The Maximum Motor Circuit Feeder Fuse (430.62)

1. *For the one motor in the group with the highest starting current* — Find the largest fuse permitted for branch circuit protection using Table 430.52 or 440.22(A). The fuse capacity permitted for the motor with the heaviest starting current may be considered for only one motor. If two or more motors can each have a fuse of the same maximum size, only one of them can be considered. Then add:
2. *The Amp Rating of All other Motors on that feeder.*

Feeder Motor Schedule – Example

No. of Units	HP	Amps*	Multiplier†
1	3	4.8	1¾
1	5	7.6	1¾
1	15	21	1¾
1	40	52	1¾
1	75	96	1¾

*Per Table 430.150.
†Per Table 430.52.

Calculations — Maximum:

1. Largest motor (96A x 175% = 168A) (Round up to 175A)
2. F.L.A. all other motors (85.4A)
3. Total (175A + 85.4A = 260.4A) (Round down to 250A)

Choose 250 amp dual-element fuse.

Feeder Circuit-Combination Motor, Power and Lighting Loads

Where a feeder supplies motor load and power and/or lighting load, the permitted feeder fuse size calculation is the sum of that calculated for the motor load in accordance with 430.62, plus that calculated for the other loads in accordance with Articles 210 and 220 (430.63). The conductor ampacity supplying motors and other loads must be at least the sum of that calculated for the motor load in accordance with 430.22 and 430.24, plus that calculated for the other loads in accordance with Article 220 (430.25). (For exceptions see 430.25.)

Example of Sizing of Dual-Element Fuses for Combination Load Feeder

Motor Load (Use "Motor Schedule" in preceding example)

Continuous Heating and Lighting Load 135A

Non-Continuous Loads 110A

Calculations:

1. Motor Load: (Use calculation in preceding example) 260.4A
2. Continuous Non-Motor Load 135A x 125% 168.8A
3. Non-Continuous, Non-Motor Load .110.0A

Total 539.2A

(Round down to 500A)

Choose 500 amp dual-element fuse.

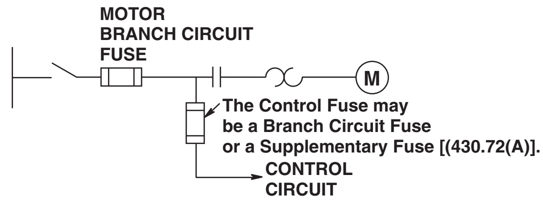
Motor Circuit Protection

General

A motor control circuit is a circuit of a control apparatus or system that carries the electric signal directing the performance of the controller (430.71). It does not carry the main power current.

A control circuit tapped on the load-side of the motor branch circuit fuse which controls the motor on that branch circuit shall be protected against overcurrent as in 430.72. Such a circuit is not considered a branch circuit and may be protected by a supplementary fuse or a branch circuit fuse. In either case, the fuse must have an adequate interrupting rating for point of application.

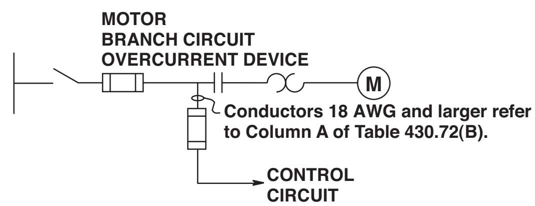
A standards requirement pertinent to motor controllers listed for available fault currents greater than 10,000 amps, states that the control circuit fuse must be a branch circuit fuse with a sufficient interrupting rating. (The use of Cooper Bussmann KTK-R, FNQ-R, LP-CC,JJS, JJN, or LPJ_SP fuses are recommended—these fuses have branch circuit listing status, high interrupting rating, and small size.)



Motor Control Circuit Conductors

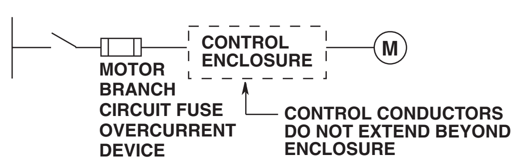
Control Circuits Tapped on Load-Side of Branch Circuit Fuse [430.72(B)]

1. Control circuit conductors 18 AWG and larger shall be protected against overcurrent in accordance with Table 430.72(B), Column A, as applicable.



430.72(B)(2)

Control conductors not extending beyond the enclosure shall be considered protected by the branch circuit fuse if in accordance with Table 430.72(B), Column B.



For control conductors extending beyond the enclosure, the motor branch circuit overcurrent device shall be considered to protect the conductors if in accordance with Table 430.72(B), Column C.

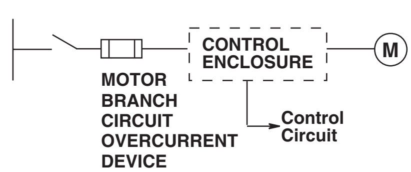


Table 430.72(B). Maximum Rating of Overcurrent Protective Device-Amperes

	Column A Basic Rule		Column B Exception No. 1		Column C Exception No. 2	
Control Circuit Conductor Size, AWG	Copper	Alum. or Copper-Clad Alum.	Copper	Alum. or Copper-Clad Alum.	Copper	Alum. or Copper-Clad Alum.
18	7	–	25	–	7	–
16	10	–	40	–	10	–
14	Note 1	–	100	–	45	–
12	Note 1	Note 1	120	100	60	45
10	Note 1	Note 1	160	140	90	75
larger than 10	Note 1	Note 1	Note 2	Note 2	Note 3	Note 3

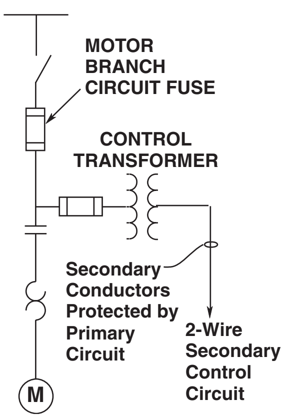
Note 1: Value specified in Section 310-15, as applicable.
Note 2: 400 percent of value specified in Table 310-17 for 60°C conductors.
Note 3: 300 percent of value specified in Table 310-16 for 60°C conductors.

430.72(C)

Secondary conductors of a single-phase transformer having only a 2-wire secondary are protected by the primary fuse (600V or less) if the primary fuse rating is:

1. Not larger than that determined in Table 430.72(B), multiplied by secondary-to-primary voltage ratio and,
2. not more than the following percent of transformer rated primary current:

Control conductors are permitted to be protected by the motor branch circuit overcurrent device where the opening of the control circuit would create a hazard.

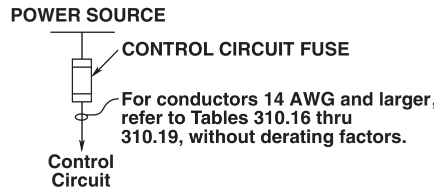


Transformer Primary Current	Primary Fuse Ampacity Must Not Exceed†
Less than 2 amps	500%
2 to 9 amps	167%
9 amps or more	125%*

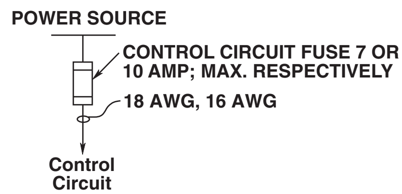
* If 125% of rated primary current does not correspond to a standard fuse rating, then the next higher standard fuse rating is permitted.
† Refer to Section 8.12 of NFPA79 for the allowable sizing for control transformers in Industrial Machinery.

Class 1 POWER LIMITED, Class 2 and Class 3 Remote Motor Control Circuits

1. Control circuit conductors shall be protected from overcurrent in accordance with Article 725.



2. Control circuit conductors 18 AWG and 16 AWG, shall be protected by a control circuit fuse not to exceed 7 and 10 amps respectively.



Exception No. 2 Relative to Transformer Protection

Refer to Exception 3, [430.72(B)], covered in preceding paragraphs.

Motor Control Circuit Transformers [430.72(C)]

Control circuit transformers (600V or less) shall be protected as shown previously in Exception No. 3 under 430.72(B).

430.72(C)(3): Control circuit transformers rated less than 50VA can be protected by a primary fuse, impedance limiting means, or other inherent means. The transformer must be an integral part of the motor controller, and be located within the controller.

430.72(C)(4): Allows transformers with primary currents less than 2 amps to be protected with primary fuses at 500% or less of primary full-load amps.

430.72(C)(1): Allows the control transformer to be protected by the motor branch circuit overcurrent device when the transformer supplies a Class 1 power-limited, circuit [see 725.11(A)] Class 2, or Class 3 remote control circuit conforming with the requirements of Article 725.

430.72(C)(5): Allows the control transformer to be protected by the motor branch circuit overcurrent device where protection is provided by other approved means.

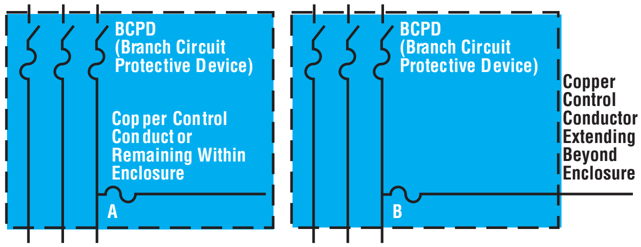
430.72(C) Exception: States that overcurrent protection shall be omitted where the opening of the control circuit would create a hazard, as for example, the control circuit of a fire pump motor and the like.

Catalog Number Designations for Fuse Blocks.

Fuse		Amp Rating	Single Pole	Double Pole	Single Pole Dove Tail for Ganging
Supplementary	13/32" x 1 ½"	1/10-30A	BM6031SQ	BM6032SQ	
Branch Circuit	FRN-R	1/10-30A	R25030-1SR	R25030-2SR	
	LPN-RK_SP	1/10-30A	R25030-1SR	R25030-2SR	
	FRS-R	1/10-30A	R60030-1SR	R60030-2SR	
	LPS-RK_SP	1/10-30A	R60030-1SR	R60030-2SR	
	SC	½-15A	BG3011SQ	BG3012SQ	
		20A	BG3021SQ	BG3022SQ	
	KTK-R	1/10-30A	BC6031S	BC6032S	
	FNQ-R	1/10-30A			
	LP-CC	½-30A			
	TCF	1-30A			TCFH 30
		1-60A			TCFH 60

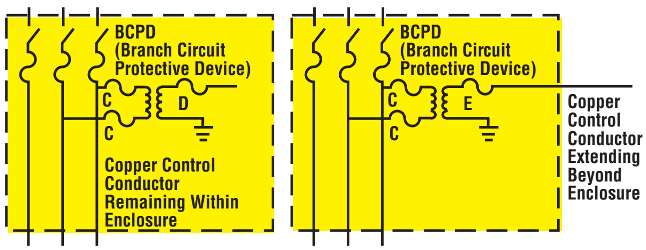
The following Selection Guide Tables simplify and permit easy application of fuses for the protection of the motor control circuits in accordance within the National Electrical Code®. Apply fuses per Table 1 for control circuit without a control transformer (see Circuit Diagrams 1 and 2). Apply fuses per Table 2 for a control circuit with a control transformer (see Circuit Diagrams 3 and 4).

Control Circuit Without Control Transformer (See Table 1)



Circuit 1 Circuit 2

Control Circuit With Control Transformer (See Table 2)



Circuit 3 Circuit 4

Table 1. Fuse Selection Guide–Control Circuit Without Control Transformer (See Circuit Diagrams 1 & 2)

Ampere Rating of Branch Circuit Protective Device (BCPD)	Circuit 1 (Control Conductor (AWG) Not Extending Beyond Enclosure)				Circuit 2 (Control Conductor (AWG) Extending Beyond Enclosure)			
	18 Wire	16 Wire	14 Wire	12 Wire	18 Wire	16 Wire	14 Wire	12 Wire
Fuse Size	7A	10A	15A	20A	7A	10A	15A	20A
Requirements For Control Circuit Protection (See footnote data)								
1⁄10 – 7	■	■	■	■	■	■	■	■
7 1⁄2 – 10	■	■	■	■	▲	■	■	■
12 – 25	■	■	■	■	▲	▲	■	■
30 – 40	▲	■	■	■	▲	▲	■	■
45	▲	▲	■	■	▲	▲	■	■
50 – 60	▲	▲	■	■	▲	▲	▲	■
65 – 100	▲	▲	■	■	▲	▲	▲	▲
110	▲	▲	▲	■	▲	▲	▲	▲
125 – up	▲	▲	▲	▲	▲	▲	▲	▲

▲ Control circuit fuse protection required.
■ Protection recommended but not mandatory when BCPD is a Class CC, G, J, R, or T fuse. Protection is mandatory when BCPD is a thermal magnetic or a magnetic-only circuit breaker (MCP), and available short-circuit current exceeds the values in the table below.

Control Circuit Conductor (AWG Copper)	Available Short-Circuit Current At Branch Circuit Protective Device (BCPD) 1 Cycle Clearing Time†	1⁄2 Cycle Clearing Time†
18	660A	940A
16	1050A	1500A
14	1700A	2400A
12	2700A	3800A

*Thermoplastic Insulation. †Based on ICEA Conductor Withstand Data.

Table 2. Fuse Selection Guide–Control Circuit With Control Transformer (See Circuit Diagrams 3 and 4)

Control Xfmr Rating	V_{pri}/V_{sec} (Volts)	Ipri (Amps)	I_{sec} (Amps)	[1]Fuse C [2]Req'd. If BCPD Exceeds These Amps Values	[4,5]Maximum Amps	Fuse D or E Required if BCPD and Fuse C (When Provided) Exceed These Amp Values 18 AWG Wire	16 AWG Wire	14 AWG Wire	12 AWG Wire	Recommended Amps Time Delay[1]	Non-Time Delay[3]
25VA	480/120	0.05	0.21	[6]See 430-72(C) Except. 1	0.25	0.25	0.25	0.25	0.25	0.25	0.60
	480/24	0.05	1.00		0.25	0.25	0.25	0.25	0.25	1.25	3.0
	240/120	0.10	0.21		0.50	0.50	0.50	0.50	0.50	0.25	0.60
	240/24	0.10	1.00		0.50	0.50	0.50	0.50	0.50	1.25	3.0
50VA	480/120	0.10	0.42	0.5	0.50	0.50	0.50	0.50	0.50	0.50	1.0
	480/24	0.10	2.10	0.5	0.50	0.50	0.50	0.50	0.50	2.5	6.0
	240/120	0.21	0.42	1.0	1.0	1.0	1.0	1.0	1.0	0.50	1.0
	240/24	0.21	2.10	1.0	1.0	1.0	1.0	1.0	1.0	2.5	6.0
100VA	480/120	0.21	0.83	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0
	480/24	0.21	4.20	1.0	1.0	1.0/.35[9]	1.0/.50[9]	1.0	1.0	5.0	12.0[7]
	240/120	0.42	0.83	2.0	2.0	2.0	2.0	2.0	2.0	1.0	2.0
	240/24	0.42	4.20	2.0	2.0	2.0/.70[9]	2.0/1.0[9]	2.0	2.0	5.0	12.0[7]
150VA	480/120	0.31	1.25	1.5	1.5	1.5	1.5	1.5	1.5	1.50	3.50
	480/24	0.31	6.25	1.5	1.5	—	1.5/0.5[9]	1.5	1.5	7.50	15.0[7]
	240/120	0.62	1.25	3.0	3.0	3.0	3.0	3.0	3.0	1.50	3.50
	240/24	0.62	6.25	3.0	3.0	—	3.0/1.0[9]	3.0	3.0	7.50	15.0[7]
200VA	480/120	0.42	1.67	2.0	2.0	2.0/1.75[9]	2.0	2.0	2.0	2.0	5.0
	480/24	0.42	8.33	2.0	2.0	—	—	2.0	2.0	10.0	20.0[8]
	240/120	0.84	1.67	4.0	4.0	4.0/3.5[9]	2.0	4.0	4.0	2.0	5.0
	240/24	0.84	8.33	4.0	4.0	—	—	4.0	4.0	10.0	20.0[8]

[1] Time-Delay Fuses: FNQ, FNW, FNM, FNA–Supplementary Type; FNQ-R, FRN-R, FRS-R, LPN-RK_SP, LPS-RK_SP, LPJ_SP, LP-CC, SC6 & above–Branch Circuit Fuses (Rejection Type).
[2] For exceptions, see 430.72(C).
[3] Non-Time-Delay Fuses: KTK, BAN, BAF, MIN, MIC–Supplementary Fuses; KTK-R, JJN, JJS, SC½-5–Branch Circuit Fuses (Rejection Types).
[4] These are maximum values as allowed by 430.72(C). Closer sizing at 125%-300% may be possible for better overload protection using time-delay branch circuit fuses.
[5] Fuse shall be a rejection type branch circuit fuse when withstand rating of controller is greater than 10,000 amps RMS symmetrical
[6] These transformers less than 50VA still need protection–either primary overcurrent protection, inherent protection, or the equivalent. Note that the primary conductors may be protected as shown in Circuit 1 Table 1. [7] Minimum copper secondary control conductor for this application is 14 AWG. [8] Minimum copper secondary control conductor for this application is 12 AWG.
[9] Smaller value applied to Fuse "E".

COOPER Bussmann®

Cooper Bussmann FNQ-R Maximum Primary Fuse Selection Guide for Motor Control Circuit Transformer Protection***

XFMR VA	600V	550V	480V	460V	415V	380V	277V	240V	230V	208V
50	4/10A	4/10A	1/2A	1/2A	6/10A	6/10A	8/10A	1A	1A	1 1/8A
75	6/10A	6/10A	3/4A	8/10A	8/10A	8/10A	1 3/10A	1 1/2A	1 6/10A	1 8/10A
100	8/10A	8/10A	1A	1A	1 1/8A	1 3/10A	1 8/10A	2A	2A	2 1/4A
150	1 1/4A	1 3/10A	1 1/2A	1 6/10A	1 8/10A	1 8/10A	2 1/2A	3A	3 2/10A	3 1/2A
200	1 6/10A	1 8/10A	2A	2A	2 1/4A	2 1/2A	3 1/2A	4A	4A	4 1/2A
250	2A	2 1/4A	2 1/2A	2 1/2A	3A	3 2/10A	4 1/2A	5A	5A	6A
300	2 1/2A	2 6/10A	3A	3 2/10A	3 1/2A	3 1/2A	5A	6 1/4A	6 1/4A	7A
350	2 8/10A	3A	3 1/2A	3 1/2A	4A	4 1/2A	6 1/4A	7A	7 1/2A	8A
500	4A	4 1/2A	5A	5A	6A	6 1/4A	9A	3 2/10A**	3 1/2A**	4A**
750	6 1/4A	6 1/4A	7 1/2A	8A	9A	9A	4 1/2A*	5A**	5A**	6A**
1000	8A	9A	3 2/10A*	3 1/2A*	4A*	4A*	6A*	6 1/4A**	7A**	8A**
1500	4A*	4 1/2A*	5A*	5A*	6A*	6 1/4A*	9A*	10A**	10A**	12A**
2000	5A*	6A*	6 1/4A*	7A*	8A*	8A*	12A*	12A**	12A**	15A**

*For increased time-delay, use FRS-R, LPS-RK_SP, LPJ_SP, or TCF **For increased time-delay, use FRN-R, LPN-RK_SP ***Based upon the NEC®

Supplementary Fuses (13/32" x 1 1/2") (All Voltage and Interrupting Ratings are AC)

Dual-Element, Time-Delay

FNA
1/10-8/10A
250V†
1-15A
125V*
20-30A
32V**

FNM
1/10-10A
250V†
12-15A
125V*
20-30A
32V**

Time-Delay

FNQ
1/10-30A
500V
10K AIR
(FNQ 1/10 - 3 2/10 Dual-Element)

FNW
12-30A
250V*

Non-Time-Delay

BAF
1/2-15A
250V†
20-30A
125V*

BAN
2/10-30A
250V††

KTK
1/10-30A
600V
100K AIR

MIC
1-15A
250V†
20-30A
32V**

MIN
1-15A
250V†
20-30A
32V**

Branch Circuit Fuses (All Voltage and Interrupting Ratings are AC)

Class R Dual-Element, Time-Delay

LPN-RK_SP
1/10-30A
250V
300K AIR

FRN-R
1/10-30A
250V
200K AIR

FRS-R
1/10-30A
600V
200K AIR

LPS-RK_SP
1/10-30A
600V
300K AIR

Class G

SC
1/2-20A 600V§
25-30A 480V§
100K AIR

Class CC Fast-Acting, Time-Delay

KTK-R
1/10-30A
600V
200K AIR

FNQ-R
1/4-30A
600V
200K AIR

LP-CC
1/2-30A
600V
200K AIR

TCF
1-30A
600V
300K AIR

† 0 to 1 amp–35 AIR; 1.1 to 3.5 amp–100 AIR; 3.6 to 10 amp–200 AIR; 10.1 to 15 amp–750 AIR; 15.1 to 30 amps–1500AIR *10K AIR. **1K AIR.

§ 1/2 thru 6 amp fuses are Non-Time-Delay Type; 7 thru 60 amp fuses are Time-Delay Type.

††0 to 3.5 amp-35 AIR; 3.6 to 10 amp-100 AIR; 10.1 to 15 amp-200 AIR; 15.1-30 amp-750 AIR

R-Rated Medium Voltage Fuses

R-rated medium voltage fuses are back-up current-limiting fuses used in conjunction with medium voltage motors and motor controllers. These fuses are designed for short-circuit protection only and do not protect themselves or other components during extended overloads. Thus, this type of fuse does not have an amp rating, but rather an R-rating. Current-limiting fuses may be designated as R-rated if they meet the following requirements:

1. The fuse will safely interrupt an currents between its minimum and maximum interrupting ratings,
2. The fuse will melt in a range of 15 to 35 seconds at a value of 100 times the "R" number (ANSI C 37.46).

Cooper Bussmann R-rated current-limiting fuses are designed for use with medium voltage starters to provide short-circuit protection for the motor and motor-controller. These fuses offer a high level of fault current interruption in a self-contained, non-venting package which can be mounted indoors or in an enclosure. All of the R-rated product comes with open fuse indication. Some of the product is available with a hookeye option. A hookstick can be used for non-loadbreak isolation.

Application

Medium voltage motors are efficiently protected by overload relays applied in conjunction with back-up current-limiting fuses which are intended to open the circuit for high fault conditions. The overload relay is chosen to interrupt currents below the minimum interrupting rating of the fuse. Since multiple devices are used to provide protection it is very important that they be properly coordinated. The motor starter manufacturer typically chooses the proper fuse R-rating, overload relay, and contactor. The following guideline can be used to insure proper coordination.

Guideline for Applying R-Rated Fuses

The current-limiting fuse should be selected so that the overload relay curve crosses the minimum melting curve of the fuse at a current greater than 110% of the locked rotor current of the motor being utilized.

A preliminary choice is obtained through the following formula:

$$\frac{6.6 \times \text{Full Load Current}}{100} = \text{R rating of fuse}$$

This value is rounded up to the next R-rating fuse.

Example:

A 2300V motor has a 100 amp full load current rating and a locked rotor current of 600 amps.

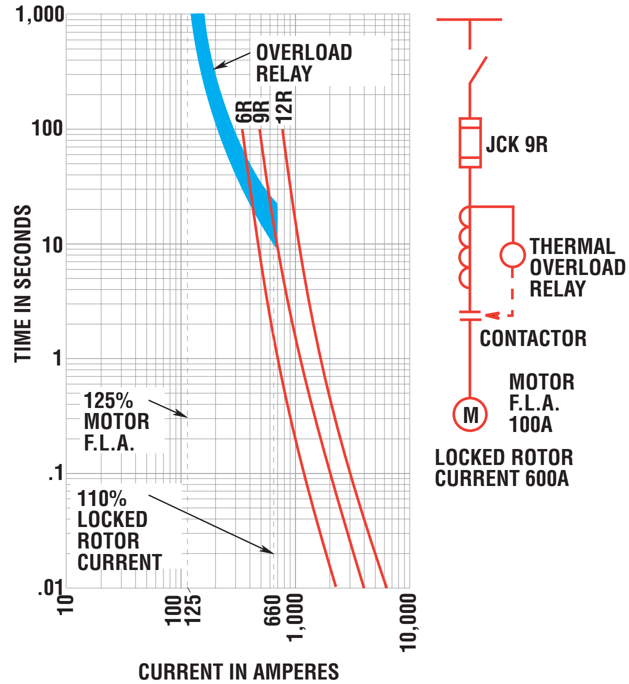
The preliminary choice is

$$\frac{6.6 \times 100}{100} = 6.6$$

Thus one rounds up to the next standard R-rating, 9R. But this must be checked with the appropriate time-current characteristics curves.

The overload relay being used has the time-current characteristic as shown in the adjacent Figure. To choose the proper fuse one must plot 110% of the locked rotor current and the family of fuses on the same graph as the overload relay.

The fuse that should be selected is the smallest fuse whose minimum melting characteristic crosses the overload relay at a current greater than 110% of the locked rotor current. In this example, it would be a 2400V 9R fuse. This agrees with the quick selection choice. Depending on the type of installation and starter being used, a JCK-9R, JCK-A-9R, or JCH-9R would be the correct choice.



Fusible Equipment vs. Circuit Breaker Equipment

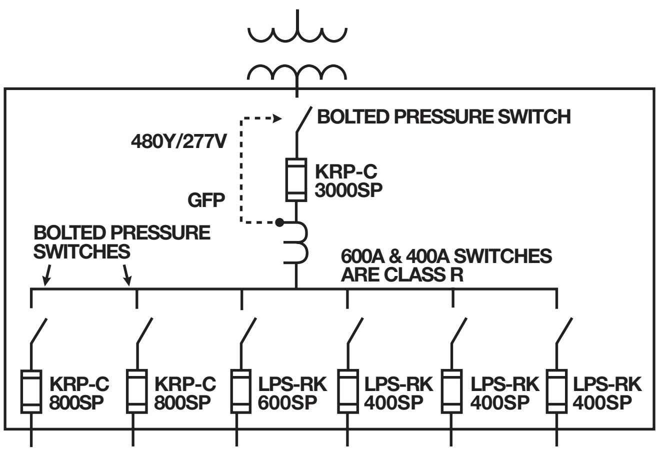
One of the basic requirements in designing an electrical distribution system involves the specification of overcurrent protective devices. Many technical issues must be resolved in order to properly specify fuses and circuit breakers. The following examines a key factor in the evaluation and design process: COST OF OWNERSHIP-FUSIBLE EQUIPMENT VS. CIRCUIT BREAKER EQUIPMENT The evaluation includes:

1. The Initial Cost of the Equipment. (This includes the overcurrent devices as well as the switchgear.)
2. The Preventive maintenance costs of the equipment during its expected life.

Overcurrent Protection Requirements

Before performing the cost of ownership comparison, basic system requirements must be established. These requirements, relative to the overcurrent protective devices are based upon:

1. Voltage Rating
2. Current Rating
3. Interrupting Rating



For the systems in Figures 1 and 2, the following ratings are established.

Figure 1 — All switches are rated, with fuses, for use where 200,000 amps or less are available. Fuses, by themselves, are rated for 300,000 AIR.

Fusible Board Ratings

1. Voltage Rating-600V
2. Current Rating-3000 Amp Switchgear
3. Interrupting Rating; 300,000 Amps-Fuses, 200,000 Amps-Switchboard

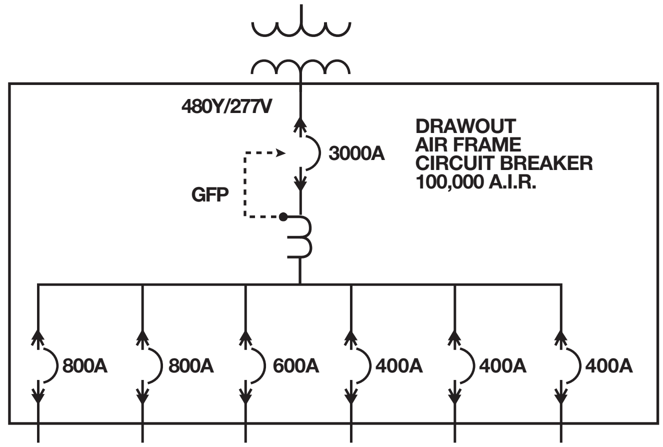


Figure 2 — All feeder CBs have 65,000 A.I.R., insulated case, drawout feature and electronic sensing capabilities.

Circuit Breaker Board Ratings

1. Voltage Rating - 480V
2. Current Rating - 3000 Amp Switchgear
3. Interrupting Rating; (multi-pole) - 100,000 Amps - Main*, (multi-pole) - 65,000 Amps-Feeders*

*Consult manufacturers or Single Pole Interrupting Ratings.

Initial Cost of Equipment

The two industrial grade switchboards illustrated in Figures 1 and 2 represent state-of-the-art specifications for fusible design and circuit breaker design, respectively.

Prices from one major switchgear manufacturer, to the end user, would be as indicated below:

Figure 1. Fusible Design: $26,000**

(Includes Spare Fuses and Acceptance Testing)

Figure 2. Circuit Breaker Design: $47,500**

(Includes Acceptance Testing. Does not include additional bracing of structure if short time delay is used on main CB.)

THE INITIAL COST OF THE CIRCUIT BREAKER EQUIPMENT IS 83% HIGHER THAN THE INITIAL COST OF THE FUSIBLE EQUIPMENT. AN ADDITIONAL COST OF $21,500 IS PAID BY THE END USER.

**These costs are typical, and will vary with market conditions and manufacturer's pricing.

Preventive Maintenance

Preventive maintenance is a planned procedure of inspecting, testing, cleaning, adjusting and lubricating electrical apparatus. A good preventative maintenance program with planned shutdowns maximizes continuity of operation. Through such a program, troubles can be detected in the early stages, and corrective action can be taken before extensive damage occurs.

Field surveys of existing overcurrent protection systems have yielded rather alarming statistics. An IEEE paper reported a survey that indicated 40 percent of all breakers tested were found to be faulty. One manufacturer has stated in its field maintenance manual, that many circuit breakers over 5 years old are **completely** inoperative. Another manufacturer states that "Nine times out of ten, circuit breakers fail because of lack of maintenance, cleaning, and lubrication." Only through a thorough, well planned, and well executed preventive maintenance program will overcurrent devices continue to provide optimum protection.

Three requirements will help assure a reliable overcurrent protection system.

The first requirement in an optimum electrical maintenance program is good apparatus, properly installed.

Secondly, properly trained, adequately equipped maintenance personnel are needed. preventive maintenance can be expensive; it requires shop facilities, skilled labor, keeping records and stocking replacement parts.

The third requirement is scheduling outages for preventive maintenance and periodic testing of electrical apparatus. When preparing routine maintenance schedules, it must be recognized that too frequent testing is a waste of money, and that insufficient testing places vital equipment and operating personnel in jeopardy.

For more information see: www.cooperbussmann.com/apen/topics/reliability.

Preventive Maintenance Costs

An accurate analysis of Cost of Ownership must also compare the ongoing cost to maintain the equipment, over the life of that equipment.

Fusible Equipment - Annual Maintenance Requirements

Schedule	Maintenance Hours/Device	# of Devices	Total Man Hours
3-Bolted Pressure Switches	1.5	3	4.5
4-Feeder Disconnects	0.5	4	2
Prep Work and Data Retrieval			6
Annual Total Man Hours			12.5

Assume $80/hour by a qualified testing/engineering firm.

Maintenance Cost = $80/Hr x 12.5 Hrs/Year = $1000/Year

Fuse Replacement Costs

Rating	Replace**	Fuse Cost* Each	Fuse Cost Over 20 Years
800A & 3000A	1/20 Yrs	$490	$490
400A & 600A	2/20 Yrs	$135	$270
Total Replacement			$760

Fuse Replacement Cost/Yr = $760/20Yrs = $38/Yr.

Total Maintenance Cost - Fusible Equipment

= Fuse Replacement + maintenance costs

= $38 + $1000 + $1038/Year

*Average Cost of Fuse Ratings

**Assumes 1 Class L Fuse and 2 Class R Fuses open in 20 Years.

Circuit Breaker Equipment - Annual Maintenance Requirements

Schedule	Maintenance Hours/Device	# of Devices	Total Man Hours
1-Main LVPCB*	4	1	4
6-Feeder ICCB**	1.5	6	9
Prep Work and Data Retrieval			6
Annual Total Man Hours			19

Assume $80/Hour by a qualified testing/engineering firm.

Total Maintenance Cost - Circuit Breaker Equipment

= $80/Hr x 19 Hrs/Year = $1520/Year

*Low Voltage Power Circuit Breaker, Drawout

**Insulated Case Circuit Breaker, Drawout

Total Cost of Ownership

We can expect a minimum 20 year useful life for the fusible and circuit breaker equipment. Life Costs, or Total Cost of Ownership, would be:

Total Cost of Ownership* = Initial Cost + (total annual maintenance cost) 20 yrs.

Fusible Equipment Cost of Ownership

Initial Cost + (total Maintenance Cost) 20 = $26,000 + ($1038)(20 Yrs) = $46,760

Circuit Breaker Equipment Cost of Ownership

Initial Cost + (total Maintenance Cost) 20 = $47,500 + ($1520)(20 Yrs) = $77,900

The Cost of Ownership of the circuit breaker equipment is 67% greater than that of the fusible equipment, over the expected 20 year life of the equipment. Additional cost would be incurred if circuit breakers need to be replaced.

*These figures and calculations do not examine the effects of the Time Value of Money. These values can be calculated using a number of methods, i.e., Present Worth, Annual Costs, etc.

Other Considerations

This evaluation has not analyzed the other necessary engineering considerations associated with overcurrent protection.

These include:

- Current Limitation
- Component Protection
- Selective coordination
- Multipole vs. Single Pole interrupting Ratings
- Electrical Safety (for more information see www.cooperbussmann.com)

Conclusions

Cost of Ownership, which includes both initial costs and preventive maintenance costs, is an important part of an engineer's decision making process. Good engineering and preventive maintenance is critical for adequate performance during the lifetime of the equipment. Fusible vs. Circuit Breaker design choices involve economic as well as engineering considerations.