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Selecting IEC 60947-6-1 Transfer Switches for Motor Loads in Mission-Critical Applications

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Transfer switches play a central role in the operation of backup systems that supply emergency electrical power. To ensure that the characteristics of Automatic Transfer Switches (ATS) will be suited for this critical role, industry standards and government regulations set forth criteria for their design, performance, and/or deployment.

Used in Australia, New Zealand, Europe, the Mideast, and other regions, the International Electrical Commission's (IEC) published standard for verifying ATS design and performance is *IEC 60947-6-1 Low-voltage switchgear and control gear - Multiple function equipment - Transfer switching equipment*. The following narrative provides a brief overview of that standard and examines why switches meeting the requirements of *Utilization Category AC-33A* are best suited for critical motor load applications.

CHARACTERISTICS OF MOTOR LOADS IN MISSION-CRITICAL APPLICATIONS

To properly select a transfer switch for an application, the mission and operation of the facility must be considered. Building codes typically require commercial and public buildings to be equipped with backup power for life-safety purposes. For a mission-critical facility such as a hospital, a continuous supply of electrical power is essential to ensure the well-being of occupants, including patients; comply with prevailing regulatory requirements; meet operational goals; and maintain revenue streams. For a data center serving large financial institutions, reliable power is needed to sustain continuous operations, serve economic needs, and avoid revenue losses from outages.

The importance of keeping vital loads online is the reason that best practices and regulatory standards require the availability of backup power. For these reasons, best practices and regulatory requirements dictate that properly designed and tested transfer switches be installed in backup power systems, and that they be periodically inspected, maintained, exercised, and tested to ensure readiness for use.

Nature of Motor Loads

Transferring motor loads in alternating current power distribution systems can result in the rush of current due to differing phenomena. When outages occur on the normal power source, a power distribution system will remain unpowered until a different power source is connected. During this interval, spinning motors slow from their operating speed. As they slow, however, they act as generators that impart a voltage onto the distribution circuits. When the circuit is reconnected to a power source, current will flow from locations of higher potential to lower potential. When those differences are sufficient, large inrush currents occur, which can electrically and mechanically stress circuits and load equipment, and can cause overcurrent protection devices to open. These effects can damage load equipment or render it inoperable, impacting mission-critical operations. Where power sources and the motors of load equipment present ***phase angle*** differences, their connection can likewise produce inrush currents.

Fault-Current Tolerance

When faults occur downstream of a transfer switch, such as those resulting from equipment ground faults or short circuits, transfer switches must withstand the resulting currents until they are cleared by overcurrent protection devices, which are specifically designed for that purpose. If a transfer switch opened before overcurrent protection devices, faults could reoccur if the transfer switch is reclosed without proper remediation of the fault condition. Likewise, transfer switches must be able to close on these same fault currents during transfers, again so that the fault can be properly cleared by overcurrent protection equipment. For this reason, testing standards around the world, including the IEC 60947-6-1 standard, require testing to verify the capacity of transfer switches to withstand and close on excessive currents presented during foreseeable fault conditions.

IEC 60947-6-1 OVERVIEW

The most essential function of an ATS is to carry current continuously while connecting loads to one of two sources of power. (Conversely, they are not intended to open circuits to stop the flow of current … that is the function of overcurrent protection devices, such as circuit breakers and fuses.) The IEC has published standards for ATS, including testing requirements, in *IEC 60947-6-1 Low-voltage switchgear and control gear - Multiple function equipment - Transfer switching equipment.*[1] The following sections summarize important provisions of the standard.

Scope

The scope of IEC 60497-6-1 includes four elements. Section1 identifies these as:[2]

1. the characteristics of transfer switching equipment
2. the conditions of operation under normal and abnormal conditions
3. tests to confirm that switches will operate under these conditions
4. data to be marked on the equipment and provided by the manufacturer

The following sections describe the first two elements of the standard.

Transfer Switch Characteristics

In order to design, test, specify, and procure transfer switches, they must be described according to a common set of characteristics. They include type and ratings, as described below.

Type

IEC 60947-6-1 differentiates transfer switches according to their capability for making and breaking circuits. Class PC describes ATS "capable of making and withstanding, but is not intended for breaking, short-circuit currents", which includes contactor-based designs. In addition to quantity of poles, type is determined by the kind of current (ac or dc) and the operating sequence of the transfer device. (For more information regarding transition sequences, review Part 1 and Part 2 of the ASCO Power Technologies document entitled *Transition Modes for Automatic Transfer Switches.*)

[1] Low-voltage switchgear and control gear – Part 6-1: Multiple function equipment – Transfer switching equipment, 2.1 ed., 2005/2013, Geneva, Switzerland: International Electrical Commission.

[2] Ibid. p. 8.

Ratings

IEC 60947-6-1 assigns the following ratings to transfer switches evaluated according to its specified testing protocols:[3]

Table 1
IEC 60947-6-1 Transfer Switch Characteristics

Characteristic	Definition
Voltage	
Operational Voltage	Equipment operational voltage
Insulation Voltage	Insulation voltage to which dielectric tests and creepage distances are referred
Impulse Withstand Voltage	The peak value of an impulse voltage of prescribed form and polarity which the equipment is capable of withstanding without failure under specified conditions of test
Current (Ie)	Rated uninterrupted current
Frequency	The supply frequency for which equipment is designed
Uninterrupted Duty	A duty without any off-load period in which the main contacts of an equipment remain closed, whilst carrying a steady current without interruption for periods of more than eight hours (weeks, months, or even years)
Making and Breaking Capacities	The rated making and breaking capacities, stated by the manufacturer, which the transfer equipment can make and break under specified conditions
Short-Time Withstand Current	The rated short time withstand current that the equipment can carry under specified test conditions
Short-Circuit Making Capacity	The short-circuit making capacity for the rated operational voltage and frequency at a specified power-factor (or time-constant)a, expressed as the maximum prospective peak current
Short-Circuit Breaking Capacity	The rated short-circuit breaking capacity for the rated operational voltage at rated frequency and at a specified power-factor (or time-constant), expressed as the value of the prospective breaking current.
Conditional Short-Circuit Current	The value of prospective current which transfer switch equipment, protected by a specified short-circuit protective device, can satisfactorily withstand for an operating time under specified test conditions

[3] Ibid. Chapter 5.

Utilization Categories

Utilization Categories are defined according to the type of current, load type of the application, and quantity of operations. In Table 2, *Operation A* and *Operation B* refer to "Frequent" and "Infrequent" switching, respectively.

Table 2
IEC 60947-6-1 Utilization Categories – AC Applications[4]

Utilization Category		Typical Applications
Operation A	Operation B	
AC-31A	AC-31B	Non-inductive or slightly inductive loads
AC-32A	AC-32B	Mixed resistive and inductive loads, including moderate overloads
AC-33A	AC-33B	Motor loads or mixed loads including motors, resistive loads, and up to 30% incandescent lamp loads
AC-35A	AC-35B	Electric discharge lamp loads
AC-36A	AC-36B	Incandescent lamp loads

Because maintenance, testing, and elective transfers such as those used for "peak shaving" or "peak loping" are performed periodically, these activities often constitute the majority of transfer switching cycles during the service life of switches installed where public power supplies are routinely stable. According to the IEC 60947-6-1 Utilization Category descriptions in Table 2 above, motor loads require Category 33B for infrequent switching and 33A for frequent switching. However, the standard does not directly specify the quantity of switch operations that constitute "frequent" or "infrequent" use. To make meaningful comparisons, it is necessary to look at the testing procedures prescribed for certifying transfer switches to the standard.

The number of switching operations required for IEC 60947 transfer switch testing are specified in section 9.3.3.6.2 of the standard, entitled *Electrical operational performance*. There, the standard specifies the quantities and durations of electrical and mechanical operational performance tests for *Operation A* (frequent) and *Operation B* (infrequent) utilization. Tests using these values are completed at the voltages and other parameters specified by the test method. The values vary according to the ampacity of the switch under test. The following table presents *Operation A* and *Operation B* values for 400 Ampere ac transfer switches.

[4] Ibid. Table 1. p. 16.

Table 3 Quantities of Cycles for AC33 Transfer Switches – 400 Amps								
	Operation A Frequent Operation				**Operation B Infrequent Operation**			
	Rated Operational Current	Power Factor	Qty. Operations[5]		Rated Operational Current	Power Factor	Qty. Operations[6]	
			Electrical	Mechanical			Electrical	Mechanical
Operation Condition	1x	0.8[7]	2000	0	1x	0.8[8]	1000	3000
	2x	0.8	2000	0				
Making/ Breaking Capacity	10x	0.35[9]	50[10]		10x	0.35[11]	12[12]	

Table 3 lists tests for *Operating Condition and Breaking Capacity*. Operating Condition tests conduct repeated transfer switch and without load at the listed power factors and levels of current for the specified quantity of operations. The primary differences are found with the rated operational currents and quantities of cycles under load. *Operation B* switches are subject to 1,000 cycles at the rated current, while *Operation A* switches are subject to 4,000 cycles, half of those at twice the rated current. This comparison shows that *Operation A* switches are subject to four times more testing and to a higher level of load.

QUANTIFYING TRANSFER SWITCH OPERATIONS

To properly specify a switch for reliable operation, it is necessary to compare the expected usage of a switch during its anticipated service life to the amount of testing conducted according to the prevailing industry standard. The following section estimates the quantity of operations that a switch would complete during its anticipated service life.

This example situation involves a hypothetical facility located in a region with a relatively reliable public utility service, and maintains a comprehensive backup power system for life-safety, legally required, and mission-critical loads. The facility implements a program of regular inspection, maintenance, and testing. It also participates in a "peak shaving" or "peak lopping" program to take advantage of utility economic. Assuming six outages, 12 monthly test runs, and 50 peak shaving events annually, the facility can anticipate 68 transfers each year:

(6 Outages + 12 Test Runs + 50 Peak Lopping Events) = 68 Cycles Annually

Multiplied over a 25-year service life, this amounts to 1,700 transfer events. This quantity of transfers exceeds the amount of *Operating Condition* test transfers completed for Operation B-rated switches, which are subject to only 1,000 operations under load. Operation A-rated switches are tested 4000 times under load. Consequently, AC-33A equipment is more likely to reliably operate throughout the service life of the equipment at this facility. Because half of the *Utilization Category 33A* operating condition tests are conducted at twice the rated current, and because 33A testing involves more than four times the *Breaking Capacity Tests* (50 vs. 12), users can also be more confident that the switches will withstand abusive fault currents that could occur over the service life of the unit.

This level of reliability and longevity is available to facilities by specifying AC-33A switches for motor loads. Backup power trends continue to place importance on reliable and continuous power, especially for mission-critical facilities such as hospitals and data centers. Emerging opportunities in technologies such as microgrids suggest that load transfer frequency is unlikely to decrease. The more stringent testing requirements for AC-33A transfer switches indicate that they should provide higher reliability for motor loads in mission-critical applications.

[5] Ibid. Table 9. p. 33.
[6] Ibid. Table 10. p. 33.
[7] Ibid, Table 3. p. 21.
[8] Ibid, Table 3. p. 21.
[9] Ibid. Table 2. p. 20.
[10] Ibid. Table 8. p. 31.
[11] Ibid. Table 2. p. 20.
[12] Ibid. Table 8. p. 31.

SUMMARY

Used in Australia, New Zealand, Europe, the Mid-East, and other regions of the globe, IEC 60947-6-1 specifies criteria for testing and characterizing transfer switches for various applications based on load type and frequency-of-use. For alternating current motor loads, the standard specifies two *Utilization Categories*, AC33-Aand AC-33B for "frequent" and "infrequent" use applications, respectively. The quantity of operating tests under electrical load for AC-33A is approximately four times greater than for AC-33B. For AC-33A, some of these tests are conducted using higher current levels as well. Furthermore, the quantity of expected transfer operations over the service life of equipment at many mission-critical facilities can reasonably exceed the quantity of tests conducted for infrequent utilization categories. Consequently, Utilization Category AC-33A transfer switches can be best suited for motor load applications serving mission critical facilities, such as healthcare facilities and data centers.

FURTHER READING

For additional information about transferring motor loads, see the ASCO Power Technologies document entitled ***White Paper - Transferring Motor Loads Between Power Sources*** at **www.ascopower.com**.

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