Maintenance and Testing for the Healthcare Industry — Isolated Power Systems

The electrical maintenance and testing requirements for a healthcare facility vary significantly within the overall electrical infrastructure. In this discussion, we will present specialty maintenance and testing requirements associated with isolated power systems which are considered critical circuits within the emergency power system of the essential electrical system.

Isolated electrical power systems, or equipotential grounded power systems, have been in use in hospital operating rooms and critical care areas since the 1930s. These systems are typically found in a number of areas throughout a healthcare facility:

- Operating Rooms
- Catheterization Labs
- Urology Labs
- Labor and Delivery Rooms
- ICU/CCU Areas
- Emergency Rooms
- Radiology Rooms
- Specialty Testing Areas

Initially, their primary purpose was to prevent the possibility of electrical arcs and sparks which could provide a source of ignition for flammable anesthetics. The use of flammable anesthetics was discontinued in the U.S. in the 1970s; however, the use of isolated power systems has continued due to the superior protection provided against leakage current and electric shock to the patient in wet locations. This leakage current is any current, including capacitively-coupled current, not intended to be applied to a patient. These currents can be conveyed from exposed conductive parts of equipment to ground or to other equipment or equipment surfaces.

Experience with isolated power systems has resulted in specific requirements in NFPA 70, National Electrical Code (NEC), (Section 517.160) and NFPA 99, Standard for Healthcare Facilities, (Section 4). Specific to the NEC, Article 517-20(a) states that “(a)ll receptacles and fixed equipment within the area of the wet location shall have ground-fault circuit-interrupter protection for personnel if interruption of power under fault conditions can be tolerated, or be served by an isolated power system if such interruption cannot be tolerated....” The techniques and devices utilized for monitoring the electrical isolation characteristics of these power systems have evolved over time due to technological advances as well as experience with electrical safety for patients and personnel within the operating room and critical care areas. NFPA 99 is the benchmark for information and guidelines for the application and performance monitoring of isolated power systems. Here are some highlights from NFPA 99 associated with maintaining and testing isolated power systems:
• Line Isolation Monitor (LIM) circuits shall be tested after installation, repair or renovations. LIM performance testing shall also be performed periodically (at least every 12 months) and documented.

• Grounding systems shall be tested after installation and retested after alteration or replacement by voltage and impedance measurements.

• Receptacles shall be inspected and tested after installation, replacement, or servicing. Receptacle testing shall also be performed periodically (at least every 12 months) and documented.

For healthcare facilities, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) has also published requirements applicable to isolated power systems in its Environment of Care, Section EC.2.14, which states that all critical operating components of the utility system must be inventoried, tested, and documented. While the JCAHO requirements can be stringent, NFPA 99 requirements associated with electrical systems testing and maintenance are typically recommended and considered acceptable by JCAHO.

As presented from NFPA 99 highlights above, most systems utilize a LIM for monitoring and testing system status. The LIM is designed to continually check the balanced and unbalanced impedance from each line of an isolated circuit to ground. This device is required to monitor and alarm with a fault hazard of >3.7 mA or a total hazard current of >5 mA. The device is typically equipped with a built-in test circuit to exercise the alarm without adding to the leakage current hazard. Using this test circuit on a periodic basis (at least once per month) is considered to be adequate for meeting maintenance testing requirements. Automated self-test and self-calibrating LIMs need only be tested annually. However, any modification to the isolated power system (e.g., replacement of receptacle, the addition of new receptacles, etc.) requires that an independent performance test be performed to ensure system operability.

This test is performed by successively grounding each line of the distribution system through a resistor of (200 X V) ohms where V is the measured line voltage. Test equipment, similar to the device shown, can be used to perform this performance testing. The units typically measure line voltage and LIM and GFI currents.

As with LIM testing, the effectiveness of the grounding system in patient care areas shall also be monitored through testing by voltage and impedance measurement for new construction and following system modification. The measurement accuracy should be at least +/- 20 percent. The voltage measurements shall be made under no-fault conditions between a ground reference point and various exposed conductive surfaces. The impedance measurements shall be made between a ground reference point and at least 10 percent of associated receptacles. The impedance measurement is determined using the ratio of the voltage measured and current applied between the associated measurement points.

Receptacles in patient care areas are required to be tested for physical integrity, polarity, continuity of the grounding circuit, and grounding blade retention force (not less than 4 oz.). Receptacle testing shall be performed at least annually.

In conclusion, isolated power systems are used extensively within the healthcare industry. Most of these system applications are part of the essential electrical system within the facility. Due to their unique design and implementation requirements, isolated power systems have very specific maintenance and testing requirements. Specifically, acceptance testing and periodic maintenance testing should be performed for the associated LIM device, the grounding portion of the system, and the associated receptacles.

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