How Secure Power Solutions Support Healthcare Facility Infrastructure Stability and Safety

by Hans Luppens

Executive summary

Healthcare enterprises must meet a dual objective: provide excellent patient care while ensuring a productive, always-on facility. Within the context of standards and compliance, this white paper will explain the role of secure power in a healthcare facility's critical care processes, both medical and nonmedical. The paper will also discuss how healthcare facilities can achieve energy efficiency for improved performance and financial savings via integrated systems.

998-2095-07-28-15AR0

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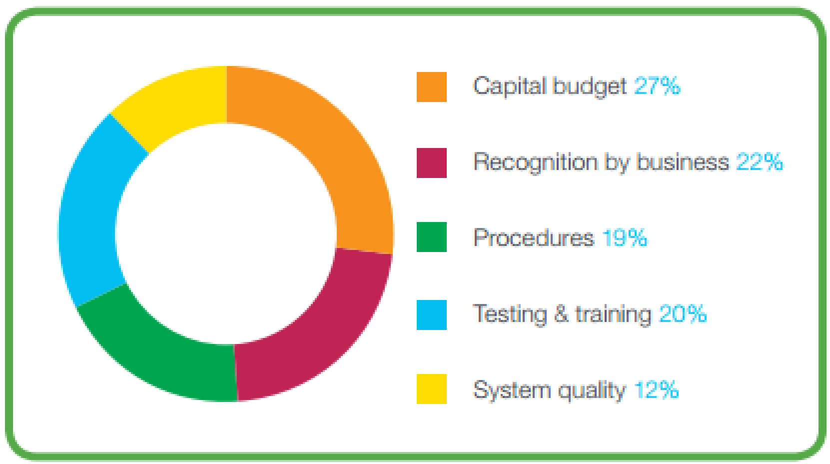
Introduction

The driving force for today's healthcare providers is twofold: to provide the highest level of patient care, while ensuring reliable performance of a facility's infrastructure throughout its lifecycle – both at the best possible cost.

A basic element involved in meeting these objectives is secure power, or power reliability. For instance, when a 200-bed hospital experiences a power outage and its backup generator solution fails, the cost is $1 million – or $5 million for a 500-bed hospital.

Delivering critical care to patients depends upon uninterrupted power. Areas such as operating rooms, emergency departments, and intensive care units require constant power to stabilize and treat critically ill people. Hospitals also must meet strict regulatory requirements related to keeping the power infrastructure compliant, which creates challenges such as capital budget allocation, stakeholder acknowledgment of the importance of secure power to patient safety and health, and the need for continuous testing and training (see **Figure 1**).

Figure 1
Power reliability compliance challenges for healthcare facilities by category



Managing a healthcare facility's data stream is equally important. It's expected that in the coming years, 30% of global data center space will be used for health-related data. Each year, hundreds of thousands of people die or suffer adverse effects as a result of inaccurate or incomplete medical records that can mislead a diagnosis and affect testing and treatment. Integrated and improved IT solutions can potentially cut this number in half by enabling more accurate and accessible medical records that can support the right medical decisions.

Within the context of standards and compliance, this paper will explain the role of secure power in a healthcare facility's critical care processes, both medical and nonmedical. The paper will also discuss how healthcare facilities can achieve energy efficiency and savings via integrated systems.

Critical role of power availability

Keeping in mind the top missions of a healthcare facility – cost-effective patient care, patient comfort and safety, and infrastructure performance – the need for 24/7 power availability and quality is clear. Since even a momentary power failure can have serious consequences for patients, secure power is basic to a healthcare facility's processes, which comprise two basic categories:

- **Critical medical processes** within a healthcare facility carry the highest risk in terms of a power outage. Operating rooms, emergency departments, and intensive care units rely upon commercial loads (computers and servers) and industrial loads (medical gas systems and scanners), all of which require continuous power quality.

- **Critical nonmedical processes** involve management of patient data systems. Rather than the manual, paper recordkeeping of the past decades, patient records are now digitized. This makes it essential for medical staff to have consistent, quick access to the IT system and also requires reliable power for backup procedures and archiving. For the data center that supports the medical records system, white space infrastructure, rack system, security, IT management software – and critical power and cooling – are basic to supporting nonmedical processes.

Patient care availability links directly to power availability, which is vital for these critical processes.

Standards for electrical installation

To protect patients, national and international standards exist that guide healthcare organizations in managing power solutions. As a result, hospitals must meet strict regulations in terms of tolerances for power interruptions to critical procedures and medical care zones, which further complicate the task of ensuring power availability.

IEC standard: Medical locations and critical power levels

Each country has its own installation standard, but in most cases, standards are based on the International Electro-Technical Commission (IEC), which clearly defines critical applications within healthcare facilities. Electrical installation for buildings is standardized by IEC Bulletin 60364-7-710. This document defines healthcare facilities as medical locations:

> "These requirements mainly refer to hospitals, private clinics medical and dental practices, healthcare centers, and dedicated medical rooms in the workplace. Medical locations are intended for purposes of diagnosis, treatment, monitoring and care of patients."

(See **Appendix A** for a listing of medical locations.)

IEC defines three critical levels and maximum duration times for power supply downtime. The tolerance depends on the power architecture of the healthcare facility and whether a generator is covering the critical areas. It takes a generator set approximately 30 seconds to fully power up, so a critical power system such as an uninterruptible power supply (UPS) must bridge the time between power outage and generator launch for critical levels 1 and 2. The endurance time is the minimum time needed to cover the power outage.

These critical levels and endurance times are shown in **Table 1**.

Table 1
IEC critical power supply levels and duration allowances

Criticality level	Continuity of service requirement	Maximum duration for power cut and switching to a backup power source	Minimum endurance of backup source
1	Permanent power supply	≤ 0.5 s	3 h
2	Brief interruption	≤ 15 s	24 h
3	Long interruption	> 15 s	24 h

All medical locations within healthcare facilities have been assigned to a critical level as shown in **Table 2**. A UPS is mandatory for any critical loads designated as critical level 1 or 2, where a patient's life is compromised by a power outage.

Table 2
IEC critical levels According to critical application

Application of criticality level to building care department and utilities		Criticality 1 ≤ 0.5s	Criticality 2 ≤ 15s	Criticality 3 > 15s
Technical installation	Operating theaters	X		
	Obstetrics	X		
	Intensive care	X		
	Emergency ward	X		
Hospitalisation	Attentive care	X		
	Intensive care	X	X	
	Standard care			
Medical imaging		X (A)	X	X
Administration		X (B)	X	X
Laboratories		X (C)		X
Pharmacy				X
Equipment rooms	Elevator			X
	Medical air conditioning			X
	HVAC			X
	Cold room			X
	Automation systems	X		
Fire safety	Detection	X		
	Smoke extraction + obstetrics	X		

(A): Computer and monitoring equipment
(B): Information technology equipment
(C): Automated analysis equipment

NFPA standard: Essential branches and medical locations

In the U.S., the standard is defined by the NFPA 99 which sets the performance requirements for healthcare facilities and NFPA 70 (NEC 517) which sets the installation requirements for the essential electrical system. The new editions of NFPA 99 and NFPA 70 divide the essential electrical system into three branches: life safety, critical care, and equipment. These three branches of criticality are defined, as shown in **Table 3**. In each case, a generator set is required to assume power supply in case of power outage. Since a generator set cannot power up instantaneously, a UPS source is often built into designs in order to assume power supply for the two higher critical loads.

Table 3
NFPA essential branches

Essential Branches	Continuity of service requirement	Maximum duration of power outage to load	Minimum duration of backup source
Life Safety	Diesel fuel Engine Gen	≤ 10 sec	72 h
Critical	Diesel fuel Engine Gen	≤ 10 sec	72 h
Equipment	Diesel fuel Engine Gen	≤ 10 sec	72 h

Table 4 shows the three NFPA essential branches and all healthcare applications (see **Appendix B** in the back of this paper for more detailed annotation of this table)

Table 4
NFPA essential branches according to critical applications

Application of criticality level to building critical care department and utilities		1 ≤ 10 sec Life safety	2 ≤ 10 sec Critical	3 ≤ 10 sec Equipment
Technical Installation	Technical operating theatres	X		
	Obstetrics (delivery room)	X		
	Anaesthetics room	X		
	Intensive care	X		
	Intensive monitoring room	X		
	Emergency ward	X		
Hospitalization	Attentive care			X
	Ward general			X
Other Rooms	ECG,EEG,EMG room		X	
	Endoscopic room		X	
	Examination room		X	
	Labour room		X	
	Renal		X	
	Central monitoring room		X	
	Nursery rooms			X
Laboratories	Diagnostics		X	
	Blood bank refrigerators			X
Medical Imaging	Heart catheterization rooms		X	
	Angiographic laboratories		X	
	Coronary care units		X	
Equipment	Nurse call			X
Equipment Rooms	Communication systems		X	
	Elevators			X

A power outage should affect loads for only 10 seconds or less. A generator set should be integrated to assume power supply during power outage. Life Safety and Critical Branches, known as the “original emergency system” in the NEC Article 517, should be secured by a UPS.

AS/NSZ standards: Medical locations and critical power levels

In Australia and New Zealand, standards are defined by the Joint Standards Committee. The purpose of this standard is to specify special requirements for electrical installations in patient areas for defined critical levels, as shown in **Table 5**. A UPS is mandatory for both critical levels 1 and 2 to deliver power during the 30 seconds it takes for a generator set to power up.

Table 5
AS/NZS critical levels

Criticality level	Continuity of service requirement	Maximum duration for power cut and switching to a backup power source	Minimum endurance with battery	Minimum endurance with generator
1	Instantaneous power supply	< 1 s	4 h	120 min
2	Vital	< 30 s	4 h	120 min
3	Delayed vital	> 2 min	4 h	120 min

Table 6 shows critical levels according to healthcare application loads. Medical loads are assigned to "Vital" or "Delayed Vital" levels ("Vital" meaning power supplied within 30 seconds and "Delayed Vital" meaning power supplied within 2 minutes). For critical level 1, specifiers or consultants must determine which medical locations will be assigned and designed with an instantaneous power supply system.

Table 6
AS/NZS critical levels according to locations loads

Application of criticality level to building Critical care department and utilities		1 < 1.0 sec Instantaneous Power Supply	2 < 30 sec Vital	3 > 2 min Delayed Vital
Technical installation	Technical operating theatres		X	
	Obstetrics (Delivery Room)		X	
	Anaesthetics room		X	
	Intensive care		X	
	Intensive Monitoring Room		X	
	Emergency ward		X	
Hospitalization	Attentive care			X
	Ward general			X
Other Rooms	ECG,EEG,EMG Room		X	
	Endoscopic room		X	
	Examination Room		X	
	Labour Room		X	
	Renal		X	
	Central Monitoring Room		X	
	Nursery Rooms			X
Laboratories	Diagnostics		X	
	Blood bank refrigerators			X
Medical Imaging	Heart Catherization Rooms		X	
	Angiografic laboratories		X	
	Coronary care Units		X	
Equipment	Nurse call			X
Equipment Rooms	Communication Systems		X	
	Elevators			X

Integrating secure power with facility systems

Secure power is mandatory for running a healthcare facility's systems, but energy efficiency is also a factor. On average, 75% of a hospital's energy usage stems from lighting, heating, cooling and ventilation, and hot water heating.

Building energy management systems can boost energy efficiency for a facility through such measures as:

- Integrated variable speed drives
- Power metering
- Load management
- Retro-commissioning and audits
- Greenhouse gas monitoring

Hospitals today handle a myriad of patient data each day – such as registrations, examination reports, test results, images, billing, and communication with insurance firms. The efficiency of this workflow relies upon the capability of a facility's IT solution and data center. Modular, scalable data centers can help hospitals address their growing needs for data processing while improving system reliability and optimizing energy efficiency.

Hospitals also have a growing need for security solutions to protect patients and staff. Systems such as access control, video cameras, alarm systems and improved training offer peace of mind to a facility and its occupants.

By integrating power distribution with building and security systems, healthcare facilities can realize savings that can help improve financial performance while protecting and better serving patients.

Conclusion

Power reliability and quality is vital to maintaining the infrastructure and operations of a healthcare facility. Both medical and nonmedical critical processes rely upon a stable power system to serve patients without fail.

In light of potential life-threatening healthcare consequences, hospitals must adhere to strict standards and regulations for electrical installations and in how they conduct patient care involving power and electrical applications.

Designing or retrofitting integrated solutions for healthcare facilities – connecting power distribution, building management, IT, and security – can aid healthcare enterprises in achieving their objectives for superior patient care and satisfaction, a safe environment for patients and staff, positive financial performance, and long-term productivity.

About the author

Hans Luppens is the Global Business Development Manager for Industrial Solutions for Critical Power for Schneider Electric, specializing in the healthcare, water/wastewater, and airport segments. He has participated as an event speaker in many sessions, covering critical power infrastructures in buildings, industry and transportation, and he contributes to the Schneider Electric blog site. Hans joined Schneider Electric 15 years ago and previously worked for Phillips Medical Systems in a global capacity. He holds a B.Sc degree in telecommunication engineering from the HTS Haarlem in Holland and a master's degree in marketing and business administration from ESMA, Barcelona, Spain.

References

Information on electrical standards is available in the following references:

- IEC 60364-7-710: Requirements for special installations or locations – Medical locations
- IEC 60364-4-41: Protection for safety - Protection against electric shock
- IEC 60601-1: Medical electrical equipment - General requirements for safety
- IEC 60601-1-1: Medical electrical equipment - General requirements for safety - Collateral standard: Safety requirements for medical electrical systems
- IEC TS 60379: Effects of current on human beings and livestock - General aspects
- NFPA 70: National Electrical Code - Article 517 Health Care facilities
- NFPA 99: Standard for Heath Care Facilities - Chapter 6 Electrical systems
- NFPA 99: Standard for Heath Care Facilities - Chapter 10 Electrical equipment
- UL 2601-1: Underwriters laboratories - Medical & dental equipment
- CAN/CSA-C22.2: Canadian standard association – Industrial control equipment
- AS/NZS 3003: Australia/New Zealand Standard - Electrical installations – Patient Areas
- AS/NZS 2500: Australia/New Zealand Standard - Guide to the safe use of electricity in patient care
- AS/NZS 3009: Australia/New Zealand Standard - Electrical installations – Emergency power supply in hospitals
- AS/NZS 3200.1: Australia/New Zealand Standard - Medical electrical equipment – General requirements for safety
- JIS-T 601-1: Medical electrical equipment - General requirements for safety

Appendix A

Table 7
IEC groups according to medical location

Medical location	Group 0	Group 1	Group 2
1. Massage room	X	X	
2. Bedrooms		X	
3. Delivery room		X	
4. ECG, EEG, EHG room		X	
5. Endoscopic room		X	
6. Examination or treatment room		X	
7. Urology room		X	
8. Radiological diagnostic and therapy room, other than mentioned under 21		X	
9. Hydrotherapy room		X	
10. Physiotherapy room		X	
11. Anesthetic room			X
12. Operating theatre			X
13. Operating preparation room		X	X
14. Operating plaster room		X	X
15. Operating recovery room		X	X
16. Heart catheterization room			X
17. Intensive care room			X
18. Angiographic examination room			X
19. Haemodialysis room		X	
20. Magnetic resonance imaging (MRI) room		X	
21. Nuclear medicine		X	
22. Premature baby room			X

Appendix B

(Annotations to Table 4)

In reference to criticality level 3: Standard permits delayed automatic transfer to alternate source.

6.4.2.2.3.2 The life safety branch shall supply power for lighting, receptacles, and equipment as follows:

1. Illumination of means of egress in accordance with NFPA 101, Life Safety Code
2. Exit signs and exit directional signs in accordance with NFPA 101, Life Safety Code
3. *Hospital communications systems, where used for issuing instruction during emergency conditions
4. Generator set location as follows:
    a. Task illumination
    b. Battery charger for emergency battery-powered lighting unit(s)
    c. Select receptacles at the generator set location and essential electrical system transfer switch locations
5. Elevator cab lighting, control, communications, and signal systems
6. Electrically powered doors used for building egress
7. Fire alarms and auxiliary functions of fire alarm combination systems complying with NFPA 72, National Fire Alarm and Signaling Code

6.4.2.2.4.2 The critical branch shall supply power for task illumination, fixed equipment, select receptacles, and select power circuits serving the following areas and functions related to patient care:

1. Critical care areas that utilize anesthetizing gases, task illumination, select receptacles, and fixed equipment
2. Isolated power systems in special environments
3. Task illumination and select receptacles in the following:
    (a) Patient care rooms, including infant nurseries, selected acute nursing areas, psychiatric bed areas (omit receptacles), and ward treatment rooms
    (b) Medication preparation areas
    (c) Pharmacy dispensing areas
    (d) Nurses' stations (unless adequately lighted by corridor luminaires)
4. Additional specialized patient care task illumination and receptacles, where needed
5. Nurse call systems
6. Blood, bone, and tissue banks
7. *Telephone equipment rooms and closets

8. Task illumination, select receptacles, and select power circuits for the following areas:
    (a) General care beds with at least one duplex receptacle per patient bedroom, and task illumination as required by the governing body of the health care facility
    (b) Angiographic labs
    (c) Cardiac catheterization labs
    (d) Coronary care units
    (e) Hemodialysis rooms or areas
    (f) Emergency room treatment areas (select)
    (g) Human physiology labs
    (h) Intensive care units
    (i) Postoperative recovery rooms (select)
9. Additional task illumination, receptacles, and select power circuits needed for effective facility operation, including single-phase fractional horsepower motors, which are permitted to be connected to the critical branch

6.4.2.2.5.3* Equipment for Delayed-Automatic Connection.
(A) The following equipment shall be permitted to be arranged for delayed-automatic connection to the alternate power source:
(1) Central suction systems serving medical and surgical functions, including controls, with such suction systems permitted to be placed on the critical branch

(2) Sump pumps and other equipment required to operate for the safety of major apparatus, including associated control systems and alarms

(3) Compressed air systems serving medical and surgical functions, including controls, with such air systems permitted to be placed on the critical branch

(4) Smoke control and stair pressurization systems

(5) Kitchen hood supply or exhaust systems, or both, if required to operate during a fire in or under the hood

(6) Supply, return, and exhaust ventilating systems for the following:
    (a) Airborne infectious/isolation rooms
    (b) Protective environment rooms
    (c) Exhaust fans for laboratory fume hoods
    (d) Nuclear medicine areas where radioactive material is used
    (e) Ethylene oxide evacuation
    (f) Anesthetic evacuation

(B) Where delayed-automatic connection is not appropriate,the ventilation systems specified in 6.4.2.2.5.3(A)(6) shall be permitted to be placed on the critical branch.

6.4.2.2.5.4* Equipment for Delayed-Automatic or Manual Connection. The following equipment shall be permitted to be arranged for either delayed-automatic or manual connection to the alternate power source *(also see A.6.4.2.2.5.3)*:

(1) Heating equipment used to provide heating for operating,delivery, labor, recovery, intensive care, coronary care, nurseries, infection/isolation rooms, emergency treatment spaces, and general patient rooms; and pressure maintenance (jockey or make-up) pump(s) for water-based fire protection systems

(2)*Heating of general patient rooms during disruption of the normal source shall not be required under any of the following conditions:
    (a) Outside design temperature is higher than −6.7°C (+20°F)
    (b) Outside design temperature is lower than −6.7°C (+20°F), where a selected room(s) is provided for the needs of all confined patients [then only such room(s) need be heated].

(3) Elevator(s) selected to provide service to patient, surgical, obstetrical, and ground floors during interruption of normal power

(4) Supply, return, and exhaust ventilating systems for surgical and obstetrical delivery suites, intensive care, coronary care, nurseries, and emergency treatment spaces

(5) Hyperbaric facilities

(6) Hypobaric facilities

(7) Autoclaving equipment, which is permitted to be arranged for either automatic or manual connection to the alternate source

(8) Controls for equipment listed in 6.4.2.2.4

(9)*Other selected equipment