Southern
States

The Quality Name in High Voltage Switching

Application of Power Fuses

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APPLICATION

High-voltage power fuses provide short-circuit protection for applications where circuit breakers are economically inadvisable. It does not provide automatic restoration of service, and it is not advisable to use them in locations where the frequency of operation is likely to be great. The principal application of power fuses is for the primary or secondary protection of power transformers. Power fuses can also be used on feeder circuits and capacitor banks.

SELECTION

The following factors should be considered in the selection of a power fuse:

1. Voltage Rating – Select a fuse having a maximum design voltage rating equal to or greater than the system line to line voltage.
2. Interrupting Rating – Determine the maximum asymmetrical short-circuit current available on the system at the fuse location. Select a fuse holder having an interrupting capacity equal to or greater than the available short-circuit current.
3. Fuse Element Characteristic – Southern States power fuse elements are available on two bases of rating;
   a. The NEMA Standard "E" rating – An "E" rated fuse element 100 amperes and below will melt in 300 seconds at a current within the range of 200 to 240 percent of the continuous current rating. Fuse elements rated more than 100 amperes will melt in 600 seconds at a current within the range of 220 to 264 percent of the continuous current rating.
   b. The "N" rating – An "N" rated fuse element will melt in 300 or 600 seconds at a current within the range of 115 to 125 percent of the continuous current rating.

Power fuse elements are available in three speed ratios* to provide the best possible coordination.

FUSE ELEMENT TYPE		SPEED	APPROX. SPEED** RATIO
"E"	"N"		
***	PF	Slow	19
PE	PM	Medium	12
***	PX	Fast	7

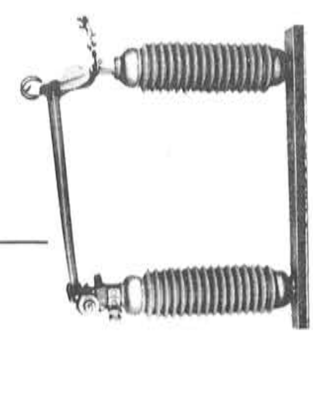
4. Fuse Element Current Rating – The current rating of a fuse element must be sufficiently large to handle normal short-time overloads and energizing and switching surges under normal operating conditions without blowing. The current rating of the fuse element recommended for various size transformers is tabulated in the following tables and takes into account these factors:
   a. Short-time daily overloads within the limits recommended by the ASA Publication, "Guide for Overloading Oil Immersed Distribution and Power Transformers", Appendix C57.92 dated January, 1956.
   b. Transformer magnetizing inrush current up to 12 times the transformer full load current for 0.1 second.
   c. Switching surges normally experienced on a utility system.
   d. Ambient temperature up to 40° C.

   Where coordination with other protective devices is not of primary importance, the type "PE" fuse unit is recommended.

* The speed ratio of a fuse is defined as the ratio of the minimum melting current at 0.1 second to the minimum melting current of 300 seconds (600 seconds for fuses above 100 amperes).

** Refer to the time-current curves for the speed ratio of a particular ampere rating and type of fuse element.

*** Proposed fuses – not available at the time of this printing.



SINGLE PHASE DISTRIBUTION TRANSFORMERS

FUSE ELEMENT RATINGS

SYSTEM KV	13.8			22			33			44			66		
FUSE KV	14.4			23			34.5			46			69		
TRANSFORMER KVA RATING	FULL-LOAD CURRENT	FUSE RATING E	FUSE RATING N	FULL-LOAD CURRENT	FUSE RATING E	FUSE RATING N	FULL-LOAD CURRENT	FUSE RATING E	FUSE RATING N	FULL-LOAD CURRENT	FUSE RATING E	FUSE RATING N	FULL-LOAD CURRENT	FUSE RATING E	FUSE RATING N
25	1.8	3	5	1.14	3	3	.76	3	3	---	--	--	---	--	--
50	3.6	5	8	2.3	5	5	1.5	3	3	1.14	3	3	---	--	--
100	7.3	10	15	4.5	7	10	3.0	5	8	2.3	5	5	1.5	3	3
167	12	20	25	7.6	10	15	5.1	7	12.5	3.8	5	8	2.5	5	5
333	24	40	50	15	20	30	10	15	20	7.6	10	15	5	7	10
500	36	50	75	23	30	50	15	20	30	11	15	25	7.5	10	15

TABLE 1

THREE PHASE POWER AND DISTRIBUTION TRANSFORMERS

FUSE ELEMENT RATINGS

SYSTEM KV	13.8			22			33			44		
FUSE KV	14.4			23			34.5			46		
TRANSFORMER KVA RATING	FULL-LOAD CURRENT	FUSE RATING E	FUSE RATING N	FULL-LOAD CURRENT	FUSE RATING E	FUSE RATING N	FULL-LOAD CURRENT	FUSE RATING E	FUSE RATING N	FULL-LOAD CURRENT	FUSE RATING E	FUSE RATING N
75	3.2	5	8	2.0	5	5	1.3	3	3	1.0	3	3
150	6.3	10	12.5	3.9	7	8	2.6	5	8	2.0	5	5
225	9.4	15	20	5.9	10	12.5	3.9	7	10	3.0	5	8
300	13	20	25	7.9	15	20	5.3	10	12.5	3.9	7	10
500	21	30	40	13	20	30	8.8	15	20	6.6	10	15
750	31	50	75	20	30	40	13	20	30	9.8	15	20
1000	42	65	100	26	40	60	18	25	40	13	20	30
1500	63	100	125	39	65	100	26	40	60	20	30	40
2000	84	125	200	53	80	125	35	65	75	26	40	60
2500	105	150	250	66	100	150	44	65	100	33	50	75
3750	157	-	300	98	150	200	66	100	150	49	80	100
5000	209	-	400	131	200	300	88	125	200	66	100	150
7500	-	-	-	197	-	400	131	200	300	98	150	200
10000	-	-	-	-	-	-	175	-	350	131	200	300
15000	-	-	-	-	-	-	-	-	-	197	-	400

TABLE II

THREE PHASE POWER AND DISTRIBUTION TRANSFORMERS

FUSE ELEMENT RATINGS

SYSTEM KV	66			110			132			161		
FUSE KV	69			115			138			161		
TRANSFORMER KVA RATING	FULL-LOAD CURRENT	FUSE RATING E	FUSE RATING N	FULL-LOAD CURRENT	FUSE RATING E	FUSE RATING N	FULL-LOAD CURRENT	FUSE RATING E	FUSE RATING N	FULL-LOAD CURRENT	FUSE RATING E	FUSE RATING N
225	2.0	5	5	-	-	-	-	-	-	-	-	-
300	2.6	5	8	-	-	-	-	-	-	-	-	-
500	4.4	7	10	-	-	-	-	-	-	-	-	-
750	6.6	10	15	-	-	-	-	-	-	-	-	-
1000	8.8	15	20	5.3	10	12.5	-	-	-	-	-	-
1500	13	20	30	7.9	15	20	6.6	10	15	-	-	-
2000	18	25	40	10.5	20	25	3.8	15	20	7.2	15	15
2500	22	30	50	13	20	30	11	20	25	9	15	20
3750	33	50	75	20	30	40	16	25	30	13	20	30
5000	44	65	100	26	40	60	22	30	50	18	30	40
7500	66	100	150	39	65	100	33	50	75	27	40	60
10000	88	125	200	53	80	125	44	65	100	36	65	75
15000	131	200	300	79	125	200	66	100	150	54	80	125
20000	175	-	350	105	150	-	88	125	200	72	125	150
25000	-	-	-	131	200	-	110	200	-	90	150	200
37500	-	-	-	-	-	-	-	-	-	135	200	-

TABLE III

5. Coordination – Coordination is based on the principle that the protective device nearest the short circuit or overload will operate, thus isolating a minimum portion of the system.

   a. For general application, the fuse unit selected from the chart will provide adequate coordination with usual primary and secondary protective devices.

   b. If closer coordination is required, it can be obtained by plotting the time-current characteristic curves of the devices involved on the same or separate sheets of log-log paper and selecting breaker relay settings, fuse current ratings and types so that the desired selectivity is obtained. All currents must be referred to a common voltage, either primary or secondary, before attempting to determine coordination. On a Delta-Wye system, the current the primary fuse sees due to a secondary fault depends on the type of fault as well as the magnitude of the short circuit.

      (1) Secondary Protection – Plot the total-clearing time-current curve of the secondary power fuse or the total-operating time-current characteristics of the secondary breaker or recloser.

      (2) Transformer Heating Curve – Plot the permissible time-current characteristic curve as supplied by the transformer manufacturer. In the absence of manufacturer's data, use the American Standards Association curve which is reproduced in part "A".

      (3) Source Breaker Relays – Plot the time-current curve on the source breaker relays.

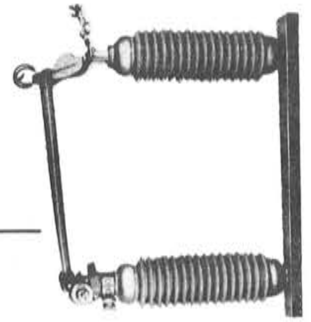
      (4) Primary Fuse – The time-current curves on all Southern States fuse units are printed on translucent paper so that they may be duplicated or laid directly over other curves for comparison. The minimum-melting time-current curves of fuses are plotted on the basis of no previous loading and an ambient of 25° C. In service, the fuses are carrying load current, and are frequently operated in an ambient above 25° C. The amount of adjustment to apply for each of these factors can be determined from parts "B" and "C".

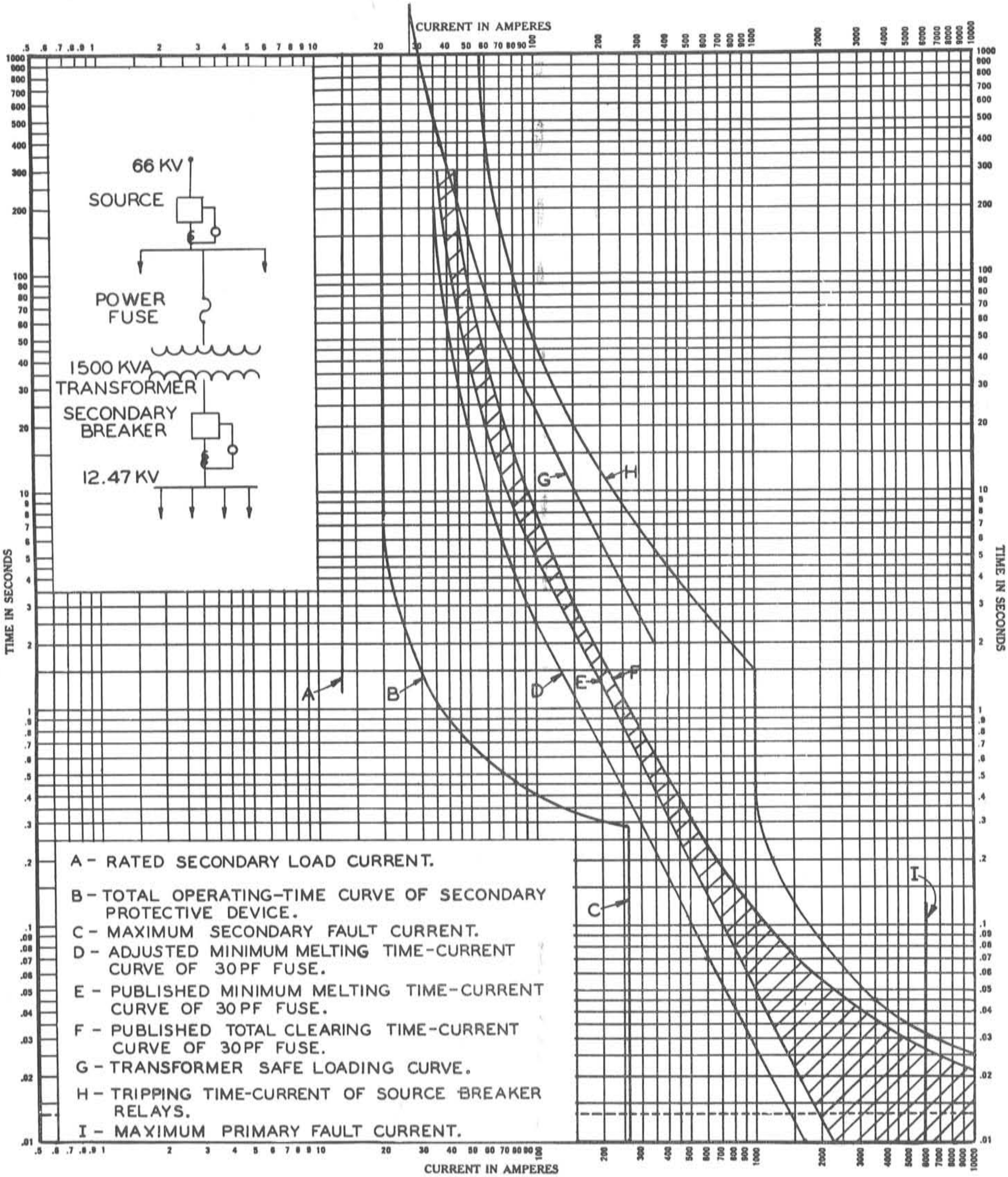
      However, for general coordination, it is not necessary to determine the adjustment accurately, and a total factor of 75 percent of the minimum-melting time can be used for the type "E" fuses and 55 percent for the type "N" fuses. The minimum-melting time of the selected fuse should be multiplied by the proper factor before plotting it on the coordination curve.

      If the adjusted minimum-melting curve of the fuse lies above and to the right of the curve on secondary protective device for currents up to the maximum secondary short circuit, the coordination in this area is correct. (See Figure 1.) If coordination is not achieved, a fuse with a greater speed ratio or a larger current rating should be selected or a change made in the secondary relay settings.

      Plot the total-clearing time-current curve of the fuse and compare it with the transformer heating curve. The total clearing curve of the fuse should be to the left and below the transformer heating curve for all values of secondary short-circuit current. The fuse curve will probably cross the transformer heating curve in the low current region. A fuse is generally not expected to protect the transformer from damaging long-time overloads. One hundred percent protection can be obtained with available fuse elements only by sacrificing the overload capabilities of the transformer.

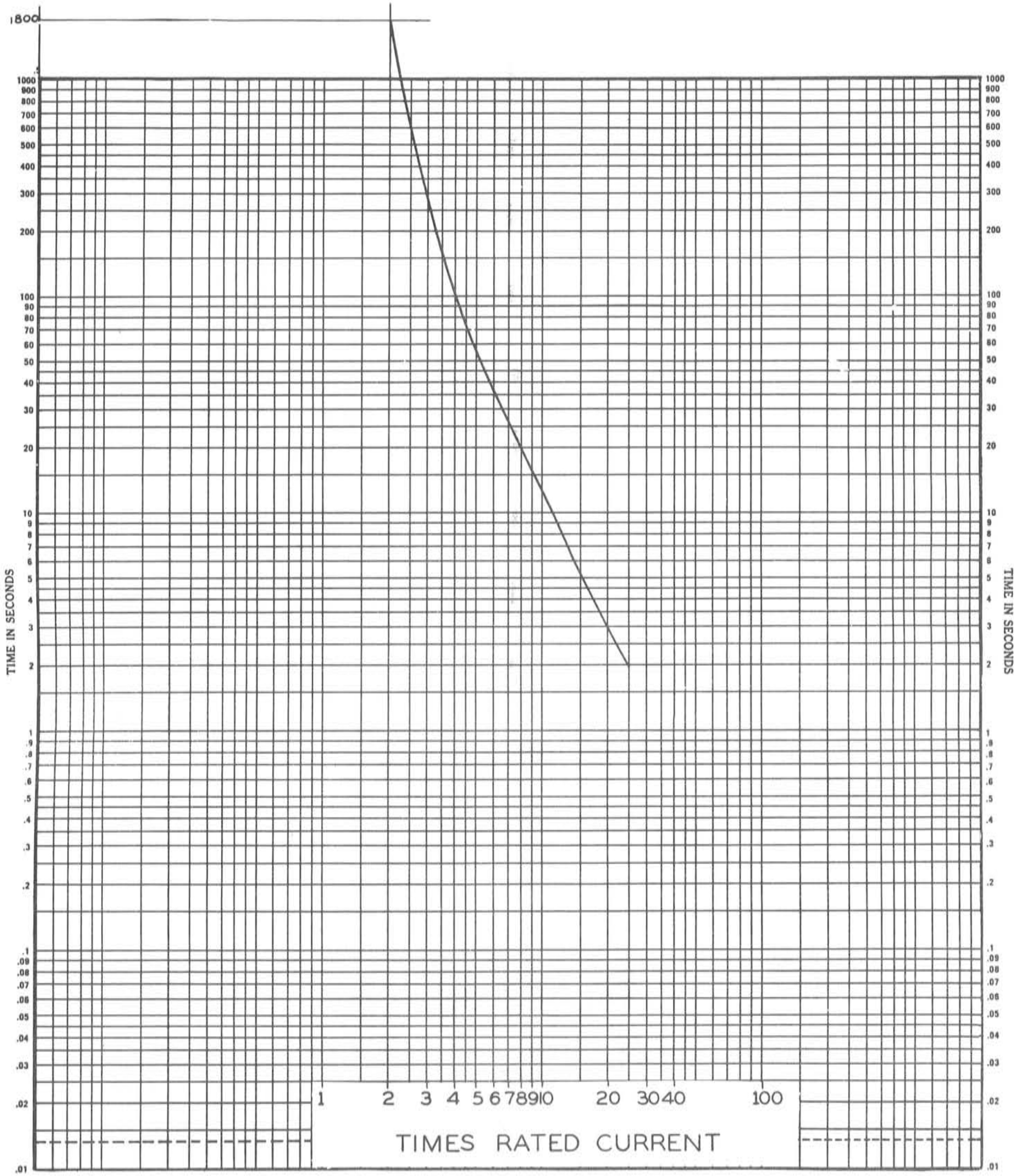
      Now compare the fuse total-clearing curve with the tripping time-current curve on the source breaker for all expected values of primary fault current. The fuse curve should lie below and to the left of the source breaker relay curve for all values of primary short circuit. There need be no margin between the two curves since the values are maximum and minimum, respectively.





TYPICAL COORDINATION OF TRANSFORMERS FUSES RELAYS AND BREAKERS.
ALL CURRENTS REFERRED TO THE TRANSFORMER PRIMARY.

FIG. 1



For OIL IMMERSED TRANSFORMERS SHORT-TIME LOAD TIME-CURRENT CHARACTERISTIC CURVES SHORT-TIME LOAD FOLLOWING FULL LOAD

BASIS FOR DATA Standards ASA APPENDIX C57.92 Dated APRIL 1959

1. Tests made at ———— Volts a-c at ———— p-f., Starting at 25C with no initial load ————

2. Curves are plotted to ———— Test points so variations should be ————

No. B-20600

Date 10-5-59

PART A

PART "B"

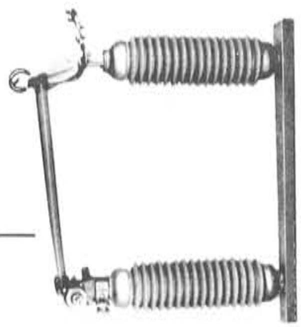
PRE-LOAD ADJUSTMENT

The published minimum-melting curves on power fuses are based on no initial loading. In service, the fuses are normally carrying load current prior to a fault on the circuit. As the load changes, the element temperature changes and, consequently, the minimum-melting time of the fusible element is affected. The amount of the effect on the minimum-melting time is dependent upon the melting temperature of the material used in the design of the fusible element and the current which the element is carrying compared to its minimum-melting current. The temperature of the element at rated current on the "N" rated fuse elements is closer to the melting value than on the "E" rated elements. Consequently, a greater adjustment is required on the "N" rated fuses than on the "E" rated fuses.

In the short-time or lower portion of the minimum-melting curve, the fusible element is a relatively high-melting temperature metal, such as copper. The change from no load to full load produces only a small percentage change in the temperature of the fusible element, and the percent change in the minimum-melting curve is low. The percentage change in the melting time in this short-time portion of the time-current curve is shown by Curve "A" in Figure 2 for the Type "E" rated fuse elements and Figure 3 for the type "N".

In the medium-time or upper portion of the minimum-melting curve, the fusible element separates by melting a metal having a low melting temperature. Since the melting temperature is relatively low, the load current has a greater effect on the minimum melting of the fusible element in this portion of the curve than it does in the short-time portion. The maximum percentage change in the minimum-melting time in this portion of the curve is shown by Curve "B" in Figure 2 for the type "E" rated fuse elements and Figure 3 for the type "N". The effect of pre-loading diminishes rapidly with time and is negligible above 1000 seconds.

Coordination is normally more critical in the short-time portion of the time-current curve. In this area, the more favorable adjustment factor is applicable.



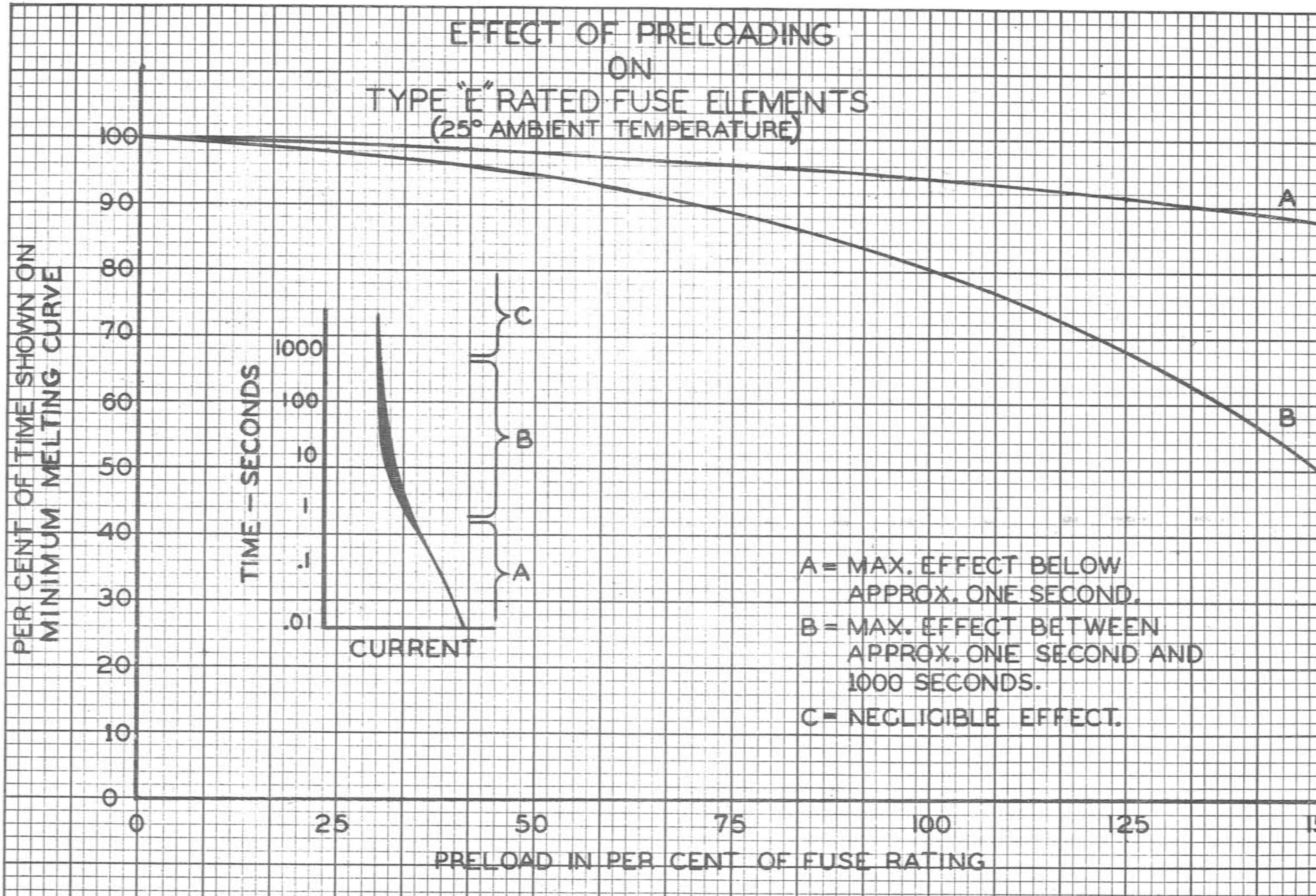
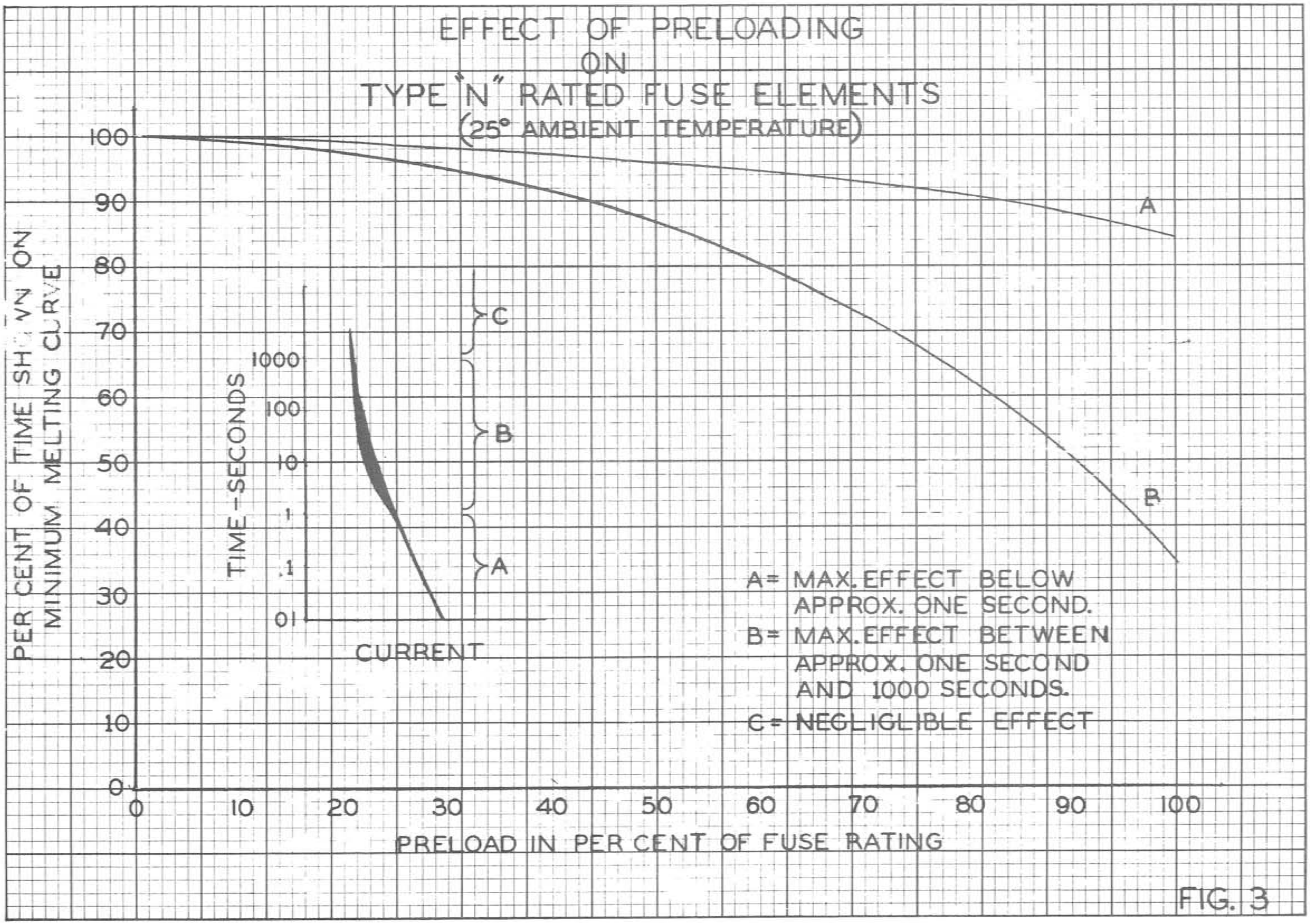

EFFECT OF PRELOADING
ON
TYPE "E" RATED FUSE ELEMENTS
(25° AMBIENT TEMPERATURE)
PER CENT OF TIME SHOWN ON MINIMUM MELTING CURVE
100
90
80
70
60
50
40
30
20
10
0
0
25
50
75
100
125
150
PRELOAD IN PER CENT OF FUSE RATING
A
B
TIME – SECONDS
1000
100
10
1
.1
.01
CURRENT
C
B
A
A = MAX. EFFECT BELOW APPROX. ONE SECOND.
B = MAX. EFFECT BETWEEN APPROX. ONE SECOND AND 1000 SECONDS.
C = NEGLIGIBLE EFFECT.

FIG. 2


EFFECT OF PRELOADING
ON
TYPE "N" RATED FUSE ELEMENTS
(25° AMBIENT TEMPERATURE)
PER CENT OF TIME SHOWN ON MINIMUM MELTING CURVE
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
PRELOAD IN PER CENT OF FUSE RATING
A
B
TIME - SECONDS
1000
100
10
1
.1
01
CURRENT
C
B
A
A= MAX. EFFECT BELOW APPROX. ONE SECOND.
B= MAX. EFFECT BETWEEN APPROX. ONE SECOND AND 1000 SECONDS.
C= NEGLIGIBLE EFFECT
FIG. 3

PART "C"

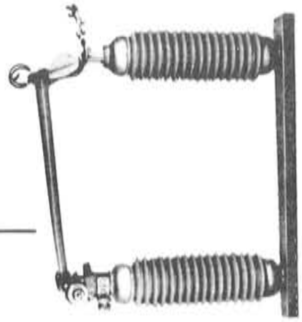
AMBIENT TEMPERATURE ADJUSTMENT

The published minimum-melting curve on fuse elements is based on an ambient of 25^{o} C. As the ambient temperature changes, the element temperature also changes, and the time to melt at a specified current is affected. The amount of the effect on the melting time is dependent upon the melting temperature of the material used in the design of the fusible element and the ambient temperature.

In the short-time or lower portion of the minimum-melting curve, the fusible element is a relatively high-melting temperature metal, such as copper. The normal ambient temperature changes produce only a small percentage change in the temperature of the fusible element and, consequently, the percent change in the minimum-melting curve is low. The percentage change in the melting time in this short-time portion of the time-current curve is shown in Figure 4 by Curve "A".

In the medium-time or upper portion of the minimum-melting curve, the fusible element separates by melting a metal having a low melting temperature. Since the melting temperature is relatively low, the ambient temperature has a greater effect on the minimum melting of the fusible element in this portion of the curve than it does in the short-time portion. The maximum percentage change in the minimum-melting time in the medium-time portion of the curve is shown in Figure 4 by Curve "B".

Coordination is normally more critical in the short-time portion of the time-current curve. In this area, the more favorable adjustment factor is applicable.



EFFECT OF AMBIENT TEMPERATURE ON TYPE "E" & "N" RATED FUSES (NO INITIAL LOAD)

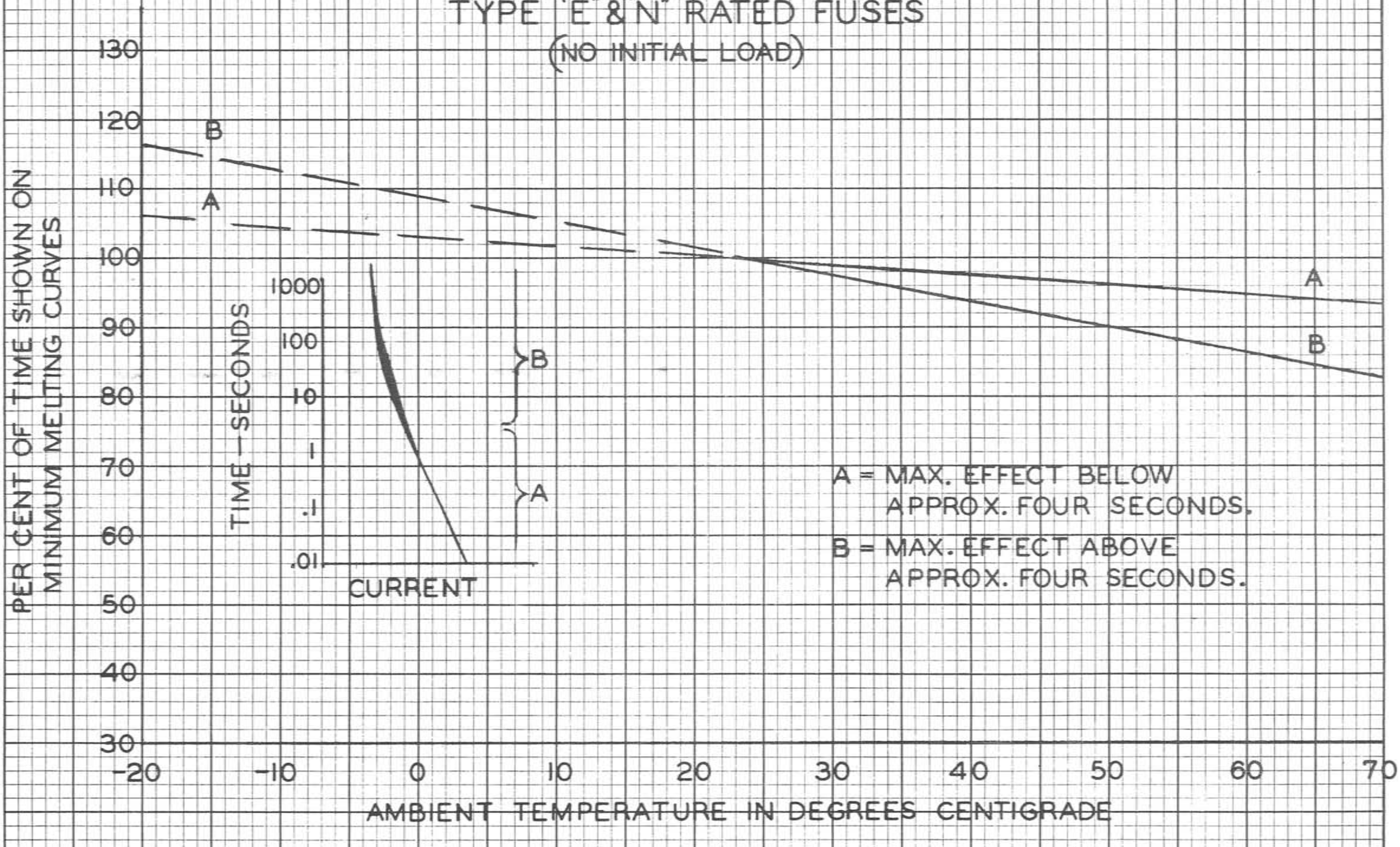


FIG. 4