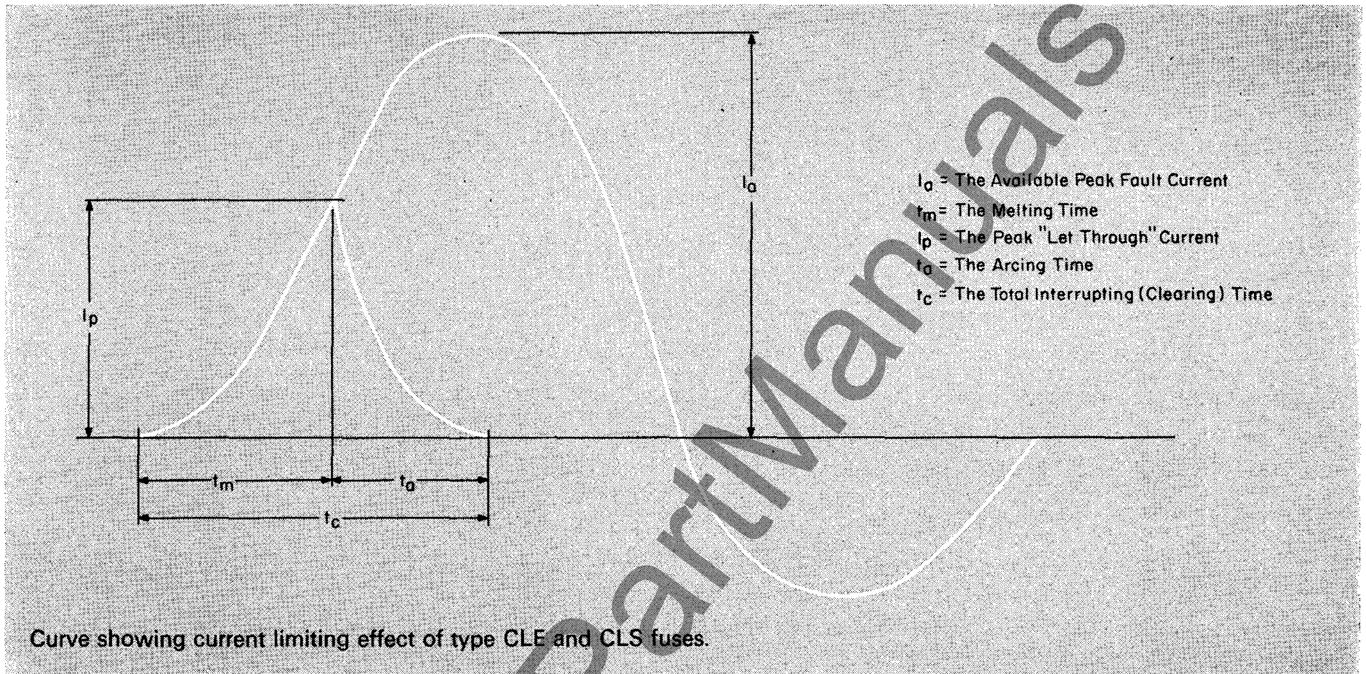
Westinghouse

High Voltage Power Fuses

Types CLV, CLE-PT and
CLE, All Types
Type CLS Motor-Starting Fuses,
All Types

Indoor, Current Limiting, 600 to 23000 Volts
½ to 400 Amperes, 50/60 Cycles



Curve showing current limiting effect of type CLE and CLS fuses.

In This Application Data

Description	Page No.	Table	Fig. No.
General information	1	..	..
Description	1	..	..
Let-through current	3	A	1,2
Threshold current	3	A	2
Ratings, voltage and continuous current	3	A	..
Fuse Selection			
Transformer protection	5	B	..
Motor protection	6, 7	C	3
Potential transformer protection	6	..	..
Fuses and lightning arresters	4	..	..
Fuse coordination	8	..	4

For time-current characteristics see AD 36-661-A.

General Information

The basic rules governing fuse selection are observance of voltage rating, full load rating, possible overloading, and the degree of protection required. Since fuses rather than circuit breakers are usually used for reasons of economy, consideration should be given to selection of the most economical rating of fuse for the task. The fuse whose interrupting rating exceeds the available fault current by the least amount is usually the most economical one.

In principal, if a circuit is to be protected by fuses, its normal load as well as frequency of permissible overloads should be known. The fuse must sustain these and it must, on the other hand, blow at specified fault currents. These requirements would make each fuse application a case of special study if it were not for the routine procedures worked out for the protection of distribution and substation transformers with conventional fuses, and for motor starters.

Each of these factors, as they apply to the selection of Types CLE and CLS current limiting fuses, is briefly outlined on the following pages.

Description

Current limiting fuses interrupt high fault currents before the first loop of fault current has reached its natural crest value. The current limiting action depends on the production of arc voltages which exceed the system voltage and thereby force current zero as illustrated in Figure 1. For any given fuse, the degree of current limitation depends on the available fault current and on the timing of fault initiation. If the fuse melts after the current has crested, it cannot limit the peak current which has already passed. With a fully asymmetrical fault, the current crests at about ½ cycle and, in the case of a symmetrical fault, in exactly one quarter cycle. Obviously, the current limiting action, usually described by the let-through current curve, changes with the degree of asymmetry of the fault. Conventional let-through current curves for high voltage fuses are drawn for faults having an asymmetry factor of 1.6. The current which melts the fuse the moment it reaches its first natural crest is called the **threshold current.** In the case presented in Figure 2, it is an asymmetrical current.

Let-through current curvesdrawn for a given asymmetry factor all have the same shape. Their only distinguishing feature for fuses of different rating is the value of the threshold current. Therefore, curve, Figure 2, plotted on a per-unit basis on threshold current holds for all current limiting fuses.

The threshold currents of Westinghouse current limiting fuses are given in Table A. In combination with Figure 2, the let-through

May, 1968
Supersedes AD 36-661 dated January, 1966
E, D, C/1971/DB

Westinghouse

current at any fault current can be determined. Since the let-through current at rated interrupting capacity is of particular interest, this is listed in Table A, although it can be read from Figure 2 as well.

Calculation of let-thru current for CLS fuse represented in Fig. 1, using graph in Fig. 2.

Fault Current = 36,500 amperes

Threshold Current = 8,850 amperes (from Table A)

$$\frac{\text{Available fault current x 1.6}}{\text{Threshold current}} = \text{per unit available asymmetrical current}$$

$$\frac{36{,}500 \times 1.6}{8{,}850} = 6.6 \text{ per unit available asymmetrical current}$$

6.6 on graph represents approximately 3.8 per unit peaks of threshold current. Let-thru current of fuse is per unit peaks times threshold.

3.8 x 8,850 = 33,630 amperes calculated let-thru current

Figure 1: **Current Limiting Action of a 225 Amp 4.8 Kv Type CLS Fuse Clearing a 5,050 Volt 36,500 Amp Fault, Equivalent 3-Phase Kva – 320,000.**

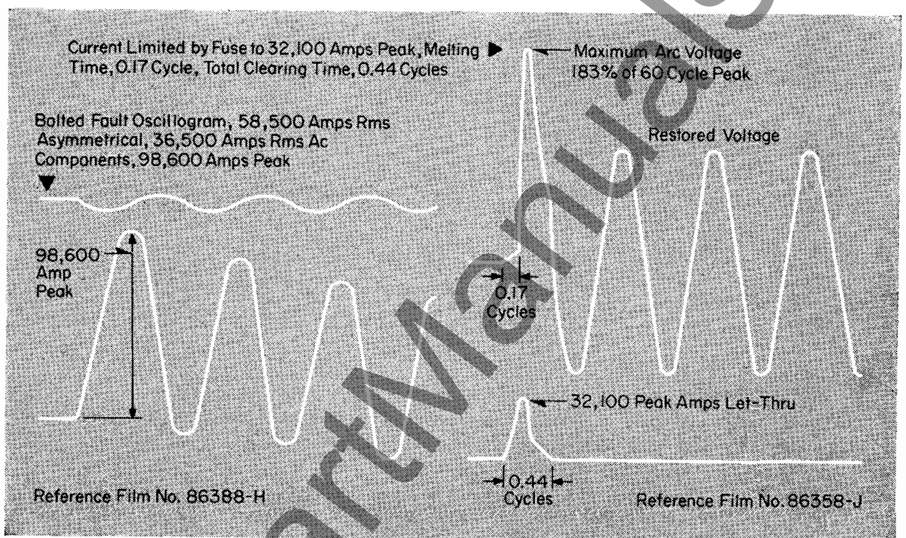
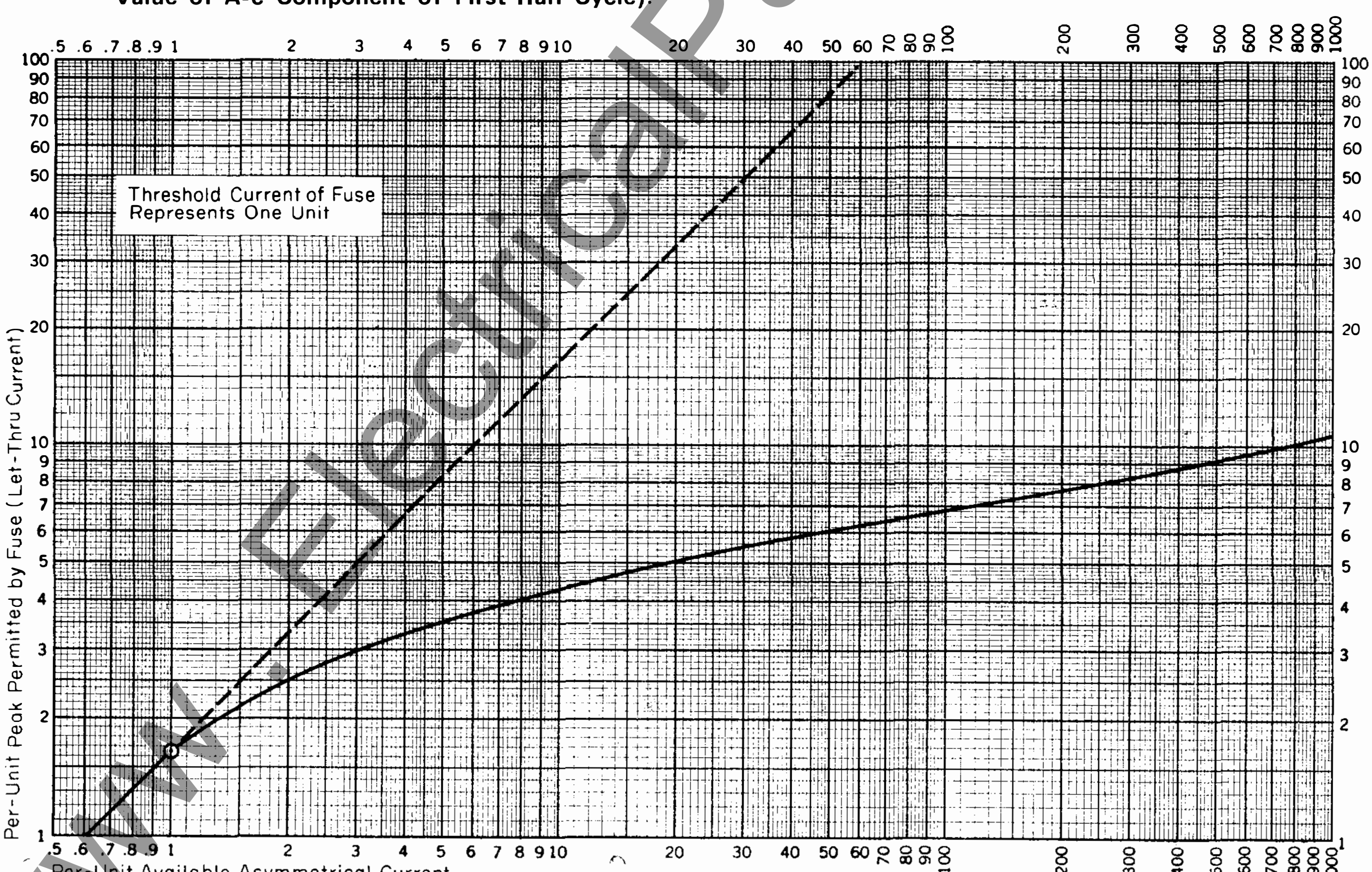


Figure 2: **Let-through Current Characteristics of Current Limiting Fuses at Asymmetrical Short-circuit (1.6 x Rms Value of A-c Component of First Half Cycle).**



High Voltage Power Fuses

Types CLV, CLE-PT and
CLE, All Types
Type CLS Motor Starting Fuses,
All Types

Indoor, Current Limiting, 600 to 23000 Volts
½ to 400 Amperes, 50/60 Cycles

Table A: Let-through Current Characteristics for Asymmetrical Fault Conditions (1.6 Asymmetrical Factor)

Fuse Type	Kv	Amps	Interrupting Rating Amperes – RMS Symmetrical	Threshold Current Amperes – RMS Asymmetrical	Let-through Current Rated Interrupting Current Asymmetrical Condition, Amperes
CLV	0.6	2E	63,000	35	450
		5E	63,000	85	935
		7E	63,000	120	1,210
		10E	63,000	170	1,615
		15E	63,000	250	2,170
		20E	63,000	350	2,870
			2.4 Kv 4.8 Kv		
CLE-PT (NI)	2.4 and 4.8	.25E	40,000 40,000	2	42
		.50E	40,000 40,000	4	70
		1.0E	40,000 40,000	26	330
		2.0E	40,000 40,000	26	330
		5.0E	25,000	112	965
CLE-PT (NI)	7.2	2E	25,000	26	300
CLE-PT (IND)	4.8	.5E	80,000	30	425
		1.0E	80,000	83	965
		1.5E	80,000	83	965
		3E	80,000	40	540
		5E	80,000	115	1,240
		10E	80,000	230	2,140
CLE-PT (IND)	7.2	.5E	80,000	30	425
		3E	80,000	40	540
		5E	80,000	115	1,240
		10E	80,000	230	2,140
CLE-PT (IND)	14.4	.5E	80,000	30	425
		1.0E	80,000	83	965
		1.5E	80,000	83	965
		3E	80,000	40	540
		5E	80,000	115	1,240
		10E	80,000	230	2,140
CLE-PT (IND)	23.0	.5E	44,000	30	380
		1.0E	44,000	83	880
CLE	2.4, 4.8 and 7.2	15E	50,000	345	2,690
		20E	50,000	460	3,450
		25E	50,000	575	4,130
CLE	14.4	15E	31,500	345	2,480
		20E	31,500	460	3,170
		25E	31,500	575	3,800
CLE-1	2.4 and 4.8	30E	50,000	750	4,930
		40E	50,000	750	4,930
		50E	50,000	1,500	8,650
		65E	50,000	2,200	11,900
		80E	50,000	2,200	11,900
		100E	50,000	2,950	14,750
		125E	50,000	4,450	21,000
		150E	50,000	5,900	25,800
		200E	50,000	7,400	30,500
		225X	50,000	8,850	34,500
CLE-1	7.2	30E	50,000	880	5,900
		40E	50,000	880	5,900
		50E	50,000	1,320	8,320
		65E	50,000	1,760	10,400
		80E	50,000	2,200	12,650
		100E	50,000	3,080	16,650
		125E	50,000	4,400	21,750
CLE-1	14.4	30E	85,000	950	6,840
		40E	85,000	1,270	8,760
		50E	85,000	1,270	8,760
		65E	85,000	1,900	12,160

Fuse Type	Kv	Amps	Interrupting Rating Amperes – RMS Symmetrical	Threshold Current Amperes – RMS Asymmetrical	Let-through Current Rated Interrupting Current Asymmetrical Condition, Amperes
			2.4 Kv 4.8 Kv		**2.4 Kv 4.8 Kv**
CLE-2	2.4 and 4.8	250E/280X	40,000 50,000	8,850	34,550 36,730
		300E/325X	40,000 50,000	10,000	38,000 40,500
		350X	40,000 50,000	11,250	41,300 43,880
		365X	40,000 50,000	12,500	44,400 43,880
		400X	40,000 50,000	13,750	48,000 50,880
CLE-2	7.2	150E	40,000	5,270	25,000
		200E	40,000	7,050	31,000
CLE-2	14.4	80E	85,000	2,530	15,430
		100E	85,000	3,170	18,550
		125X	85,000	3,800	21,660
CLE-11	2.4	30E	50,000	750	4,930
		50E	50,000	1,500	8,650
		65E	50,000	2,200	11,900
		80E	50,000	2,200	11,900
		100E	50,000	2,950	14,750
		125E	50,000	4,450	21,000
		150E	50,000	5,900	25,800
		200E	50,000	7,400	30,500
		225X	50,000	8,850	34,500
CLE-21	2.4	250E	40,000	8,850	34,550
		300E	40,000	10,000	38,000
		350E	40,000	11,250	41,300
		365E	40,000	12,500	44,400
		400X	40,000	13,750	48,000
CLE-12	2.4/4.8	30E	50,000	750	4,930
		50E	50,000	1,500	8,650
		65E	50,000	2,200	11,900
		80E	50,000	2,200	11,900
		100E	50,000	2,950	14,750
		125E	50,000	4,450	21,000
		150E	50,000	5,900	25,800
		200E	50,000	7,400	30,500
		225X	50,000	8,850	34,500
CLE-22	2.4/4.8	250E/280X	40,000	8,850	34,550
		300E/325X	40,000	10,000	38,000
		400X	40,000	13,750	48,000
Motor Starting Fuses					
CLS-1, CLS-11 & CLS-13	2.4 and 4.8	50A	50,000	1,500	9,150
		70A	50,000	2,200	12,550
		90A	50,000	2,950	15,900
		110A	50,000	3,700	18,700
		130A	50,000	4,450	22,000
		200A	50,000	6,650	30,000
		225A	50,000	8,850	37,200
CLS-2 CLS-21 & CLS-23	2.4 and 4.8	300A	50,000	11,250	43,800
		400A	50,000	15,000	54,000
CLS-12-14	2.4/4.8	30A	50,000	750	4,930
		50A	50,000	1,500	9,150
		70A	50,000	2,200	12,550
		90A	50,000	2,950	15,900
		110A	50,000	3,700	18,700
		130A	50,000	4,450	22,000
		200A	50,000	6,650	30,000
		225A	50,000	8,850	37,200
CLS-22-24	2.4/4.8	300A	50,000	11,250	43,800
CLS-22	2.4/4.8	400A	50,000	15,000	54,000
CLS-24	2.4/4.8	400A	50,000	14,000	51,000

Westinghouse

Ratings, Voltage and Continuous Current

Voltage Rating: The first rule regarding fuse selection is that the maximum line-to-line voltage of the system must not exceed the maximum design voltage of the fuse regardless of the system grounding conditions. The fuse voltage rating generally should not be permitted to exceed 140% of the system voltage because of overvoltages which are created due to the current limiting action of the fuse. The exception to this is that 600 volt-rated fuse units may be applied on circuits rated 220 to 600 volts.

Continuous Current Rating: Power fuses are designed so that they can carry their rated current continuously without exceeding the temperature rises permitted by applicable NEMA and ASA Standards. In the majority of applications, however, the rated load current of the equipment which they are to protect should not be allowed to equal the current rating of the fuse. This is because fuses, having a rather low thermal capacity, cannot carry overloads of the same magnitude and duration as motors and transformers of equal continuous current rating.

Frequency Ratings: Type CLE current limiting fuses rated 10E amperes or less are rated 25/60 cycles and may be applied on systems having frequencies of 25 to 60 cycles. Current limiting fuses rated greater than 10E are rated 50/60 cycles and may be applied at full interrupting rating on either 50 or 60 cycle systems. For operation on 25 cycle systems, the interrupting duty must be reduced in most cases.

Interrupting Ratings: The rated interrupting capacity of power fuses is the rms symmetrical value (a-c component) of the highest current which the fuse is able to interrupt under any condition of asymmetry. In other words, the interrupting rating denotes the maximum symmetrical fault current permitted at the fuse location. The accepted asymmetry factor for power fuses is 1.6. The rms asymmetrical amperes may be converted to the symmetrical value by dividing by this factor. The interrupting ratings for Westinghouse current limiting fuses are shown in DB 36-651 and PL 36-621.

Three phase kva ratings corresponding to the fuse interrupting ratings are calculated in the conventional manner by the formula I x KV x 1.73 where I is the interrupted current in symmetrical rms amperes and kv is the system line-to-line voltage.

It should be noted that current limiting fuses, when subjected to faults above the threshold current, interrupt the circuit before the current during the first half cycle reaches a peak value. Thus, the current that the fuse is required to interrupt is considered to be that current which would flow if the fuse were replaced in the circuit by a conductor having zero impedance.

Asymmetry Factor: The asymmetry factor is the ratio between the rms values of the asymmetrical current, which includes a d-c component, and that of the symmetrical current. The theoretical maximum of the asymmetry factor is 1.73. With the X/R ratios encountered in power circuits, it is hardly ever more than 1.6.

Melting Time: The minimum melting time of a particular fuse unit is the minimum amount of time in seconds required to melt the fuse elements at a particular value of current under specified conditions.

Arcing Time: The fuse arcing time is the amount of time in seconds elapsing from the melting of the fuse element to the final interruption of the circuit.

Clearing Time: The total clearing time is the maximum amount of time in seconds, measured from the beginning of a particular overcurrent condition, to complete interruption of the circuit. The total clearing time is the sum of the arcing time and melting time.

Note:

E – Ratings are defined by NEMA standards. (See Application Data 36-660, page 1 & 2)

X – Ratings define fuses where:

1. The minimum melting current is from two to three times the full load current.

Fuses and Lightning Arresters

Current limiting fuses perform their function by producing arc voltages which exceed the system voltage by a significant amount. These arc voltages of course, must not be higher than the basic insulation level of the associated equipment, nor must they cause interconnected lightning arresters to operate since a relatively high current would thereby be shunted into lightning arresters not designed for such interrupting duty.

Westinghouse current limiting fuses are designed so that the arc voltage peak at rated interrupting current is less than two times that of the nominal voltage rating. For a 4800 volt fuse, for example, this would be 2 x 4.8 x 1.41 = 13.6 kv peak volts. If short time application of such a voltage is not harmful to associated apparatus of a lower voltage class (say 2400 volt) apparatus, a 4800 volt fuse may well be employed on a 2400 volt circuit. Lightning arresters are the principal equipment to check in connection with the application of current limiting fuses which have a rating higher than the circuit voltage.

Current limiting fuse arc voltages do not effect the associated lightning arresters if the arresters are on the load side of the fuse, or if the fuse and arrester have the same voltage rating.

If the arrester is on the line side and has a voltage rating lower than that of the fuse, it will spark over. Under this condition the arrester and fuse will share the current. Distribution type arresters with their higher impedance do not get excessive amounts of current (energy) and are not damaged.

Intermediate and station type arresters having a lower impedance will be subjected to the excessive current (energy) and may become damaged.

Therefore, do not apply station and line type arresters on the line side or in parallel with the fuses.

Machine protection arresters purposely are designed to have low sparkover values. They should, however, be connected directly to the machine terminals and not on the line side of the fuse. Therefore, if connected properly, the fuse arc voltage can have no effect on them. Correctly applied Westinghouse lightning arresters found on the line side of the fuse have sparkover values sufficiently high to remain unaffected by fuse operations.

High Voltage Power Fuses

Types CLV, CLE-PT and
CLE, All Types
Type CLS Motor Starting Fuses,
All Types

Indoor, Current Limiting, 600 to 23000 Volts
½ to 400 Amperes, 50/60 Cycles

Transformer Protection

Fuses in the primary of a power transformer should not blow on transformer magnetizing or inrush current, nor should they blow or deteriorate under long duration overloads to which the transformer is subjected in normal service and in cases of emergency. On the other hand, they must protect the transformer against short circuits. These considerations usually determine the upper and lower limit of the fuse rating. The coordination with other protective devices on the system often further limits the range. In general, the "fuse rating to load current" ratio determines the fuse rating which should be selected.

In the routine process of applying fuses on the basis of the kva rating of a transformer, one does assume that adequate secondary protection is provided. The ordinary procedure then is to employ a fuse rating that does not blow nor is its structure damaged by overheating due to any inrush current or overload current which the transformer permits and can carry safely. Based on transformer characteristics as known from standards, one arrives at the following minimum current limiting fuse ratings and transformer full load currents:

Ratio of fuse rating to transformer full load rating:

1.4:1 for 4.8 kv and 7.2 kv fuses
1.49:1 for 14.4 kv fuses
(see appendix #1 of AD 36-660, page 12)

These ratios are based on the emergency overloads to which transformers may be subjected in accordance with data presented in ASA appendix C57.92.

If provisions are made, by thermal relays or otherwise, to limit transformer overloads to a lower range, the fuse-to-load ratio can be reduced below the values indicated below. It must be remembered that:

a. Under no condition must be fuse current rating be allowed to be less than the continuous load current.

b. No E-rated fuse can provide any protection between the range of one and two times the continuous load current.

c. With forced-cooled transformers, coordination must be based on the higher continuous current rating. Ratios of fuse rating to transformer full load rating forced cooled are:

1.2:1 for 4.8 kv and 7.2 fuses
1.31:1 for 14.4 kv fuses

Minumum fuse ratings for current limiting fuses to protect power transformers are shown in Table B.

Table B
Fuse Minimum Current Ratings for Power Transformers
Type CLE Current Limiting Fuses

System Kv	2.4		4.16		4.8		7.2		12		13.2		13.8	
Fuse Kv	2.4		4.8		4.8		7.2		14.4		14.4		14.4	
Transformer Kva Rating Self-Cooled	Full Load Current Amp	Fuse Rating Amp	Full Load Current Amp	Fuse Rating Amp	Full Load Current Amp	Fuse Rating Amp	Full Load Current Amp	Fuse Rating Amp	Full Load Current Amp	Fuse Rating Amp	Full Load Current Amp	Fuse Rating Amp	Full Load Current Amp	Fuse Rating Amp
Three Phase Transformer Banks														
9	2.16	15E	1.25	5E	1.1	5E	0.72	5E	0.43	5E	0.4	5E	0.38	5E
15	3.6	15E	2.08	5E	1.8	5E	1.2	5E	0.72	5E	0.66	5E	0.62	5E
30	7.2	15E	4.2	10E	3.6	5E	2.4	5E	1.44	5E	1.32	5E	1.25	5E
45	10.8	15E	6.2	10E	5.4	10E	3.6	5E	2.16	5E	1.98	5E	1.88	5E
75	18	25E	10.4	15E	9.0	15E	6	10E	3.61	10E	3.30	5E	3.1	5E
112.5	27	40E	15.6	25E	13.6	20E	9	15E	5.4	10E	4.95	10E	4.7	10E
150	36	50E	20.8	30E	18.0	25E	12	20E	7.2	10E	6.56	10E	6.2	10E
225	54	65E	31.3	50E	27.2	40E	18	25E	10.8	20E	9.9	15E	9.4	15E
300	72	100E	41.6	65E	36.0	50E	24	40E	14.4	30E	13.1	20E	12.5	20E
500	120	200E	69.4	100E	60	100E	40	65E	24.1	40E	21.9	40E	21	40E
750	180	250E	104	150E	90	125E	60	100E	36.1	65E	32.8	50E	31	50E
1000	241	350X	140	200E	120	200E	80	125E	48.1	80E	43.7	65E	42	65E
1500	360	....	208	300E	180	250E	120	200E	72.2	125X	65.6	100E	62	100E
2000	481	....	278	400X	241	350X	160	....	96.2	....	87.5	....	84	125X
2500	600	....	346	....	301	....	200	....	120	....	109	....	104	....
Single Phase Transformers														
5	2.08	15E	1.20	5E	1.04	5E	0.695	5E	0.416	5E	0.38	5E	0.362	5E
10	4.17	15E	2.40	5E	2.08	5E	1.39	5E	0.832	5E	0.76	5E	0.724	5E
15	6.25	15E	3.61	5E	3.13	5E	2.08	5E	1.25	5E	1.14	5E	1.085	5E
25	10.4	15E	6.01	10E	5.21	10E	3.47	5E	2.08	5E	1.90	5E	1.81	5E
37.5	15.6	25E	9.01	15E	7.81	10E	5.21	10E	3.12	5E	2.84	5E	2.71	5E
50	20.8	30E	12	20E	10.4	15E	6.95	10E	4.16	10E	3.80	5E	3.62	5E
75	31.3	50E	18	25E	15.6	25E	10.4	15E	6.25	10E	5.70	10E	5.43	10E
100	41.7	65E	24	40E	20.8	30E	13.9	20E	8.32	15E	7.6	15E	7.24	15E
167	70	100E	40	65E	35.0	50E	23.2	40E	13.9	20E	12.7	20E	12.1	20E
250	104	150E	60	100E	52.1	80E	34.8	50E	20.8	30E	19.0	30E	18.1	30E
333	139	200E	80	125E	69.5	100E	46.3	80E	27.7	40E	25.2	40E	24.1	40E
500	208	300E	120	200E	104	150E	69.6	100E	41.6	65E	38.0	65E	36.2	65E
667	278	....	160	225X	139	200E	92.6	150E	55.4	100E	50.5	80E	48.2	80E
833	347	....	200	280X	173	250E	115.5	200E	69.4	125X	63.5	100E	60.4	100E
1250	521	....	300	....	260	....	174	....	104	....	95	....	90.6	....

Westinghouse

Fusing of Potential Transformers

High interrupting capacity current limiting fuses are applied in the primary circuits of potential transformers to accomplish the following:

1. Provide system short circuit protection.
2. Prevent unnecessary fuse protection.

Type CLE-PT fuses provide protection for potential transformers and the respective systems to which the transformers are connected. These fuses have a high interrupting capacity. Proper application requires that the fuse unit have an interrupting rating equal to or greater than the maximum fault current available at the point of use.

Instrument potential transformer fuses are selected on the basis of the transformer magnetizing inrush current instead of the full load current rating. To prevent unnecessary fuse operation, the fuses must have sufficient inrush capacity to pass safely the magnetizing current inrush of the transformer.

In some applications, transformers are operated in a wye connection at .577 times their normal rated voltage. Types CLE-PT and CLV fuses will usually protect the transformer when applied at this reduced voltage but if the short circuit is through long leads, or if the primary voltage is materially decreased by the short circuit on the secondary (this will depend on the system and method of connection of the transformers), the short circuit may not blow the fuses.

Descriptive Bulletin 36-651 and Price List 36-621 list the "E" ratings, symmetrical and asymmetrical interrupting ratings, and maximum three phase kva interrupting rating.

Motor Protection

An adequately designed high voltage motor starter will utilize overload relays and types CLS-1 or CLS-2 current limiting fuses to provide complete overcurrent protection. The fuses operate to interrupt heavy fault currents. The overload relay will operate before the fuse and open the contactor to interrupt lesser but abnormal currents due to motor overloads, locked rotor, repeated starts, extended accelerating time or fault currents of a limited intensity. The proper combination of contactor, fuse, current transformer and overload relay must be used to obtain this coordination.

The responsibility for the coordination of the contactor, current transformers, overload relays and current limiting fuses rests with manufacture of the motor starter.

In selecting suitable components, the following points must be considered:

1. Protection of the motor against sustained overloads and against locked rotor conditions by means of the overload relays.

2. Protection of the fuses against sustained currents above their continuous ampere rating but below their melting value by means of an overload relay.

3. Protection of the circuit by means of the contactor within the interrupting limits of the contactor and below the operating time of the fuses.

4. Protection of the circuit, contactor, current transformers, and overload relays by means of properly sized current limiting fuses from the damaging effects of maximum fault currents.

Figure 3 shows the coordination for a current limiting fuse and starter combination. The motor is rated 1500 hp, 4160 volt, 3 phase. In selecting a fuse for such a coordinated scheme, the basic requirements for the fuse are:

1. A fuse continuous current rating equal to or greater than the full load current of the motor.

2. The capacity to carry, without damage, the currents due to extended acceleration time or locked rotor for sufficient time to allow the overload relay to operate.

3. The capacity to carry, without damage, currents greater than motor full load but below the trip rating of the overload relay.

Since the continuous rated current of a fuse must be at least as high as that of the apparatus it is to protect, and, since the minimum melting current of the fuse is at least twice its rated current, a power fuse cannot protect an

High Voltage Power Fuses

Types CLV, CLE-PT and
CLE, All Types
Type CLS Motor Starting Fuses,
All Types

Indoor, Current Limiting, 600 to 23000 Volts
½ to 400 Amperes, 50/60 Cycles

apparatus against anything less than 100 percent overload. Usually, this unprotected range or gap is even larger. If the user can forego protection in this range, a fuse can provide satisfactory protection at higher currents; however, certain additional restrictions are imposed by the fact that the damage characteristics of the apparatus and the clearing time-current characteristics of the fuse hardly ever coincide. Hence, fuse-protected apparatus may be exposed to overloads of somewhat longer duration than desirable, or the fuse may limit the equipment's overload capacity.

Full-range protection can be provided only by a combination of fuses and other sensing devices; for example, relays could be used to cover the range up to and somewhat beyond the maximum possible load current of the equipment; fuses would furnish only short-circuit protection. In this type of motor-protection scheme, the fuses are not protecting the motor itself but rather the circuit up to the motor terminals, particularly the starting equipment. In this type of application, the possibility of the fuse becoming affected by long-duration overloads (locked-rotor condition) should be avoided. This can be accomplished by selecting a fuse with a minimum melting current equal to, or in excess of, the locked-rotor current. Ten percent is a reasonable margin (where the manufacturer's application instructions will permit working this close), which means that the relay curve properly transposed into the fuse-melting characteristic should inersect the latter at a current ten percent or more in excess of the locked-rotor current. (Lacking specific information, the locked-rotor current may be assumed to be six times full-load current.)

The duty of fuses in motor-starter circuits is characterized by the frequent application of high overloads, i.e., motor starting currents. Properly designed motor-starter fuses are constructed to withstand these frequent and severe heating and cooling cycles without fatigue failures.

The ratings and styles of current limiting fuses particularly suited for motor starting duty are listed in Table C on right.

Figure 3: Fuse and Motor Starter Coordination Diagram

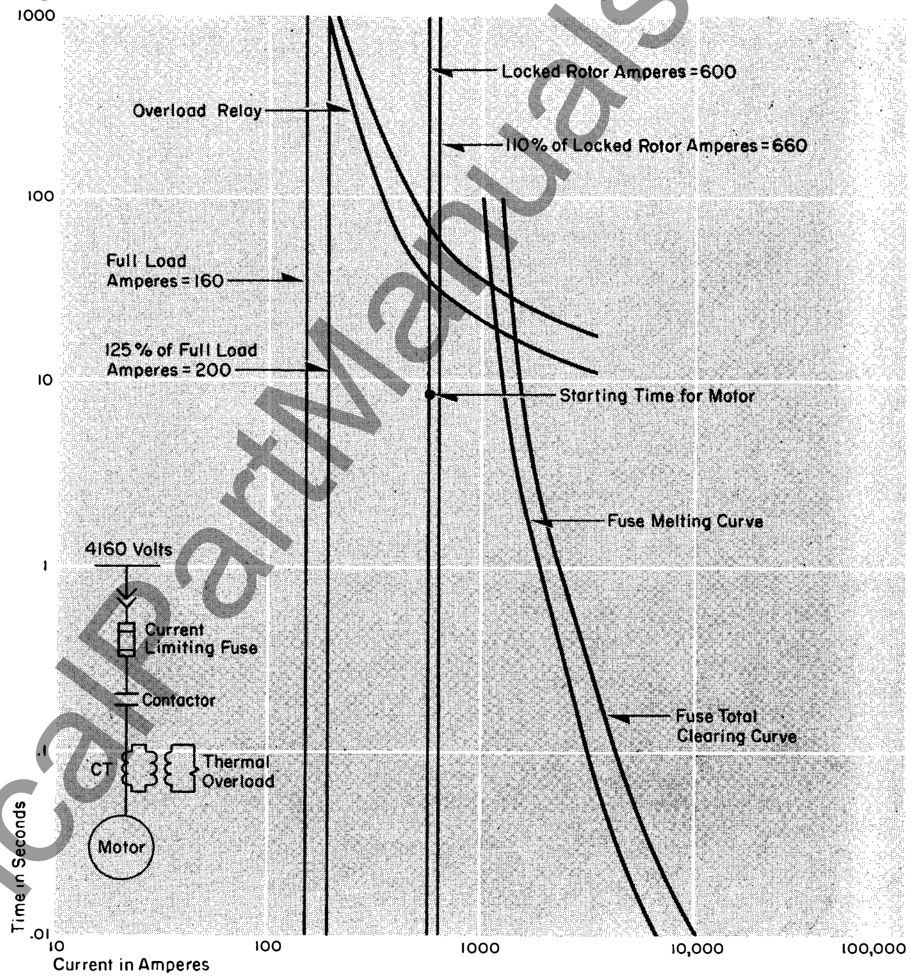


Table C: Ratings and Styles of Current Limiting Fuses Recommended for Motor Starters

Type	Continuous Current Amperes	Melting Current Amperes at 100 Sec.	Interrupting Rating Amps – Rms Symmetrical	Style Number 2.4 Kv	Style Number 4.8 Kv
CLS-1	50	170	50,000	676C546G02	676C546G15
	70	255	50,000	676C546G03	676C546G16
	90	340	50,000	676C546G04	676C546G17
	110	425	50,000	676C546G05	676C546G18
	130	510	50,000	676C546G06	676C546G19
	200	765	50,000	676C546G09	676C546G22
	225	1020	50,000	676C546G12	676C546G25
CLS-2	300	1530	50,000	304C463G01	304C463G03
	400	2040	50,000	304C463G02	304C463G04

High Voltage Power Fuses

Types CLV, CLE-PT and
CLE, All Types
Type CLS Motor Starting Fuses,
All Types

Indoor, Current Limiting, 600 to 23000 Volts
½ to 400 Amperes, 50/60 Cycles

Fuse Coordination

Coordination with Low Voltage Circuit Breakers: There are certain specific features of the current limiting fuses which make them the most desirable choice of fuse when coordinating with a low voltage circuit breaker. Current limiting fuses are generally available with greater maximum interrupting abilities than non-current limiting fuses. The current limiting fuse possesses a steeper melting and total clearing characteristic than expulsion type fuses. This can be an important factor when close coordination is required with load side low voltage air circuit breakers.

Figure 4 shows the coordination of a high voltage current limiting fuse with low voltage main and feeder breakers. The current limiting fuse can be seen to coordinate without any overlap and yet allows a minimum energy let-through current in event of a bus fault.

In a current limiting fuse application of this type, the current rating of the fuse selected is generally a minimum of 140 percent of the transformer self-cooled rated current. The exception is the case of 15 kv fuses which should be 149 percent of the transformer rated current. Such a selection will provide fault protection without blowing because of transformer inrush current. The requirements for fuses on the primary side of transformers may be stated in the order of importance as follows:

1. Protect the system against outages.
2. Protect against bolted secondary faults.
3. Coordinate with protective devices on the low voltage side.
4. Protect against higher impedance secondary faults to whatever extent is feasible.

In implementing the requirements of 3 and 4 above, the secondary circuit breaker should provide the best possible coordination with the fuses of the primary. The total clearing time of the breaker should lie below the minimum melting curve of the fuse for all values of current up to the maximum value of symmetrical fault current that can flow through the transformer to a secondary fault.

The melting curves of primary fuses and the tripping curves of the transformer secondary breakers frequently have widely different characteristics, and selective coordination without any overlap may be difficult to obtain. The fuse rating should not be increased arbitrarily in an attempt to secure complete coordination if it would mean that adequate protection would be sacrificed. It would be more desirable to allow a partial overlap of the primary fuse and the secondary main breaker curves since concurrent operation of the fuse and breaker would occur only for the relatively rare bus fault.

For coordination with secondary circuit breakers, a sufficient margin of safety must be provided against melting of the primary fuse because, in service, the melting times are reduced below those shown in the standard characteristic by preloading and other variables. This margin commonly is introduced into the coordinating procedure by lateral or perpendicular shifting of the no-load melting curve, the amount of the shift, to some extent, being left to engineering judgment. The melting curves in Application Data 36-660A make provision for this lateral shift. It is equivalent to a reduction of the no-load melting times to about 65 percent.

On applications where some overlap cannot be avoided, it is recommended that the primary fuses should be replaced as a matter of operating procedure whenever the secondary main breaker trips for a bus fault, as there is a possibility of damaging and still not blowing the fuses. Again, since bus faults are rare, particularly in enclosed switchgear assemblies, the probabilities of this condition ever occurring are very low.

Figure 4: Fuse and Breaker Coordination Diagram