CODE REQUIREMENTS

The NEC or CEC requires that motor branch circuits be protected against overloads and short circuits. Overload protection may be provided by fuses, overload relays or motor thermal protectors. Short circuit protection may be provided by fuses or circuit breakers.

OVERLOAD PROTECTION

The NEC or CEC allows fuses to be used as the sole means of overload protection for motor branch circuits. This approach is often practical with small single phase motors. If the fuse is the sole means of protection, the fuse ampere rating must not exceed the values shown in Table 1.

Most integral horsepower 3 phase motors are controlled by a motor starter which includes an overload relay. Since the overload relay provides overload protection for the motor branch circuit, the fuses may be sized for short circuit protection.

SHORT CIRCUIT PROTECTION

The motor branch circuit fuses may be sized as large as shown in Table 2 when an overload relay or motor thermal protector is included in the branch circuit. Time delay fuse ratings may be increased to 225% and non-time delay fuse ratings to 400% (300% if over 600 amperes) if the ratings shown in Table 2 will not carry motor starting current.

Some manufacturers' motor starters may not be adequately protected by the maximum fuse sizing shown in Table 2. If this is the case, the starter manufacturer is required by UL 508 to label the starter with a maximum permissible fuse size. If so labeled, this maximum value is not to be exceeded.

Where the percentages shown in Table 2 do not correspond to standard fuse ratings the next larger fuse rating may be used. Standard fuse ratings in amperes:

15	20	25	30	35	40	45	50
60	70	80	90	100	110	125	150
175	200	225	250	300	350	400	450
500	600	700	800	1000	1200	1600	2000
2500	3000	4000	5000	6000			

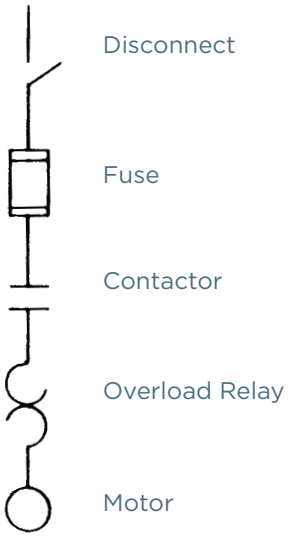
FUSE SELECTION GUIDELINES

What fuse type and ampere rating is best for a given application? The answer depends upon the application and objective to be met. Here are some suggestions.

WHICH FUSE CLASS?

UL Classes RK5, RK1, and J are the most popular. The Class RK5 (Tri-onic®) is the least expensive. The Class RK1 (Amp-Trap®) is used where a higher degree of current limitation is required for improved component protection or system coordination. The RK5 and RK1 are dimensionally interchangeable.

The Class J time delay fuse (AJT) provides advantages over the RK5 and RK1 fuses. Class J fuses provide a higher degree of current limitation than the RK's. This reduced fault current will reduce arc faults in cases of an arc flash incident.



MOTOR BRANCH CIRCUIT

TABLE 1- MAXIMUM FUSE RATING FOR OVERLOAD PROTECTION

Motor Service Factor or Marked Temperature Rise	Fuse Rating as %* Motor Full Load
Service factor of 1.15 or greater	125
Marked temperature rise not Exceeding 40°C	125
All Others	115

** These percentages are not to be exceeded.*

TABLE 2- MAXIMUM FUSE RATING FOR SHORT CIRCUIT PROTECTION

Type of Motor	Fuse Rating as %* Motor Full Load* Fuse Type	
	Non-Time Delay	Time Delay
All Single-phase AC motors	300	175
AC polyphase motors other than wound-rotor:		
Squirrel Cage		
Other than Design E	300	175
Design E	300	175
Synchronous	300	175
Wound rotor	150	150
Direct-current (constant voltage)	150	150

** The non-time delay ratings apply to all class CC fuses.*

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The Class J fuse is also about half the physical size of the RK5 and RK1 reducing panel space and saving money.

TIME DELAY VS. NON-TIME DELAY

Time delay fuses are the most useful fuses for motor branch circuit application. A time delay fuse can be sized closer to motor full load current, providing a degree of overload protection, better short circuit protection, and possible use of a smaller disconnect switch.

WHAT AMPERE RATING?

The selection of fuse ampere rating is a matter of experience and personal preference. Some prefer to size time delay fuses at 125% of motor full load amperes. This sizing will provide a degree of overload protection for motors with a service factor of 1.15. Sizing fuses at 125% of motor nameplate amperes in some applications may result in nuisance fuse openings. Time delay fuses sized at 125% may open at motor locked rotor current before some NEMA Class 20 overload relays operate. Nuisance fuse openings may result if Class RK1 or Class J fuses are sized at 125% of motor full load current. These fuses are more current limiting than the RK5 and have less short time current carrying capability.

Sizing time delay fuses between 125% and 150% of motor full load current provides advantages. The fuse will coordinate with NEMA Class 20 overload relays. Nuisance fuse opening will virtually be eliminated and effective short circuit protection will be maintained.

For newer, premium efficiency motors, sizing fuses between 125% and 150% may not be sufficient enough to handle the expected higher motor locked-rotor currents. For suggestions on sizing fuses for these situations, refer to the high-efficiency sizing summary at the end of this section.

PROTECTING IEC STYLE MOTOR STARTERS

The new IEC European style motor starters and contactors are popular but they present different problems in protection. These devices represent substantial savings in space and cost but they have a lower withstand capability than their NEMA counterparts.

In order to achieve the same level of protection for IEC style devices that we expect for NEMA devices, the AJT Class J Time Delay fuse is the best choice, sized at 1.25 to 1.50 times motor full load amperes. Also, the AJT has the advantage of being half the size of RK5 and RK1 fuses and thereby fits the trim IEC package.

SINGLE PHASE MOTOR FUSE SELECTION UL CLASSES RK1, RK5, J & CC

Motor Characteristics*		Fuse Classes and Ampere Ratings					
		Class CC (ATDR)			Class J (AJT) and RK5/1 (TR/A2D)		
Motor HP	Full Load Current	Recommended Rating	Max. Rating per NEC 430.52(C)(1), Exception No. 1†	Max. Rating per NEC 430.52(C)(1), Exception No. 2††	Recommended Rating	Max. Rating per NEC 430.52(C)(1), Exception No. 1†	Max. Rating per NEC 430.52(C)(1), Exception No. 2††
Single Phase, 115 V							
1/6	4.4	15	15	15	7	10	10
1/4	5.8	17-1/2	20	20	9	15	15
1/3	7.2	25	25	25	12	15	15
1/2	9.8	30	30	30	15	20	20
3/4	13.8	-	-	-	20	25	30
1	16	-	-	-	25	30	35
1-1/2	20	-	-	-	30	35	45
2	24	-	-	-	35	45	50
3	34	-	-	-	60	60	70
5	56	-	-	-	80	100	125
7-1/2	80	-	-	-	125	150	175
10	100	-	-	-	150	175	225
Single Phase, 230 V							
1/6	2.2	7	10	10	3-1/2	6	6
1/4	2.9	9	10	10	4-1/2	6	6
1/3	3.6	12	15	15	5-6/10	10	10
1/2	4.9	15	15	15	7	10	10
3/4	6.9	20	25	25	12	15	15
1	8	25	25	30	12	15	17-1/2
1-1/2	10	30	30	30	15	20	20
2	12	-	-	-	20	25	25
3	17	-	-	-	25	30	35
5	28	-	-	-	40	50	60
7-1/2	40	-	-	-	60	70	90
10	50	-	-	-	80	90	110

* *Values obtained from NEC 2017 Table 430.250. Fuse ampere ratings based on percentages of full-load current values from this table.*

† *Sizing based on 175% of motor FLA for Time-Delay Class J/R fuses and 300% of motor FLA for Time-Delay Class CC fuses. Values rounded up to the next standard rating.*

†† *Sizing based on 225% of motor FLA for Time-Delay Class J/R fuses and 400% of motor FLA for Time-Delay Class CC fuses. Fuse ratings cannot exceed these values.*

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THREE PHASE MOTOR FUSE SELECTION UL CLASSES RK5, RK1, J & CC

Motor Characteristics*		Fuse Classes and Ampere Ratings					
		Class CC (ATDR)			Class J (AJT) and RK5/1 (TR/A2D)		
Motor HP	Full Load Current	Recommended Rating	Max. Rating per NEC 430.52(C)(1), Exception No. 1†	Max. Rating per NEC 430.52(C)(1), Exception No. 2††	Recommended Rating	Max. Rating per NEC 430.52(C)(1), Exception No. 1†	Max. Rating per NEC 430.52(C)(1), Exception No. 2††
Three Phase, 208 V							
0.5	2.4	8	10	10	3-1/2	6	6
0.75	3.5	10	15	15	5	10	10
1	4.6	15	15	15	7	10	10
1.5	6.6	20	20	25	10	15	15
2	7.5	25	25	30	12	15	15
3	10.6				15	20	20
5	16.7				25	30	35
7.5	24.2				35	45	50
10	30.8				45	60	60
15	46.2				70	90	100
20	59.4				90	110	125
25	74.8				110	150	150
30	88				150	175	175
40	114				175	200	250
50	143				225	300	300
60	169				250	300	350
75	211				350	400	450
100	273				400	500	600
125	343				500	600	-
150	396				600	-	-
Three Phase, 230 V							
0.5	2.2	7	10	10	3-1/2	6	6
0.75	3.2	10	10	12	5	6	7
1	4.2	12	15	15	6-1/4	10	10
1.5	6	17-1/2	20	20	9	15	15
2	6.8	20	25	25	10	15	15
3	9.6	30	30	30	15	20	20
5	15.2				25	30	30
7.5	22				35	40	45
10	28				40	50	60
15	42				70	80	90
20	54				80	100	110
25	68				110	125	150
30	80				125	150	175
40	104				150	200	225
50	130				200	250	250
60	154				225	300	300
75	192				300	350	400
100	248				350	450	500
125	312				450	600	600
150	360				500	600	-

* *Values obtained from NEC 2017 Table 430.250. Fuse ampere ratings based on percentages of full-load current values from this table.*

† *Sizing based on 175% of motor FLA for Time-Delay Class J/R fuses and 300% of motor FLA for Time-Delay Class CC fuses. Values rounded up to the next standard rating.*

†† *Sizing based on 225% of motor FLA for Time-Delay Class J/R fuses and 400% of motor FLA for Time-Delay Class CC fuses. Fuse ratings cannot exceed these values.*

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THREE PHASE MOTOR FUSE SELECTION
UL CLASSES RK5, RK1, J, CC

Motor Characteristics*		Fuse Classes and Ampere Ratings					
		Class CC (ATDR)			Class J (AJT) and RK5/1 (TRS/A6D)		
Motor HP	Full Load Current	Recommended Rating	Max. Rating per NEC 430.52(C)(1), Exception No. 1†	Max. Rating per NEC 430.52(C)(1), Exception No. 2††	Recommended Rating	Max. Rating per NEC 430.52(C)(1), Exception No. 1†	Max. Rating per NEC 430.52(C)(1), Exception No. 2††
Three Phase, 460 V							
0.5	1.1	3-1/2	6	6	1-6/10	3	3
0.75	1.6	5	6	6-1/4	2-1/2	3	3-1/2
1	2.1	6-1/4	10	10	3-2/10	6	6
1.5	3	9	10	12	4-1/2	6	6-1/4
2	3.4	10	15	15	5	6	7
3	4.8	15	15	15	7	10	10
5	7.6	25	25	30	12	15	15
7.5	11				17-1/2	20	20
10	14				20	25	30
15	21				35	40	45
20	27				40	50	60
25	34				50	60	70
30	40				60	70	90
40	52				80	100	110
50	65				100	125	125
60	77				125	150	150
75	96				150	175	200
100	124				200	225	250
125	156				225	300	350
150	180				250	350	400
200	240				350	450	500
250	302				450	600	600
300	361				600	-	-
Three Phase, 575V							
0.5	0.9	2-8/10	3	3-1/2	1-1/2	3	3
0.75	1.3	4	6	6	2	3	3
1	1.7	5-6/10	6	6-1/4	2-8/10	3	3-1/2
1.5	2.4	8	10	10	3-1/2	6	6
2	2.7	8	10	10	4	6	6
3	3.9	12	15	15	6	10	10
5	6.1	17-1/2	20	20	10	15	15
7.5	9	30	30	30	15	20	20
10	11				17-1/2	20	20
15	17				25	30	35
20	22				35	40	45
25	27				40	50	60
30	32				50	60	70
40	41				60	80	90
50	52				80	100	110
60	62				90	110	125
75	77				125	150	150
100	99				150	175	200
125	125				200	225	250
150	144				225	300	300
200	192				300	350	400
250	242				350	450	500
300	289				450	600	600

* *Values obtained from NEC 2017 Table 430.250. Fuse ampere ratings based on percentages of full-load current values from this table.*

† *Sizing based on 175% of motor FLA for Time-Delay Class J/R fuses and 300% of motor FLA for Time-Delay Class CC fuses. Values rounded up to the next standard rating.*

†† *Sizing based on 225% of motor FLA for Time-Delay Class J/R fuses and 400% of motor FLA for Time-Delay Class CC fuses. Fuse ratings cannot exceed these values.*

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FUSE SIZING CONSIDERATIONS FOR HIGHER EFFICIENCY MOTORS

When selecting the proper fuse for short circuit protection in motor starting applications, it is important to not only ensure that the fuse will not nuisance open during motor start up times, but also that the fuse will coordinate as required with overload relays. When sizing fuses between 125% and 150% of the motor nameplate current, several advantages, including ease of coordination with an overload device, a smaller disconnect, and increased short circuit protection from a lower fuse rating, can be achieved. However, if sizing at this level prevents the motor from starting, it may then be necessary to increase the fuse ampere rating and it then becomes important to know the NEC sizing limitations.

As of June 1, 2016, the US Department of Energy has mandated that newly manufactured electric motors will need to meet NEMA Premium® efficiency standards. As motor efficiencies increase, motor locked rotor currents can also be expected to increase. In addition to this, with across-the-line starting applications, it is critical to understand not only the locked rotor current, but also the starting time that can be expected.

With previous efficiencies, typically motor locked rotor currents between 300% and 600% of motor nameplate currents were common. However, with the new efficiency standards, locked rotor currents for NEMA Design B, C, and D motors can reach between 600% and 700% of nameplate currents and are restricted to maximum levels per the NEMA design standards. With NEMA Design E motors, these levels can be expected to be as high as 1000% of the rated current. Design A motors have no standardized maximums for locked rotor currents, but can be very high depending on the motor kVA code value. Special attention should be paid to the motor nameplate values when sizing motor protection fuses.

For Premium Efficiency motors, sizing fuses between 125% and 150% of the rated current may not be sufficient to allow the motor to start due to the potential magnitude of locked rotor currents. In addition to this, if the expected start time of the motor is over 5 seconds, this may be too long for this size fuse to handle without opening. Section 430.52(C)(1), Exception 1 in the NEC allows for Time-Delay Class R and J fuses to be sized at 175% of the rated motor current up to the next standard fuse size.

If sizing at 175% still does not allow for the motor to start, section 430.52(C)(1), Exception 2 in the NEC permits an absolute maximum fuse size of 225% of the motor rated current. In these cases, depending on the value determined from these multiplication factors, fuse sizes between Exceptions 1 and 2 may be exactly the same. Where Exception 1 permits rounding up to the next standard size, fuses sized to Exception 2 may not exceed the mentioned 225% value in any way.

For Time-Delay Class CC fuses, similar exceptions in the NEC also apply. Section 430.52(C)(1), Exception 1 allows for a fuse size of 300% up to the next standard rating. Section 430.52(C)(1), Exception 2 permits a fuse size not exceeding 400% of the motor rated current, should 300% sizing still not allow the motor to start.

NEC 430.52 Fuse Sizing Limits

NEC Sections	Time-Delay Class R/J Fuse	Time-Delay Class CC Fuse
NEC 430.52(C)(1), Exception 1	175%*	300%*
NEC 430.52(C)(1), Exception 2	225%**	400%**

* *Values may be rounded up to next standard fuse ampere rating.*

** *Permitted when Exception 1 ratings are not sufficient for motor starting current. Ratings may not exceed these limits.*

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