitor unit. The pressure is generated by the hot arc making contact with the fiber lining of the fuse tube. The link is cooled and stretched as it is forced out of the tube. The fuse continues to conduct until a natural current zero occurs. The current zero is caused by the power system fault current crossing zero. If other capacitors are connected in parallel with the failed unit, all the stored energy in these capacitors will be absorbed in either the fuse operation or the failed capacitor unit. Most of the energy is absorbed in the failed capacitor.

Current-limiting fuses
Capacitor current-limiting fuses can be designed to operate in two different ways. The COL fuse uses ribbons with a non-uniform cross section. This configuration allows the fuse to be used to interrupt inductively limited faults. The pressure is generated by the arc contained in the sealed housing. The cooling is provided by the sand around the fuse element. The element melts at each non-uniformity and develops a low back voltage. The back voltage limits the peak current by inserting what appears to be a higher impedance in the fuse path. The element path provides the stretching. The COL will not force the current to a zero value. The arc will wait for the first natural current zero and extinguish the arc at that time. The low current element will then drop out to provide an air gap for dielectric isolation. Since this fuse conducts to a natural zero and is developing a back voltage, a large portion of the energy is absorbed in the fuse. The energy is shared between the fuse and the failed capacitor unit.

The CLXP fuse uses a long uniform cross section element. This configuration makes the fuse a current chopping fuse. The fuse develops a back voltage per inch of element across the entire length of the element. When this voltage exceeds the available voltage across the fuse, the fuse forces the arc to extinguish. The cooling and pressure are provided in the same manner as on the COL fuse. The result is that a trapped voltage may and probably will remain on the other capacitors in the series group. The fuse, by its design, avoids absorbing all of the available energy on the series group. This fuse is used for capacitor banks with a large number of parallel capacitors. It can be used on applications with essentially infinite parallel stored energy, as long as sufficient back voltage can be developed to force the current to extinguish. This is the fuse we apply to series, large shunt and DC banks. Because of the high back voltage that is developed, this fuse must be used with several capacitors in parallel to limit the voltage build up or a flashover may occur elsewhere in the capacitor rack. The design cannot be used in inductively limited fault applications.

Type CLC
Indoor current-limiting capacitor fuse, 1.2–3.0 kV

The type CLC fuse is a full range (partial range for 4.3/2.5 kV ratings) current-limiting capacitor fuse. It is designed for indoor use or in an enclosure, protected from outdoor weather conditions. The CLC fuses exist in 1200, 1800, 2500, 3000 volt and 4.3/2.5 kV ratings. The primary application of these fuses is individual unit fusing of low voltage single- and three-phase capacitors in metal-enclosed equipment. The 1200, 1800 and 3000 volt ratings are current-limiting, indicating and non-disconnecting. The 2500 volt and 4.3/2.5 kV ratings are current-limiting, non-indicating and non-disconnecting.

Application

CLC fuses are selected with the following steps:

- Voltage: The voltage of the capacitor being protected should be less than or equal to the voltage of the fuse selected. The nearest available fuse should be used to ensure that the voltage developed by the fuse during interruption does not damage the system. The 4.3/2.5 kV fuse is a special rating for 2500 V single-phase applications or 4300 V three-phase applications. To protect a 4800 V single-phase capacitor, use two 4.3/2.5 kV fuses in series.
- Interrupting capacity: The interrupting capacity on CLC fuses is more than adequate to protect most applications. Available fault current:
  - Rated kVA source XFMR/impedance (source)
  - Divide by voltage to obtain available fault current
  - Example: 50 kVA/10% = 500,000 VA for 480 V, I = 1042 A
- Continuous current: The continuous current rating of the fuse should be 1.65 times the current flowing in each phase to protect against harmonics and switching currents.

Selecting CLC fuses

Single-phase: Ampere rating $1.65 \times \frac{\text{kVAR}}{\text{kV}}$

Three-phase: Ampere rating $1.65 \times \frac{\text{kVAR}}{\sqrt{3}\,\text{kV}}$

Type CLC fuse ratings: Normal application on typical 2400 and 4160 volt capacitor

Three-phase units

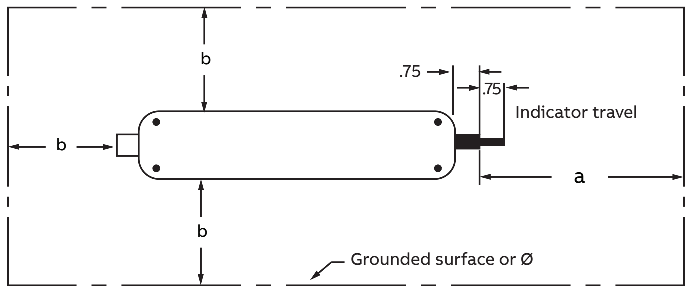
Three-phase kV AC	2400 V	4160 V
25	25 A, 2.5 kV	25 A, 4.3/2.5 kV
50	25 A, 2.5 kV	25 A, 4.3/2.5 kV
75	50 A, 2.5 kV	25 A, 4.3/2.5 kV
100	50 A, 2.5 kV	25 A, 4.3/2.5 kV
125	50 A, 2.5 kV	50 A, 4.3/2.5 kV
150	75 A, 2.5 kV	50 A, 4.3/2.5 kV
175	75 A, 2.5 kV	50 A, 4.3/2.5 kV
200	75 A, 2.5 kV	50 A, 4.3/2.5 kV

Selection guide — CLC current-limiting, indoor (enclosed) fuse

Ampere rating	Interrupting capacity amps	Style number
1200 volt, indicating		
25	115,000	4989C12A21
50	115,000	4989C12A22
75	115,000	4989C12A23
100	115,000	4989C12A24
120	115,000	4989C12A25
135	115,000	4989C12A26
150	115,000	4989C12A27
165	115,000	4989C12A28
175	115,000	4989C12A29
1800 volt, indicating		
25	40,000	4989C12A41
50	40,000	4989C12A42
75	40,000	4989C12A43
100	40,000	4989C12A44
120	40,000	4989C12A45
135	40,000	4989C12A46
150	40,000	4989C12A47
165	40,000	4989C12A48
175	40,000	4989C12A49
2500 volt, non-indicating		
25	35,000	4989C13A01
50	35,000	4989C13A02
75	35,000	4989C13A03
3000 volt, indicating		
25	35,000	4989C12A61
50	35,000	4989C12A62
75	35,000	4989C12A63
100	35,000	4989C12A64
115	35,000	4989C12A65
130	35,000	4989C12A66
4.3/2.5 kV, non-indicating		
25	60,000	4989C13A06
50	60,000	4989C13A07
75	60,000	4989C13A08

Note: Rated maximum voltage is 110% of nominal. Ref: IEEE C37.40

Blown fuse indicator

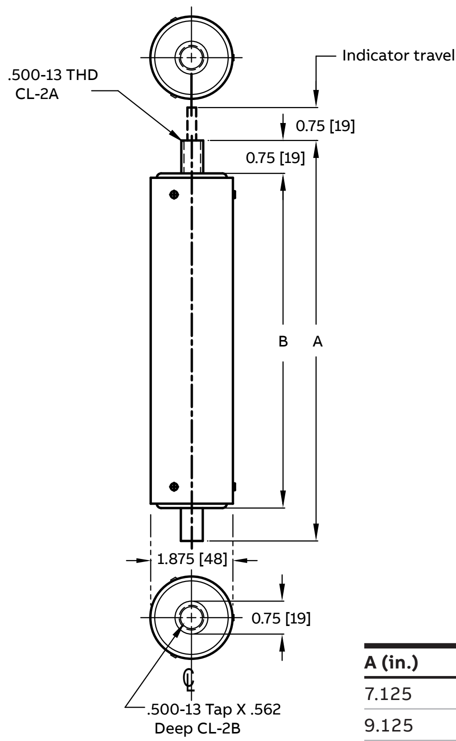


CLC fuse voltage	Indicating?	a (in.)*	b (in.)**
1200	Yes	4.0	2.5
1800	Yes	5.0	2.5
2500	No	2.5	2.5
3000	Yes	6.0	2.5
4.2/2.5 kV	No	2.5	2.5

*These dimensions are the recommended clearances for 60 kV BIL equipment. Increase these dimensions if higher BIL is required.

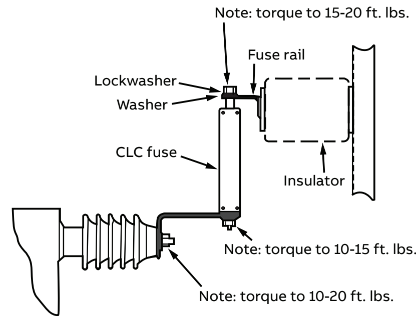
**These dimensions are the minimum recommended clearances as determined by various 60 Hz tests. These dimensions should be increased, if feasible, due to possible circuit variations and voltage transients.

Unit dimensions



A (in.)	B (in.)	Volts
7.125	5.625	1200
9.125	7.625	1800
12.375	10.875	2500
12.375	10.875	3000
12.375	10.875	4.3/2.5 kV

CLC fuse mounting arrangements



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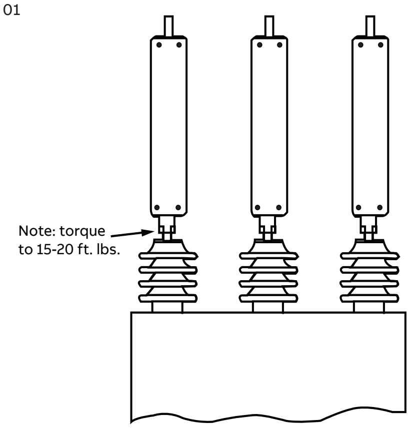

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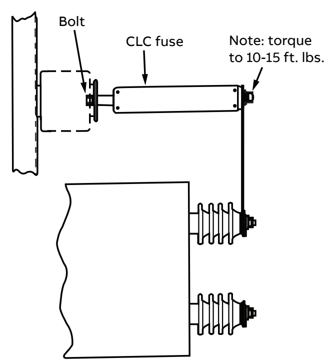

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01 CLC fuse/capacitor edge-mount single-phase capacitor
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02 CLC fuse/(3) 4.3/2.5 kV fuses mounted on three-phase capacitor
—
03 CLC fuse/capacitor edge-mount on single-phase capacitor

Type COL
Outdoor current-limiting capacitor fuse

The COL fuse is a full range current-limiting capacitor fuse designed for outdoor use only. COL fuses exist in voltage classes of 2.8 kV, 5.5 kV, 8.3 kV, 15.5 kV and 23 kV and are applied to individual capacitor units in outdoor stacking equipment. The COL fuse is current-limiting, indicating and disconnecting.

The COL current-limiting capacitor fuse has a two-part design. The high current section interrupts high 60 Hz fault currents and/or high frequency discharge current from parallel capacitors. The low voltage section consists of a standard NEMA Type K fuse link mounted in a fiber tube. The low current section interrupts fault current associated with progressive failure of the capacitor unit's dielectric, or 60 Hz fault current limited by the circuit impedance to low values. This type of design helps reduce fuse replacement cost to the price of a NEMA Type K fuse link when low current interruption occurs.

The COL capacitor fuse must be used with an ejector spring (see page 11). This spring ejects the link's leader, providing a positive indication of a blown fuse.

Application

- Voltage: The COL fuse is used only for fusing individual single-phase capacitor cans; therefore, the COL fuse voltage rating can be determined from the voltage rating of the capacitor unit (see table 1). Do not apply COL fuses above this rated voltage.
- Energy: The COL fuse is generally used on capacitor banks where parallel energy is more than 20 kilojoules or 6000 kVAR. The COL fuse's maximum parallel capacitor discharge energy rating is shown in the technical data table at right. COL fuses are to be applied ONLY where there are two or more capacitors in parallel per group and where low inductively limited faults can flow. See appendix.
- Current: Table 1 lists the individual fusing recommendations for applying COL fuses in outdoor capacitor banks. The fusing tables are based on the following:

$$\text{Capacitor current} = \frac{\text{kVar unit}}{\text{kV unit}}$$

Minimum fuse current = capacitor current x 1.35 protective margin

The protective margin accounts for normal overvoltages, harmonics, capacitor tolerances and a 25 °C (77 °F) ambient.

Table 1: Fuse current rating based on available styles in table 2

Capacitor voltage rating	Fuse voltage rating (kV)	kVAR 50	100	150	200	300	400
2400	2.8	35	65	92	-	-	-
2770	2.8	35	54	80	-	-	-
4160	5.5	21	34	49	65	-	-
4800	5.5	21	34	49	56	-	-
6640	8.3	11	21	33	47	-	-
7200	8.3	11	21	26	39	-	-
7620	8.3	11	21	33	39	-	-
7960	8.3	11	17	26	39	-	-
8320	8.3	11	17	26	33	-	-
9960	15.5	9	14	21	32	-	-
12470	15.5	9	12	21	26	-	-
13280	15.5	9	12	16	21	32	-
13800	15.5	9	12	16	21	32	-
14400	15.5	9	12	16	21	32	-
19920	23.0	-	8	11	14	21	-
21600	23.0	-	8	11	14	21	26
22800	23.0	-	8	11	14	21	26

Technical data

Maximum design voltage (kV)	2.8	5.5	8.3	15.5	23.0
Maximum parallel capacitor discharge energy rating (kilojoules)	85	77	75	88	50
Maximum 60 Hz inductive current interrupting (kA RMS symmetrical)	40	40	60	90	60
Maximum peak recovery voltage (kV)	9	17	26	48	72

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04 Upright capacitor with torsion spring
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05 Edge-mount capacitor with torsion spring

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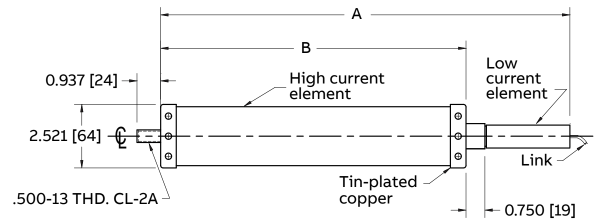
Table 2: Fuse style number (includes fuse link)

Max. fuse design voltage (kV)	Continuous current rating (amps)	NEMA Type K fuse link (amps)	Type COL with mounting
2.8	35	25	279C410A01
2.8	42	30	279C410A02
2.8	54	40	279C410A03
2.8	65	50	279C410A04
2.8	80	65	279C410A05
2.8	92	80	279C410A06
5.5	21	15	279C410A08
5.5	27	20	279C410A09
5.5	34	25	279C410A10
5.5	40	30	279C410A11
5.5	49	40	279C410A12
5.5	56	50	279C410A13
5.5	65	65	279C410A14
8.3	11	8	279C410A16
8.3	14	10	279C410A17
8.3	17	12	279C410A18
8.3	21	15	279C410A19
8.3	26	20	279C410A20
8.3	33	25	279C410A21
8.3	39	30	279C410A22
8.3	47	40	279C410A23
8.3	50	50	279C410A24
8.3	65	65	279C410A25
15.5	9	6	279C410A26
15.5	12	8	279C410A27
15.5	14	10	279C410A28
15.5	16	12	279C410A29
15.5	21	15	279C410A30
15.5	26	20	279C410A31
15.5	32	25	279C410A32
23.0	8	6	279C410A36
23.0	11	8	279C410A37
23.0	14	10	279C410A38
23.0	16	12	279C410A39
23.0	21	15	279C410A40
23.0	25	20	279C410A41

* Based on 35 °C (95 °F) ambient. Fuse links are rated based on their melting characteristics. They can carry approximately 150% of their rating continuously.

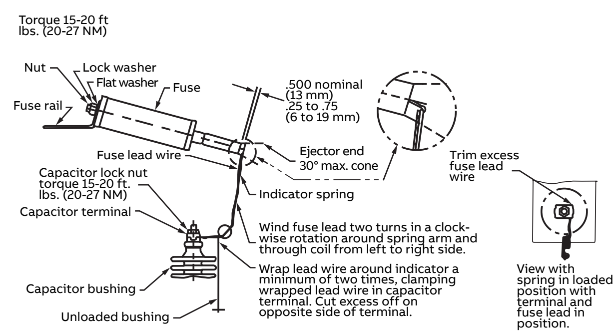
Unit dimensions



kV	A (in.)	B (in.)	Weight (lbs)
2.8	11.075	7.75	3.0
5.5	11.075	7.75	3.0
8.3	11.075	7.75	3.0
15.5	14.125	10.00	3.6
23.0	16.250	12.125	4.3

Mountings and ejector spring

The COL fuse must be used with ejector springs. The critical dimension is the distance from the capacitor bushing to the end of the fuse tube. Proper fit is important to avoid unnecessary adjacent capacitor fuse operations. Many styles of the torsion springs shown below are available. Contact your ABB representative for proper fit.



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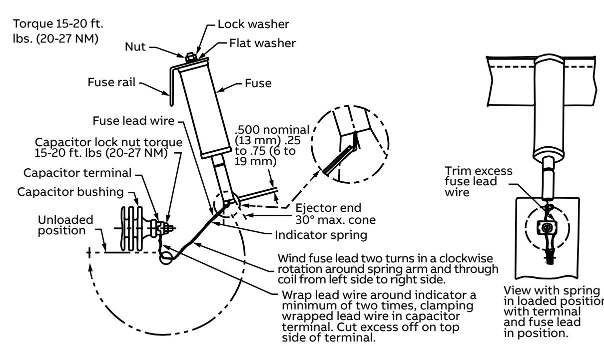

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Type CIL
Indoor current-limiting capacitor fuse

The Type CIL fuse is a full range current-limiting capacitor fuse designed for indoor use only. CIL fuses exist in voltage classes of 5.5 kV, 8.3 kV, 15.5 kV and 23 kV. The primary application for these fuses is individual capacitor unit fusing for metal-enclosed equipment. The CIL fuse is current-limiting, indicating and disconnecting.

The CIL current-limiting capacitor fuse has a two-part design. The high current section interrupts high 60 Hz fault currents and/or high frequency discharge current from parallel capacitors. The low voltage section consists of a standard NEMA Type K fuse link mounted in a fiber tube. The low current section interrupts fault current associated with progressive failure of the capacitor unit dielectric, or 60 Hz fault current limited by the circuit impedance to low values. This type of design reduces fuse replacement cost to the price of a NEMA Type K fuse link when low current interruption occurs. The CIL capacitor fuse must be used with an ejector spring (see page 13). This spring ejects the link's leader, providing a positive indication of a blown fuse.

Application

- Voltage: The CIL fuse is used only for fusing individual single-phase capacitor cans; therefore, the CIL fuse voltage rating can be determined from the voltage rating of the capacitor unit (see table 1). Do not apply CIL fuses above their rated voltage.
- Energy: The CIL fuse is generally used on capacitor banks where parallel energy is more than 20 kilojoules or 6000 kVAR. The CIL fuse's maximum parallel capacitor discharge energy ratings are shown in the technical data table. CIL fuses are to be applied ONLY where there are two or more capacitors in parallel per group and where low inductively limited faults can flow. See appendix.
- Current: Table 1 lists the individual fusing recommendations for applying CIL fuses in indoor capacitor banks. The fusing tables are based on the following:

  $$\text{Capacitor current} = \frac{\text{kVar unit}}{\text{kV unit}}$$

  Minimum fuse current = capacitor current x 1.35 protective margin

- The protective margin accounts for normal overvoltages, harmonics, capacitor tolerances and a 40 °C (104 °F) ambient.
  Note: Table 1 current ratings are based on 40 °C (104 °F) ambient style numbers shown in Table 2. Derated current ratings for 55 °C (131 °F) ambient applications are also shown in Table 2.

Table 1: Fuse current rating based on available styles in Table 2

Capacitor voltage rating	Fuse voltage rating (kV)	kVAR				
		50	100	150	200	300
2400	5.5	34	56	-	-	-
2770	5.5	27	56	-	-	-
4160	5.5	21	34	49	65	-
4800	5.5	21	34	49	56	-
6640	8.3	11	21	33	47	-
7200	8.3	11	21	33	39	-
7620	8.3	11	21	33	39	-
7960	8.3	11	17	26	39	-
8320	15.5	9	16	26	32	-
9960	15.5	9	14	21	32	-
12470	15.5	9	12	16	26	32
13280	15.5	-	12	16	21	32
13800	15.5	-	12	16	21	32
14400	15.5	-	9	14	21	32
19920	23.0	-	-	-	21	21
21600	23.0	-	-	-	21	21

Technical data

Maximum design voltage (kV)	2.8	5.5	8.3	15.5	23.0
Maximum parallel capacitor discharge energy rating (kilojoules)	85	77	75	88	50
Maximum 60 Hz inductive current interrupting (kA RMS symmetrical)	40	40	60	90	60
Maximum peak recovery voltage (kV)	9	17	26	48	72

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06 Indoor installation, type CIL fuse/ capacitor upright
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07 Indoor installation, type CIL fuse/capacitor edge-mount

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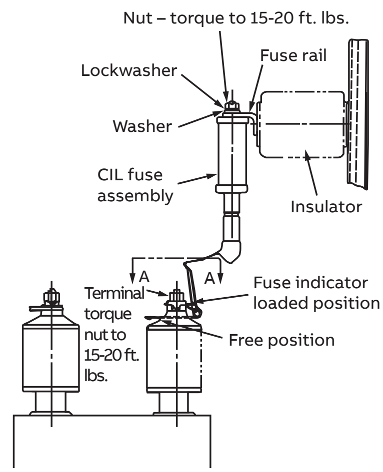
Table 2: Fuse style number (includes fuse link)

Max. fuse design voltage (kV)	Rated max. voltage**	Continuous current rating (A) 40 °C	Continuous current rating (A) 55 °C*	NEMA Type K fuse link hardware	Type CIL with mounting
5.5	6.05	21	18	15	279C420A08
5.5	6.05	27	23	20	279C420A09
5.5	6.05	34	29	25	279C420A10
5.5	6.05	40	34	30	279C420A11
5.5	6.05	49	42	40	279C420A12
5.5	6.05	56	48	50	279C420A13
5.5	6.05	65	55	65	279C420A14
8.3	9.13	11	9	8	279C420A16
8.3	9.13	14	12	10	279C420A17
8.3	9.13	17	14	12	279C420A18
8.3	9.13	21	18	15	279C420A19
8.3	9.13	26	22	20	279C420A20
8.3	9.13	33	28	25	279C420A21
8.3	9.13	39	33	30	279C420A22
8.3	9.13	47	40	40	279C420A23
15.5	17.05	9	8	6	279C420A26
15.5	17.05	12	10	8	279C420A27
15.5	17.05	14	12	10	279C420A28
15.5	17.05	16	14	12	279C420A29
15.5	17.05	21	18	15	279C420A30
15.5	17.05	26	22	20	279C420A31
15.5	17.05	32	27	25	279C420A32
23.0	25.3	21	18	15	273C420A40

*Fuse links are rated based on their melting characteristics. They can carry approximately 150% of their rating continuously.
**Ref: IEEE C37.40

Mounting and ejector spring

The CIL fuse must be used with style number 898A431H02 ejector spring (fuse indicator). The gas-deflecting elbow must be positioned so the opening points to the capacitor unit.



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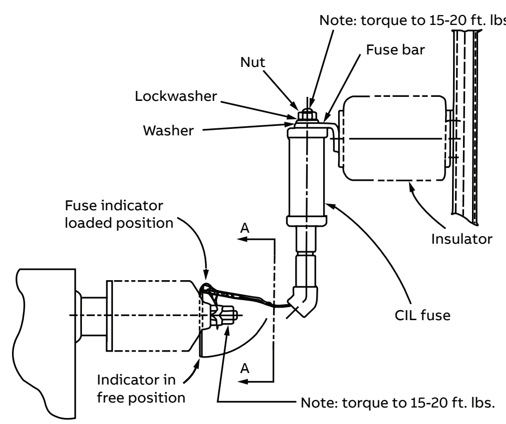

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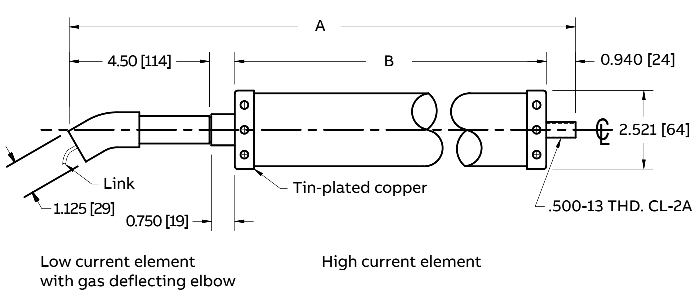
Unit dimensions



kV	A (in.)	B (in.)	Weight (lbs)
5.5	14.0	7.75	3.5
8.3	14.0	7.75	3.5
15.5	16.25	10.0	4.2
23.0	18.375	12.125	4.5

Type CLXP
Indoor current-limiting capacitor fuse — high energy

The CLXP fuse is an individual capacitor fuse with very high energy capability that is used in outdoor capacitor banks with many parallel capacitor units. It contains a current-limiting section of the “silversand” type of construction, with an interrupting rating of 60,000 amperes asymmetrical and can successfully dissipate the stored energy discharge of any number of parallel-connected capacitors. In addition, it has a separate low current interrupting section similar to the CXP fuse, which contains a standard fuse link.

Advantages of the CLXP fuse over earlier current- limiting fuses are:
- Improved interrupting characteristics
- Improved energy-dissipating ability
- Less susceptible to unwanted fuse blowing
- Low current faults — may be inexpensively re-fused simply by replacing the fuse link in the low current section

The CLXP capacitor fuse must be used with an ejector spring (see page 15). This spring ejects the link’s leader, giving a positive indication of a blown fuse.

Application
- Voltage: The CLXP fuse is used only for fusing individual single-phase capacitor cans; therefore, the CLXP fuse voltage rating can be determined from the voltage rating of the capacitor unit. Do not apply CLXP fuses above their rated voltage.
- Energy: The CLXP fuse is generally used on those capacitor banks where parallel energy is more than 20 kilojoules or 6000 kVAR. The CLXP fuse’s maximum parallel capacitor discharge energy rating is unlimited.
- The CLXP fuse should not be used on single series group grounded wye or single series group delta connected capacitor banks.

The CLXP fuse is used on capacitor banks with large numbers of parallel capacitors. The CLXP can be used in applications with essentially infinite parallel stored energy, as long as sufficient back voltage can be developed to force the current to extinguish. The fuse is usually applied to series, large shunt and DC capacitor banks. Because of the high back voltage that is developed, this fuse must be used with several capacitors in parallel to limit the voltage build up, or a flashover may occur elsewhere in the capacitor bank. The CLXP cannot be used in inductively limited fault applications.

Current
The CLXP fuse current rating is based on the following:

$$\text{Capacitor current} = \frac{\text{kVar unit}}{\text{kV unit}}$$

Fuse current rating = capacitor current x 1.35 protective margin

The protective margin accounts for normal overvoltages, harmonics, capacitor tolerances and a 25 °C (77 °F) ambient.

CLXP fuse styles
Many styles of CLXP fuses are available. The designs range from 2.5 kV to 25 kV maximum AC design voltage, to 50 amps high current elements and low current element tube capable of using up to 65K links.

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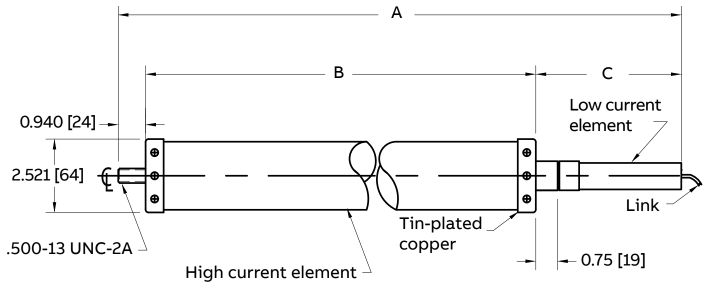
Fuse style number (includes fuse link)

Max. fuse design voltage (kV)	kVAR	Amps	65T	CLXP style number
2.5	100	54	65K	174C660A09
5	200	54	40T	174C660A30
8	200	33.75	30T	174C660A31
10	200	27	20T	174C660A32
15	200	18	15T	174C660A33
20	200	13.5	25T	174C660A34
25	150	8.1	40K	174C660A27
8	178	30	20T	4995C51A04
15	222	20	20K	4995C51A15
20	311	21	30K	4995C51A23

*Fuse links are rated based on their melting characteristics. They can carry approximately 150% of their rating continuously.
**Ref: IEEE C37.40

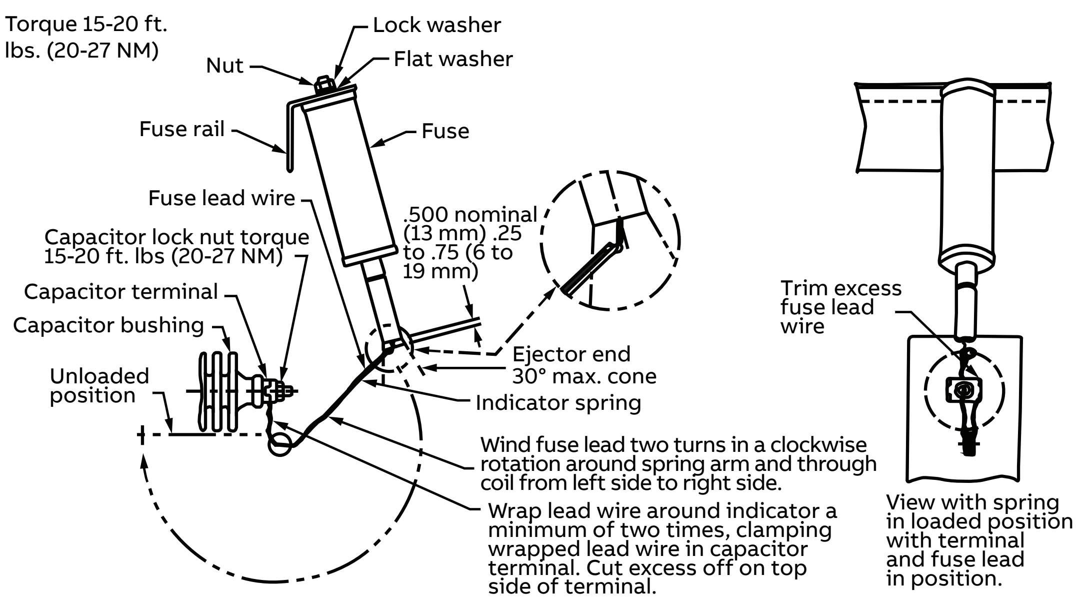
Unit dimensions



kV	A (in.)	B (in.)	C (in.)	Weight (lbs)
2.5	12.625	7.625	5.0	3.0
5.0	12.625	7.625	5.0	3.0
8.0	12.625	7.625	5.0	3.0
10	12.625	7.625	5.0	3.0
15	17.125	12.125	5.0	4.3
20	17.125	12.125	5.0	4.3
25	17.125	12.125	5.0	4.3

Mountings and ejector spring

The CLXP fuse must be used with ejector springs. The critical dimension is the distance from the capacitor bushing to the end of the fuse tube. Proper fit is important in order to avoid unnecessary adjacent capacitor fuse operations. Many styles of the torsion springs shown below are available. Contact your ABB representative for proper fit.



Type CXP
Outdoor expulsion capacitor fuse

The CXP fuse is an expulsion fuse designed for outdoor use only. CXP fuses exist in voltage classes of 8 kV, 15/20 kV and 25 kV. The primary application of these fuses is individual capacitor unit fusing in outdoor standard equipment. These fuses have a parallel energy capability of 30,000 Joules. They are not normally applied with more than 20,000 Joules of parallel energy, equivalent to 6000 kVAR of capacitors, because of the possibility of capacitor case rupture. Do not use CXP fuses if the available fault current exceeds the levels indicated below:

Fuse rating (kV)	Rated max. voltage*	Fused applied at (kV)	Interrupting rating**	
			Sym.	Asym.
9.7	10.67	8	7400	10,000
16.6	18.26	15	3600	5000
26.2	28.82	20	1800	2500
26.2	28.82	25	1800	2500

*Ref: IEEE C37.40
** 60 Hz, amps RMS

Fuse style number (does NOT include fuse link)

Fuse rating (kV)	Capacitor unit voltage (kV)	Style number	
		For aluminum or copper bus, tin-plated brass end cap	For aluminum bus only (aluminum end cap)
9.7	2.4 to 8.8	1C09100A02	1C09100A01
16.6	8.3 to 15.1	1C09100A04	1C09100A03
26.2	15.1 to 23.8	1C09100A06	1C09100A05

The CXP fuse is a 100 A expulsion fuse designed for outdoor use only and should be used only in the following cases:
- In all ungrounded wye applications.
- In all grounded wye applications when the capacitor units are connected in two or more series groups.
- In a grounded wye application with one series group and the available fault current does not exceed the level indicated above.

Note: The CXP capacitor fuse must be used with an ejector spring (see page 17). This spring ejects the link's leader, giving a positive indication of a blown fuse.

Interrupting and energy limits

Available short circuit current must be measured at the capacitor unit location. Type CXP fuses applied on capacitor units in a single series group will see the full short circuit current of the system series group with a failed capacitor. In applying the CXP fuse, it is recommended that no more than 6000 kVAR (20,000 Joules) be applied in parallel in a series group to avoid possible capacitor case rupture.

Voltage

The CXP voltage rating should be equal to or greater than the capacitor can voltage times 1.1.

Link selection

$$\text{Capacitor current (Ic)} = \frac{\text{kVar unit}}{\text{kV unit}}$$

Select a link where link rating is equal to or greater than 0.9 of the Ic.

Link rating >= 0.9 x Ic
Link ratings to choose from: 8K, 10K, 12K, 15K, 20K, 25K, 30K, 40K, 50K or 65K

Rationalization

- Desired fusing factor is Ic x 1.35 or greater
- Link ampacity is rating times 1.50
- 1.35 / 1.5 = 0.9; therefore, choosing a link at ≥ 0.9 of Ic will result in a minimum fusing factor of 1.35
- Example: 200 kVAR, 9960 volt capacitor
  Ic = 200 / 9.96 = 20.08 x 0.9 = 18.07
  Next higher link rating = 20K
  Link ampacity is 20 x 1.5 = 30
  Fusing factor 30 / 20.08 = 1.49

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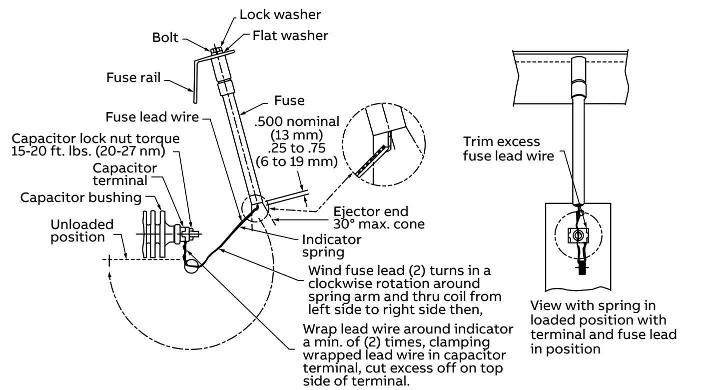
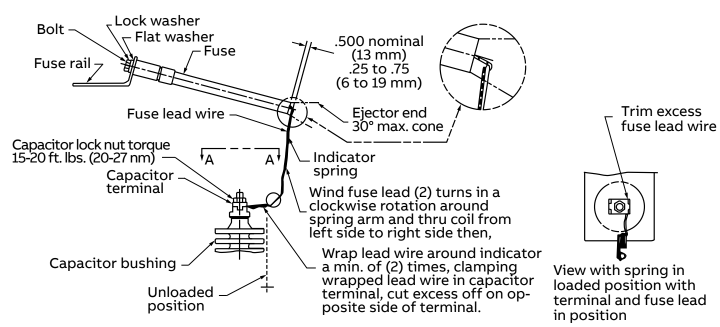
Fuse link current ratings (for Type K fuselinks)

Capacitor voltage rating (kV)	Capacitor unit kVAC (K)					
	50	100	150	200	300	400
2.40	20	40	65	–	–	–
4.16	12	25	40	50	–	–
4.80	10	20	30	40	65	–
6.64	8	15	25	30	50	65
7.20	8	15	20	25	40	50
7.62	6	12	20	25	40	50
7.96	6	12	20	25	40	50
8.32	6	12	20	25	40	50
9.54	6	10	15	20	30	40
9.96	6	10	15	20	30	40
11.40	6	8	12	20	25	40
12.00	6	8	12	15	25	30
12.47	6	8	12	15	25	30
13.28	6	8	12	15	25	30
13.80	6	8	10	15	20	30
14.40	6	8	10	15	20	25
17.20	6	6	8	12	20	25
19.92	6	6	8	10	15	20
20.80	6	6	8	10	15	20
21.60	6	6	8	10	15	20
22.80	6	6	6	8	12	20
23.80	6	6	6	8	12	20
24.94	6	6	6	8	12	15

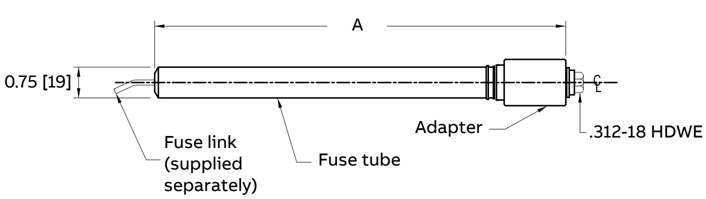
Mountings and ejector spring

The CXP fuse must be used with ejector springs. The critical dimension is the distance from the capacitor bushing to the end of the fuse tube. Proper fit is important in order to avoid unnecessary adjacent capacitor fuse operations. Many styles of the torsion springs shown below are available. Contact your ABB representative for proper fit.





Unit dimensions



Fuse rating (kV)	A (in.)	Fuse tube OD (in.)	Max. link size (A)	Weight (oz.)
9700	8.25	0.875	100	6.5
16,600	10.00	0.75	50	6.0
26,200	10.00	0.75	50	6.0

Appendix

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08 Ungrounded “Y” bank
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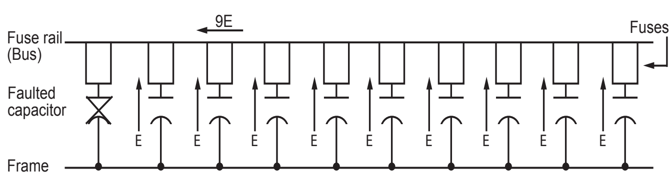
09 Grounded “Y” bank

Example: Determine maximum parallel energy
E = 2.64 $(1.10)^2$ watt-seconds per kVAR
E = 3.19 watt-seconds per kVAR for 10% overvoltage condition
E = 3.80 watt-seconds per kVAR for 20% overvoltage condition

Rule: The size and number of capacitors connected in parallel in any one series group should not result in more than 20,000 watt-seconds being liberated into a faulted capacitor unit when using type CXP expulsion fuse.

Example:
5 series groups, 10 ea. 200 kVAR, 13280 V capacitor units per series group.

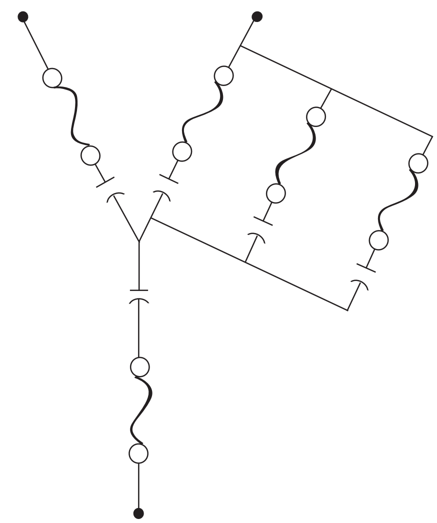


Energy through fuse ahead of faulted capacitor $= 3.19 \frac{\text{watt-seconds}}{\text{kVAR}} \times 9 \text{ units} \times 200 \frac{\text{kVAR}}{\text{unit}} = 5742$ watt-seconds

Select a 15 kV type CXP expulsion fuse

Rule: Current-limiting type COL fuses should be used when the maximum parallel kVAR exceeds 6000 kVAR.

Single series group capacitor bank



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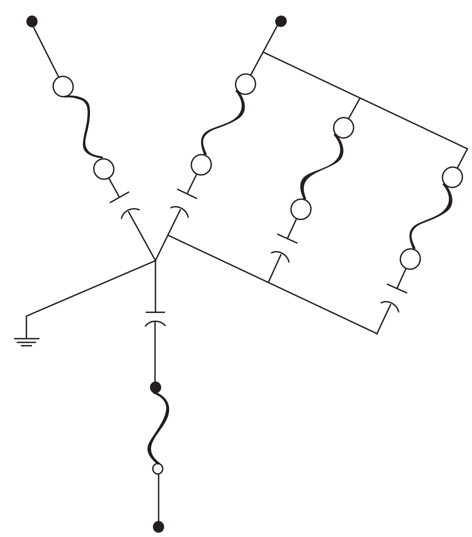

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