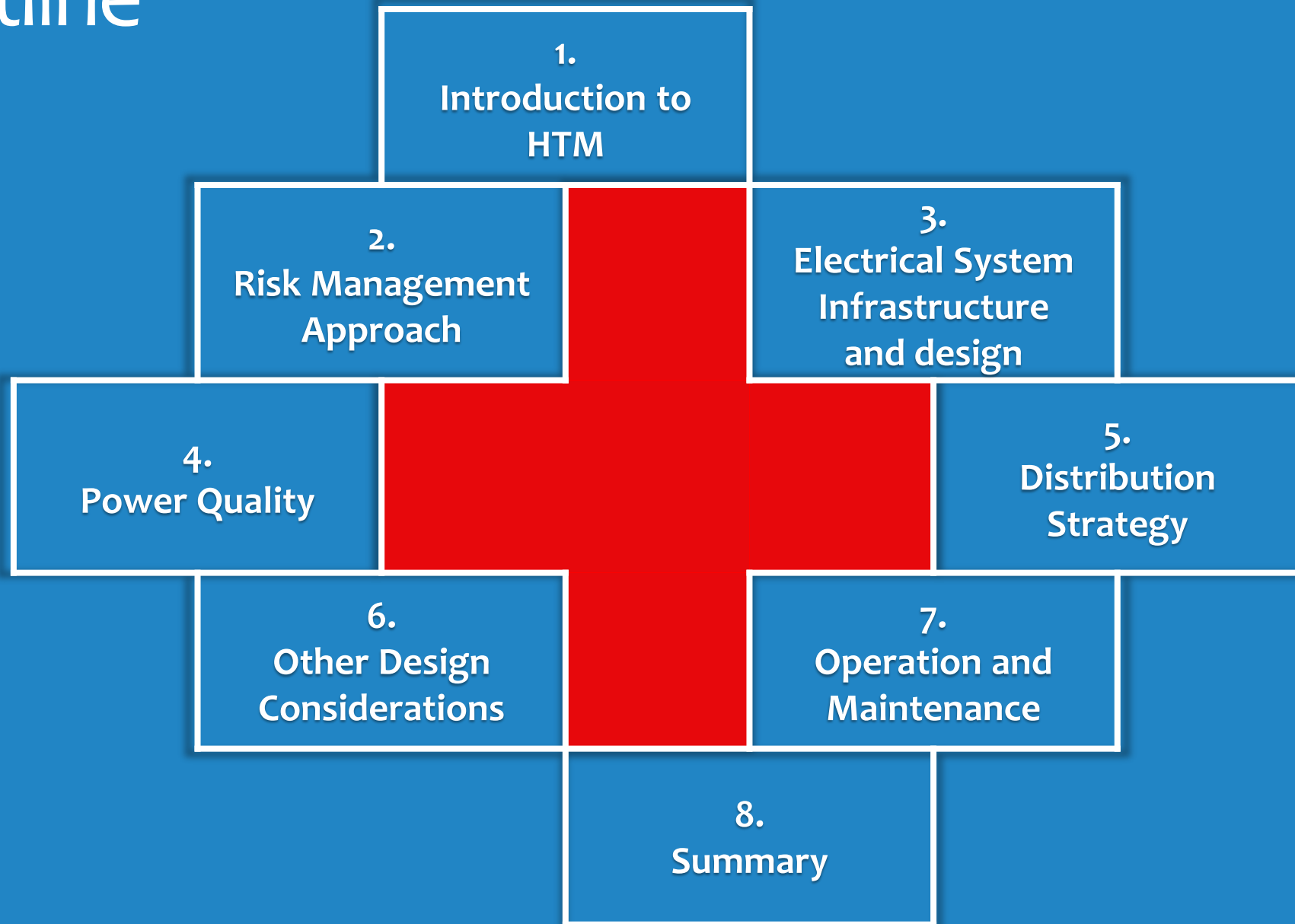


Electrical Installation for hospitals

Ir Eric C. L. Lee

Electrical and Mechanical Services Department

Outline



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



<https://www.gov.uk/government/collections/health-technical-memorandum-disinfection-and-sterilization>

2. HTM 06-01 Risk Management Approach

- ▷ Design of electrical services based on **risk of loss of supply**
- ▷ Risk Assessment Process



Risk Management Approach

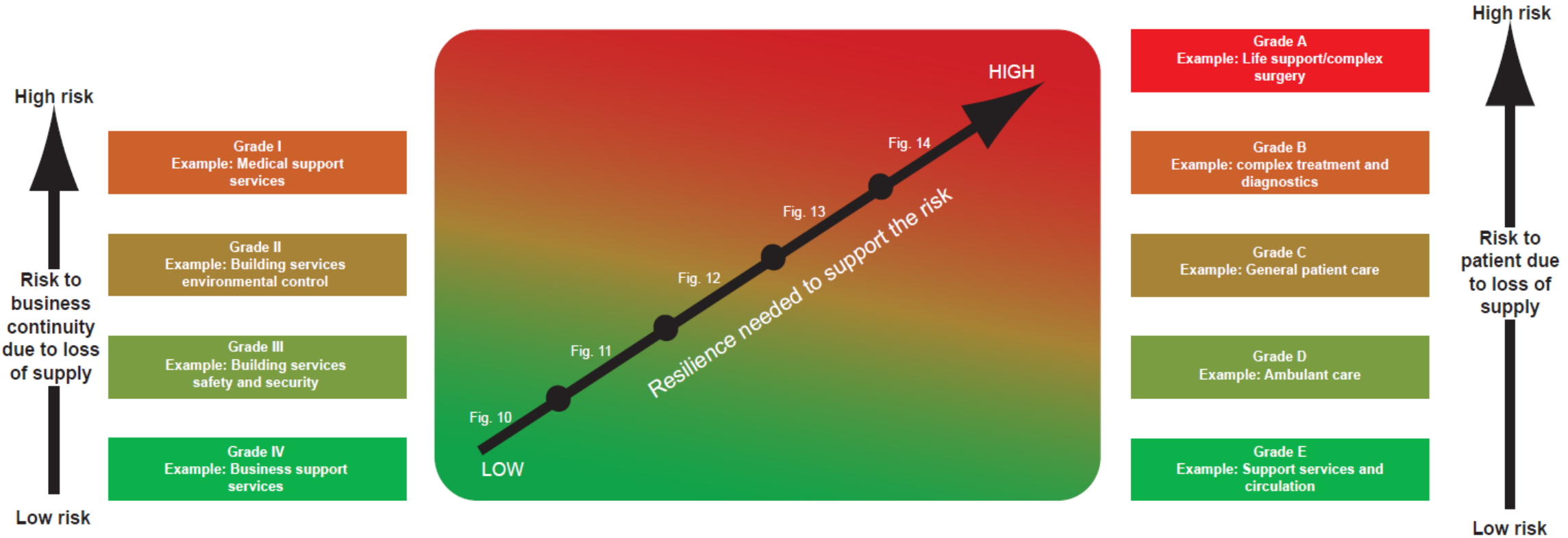
Risk grading example

Risk ↑

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

Business Continuity Services	Risk due to Loss of Supply
I – Medical support services	Treatment or welfare of patient disrupted
II – Building Services and environmental control	Treatment or welfare of patients compromised
III – Building services safety and security	Safety and welfare of patients compromised
IV – Business support services	Treatment or welfare of patient not immediately compromise

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

Figure 2 Grading of risk in relation to loss of supply

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

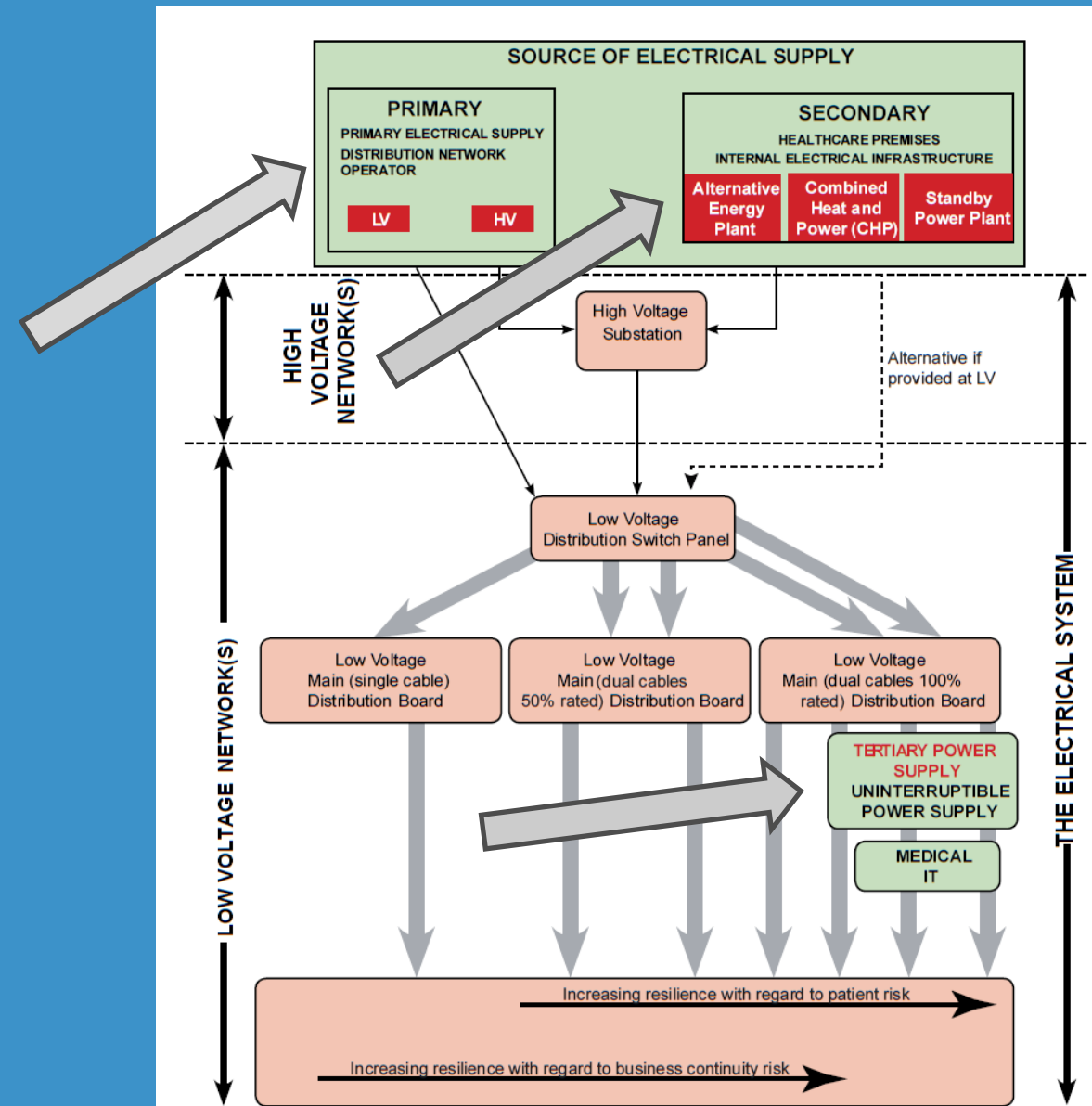


Figure 5 Electrical infrastructure generic flow diagram

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

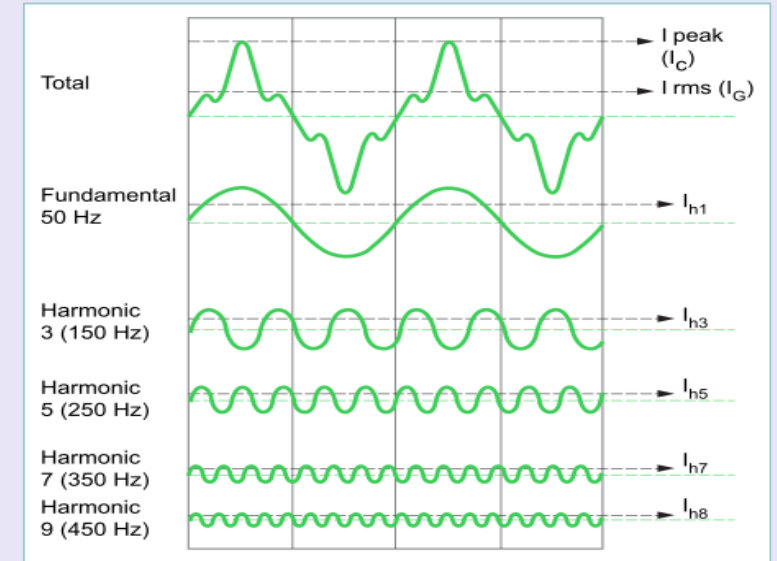
Growth and Change

- 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

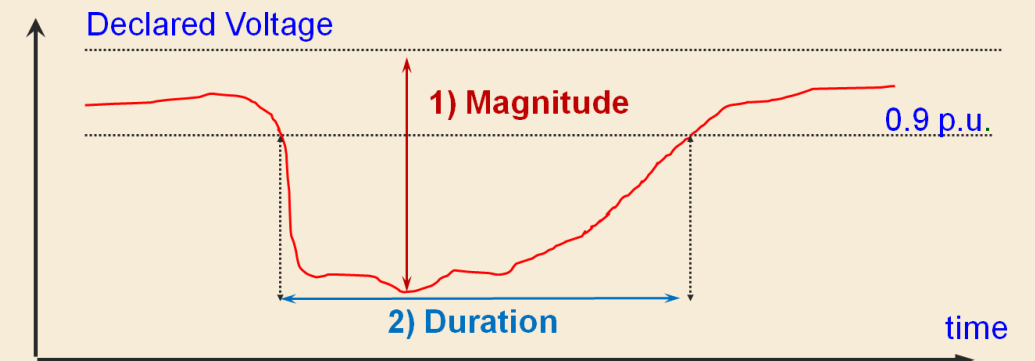
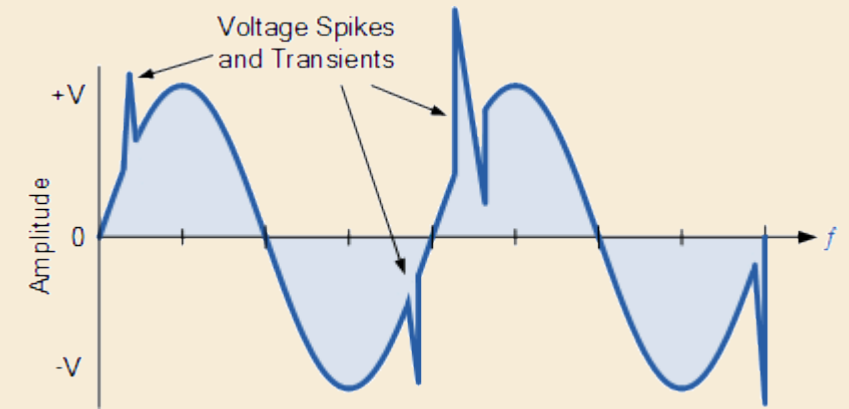
- ▷ HTM06-01 for hospitals:
 - 5% max. for voltage up to 0.4 kV
 - 4% max. for voltage up to 11 kV
- ▷ Building Energy Code (BEC) - Table 7.6.2

Table 7.6.2 : Maximum Total Harmonic Distortion of Current	
Designed Circuit Current (I, in A)	Maximum Total Harmonic Distortion (THD) in Percentage of Fundamental Current
$I < 40A$	20.0 %
$40A \leq I < 400A$	15.0 %
$400A \leq I < 800A$	12.0 %
$800A \leq I < 2000A$	8.0 %
$I \geq 2000A$	5.0 %

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



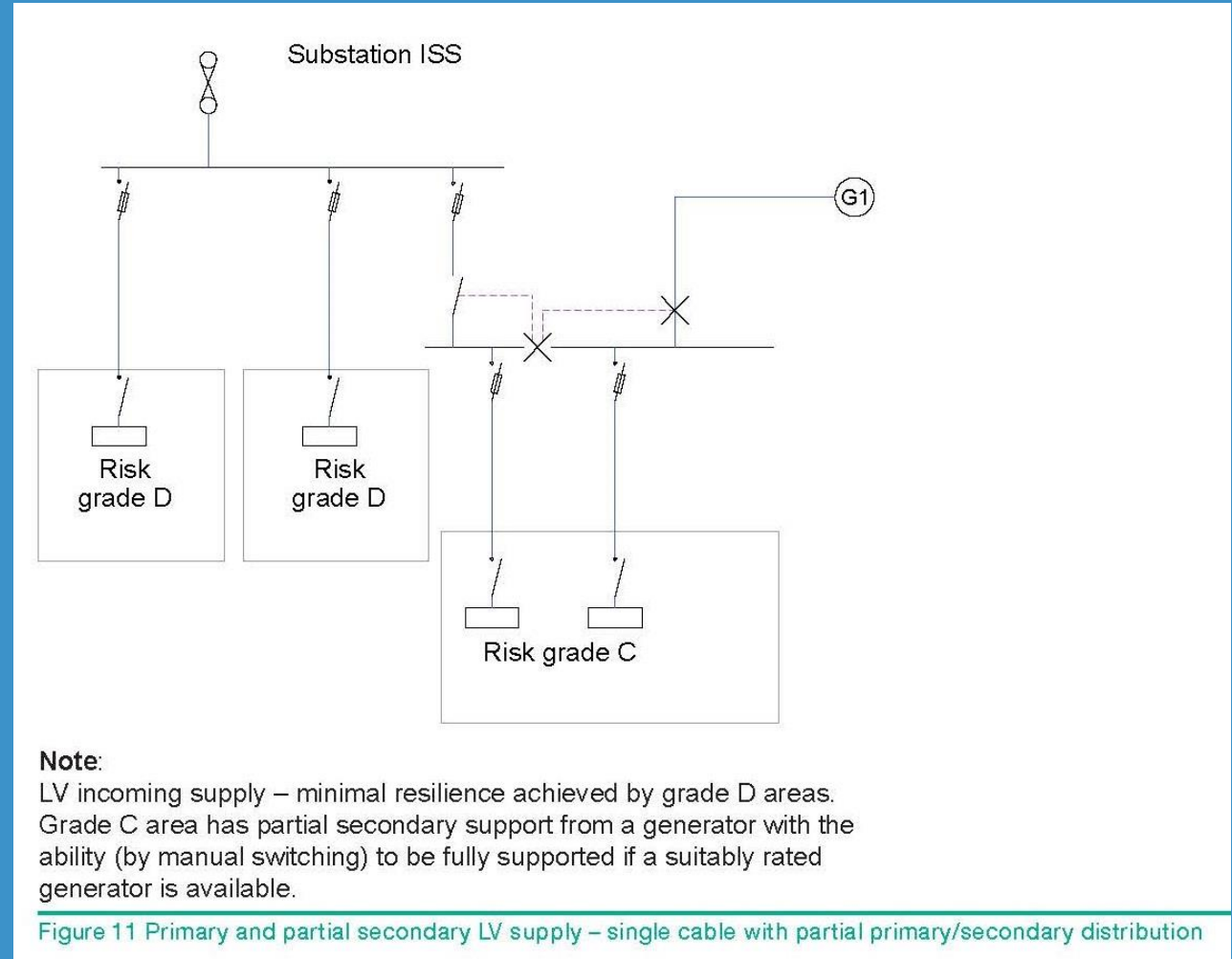
5. DISTRIBUTION STRATEGY

Primary supply configuration (i)

Typical Configurations:

Primary and partial secondary LV supply

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



Source: Extracted from HTM 06-01, 2017 edition

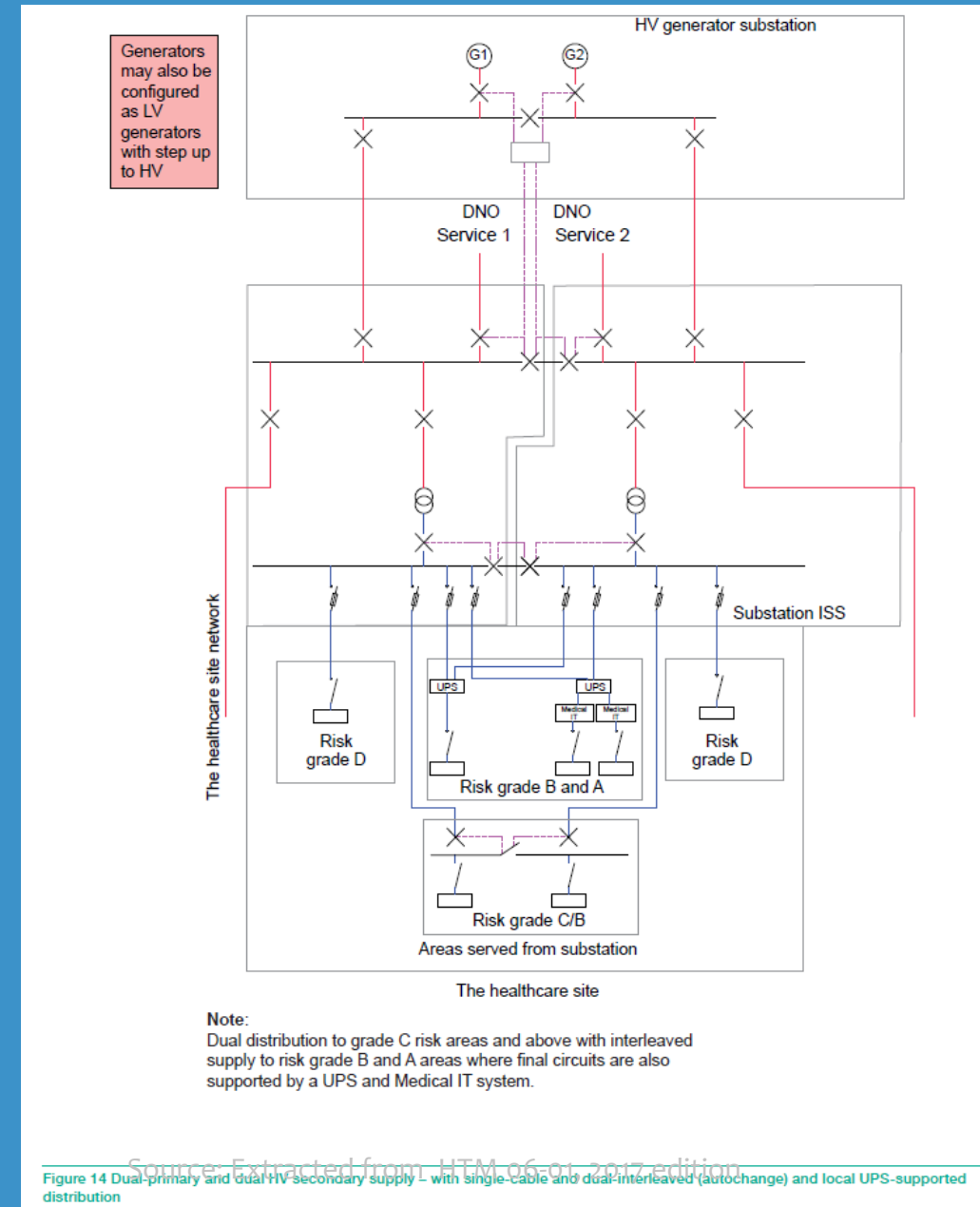
5. DISTRIBUTION STRATEGY

Primary supply configuration (ii)

Typical Configurations:

Dual-primary and dual-secondary LV supply

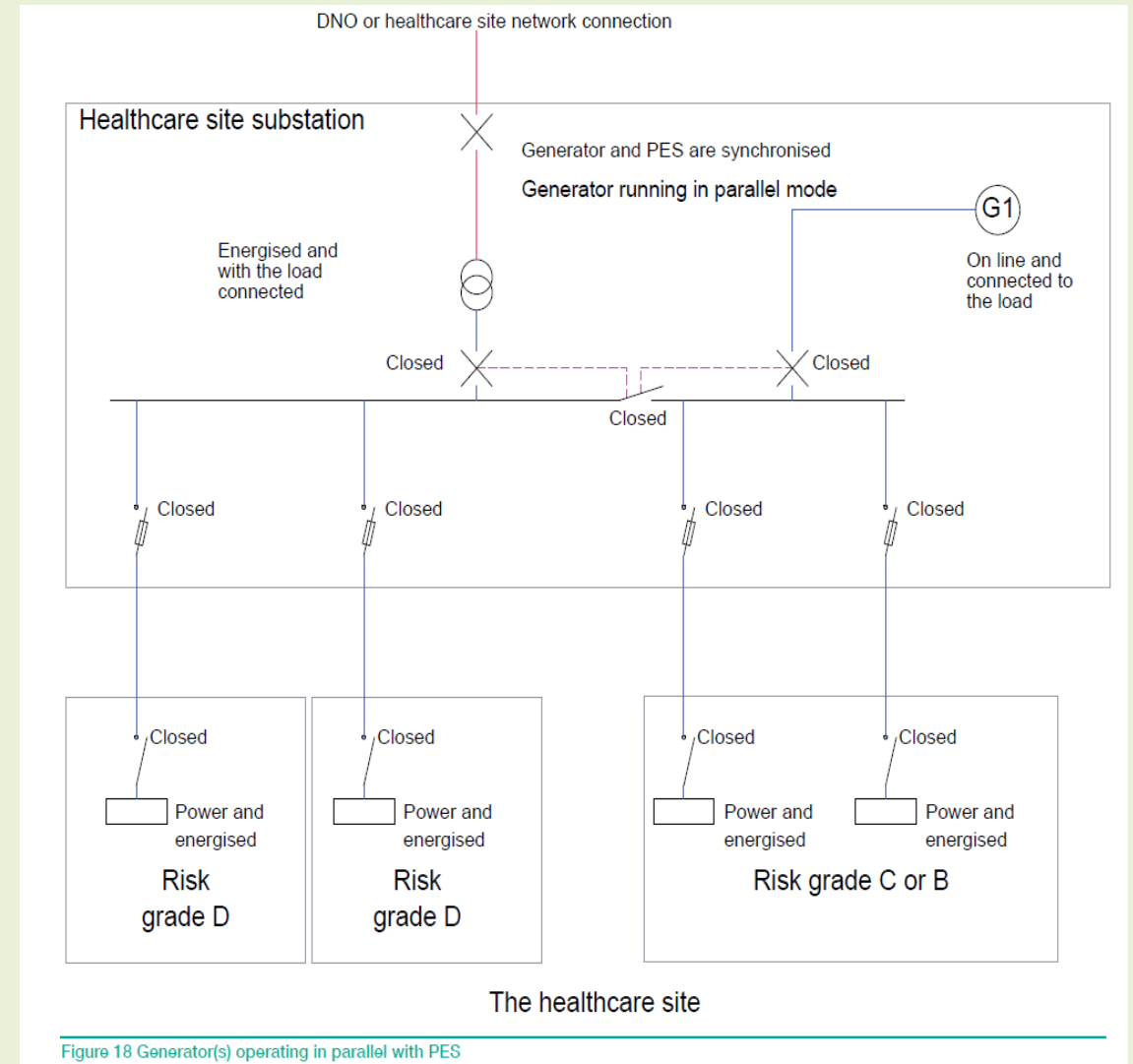
- ▷ with single-cable and
- ▷ with dual-cable infrastructure (auto-changeover) distribution for area of higher risk



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



5. DISTRIBUTION STRATEGY

Secondary Supply

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

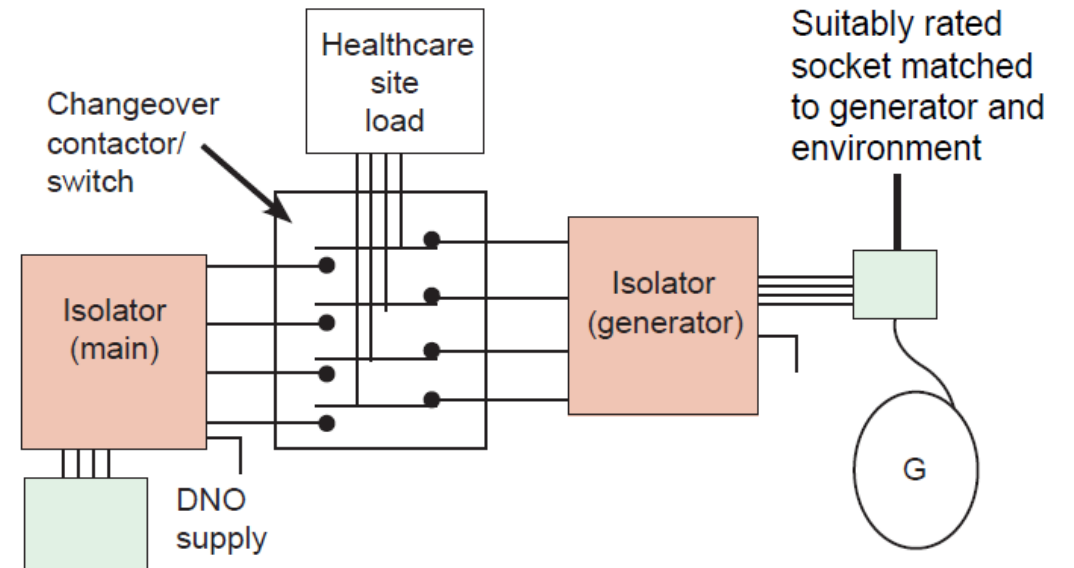


Figure 16 Mobile generator connection

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

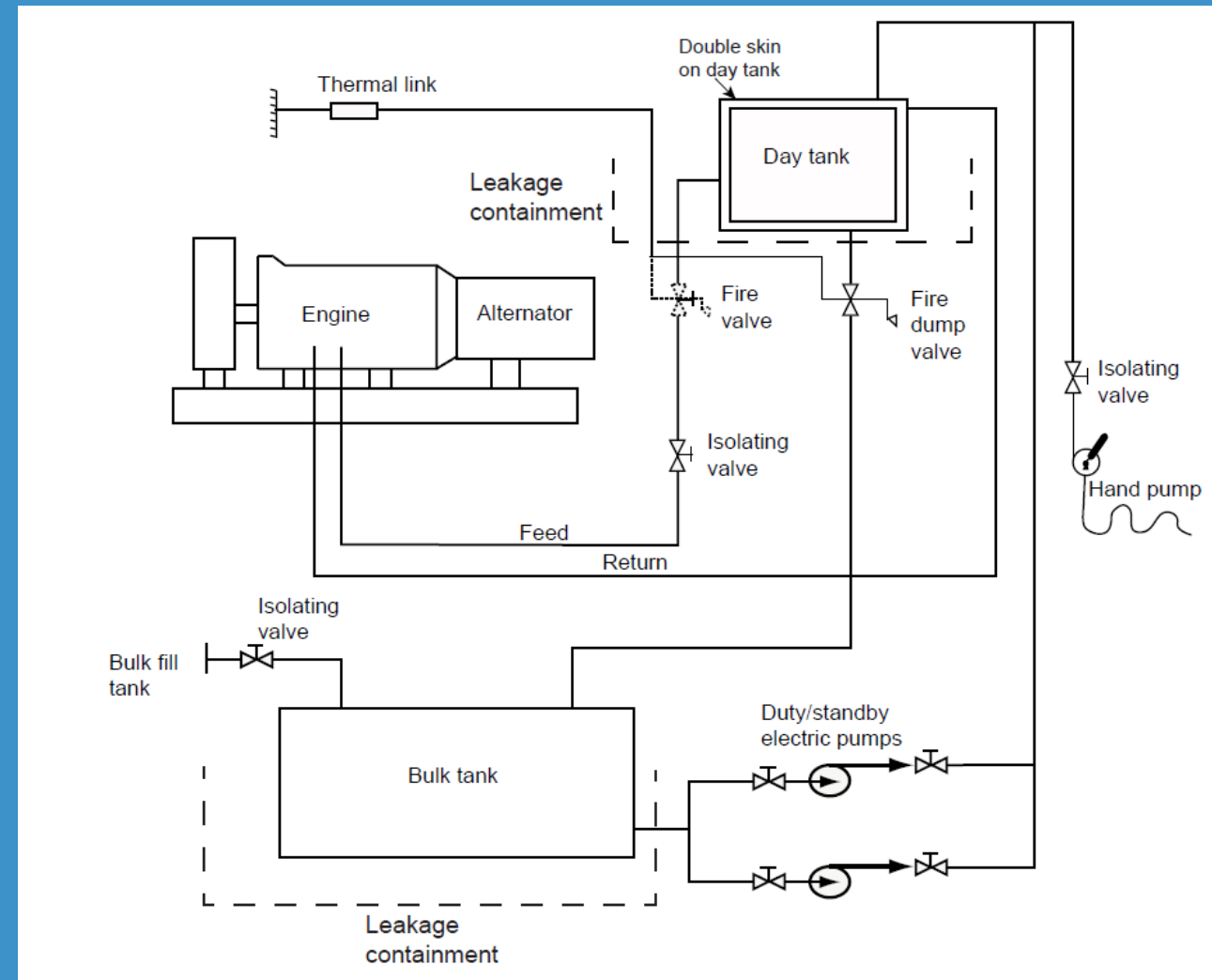


Figure 19 Fuel day and bulk tanks with dual pumps and fire dump

Source: Extracted from HTM 06-01, 2017 edition

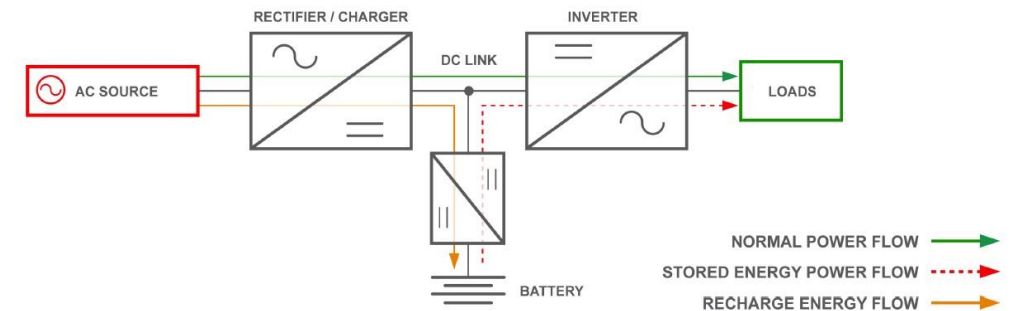
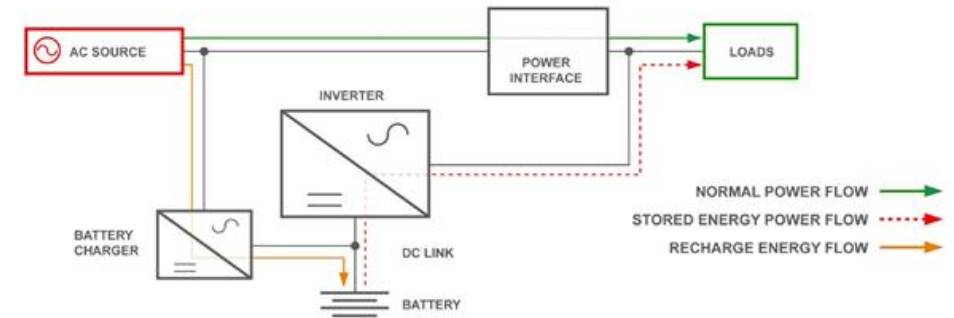
5. DISTRIBUTION STRATEGY

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)

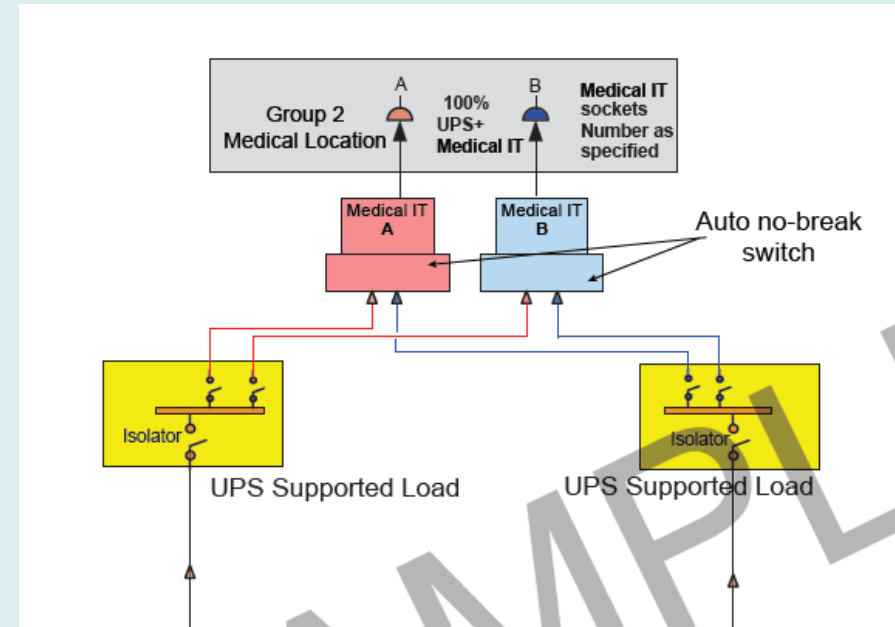
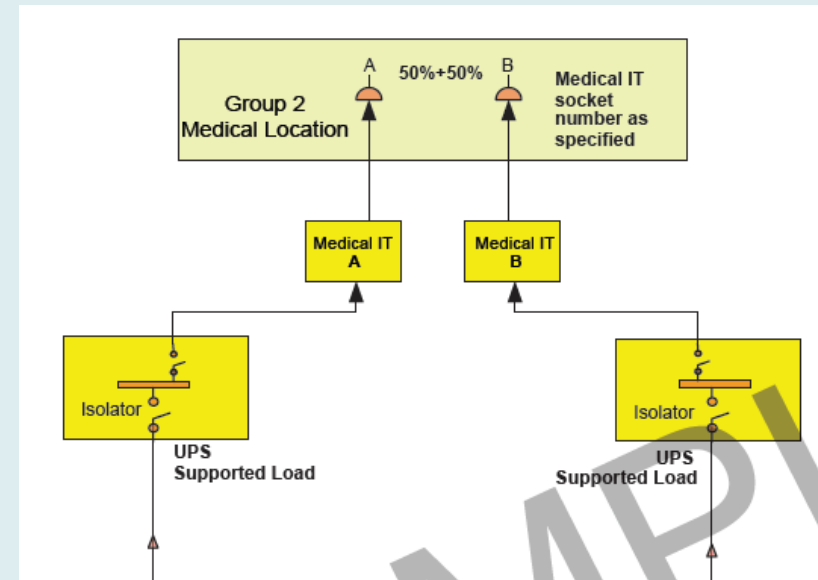


5. DISTRIBUTION STRATEGY

Tertiary Supply

UPS Configurations

- ▷ UPS N+1 resilience
 - Grouping multiple UPS units for single location
 - Redundant UPS units each capable of supporting full load with auto-changeover

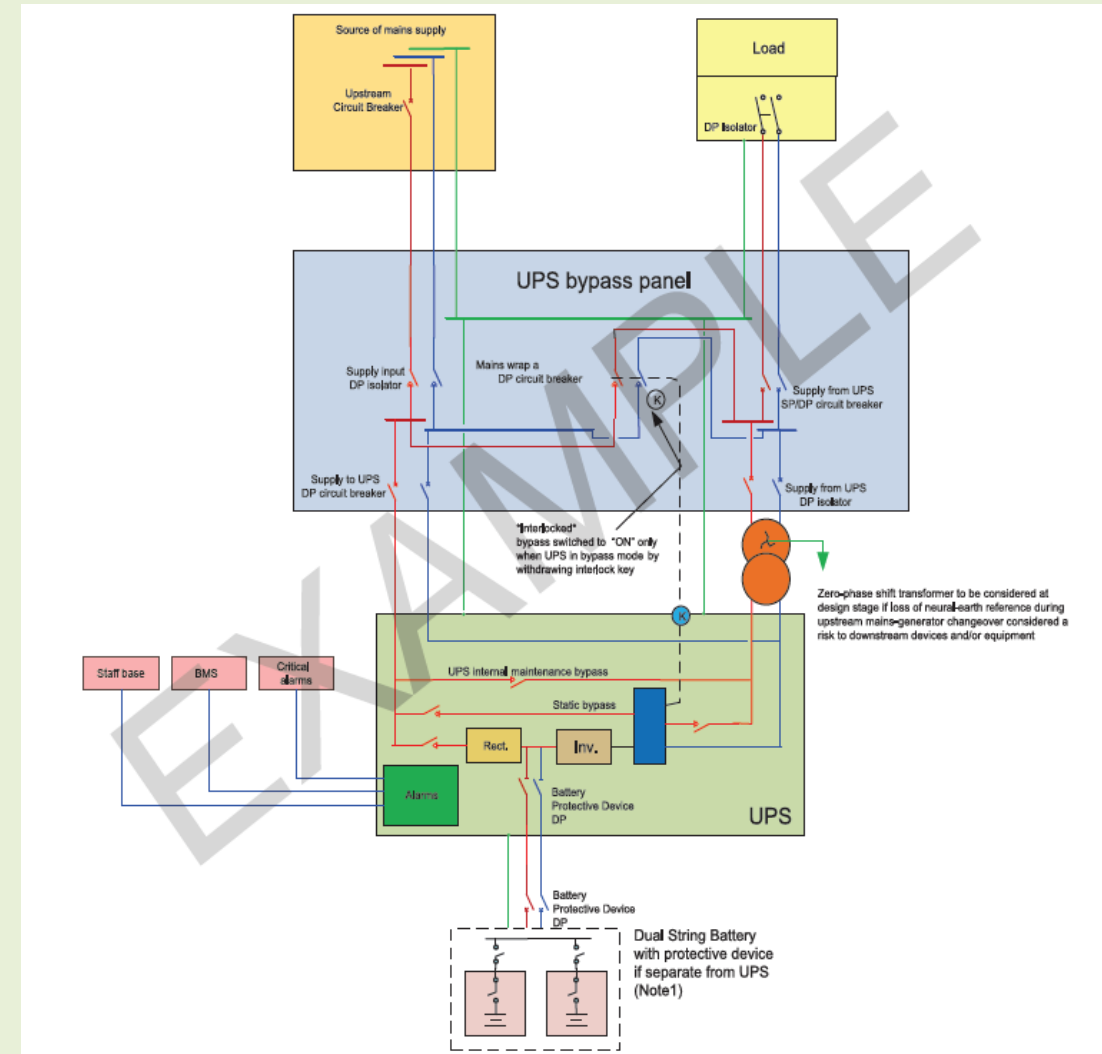


Source: Extracted from HTM 06-01, 2017 edition

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



Source: Extracted from HTM 06-01, 2017 edition

6. Other design considerations

Electromagnetic compatibility (EMC):

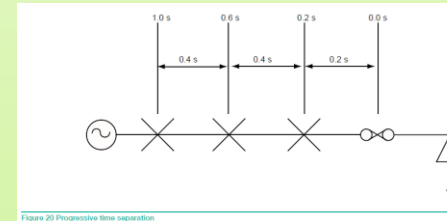
- Prevent interference with medical equipment

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

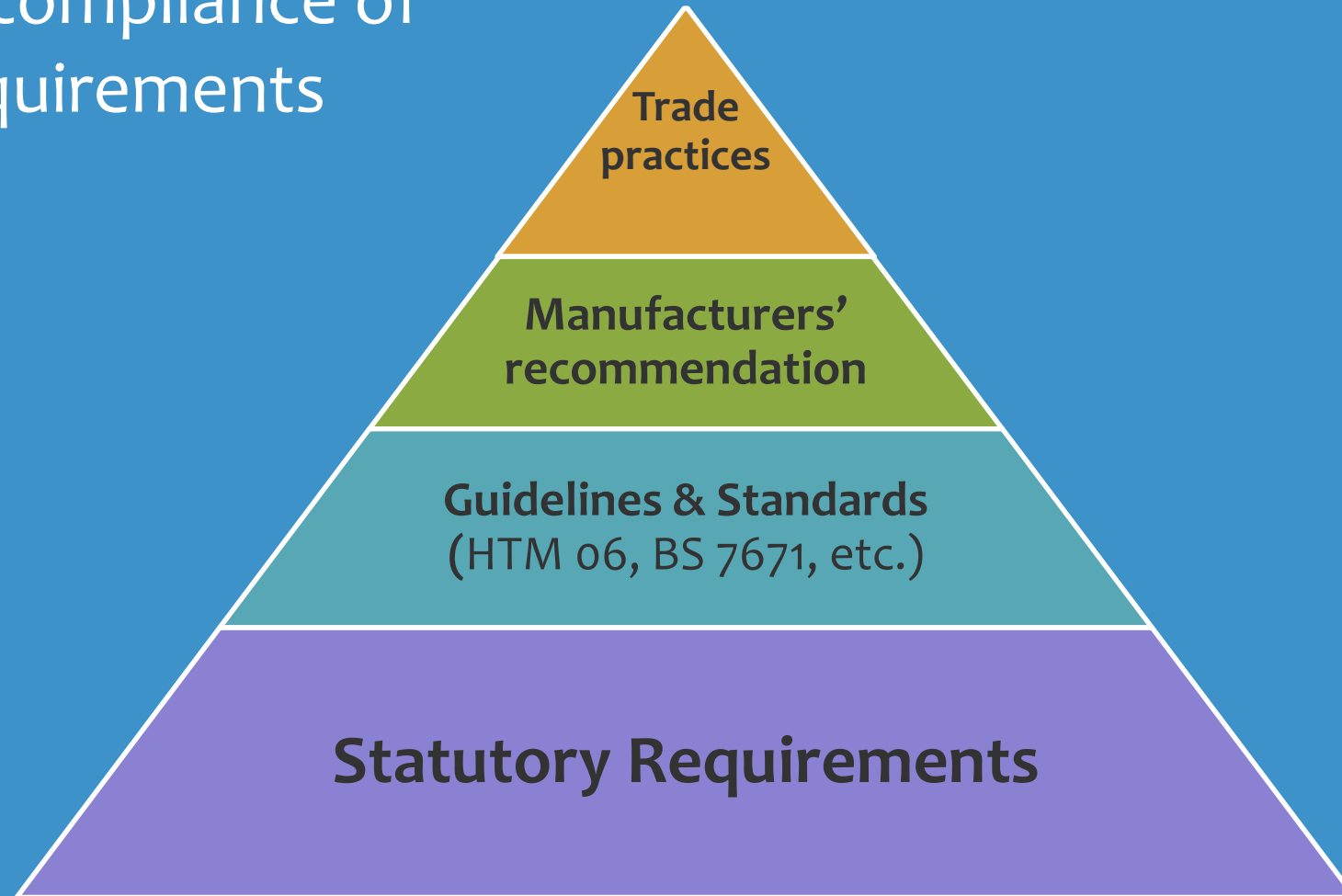


Future maintainability and operability:

- Eliminate single point of failure
- Allow partial system shutdown for maintenance / PITC without affecting hospital operation

7. Operation and maintenance

- ▷ In compliance of requirements



7. Operation and maintenance

Preventive maintenance of critical equipment

Emergency generators	UPS batteries	Switchboard
<ul style="list-style-type: none">• On-load test using building load• Test function of interlocks and changeover	<ul style="list-style-type: none">• On load Discharge test• Test for batteries health status	<ul style="list-style-type: none">• 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

SUMMARY



Thank You