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Testing Hospital Power Backup Systems in the United Kingdom

A Primer on Health Technical Memorandum 06-01 - Electrical Supply and Distribution

White Paper 115

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Health Technical Memorandum 06-01 Electrical Services Supply and Distribution

A Primer on Testing Backup Power Systems in the United Kingdom

The NHS Constitution for England states that patients have a right "to be cared for in a clean, safe, secure and suitable environment."[1] To provide this environment, healthcare organisations must ensure a reliable supply of electrical power for life safety and critical equipment in their buildings. Consequently, healthcare facilities use backup power systems to mitigate the impacts of public electric service outages.

Verifying readiness of backup power systems requires testing of generators and other backup power equipment. For facilities in the United Kingdom, ***Health Technical Memorandum 06-01 Electrical Services Supply and Distribution*** provides guidance for completing this testing.[2] This document summarises back-up power requirements, describes the scope of responding test programs, and offers approaches for streamlining compliance testing activities.

UK HEALTHCARE TECHNICAL MEMORANDA

Requirements to provide safe and secure facilities to healthcare patrons begins with pledges in The ***NHS Constitution for England***. Pledges to patients include the following statement:

> *"You have the right to be treated with a professional standard of care, by appropriately qualified and experienced staff, in a properly approved or registered organisation that meets required levels of safety and quality."*[3]

To meet this standard of care, the government of the United Kingdom issued guidance on the design of healthcare facilities and the management of their systems in a series of Healthcare Technical Memoranda (HTM). ***Health Technical Memorandum 00 - Policies and Principles of Healthcare Engineering*** responds to the pledges in the constitution by stating, "Patients and staff have a right to expect that engineering systems and equipment will be designed, installed, operated and maintained to standards that will enable them to function efficiently, reliably and safely."[4] Section 2.6 further states, "... systems must be resilient in order to maintain the continuity of health services and ensure the ongoing safety of patients, visitors and staff." Subsequent HTM documents address topics ranging from laboratory design and fire safety to water management and disinfection.

Within the series, ***Health Technical Memorandum 06-01 - Electrical Services Supply and Distribution*** (HTM 06-01) sets forth guidance for electrical power supply and distribution systems, including backup power systems. It requires that facilities maintain and test backup power systems to ensure that they will be available for service when public power outages occur. The following sections summarise key provisions.

[1] Department of Health and Social Care. The NHS Constitution of England. 2015 Edition. p. 7. https://www.gov.uk/government/publications/the-nhs-constitution-for-england. Viewed February 18, 2020.

[2] Department of Health. Health Technical Memorandum 06-01 - Electrical Services Supply and Distribution. 2017 Edition. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/608037/Health_tech_memo_0601.pdf. Downloaded February 18, 2020.

[3] NHS Constitution, p. 7.

[4] Department of Health. Health Technical Memorandum 00 - Policies and Principles of Healthcare Engineering. 21014 Edition. p.4. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/299276/HTM_00.pdf. Downloaded February 18, 2020.

KEY HTM 06-01 MAINTENANCE AND TESTING REQUIREMENTS

The following sections summarise selected HTM 06-01 requirements for backup power system maintenance and testing of generators, switchgear, and power source paralleling (power control) systems that comprise backup power systems. They also summarise record keeping requirements and application considerations. Notably, HTM 06-01 17.35 specifies that the provisions of manufacturer operation and maintenance manuals should be observed "as far as reasonably practical."[5]

Generator Testing

To verify the readiness of generators or other secondary power sources, they must be tested at regular intervals. HTM 06-01 17.83 requires "All standby generator plant should be tested online with the building load every month. The duration of the online test should be at least one hour, but preferably two hours." The requirement allows the healthcare organisation to define test start procedures.[6] Notably, the text specifies using building load to test generators.

Using building load necessarily tests critical gear in the backup power system, including switchgear and transfer switches. However, transferring building load between power sources will require "short-term isolation of the electrical supply." In this instance, HTM 06-01 17.84 specifies that long-term paralleling of the generators and the PES (primary electrical supply) "will minimise the inconvenience to healthcare staff". Resistive-Reactive Load Banks may instead be used to test generators in these instances.[7] Where these paralleling arrangements exist, the HTM also states that generator loading should exceed 70 percent of capacity, and that the testing frequency can be reduced to six-month intervals.[8,9]

To verify test gen-set mechanical performance and endurance, HTM 06-01 17.88 specifies an annual high-output generator test of longer duration. A minimum run-time of 3 hours is required, and 4 hours is recommended. Load is specified at "up to 110%".[10] Testing of any overspeed governor and over-temperature and fuel safety alarms and controls should be conducted during these tests, unless a facility uses only a single generator.[11] Likewise, long-term tests should verify the function of any switchgear used to transfer load between primary and secondary power sources.[12]

HTM 06-01 also requires periodic visual and functional checks of primary and secondary power sources and their components. A visual inspection of each power source is required weekly, and should check instrument readings as well as coolant levels, lubricant leakage, and charge levels for engine start batteries.[13] Quarterly tests should verify that battery cell voltages and battery charging current are within specifications.[14]

[5] HTM 06-01 Health Technical Memorandum 06-01 - Electrical Services Supply and Distribution. Article 17.35. p. 143.
[6] Ibid. Article 17.83. p. 147.
[7] Ibid. Article 17.84. p. 147.
[8] Ibid. Article 17.85. p. 147.
[9] Ibid. Article 17.92. p. 147.
[10] Ibid. Article 17.88. p. 147.
[11] Ibid. Article 17.89. p. 147.
[12] Ibid. Article 17.90. p. 147.
[13] Ibid. Article 19.93. p. 148.
[14] Ibid. Article 19.94. p. 148.

Low Voltage Switchgear Inspection and Maintenance

HTM 06-01 17.63 requires inspection of low voltage switchgear. Maintenance tasks should include a visual inspection of any low voltage switchgear at least twice annually.[15] They should also include a maintenance programme for low voltage switchgear and air circuit breakers, molded case circuit breakers and tests on protection relays, battery units, auxiliary relays, timer relays, coils, terminations and linkages of open/close mechanisms, busbar shutter mechanisms, and any sliding/plug contacts.[16] In transfer switches, the main contacts and auxiliary contacts in switching mechanisms should be routinely inspected for alignment, wear, burning, spring tension, and any other manufacturer-recommended parameters.[17]

Summary of Test Requirements

The following table summarises backup power inspection, maintenance and testing requirements. Consult HTM 06-01 for requirements for high voltage systems.

DEVICE	INTERVAL	TEST PARAMETERS	SOURCE
Primary & Secondary Power Sources	Weekly	Visual Inspection	HTM 06-01 19.93
Generators	Monthly	1-2 Hrs. Using Building Load	HTM 06-01 17.83
	Quarterly	Battery Cell Voltages and Charging Current	HTM 06-01 19.94
LV Switchgear	Twice Annually	Inspect & Maintain	HTM 06-01 17.63 HTM 06-01 17.64
Generators & Associated Switchgear	Annual	3-4 Hrs. at 110% of Full Load	HTM 06-01 17.88

Recordkeeping

Maintenance audits and feedback are important mechanisms for verifying that critical power systems will be available when needed during outages. This requires records of the maintenance and testing activities that can and should be reviewed to ensure that associated equipment is operating and performing as intended. HTM 06-01 17.27 states:

> *Test results, condition observations, performance statistics and records of parts/components replaced can provide useful information to support an evaluation. It is also important to record completion of tasks; any consistent non-completions should be noted, reviewed and reported to management. This is important information and should be safely stored for future reference and trend analysis.*[18]

Throughout Section 17, recordkeeping requirements are stated for various maintenance tasks. With specific regard to testing backup power systems, the section states that "Records should be kept of all hours that the standby generator is run, whether the purpose is for testing, parallel operation or outage of the PES (Primary Electrical System)."

Two statements indicate that recordkeeping extends to transfer switches in the power distribution system. 17.136 states that action should be taken to correct faulty switchgear, protective devices or circuits found during maintenance, and 17.137 indicates the quality of the information that should be recorded for these devices.[19,20] In addition, information should be recorded to support any manufacturer-specified testing and maintenance protocols that exceed the HTM guidance.

[15] Ibid. Article 17.63. p. 145.
[16] Ibid. Article 17.64. p. 145.
[17] Ibid. Article 17.65. p. 145.
[18] Ibid. Article 17.27. p. 142.
[19] Ibid. Article 17.136. p. 151.
[20] Ibid. Article 17.137. p. 151.

Application Considerations

Electronic and digital equipment can be susceptible to impacts from electrical phenomena resulting from outages. HTM 06-01 17.139 directs facilities to consider the impacts of needs of equipment and services supported by the electrical supply, including laboratory, imaging, communication, IT and electronic record systems. The electrical needs of critical systems such as communication, lighting, signage, medical, and other systems that ensure safety and welfare of occupants also require consideration and protection.[21,22]

OPTIMISING CRITICAL POWER SYSTEMS

For healthcare facilities, 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.

Mitigating Potential Impacts from Load Transfers

Use Closed Transition Transfer Switches

When primary power fails, generator systems must be started before load can be transferred. The time required to bring generators online and transfer loads to them varies, but results in a short interruption in power. However, when primary power is restored, both power sources are available. Using a standard Open Transition Transfer Switch to retransfer 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 instantaneous power disruption. By doing so, closed transition switches can streamline use of building load for generator testing. Figures 1 and 2 compare open and closed transfer switching sequences.

Photograph 1 – This large-ampacity Closed Transition Bypass-Isolation Switch can carry current to loads while the transfer switch mechanism is isolated. Draw-out design enables technicians to access the transfer switch for inspection and service without disrupting power to loads.

[21] Ibid. Article 17.139. p. 151.
[22] Ibid. Article 17.140. p. 151.

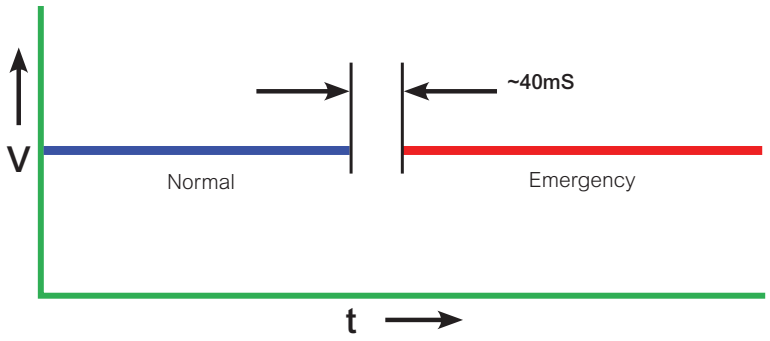

Figure 1: Open Transition Transfer Sequence

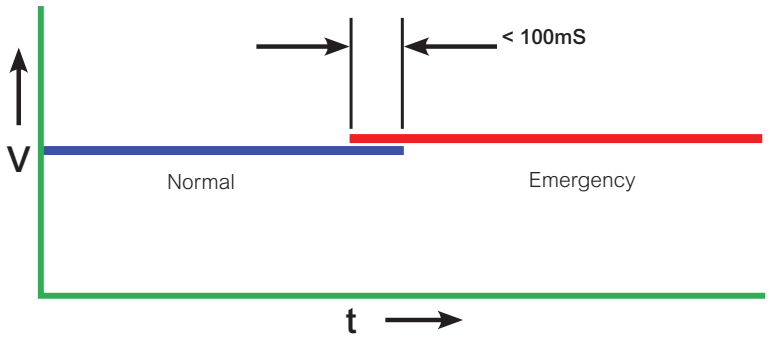

Figure 2: Closed Transition Transfer Sequence

In ASCO's experience, healthcare facilities in the UK routinely select closed transition transfer switches. 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*.

Consider Load Shedding Features

Depending on the characteristics of the power source and loads, placing an entire building load onto a power source can momentarily overload the power source. An outage could occur if the source cannot recover. To prevent this outcome, transfer switches and power control system can be configured with load shed features. These disconnect low priority loads prior to transfer to reduce block loading. Both transfer switches and power control systems can be configured to provide this function.

Ensure Control Power Continuity

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.

Enabling Interruption-Free Maintenance

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 primary transfer switch is isolated. Thereafter, the transfer switch can be withdrawn for inspection and service. Figure 3 illustrates the principle of operation.

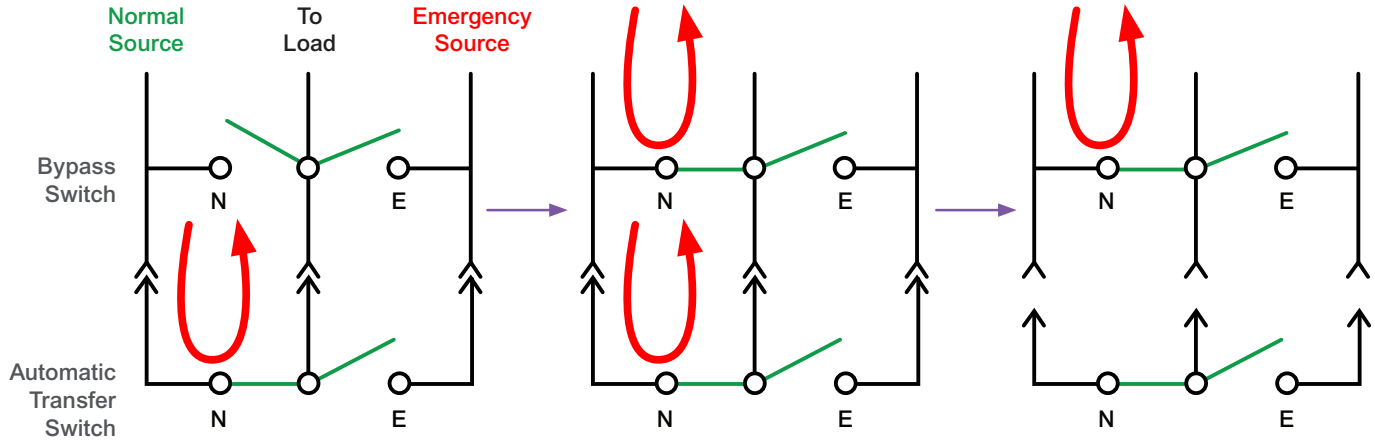

Figure 3: Bypass-Isolation Switches enable a transfer switch to be isolated for service without interrupting power to loads.

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

Minimising Load Transfers and Supplementing Test Load

HTM 06-01 17.84 allows for testing secondary power sources using load banks instead of building load in some instances.[23] This can be done to avoid short-term power interruptions to downstream equipment loads. Load banks can also be used to supplement load to reach load levels required by functional and performance tests. Combination resistive/reactive load banks should be used for this purpose. For additional information, refer to the ASCO documents entitled Load Testing for Healthcare Compliance and Load Banks for Hospitals and Healthcare Facilities.

Streamlining Operation and Compliance

Power control systems and transfers 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 indicated conditions out of normal ranges, these systems can send data and alarm signals to annunciators to notify authorised personnel through local or remote annunciators.

Monitor and Control Equipment Remotely

Critical power 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 authorised users through network terminals and mobile communication devices.

Solutions typically involve fitting transfer switches and other critical power equipment with accessories that enable IP communications; a means of networking IP communications to a central monitoring system; and running a monitoring software on that system to provide the necessary functions. Examples of these platforms include third party power and building 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. Centralising access to critical power information allows users 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 power monitoring system is a key to automating time-consuming testing and compliance tasks. Data can be collected from every connected device regarding electrical conditions and events, including the 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.

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 prepare for audits and document compliance. 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, avoiding the associated effort and cost.

[23] Ibid. Article 17.84. p. 147.

SUMMARY

HTM 06-01 provides maintenance and testing guidance for backup power systems used in healthcare facilities in the United Kingdom. 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 both monthly and annually, and additional inspections and checks are required more frequently.

Power control systems, transfers switches, and other critical power equipment can be configured to optimise 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 and reduce the number of necessary backup system test events.

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