Medical Locations & Healthcare Electrics
Part 2
Richard Knight
C Eng. MCIBSE, FIHEEM
Village Hotel, Coryton, Cardiff
Wednesday 7th November 2018

Medical Locations & Healthcare Electrics
Part 1
Richard Knight
C Eng. MCIBSE, FIHEEM
Village Hotel, Coryton, Cardiff
Monday 6th March 2017

Emergency Isolation Room
Paediatric Isolation Room
Paediatric HDU

Patient Monitor

HTM 06-01, 'Electrical services supply and distribution': 2017

Description of systems, objectives and method of working, resilient electrical systems

Safety issues, resilience and review of guidance and developments
Why resilience?

Risk categorisation:
• Medical risk
• Business risk

The HTM splits these into:
• Medical risk categories
• Business risk categories

Giving rise differing levels of Resilient systems

Introduction

• Over the years the reliance of the patient on our electrical supplies and installation have changed
• NHS guidance has largely kept up with these changes HTM 7, 11 etc in the early 1960s, 70s, HTM 2007, 2011 etc in the 1990s
• And now HTM 06 series in 2006/7 and now 2017
• The patient and business needs are now quite different

Introduction

• Patients are now routinely on life support of one form or another even in the most ordinary of wards; compared to the 1970 there is just no comparison with the electrical equipment used to support patients in CCUs and theatres......
• The current HTM series acknowledges these issues, this will need considerable fortification of our electrical infrastructure

Risk categorisation

• Resilient and robust electrical services should only be installed where there is a medical risk to the patients, hence “clinical Risk”
• Like wise for operational risk no less important hence “business risk”

Clinical risk “Risk grade”

Non Clinical and Business continuity risk “Risk grade”
Risk Grade E
Support service circulation

The non patient environment.

These areas include:
• circulation spaces,
• waiting areas,
• offices and
• non-patient care areas such as laboratories.

Consequently, engineering services do not have an immediate effect on the clinical treatment or safety of patients.

Risk grade D –
Ambulant care and diagnostics

These do not directly relate to the patient environment.
These areas may include:
• patients in consultation (excluding examination) or
• general out-patient areas.

Loss of supply may give rise to disruption, inconvenience and a reduced environmental quality but would not directly compromise patient clinical treatment and safety.

Risk grade C –
General patient care

Patient not connected to ME equipment for > 24 hours.
The procedures include:
• electrocardiogram or
• ultrasound.

Likely to be Group 1 location where applied parts intended to be used externally and internally if no life risk
Generation <15s

Risk grade B –
Patients in special medical locations

These areas may include:
• LDRP (labour, delivery, recovery, post-partum) areas (maternity),
• endoscopy rooms,
• accident and emergency general/minors,
• haemodialysis areas,
• ECG areas,
• nuclear medicine,
• radiography diagnostic,
• magnetic resonance imaging (MRI),
• endoscopic examination rooms,
• urology treatment areas, or
• therapy rooms and ultrasound.

Likely to be Group 1 location where applied parts intended to be used externally and internally if no life risk, but group 2 for any life support

Risk grade B –
Patients in special medical locations

Patients may have electro-medical equipment, medical monitoring or medical test equipment connected externally to their body for a prolonged period.

Clinical treatment and patient safety may be compromised (but not endangered) by any interruption of electrical supply.

Electrical protective devices likely include an RCD, but may not require an UPS, IPS circuits.

This by inference includes Dental in 17th Ed 716.415.2.1

Seen this in your high street Dentist?!
Risk grade A – Life support or complex surgery
Patient environment of group “2” IET GN7, if life support.
The areas are defined as:
- operating theatre suites,
- critical care areas,
- cardiac wards,
- catheterising rooms,
- accident & emergency resuscitation units,
- MRI,
- angiographic rooms,
- PET and CT scanner rooms.

Risk grade A – Life support or complex surgery
Patients may have electro-medical equipment, medical monitoring or medical test equipment (for example intracardiac procedures) connected externally or internally to their bodies for a prolonged period.

Clinical treatment and patient safety may be compromised by any interruption of electrical supply.

Risk grade A – Life support or complex surgery
- Requires IPS and UPS in most part
- Also requires support e.g. Generators for Support services including engineering
- Some recommendations being extended into category B areas

Electrical failure risks evaluation

HV radial network
Primary and partial secondary LV supply – single cable with partial primary/secondary distribution

Dual-primary and dual-secondary LV supply and dual infrastructure (autochange)

Don’t forget fire segregation

Dual primary and dual HV secondary supply – dual-interleaved (autochange)

From the old HTM 06-01 additional switches added to those in this older standard
HV with two network incomers (8.24, 8.30 for LV)

Note
For the 2017 publication a Possible weak link
If fire in DNO room 1 could easily take out DNO room 2 supply
The solution of fitting switches in DNO room 2 to convert bus connector into link cable has been adopted.

Main site earthing, what has this to do with resilience and the EAWR:1989?

STATUTORY INSTRUMENTS

1989 No. 635
HEALTH AND SAFETY
The Electricity at Work Regulations 1989

Came into force 1st April 1990

EaWR 1989 guidance on regulation 3
Persons on whom duties are imposed by these Regulations

Absolute/reasonably practicable
• 'reasonably practicable'. Where qualifying terms are absent the requirement in the regulation is said to be absolute.
• By definition if the clause is “absolute” the requirement must be met regardless of cost or any other consideration

Regulation 29 can give some defence, but very little

EaWR 1989 guidance on regulation 8
Earthing or other suitable precautions

(a) double insulation;
(b) earthing;
(c) connection to a common voltage reference point on the system;
(d) equipotential bonding; (e.g. ERB)
(e) use of safe voltages;
(f) earth-free non-conducting environments;
(g) current/energy limitation; and
(h) separated or isolated systems (e.g. IPS).

This regulation is “absolute”
Earthing Protection

Earthing so easy, not to be resilient

Earthing so easy to get wrong
Is it likely that one rod under a building is going to do the trick?
How would you test this with the building occupied?

Because of the soil type this required many earth spikes to be installed
12 per array!

Example of upgraded earth array

External Trench
New earth arrays
Equipotential bonds, mechanical, MCWS, Heating, Med Gas
Link to main LV panels
Link to old earth bar and old earth array
Testing of earth rods

- GN3:2015 clause 2.6.14 makes it very clear “switch off supply before disconnecting the earth” (was 2.7.13 previously)
- The GN gives two test methods for testing earth rod:
  - For RCD protected TT installations using earth loop impedance tester
  - For all other circuits using earth tester

Carry out tests in dry weather

Earth electrode test

2.6.14 recommends test spikes place at 10x depth of electrodes. So test spikes should be 48m away from 4.8m deep electrodes

Water and electricity do not mix!

Sauna

Note how isolating the earth rod from the rest of the array, splits the rest of the array.

Reinforcing the need to isolate the supply as 2.6.14 (was 2.7.13 previously)

Water and electricity do not mix!

Electrics and basements do not mix
Lessons learned

- So make it resilient and not just with flooding
- Just like all resilient engineering,
- list all the risks, in a engineering resilience risk assessment a record for all
- and that could be incorporated into the organisations estates emergency plan

Introduction

Resilient facilities are those that have the following features:

- robustness – the system or facility should be able to absorb the effects of an event and continue to operate at the required level;
- redundancy – where robustness cannot be absolutely guaranteed, it is essential to provide more than one key facility or subsystem;
- reconfigurability – the unanticipated risk is often the most devastating. To be truly resilient, a system or facility should be adaptable to cope with the effects of an unexpected event, where practicable.

Presumably “essential” A B power cubical

No sign
One fire one big problem
The loss of this will black out allot of a hospital and all critical care

UPS

“Presumably” as the small label does not say!

But how can they be tested?
Any duplex panel must be totally separate with no electrical interconnections
Presumably “essential” A B power cubical

A panel like this should not be located in a UPS room as a fire etc. in this room would not only take out the UPS fed “essential” circuits and also the “essential” A and B circuits fed by this panel!

Significant business risk and medical risk

IPS

IPS unit located remote from ICU

note location of DX unit above IPS units that are not water proof

One fire takes out the power to ALL patients

IPS Transformers and circuit protection above

Often these not labelled
Also sometimes not provided with earth reference bar (AKA GN7/MEIGaN/HTM)
again, note one bang could take out all three!

Existing G 500

Exist Clinical

Industrial

Exist Clinical

Panel

Exist Clinical

Panel

×

×

×

×

×

×

Exist Door

Exist Door

Exist Door

New G 1250

Clinical

New G 1250

Clinical

New G 1250

Clinical

×

×

×

×

×

×

Exist Door

Exist Door

Exist Door

Capacity and resilience improved works complete
**Its important to get it right**

Whilst not covered directly by HTM

Design + loose specification & poor delivery = 

Design + detailed specification & robust delivery =

---

This certainly reminded me of

"You're only supposed to blow the bloody doors off!",

as his explosives expert blows a van to smithereens.

*The Italian Job* 1969

---

**Let's look at a sample of resilience from our current (and earlier) BS 7671....**

<table>
<thead>
<tr>
<th>BS 7671 Wiring Regulations</th>
<th>BS 7671 Wiring Regulations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter 56 Safety Services (560.1)</td>
<td>Safety services include (amongst others):</td>
</tr>
<tr>
<td>Safety services include (amongst others):</td>
<td>• Emergency lighting</td>
</tr>
<tr>
<td>• Fire pumps</td>
<td>• Fire rescue service lifts</td>
</tr>
<tr>
<td>• Fire detection and alarm systems</td>
<td>• Fire evacuation systems</td>
</tr>
<tr>
<td>• CO detection and alarm systems</td>
<td>• Smoke ventilation systems</td>
</tr>
<tr>
<td>• Fire evacuation systems</td>
<td>• Fire services communication systems</td>
</tr>
<tr>
<td>• Essential medical systems</td>
<td>• Industrial safety systems</td>
</tr>
</tbody>
</table>

---

**BS 7671 Wiring Regulations**

Chapter 56 Safety Services (560.7.x)

Safety service circuits:

- Shall be independent of other circuits
  - this means any fault, maintenance or modification work must have no effect on the other (560.7.1)
- Switch gear and control gear shall be clearly identified and grouped in locations... (560.7.5)
  - Also consider how this might adversely affect resilience

---

Colour coded cabinets can be used to identify essential life safety services.
Safety service circuits:

In addition to a general schematic diagram, full details of all electrical safety sources shall be given. The information shall be maintained and displayed adjacent to the relevant distribution board.

Its also the documentation and information available in many locations (local to disaster).

Safety service circuits, a copy of the drawings to be displayed at the origin of the installation showing:

- All control equipment and DBs
- Safety equipment with particulars and purpose of the equipment
- Special warning and monitoring equipment

Safety service circuits:

- A list of all safety equipment with indicated rated currents perhaps in circuit diagrams
- Operating instructions for all equipment

Without this how could the inspector sign the EIC to say the installation complies with BS 7671

• N+1
• Performance, single and multiple sets
• How much oil!!

Operating parameters (9.58)

Multiple Generator run initiation:

- Voltage sensing/phase failure relay sense loss of supply
- Start timer to confirm not transient set to 0.5s and 6s
- Then start set(s), the set(s) must take the load within 15s of the start signal
  i.e. >15.5s<21s not 15s as (9.15) & IEC, etc

Design

- Requires 200 hours of oil storage for generating plant operating at full load (in addition to day tank) (9.81) (9.84) (16.12) and HBN 00-07
- Where combined fuel storage exists then the greater of 200 h full load for generator or 10 days peak thermal load can be taken as storage.
  (9.64) and HBN 00-07
Generator oil storage

Electrical energy usage profile

Fuel usage for 1500kVA set

<table>
<thead>
<tr>
<th>Generator Fuel Consumption (L/hr)</th>
<th>1330 kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine rating</td>
<td>3000 L of diesel</td>
</tr>
<tr>
<td>Weight of 1' of diesel</td>
<td>900 g</td>
</tr>
<tr>
<td>Load Applied % of engine rating Consumption (L/hr)</td>
<td></td>
</tr>
<tr>
<td>0.0</td>
<td>0%</td>
</tr>
<tr>
<td>332.5</td>
<td>25%</td>
</tr>
<tr>
<td>665.0</td>
<td>50%</td>
</tr>
<tr>
<td>997.5</td>
<td>75%</td>
</tr>
<tr>
<td>1330.0</td>
<td>100%</td>
</tr>
</tbody>
</table>

Hourly fuel consumptions

<table>
<thead>
<tr>
<th>Time (hh:mm)</th>
<th>05:00</th>
<th>06:00</th>
<th>07:00</th>
<th>08:00</th>
<th>09:00</th>
<th>10:00</th>
<th>11:00</th>
<th>12:00</th>
<th>13:00</th>
<th>14:00</th>
<th>15:00</th>
<th>16:00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Factor</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>% of Load</td>
<td>85%</td>
<td>85%</td>
<td>85%</td>
<td>85%</td>
<td>85%</td>
<td>85%</td>
<td>85%</td>
<td>85%</td>
<td>85%</td>
<td>85%</td>
<td>85%</td>
<td>85%</td>
</tr>
<tr>
<td>Calculated Load (L/hr)</td>
<td>351.9</td>
<td>351.9</td>
<td>351.9</td>
<td>351.9</td>
<td>351.9</td>
<td>351.9</td>
<td>351.9</td>
<td>351.9</td>
<td>351.9</td>
<td>351.9</td>
<td>351.9</td>
<td>351.9</td>
</tr>
</tbody>
</table>

So how much oil for 1000KVA Generator

- Based on actual usage aprox 20,000 Litres
- This increases to >38,000 Litres for 200 hours at full load as defined in HTM 06 (9.81) (9.84) (16.12)

Now that’s allot of fuel! (and that’s based on actual electricity usage not HTM 06/HBN 00-07)
Derogations
From HTM 00:2014

- Can we derogate?
- What is needed to successfully derogate?

HTM 00 – Policies and principles of healthcare engineering, 2014
clause 1.3

“Adhering to the guidance outlined in this Health Technical Memorandum (HTM) will be taken into account as evidence towards compliance with these legal requirements and standards.”

What does this mean?
From this DoH are saying follow the HTMs and you have followed the legal requirements, if you don’t follow HTM you won’t be following legal requirements, effectively the HTMs are ACOPs, generally follow them and you have met legal aspects.

Then in the following clause

“Where the principles of the guidance are not to be followed, organisations should document how the expectations are being met by equal and alternative means.”

What is 1.4 saying?
“documented”, equal or better route, this effectively means evidence based, research and the like, not “in my view” or “experience” as these are just words unless backed up by something substantial, not very likely as much in HTMs are evidence based.

What can the army teach us about resilient engineering?

You never know what you will find installed in that generator room?

Ex chieftain tank engine, complete with original “run to destruction button”!

As installed in a General Hospital

Defiantly an alternative solution!
What is this guy on!!

Thank you

- Richard Knight
- Mobile +44 (0) 77 949 14 211
- Email millham.orchard@tiscali.co.uk