ASCO Power Technologies™

Testing Hospital Backup Power Sources

White Paper 118

Hospitals provide life-saving services to patients. To ensure patient safety, welfare, and satisfaction, electrical power must be available 24 hours per day, 365 days per year. For this reason, these facilities rely on backup systems that can provide electrical power when utility outages occur. This document provides an overview of the testing required to verify readiness and performance and summarizes an approach for streamlining testing activities.

THE NEED TO TEST

For critical facilities, the occurrence of power outages is regarded as a normal operating condition. As such, facilities must be ready to function on backup power at any time, without notice. To do so, equipment must be maintained in a service-ready state, which must be verified to provide confidence that it will function properly during a utility outage. Best practices, industry codes, and government regulations require periodic testing to verify proper function and performance. More specifically, maintenance and testing are mandated in the *National Electrical Code*® (NEC®). The associated practices are more precisely articulated in *NFPA 110 – Standard for Emergency and Standby Power Systems*.

NEC Requirements

In North America, the *NFPA 70 - National Electrical Code*® (NEC®) provides electrical safety standards for equipment installed in facilities. With regards to backup power, the NEC divides a power distribution system according the nature of loads that they serve, specifically Emergency Systems (Article 700), Legally Required Standby Systems (Article 701), and Optional Standby Systems (Article 702). The following quotes from the NEC describe the respective load types:

> ***Emergency systems*** *are generally installed in places of assembly where artificial illumination is required for safe exiting and for panic control in buildings subject to occupancy by large numbers of persons, such as hotels, theaters, sports arenas, health care facilities, and similar institutions. Emergency systems may also provide power for such functions as ventilation where essential to maintain life, fire detection and alarm systems, elevators, fire pumps, public safety communications systems, industrial processes where current interruption would produce serious life safety or health hazards, and similar functions.*[1]
>
> ***Legally required standby systems*** *are typically installed to serve loads, such as heating and refrigeration systems, communications systems, ventilation and smoke removal systems, sewage disposal, lighting systems, and industrial processes, that, when stopped during any interruption of the normal electrical supply, could create hazards or hamper rescue or fire-fighting operations.*[2]
>
> ***Optional standby systems*** *are typically installed to provide an alternate source of electric power for such facilities as industrial and commercial buildings, farms, and residences and to serve loads such as heating and refrigeration systems, data processing and communications systems, and industrial processes that, when stopped during any power outage, could cause discomfort, serious interruption of the process, damage to the product or process, or the like.*[3]

[1] National Fire Protection Agency. *NFPA 70 – National Electrical Code*. 2020 Edition. Quincy, MA, USA. Article 700.2. p. 605.
[2] Ibid. Article 701.2. p. 612.
[3] Ibid. Article 702.2. p. 615.

Figure 1 is adapted from the NEC and shows the arrangement of circuit types.

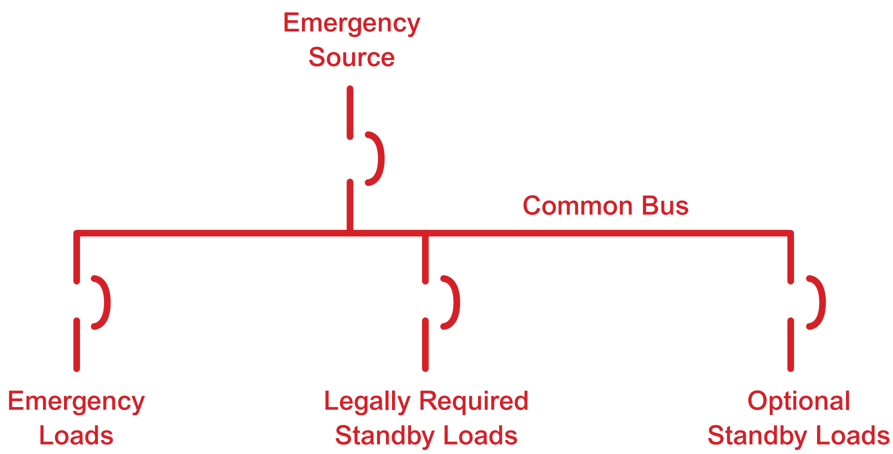

Figure 1: NEC-Defined branches of Backup Power Systems

Articles 700 and 701 also specify that these systems must be periodically tested and maintained.[4,5] Placing systems under load is a required testing condition and recordkeeping is required to prove compliance. For hospitals, or portions thereof, that operate designated *Critical Operations Power Systems*, similar requirements are restated in NEC Article 708.6. Importantly, the NEC requires that Emergency and Legally Required Standby systems provide backup power within 10 and 60 seconds, respectively, of the occurrence of an outage.[6,7]

NFPA 110 Requirements

Testing requirements are also presented in *NFPA 110 – Standard for Emergency and Standby Power Systems*, primarily in *Chapter 8 - Routine Maintenance and Operational Testing*. This chapter states that operational testing shall be conducted according to manufacturer's recommendations, instruction manuals, the minimum requirements of the chapter, and any requirements by the authority having jurisdiction.[8] Note that testing required to commission backup power systems is specified in Chapter 7 of NFPA 110; those requirements are not addressed in this report.

[4] Ibid. Article 700.3. p. 605.
[5] Ibid. Article 701.3. p. 612.
[6] Ibid. Article 700.12. p. 608.
[7] Ibid. Article 701.12. p. 613.
[8] National Fire Protection Agency. *NFPA 110 – Standard for Emergency and Standby Systems.* 2019 Edition.Quincy, MA, USA. Article 8.1.1. p. 110-20.

Monthly Testing

Chapter 8 of NFPA 110 also specifies that an *Essential Power Supply System* (EPSS) including its transfer switches, "shall be exercised under load at least monthly" using loading that maintains either the manufacturer's minimum exhaust gas temperature or 30 percent of the power source nameplate rating.[9,10,11,12] Diesel generators that do not meet the requirement must be exercised annually for at least 30 minutes at loads exceeding 50 percent of the power source rating plus at least another hour above 75 percent of that rating. Testing shall be initiated by a qualified person, who can do so by opening a breaker or using the test switch on an ATS.[13,14] Where multiple transfer switches are present, tests shall be started from different switches each month to ensure that all function properly.[15]

Triennial Testing

Once every 36 months, the entire backup power system must be tested for four hours.[16] For diesel gensets, loading shall maintain at least the minimum exhaust temperature and at least 30 percent of the nameplate kW rating. Spark-ignited gensets shall use the available EPSS load. Triennial testing can be combined with a monthly test event, provided that the test parameters meet or exceed the runtime and loading requirements of both the monthly and triennial test requirements.

NFPA 99 Requirements

NFPA 99 - Health Care Facilities Code specifies requirements for the installation, inspection, testing, maintenance, performance, and safe practices for various systems in hospitals, including medical gas, information technology, plumbing, security and electrical systems.[17] Several articles refer back to NFPA 110 to require that alternate power sources must provide power within 10 seconds of the occurrence of an outage of the primary power sources.[18,19,20] If the 10-second criterium is not met during monthly tests, this capability must be confirmed annually.[21]

NFPA 99 offers some flexibility in test scheduling, stating the testing must occur 12 times per year at intervals of 20 to 40 days. Tests must include "a complete simulated cold start and appropriate automatic and manual transfer of all essential electrical system loads," and must be conducted by "qualified persons capable of detecting causes of malfunction" and training others on operating procedures.[22]

9 Article 3.3.4 of NFPA 110 defines the Emergency Power Supply System as a *"complete functioning EPS system coupled to a system of conductors, disconnecting means and overcurrent protective devices, transfer switches, and all control, supervisory, and support devices up to and including the load terminals of the transfer equipment needed for the system to operate as a safe and reliable source of electric power."*
10 National Fire Protection Agency. NFPA 110 – *Standard for Emergency and Standby Systems.* 2019 Edition. Quincy, MA, USA. Article 8.4.6. p. 110-21.
11 Ibid. Article 8.4.1. p. 110-20.
12 Ibid. Article 8.4.2. p. 110-20.
13 Ibid. Article 8.4.8. p. 110-21.
14 Ibid. Article 8.4.3. 110-21.
15 Ibid. Article 8.4.3.1. p. 110-21.
16 Ibid. Article 8.4.9 et seq. p. 110-21
17 National Fire Protection Agency. NFPA 99 – *Health Care Facilities Code.* 2018 Edition. Article 1.2. p. 99-15.
18 NFPA 110. Article 4.1. p. 110.8.
19 NFPA 99, Article 6.7.1.2.4.1. p. 99-74.
20 Ibid. Article 6.7.5.3.1. p. 99-82.
21 Ibid. Article 6.7.4.1.1.2. p. 99.79.
22 Ibid. Article 6.7.4.1.1.5 et seq. p. 99-79.

Joint Commission Requirements

The above referenced NFPA regulations are reflected in The Joint Commission guidance that is used to establish and maintain accreditation for hospitals.[23] To obtain and maintain accreditation, the Joint Commission audits hospitals against its guidance, including guidance for the management and testing of backup power systems. Poor audit performance, including audits of power testing records, can lead to loss of accreditation. Because payors may require accreditation as a condition of payment for patient services, it is important to perform the necessary testing and document its results.

Actions required to comply with Joint Commission standards are similar to those required to comply with the NFPA standards. For instance, Standard EC.02.05.07 states, "The hospital inspects, tests, and maintains emergency power systems."[24] *Elements of Performance for EC.02.05.07* states that the following are among of the elements of compliance: (1) monthly testing from a cold start under load for at least 30 minutes at a minimum of 30% of generator nameplate capacity or the engine manufacture's minimum exhaust gas temperature; (2) monthly test of all automatic and manual transfer switches, and (3) triennial testing for 4 continuous hours at the aforementioned output levels.[25]

OPTIMIZING HOSPITAL BACKUP POWER SYSTEMS

Earlier, Figure 1 showed the segregation of load circuits by priorities specified in NEC Articles 700, 701, and 702. Figure 2 shows a simplified conceptual arrangement of a hospital power system served by two utility feeds and multiple generators. A power control system with a split bus arrangement is used to connect high priority loads to the first generators to come online. Note that the actual configurations of these systems can vary widely, with differing quantities of power sources, simpler or more complex power control systems and bus arrangements, and greater numbers of transfer switches. For more information about Power Controls Systems, review ASCO's document entitled [Power Control System Basics]().

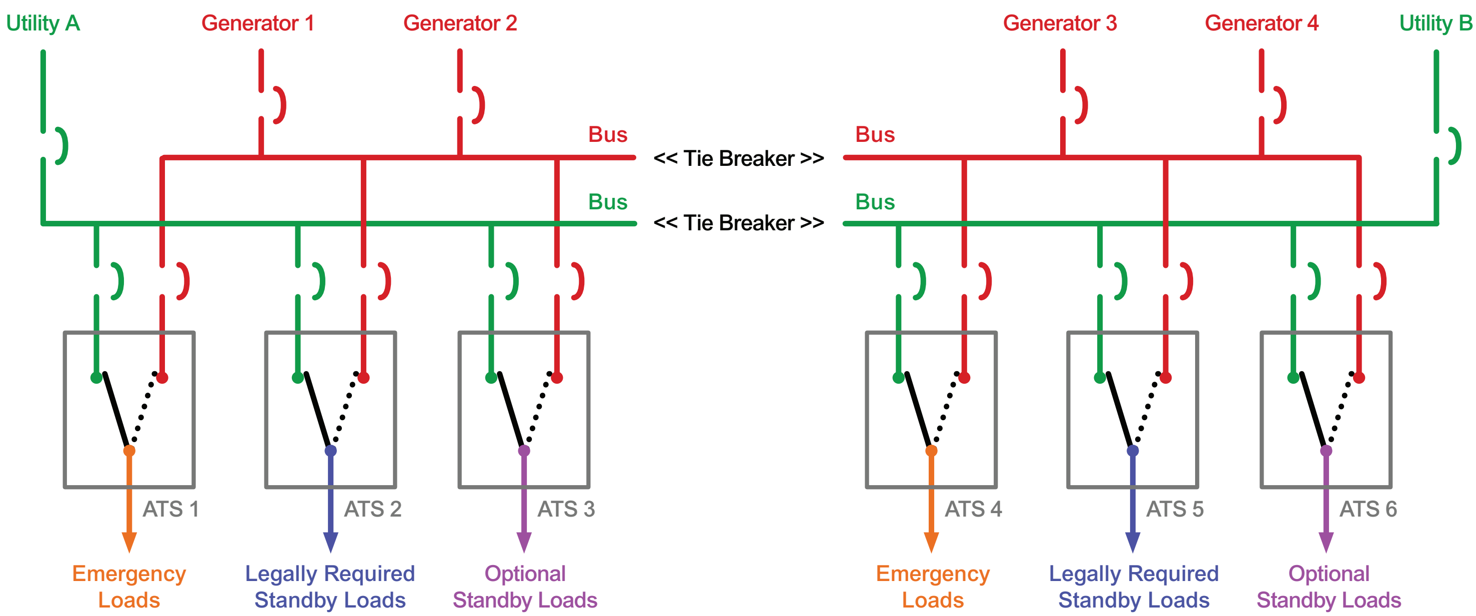

Figure 2: Conceptual Hospital Backup Power System

Regardless of configuration, the scope of testing for generators and critical power devices that make up the system requires planning and coordination. In the end, facilities need to verify that (1) the equipment functioned when needed, and (2) that generators and transfer switches provided backup power within require timeframes. Because transferring load can impact hospital operations, methods for minimizing or avoiding disruptions should be considered. Because the testing efforts and resulting compliance documentation can require considerable resources, methods for streamlining compliance programs warrant review.

[23] The Joint Commission. Hospital Accreditation Standards. 2019 Edition. Oak Brook, IL, USA. Environment of Care.
[24] Ibid. Standard EC.02.05.07. p. EC-35.
[25] Ibid. Elements of Performance for Standard EC.02.05.07. p. EC-36 to EC-37.

Mitigating Potential Impacts from Load Transfers

Proper specification of critical power equipment can mitigate or eliminate impacts to downstream equipment from interruptions associated with transfer switching, equipment maintenance, or controller malfunction. In addition, critical power systems can be provisioned with features that streamline operation and compliance activities. These are detailed in the following sections.

Closed Transition Transfer Switches

When primary power fails, generators must be started before load can be transferred to them. When public utility outages occur, the time required to bring generators online and transfer loads to them results in a short interruption in power. However, when primary power is restored, both power sources become available. Using standard *open transition transfer switches* to reconnect loads typically results in another momentary power interruption.

Potential disruption to sensitive equipment can be mitigated by specifying *Closed Transition Transfer Switches* that avoid momentary power interruptions associated with transferring building loads back to the primary power source. These switches very briefly overlap the closure of switch mechanism contacts of both power sources to avoid power disruption. Figures 1 and 2 compare open and closed transfer sequences.

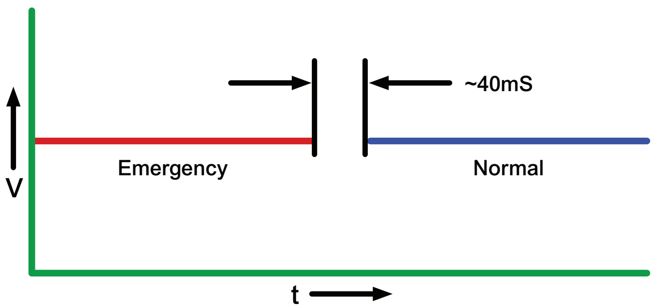

Figure 1
Open Transition Retransfer to Normal Power

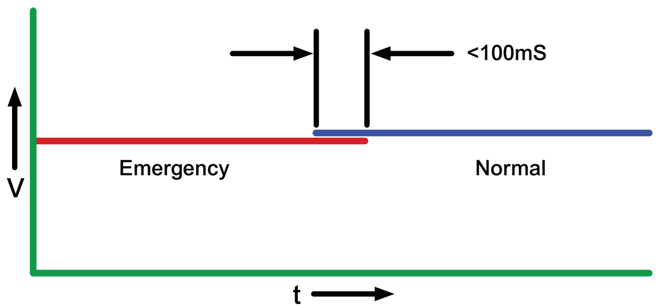

Figure 2
Closed Transition Retransfer to Normal Power

In ASCO's experience, hospitals routinely select closed transition transfer switches to minimize disruption to electrical loads. Additional information about transition modes, including closed transfer, is presented in Part 1 and Part 2 of ASCO's document entitled *Transition Modes for Automatic Transfer Switches.*

Continuity for Control Power

When outages occur on a primary source, a transfer switch controller can be left without power. To ensure that it can complete load transfer as backup power comes online, transfer switches can be equipped to provide ride-thru power to their controller during normal-to-emergency transfer.

Interruption-Free Maintenance

Testing is only part of a larger equipment maintenance program. Whether service is regularly scheduled or becomes necessary following testing, bypass-isolation switches can be used to enable switch inspection, maintenance, and repair without disrupting the flow of current to loads. In these units, a second transfer switch closes on the primary source, allowing current to flow through both transfer mechanisms until the transfer switch mechanism is isolated. Thereafter, the transfer switch can be withdrawn for inspection and service without impacting operations. Figure 3 illustrates the principle of operation.

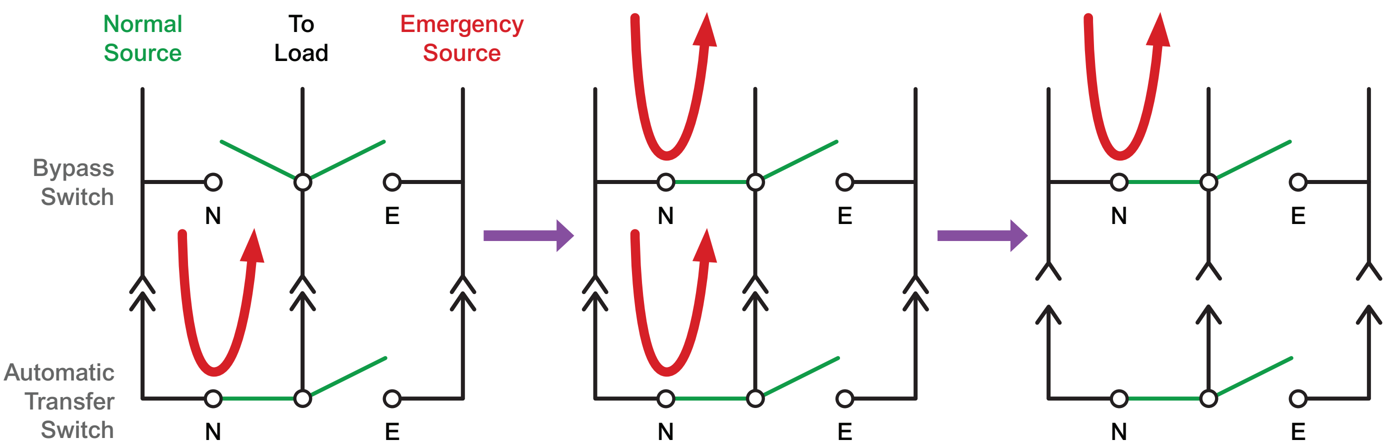

Figure 3 - Bypass-Isolation Switches enable transfer switches to be isolated for service without interrupting power to loads.

By isolating a transfer switch, it can be inspected and serviced according to manufacturer and application requirements, without introducing a need to depower the associated downstream circuits. This streamlines operation and compliance by avoiding complex logistics that would otherwise be needed to depower the transfer switch.

Streamlining Operation and Compliance

Power control systems and transfer switches can be monitored and controlled remotely when equipped with appropriate communication features. Signals and data can be transmitted to electronic monitoring systems that store and assess data. If monitoring indicates abnormal conditions, these systems can send data and alarm signals to annunciators to notify authorized personnel through local or remote annunciators, dedicated power management systems, or building management systems. Many of these systems can be provisioned to monitor and control equipment remotely and to automate the processes for recording, storing, compiling, and reporting information needed to demonstrate regulatory compliance.

Monitor and Control Equipment Remotely

Critical power PCS and transfer switch equipment can be fitted with communication accessories that enable remote monitoring and data logging of equipment status and electrical parameters. When-out-of-range conditions are detected, these systems can send signals to local or remote annunciators and provide real-time notification to authorized users through network terminals and mobile communication devices.

Solutions typically involve (1) fitting transfer switches and other critical power equipment with accessories that enable IP communications; (2) a means of networking IP communications to a central monitoring system; and (3) running monitoring software to provide the necessary functions. Examples include third party power and IT monitoring platforms as well ASCO's advanced Critical Power Management System. These systems can be scaled to monitor a single clinic or outpatient center, an entire hospital building, or multiple hospital campuses from a single device. Centralizing access to critical power information allows the user to respond to evolving conditions quickly. Providing remote access to a large backup power system increases operational productivity. For additional Information, review ASCO documents entitled ***Communication Modules for Critical Power Equipment*** and ***Data Communications for Critical Power Management Systems***.

Automate Compliance Reporting

Collecting power data through a power monitoring system is a key to automating time-consuming testing and compliance tasks. Data can be collected regarding electrical conditions and events from every connected device, including the exact time that they occurred. This can offer benefits in the following ways.

First, power monitoring systems log data, obviating the need for manual data collection. For instance, such a system can collect timestamped data about transfer operation from each transfer switch automatically, eliminating the need for someone to manually collect the data by scrolling through interface screens at every transfer switch and critical power device.

Second, these systems can compile the data, compare it to operational criteria, and automatically prepare reports that document the state of compliance with industry standards, regulatory requirements, and facility goals. In a large facility, this can substantially reduce the time required to document compliance and prepare for audits. Stored data also remains available for forensic evaluation.

Third, power monitoring systems can automatically evaluate data resulting from equipment activity during outages of the primary source. If equipment performance parameters such as run-time duration and minimum power level are met, the data set could be used to demonstrate compliance, and may reduce the need for conducting a periodic backup power system test and avoid the associated effort and cost.

More information regarding automated compliance reporting can be viewed in ASCO's document entitled ***The Value of Automated Power Compliance Reporting***.

SUMMARY

NFPA standards specify maintenance and testing requirements for backup power equipment and systems used in hospitals in North America. These tasks are necessary to ensure that backup power systems will be ready to provide backup power during public power outages. Performance tests are to be conducted at prescribed intervals, and additional inspections and checks are required more frequently.

Power control systems, transfer switches, and other critical power equipment can be configured to optimize and streamline operation and compliance activities. Closed Transition Transfer Switches eliminate momentary outages that occur during retransfer to the primary power source. Internet-enabled communication capabilities can provide remote access to real-time data about power events and conditions and can automate compliance reporting tasks.

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