GET-6779

HOW TO SELECT AND APPLY

9F62 GENERAL ELECTRIC

CURRENT-LIMITING FUSES

TYPE EJO-1

GENERAL ELECTRIC

INTRODUCTION

To a large extent, Model 9F62 EJO-1 fuses replace Model 9F60 EJ-1 and EJO-1 fuses described in General Electric bulletin GET-3039 entitled, "How to Select and Apply General Electric Current-Limiting Power Fuses - Types EJ-1 and EJO-1". Since the 9F62 and 9F60 model fuses are selected and applied in a similar manner, much of the information presented herein is common to that contained in GET-3039. The 9F62 designs do differ in several respects, however, from the 9F60 designs. Therefore, the current rating of the fuse best suited for a particular application may be different for the 9F62 model than for the 9F60 model.

Before discussing the factors to be considered in selecting and applying 9F62 model fuses, it is appropriate to point out some of the application advantages afforded the user by the 9F62 fuses. These include:

- Smaller physical size
- Lower I^2R losses
- Improved low-current clearing capability
- Reduced susceptibility to damage from surges
- Higher interrupting ratings
- Larger current ratings
- Filament-wound epoxy bodies in all ratings

The significance of each of these advantages to the user will be addressed as the various selection and application considerations are discussed throughout this bulletin.

GENERAL APPLICATION

Overcurrent protection is fundamental to the operation of all medium- and high-voltage distribution systems used in industrial plants, large commercial office or apartment buildings, shopping centers, schools, and hospitals. Current-limiting fuses provide an economical means of providing overcurrent protection, particularly on high-capacity systems where it is frequently necessary to limit short-circuit currents. Here, the current-limiting fuse operates in approximately one-half cycle to provide maximum protection to the apparatus on the system.

Current-limiting fuses, selected so they coordinate properly, can be used in conjunction with circuit breakers, or can even replace oil or air circuit breakers in some applications.

All General Electric EJ power-class current-limiting fuses (both Models 9F62 and 9F60) are designed to meet the stringent requirements associated with industrial applications. In addition to circuit interruption, they have the following advantages over expulsion-type fuses:

- High interrupting capacity - typical interrupting ratings of 50,000 A symmetrical (80,000 A asymmetrical)
- Noiseless operation - designed for silent operation
- No expulsion products - eliminates the flame discharges associated with expulsion fuse operation
- Substantially reduced let-through energy - the energy-limiting action limits the magnitude of electro-mechanical stresses in the apparatus and that part of the circuit being protected by the fuse
- Capability for use in confined spaces - having been designed to eliminate flame and/or gas discharges during operation, the fuse requires no discharge filters, fire boxes, special vents, or enclosure reinforcing

SELECTION

In selecting current-limiting power fuses for a particular application, it is important to consider all factors affecting the installation. Thus, it is necessary to consider not only anticipated load current and transformer magnetizing inrush, but also overloads and the characteristics of other protective devices to ensure a properly coordinated installation. Generally, the following important factors should be fully considered:

- Current rating
- Voltage rating
- Interrupting rating
- Location
- Mounting
- Coordination

Each of these factors, insofar as it characteristically applies to General Electric power fuses, is briefly discussed in the following paragraphs. Much of the data in these paragraphs is summarized in Table I.

CURRENT RATINGS

All General Electric Model 9F62 current-limiting power fuses are general purpose fuses (function class "g" - ANSI/IEEE C37.40-3.1-1981). The fuses are designed to carry their rated current continuously without exceeding the temperature rises permitted by standards (ANSI/IEEE C37.40-3.2-1981 and C37-41-11-1981). The ribbon-style fusible elements, with the patented notch configuration used in all 9F62 fuses, run considerably cooler than do the wire fusible elements used in fuses of an equivalent size. Therefore, for a given body size, the 9F62 fuses have a higher continuous-current rating than the 9F60 fuses. The reason for this is that with notched-ribbon elements, the melt I^2t is determined by the cross-sectional area of the ribbon at the notch. Since the cross-sectional area of the ribbon between the notches is much larger than it is at the notches, for a given melt I^2t, a notched ribbon will have a considerably lower resistance than a constant-diameter wire element. Thus, for a given continuous current, the notched ribbon element fuse will generate less heat than a comparably rated wire fuse. This and the use of GE's patented process of binding grains of the quartz sand filler together to

TABLE I
SUMMARY OF RATINGS OF 9F62 CURRENT-LIMITING POWER FUSES

Voltage kV	Continuous Current Ratings Amperes	Interrupting Ratings 60 Hertz	
Max.	EJ-1 (Indoor/Outdoor)	Amperes (rms) Symmetrical	Max. 3ϕ MVA (symm.)*
2.8	25E - 65E	50,000	242
5.5	25E - 450E	50,000	476
8.3	20E - 250E	50,000	718
15.5	20E - 200E	50,000	1342

* - These symmetrical ratings can be converted to asymmetrical values by multiplying them by 1.6.

improve the transfer of heat away from the element to the fuse body are the primary reasons for the smaller physical size of many 9F62 current ratings, the higher available current ratings, and the replacement of the glass bodies with filament-wound epoxy bodies.

The continuous-current rating of the fuse must be equal to, or higher than, the maximum continuous current which might be expected to pass through the fuse. Therefore, in applications where the equipment being protected by the fuse may be overloaded, the fuse's continuous-current rating must be selected **on the basis of the maximum anticipated overload current**, not the rated load current of the equipment. Fuses of higher current rating may be required for other reasons, such as to obtain coordination with other protective devices, or to carry higher currents for shorter periods of time. The general purpose current-limiting fuse should not be applied as an overload protection device since, by definition, this type fuse can only be relied upon to provide interruption of continuous currents causing melting to occur in one hour or less (i.e., the current corresponding to approximately two times the rated continuous current of the "E"-rated 9F62 model fuses). Low current, "long time" melting tests have indicated that 9F62 fuses, with the patented element notch design and patented method of attaching gas evolving "beads" to the element, can clear currents lower than the one-hour melting currents. To obtain reliable circuit interruption at current values below two times the fuse rating, however, auxiliary devices must be applied.

No-Damage Boundary

Rigid rules cannot be given to ensure that damage to the current-responsive element from short-time overcurrents can be avoided in all cases. The fuse characteristics will not be altered, however, if the overcurrent is at least 15 percent below the minimum melting current for a melting time equal to the overcurrent duration. Such a margin establishes a no-damage boundary fuse characteristic that is useful when a fuse is the "protected" device in a coordination study.

The 9F62 fuses, with their notched ribbon elements, are inherently less susceptible to damage from surges than are fuses having wire elements. The reason for this is that the larger cross-sectional areas on both sides of each notch act as heat sinks for the restrictions under surge conditions. This heat-sink effect reduces the likelihood of the restriction reaching the melting temperature of the material from which the element is made and thereby minimizes the likelihood of restriction damage and subsequent melting under normal load currents.

VOLTAGE RATINGS

In applications where the three-phase load is delta-connected, it is recommended that the maximum line-to-line voltage of the system not exceed the maximum design voltage of the fuse, regardless of the system grounding conditions. In these cases, the fuse is typically selected so that circuit maximum operating line-to-line voltage is in the range of 70 to 100 percent of the fuse's rated voltage (except for 5.5 kV fuses*).

For three-phase applications in grounded-wye grounded-wye systems, however, an evaluation in many instances will show the use of a line-to-ground rated fuse to be permissible or even desirable, since it results in a smaller, less-expensive fuse which produces lower arc voltage. On the other hand, the fuse voltage rating is permitted to exceed the system voltage, except for limitations imposed by generated transient voltage. This is important because the unique current-limiting action of the fuse is characterized by the generation of transient (100 to 500 microseconds to peak) arc voltages above normal circuit voltage. The maximum peak arc voltage which can occur on General Electric 9F62 current-limiting power fuses at fuse maximum-rated voltage is specified in Table II. Wire-element fuses normally produce arc voltages independent of system voltage. In the 9F62 fuse, however, where arc voltage control is achieved by the use of notched ribbon elements, the maximum peak overvoltage is affected by the system voltage. Therefore, at reduced system voltage, the arc voltage will be less, as indicated in Fig. 1.

The current-limiting fuse must be selected strictly on the basis of actual service voltage. Where over-insulation is required, the mounting for the fuse can be supplied with insulators of a higher voltage rating to provide additional insulation to ground.

INTERRUPTING RATINGS

The interrupting rating of power fuses should equal or exceed the maximum available short-circuit duty at the point in the system where the fuses are to be installed. Note that the interrupting ratings for 9F62 fuses are expressed in symmetrical amperes as opposed to the asymmetrical amperes interrupting ratings published for the 9F60 fuses. Thus, any comparison between interrupting ratings of the two designs must recognize this difference. Since system fault calculations are usually performed in terms of symmetrical currents, this change in how the fuse interrupting rating is expressed eliminates the need for conversion from asymmetrical to symmetrical values.

* where normal insulation practices often permit their use at 2.54kV

TABLE II

FUSE MAXIMUM PEAK OVERVOLTAGE (ARC VOLTAGE) AT SPECIFIED TEST VOLTAGE

Test Voltage	Model	Maximum Arc Voltage	Maximum Arc Voltage Permitted, ANSI
15.5 kV	FDD200 FDD125	48 kV	49 kV
15.5 kV	DDD100 DDD080	46 kV	49 kV
15.5 kV	DDD065 DDD050	43 kV	49 kV
15.5 kV	DDD030 DDD020	34 kV	49 kV
8.3 kV	FCC250 FCC175	23.5 kV	26 kV
8.3 kV	DCC150 DCC125	22 kV	26 kV
8.3 kV	DCC100 DCC065	20.5 kV	26 kV
8.3 kV	HCC050 HCC020	18.5 kV	26 kV
5.5 kV	FCB450 FCB250	16 kV	18 kV
5.5 kV	DCB200 DCB080	14.5 kV	18 kV
5.5 kV	HCB065 HCB025	13 kV	18 kV
2.75 kV	HCB065 HCB025	7.5 kV	9 kV

The three-phase MVA interrupting ability for power fuses is based on the maximum symmetrical value of available rms amperes to which a set of fuses will be subjected in interrupting a three-phase short circuit. The values in these columns in Table I are derived as follows:

Three-phase MVA =

$$\sqrt{3} \times \frac{\text{fuse rated kV}}{1000} \times \text{fuse rated interrupting amps}$$

Along with the tabulated values of symmetrical-current interrupting ratings in Table I are corresponding three-phase MVA interrupting ratings. These latter values are sometimes more convenient to use in particular applications. If a system has little or no short-circuit contribution from motors, then a single calculation will establish a three-phase symmetrical value for the first cycle or any later time. This value forms the basis for expressing the interrupting duty for fuses as well as the momentary and interrupting duty for power circuit-breaker application. For systems of this description, a selected three-phase MVA base may be divided by the source subtransient per unit reactance on the same base, and the result may be compared directly with the maximum three-phase MVA ratings in Table I. Actually, the fuse MVA values should be multiplied by the ratio of operating kV to fuse-rated kV, if this ratio is other than 1.0.

All General Electric 9F62 fuses have been simultaneously short-circuit tested at their maximum interrupting rating (50 kA) and at their maximum voltage rating.

Testing standards ANSI C37.41 and IEC282.1 permit testing with the less onerous duties of 87 percent of maximum voltage rating at 100 percent of maximum interrupting rating and 100 percent of maximum voltage rating at 87 percent of maximum interrupting rating. Because this less onerous method was not used during the tests to establish the interrupting ratings for the 9F62 designs, the fuses' maximum interrupting ratings do not need to be reduced for single-phase applications.

The key to achieving the higher interrupting ratings in the 9F62 fuses, particularly with the double-barrelled designs, is the use of a patented process of binding grains of the quartz sand filler together. This process also results in a much more consistent sand fill than could otherwise be obtained and results in parallel fuses (i.e., double-barrelled designs) sharing the interrupting duty on a nearly equal basis. Hence, the parallel combination can have a higher maximum interrupting capacity and/or continuous-current rating since the two bodies share the current equally.

It should be pointed out that fuses which were not designed for parallel application should not be paralleled. The only GE 9F62 fuses designed to be used in parallel are those supplied by the factory as a parallel pair (i.e., DD designs).

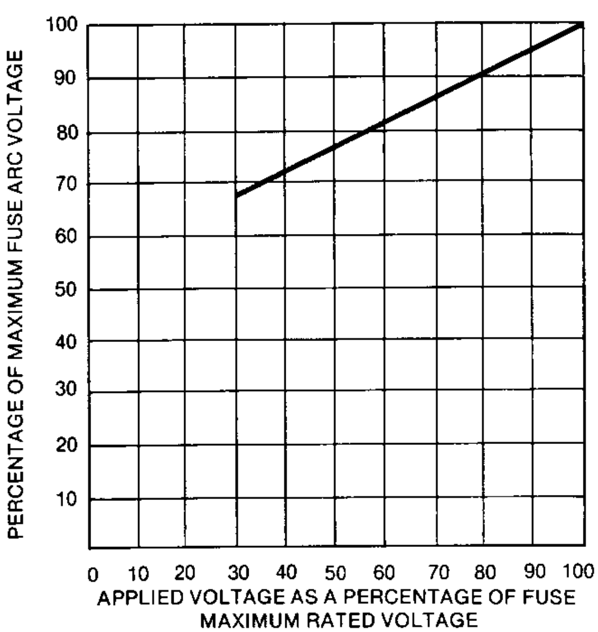

Fig. 1. Effect on maximum fuse peak overvoltage (arc voltage) with reduction in applied current voltage.

CURRENT-LIMITING CHARACTERISTICS OF A FUSE

It is in the region of high overcurrents that the current-limiting fuse displays its superior performance. High short-circuit currents can create massive damage, and even total destruction, in a surprisingly short time. No other form of protective interrupter can match the fast, effective disposal of high fault currents afforded by the current-limiting fuse. The fuse can react so fast that the fault current does not reach its first loop natural crest value but is substantially reduced, and brought to zero with an amazingly small total I^2t let-through (ampere-squared seconds). This outstanding characteristic of a current-limiting fuse to limit the I^2t let-through minimizes damage to buswork and equipment between the source and the fault. Because current-limiting fuses reduce the peak value of fault current, mechanical forces (proportional to the peak current squared) are reduced as are thermal stresses (proportional to the I^2t). I^2t limitation also reduces the energy liberated at the source of the fault.

The current-limiting action depends on the production of an arc voltage which exceeds the system voltage, thus forcing a current zero. For any given fuse, the degree of current limitation depends on the available fault current and on the time of fault initiation. If the fuse melts after the current has crested, it can obviously no longer act as a current limiter. With a fully asymmetrical fault, the current crests at about one-half cycle; with a symmetrical fault, the current crests in exactly one-quarter cycle. The current-limiting action changes with the degree of asymmetry of the fault. Figures 2, 3, and 4 present data for peak let-through current as a function of available current (rms symmetrical) for worst-case conditions (symmetrical or asymmetrical, depending on current magnitude).

APPLICATION OF SURGE ARRESTERS

An inherent characteristic of any current-limiting device is that it produces an arc voltage significantly higher than the system voltage to drive the current to zero.

For the 9F62 fuse, the maximum arc voltage produced can be determined either directly from Table II (if the maximum system voltage corresponds to the fuse rated voltage) or by using Table II in conjunction with the curve presented in Fig. 1 (if the system voltage is less than the fuse rated voltage). Such arc voltages are transient voltage surges simi-

CURRENT-LIMITING POWER FUSE

EJO-1 Type 9F62 5.5 KV MAX

MODELS 9F62HCB, 9F62DCB, 9F62FCB

Let-through Current Characteristics

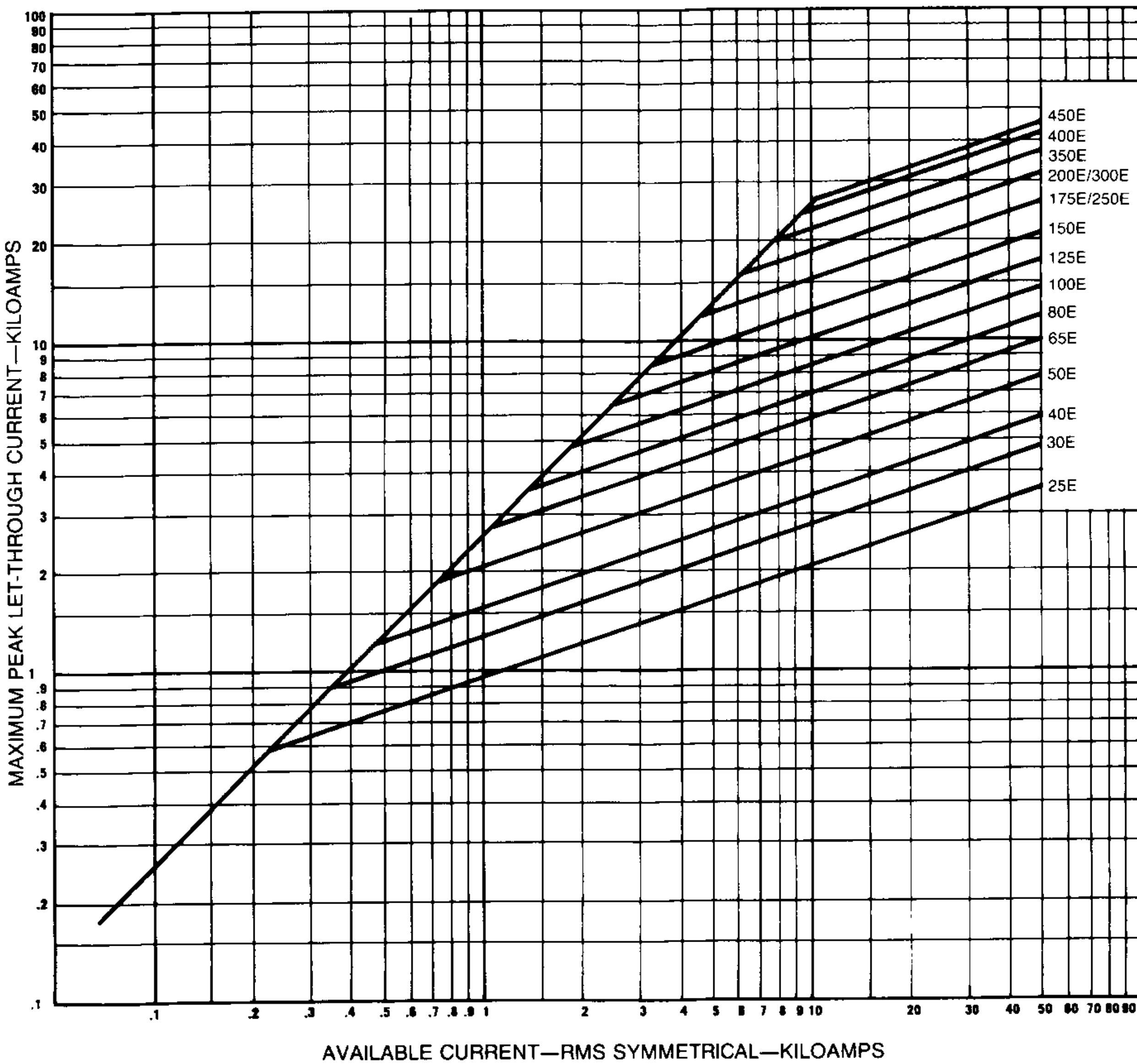

Figure 2

CURRENT-LIMITING POWER FUSE

EJO-1 Type 9F62 8.3 KV MAX

MODELS 9F62HCC, 9F62DCC, 9F62FCC

Let-through Current Characteristics

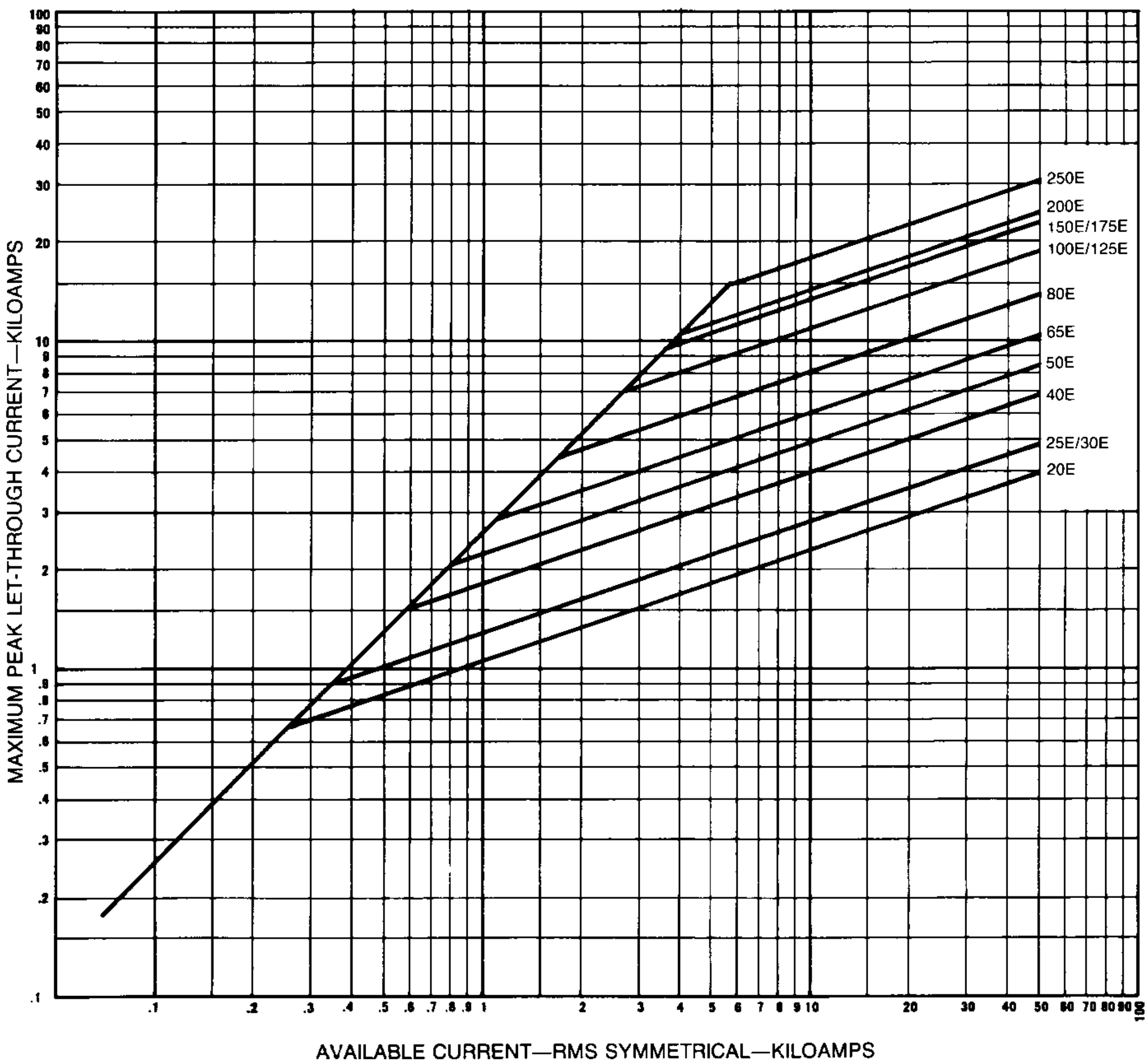

Figure 3

CURRENT-LIMITING POWER FUSE

EJO-1 Type 9F62 15.5 KV MAX

MODELS 9F62HDD, 9F62DDD, 9F62FDD

Let-through Current Characteristics

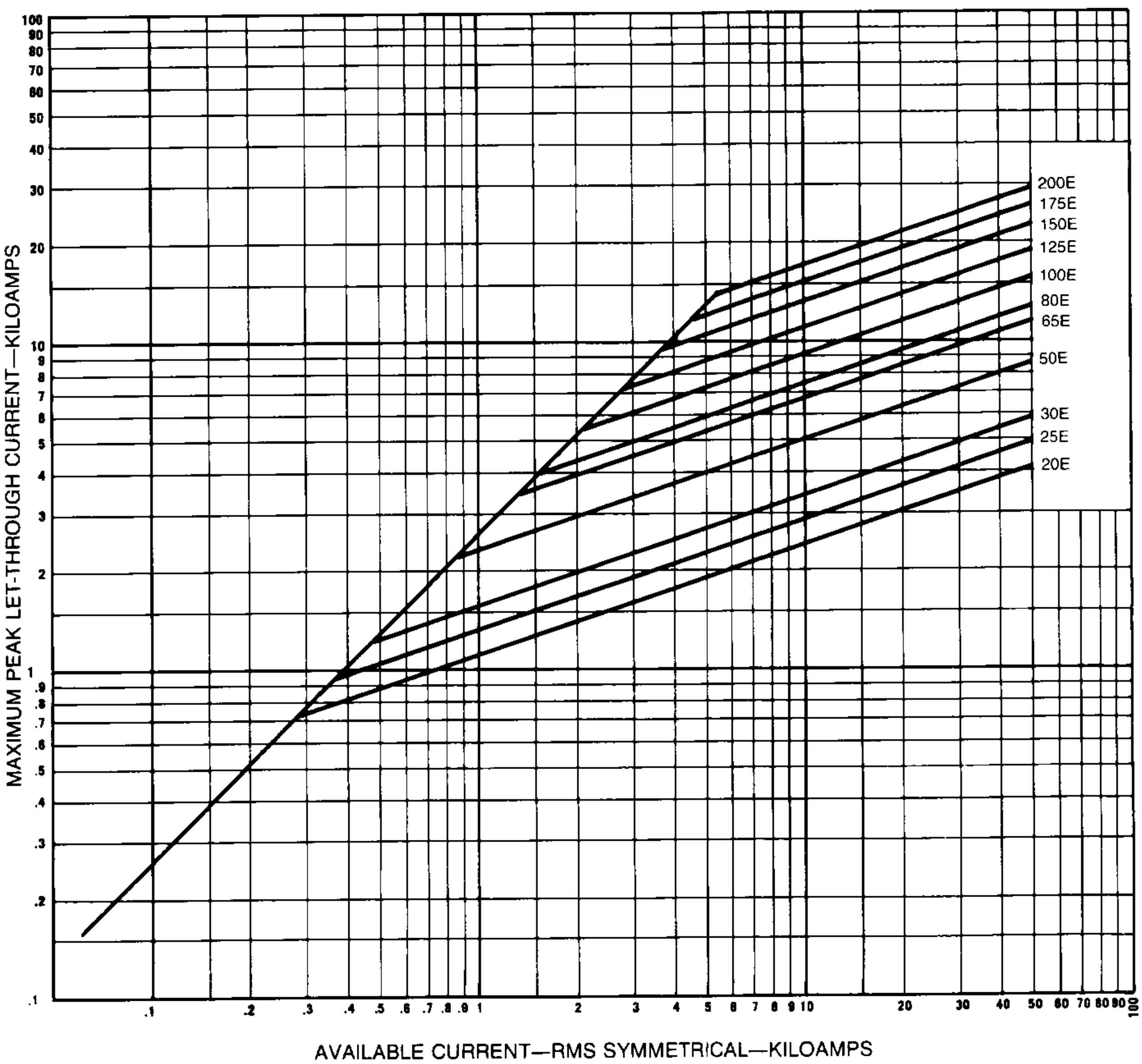

Figure 4

lar to those produced by many kinds of switching. When current-limiting fuses are applied in circuits protected by surge arresters which meet minimum ANSI standards of discharge capability and which have voltage ratings less than the voltage rating of the fuse, overvoltages, produced by higher values of available short-circuit current, may be great enough and last long enough to exceed the safe volt-time characteristics of the arrester.

When surge arresters are required in the same circuit as current-limiting fuses, the following rules apply:

1. Use distribution arresters or full-voltage-rated station or intermediate arresters on either the source or the load side of the fuse.

2. Use reduced-voltage-rated station or intermediate arresters on load side of fuse only.

3. If reduced-voltage-rated station or intermediate arresters are required on the source side of the fuse, refer to the General Electric Company for recommendations.

LOCATION

All 9F62 fuses are designed for outdoor use and therefore may also be used either in outdoor enclosures or indoor.

For unusual requirements (i.e., special locations), refer to the General Electric Company for recommendations.

MOUNTING

Fuse Supports

Mountings of the nondisconnecting type are available. They are generally used in voltage transformer circuits, or where there is some other disconnecting or isolating device in series with the fuse in the circuit.

When replacing a larger-diameter 9F60 fuse with a smaller-diameter 9F62 fuse, two options are available. Obviously, one option is to change the clips into which the fuse fits. New clips of the proper size can be identified by referring to General Electric Apparatus Handbook Section 7078. The other option is to purchase a pair of adapters to slip over the ferrules of a 2-inch diameter (C) fuse that allow it to be used in clips intended for 3-inch diameter (D) fuses. Where a single 3-inch diameter (D) fuse replaces a two-barrel (DD) fuse, the outer clips may be removed.

Fuse Disconnecting Switches

Disconnecting switches that isolate the equipment they protect are also available. They are not intended to be used for breaking load or magnetizing current.

When replacing a larger-diameter 9F60 fuse with smaller-diameter 9F62 fuse, new disconnect hardware designed for that diameter fuse must be used. We **do not recommend** using the 2-inch to 3-inch diameter adapters in disconnect switch applications. For further details, refer to Handbook Sections 7077 and 7078.

POWER TRANSFORMER PROTECTION

A transformer primary-side fuse is chosen to protect the distribution system on which it is installed against outages resulting from faults within the transformer, and, under certain conditions, to protect the system and transformer from faults occurring on the load side of the transformer that the secondary protective devices do not clear. There are several factors that must be considered when selecting a fuse for such applications. These include:

- The fuse must not operate or be damaged by the transformer's inrush current.
- Under no circumstances must a fuse be selected that has a current rating less than the transformer's anticipated maximum load current. Therefore, for forced-cooled transformers, fuse selection must be based on the higher continuous-current rating.
- Since auxiliary devices must be used to provide overload protection below 1.4 to 2 times the continuous rated current of the fuse, the fuse must coordinate with these devices in order to avoid unnecessary fuse operation.

TABLE III

SUGGESTED FUSE CURRENT RATINGS FOR POWER TRANSFORMER APPLICATIONS

9F62 SERIES, TYPE EJO-1 POWER FUSES

SYSTEM PH/PH VOLTAGE		2400V				4160V				4800V			
FUSE VOLTAGE		5.5kV(5)				5.5kV				5.5kV			
(1)	(4)		(2)	(3)	(4)		(2)	(3)	(4)		(2)	(3)	(4)
kVA	%Z	Full Load Crnt Amps	Min Fuse Rating Amps	Over-Load Rating Amps	Max Fuse Rating Amps	Full Load Crnt Amps	Min Fuse Rating Amps	Over-Load Rating Amps	Max Fuse Rating Amps	Full Load Crnt Amps	Min Fuse Rating Amps	Over-Load Rating Amps	Max Fuse Rating Amps
THREE PHASE													
30	2.25	7.2	20E	20E	40E	3.8	15E	15E	20E	3.61	10E	10E	20E
45	2.25	10.8	25E	25E	40E	6.2	15E	15E	30E	5.4	15E	15E	25E
75	2.25	18.1	30E	30E	80E	10.4	25E	25E	40E	9.02	25E	25E	40E
112.5	2.25	27.1	40E	40E	100E	15.6	30E	30E	65E	13.5	25E	25E	50E
150	3.0	36.1	50E	50E	100E	20.8	40E	40E	65E	18.0	30E	30E	50E
225	3.0	54.1	65E	80E	100E	31.2	50E	50E	65E	27.1	40E	40E	50E
300	5.0	72.2	100E	100E	125E	41.6	50E	65E	80E	36.1	50E	50E	80E
500	5.0	120	150E	175E	175E	69.4	80E	100E	125E	60.1	80E	80E	100E
750	5.75	180	200E	250E	300E	104	125E	150E	150E	90.2	100E	125E	125E
1000	5.75	241	250E	350E	350E	139	150E	200E	200E	120	125E	175E	175E
1500	5.75	361	400E	450E*	450E*	208	250E	300E	300E	180	200E	250E	300E
2000	5.75	—	—	—	—	278	300E	400E	400E	241	250E	350E	350E
2500	5.75	—	—	—	—	347	400E	450E*	450E*	301	350E	450E	450E
3000	5.75	—	—	—	—	406	450E	450E*	450E*	361	400E	450E*	450E*
SINGLE PHASE													
25	2.25	10.4	25E	25E	40E	6.01	15E	15E	30E	5.21	15E	15E	25E
37.5	2.25	15.6	30E	30E	50E	9.01	20E	20E	50E	7.81	20E	20E	25E
50	2.25	20.8	40E	40E	80E	12	25E	25E	40E	10.4	25E	25E	40E
75	3.0	31.3	50E	50E	100E	18	30E	30E	65E	15.6	30E	30E	50E
100	4.5	41.7	65E	65E	150E	24	40E	40E	80E	20.8	40E	40E	80E
167	5.0	70	100E	100E	200E	40	65E	65E	125E	35	50E	50E	100E
250	5.0	104	125E	150E	300E	60	80E	80E	150E	52.1	65E	80E	150E
333	5.75	139	150E	200E	350E	80	100E	125E	175E	69.5	100E	100E	150E
500	5.75	210	250E	300E	450E	120	125E	175E	300E	104	125E	150E	200E
667	5.75	278	300E	400E	450E	160	175E	250E	400E	139	150E	200E	350E
833	5.75	347	550E	450E*	450E*	200	200E	300E	450E	174	175E	250E	450E
1250	5.75	—	—	—	—	300	300E	400E	450E	260	300E	350E	450E
1667	5.75	—	—	—	—	401	400E	450E*	450E*	347	350E	450E	450E

SYSTEM PH/PH VOLTAGE	6900V				7200V				12,000V			
FUSE VOLTAGE	8.3kV				8.3kV				15.5kV			
(1)		(2)	(3)	(4)		(2)	(3)	(4)		(2)	(3)	(4)
kVA	Full Load Crnt Amps	Min Fuse Rating Amps	Over-Load Rating Amps	Max Fuse Rating Amps	Full Load Crnt Amps	Min Fuse Rating Amps	Over-Load Rating Amps	Max Fuse Rating Amps	Full Load Crnt Amps	Min Fuse Rating Amps	Over-Load Rating Amps	Max Fuse Rating Amps
THREE PHASE												
30	2.51	7E	7E	10E	2.41	7E	7E	10E	1.44	5E	5E	10E
45	3.77	10E	10E	20E	3.61	10E	10E	20E	2.16	7E	7E	15E
75	6.28	20E	20E	25E	6.01	20E	20E	20E	3.6	10E	10E	30E
112.5	9.4	20E	20E	40E	9.0	20E	20E	30E	5.4	20E	20E	20E
150	12.6	20E	20E	40E	12.0	20E	20E	40E	7.2	20E	20E	20E
225	18.8	25E	25E	40E	18.0	25E	25E	40E	10.8	20E	20E	30E
300	25.1	40E	40E	50E	24.1	40E	40E	50E	14.4	20E	20E	25E
500	41.8	50E	65E	80E	40.1	50E	65E	65E	24.1	25E	50E	50E
750	62.8	65E	80E	80E	60.1	65E	80E	80E	36.1	50E	50E	50E
1000	83.7	100E	125E	125E	80.2	100E	125E	125E	48.1	50 E	65E	80E
1500	126	125E	175E	200E	120	125E	175E	200E	72.2	80E	100E	100E
2000	167	175E	250E	250E	160	175E	250E	250E	96.2	100E	125E	150E
2500	209	250E	250E*	250E*	200	250E	250E*	250E*	120	125E	175E	175E
3000	251	250E	250E*	250E*	240	250E	250E*	250E*	144	150E	200E	200E
SINGLE PHASE												
25	3.62	10E	10E	20E	3.47	10E	10E	20E	20.8	7E	7E	10E
37.5	5.43	15E	15E	40E	5.2	15E	15E	30E	3.13	10E	10E	30E
50	7.25	20E	20E	25E	6.9	20E	20E	20E	4.17	20E	20E	20E
75	10.87	20E	20E	40E	10.4	20E	20E	40E	6.25	20E	20E	30E
100	14.5	25E	25E	50E	13.9	25E	25E	50E	8.33	20E	20E	30E
167	24.2	40E	40E	80E	23.2	40E	40E	80E	13.9	25E	25E	50E
250	36.2	50E	50E	100E	34.7	50E	50E	100E	20.8	30E	30E	65E
333	48.2	65E	65E	125E	46.2	65E	65E	125E	27.8	50E	50E	65E
500	72.5	80E	100E	200E	69.4	80E	100E	200E	41.7	50E	65E	100E
667	96.7	100E	150E	250E	92.6	100E	125E	250E	55.6	65E	80E	125E
833	120.7	125E	175E	250E	115.7	125E	175E	250E	69.4	80E	100E	175E
1250	181	200E	250E	250E	173.6	175E	250E	250E	104	125E	150E	200E
1667	241	250E	250E*	250E*	231	250E	250E*	250E*	138.9	150E	200E	200E

SYSTEM PH/PH VOLTAGE	12,470V				13,200V				13,800V			
FUSE VOLTAGE	15.5kV				15.5kV				15.5kV			
(1)		(2)	(3)	(4)		(2)	(3)	(4)		(2)	(3)	(4)
kVA	Full Load Crnt Amps	Min Fuse Rating Amps	Over-Load Rating Amps	Max Fuse Rating Amps	Full Load Crnt Amps	Min Fuse Rating Amps	Over-Load Rating Amps	Max Fuse Rating Amps	Full Load Crnt Amps	Min Fuse Rating Amps	Over-Load Rating Amps	Max Fuse Rating Amps
THREE PHASE												
30	1.39	5E	5E	10E	1.32	5E	5E	10E	1.25	5E	5E	10E
45	2.1	7E	7E	15E	1.98	7E	7E	15E	1.9	7E	7E	15E
75	3.47	10E	10E	25E	3.3	10E	10E	25E	3.13	10E	10E	25E
112.5	5.2	20E	20E	20E	4.9	15E	15E	30E	4.7	15E	15E	30E
150	7.0	20F	20E	20E	6.6	20E	20E	30E	6.3	20E	20E	30E
225	10.4	20E	20E	30E	9.8	20E	20E	30E	9.4	20E	20E	30E
300	13.9	20E	20E	25E	13.1	20E	20E	20E	12.6	20E	20E	20E
500	23.1	25E	30E	50E	21.9	25E	30E	30E	20.9	25E	30E	30E
750	34.7	50E	50E	50E	32.8	50E	50E	50E	31.4	50E	50E	50E
1000	46.3	50E	65E	65E	43.7	50E	65E	65E	41.8	50E	65E	65E
1500	69.6	80E	100E	100E	65.5	80E	100E	100E	62.8	65E	100E	100E
2000	92.5	100E	125E	125E	87.5	100E	125E	125E	83.7	100E	125E	125E
2500	115.5	125E	175E	175E	109	125E	150E	175E	105	125E	150E	150E
3000	139E	150E	200E	200E	131	150E	200E	200E	126	150E	175E	175E
SINGLE PHASE												
25	2.0	7E	7E	10E	1.89	7E	7E	10E	1.81	5E	5E	10E
37.5	3.01	10E	10E	30E	2.84	10E	10E	30E	2.72	10E	10E	30E
50	4.01	20E	20E	20E	3.8	10E	10E	40E	3.6	10E	10E	40E
75	6.01	20E	20E	25E	5.7	20E	20E	30E	5.4	20E	20E	30E
100	8.02	20E	20E	25E	7.6	20E	20E	25E	7.25	20E	20E	25E
167	13.4	25E	25E	50E	12.7	20E	20E	30E	12.1	20E	20E	30E
250	20.0	30E	30E	65E	19	30E	30E	50E	18.1	30E	30E	50E
333	26.7	50E	50E	65E	25.2	50E	50E	65E	24.1	50E	50E	65E
500	40.1	50E	65E	100E	38	50E	65E	100E	36.2	50E	50E	100E
667	53.5	65E	80E	125E	50	65E	80E	125E	48.3	65E	65E	125E
833	66.8	80E	100E	175E	63	65E	100E	150E	60.4	65E	80E	150E
1250	100.2	100E	150E	200E	95	100E	125E	200E	90.6	100E	125E	200E
1667	133.7	150E	200E	200E	126.3	150E	175E	200E	120.8	125E	175E	200E

* Max fuse size will not permit full transformer overload of 133%/140% see note 3.

Ratings in italics, above heavy line, are 9F60 series fuses

NOTES:

1. Transformer kVAs are based on their self cooled rating.

2. The minimum fuse rating shown is the smallest fuse which will withstand transformer inrush. For transformers rated 0-300kVA and 2500-3000kVA inrush is taken to be 12 times full load current for 0.1 seconds and 25 times full load current for 0.01 seconds. For transformers rated 500kVA-2000kVA, inrush is taken as 8 times full load current for 0.1 seconds and 20 times full load current for 0.01 seconds.

3. The overload fuse size shown will permit transformer overloading to at least 133% of its self cooled rating (140% for 2500kVA and above) unless otherwise indicated by *. All overload fuse sizes meet the 12 times/25 times inrush criteria for all transformer kVAs.

4. The maximum fuse size is the largest fuse rating which will meet the two second "ANSI Point" to protect for through faults, phase to ground on a delta-wye three phase transformer or line to line on a single phase transformer, of the quoted, or lower impedance. All maximum fuse sizes meet the 12 times/25 times inrush criteria for all tranformer kVAs. For dry type transformers, categories II and III, if system impedance is significant, a smaller fuse may have to be chosen to meet the two second "ANSI Point".

5. Fuses rated 5.5kV maximum with ratings of 80E and higher do not meet the ANSI permitted arc voltage requirement for 2.8kV fuses, when used at 2.4kV. For the actual arc voltage see arc voltage table.

INRUSH SELECTION

To prevent the fuse from becoming damaged or blown on inrush, a general rule is that the power fuse selected should have a minimum melt time current characteristic falling to the right of points corresponding to 12 times the transformer rated primary current and 0.10 seconds and 25 times the rated current and 0.01 seconds. Tests and considerable field experience with General Electric medium power transformers, however, have shown that, in sizes from 301-2000 kVA, the use of a point corresponding to eight times the rated primary current and 0.10 seconds should give satisfactory service. Consequently, Table III includes a column of minimum fuse sizes selected using these criteria. Note that due to the improved inrush withstand capability of the 9F62 fuses, care must be taken that a fuse with a sufficiently large continuous-current rating is chosen for a given transformer.

CONTINUOUS-CURRENT RATING SELECTION

Under no circumstances must a fuse be selected with a current rating less than the transformer continuous load current. Because fuses are of a much smaller mass, and hence thermal time constant, than the transformers they protect, they cannot be subjected to short duration overloads as the transformers can. Therefore, a transformer overload, which persists for more than a few minutes, must be considered to be a normal fuse load current and the fuse rating must be selected to be equal to or greater than this current. Forced-cooled transformers must be coordinated with fuses based on the higher forced-cooled continuous-current rating. Consequently, Table III has a column based on fuses capable of continuously carrying 133 percent of the transformer full-load current rating. Incidentally, all such fuses exceed the 12-times-inrush criteria.

As outlined earlier, many interrupting tests have demonstrated the ability of 9F62 fuses to clear currents below those causing melting in one hour; it is recommended, however, that auxiliary devices be used to provide protection in the region between rated current and the one-hour current (between 1.4 and 2 times rated current, depending on fuse rating). It should also be noted that pre-loading (the fuse carrying current before a fault) can sometimes reduce fuse melting times between 30 percent and 50 percent. This should be included when considering coordination with secondary devices, at times longer than about 0.5 seconds.

The upper limit to the size of fuse selected is a function of the desired degree of protection for the transformer from through (secondary) faults. The basic criterion, long used, has been the transformer thermal curve published in ANSI Loading Guide C57.92-1962, entitled "Short-time Loads (following full load) Oil Immersed Transformers". The permitted duration of a fault, limited only by the transformer impedance, specified in C57.12-1973, is similar to values from this curve, so that for a four-percent impedance transformer it is two seconds (25 times the rated current), while for six-percent impedance transformer it is four seconds (16.6 times the rated current).

With the publishing of ANSI/IEEE C57.12.00-1980 and C57.12.01-1979 (standard general requirements for liquid-immersed and dry-type transformers, respectively), the situation has changed somewhat. Transformers are now divided into four categories as shown in Table IV.

For liquid-immersed transformers in categories II, III, and IV, and dry-type transformers in categories I, II, and III, a short-circuit point at two seconds (the "two-second ANSI point") is now often used, the current being determined by the transformer impedance. Whichever ANSI point is used, adequate protection from through faults is considered to be obtained if the fuse's maximum total clearing time current curve lies to the left of this point. When a three-phase fault occurs on a transformer, the per-unit primary current corresponds to per-unit winding current, and the "ANSI point", or loading curve previously described, applies. If line-to-line or line-to-neutral faults occur in a delta-delta or delta-wye transformer, then for one per-unit winding current, less than one per-unit primary line current results. This means that for a protective device located on the primary lines, the "ANSI point" or loading curve must be shifted to the left. The worst case is a delta-wye transformer with line-to-neutral fault which gives only 57 percent of the three-

TABLE IV
ANSI/IEEE TRANSFORMER CATEGORIES

Category	Transformer kVA Rating	
	Single-Phase	Three-Phase
I	5-500	15-500
II	501-1667	501-5000
III	1668-10000	5001-30000
IV (Liquid Only)	>10000	30000

phase line current but with one phase of the secondary winding carrying 100 percent of the three-phase fault current. Table III has a column which shows the maximum fuse rating, in amperes, which meets the "two-second ANSI point" criterion for a line-to-neutral fault on a delta-wye connected three-phase transformer. Note these values apply to either liquid or dry transformers. For Category I liquid transformers where the two-second point does not apply, the use of larger-sized fuses may be possible.

Recent work which led to the development of a transformer through-fault current duration guide, ANSI-C57.109, suggests that the thermal curves already discussed are inadequate for situations where the transformer will be subjected to repeated through faults (for example, on an overhead distribution system with reclosers). Under these conditions, a mechanical withstand curve is produced by shifting the bottom part of the thermal curve (for categories II, III, and IV) to start at a point given by the maximum current, limited only by transformer impedance, and two seconds. The curve is then extended upward at a constant I^2t. At a suitable time (category II = four seconds; categories III and IV = eight seconds each), the curve reverts to the thermal one.

The curve for "infrequent" faults (category II, less than or equal to 10 times in transformer life; category III, less than or equal to five times in transformer life) has the same form as the old loading guide curve. It is anticipated that the majority of situations where current-limiting power fuses are used will fall into the category of "infrequent", since this is also the curve to be used when the fuse is providing backup protection to a secondary protective scheme designed to handle normal secondary faults. Note that coordination between the fuse total clearing time current curve and the loading curve includes a safety factor, since preloading will shift the fuse curve to the left. (The loading curve applies to overloads following full-load current.)

For a discussion on the selection and coordination of circuit breaker trip settings, see General Electric publication GER-2766.

SELECTION OF 9F62 FUSE TO REPLACE 9F60 FUSE

Although it is anticipated that the 9F60 fuse models superseded by 9F62 fuses will be available for the foreseeable future, users may find it desirable to obtain the advantages of the smaller size, improved performance, and lower losses associated with the new fuses. Selecting a 9F62 fuse to replace a 9F60 fuse requires that coordination with transformer and secondary protection be considered as outlined previously. However, in the absence of information necessary to perform such an analysis, the recommended approach is to replace the fuse with one of an equal current and voltage rating.

Refer to page 11 and Handbook Sections 7077 and 7078 for mounting information.

GENERAL ELECTRIC COMPANY
DISTRIBUTION TRANSFORMER BUSINESS DEPARTMENT
HICKORY, NC 28603

GENERAL ELECTRIC

2–83 (10M)

PRINTED IN U.S.A.