Electrical Installation for hospitals

Ir Eric C. L. Lee

Electrical and Mechanical Services Department
1. Health Technical Memorandum (HTM) 06 Electrical Services

- Published by UK Department of Health
- Provides guidance for design, installation and operation of electrical services in healthcare premise
- Aligns with BS standards e.g. BS 7671 (Wiring), BS 5266 (Emergency lighting)

- HTM 06 includes:
  - HTM 06-01 Electrical services supply and distribution
  - HTM 06-02 Electrical safety guidance for low voltage systems
  - HTM 06-03 Electrical safety guidance for high voltage systems in healthcare premises

2. HTM 06-01 Risk Management Approach

▷ Design of electrical services based on risk of loss of supply

▷ Risk Assessment Process

- Identify Risk of Loss of supply
- Establish Risk Grading System
- Determine Facility Area / Zone Risk grading
- Evaluate Resilience Needed
- Design Distribution Strategy
Risk Management Approach

Risk grading example

<table>
<thead>
<tr>
<th>Clinical Services</th>
<th>Risk due to Loss of Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>A – Life support / Complex Surgery</td>
<td>Threat to life</td>
</tr>
<tr>
<td>B – Complex treatment and diagnostics</td>
<td>Clinical treatment and patient safety may be compromised</td>
</tr>
<tr>
<td>C - General Patient Care</td>
<td>Clinical treatment and patient safety not immediately compromised</td>
</tr>
<tr>
<td>D – Ambulant Care</td>
<td>Disruption, inconvenience and reduced environmental quality</td>
</tr>
<tr>
<td>E – Support services and circulation</td>
<td>No immediate effect on clinical treatment or safety of patients</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Business Continuity Services</th>
<th>Risk due to Loss of Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>I – Medical support services</td>
<td>Treatment or welfare of patient disrupted</td>
</tr>
<tr>
<td>II – Building Services and environmental control</td>
<td>Treatment or welfare of patients compromised</td>
</tr>
<tr>
<td>III – Building services safety and security</td>
<td>Safety and welfare of patients compromised</td>
</tr>
<tr>
<td>IV – Business support services</td>
<td>Treatment or welfare of patient not immediately compromise</td>
</tr>
</tbody>
</table>
Risk Management Approach

Note: the risk grading system A–E and I–IV is only used as a guide and may differ for each project depending on risk assessment.

Source: Extracted from HTM 06-01, 2017 edition

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3. TYPICAL ELECTRICAL SYSTEM INFRASTRUCTURE

- **Primary Electrical Infrastructure (PEI):** Supplies from Power companies (HV / LV)

- **Secondary Power Supply (SPS):**
  - Standby Generators
  - CHP systems

- **Tertiary Power Supply (TPS):**
  - Static UPS
  - Rotary UPS
  - Battery packs
System design considerations

Diversity Factor
• Diversity of services and departments vary differently
• Should assess each service and department for a site-wide normalised diversity

Access for Maintenance
• Minimise disruption caused by maintenance
• Should not compromise space and access of other services (e.g. HVAC, steam system, medical gas system, etc.), and occupational safety of maintenance personnel

Growth and Change
• Spare transformer capacity for future expansion
• Spare space in distribution board for retrofitting
4. POWER QUALITY

Harmonics

- Caused by nonlinear loads (e.g. electronic equipment)
- Could cause overheating of cables and transformers
- Mitigated by installation of Harmonic filters in electrical distribution system

Total Harmonic Distortion (THD) Requirements

- HTM06-01 for hospitals:
  - 5% max. for voltage up to 0.4 kV
  - 4% max. for voltage up to 11 kV
- Building Energy Code (BEC) - Table 7.6.2
4. POWER QUALITY

Transient voltage and currents

- Short duration of abnormal voltage or current
  - Voltage surge/spike
    - Caused by lightning or switching event
    - Mitigated by surge protection devices
  - Voltage dip
    - Could cause voltage sensitive devices to malfunction
    - Mitigated by installation of UPS or voltage dip ride-through devices
5. DISTRIBUTION STRATEGY

Primary supply configuration (i)

Typical Configurations:
Primary and partial secondary LV supply

▷ introduces secondary supply (typically standby generator) to support part of network

Note:
LV incoming supply – minimal resilience achieved by grade D areas. Grade C area has partial secondary support from a generator with the ability (by manual switching) to be fully supported if a suitably rated generator is available.

Figure 11 Primary and partial secondary LV supply – single cable with partial primary/secondary distribution

Source: Extracted from HTM 06-01, 2017 edition
5. DISTRIBUTION STRATEGY

Primary supply configuration (ii)

Typical Configurations:
Dual-primary and dual-secondary LV supply

▷ with single-cable and
▷ with dual-cable infrastructure (auto-changeover) distribution for area of higher risk
5. DISTRIBUTION STRATEGY

Secondary Supply

- Typically **standby generator set** – AC generator driven by diesel engine
- **N+1 configuration** – two generators each capable of full load or three generators each capable of 50% load

Source: Extracted from HTM 06-01, 2017 edition
5. DISTRIBUTION STRATEGY

Secondary Supply

- Point for plugin mobile generator facilitates further emergency support on generator breakdown / planned maintenance

Source: Extracted from HTM 06-01, 2017 edition
5. DISTRIBUTION STRATEGY

Secondary Supply

Diesel fuel supply and storage

❖ Dangerous Goods Ordinance

▷ Day tank
  • Diesel fed to generator by gravity
  • Capacity of 10 hours full load operation

▷ Bulk/Main tank
  • Diesel pumped to day tank
  • Capacity of 200 hours full load operation

Source: Extracted from HTM 06-01, 2017 edition
5. DISTRIBUTION STRATEGY

Tertiary Supply
Uninterruptible power supply (UPS) system

▷ Single-conversion UPS
  • Battery autonomy up to 15 min.
  • used to safely shut down small computer equipment

▷ Double-conversion UPS
  • Battery autonomy ranges from 1 to 3 hours
  • Typically used for final circuits in high risk grade area (e.g. OT or ICU of grade A or B)
UPS N+1 resilience
  • Grouping multiple UPS units for single location
  • Redundant UPS units each capable of supporting full load with auto-changeover

Source: Extracted from HTM 06-01, 2017 edition
5. DISTRIBUTION STRATEGY

Tertiary Supply
UPS system

▷ Maintenance bypass
▷ UPS room condition
  • Temperature and humidity control
  • Dust control
  • Avoid proximity to wet service
  • Arrangement of battery storage facilitating sufficient ventilation

6. Other design considerations

Electromagnetic compatibility (EMC):
• Prevent interference with medical equipment

Earthing:
• System earth for protection
• Functional earth for electronic and IT equipment

Protection Discrimination:
• Protective devices coordinated to isolate fault
• Minimise services affected in case of electrical fault

Future maintainability and operability:
• Eliminate single point of failure
• Allow partial system shutdown for maintenance / PITC without affecting hospital operation
7. Operation and maintenance

▷ In compliance of requirements

- Trade practices
- Manufacturers’ recommendation
- Guidelines & Standards (HTM 06, BS 7671, etc.)
- Statutory Requirements
7. Operation and maintenance

Preventive maintenance of critical equipment

- **Emergency generators**
  - On-load test using building load
  - Test function of interlocks and changeover

- **UPS batteries**
  - On load Discharge test
  - Test for batteries health status

- **Switchboard**
  - Test proper function of components (e.g. protective relays, etc.)
  - Test for insulation and continuity
  - Condition monitoring
7. Operation and maintenance

**Power quality and energy monitoring**

- Monitoring power supply condition and energy consumption with energy management system and devices
- Identify energy saving opportunities

**Maintenance record keeping**

- Keep track of equipment conditions
- Complete record of past adjustment, inspection and test results
- Maintenance schedule, replacement and resource planning
Thank You