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NEMA APPLICATION GUIDE FOR ELECTRIC FIRE PUMP CONTROLLERS

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NEMA Standards Publication ICS 14-1998

NEMA APPLICATION GUIDE FOR ELECTRIC FIRE PUMP CONTROLLERS

Published by:

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Table of Contents

Foreword ii

1.1 SCOPE 1

1.2 DEFINITIONS 1

1.3 REFERENCED PUBLICATIONS 1

2.1 POWER CONDUCTORS CONNECTED TO THE FIRE PUMP CONTROLLER AND MOTOR 1

2.2 ENVIRONMENTAL CONSIDERATIONS FOR ENCLOSURES 3

2.3 TRANSFORMER SIZING 4

2.4 TRANSFER SWITCH CONSIDERATIONS 5

2.5 CONSIDERATIONS FOR SPECIFYING SHORT CIRCUIT RATING (RMS SYM) 8

2.6 REDUCED VOLTAGE STARTING METHODS 11

2.7 PHASE SEQUENCE 11

2.8 LISTED AND APPROVED EQUIPMENT 12

2.9 TESTING AND MAINTENANCE 12

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Foreword

This Application Guide was prepared by a technical committee of the NEMA Industrial Control and Systems Section. It was approved in accordance with the bylaws of NEMA.

This Application Guide provides practical information concerning the general technical considerations in the installation of electric fire pump controllers. It is intended to be used by specifiers, purchasers, installers, and owners of fire pump controllers.

This Application Guide represents the result of many years of research, investigation, and experience by the members of the NEMA Industrial Control and Systems Subcommittee on Fire Pump Control. It was written as a service in response to the many questions from the user public, specifiers, and inspection authorities regarding fire pump controller installations. The intent is to pursue excellence in design, manufacture, and service of products made by NEMA member companies. It has been developed through continuing consultation among manufacturers, users, and national engineering societies. It is not intended to instruct the user of fire pump control equipment, but to provide recommendations and some application guidance.

This Application Guide is necessarily confined to providing recommendations for a successful installation. When equipment conforming with these recommendations is properly selected, is installed in accordance with the *National Electrical Code* (NFPA 70) and the *Standard for the Installation of Centrifugal Fire Pumps* (NFPA 20), and is properly maintained, the hazards to persons and property will be reduced. However, since any piece of industrial control equipment can be installed, operated, and maintained in such a manner that hazardous conditions may result, following the recommendation of this guide does not by itself assure a safe installation.

NEMA publications are subject to periodic review. They are revised frequently to reflect user input and to meet changing conditions and technical progress. Users should secure the latest editions.

Proposed revisions to this Application Guide should be submitted to:

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Section 1
GENERAL

1.1 SCOPE

This Application Guide is intended to provide general guidelines for the proper application of fire pump controllers. The emphasis of these guidelines is to stress those considerations specific to fire pump installations. Applicable NEMA standards and the standards of other standards developing organizations should also be consulted.

1.2 DEFINITIONS

There are no definitions unique to fire pump controllers.

1.3 REFERENCED PUBLICATIONS

NFPA 20-1996, *Standard for the Installation of Centrifugal Fire Pumps*[1]
NFPA 25-1995, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*[2]
NFPA 70-1996, *National Electrical Code*
IEEE Standard 242-1986, *IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial power Systems*
NEMA Standards Publication 250, *Enclosures for Electrical Equipment (1000 Volts Maximum)*

Section 2
REQUIREMENTS

2.1 POWER CONDUCTORS CONNECTED TO THE FIRE PUMP CONTROLLER AND MOTOR

2.1.1 For properly sizing power supply conductors to the fire pump controller and motor to meet the requirements of NFPA 20 and NFPA 70, the following procedure is suggested:

a. Determine the motor full-load current from the motor nameplate or NFPA 70, Table 430-150.
b. Multiply the full-load current by 1.25 per NFPA 70, Section 430-22.
c. Select supply conductor size per NFPA 70, Section 310-15 and Table 310-16, based upon current calculated in step b, above. Use 75°C column as appropriate. See NFPA 70, Section 110-14.
d. Conductors from the controller to wye-delta and part winding motors requiring six leads should be as follows:
    1. Part winding—Each conductor carries 50 percent of the motor full-load current. See NFPA 70, Section 430-3.
    2. Wye Delta—Each conductor carries 58 percent of the motor full-load current. See NFPA 70, Section 430-22.
e. Parallel conductors may be required for large motors. See NFPA Section 310-4, and refer to controller manufacturers field connection instructions for conductor termination information.
f. Verify that the conductor size will provide compliance with the voltage drop limitations as outlined in NFPA 20, Sections 6-3.1.2 or NFPA 70 Article 695, Section 695-8(e).
    NOTE—The NEC *does not* require conductors to be sized to carry a minimum of 300 percent of motor full-load current nor locked-rotor current indefinitely.
g. Consult motor manufacturers connection diagram for proper connections to the controller.

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[1] Particular attention should be given to Chapters 6 and 7.
[2] Particular attention should be given to Article 695.

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Example: 300 Hp, 460 Volt, 60 hertz controller is located 500 feet from the utility supply and the motor is 25 feet from the controller. Example is based on the use of copper conductors. Refer to controller manufacturers field connection instructions for use of aluminum conductors.

1. Motor full-load current is 361 amperes.
2. 361 x 1.25 = 451 amperes.
3. 700 kcmil, 75°C, is rated for 460 amperes for three conductors in one conduit. For two conductors per phase, 2-4/0, 75°C, in two separate conduits is also rated for 460 amperes. For two conductors per phase, 2-300 kcmil, 75°C, in one conduit is rated for 456 amperes. See Note 8a to NFPA 70, Table 310-16.
   NOTE—Had the ambient temperature been 40°C in the above examples the conductor sizes would have been 900 kcmil, 2-300 kcmil, and 2-400 kcmil respectively. See correction factors of NFPA 70, Table 310-16.
4. Maximum allowable voltage drop.
   a) Method of calculating the motor running voltage drop for 700 kcmil copper conductor in 500 feet of steel conduit.
      NOTE—Total voltage drop to the controller should not exceed 5 percent (5 percent x 460 = 23 volts (line-to-line)).
      1) See NFPA 70, Chapter 9, Table 9, effective Z at 85 percent power factor for uncoated copper wire which equals 0.047 ohms/1000 feet.
         NOTE—The value for 600 kcmil is used since the table does not list a value for 700 kcmil.
      2) Divide 0.047 ohms/1000 ft. by 1000 and multiply the result by 525 ft. which equals 0.0247 ohms.
      4) Multiply motor full-load amperes 361 by 1.15 which equals 415 amperes. Refer to NFPA 70, Section 695-8(e) or NFPA 20, Section 6-3.1.2.
      5) Multiply 415 amperes by 0.0247 ohms which equals 10.2 volts.
      6) Multiply 10.2 times 1.732 which equals 17.7 volts (line-to-line).

      This equals 3.8 percent which is less than the 5 percent permitted. Using only effective Z provides a simplified estimate of voltage drop.

   b) Method of calculating the motor starting voltage drop for 700 kcmil copper conductor in 500 feet of steel conduit.
      NOTE—Total voltage drop to the controller should not exceed 15 percent (15 percent x 480 =72 volts (line-to-line)).
      1) See—NFPA 70, Chapter 9, Table 9, effective Z at 30 percent power for for uncoated copper wire which equals 0.053 ohms/1000 feet.
         NOTE—The value for 600 kcmil is used since the table does not list a value for 700 kcmil.
      2) Divide 0.053 ohms/1000 ft. by 1000 and multiply the result by 500 ft. which equals 0.0265 ohms.
      3) Multiply motor full-load amperes 361 by 6 which equals 2,166 amperes. Refer to NFPA 20, Section 7-4.4(a)1.
      4) Multiply 2,166 amperes by 0.0265 ohms which equals 57.4 volts.
      5) Multiply 57.4 times 1.732 which equals 99.4 volts (line-to-line).

      This equals 20.7 percent which is not less than the 15 percent permitted. Use the next largest conductor size and recalculate. Using only effective Z provides a simplified estimate of voltage drop.
      NOTE—Confirmation of voltage drop under motor starting conditions typically cannot be accomplished with a standard voltmeter. Special instrumentation is normally required.

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2.1.2 Special attention should be given to the termination of approved wiring systems to the controller when applied with the recommendations of the manufacturer and the listing agency. In addition, attention should be given to the use of listed wire connectors at the motor.

2.2 ENVIRONMENTAL CONSIDERATIONS FOR ENCLOSURES

2.2.1 Fire pump controller enclosures are rated Type 2 as a minimum.

2.2.2 Type 2 enclosures are intended for indoor use, primarily to provide a degree of protection against limited amounts of falling water and dirt.

2.2.3 Type 3R enclosures are intended for outdoor use, primarily to provide a degree of protection against rain, sleet and damage from external ice formation.

2.2.4 Type 4 enclosures are intended for indoor or outdoor use, primarily to provide a degree of protection against windblown dust and rain, splashing water, hose-directed water, and damage from external ice formation.

2.2.5 Type 4X enclosures are intended for indoor or outdoor use, primarily to provide a degree of protection against corrosion, windblown dust and rain, splashing water, hose-directed water, and damage from external ice formation.

2.2.6 Type 12 enclosures are intended for indoor use, primarily to provide a degree of protection against circulating dust, falling dirt, and dripping noncorrosive liquids.

Table 1
Comparison of Specific Applications of Enclosures for Indoor Nonhazardous Locations[1]

Provides a Degree of Protection Against the Following Environmental Conditions	Type of Enclosure				
	2	3R	4	4X	12
Indoor Only	X	-	-	-	X
Indoor or Outdoor	-	X	X	X	-
Incidental contact with the enclosed equipment	X	X	X	X	X
Rain	-	X	X	X	-
Falling dirt	X	X	X	X	X
Falling liquids and light splashing	X	X	X	X	X
Circulating dust, lint, fibers, flyings**	-	-	X	X	X
Windblown dust	-	-	X	X	-
Settling airborne dust, lint, fibers, and flyings**	-	-	X	X	X
Hosedown and splashing water	-	-	X	X	-
Oil and coolant seepage	-	-	-	-	X
Oil or coolant spraying and splashing	-	-	-	-	-
Corrosive agents	-	-	-	X	-
Occasional temporary submersion	-	-	-	-	-
Occasional prolonged submersion	-	-	-	-	-

* These enclosures may be ventilated. Consult the manufacturer.
** These fibers and flyings are nonhazardous materials and are not considered the Class III type ignitable fibers or combustible flyings. For Class III type ignitable fibers or combustible flyings see the *National Electrical Code*, Article 500.

[1] For additional information on enclosures, see NEMA Standards Publication 250 *Enclosures for Electrical Equipment (1000 Volts Maximum).*

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2.2.7 When controllers are placed into environments that are unusual service conditions, such as direct sunlight, freezing, vandalism, infestation, etc., additional considerations should be given. See also NFPA 20, Section 2-7.1. Consult controller manufacturers for recommendations.

2.2.8 Top entry conduit fittings into the fire pump controller should be as a minimum watertight. Conduit fittings on other sides of the controller should be suitable for the environment and enclosure type.

2.3 TRANSFORMER SIZING

2.3.1 Where a transformer supplies an electric motor driven fire pump, it should be rated at a minimum of 125 percent of the sum of the fire pump motor(s) full-load current(s) and pressure maintenance pump(s) motor loads, and 100 percent of the associated fire pump accessory equipment current supplied by the transformer.

2.3.2 Regulation of the transformer should be adequate to meet the 5 percent motor running and 15 percent motor starting voltage drop limitations of NFPA 20, Sections 6-3.1.2 or NFPA 70, Article 695, Section 695-8(e).

2.3.3 Similar considerations should be given to transformers serving the fire pump and other system loads.

Example: Calculate the minimum transformer size for a transformer dedicated to a 300 Hp, 460 volt fire pump motor. Assuming the transformer impedance is 5.75 percent, calculate the voltage drop during motor running and motor starting. Verify that these voltage drops do not exceed 5 percent during running or 15 percent during starting (NFPA 70, Section 695-8(e) or NFPA 20, Section 6-3.1.2).

a. Transformer minimum size (kVA) $= \dfrac{V_{L-L} \times MFLA \times 1.25 \times \sqrt{3}}{1000}$

$= 460 \times 361 \times 1.25 \times 1.732$

$= 360$ kVA

The next available size is $= 500$ kVA

b. Percent voltage drop during motor running $= \dfrac{Z \times MFLA \times 1.15 \times V_{L-L} \times \sqrt{3}}{\text{Transformer size} \times 1000}$

$= \dfrac{5.75 \times 361 \times 1.15 \times 460 \times 1.732}{500 \times 1000}$

$= 3.8$ percent

c. Percent voltage drop during motor starting $= \dfrac{Z \times MFLA \times 6 \times V_{L-L} \times \sqrt{3}}{\text{Transformer size} \times 1000}$

$= \dfrac{5.75 \times 361 \times 6 \times 460 \times 1.732}{500 \times 1000}$

$= 19.8$ percent

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d. Since the voltage drop during motor starting exceeds the NFPA limits, a larger transformer must be selected.
e. Using a 750 kVA transformer for the above example, the percent voltage drop during motor running equals 2.4 percent and the percent voltage drop during motor starting equals 12.7 percent.

NOTES
1—Even though the voltage drop of a 750 kVA transformer does not exceed the NFPA limits, care must be taken ensure that the total voltage drop from the source, the transformer, and the power wiring added together does not exceed 5 percent during motor running or 15 percent during motor starting as required by NFPA 70, Section 695-8(e) or NFPA 20, Section, 6-3.1.2.
2—Using the transformer impedance multiplied by the ratio of the motor current and the transformer full-load current provides a simplified estimate of the voltage drop.

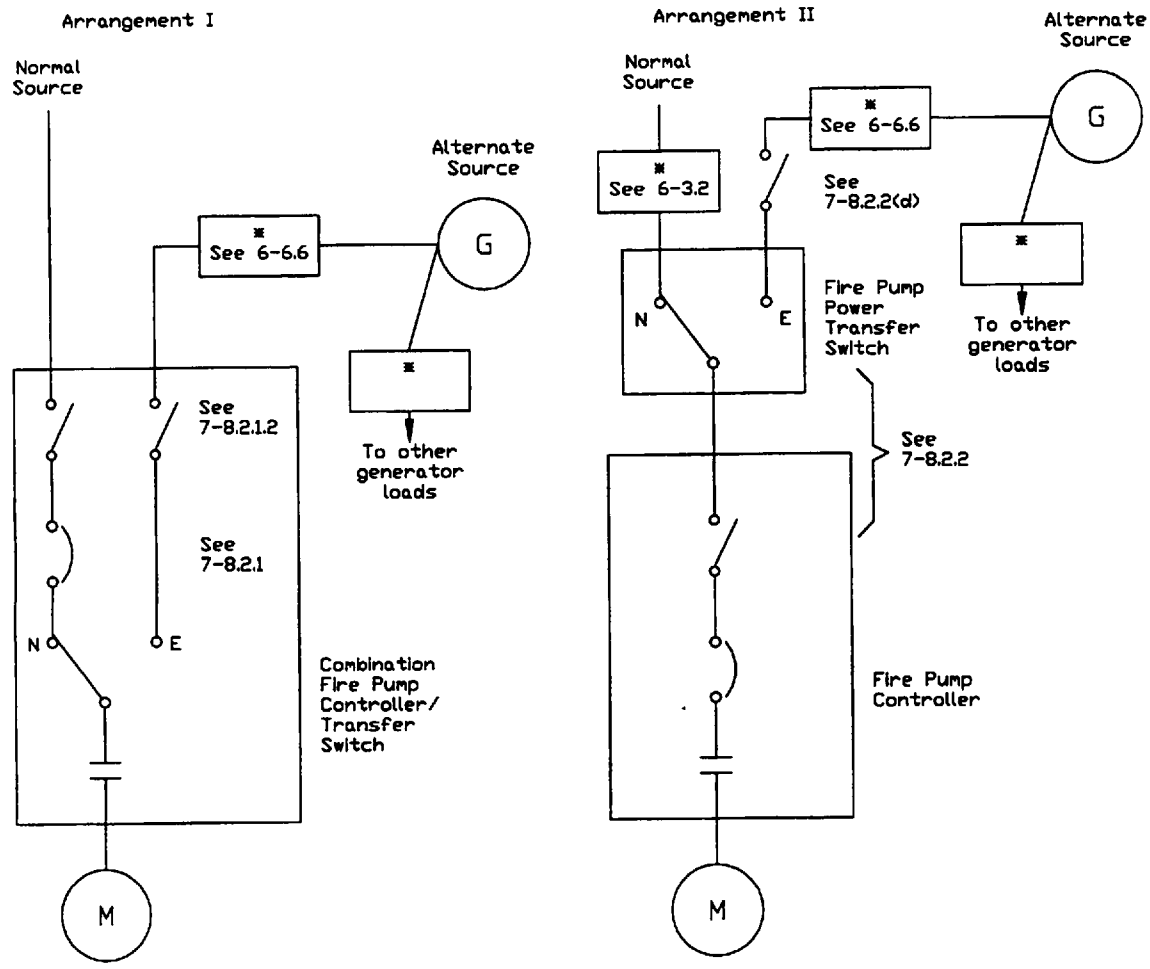
2.4 TRANSFER SWITCH CONSIDERATIONS

2.4.1 Automatic transfer switches for fire pump control applications are applied per NFPA 70, Section 695-4, and NFPA 20, Section 7-8 as in Figure 1.

2.4.2 When an arrangement as shown in Figure 2 is used, special attention should be given to the following issues:
a. The combination fire pump controller/transfer switch must be listed for use with two utilities since the alternate side can be connected to the second utility.
b. The upstream transfer switch should comply with NFPA 20, Section 7-8.2.2 and Section 7-8.3.
c. Upstream overcurrent protection must be sized to carry the locked-rotor current indefinitely in accordance with NFPA 70, Section 695-3(c) Exception No. 1. The transfer switch short circuit rating should be coordinated with the overcurrent protection device.

NOTE—In the event of a distressed pump causing locked-rotor currents of duration in excess of those permitted in NFPA 20, Section 7-4.3.3, the locked-rotor protective device in the *controller* should be the only device to trip. This device can be readily reset since the controller is located within sight of the fire pump motor. Upstream devices may be located in or beyond fire zones and should carry the locked-rotor current indefinitely in accordance with NFPA 70, Section 695-3(c) Exception No. 1.

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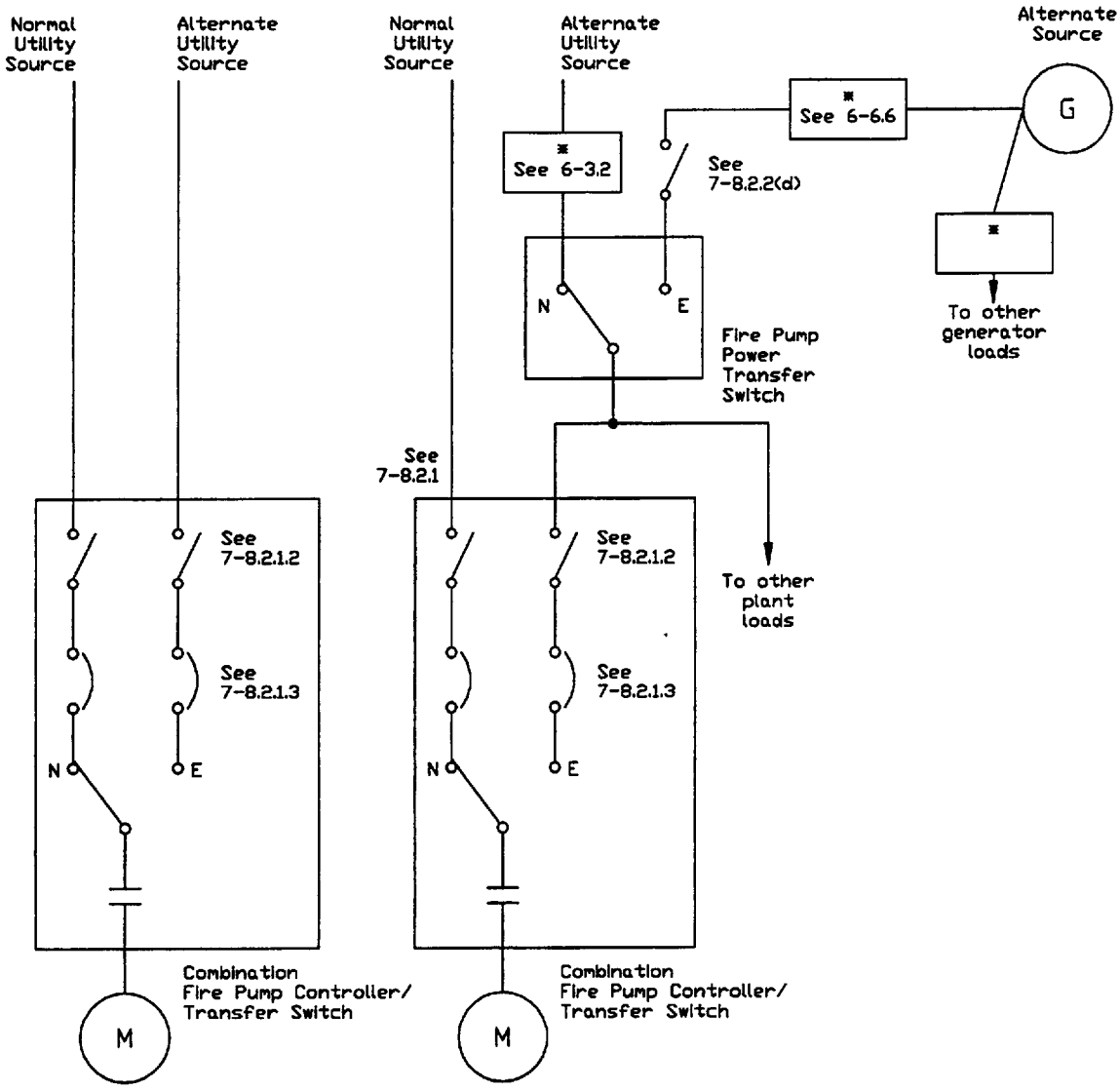


*Disconnecting means and overcurrent protective device(s) - circuit breakers or fusible switches may be used

NOTE: All references are to NFPA 20-1996.

Figure 1
Typical Fire Pump Controller and Transfer Switch Arrangements

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*Disconnecting means and overcurrent protective device(s) - circuit breakers or fusible switches may be used

NOTES

1— Examples where the combination fire pump controller/transfer switch must be suitable for use with two (2) utilities. See NFPA 20 7-8.2.1.3

2—All references are to NFPA 20.

Figure 2
Alternate Fire Pump Controller and Transfer Switch Arrangements

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2.5 CONSIDERATIONS FOR SPECIFYING SHORT CIRCUIT RATING (RMS SYM)

2.5.1 This is a simplified procedure, with examples, for specifying the fire pump controller short circuit rating. All calculations assume unlimited short-circuit current at the transformer primary.

2.5.1.1 "Method One" is the simplest, requiring limited calculations. Selection of the fire pump controller short circuit rating is made from Table 3. This method is applicable for systems with power transformers ranging from 500 kVA through 2500 kVA with standard impedance values of 2.0 percent and higher.

2.5.1.2 "Method Two" covers all other systems which cannot be established from Table 4. This is a simplified procedure for determining the available short-circuit current with a reasonable degree of accuracy.

2.5.1.3 Information required:

a. Transformer kVA and secondary voltage
b. Transformer percent impedance
c. Length of circuit and size of power conductor between the transformer and controller line terminals
d. Motor full-load current (required for Method Two only)

NOTE—The above information can be obtained from nameplate data and the local power utility.

2.5.2 Method One: Fire pump controller short circuit rating selection from Table 3.

a. Refer to the appropriate transformer kVA section and power cable column.
b. Establish the cable length that is closest to, without exceeding, the circuit length for the given transformer secondary rating column.
c. The required fire pump controller short circuit rating is then established from the fire pump controller short-circuit current rating column.

Example: A 200 HP, 460 volt, 60 Hz controller is located 100 feet from a 2000 kVA supply transformer (transformer impedance is 5.75 percent). The power conductor consists of one 350 kcmil cable per phase in a steel conduit.

d. Refer to Table 3 for a 2000 kVA transformer with a 480 volt secondary and a 350 kcmil power cable.
   1. With 119 feet minimum cable length, a fire pump controller with a 22,000 amp short circuit rating can be used.
   2. With 42.3 feet minimum cable length, a fire pump controller with a 30,000 amp short circuit rating can be used.

Conclusion: 42.3 feet is the closest to, without exceeding, the 100 foot conductor length. Therefore, the fire pump controller with a 30,000 ampere minimum short circuit rating is required.

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Table 3
Fire Pump Controller Short Circuit Current Rating

Transformer kVA	% Impedance	Secondary Volts	Transformer Secondary S-C Current	Controller S-C Current Rating	Minimum Length of Cable Between Transformer and Controller in feet. Wire Size in kcmil								
					500	350	300	250	4/0	3/0	1/0	1	2
500	2.00%	200	72,171	42000	20.8	18.6	17.0	15.5	14.1	12.0	8.3	6.8	5.5
		240	60,142	42000	18.0	16.1	14.7	13.4	12.2	10.4	7.2	5.9	4.7
		380	37,985	30000	27.8	24.9	22.8	20.8	18.9	16.0	11.1	9.0	7.3
		480	30,071	30000	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.1	0.1
750	5.75%	200	37,654	42000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		240	31,379	42000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		380	19,818	30000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		480	15,689	30000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1000	5.75%	200	50,206	42000	8.1	7.3	6.7	6.1	5.5	4.7	3.2	2.6	2.1
		240	41,838	42000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		380	26,424	30000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		480	20,919	30000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1250	5.75%	200	62,757	42000	16.5	14.7	13.5	12.3	11.2	9.5	6.5	5.3	4.3
		240	52,298	42000	11.8	10.5	9.6	8.8	8.0	6.8	4.7	3.8	3.1
		380	33,030	30000	12.1	10.9	9.9	9.1	8.3	7.0	4.8	3.9	3.2
		480	26,149	30000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1500	5.75%	200	75,309	42000	22.0	19.7	18.0	16.4	15.0	12.6	8.7	7.2	5.8
		240	62,757	42000	19.8	17.7	16.2	14.7	13.4	11.3	7.8	6.4	5.2
		380	39,636	30000	32.2	28.8	26.3	24.0	21.9	18.5	12.8	10.5	8.5
		480	31,379	30000	7.3	6.6	6.0	5.5	5.0	4.2	2.9	2.4	1.9
2000	5.75%	200	100,412	42000	28.9	25.9	23.7	21.6	19.7	16.6	11.5	9.4	7.6
		240	83,676	42000	29.7	26.6	24.3	22.2	20.2	17.1	11.8	9.7	7.8
		380	52,848	30000	57.2	51.2	46.8	42.7	38.9	32.9	22.7	18.6	15.1
		480	41,838	30000	47.3	42.3	38.7	35.3	32.2	27.2	18.8	15.4	12.4
2500	5.75%	200	125,515	42000	33.1	29.6	27.1	24.7	22.5	19.0	13.2	10.8	8.7
		240	104,596	42000	35.7	32.0	29.2	26.7	24.3	20.5	14.2	11.6	9.4
		380	66,060	30000	72.3	64.7	59.1	53.9	49.1	41.5	28.7	23.5	19.0
		480	52,298	30000	71.3	63.8	58.3	53.2	48.4	41.0	28.3	23.2	18.7

NOTE—Calculations are based on a simplified method of determining short circuit currents. The values given are for relative comparison only.

2.5.3 Method Two: Use this method only when the transformer secondary voltage and available secondary short-circuit current is known.

Example: A 200 HP, 460 volt, 60 Hz controller is located 150 feet from a transformer having a 200,000 ampere secondary short circuit current availability. The motor has a full-load current rating of 240 amperes, thus requiring conductors capable of carrying 300 amperes (240 x 1.25 = 300). Table 310-16 of the NEC specifies 350kcmil cable. Refer to Table 4. Under the 350 kcmil cable column the minimum cable length between the transformer and the controller is 127.2 feet. Since the 150 foot cable length exceeds the allowable length of 127.2 feet, a controller having a 30,000 ampere short-circuit rating is suitable.

Table 4
Transformer Secondary Voltage and Available Secondary Short-Circuit Current

			Minimum Length in Feet of Cable Between Transformer and Controller								
			Wire Sizes								
Secondary Volts	Maximum Transformer Secondary Short-Circuit Current	Controller Short Circuit Current Rating	500 kcmil	350 kcmil	300 kcmil	250 kcmil	4/0 AWG	3/0 AWG	1/0 AWG	1 AWG	2 AWG
200	200,000	42000	39.3	35.2	32.1	29.3	26.7	22.6	15.6	12.8	10.3
240	200,000	42000	47.2	42.2	38.6	35.2	32.1	27.1	18.7	15.3	12.4
380	200,000	30000	112.5	100.7	92.0	83.9	76.5	64.6	44.7	36.6	29.6
480	200,000	30000	142.1	127.2	116.2	106.0	96.6	81.7	56.5	46.2	37.4
200	100,000	42000	28.9	25.8	23.6	21.5	19.6	16.6	11.5	9.4	7.6
240	100,000	42000	34.6	31.0	28.3	25.8	23.5	19.9	13.8	11.3	9.1
380	100,000	30000	92.7	82.9	75.8	69.1	63.0	53.2	36.8	30.1	24.4
480	100,000	30000	117.0	104.8	95.7	87.3	79.5	67.3	46.5	38.0	30.8

NOTE—Calculations are based on a simplified method of determining short circuit currents. The values given are for relative comparison only.

The calculations and data in Table 4 assume that the fire pump controller is connected in the preferred manner to a dedicated transformer supplied by a utility service (for calculation purposes, power availability from a utility source is considered to be infinite). It therefore assumes there are no motor contributions to the available short circuit currents. Where connected motors contribute to the available short circuit current, a more detailed analysis should be made. (See IEEE 242.)

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2.6 REDUCED VOLTAGE STARTING METHODS

Table 5
Reduced Voltage Starting Methods

Starting Method	Controller Operation	Starting Current	Starting Torque	Open Or Closed Transition
Across the Line	Initially connects motor directly to power lines	100%	100%	None
Primary Reactor	Inserts reactance in series with motor during starting.	50% 65%	25% 42%	Closed
Primary Resistance	Inserts resistance units in series with motor during starting.	50% 65%	25% 42%	Closed
Autotransformer	Uses auto-transformer to reduce voltage to motor	Tap / Current 50% / 25% 65% / 42% 80% / 64%	25% 42% 64%	Closed
Wye-Delta	Starts motor with windings wye connected, then controller reconnects them in delta.	33%	33%	Open or Closed
Solid State Soft Start/Stop	Uses special soft start module to control current and voltage to motor.	Varies (35 - 100%)	Varies (12 -100%)	Closed
Part Winding	Starts motor with only part of winding connected, then adds remainder for running.	70 - 80%	50 - 60% Minimum pull-up torque 35% of full load.	Closed

NOTES
1—Consideration should be given to the method of starting and the power source. Consult the controller manufacturer for additional information.
2—The voltage drop limitation requirements of NEC Section 695-8(e) are not applicable when the manual emergency handle is used on reduced voltage controllers. Under that condition the power supply need only be capable of starting and running the motor as demonstrated during acceptance testing of the fire pump system.
3—Consideration should be given to the effects of transition currents of open transition controllers on circuit breakers, generators, couplings, pump shafts, and other components of the fire pump system .

2.7 PHASE SEQUENCE

2.7.1 Electric fire pump controllers are phase sequence sensitive, and will cause an alarm to be issued if connected to a power source incorrectly (see NFPA 20, Sections 7-4.7(c) and 7-4.8). If incorrect phase sequence is detected upon initial installation, the proper corrective action is to interchange any two power supply conductors connected to the line terminals of the controller. Proper motor rotation must be verified after proper controller phase sequence is established.

2.7.2 Motor rotation correction may be accomplished as follows:

a. Three lead motors—Interchange any two motor leads on the load side terminals of the main contactor.
b. Six lead motors used with part-winding or wye-delta controllers—Interchange any two motor leads on the load side terminals of both the start and the run contactors (i.e., interchange phase 1 and phase 2 on the run contactor and the start contactor or phase 2 and phase 3 on each contactor).

2.7.3 On controllers having multiple power sources, the alternate source is also phase sensitive.

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2.8 LISTED AND APPROVED EQUIPMENT

Controllers that bear the mark of a Nationally Recognized Testing Laboratory (NRTL) have been evaluated to be in compliance with NFPA 20 when installed in accordance with NFPA 70 NEC (see NEC, Section 90-7).

2.9 TESTING AND MAINTENANCE

The procedures as stated in NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems* should be followed for proper maintenance and periodic testing.

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