■ Application and selection guide BLC, CR and CS-type – Super rapid fuse

When selecting fuses for semiconductor rectifier circuit protection the following conditions must be satisfied.
For additional details contact FUJI.

■ Conditions of application

1. The rated interrupting current of the fuse must be greater than the estimated short circuit current of the circuit.

   Available short circuit current of rectifier circuit $<$ Rated interrupting current of fuse

2. The let-thru current value of fuse must be less than the allowable 1/2 cycle surge current value.

   Fuse let-thru current value $\leqq$ Semiconductor – 1/2 cycle allowable surge current 10ms (at 50Hz)

3. The total clearing I^2t value which the fuse requires to complete interruption must be less than the allowable I^2t value of semiconductor.

   Fuse – total clearing I^2t $\leqq$ Semiconductor – I^2t

4. The rated current of the fuse must be greater than the average forward current of the semiconductor.

   Fuse – rated current $>$ Semiconductor – average forward current

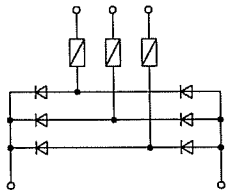
5. The rated current and voltage of the fuse must be greater than those of the rectifier circuit.

   Fuse – rated current and voltage $>$ Rectifier circuit – current and voltage

Method of application

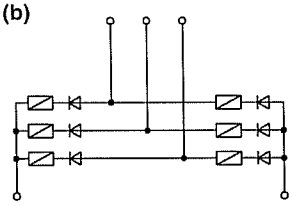
Semiconductor rectifier equipment has a variety of rectifier circuits. Taking the 3-phase bridge rectifier circuit as an example – Fig. (a) and (b) as shown in the following.
Although the number of fuses used in the line fuse method (a) is half the number used in the element fuse method (b), the fuses must have a larger current capacity.

Fig. (a)



Line fuse method
In this method the fuses are connected to the AC line side.

Fig. (b)



Element fuse method
In this method the fuses are connected in series to the semiconductor element.

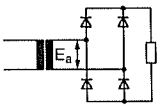
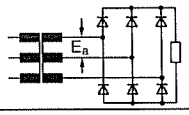
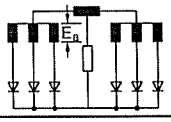
■ Fuse ratings

When selecting fuses various factors such as protection, coordination and load, etc. must be considered.
However, in this catalog the main matters such as voltage, current and I^2t only are explained.

• Rated voltage

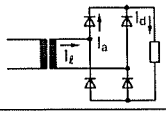
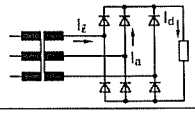
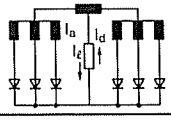
The rated voltage of the fuse indicates the maximum operational voltage and this also indicates the root-mean-square value of the AC sinusoidal wave voltage. Select fuses having a rated voltage exceeding the voltage obtained by the formula shown in the following table. (Fig. 1)
Do not select current-limiting fuses with rated voltages drastically exceeding the rectifier circuit voltage. It is necessary to consider the arc voltage.

Fig. 1 Rated voltage required by fuses

Wire connection type	Wiring diagram	Rated voltage of Fuse (V_{FN} rms) For line fuse	For element fuse
Single-phase bridge		$V_{FN} \geqq a \cdot E_a$	$V_{FN} \geqq a \cdot E_a$
3-phase bridge		$V_{FN} \geqq a \cdot E_a$	$V_{FN} \geqq a \cdot E_a$
3-phase, double star		$V_{FN} \geqq a \cdot \sqrt{3} \cdot E_a$	$V_{FN} \geqq a \cdot \sqrt{3} \cdot E_a$

Remarks: The 'a' is a coefficient where the regulation of the AC input voltage is taken into account. This is a=1.1 in case of voltage regulation ±10%.

Fig. 2 Element current and line current

Wire connection type	Wiring diagram	Element fuse method Element current Ia	Line fuse method Line current Iℓ
Single-phase bridge		$Ia = \frac{Id}{\sqrt{2}} = 0.707d$	$I\ell = d$
3-phase bridge		$Ia = \frac{Id}{\sqrt{3}} = 0.577dl$	$I\ell = \sqrt{\frac{2}{3}}\,Id = 0.816dl$
3-phase, double star		$I\ell = Ia = \frac{Id}{2\sqrt{3}} = 0.289dl$	

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• **Rated current**
The current values in fuses in the line fuse system and the element fuse system are different. Obtain the correct current value from the table on *page 08/48* (Fig. 2).
When selecting the rated current of a fuse choose a fuse having an amperage rating greater than the current which flows in the semiconductor if the load is continuous and a fixed current.
If the current which flows in the semiconductor is greater than the rated current of the fuse connect the fuses in parallel. However, in this case, if the numbers of fuses arranged in parallel are 'n', then the I^2t value of the fuse will be $n^2 \cdot I^2t$ and n^2 times the I^2t value of one fuse. This should be taken into consideration when protective coordination is taken into account.
In the case of the circuit where the load rapidly varies the fuse element will suffer from mechanical deterioration and be damaged by thermal stress. In loads of this type the deterioration characteristics of the fuse must be closely considered.
Moreover if the fuse current – time characteristics of the fuse selected is less than the overload characteristics of the semiconductor element then complete protection can be obtained. However, if the semiconductor element has a large capacity then protective cooperation is very difficult to arrange. The fuses are used to isolate the shorted semiconductor element circuit from sound operating circuits.

■ **Total clearing I^2t**
The total clearing I^2t of fuse is a very important factor when considering the protective coordination of the semiconductor. This total clearing I^2t is the value where the arcing I^2t is added to the melting I^2t. Therefore it is necessary to satisfy the following formula.

Fuse – total clearing I^2t $\leqq$ Semiconductor I^2t

The total clearing I^2t of fuse depends upon the operational voltage and interrupting current.

Therefore, for this reason if a 500 Volts fuse is used in a 300 Volts circuit the total clearing I^2t is reduced by 50–70%. However, the reduction rate varies according to the type of fuse construction. This must be checked and confirmed once more.

Example
I^2t
All I^2t values are ampere^2 seconds.

The I^2t data for silicon diodes or thyristor elements are normally given in their respective catalogs. If the A^2S data is not given in their catalog obtain the value in the following manner. If protection is needed for a 250V, 150A (I_o) diode having a maximum allowable peak half sine wave current of 2700A, it is important that the fuse has a total I^2t value lower than that of the diode.

Calculation

$$\text{Maximum } I^2t \text{ diode} = \left(\frac{1 \text{ Peak}}{2}\right)^2 0.0167$$
$$= \left(\frac{2700}{2}\right)^2 0.0167$$
$$= 30{,}400A^2 \text{ Sec.}$$

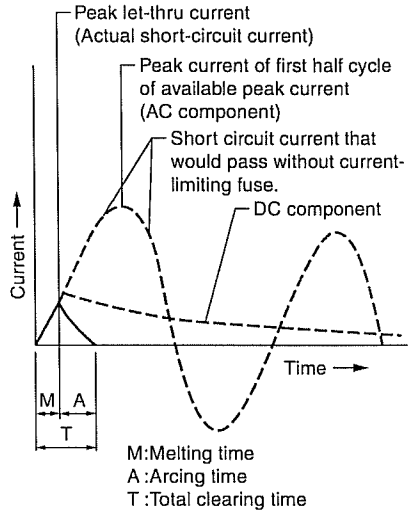
From the table (*Page 08/38*), the fuse with a total I^2t nearest to 30,400A^2 Sec. is the 260 Ampere fuse (CR 2L-260).

■ **Interrupting current**
The rated interrupting current of the fuse must exceed the maximum value (Symmetrical RMS value) of the estimated circuit fault current.

■ **Peak arc voltage**
In the case of the current-limiting fuse an arc voltage (overvoltage) is generated at the time of interruption due to its fusible element construction. It is necessary to check that this peak arc voltage does not exceed the semiconductor's maximum (Non-repetitive peak) reverse voltage value.

■ **Current limitation**
Select a fuse whose let-thru current value does not exceed the allowable 1/2 cycle surge current of the semiconductor. The allowable surge current is the peak value of the current which in case at 50Hz is allowed to flow for 10ms. In the current-limiting fuse the fault must be cleared in the shortest possible time or in the first 1/2 cycle.
Available current is the current which would flow if the fuse were not current-limiting.
This would cause damage to equipment. Let-thru current is the actual current allowed to flow by the current limiting action of the fuse. A number of let-thru current graphs are given in this catalog and example is given in the following paragraph. The method of reading this graph is provided for your reference.

How to find a let-thru current – Example
Fuse: 200 Amps 500V
Available R.M.S symmetrical current:
100,000 Amps
Let-thru peak current (Instantaneous):
11,600 Amps
Let-thru R.M.S. current
11,600 ÷ 1.7 = 6,800 Amps
This example clearly shows that while a 100kA (rms, sym) current is available, the fuse limits the current let-thru to 6,800 Amperes (rms, sym).



M:Melting time
A :Arcing time
T :Total clearing time