NEMA ICS 10

Industrial Control and Systems

Part 1: Electromechanical AC Transfer Switch Equipment

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NEMA Standards Publication ICS 10-2005

Industrial Control and Systems
Part 1: Electromechanical AC Transfer Switch Equipment

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Foreword

This Standards Publication was prepared by a technical committee of the NEMA Industrial Automation Control Products and Systems Section. It was approved in accordance with the bylaws of NEMA and supersedes the indicated NEMA Standards Publication. This Standards Publication supersedes ICS 10-1993. Information on static transfer switches can be found in ICS 10-1999 Part 2: *Static AC Transfer Switch Equipment*.

This Standards Publication provides practical information concerning ratings, construction, test, performance and manufacture of industrial control equipment. These standards are used by the electrical industry to provide guidelines for the manufacture and proper application of reliable products and equipment and to promote the benefits of repetitive manufacturing and widespread product availability.

NEMA Standards represent the result of many years of research, investigation and experience by the members of NEMA, its predecessors, its Sections and Committees. They have been developed through continuing consultation among manufacturers, users and national engineering societies and have resulted in improved serviceability of electrical products with economies to manufacturers and users.

One of the primary purposes of this Standards Publication is to encourage the production of reliable control equipment which, in itself, functions in accordance with these accepted standards. Some portions of these standards, such as electrical spacings and interrupting ratings, have a direct bearing on safety; almost all of the items in this publication, when applied properly, contribute to safety in one way or another.

Properly constructed industrial control equipment is, however, only one factor in minimizing the hazards which may be associated with the use of electricity. The reduction of hazard involves the joint efforts of the various equipment manufacturers, the system designer, the installer and the user. Information is provided herein to assist users and others in the proper selection of control equipment.

The industrial control manufacturer has limited or no control over the following factors which are vital to a safe installation:

a. Environmental conditions

b. System design

c. Equipment selection and application

d. Installation

e. Operating practices

f. Maintenance

This publication is not intended to instruct the user of control equipment with regard to these factors except insofar as suitable equipment to meet needs can be recognized in this publication and some application guidance is given.

This Standards Publication is necessarily confined to defining the construction requirements for industrial control equipment and to providing recommendations for proper selection for use under normal or certain specific conditions. Since any piece of industrial control equipment can be installed, operated and maintained in such a manner that hazardous conditions may result, conformance with this publication does not by itself assure a safe installation. When, however, equipment conforming with these standards is properly selected and is installed in accordance

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with the National Electrical Code and properly maintained, the hazards to persons and property will be reduced.

To continue to serve the best interests of users of Industrial Control and Systems equipment, the Industrial Automation Control Products and Systems Section is actively cooperating with other standardization organizations in the development of simple and more universal metrology practices. In this publication, the U.S. customary units are gradually being supplemented by those of the modernized metric system known as the International Systems of Units (SI). This transition involves no changes in standard dimensions, tolerances, or performance specifications.

NEMA Standards Publications are subject to periodic review. They are revised frequently to reflect user input and to meet changing conditions and technical progress. Proposed revisions to this Standards Publication should be submitted to:

Vice President, Technical Services
National Electrical Manufacturers Association
1300 North 17th Street, Suite 1847
Rosslyn, Virginia 22209

This standards publication was developed by the Industrial Automation Control Products and Systems Section. Section Approval of the standard does not necessarily imply that all section members voted for its approval or participated in its development. At the time it was approved, the Section was composed of the following members:

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ABB Automation Technologies – Raleigh, NC
ASCO Power Technologies—Florham Park, NJ
Automatic Switch Company – Florham Park, NJ
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Part 1
AC TRANSFER SWITCH EQUIPMENT

1 GENERAL

The definitions and standards of ICS 1, except for clause 7 pertaining to spacings as indicated, also apply to this standard.

Emergency systems are those that meet the requirements of Articles 517 and 700 of NFPA 70 (NEC) and NFPA 99. Emergency systems are those legally required to automatically supply alternate power within 10 seconds of power interruption to a number of prescribed functions essential for safety to human life.

Legally required standby systems are those that meet the requirements of Article 701 of NFPA 70 (NEC). These systems are intended to automatically supply power to selected loads (other than those classed as emergency systems) in the event of failure of the normal source.

Optional standby systems are those that meet the requirements of Article 702 of NFPA 70 (NEC). These systems are intended to supply power either automatically or non-automatically to selected loads other than those classed as Emergency or Legally Required Standby.

1.1 Referenced Standards

In this NEMA Standards Publication reference is made to the following standards listed below. Copies are available from the indicated sources.

National Electrical Manufacturers Association
1300 North 17th Street
Rosslyn, VA 22209

ICS 1-2000 *Industrial Control and Systems, General Requirements*

ICS 1.3-1986 (R2001) *Preventive Maintenance of Industrial Control and Systems Equipment*

MG 1-1999 *Motors and Generators*

Underwriters Laboratories Inc.
333 Pfingsten Road
Northbrook, IL 60062

UL 1008-1996 *Automatic Transfer Switches*

National Fire Protection Association
Batterymarch Park
Quincy, MA 02269

NFPA 20-1999 *Installation of Centrifugal Fire Pumps*

NFPA 70-1999 *National Electrical Code (NEC)*

NFPA 99-1999 *Health Care Facilities*

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1.2 Scope

The standards in this section apply to electromechanical automatic and nonautomatic transfer switches and bypass isolation switches rated 600 volts AC or less, 60 Hertz, for use on single-phase and polyphase AC circuits.

2 DEFINITIONS

For the purposes of this NEMA Standards Publication, the following definitions apply.

2.1 Switching Devices

automatic transfer switch: Self-acting equipment for transferring one or more load conductor connections from one power source to another.

An automatic transfer switch may be supplied with or without a bypass isolation switch. An automatic transfer switch may include logic to inhibit automatic operation in either or both directions provided the switch reverts to automatic operation upon loss of power to the load.

bypass isolation switch: A manually operated device used in conjunction with a transfer switch to provide a means of directly connecting load conductors to a power source and of disconnecting the transfer switch.

A bypass isolation switch may be supplied with an automatic or nonautomatic transfer switch.

dual source bypass isolation switch: provides a means of maintaining power to the building load during transfer switch service or repair. It also provides means to manually connect the building load to the alternate source in the event the source feeding the load fails while the transfer switch is disabled.

nonautomatic transfer switch: A device, operated by direct manpower or electrical remote manual control, for transferring one or more load conductor connections from one power source to another.

A nonautomatic transfer switch may be supplied with or without a bypass isolation switch.

transfer switch: A device for transferring one or more load conductor connections from one power source to another.

A transfer switch may be automatic or nonautomatic.

2.2 Operation of AC Transfer Switch Equipment

conditional short-circuit rating: The prospective current that a transfer switch can satisfactorily withstand for a total operating time of the overcurrent protective device under specified conditions of use and behavior.

contact transfer time: The time measured from the parting of one set of main contacts to the closing of a second set of main contacts on an alternate power source.

monitored source deviation: A variation in the power source being monitored that signals the transfer switch to operate.

For clarification of terms:

a. Typical variations that can be detected are changes in voltage and frequency.

b. “Normal Source Failure” is a term often used to describe the loss or reduction of voltage supplied by the normal power source. It is one type of monitored source deviation.

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c. "Transfer Signal" is a term used to describe the signal that is initiated by the monitored source deviation and that signals the transfer switch to operate.

operating transfer time: The time measured from the instant of the monitored source deviation to the closing of main contacts on an available alternate power source exclusive of any purposely introduced time delay.

total system transfer time: The time measured from the instant of the monitored source deviation in one power source to the closing of main contacts on another power source, including any purposely introduced time delays and engine-generator start-up time. "Total System Transfer Time" is a parameter of the total system and not solely of the automatic transfer switch.

3 CLASSIFICATIONS

Transfer switches are classified Type A or Type B as follows:

Type A (PC*): A transfer switch that is not intended to provide required overcurrent (overload and short-circuit) protection.

Type B (CB*): A transfer switch that is intended to automatically provide required overcurrent (overload and short-circuit) protection.

*International Electrotechnical Commission (IEC)

4 CHARACTERISTICS AND RATINGS

4.1 Rated and Limiting Values for the Main (Power) Circuit

4.1.1 System Voltage Ratings

The system voltage rating of transfer switch equipment shall be 120, 208, 240, 480, or 600 VAC, single phase or polyphase.

4.1.2 Continuous Current Rating

The continuous current rating of transfer switch equipment shall be in the range of 30 to 4000 amps, based on an ambient temperature of 40°C.

4.1.3 Rating Based on Load Characteristics

Transfer switch equipment shall be rated for one or more of the following types of loads:

a. Total system load consisting of any combination of motors, electric discharge lamps, electric heating (resistive) loads, and tungsten lamp loads, provided the latter does not exceed 30 percent of the continuous current rating of the transfer switch equipment

b. Tungsten lamp load consisting entirely of tungsten lamps

c. Electric discharge lamp load consisting entirely of electric discharge lamps, including fluorescent lamps

d. Resistive load consisting of heater and other noninductive loads in which the inrush current does not exceed 150 percent of the continuous current rating of the switch

4.1.4 Interrupting Rating

Current interrupting ratings shall be expressed in rms symmetrical amperes.

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4.1.5 Motor Starter Rating

Transfer switch equipment intended for a load consisting of a single motor may include overload relays and may be rated in horsepower or in full-load and locked-rotor current.

4.1.6 Withstand and Closing Ratings

Transfer switch equipment shall have withstand and closing ratings, expressed in maximum available fault current (rms symmetrical amperes) at maximum rated voltage, and marked in accordance with UL 1008 and this standard. The type and rating of any associated protective devices necessary to meet the requirements of UL 1008 shall also be marked on the transfer switch equipment.

The withstand and closing current rating shall be one of the values specified in Column 1 of Table 4–1.

Standard withstand and closing ratings are based on transfer switch equipment testing conducted at maximum allowable test circuit power factors and corresponding minimum X/R ratios specified in Table 4–1. When applying transfer switch equipment, consideration should be given to both available fault current and circuit X/R ratio at the point of application.

4.1.7 Overcurrent Protection

Each service, feeder, and branch circuit should have the appropriate short-circuit, ground-fault and overload protection, provided either externally or as an integral part of the transfer switch equipment.

Table 4–1
AVAILABLE FAULT CURRENTS AND RESPECTIVE TEST POWER FACTORS AND CORRESPONDING X/R RATIOS

Withstand and Closing Rating (rms symetrical amperes)	Maximum Test Power Factor	Minimum Corresponding X/R Ratio
5,000	0.50	1.73
7,500	0.50	1.73
10,000	0.50	1.73
14,000	0.30	3.18
18,000	0.30	3.18
22,000	0.20	4.90
25,000	0.20	4.90
30,000	0.20	4.90
35,000	0.20	4.90
42,000	0.20	4.90
50,000	0.20	4.90
65,000	0.20	4.90
85,000	0.20	4.90
100,000	0.20	4.90
125,000	0.20	4.90
150,000	0.20	4.90
200,000	0.20	4.90

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5 PRODUCT MARKING, INSTALLATION, AND MAINTENANCE INFORMATION

5.1 Markings

5.1.1 Transfer Switches

The nameplate markings for transfer switches shall include:

a. Name of manufacturer and catalog number, or the equivalent serial number

b. Voltage and frequency ratings

c. Continuous current rating

Additional markings shall be those required by UL 1008 and shall include the following, where applicable:

d. Suitability for emergency or standby service as defined by the NEC

e. Suitability for specific loads. See 4.3.5 of UL 1008

f. Suitability for use as service equipment

g. Interrupting or short-circuit ratings

   1. For Type A: Short-circuit rating or conditional short-circuit rating with the type and rating of the additionally required short-circuit protective device

   2. For Type B: Interrupting rating

h. Cautions or warnings, or both

i. Automatic or nonautomatic

5.1.2 Bypass Isolation Switch Equipment

The nameplate markings for bypass/isolation switches shall include:

a. Name of manufacturer and catalog number, or the equivalent serial number

b. Voltage and frequency ratings

c. Continuous current rating

5.1.3 Control Circuits

Transfer switch equipment control circuits shall meet the marking requirements of UL 1008.

5.1.4 Maintenance of Transfer Switch Equipment

A maintenance program and schedule should be established for each particular installation to assure minimum down time. The program should include periodic testing, tightening of connections, inspection for evidence of overheating and excessive contact erosion, removal of dust and dirt, and replacement of contacts when required.

See NEMA Standards Publication ICS 1.3 for preventive maintenance instructions.

6 SERVICE AND STORAGE CONDITIONS

ICS 1, Clause 6 applies.

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7 CONSTRUCTION

7.1 Spacings

Except as otherwise specified in the following paragraphs, spacings in automatic transfer switches and bypass isolation switches shall be not less than those shown in Table 7-1.

The spacings on printed wiring assemblies may be as small as 0.031 inch (0.8 mm) where the power to the printed wiring assembly is limited and transient voltages are controlled as specified in ICS 1, Clause 7.

The spacings given in Table 7–1 do not apply to snap switches, lampholders and similar wiring devices that are used as a part of transfer switch equipment.

In a circuit involving potentials of not more than 50 VAC, the spacings at field-wiring terminals may be 0.125 inch (3.2 mm) through air and 0.250 inch (6.4 mm) over the surface, and the other spacings may be 0.053 inch (1.4 mm) through air and over the surface, provided that insulation and clearances between the low-potential circuit and any high-potential circuit are in accordance with the requirements that are applicable to the high-potential circuit.

7.2 Test Switch

An external test switch or terminals for connection to an external test switch shall be provided. Such a test switch shall be connected so that operation of the test switch simulates a failure of the normal power source.

7.3 Interlock

7.3.1 Protection from Cross-Connection

The operating mechanism of a transfer switch shall have a mechanical or electromechanical interlock to prevent simultaneous connection of the load to both the normal and alternate power sources.

7.3.2 Bypass Isolation Switch Interlock

Bypass isolation switches shall be provided with necessary interlocks to prevent the unintentional simultaneous connection of two power sources. In addition, bypass isolation switches provided with overlapping contacts shall be provided with a means of interlocking to prevent the opening of nonload-break contacts under load.

7.4 Service Equipment

Transfer switches which are designed to be suitable for use as service equipment shall:

a. Have spacings in accordance with Table 7-1, Item 2

b. Have accessible independent disconnecting means for both the normal and alternate power sources

c. Be marked “suitable for use as service equipment”

d. Where provided with a neutral, have provision for connection of the service grounding conductor to the neutral terminal in accordance with Table 7-2

e. Be provided with ground-fault protection where applied on solidly grounded wye electrical services of more than 150 VAC to ground, but not exceeding 600 VAC phase-to-phase for each service disconnect rated 1000 amperes or more. See 7.5 for fire pump control and 8.6 for emergency power circuits.

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f. The control circuit shall have short-circuit protection and a disconnecting means suitable for the available current of the supply, where the control circuit is located ahead of the service disconnecting means. See 7.5 for fire pump control.

g. Be provided with overcurrent protection either immediately adjacent to, or as part of, the transfer switch disconnecting means

7.5 Fire Pump Circuit Service

Where a transfer switch is used in a fire pump circuit, the requirements of NFPA 20 shall apply.

7.6 Emergency Power Circuit Service

The alternate source for emergency systems shall not be required to have ground-fault protection of equipment.

7.7 Control Circuits

Transfer switch equipment shall be exempted from the motor control circuit overcurrent protection requirements of ICS 1, Clause 7.

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Table 7-1
SPACINGS

		Minimum Spacings (inches) Nominal Operating Voltage		
		51-150 Volts	**151-300 Volts**	**301-600 Volts**
1. Power Circuits Rated Not more Than 400 Amperes and Control Circuits				
a. Between any uninsulated live part and (1) an uninsulated live part of the opposite polarity and (2) an exposed metal part.*	through air or oil	0.125 (3.2 mm)	0.250 (6.4 mm)	0.375 (9.5 mm)
	over surface	0.250 (6.4 mm)	0.375 (9.5 mm)	0.500 (12.7 mm)
b. Between any uninsulated live part and the walls of a metal enclosure, including fittings for conduit or armored cable**	shortest distance	0.500 (12.7mm)	0.500 (12.7mm)	0.500 (12.7 mm)
2. Power Circuits Rated Over 400 amperes and Service Equipment.				
a. Between any uninsulated live part and an uninsulated live part of the opposite polarity.	through air or oil	0.500 (12.7mm)	0.750 (19.1mm)	1.000* (25.4 mm)
	over surface	0.750 (19.1mm)	1.250 (31.8mm)	2.000 (50.8 mm)
b. Between any uninsulated live part and an uninsulated grounded part, exposed metal part, or the walls of a metal enclosure, including fittings for conduit or armored cable.**	through air or oil	0.500 (12.7mm)	0.500 (12.7mm)	1.000† (25.4 mm)

* The spacing between wiring terminals of opposite polarity and the spacing between a wiring terminal and a ground part shall be not less than 0.250 inch (6.4 mm) if short-circuiting of grounding of such terminals may result from projecting strands of wire.

** For the purpose of this requirement, a metal piece attached to the enclosure is considered to be a part of the enclosure if deformation of the enclosure is likely to reduce spacings between the metal piece and uninsulated live parts.

† The through-air spacing may be not less than 0.500 inch (12.7 mm) at the main terminals and also between grounded dead metal and the neutral of a 277/480-VAC, 3-phase, 4-wire transfer switch.

Table 7-2
SIZE OF GROUNDING CONDUCTORS

Size of Largest Service Conductor or Equivalent Size of Multiple-conductor Cables*		**Size of Grounding Conductor**	
Copper	Aluminum	Copper	Aluminum
2 AWG or smaller	0 AWG or smaller	8 AWG	6 AWG
1 or 2 AWG	2/0 or 3/0 AWG	6 AWG	4 AWG
2/0 or 3/0 AWG	4/0 AWG or 250 kcmil	4 AWG	2 AWG
Over 3/0 AWG to 350 kcmil	Over 250 to 500 kcmil	2 AWG	0 AWG
Over 350 to 600 kcmil	Over 500 to 900 kcmil	0 AWG	3/0 AWG
Over 600 to 1100 kcmil	Over 900 to 1750 kcmil	2/0 AWG	4/0 AWG
Over 1100 kcmil	Over 1750 kcmil	3/0 AWG	250 kcmil

*The equivalent size for multiple conductor cables shall be the sum of the circular-mil areas of the individual conductors.

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8 PERFORMANCE REQUIREMENTS AND TESTS

8.1 Performance Requirements

8.1.1 Control Circuits

Transfer switch equipment control circuits shall meet the overcurrent and mechanical protection requirements of UL 1008.

8.1.2 Ground-Fault Protection

Where ground-fault protection is provided, the performance requirements are as follows:

a. The maximum setting of the ground-fault protection shall be 1200 amperes.

b. The maximum time delay shall be 1 second for ground-fault currents equal to or greater than 3000 amperes.

c. In health care facilities, the ground-fault protection on the service disconnect must be coordinated with the ground-fault protection on the next downstream feeder to ensure 100 percent selectivity such that the feeder device and not the service disconnect shall open on ground faults on the load side of the feeder device. There shall be a minimum time separation of six cycles between tripping bands.

8.1.3 Undervoltage Monitoring Characteristics

Unless otherwise specified, transfer switch equipment shall have provision for initiating the transfer of load conductor connections to an alternate power source when the voltage on any phase of the normal power source falls below 70 percent of rated voltage. Provision shall also be made for transferring the connections back to the normal power source when the voltage on all phases of the normal power source returns to at least 90 percent of rated voltage.

Voltage critical loads may require adjustable voltage-monitoring and control means.

8.2 Design Tests

8.2.1 General

Transfer switch and bypass isolation switches shall be capable of meeting performance tests as specified in UL 1008.

8.2.2 Test Sequence

The following design tests conducted on enclosed transfer switch equipment are usually performed in the sequence shown below.

8.2.2.1 Normal Operation Test

Verify the correct functioning of controls for automatic and test operation.

8.2.2.2 Overvoltage Test

Verify the ability of coils to withstand 110 percent of rated voltage for the maximum time during which they are normally energized.

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8.2.2.3 Undervoltage Test

Verify the ability of phase-voltage-sensing relay coils to withstand 95 percent of rated pull-in voltage with the relay armatures open.

8.2.2.4 Overload Test

Verify the ability of the switch to interrupt specified loads at rated voltage.

8.2.2.5 Temperature test

Verify the ability of the switch to carry rated current. (As an alternative, this test may be run after the endurance test.)

8.2.2.6 Endurance Test

Verify the ability of the switch to operate for a prescribed number of operations under specified conditions. The endurance test requirements for switches used in standby systems are less severe than those for switches used in emergency systems.

8.2.2.7 Dielectric Test

Verify the ability of the switch to withstand the prescribed dielectric test.

8.2.2.8 Withstand Test

Verify the ability of the switch, with the contact initially closed, to withstand the prescribed level and duration of available short-circuit current.

8.2.2.9 Circuit-Closing Test

Verify the ability of the switch to close onto and withstand the prescribed level and duration of available short-circuit current.

a. Type A transfer switches for which the manufacturer has not assigned a conditional short-circuit rating shall withstand the level and duration of available short-circuit current for which they are rated.

b. Type A transfer switches for which the manufacturer has assigned a conditional short-circuit rating shall withstand the available short-circuit current for which they are rated until the protective device clears the short circuit.

c. Type B transfer switches shall be capable of automatically interrupting the available short-circuit current for which they are rated.

8.2.2.10 Repeated Dielectric Test

Verify the ability of the switch to withstand a reduced dielectric test after the withstand and circuit closing tests.

8.2.3 Test Samples

One sample shall be used to complete the overload, temperature, endurance, and dielectric tests.

A previously untested sample shall be permitted to be used for the withstand, circuit closing and repeated dielectric tests.

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Where transfer switch equipment is rated for multiple specific loads, as listed in 4.1.3, additional samples shall be permitted to be used.

9 APPLICATIONS

9.1 Motor Transfer

Motors rated approximately 50 horsepower and greater are susceptible to damage when, in an ON-OFF-ON operation, they are switched before the residual motor voltage has decayed to a safe level. The high abnormal currents that may result from the out-of-phase relationship between the motor's residual voltage and the voltage of the reconnected power source may also trip overcurrent protective devices and, therefore, should be avoided. Consideration should be given to include controls in AC transfer switch equipment to minimize these abnormal currents.

For a fuller treatment of motor transfer, see the section on bus transfer or reclosing in MG 1.

9.2 AC Transfer Switch Equipment Specification

The following characteristics of normal and alternate power sources should be specified in order to properly match the transfer switch equipment to the system:

a. Voltage

b. Number of phases

c. Number of wires

d. Frequency

e. Number of switched poles

f. Type of load as defined in 4.1.3

g. Continuous current or horsepower, or both, requirements of the load

h. Available fault current

i. Whether the switch is intended for emergency or standby service

j. Whether it is necessary to disconnect the load from both power sources simultaneously

k. Whether the switch is to be suitable for use as service equipment

l. Whether the switch is to include integral overcurrent protection

m. Whether it is necessary to provide a bypass isolation switch in conjunction with the transfer switch. Where a bypass isolation switch is provided, it should be compatible with the transfer switch.

9.3 Features for Particular Applications

Some conditions or requirements of particular applications may make additional features necessary. These may include the following:

a. *Time delay to override monitored source deviation*—A fixed or adjustable time delay which delays all signals for operation. This time delay prevents starting of the engine or the transfer of the load from the normal power source to the alternate power source during momentary voltage dips or disturbances of the normal power source.

b. *Time delay before transfer to alternate power source*—A fixed or adjustable time delay which delays the transfer of the load to an available alternate power source. This delay

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allows an engine-generator time to stabilize at rated voltage and frequency before accepting the load.*

c. *Time delay before transfer to normal power source*—An adjustable time delay which inhibits transfer of the load back to the normal power source. This delay allows the normal power source time to stabilize before accepting the load. The time delay may be automatically nullified if the alternate power source fails and power is available at the normal power source.

d. *Time delay before engine shutdown*—A fixed or adjustable time delay which delays the shutdown of the engine-generator (alternate power source) after the load is transferred back to the normal power source. This delay allows the engine to run at no load and thereby minimizes the possibility of shutdown due to an increase in the temperature of the cooling water. It also permits the immediate transfer of the load back to the engine-generator in the event that the normal power source has not fully stabilized.*

e. *Time delay to limit cranking*—A fixed or adjustable time delay to limit the cranking time of the engine-generator if the engine fails to start when the normal power source fails.*

f. *Engine exerciser*—A programmable time switch to initiate the starting of the engine-generator for a preset period of time at preset intervals without transferring the load from the normal to the alternate power source.*

Caution: *No load operation may be detrimental to the engine, and the engine generator manufacturer should be consulted. Paragraph g would be considered.*

g. *Alternate system exerciser*—A programmable time switch to initiate the starting of the engine-generator and to transfer the load from the normal to the alternate power source for a preset period of time at preset intervals. The load is transferred back to the normal power source at the end of the exercise period.*

Provision should be made for the initiation of immediate retransfer to the normal source in the event of an engine generator failure during the exercise period.

h. *Auxiliary contact*—A contact, other than the power circuit contacts, that is part of transfer switch and is available for connection by the user. The number of auxiliary contacts, mode of operation and function of each contact should be specified.

i. *Engine start contact*—A contact that initiates cranking of the engine generator set when the normal power source fails.*

j. *Alternate source monitor*—A device(s) that monitors voltage or frequency, or both, of the alternate power source, and inhibits transfer to the alternate source until the monitored parameters reach specified levels.

k. *Test switch*—A switch to simulate failure of the normal power source, causing transfer of the load to the alternate power source.

l. *Close-differential protection*—A device(s) that monitors all lines of the normal power source and initiates transfer of the load from the normal power source to the alternate power source when any line of the normal power source drops below a predetermined value of voltage. It initiates transfer of the load back to the normal power source when all lines of the normal power source return to within specified limits. This feature is generally used for installations where only a limited reduction in voltage can be tolerated.

m. *Time-delay-bypass switch*—A momentary contact switch that initiates immediate transfer of the load back to the normal power source, bypassing any optional time delays.

n. *Manual return-to-normal switch*—A momentary contact switch that initiates transfer from the alternate to the normal power source where automatic transfer is not desired.

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o. *Overcurrent protection*—The addition of elements to permit the transfer switch equipment to provide running overcurrent protection for a single motor.

p. *Service equipment*—See 7.4.

q. *In-phase monitor*—A device that monitors the relative voltage and phase angle between the power source to be transferred to and the power from which the transfer is to be made, and initiates transfer when acceptable values of voltage and phase angle are present. Such a device may function on the transfer from either power source.

r. *Delayed transition*—Provides a timed disconnection of the load from the power sources during transfer, primarily to allow decay of motor residual voltage.

s. *Load disconnect device*—A device that initiates opening of a pilot contact prior to transfer from either source and then provides a timed closure after transfer. It is used primarily to allow decay of motor voltage without affecting the speed of transfer.

t. *Closed transition switch*—Transfer switch equipment providing momentary paralleling of both power sources during transfer in either direction. The closed transition is possible only when the sources are properly interfaced and synchronized.

u. *Bypass isolation switch*—A switch that may provide any of the following features or functions:

1. Load-break contacts
2. Overlapping contacts
3. Combination of 1 and 2
4. Single-source bypass
5. Dual source bypass
6. Total isolation of the transfer switch for purpose of maintenance, testing, modification, or repair. A bypass isolation switch can function as an independent nonautomatic transfer switch.

**Applicable to installations where the alternate power source is an engine-generator set.*

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Annex A
Short Time Rating

Section 4.1.6 of ICS 10 outlines withstand and closing ratings for transfer switch equipment. As noted, the requirement parallels those of UL Standard 1008. With the introduction of circuit breakers with electronic trips, the requirements for withstand and closing capability of transfer switch equipment (TSE) is more complex. UL 1008 addresses this issue by providing the option for "short time ratings."

Traditional thought said that the transfer switch is a piece of wire, and that it was protected by the common thermal/magnetic circuit breaker. When protected by a circuit breaker with the familiar I^2T (thermal) trip, and instantaneous trip, the transfer switch merely had to be able to "withstand" a short-circuit fault long enough to allow the upstream device to clear the fault. However, with a short time trip element, it is possible that the upstream breaker may not trip during a fault. This means the transfer switch contacts must survive this event as defined by UL 1008.

The worst case condition is determined by the Instantaneous pickup and Short Time Delay setting on the Upstream Protective Device. The Transfer Switch must "survive" a current that is just below the instantaneous pickup until the short time delay expires. If the TSE contacts fail to survive, and the upstream device does not trip, then loss of power to the load results.

In electrical systems it is highly desirable to make sure that a fault is cleared by the upstream protective device that is closest to the fault. To achieve this, the application for a "short time" trip rating on upstream circuit breakers has become a necessity. The short time trip characteristic gives the user the ability to program the trip curve of a particular circuit breaker so that it will intentionally wait for a downstream device to clear the fault. This means that a transfer switch applied between this upstream breaker and a downstream device must then truly withstand the fault current seen while the protective devices react. Failure to do so will make the transfer switch the weak link in the system.

The short-time characteristic is usually a "flat response" type. This means that a timer in the circuit breaker is started when the fault current exceeds the short time pickup setting. If the current remains above the pickup point and the timer times out, then the circuit breaker will trip. The designer should be aware that there may be I^2T short time characteristics available in certain trip units, and these offer some increased coordination possibilities.

In either case it is important to note that should the fault current continue to increase, and reach the instantaneous pickup point for the trip, that the breaker would then trip instantaneously. Therefore, the worst case scenario for the transfer switch is the case where the fault current rises to just below the instantaneous pickup, and the short time has to time out. This is the particular point the user must be aware of, and allow for in the application of the transfer switch. In other words, it is important to make sure that the transfer switch will truly withstand a current equal to the instantaneous current pickup for the maximum time of the short time delay. It is also important to realize that the instantaneous pickup point, and the maximum interrupt rating of the breaker are not synonymous.

Let us use a generic example that may explain the application. We will deal with a 3000A circuit breaker having an adjustable short-time pick up settable between 2 and 6 times the nominal rating, and an instantaneous pickup settable between 2 and 10 times the nominal rating. The maximum short time delay setting is 0.5 seconds, or 30 cycles on a 60 Hz system. Given this example, proper application of a transfer switch would require a short time rating (for the transfer switch) of 30 kA for 0.5 seconds. This relates to setting both the instantaneous pickup

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and the short time delay of the upstream breaker at their maximums. Since various circuit breakers offer different options relating to pickups and time ranges, responsibility to properly apply the transfer switch must fall on the designer.

The designer should understand that the short time rating of a transfer switch is much different than the short-circuit rating . The short-circuit rating is based on tripping of the upstream device and the need to transfer to the alternate source. The short time rating deals with a non-tripping condition of the upstream device for a period of time, and the fact that the primary source of power will not be interrupted. The transfer switch will not see a need to transfer, and must therefore remain in a state to handle load current from the uninterrupted source during, and after the fault is cleared by the downstream device.

When applying a transfer switch with a short time rating, the designer should always apply the transfer switch having short-time current ratings equal to or greater than the selected instantaneous pickup setting and short time delay setting of the properly coordinated upstream breaker.

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Annex B
Neutral Conductors in Power Transfer Systems

Many transfer switching systems involve three phase AC power sources with a neutral conductor (normally referred to as "4-wire distribution") or single-phase sources with neutral. Single-phase sources can be either 2-wire (line-neutral) or 3-wire (line-neutral-line) circuits. The application of transfer systems for switching neutral connected loads between such power sources requires consideration of several issues to achieve satisfactory operation, including compliance with the National Electrical Code and preserving the functionality of ground fault monitoring equipment.

The National Electrical Code defines when power sources are required to be grounded and also addresses the required grounding practices. In broad terms there are two types of sources, those that are "separately derived" and those that are "non-separately derived." Separately derived sources are those with no direct connection (including a neutral conductor) to another source. A non-separately derived source is directly connected to another power source, typically through solidly connected neutral conductors. The determination as to whether a source is to be separately derived or non-separately derived is typically made by the system designer and/or authority having jurisdiction.

Separately Derived Sources

If it is determined that a power system consists of separately derived sources, each neutral must be bonded to ground at its respective source. When transfer equipment is used in this type system the neutral conductor must be switched along with the phase (line) conductors to prevent multiple connections between neutral and ground within the system. Multiple connections between neutral and ground can result in current flow through the grounding system, violating the requirement that the ground system is never allowed to carry current, except in the case of a fault. Multiple connections may also defeat or cause false operation of ground fault detection by allowing ground fault currents to bypass monitoring equipment, or by allowing normal neutral currents to appear as fault currents.

When switching the neutral conductor, timing of the opening and closing of the phase (line) and neutral poles is important. If the phase conductors are connected without connection of the neutral conductors a transient over-voltage can occur at the load.

The current rating of the neutral pole in transfer equipment is another consideration. Unbalanced loads can result in high neutral currents. Also, nonlinear electronic loads connected to transfer equipment can create current harmonics that add in the neutral conductors that might make it necessary to over size the neutral current capacity to prevent overheating of conductors or the switch poles. Depending on the nature of loads, the neutral rating may need to be up to 200% of the phase rating.

Non-Separately Derived Sources

For systems consisting of non-separately derived sources it is not appropriate to switch the neutral conductors. If a power system consists of non-separately derived sources, the neutral conductors from the sources must be solidly connected together. This "shared neutral" must be bonded to ground at only one source. There must not be any switching device between the neutral conductors of the sources. This technique allows the neutral conductor of each source to carry its respective neutral current, and the ground conductors to carry only ground fault current. By not switching the neutral conductors the possibility of transient overvoltage from neutral switching delays or failures is eliminated.

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