3. Electrical Services

This document is intended for the Architect/Engineer (A/E) and others engaged in the design and renovation of DHA facilities. Where direction described in applicable codes are in conflict, the A/E shall comply with the more stringent requirement. The A/E is required to make themselves aware of all applicable codes.

The document should be read in conjunction with other parts of the Health Facility Guidelines (Part A to Part F) & the typical room data sheets and typical room layout sheets.

3.1 Introduction

This section of DHA health facility design guideline provides, Healthcare Planners and Designers guidance on the acceptable level of standards to be achieved for all fixed electrical wiring installation within healthcare facilities in The Emirate of Dubai. This applies to all new installations and modifications to existing facilities within the framework of Part A of this document.

It is not the intention of this document to unnecessarily repeat national, international or industry standards. Where appropriate, these standards are referenced, and additional specific requirements are described in the following sections.

In addition, guidance is also given on ELV and ICT systems.

3.2 Abbreviations, Standards and References

Abbreviation	Description
BMS	Building Management System
CIBSE	Chartered Institute of Building Services
CCTV	Closed-Circuit Television
CE	European Conformity

Abbreviation	Description
CT	Current Transformer
DEWA	Dubai Electricity and Water Authority
EBB	Equipotential Bonding Bar
ELCB	Earth Leakage Circuit Breaker
ELV	Extra Low Voltage
EMC	Electromagnetic Compatibility
EMR	Electronic Medical Records
EMR	Electronic Health Record
EPS	Emergency Power Supply (Also referred as Secondary Power Supply)
FL	Full Load
HIS	Hospital Information System
ICU	Critical Care Unit
IEC	International Electrotechnical Commission
IEE	Institute of Electrical Engineering
IGBT	Insulated Gate Bipolar Transistor
IPS	Isolated Power Supply (also referred as Medical IT)
ISO	International Standards Organisation
IT	Impedance Terra Earthed (Derived from an Isolated Power Supply)
ICT	Information and Communication Technology
LAN	Local Area Network
LPS	Lightning Protection System
LS0H	Low Smoke Zero Halogen
LV	Low Voltage
MV	Medium Voltage
NTP	Network Time Protocol

Abbreviation	Description
PACS	Picture Archiving and Communication System
PEC	Protective Earth Conductor
PPS	Primary Power Supply
PTZ	Pan Tilt and Zoom
RCBO	Residual Current Breaker with Overcurrent
RCD	Residual Current Device
RDS	Room Data Sheet
SPS	Secondary Power Supply (Also referred as Emergency Power Supply)
TPS	Tertiary Power Supply (Also referred as UPS Power Supply)
TRA	Telecom Regulatory Authority
UPS	Uninterruptible Power Supplies
VRLA	Valve Regulated Lead Acid Battery

3.3 Risk assessment

1. Electrical power distribution systems are inherently designed to isolate power supplies to parts of the installation where an electrical fault is detected for safety and reliability of electrical distribution in general.
2. In any electrical installation the power supply may fail at some point and contingency needs to be in place to mitigate the impact of the power failure by providing redundancy in power source and distribution.
3. The level of redundancy to be contusive for the type of healthcare premises and level of care rendered. A power failure in an outpatient care facility may not have much detrimental effect on the patient safety while a power failure in an acute care facility could have disastrous

consequences.

4. Depending on the level of care provided in the healthcare facility, the stake holders should carefully consider the risks involved due to a power failure for clinical, non-clinical and engineering applications and come up with an optimum arrangement that will minimize the risk to the patient safety and healthcare facility operation in general.
5. The risk assessment can be a simple or complex approach depending on size and nature of the medical services being provided in the healthcare facility. This guideline recommends the risk assessment approach described in HTM 06-01 2017 edition, chapter 4 be followed for determining the risks; business continuity risks are graded from Grade 1 to Grade 4 (Grade 1 being highest risk) while clinical risks are graded from Grade A to Grade E (Grade A being highest risk).
6. Specific requirements given in this guideline takes precedence over HTM or any other Standard or regulation.
7. Within an outpatient department in a large healthcare facility or in a clinic, it may be determined as acceptable to have single points of failure in a system, since ambulant patients are likely to be more mobile than patients in critical care areas and staff will be able to move them away from the affected area in the event of a power failure. On the other hand, in critical care areas or operating theatres, the consequence of a prolonged, or even a very short, power failure could result in serious health disabilities or, in the worst cases, fatality. In this instance, a more resilient infrastructure with additional levels of secondary and/or tertiary power supplies are appropriate. Also, the eventual stakeholder's (hospital owner/end user) vision with respect to management of business continuity risks to be considered while finalizing the risk levels (clinical and business continuity).

3.4 Design considerations

1. It is important to access the requirements of a healthcare facility project in terms of power supply requirement for equipment, small power outlet, lighting etc.; it is particularly important to identify those areas or functions that will require special consideration, for example Group 2 Medical Locations (HD 60364-7-710:2012, IET Guidance Note 7) in healthcare facilities.
2. Local/international regulations or standards as listed below are required to be considered while designing healthcare facilities in the Emirate of Dubai.

Sl. No.	Standard/Guideline
1	Dubai Electricity and Water Authority - Regulations for Electrical Installations 2017 Edition or later edition.
2	UAE fire code.
3	Al Sa'fat Green Building Evaluation System.
4	Local Telecom Company Regulations as applicable.
5	HD 60364-7-710:2012 (or later) Electrical installations of buildings - Part 7-710: Requirements for special installations or locations - Medical locations.
6	CIBSE Lighting Guide 2: Hospitals and healthcare buildings,2008, by The Society of Light and Lighting.
7	IEC 60079 - Electrical apparatus for explosive gas atmospheres.
8	IEEE 519 - IEEE Recommended practices and requirements for harmonic control in electrical power systems.
9	HTM 06-01 - Electrical service supply and distribution, 2017 or later edition.
10	NFPA 99 – Health Care Facilities, Chapter 6, Section 6.4.2.2 (Edition 2012 or later).
11	Equipment and installation material standards/listing: IEC, EU Declaration of Conformity, or UL Listed.

3. The requirements given in the above regulations or standards are not repeated generally in

this document; however specific additional healthcare specific requirements emphasised in the following section will take precedence over the referenced standards above.

4. It is important to note that, the services outlet (power, data etc.) quantities and their types provided in the various medical locations shall be based on the guidance provided as per the RDS (Room Data Sheets) included under Part B of this guideline.
5. Non-medical equipment should not be used in a patient environment unless it meets the electrical safety requirements of IEC 60601-1, particularly with respect to touch and leakage currents.
6. Primary Power Supply (PPS): - Primary Power Supply is the electricity supply provided by the local utility company, Dubai Electricity and Water Authority (DEWA). Power supply from DEWA is generally reliable, however, while power supply allocation requests are made to the local utility company, level of care provided by the proposed healthcare facility should be conveyed to the utility company so that appropriate level of redundancy could be considered by the utility supply company for power intake provisions.
7. Secondary Power Supply (SPS): - Secondary Power Supply is the electricity supply provided from an on-site power source such as a Diesel Generator Set (s). The secondary power source shall be suitably supplemented by appropriate secondary distribution system to reduce the risk of single point failure. Single point of failure to be as close as practically possible to the load. Secondary power supply shall be available to the associated loads in 15 seconds or less from the PPS interruption. Power outlets fed from the SPS are also referred as Emergency Power Supply (EPS) outlets.
8. In the event of a primary power supply failure the secondary power supply should be available to the associated emergency loads in 15 seconds or less.
9. Providing a resilient secondary power source is only one part of the solution while providing

a redundant secondary distribution network is equally important. Refer to section 3.8.

10. Tertiary Power Supply (TPS): - Tertiary Power Supply (with less than 0.5 Sec break) is required to provide additional (in addition to PPS and SPS) power source in clinical risk Grade A and B areas where loss of power supply could have disastrous consequences. Static double conversion Uninterruptible Power Supplies shall be provided as TPS sources. Refer to section 3.9.
11. Isolated Power Supplies (IPS): Isolated power supplies incorporating an isolation transformer, distribution arrangement and Isolation monitoring system are used to deliver power supplies to power outlets intended for relevant critical medical equipment in critical medical locations where enhanced level of resilience is required. Refer to section 3.9.
12. Following clinical risk grading and associated recommendation on power supply types are provided based on the interpretation of HTM 06-01 and HD 60364-7-710:2012 in the context of Emirate of Dubai where quality and reliability of primary power supply is generally excellent. Therefore, this clinical risk grading may not be applicable for other geographic locations.

Clinical Risk Grade (Interpretation of HTM 06-01: 2017)	Medical Location (Interpretation of HD 60364-7-710:2015)	Area Description	Power Supply Types
Grade A	Group 2	These are areas where treatment and patient safety will be compromised and endangered by any minor interruption of electrical supply; such areas include but not limited to the following;	SPS: Required TPS: Required IPS: Required (Note: PPS is also recommended in these areas to serve power outlets intended for non-clinical

Clinical Risk Grade (Interpretation of HTM 06-01: 2017)	Medical Location (Interpretation of HD 60364-7-710:2015)	Area Description	Power Supply Types
		Operating Rooms Anaesthetic Induction rooms Recovery Bays (Stage 1) Critical Care Angiography and Cath labs Emergency resuscitation bays IVF Procedure rooms High dependency units Neo-Natal Intensive Care Units Brachytherapy rooms Chemo embolization rooms	applications such as cleaning. Power supply for support systems such as HVAC, hot & cold water, and medical gas alarms shall be connected to SPS)
Grade B	Group 1	These are areas where treatment and patient safety may be compromised (but not endangered) by any minor interruption of electrical supply; such areas include but not limited to the following areas; Delivery rooms Endoscopy Procedure Rooms Emergency treatment areas. Haemodialysis bays Urology treatment rooms Radiation therapy rooms Imaging equipment Procedure rooms Triage	SPS: Required TPS: Generally, not required. However, TPS may be required for specific medical equipment. IPS: Not Required (Note: A few power outlets connected from TPS is recommended at Nurse stations serving critical care areas, PPS is recommended in these areas to serve power outlets intended for non-clinical applications such as cleaning Power supply for support systems such as HVAC, hot &

Clinical Risk Grade (Interpretation of HTM 06-01: 2017)	Medical Location (Interpretation of HD 60364-7-710:2015)	Area Description	Power Supply Types
		Staff stations.	cold water, and medical gas alarm shall be connected to SPS) SPS backup for imaging equipment are optional depending upon the level of care provided in the facility. If the healthcare facility is having interventional procedures at least one of each type of imaging system to be connected to SPS.
Grade C	Group 1	These are areas where treatment and patient safety will not be immediately compromised by an interruption of electrical power; such areas include but not limited to the following areas; Outpatient Treatment rooms Consult/Exam rooms Pharmacy Patient bed room Recovery – Stage II Observation bays	PPS: Required SPS: Required TPS: Not Required IPS: Not Required (Note: Power supply for support systems such as HVAC, hot & cold water, and medical gas alarms shall be connected to SPS)
Grade D	Group 0	These are areas where loss of power supply may give rise to disruption, inconvenience and a reduced environmental quality	PPS: Required SPS: Optional TPS: Not Required

Clinical Risk Grade (Interpretation of HTM 06-01: 2017)	Medical Location (Interpretation of HD 60364-7-710:2015)	Area Description	Power Supply Types
		but would not directly compromise clinical treatment and safety; such areas include but not limited to the following areas; Consult rooms Waiting areas Sterile Supply Unit (SSU)	IPS: Not Required (Note: SPS for small power outlets in these areas are optional; the designer may provide SPS to mitigate business continuity risk, if required by the end user. It is recommended that 50% of lighting circuits are connected to SPS. SPS backup is highly recommended for at least one of each type of sterilizing and cleaning equipment in Sterile Supply Unit (SSU) as a minimum)
Grade E	-	These are areas where loss of the electrical supply does not have an immediate effect on the clinical treatment or safety of patients; such areas include but not limited to the following areas. General circulation areas Offices Other Non-clinical areas	PPS: Required SPS: Optional TPS: Not Required IPS: Not Required (Optional: SPS and TPS for areas such as offices are optional; the designer may provide SPS and TPS to mitigate business continuity risk, if required by the end user)

TABLE: E.3.1 Clinical Risk Grading

13. Notwithstanding the guidance provided above, there may be situations where enhanced level of power supply resilience is required based on the specific medical treatment envisaged. The designer is required to assess the risks involved and shall include further enhancements in the design as necessary. In addition, power supplies for building's life safety system shall be supplied from SPS as per the local fire code.

3.5 Power quality

1. Electrical disturbances may affect the reliability of high-tech medical equipment. As medical equipment is often connected to vulnerable patients, such a malfunction may result in fatal consequences. To mitigate this problem careful consideration shall be made in terms of the design of the electrical distribution system as well as selection of electrical distribution equipment. The following approaches shall be considered.

Power supply feeders for sensitive medical equipment such as X-Rays, CT, MRI and Linac. etc, shall be directly sourced from the Main Distribution Boards (MDB) rather than from shared sub-distribution panels. Alternatively, dedicated appropriately sized submain distribution board (SMDB) located in the MDB room to serve a group of imaging equipment will also suffice.

Providing surge protection devices.

Providing active harmonic filters: Power system harmonics of order 3rd, 5th, 7th, 9th, 11th and 15th order can create significant problems such as over current and overheating of cables, busbars and transformers. since it is not practical to accurately estimate the rating of active harmonic filters required for any project in advance, provision such as breakers shall be made in the Main Distribution Boards to install harmonic filters when actual harmonics can be measured at the earliest. Spare breakers designated for this

application shall be labels as " For Harmonic Filter Only".

Harmonics to be measured once the majority of the mechanical, electrical and medical equipment are in operation. This guideline recommends that this measurement be made within 6 months following the opening of the facility. Suitably rated harmonic filters shall be installed to limit the harmonics stipulated as per IEEE 519 (Recommended practices and requirements for harmonic control in electrical power systems).

Power factor correction meeting DEWA requirement; Power factor correction equipment can also contribute to the harmonic generation; unless properly designed detuning reactors are incorporated into the design of the power factor correction capacitor banks. Power factor correction capacitor banks shall be with detuning reactors. Capacitor banks employing Thyristor based capacitor switching is recommended.

Special attention is drawn to DEWA regulation clause 1.10 and 8.2 with respect to under voltage release and auto-reclosing for feeders serving air condtioning units or similar equipment employing compressors drawing large inrush current at start-up.

Facility to display power quality parameters such as THD is recommended to be provided in the Main Distribution Boards.

3.6 Power supply and distribution resilience

1. The resilience of power supply and distribution shall be as per the type of health care facility and level of care provided in that part of the facility.
2. When designing the strategy for the electrical distribution, it is important to take an all-inclusive approach.
3. All Main Distribution Boards serving non-critical applications shall have temporary generator connection provision to connect temporary generator in case of any prolonged

utility power supply outage.

4. Refer to Fig. E.3.1 for a diagrammatic representation of a typical Hospital high-level power distribution arrangement. The number of Automatic Transfer Switches indicated in this diagram may have to be increased or decreased based on the layout of the hospital, load considerations and distribution arrangement.
5. All automatic transfer switches serving critical areas shall be bypass isolation type to enable ATS maintenance or fault rectification without loss of power supply to critical services.

3.7 Primary (Normal) power supply and distribution

1. Primary power supply shall be sourced from local utility provider DEWA, based on the standard procedures and approval process mandated by the local power supply authority.
2. Main power supply intake rooms (RMU, Transformer and MDB) shall be provided as per DEWA regulations.
3. With fast evolving advancements in the medical treatment field there is an ever-increasing need for electrical power for healthcare facilities and this trend is likely to continue. Considering this spare capacity may be allowed in the power distribution equipment such as transformers.
4. Typically, in healthcare facilities, large number of small power sockets are provided at patient locations on service panels and pendants for redundancy and convenience than simultaneous use. As such, suitable diversity shall be worked out by a qualified and experienced designer to avoid ending up with an inappropriately expensive overdesigned electrical system.
5. For critical care facilities separate, dedicated Main Distribution Board rooms shall be provided for primary and secondary power supplies to segregate primary and secondary Main Distribution Boards.

6. Figure E.3.1 below indicates a typical primary and secondary distribution arrangement for a hospital. Note that this is a typical high-level arrangement and the number of different equipment and connection arrangement may vary depending upon the size of the facility, associated loads and relative location of loads.

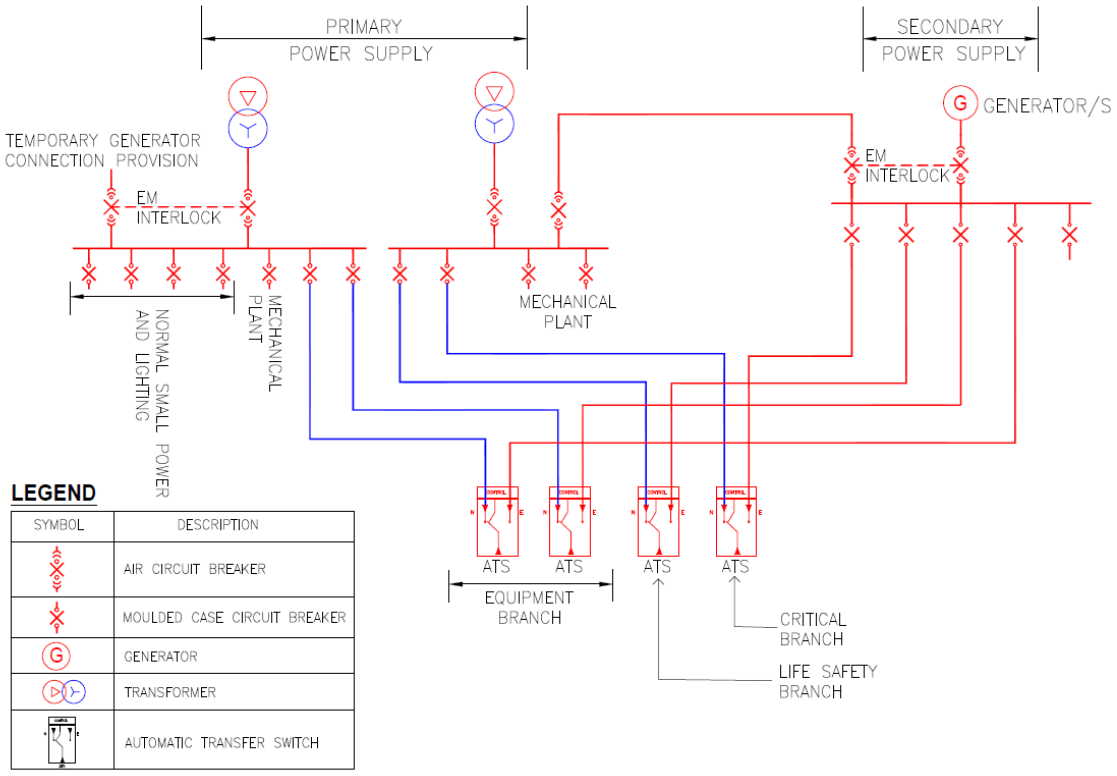

Figure E.3.1 Typical high-level power distribution arrangement schematic for a Hospital

3.8 Secondary (Emergency) power source and distribution

1. Onsite secondary power supply source (Diesel Generator Set) and associated distribution shall be provided for Healthcare facilities. Coverage of the secondary power supply shall be as per the level of care provided in the facility.

2. Location of the Generator Set shall optimise the secondary distribution by reducing the amount of power distribution elements between the critical load and the power source. The location of the generator room shall also be protected from general flooding levels.

3. It is recommended that Diesel Generator Sets serving healthcare facilities are not located

below the grade level.

4. It is recommended that Diesel Generator Sets serving healthcare facilities are prime rated (ISO 8528-1) and not standby rated.
5. Where multiple Diesel Generator Sets are forming the Secondary Power Supply source and is only supporting critical loads in Grade A, B and C medical locations, N+1 source redundancy shall be provided.
6. Where the secondary power source is providing power backup for the entire facility, in addition to clinical risk grade A, B and C locations, N+1 redundancy may not be required. However, in the event of one Generator failure, the remaining arrangement shall be capable of supporting the entire Grade A, B and C medical locations.
7. For healthcare facilities where, the total capacity of the Secondary Power Source requirement is within the limit of a single generator set, it is acceptable to have one diesel generator set.
8. This guideline does not recognize an alternate power supply (in addition to PPS) from the local utility company or a Solar PV/Concentrated plant as a means of secondary power source.
9. Special consideration shall be given to the choice of starting batteries and battery chargers for diesel generator sets. The diesel generator plant is highly dependent upon the availability of the batteries for cranking the engine when required. The batteries shall be either VRLA or Ni-Cd type; However, Ni-Cd batteries are highly recommended.
10. Battery status to be monitored and alarmed though the building management system or any other sperate monitoring system.
11. Onsite fuel storage shall be provided for diesel generator sets. The fuel storage quantity requirements shall be carefully determined considering the level of care provided in the

facility; it is recommended that healthcare facilities providing inpatient and critical care functions are provided with a minimum of 24 Hours of fuel storage at 70% average loading of the respective diesel generator sets. This can be reduced to 4 hours in case of outpatient clinics.

12. The diesel fuel storage within the generator room shall not exceed 2400 litres.
13. Separate, dedicated Main Distribution Board rooms shall be provided for secondary Main Distribution Boards serving emergency functions of the facility.
14. Secondary power supply outlets in clinical areas shall be logically grouped in distribution branches with segregated distribution. Automatic change over between PPS and SPS shall be as close as practically possible to the point of utilization depending upon the criticality of the application.
15. Feeder cables for radiology equipment incorporating high voltage generators drawing pulse currents for a short duration (not exceeding 5 Sec.) need not be sized considering the peak current as continuous current. The following general guideline may be followed while determining the demand load and associated feeder cable sizes for medical equipment drawing short duration impulse current.

    One imaging equipment: Demand load and cable size shall be designed based on 50% of the short time peak rating of such equipment or 100% of the continuous rating of the equipment; whichever is higher.

    Two imaging equipment: Demand load and cable size for an upstream feeder serving two such imaging equipment shall be designed based on the sum of (50% of the short time peak rating of the first equipment or 100% of the continuous rating of the first equipment; whichever is higher) and (50% of the short time peak rating of the second equipment or 100% of the continuous rating of the second equipment; whichever is

higher).

More than two imaging equipment: Demand load and cable size for an upstream feeder serving more than two such imaging equipment shall be designed based on the sum of the (demand load for largest of the two imaging equipment based on "b" above) and 20% of the sum of peak current of the all the remining imaging equipment.

16. Note that the above criteria is a general guideline for the design stage, final section of the cable shall be verified against manufacturer's certified requirement once the final selection of the equipment has been made.

17. The secondary power supply distribution shall be logically organized in separate change over (ATS) and distribution branches. Refer to table E.3.2 as example of grouping of circuits for secondary power distribution.

Secondary Power Distribution Branch	Connected Equipment/systems
Life Safety Branch	1. Fire pumps 2. Emergency lighting 3. Fire detection and signalling 4. Smoke management systems 5. Firefighting lifts 6. Other fire and life safety equipment as per local fire code. 7. (Building life safety systems in general)
Critical branch	1. Socket outlets in Grade A clinical risk areas 2. Socket outlets in Grade B clinical risk areas 3. Socket outlets in Grade C clinical risk areas 4. Critical medical equipment power supplies 5. Medical gas power supplies 6. Critical area illumination

Secondary Power Distribution Branch	Connected Equipment/systems
	7. UPSs serving ICT Systems 8. UPSs serving IPSs and medical locations
Equipment branch	1. Domestic water pumps 2. Pneumatic tube system blowers 3. HVAC system equipment as applicable (part/full) as per design. 4. Lifts 5. Drainage sump pumps 6. Water treatment plants 7. Applicable loads in Kitchen 8. Laundry equipment 9. Standby lighting

TABLE: E.3.2 Secondary Power distribution branches

18. 100% Power supply backup for chilled water generating plant for space cooling is not mandatory but desirable. However, SPS shall have enough capacity to serve chilled water for space cooling in clinical risk grade areas A and B as a minimum. In cases where the primary cooling for the healthcare faciloty is provided by remote district cooling plant, power backup should be provided for backup cooling plant as described in Part E, section 2.12.2 of this guideline.

19. SPS backup shall be provided for HVAC air plant such that loss of PPS will not compromise the pressure differential regime mandated by the HVAC section of this guideline.

3.9 Tertiary (UPS) power source and distribution

1. Tertiary power supply source in the form of Uninterruptable Power supplies (UPS) shall be provided for Healthcare facilities to serve critical applications in clinical risk areas Grade A and Grade B defined in HD 60364-7-710:2012. In addition, tertiary power supplies may be provided for sensitive equipment in other areas such as laboratories, pharmacy, critical care

supervision stations, PACS and HIS workstations etc.

2. In some cases, sensitive medical equipment are provided with individual UPS units provided adjacent to the respective equipment. In such cases, secondary power supply would suffice.
3. In consideration of mitigating business continuity risks, the designer may provide UPS power outlets in non-clinical areas such as the finance department and receptions desks if required by the end user.
4. The UPS units shall be static double conversion type either monolithic or modular type.
5. Long life (10 Years) VRLA type batteries meeting IEC 60896 connected in dual string arrangement is recommended for UPS units. Multiple string battery connection assists in maintaining the batteries without completely eliminating the backup capacity of the UPS while in operation.
6. Since the battery life is closely related to the ambient room temperature it is critical that the UPS/battery rooms temperature is maintained within a temperature range of 20 to 22°C. Alarm systems may be considered to monitor the UPS room temperature and raise local and remote alarm when the temperature exceeds the limit.
7. In general, it is recommended that UPS units are not shared between building services (IT, Security system etc) and clinical applications. However, in case of healthcare facilities such as outpatient clinics it may be more feasible to have combined UPS units to serve clinical and nonclinical applications.
8. Careful consideration shall be given to the UPS connection arrangement and redundancy. An appropriate number of central UPS systems connected in N+1 redundancy, closer to the critical loads, are recommended, rather than one single large UPS plant serving the entire facility. On one hand the single large UPS plant increases the risk of single point failure while on the other hand having large number of UPS units to monitor and maintain would become

an operational challenge; thus, careful consideration shall be made by the designer to have an optimum number of UPS units based on the nature of the healthcare facility. Refer to HTM 06-01, 2017 figure 22 as an example of recommended secondary power source and distribution arrangement for a group 2 medical location.

9. A parallel synchronous redundant UPS arrangement is recommended for serving non-clinical applications such as building IT systems. Refer to HTM 06-01, 2017 figure 25 as an example. N+1 modular UPS arrangement is also acceptable.
10. An autonomy time of 60 minutes shall be provided for UPS units serving clinical services in critical care areas while the input power to the UPS units are sourced from secondary power supply.
11. This guideline does not recognise rotary UPS units as tertiary power source (TPS) for Healthcare facilities due to the following reasons.

    Autonomy time provided by the Rotary UPS systems are not comparable to autonomy times that can be achieved with Static UPS systems.

    Rotary UPS units are normally installed together with Diesel Generator Sets, making it not suitable for installation closer to sensitive medical locations such as Operating Theatres.
12. UPS units of 20kVA and larger or serving clinical risk grade A areas shall be provided with external by pass panel. Ability to by-pass the UPS unit in the event of a total failure of the UPS unit is a critical last option that should be available to the operator to maintain the power supply.
13. Separate UPS rooms are recommended for UPS units larger than 20kVA, than housing the UPS units in sub-electrical rooms.
14. UPS status and alarms shall be available in the Operating Theatres through the Surgeons' control panels or other annunciator units.

15. In general imaging equipment such as X-Rays, CTSs, MRI do not require power backup for the entire equipment from a central UPS, but a smaller local UPS to power the respective control console (not x-ray generator and magnet) would be sufficient.
16. If the imaging equipment is forming part of an interventional operating theatre suite, UPS unit serving such imaging equipment shall be specially designed to power the entire imaging equipment including x-ray generator or magnet to avoid the UPS units switching to bypass in case of transient overload and to ensure power quality.
17. If the designer opts for backing up the entire imaging equipment such as CT including the X-Ray generator, individual UPS units specially designed to handle transient currents should be provided. It is recommended that this UPS is not shared to serve other medical locations. Autonomy time for UPS serving noninterventional imaging only and fed from SPS can be limited to 10 Minutes.
18. Power outlets intended for connecting critical medical equipment in clinical risk grade A locations shall be fed from propitiatory Isolated Power Supply (IPS) panel meeting relevant IEC standard or UL listed.
19. It is recommended that IPS panels serving operating theatres are provided with integral automatic transfer switch for additional resilience. Power sources for the ATS shall be primarily from the tertiary power source while alternate power supply can be from the secondary power source.
20. Isolated power panels shall be located closer (within 30m) to the area of application to minimise the leakage currents due to conductor capacitance.
21. Maximum capacity of the IPS panels shall be limited to 10kVA, with single phase input.
22. It is recommended that at least two IPS circuits are provided for each patient care location in clinical risk grade A locations where critical medical equipment are likely to be connected

to the patient.

23. Where multiple IPS panels are provided to serve multiple Operating Theatres or critical care areas it is recommended that the IPS final circuits are interleaved between the different rooms so that failure of one IPS unit will not render all IPS outlets in any given patient location without power simultaneously.
24. IPS panels are not recommended to be located within operating theatres; rather these shall be located in suitably designed ventilated spaces to facilitate cooling and maintenance access.
25. This guideline recommends that a maximum of 4 Nos. 13A sockets outlets are connected to any given IPS final circuit. No ring circuits are not permitted for IPS final circuits.
26. IPS final circuits shall not be protected with RCD or RCBOs.
27. Due to the inherent nature of isolated power supply final circuits, both conductors of the final circuit will be live and will be at a higher potential with respect to the ground; considering this both conductors of IPS final circuits shall be wired with same phase colour as that of primary power supply input to the IPS and should be ferruled as L1 and L2.
28. The IPS sockets shall be double pole unswitched, with blue colour face plate with engraving “For Medical Equipment Only”.
29. Luminaires including operating theatre surgical lights are not required to be connected to IPS panels
30. Remote Alarm Annunciator Unit for the IPS panel shall be located in the respective Operating Theatre and associated nurse stations.
31. In case of IPS panels serving critical care areas other than operating theatres, the Remote Alarm Annunciator unit shall be located at the respective supervision (nurse) station.
32. It is recommended that the IPS Remote Alarm Annunciator Unit in the operating theatres

have the following parameters displayed.

IPS insulation status/Leakage current

IPS load information

IPS temperature

Input ATS status (if applicable)

UPS Alarm

33. Isolated circuit fault locator system in conjunction with IPS leakage monitoring system is desirable but not mandatory.

34. Socket outlets supplied from IPS panels are also referred as “Cardiac Protected” outlets elsewhere in these guidelines.

3.10 Protection and switchgear

1. Since it is critical to ensure availability of critical healthcare facilities during any natural calamities it is important that the main intake switchgear (both LV and MV) are not placed below grade level. Potential flooding risks are to be assessed carefully before finalizing the location of main electrical intake rooms.
2. Main 11kV intake switchgear and its arrangement shall be as per DEWA standard.
3. Main Intake LV switchgear (MDB) serving the critical care facility shall be a minimum of Form 4b assembly meeting IEC 61439-2 and relevant sections of DEWA regulations.
4. All Motor Control Centres (MCC) shall be a minimum of Form 4a or 4b type tested assembly meeting IEC 61439-2 and relevant sections DEWA regulations.
5. Final circuit distribution boards shall be factory-built assemblies meeting IEC 61439. To reduce the impact of cumulative natural earth leakages of medical equipment on the protective device, that may cause nuisance tripping, it is recommended that final circuits

serving clinical areas are protected with RCBOs, rather than RCDs covering multiple MCB circuits.

6. RCBOs and RCDs serving small power circuits in Group 0, Group1 and Group 2 (as per HD 60364-7-710) medical locations shall have a tripping characteristic of Type A or Type B with a maximum tripping current of 30mA: Type AC, RCBOs or RCDs shall not be used in Group1 and Group 2 medical locations.
7. Socket outlets protected for earth leakage is also referred as “Body Protection” elsewhere in these guidelines.

3.11 Electromagnetic Compatibility

1. In general, all electrical and electronic equipment used in healthcare facilities shall be CE (or Equivalent) marked or certified. Careful consideration shall be given to power distribution induced electromagnetic interferences on sensitive medical equipment.
2. Where non-CE marked or equivalent non-certified, equipment has to be used in the facility the original equipment manufacturer shall confirm that the proposed equipment use in the facility will not have any adverse effect on other sensitive equipment in the facility.
3. The following are recommended for healthcare facilities for EMC.

   Cable containment (conduits and cable trays) used shall be metallic rather than plastic. Conduits recessed in concrete, masonry or cement plaster can be plastic.

   Cable trays with slots longitudinal to the length of the cable trays are recommended for carrying communication cables rather than caged or basket type cable containment.

   Where screened or armoured cables are used the screen shall be earthed at both ends of the cable.

   Follow IEC 61000-5-2 with respect to electromagnetic compatibility.

Follow IEC 60364-5-54 with respect to earthing and bonding.

Follow EN 50310:2016 Application of equipotential bonding and earthing in buildings with information technology equipment.

Follow IEC 60364-5-52 with respect to segregation of cables at various voltages from one another.

Total harmonic distortion shall be limited below 5%.

Single core power cables emanating from the secondary side of the transformers shall be armoured and armouring to be earthed at both ends to reduce magnetic coupling of the cables with structural steel reinforcement of the building.

Communication or Extra-Low voltage system cable shall not be run in the same cable tray or trunking as power cables

3.12 Earthing and bonding

1. High voltage and Low Voltage system earthing to be as per DEWA practice. In addition, safety requirements given below shall be met.
2. Equipotential bonding to be provided for all Group 1 and Group 2 Medical locations by providing equipotential bonding to all fixed medical equipment including service panels, pendants and bedhead units by bonding the metal frames or metal bodies of these equipment with the Earth Bonding bar (EBB). Refer to DEWA regulation Appendix 9 for the applicable conductor sizes for supplementary bonding.
3. Critical medical locations such as Operating Theatres shall have dedicated EBBs located near the Operating Theatre. For other areas EBB shall be in the respective sub-electrical rooms, where the final distribution boards are located.
4. Medical imaging and treatment locations requiring multiple supplementary bonding such as

CT Room, MRI Room and Radio Therapy Bunkers shall be provided with dedicated EBB.

5. Connections to the EBBs shall be carefully labelled and easy to inspect.
6. When earth mats are provided in Operating Theatres, the mat to be made continuous and should be connected to EBB.
7. Dedicated earthing jacks may be provided in critical care areas such as Operating Theatres, however these are not mandatory. (IEEE Std. 241)
8. IPS panels shall have a dedicated earthing as illustrated in the typical operating theatre earthing as illustrated in diagram E.3.2

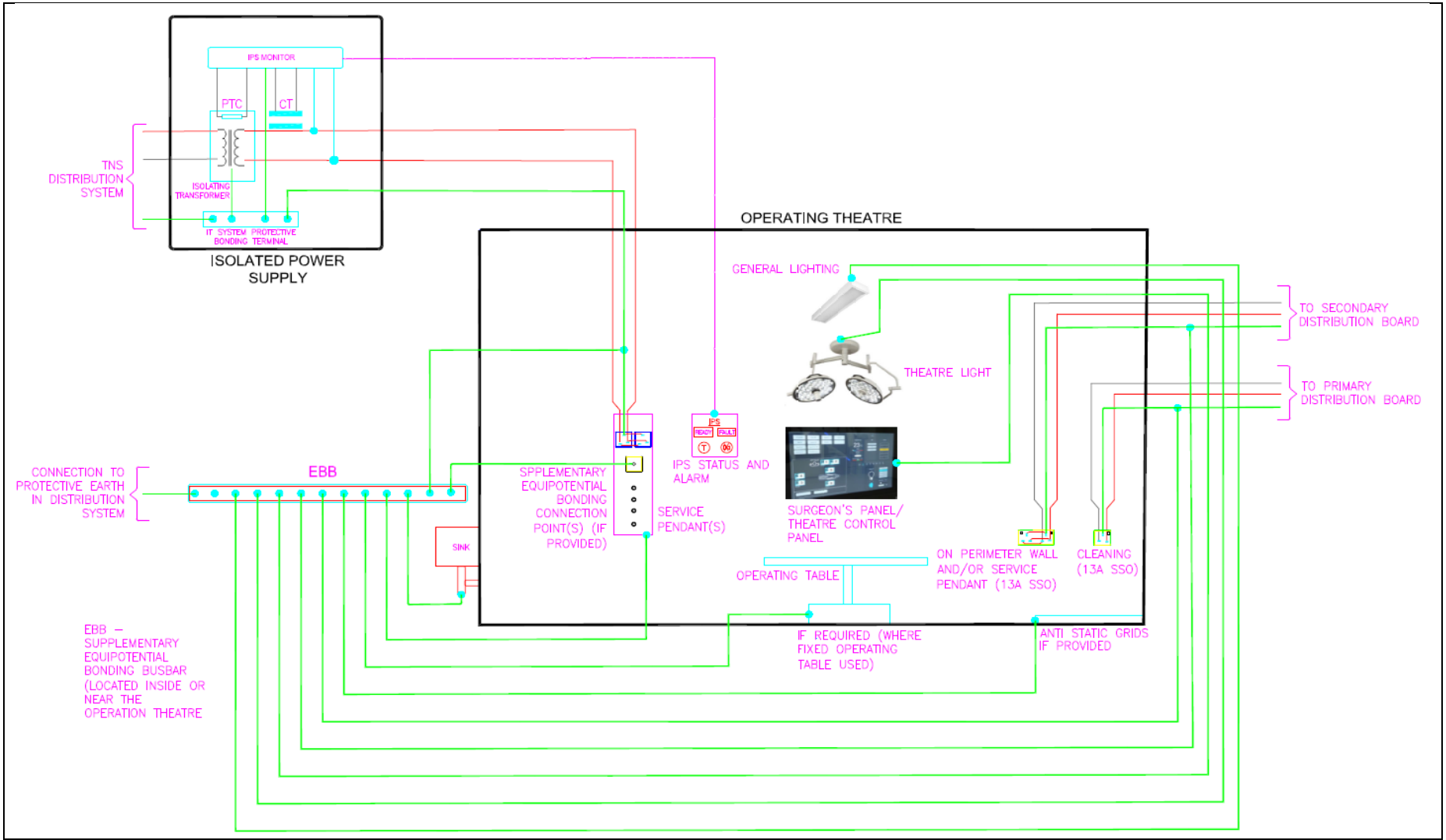

Figure E.3.2 Typical earthing arrangement for an operating theatre

3.13 Lightning protection

1. Lighting protection system for healthcare facilities to be designed based on IEC 62305.
2. The class of lighting protection required for the facility to be determined by the designer based on IEC 62305 Part 2.
3. Surge protection devices to eb provided at the incomer of each main distribution boards (MDB).
4. Special consideration to be given for protection of electronic devices and medical equipment within healthcare facilities for damages from lighting strike. Surge protection devices (SPDs) shall be provided for submain electrical branch circuits serving critical medical and communication equipment. The surge protection device to be carefully selected based on the surge protection environment (defined in IEC 62305) in which it is located.

3.14 Containment and cables

1. Power supply distribution cables serving life safety equipment such as fire pumps, firefighting lifts and smoke management systems shall be fire proof as per local civil defence requirement, while SPS cables serving medical equipment other than life safety systems shall be same type of cables as used for PPS.
2. Wiring cables and power cables used in healthcare facilities shall be with LS0H insulation. Armoured power cables installed outdoor or buried underground shall be with PVC outer sheath.
3. Separate cable containment for PPS, SPS and TPS distribution is required for clinical risk grade A and B areas.
4. Isolated power supply (IPS) final circuits shall be provided with separate cable trunking and conduits.

5. Conduits used in clinical risk grade A and B areas are highly recommended to be of galvanized steel, while galvanized steel conduits are desirable in clinical grade areas C, D and E.
6. Separate containment to be provided for emergency lighting circuits.
7. Containment to be labelled suitably for ease of identification of services it carries.

3.15 Final circuits

1. Using of floor power outlet boxes in healthcare facilities shall be minimized due to housekeeping considerations. Where floor boxes are used in open public spaces, it shall be with stainless steel lid and suitable for wet mopping with lid in closed position.
2. Use of multi-plug extension cords are not permitted in healthcare facilities, as extension cords are prime cause for overloading of circuits and safety risks associated with it.
3. Primary (Normal) power supply sockets (13A) shall be identified with white rocker switches. Faceplate shall be either plastic or metal. Plastic faceplates shall be white coloured with white rocker switch. Where metal face plates are used, the rocker switch to be of similar colour as that of faceplate.
4. Secondary (Emergency) power supply sockets (13A) shall be identified with red rocker switches. Faceplate shall be either plastic or metal. Plastic faceplate shall be white coloured with red rocker switch. Where metal face plates are used, the rocker switch to be red.
5. UPS power supply sockets (13A) shall be identified with blue rocker switches. Faceplate shall be either plastic or metal. Plastic faceplate shall be white coloured with blue rocker switch. Where metal face plates are used the rocker switch to be blue.
6. Edges of Light switches and socket outlets shall be suitability spaced away from the medical gas outlets at any location so that medical gas outlet accessories do not obstruct the socket outlets.

7. USB charging sockets integrated with 13A socket outlets shall not be used in healthcare facilities. Where USB charging points are to be provided in public areas it shall be separate charging stations plugged into standard 13A sockets.
8. 13A Socket outlets indented for mobile x-ray machines in operating theatre shall not be fed from IPS, but from the primary or secondary power supply branch.
9. UPS backup shall be provided for operating theatre surgical lights.
10. UPS backup shall be provided for Operating Theatre IT equipment and Theatre Control Panel.
11. Socket outlets intended for highly sensitive medical equipment such as automated medication cabinets shall be provided with dedicated circuits.
12. All power outlets to be clearly labelled with respective final circuit reference.

3.16 Lighting

1. While designing healthcare lighting, follow detailed recommendations given in CIBSE Lighting Guide 2: Hospitals and healthcare buildings,2008 or later version, by The Society of Light and Lighting.
2. It is recommended that lighting circuits serving Group 2 medical locations are protected by RCD or RCBOs with an earth leakage sensitively of 30mA.
3. Lighting circuits shall not be connected to IPS circuits.
4. Night time orientation lights, mounted low level on wall, are recommend in patient bed rooms. These lights should be operable from patient location and from main door to the patient bed room.
5. In many clinical locations varying levels of lighting is required. Careful consideration shall be given to proposed clinical function of the area while determining the lighting control

approach and design of the switching circuits. It is always advisable to employ two switching circuits in any rooms having more than two light fixtures.

6. Follow CIBSE LG2 Table 1 for recommendations on lighting levels, colour rendering index, lighting control and standby lighting requirement.
7. Standby lighting (normal lighting backed up by SPS) shall be provided for all clinical risk grade areas A, B and C.
8. Clinical risk area Grade A shall be provided with Grade A standby lighting. (100% Luminaires supplied from SPS branch)
9. Clinical risk area Grade B and C shall be provided with Grade B standby lighting. (Around 50% Luminaires supplied from SPS branch)
10. Luminaire selections to be complementing the ceiling integrity in relation to infection control; detailed recommendations given under CIBSE Lighting Guide 2 to be adhered with.
11. Life safety emergency lighting to be provided based on local fire code.
12. Recommended illumination levels, colour rendering index, method of lighting control and grade of backup lighting is summarised in table

Room/Function	**Illuminance (Lux)**	**Colour Rendering Index (%)**	**Recommended Lighting Control Method***	**Lighting Grade (Section 3.16.8,9)**
Emergency Unit				
Admissions/Reception	300	80	N	B
Stores	300	80	N/AL	A
Treatment Area	500	80	N	B
Minor Operation	500(15000 / 30000 Local)	90	N	B

Room/Function	Illuminance (Lux)	Colour Rendering Index (%)	Recommended Lighting Control Method*	Lighting Grade (Section 3.16.8,9)
Triage	500	90	N	A
Plaster Room	500	80	N	B
Procedure Room	500 (15000 / 30000 Local)	90	N	A
Resuscitation Room/Bay	500	80	N	B
Common and Circulation Areas				
Corridors (General)	200	80	S/AL	B
Entrance Canopy	50 (Min)	80	S/AL	B
Entrance Lobby	200 (Min)	80	S/AL	B
Library	300	80	S/AL	—
Lift Car	150	80	-	—
Lift Lobby	200 (Min)	80	S/AL	B
Loading Bay	100	80	S/AL	—
Reception Area	300	80	S/AL	B
Overnight Stay	150	80	S/AL	—
Lounge	150	80	S/AL	—
Shop/Kiosk	300	80	S/AL	—
Storage (General)	200	80	N/AL	—
Toilets	200	80	N/AL	—
Changing Room, Lockers	100–150	80	N/AL	—
Prayer Rooms	75-100	80	N/AL	—
Tutorial Room	300	80	N/AL	—

Room/Function	Illuminance (Lux)	Colour Rendering Index (%)	Recommended Lighting Control Method*	Lighting Grade (Section 3.16.8,9)
Consult/Exam Room	300	80	N	B
Disposal (Clinical, Domestic Waste)	200	80	N/AL	—
Doctor's Office	500	80	N/AL	B
Medication Room	500	80	N/AL	B
General Office	300	80	N/AL	B
Seminar Room	300	80	S/AL	B
Staff Change	100	80	N/AL	—
Staff Room	50/200	90	N/AL	—
Clean Utility	150	80	N	B
Dirty Utility	200	80	N	B
Critical Care				
Critical Care (Night)	5 (Max)	80	N/S	B
Observation/Night Watch	20	80	N/S	B
High Dependency Unit (HDU)	100	80	N/S	A
Intensive Care Unit (ICU)	100	80	N/S	A
Night Light	5 To 10	80	N	A
Simple Observation /Examination	300	80	N/S	A
Examination	1000 (Local)	90	N	A
Sterile Supply Unit (SSU)				
Decontamination and	500 (Local)	80	N	A/B

Room/Function	Illuminance (Lux)	Colour Rendering Index (%)	Recommended Lighting Control Method*	Lighting Grade (Section 3.16.8,9)
loading				
Maintenance (Including Rear of Cleaning Units)	200	80	N	—
Sterile Storage	150	80	N	—
Packing Area	500	80	N	B
Dental Unit				
Laboratories	500	80	N	B
Reception/Administration Areas	300	80	N/S	B
Dental Surgeries	8000 To 20000	90	N/S	A
White Teeth Matching	5000	90	N	B
Laboratory				
Aseptic Laboratory	300	80	N	B
Blood Bank	300	80	N	A
Colour Inspection	1000 (Local)	90	N/V	A
Cold Rooms	200	80	N	B
Inspection	500 (Local)	80	N	A/B
Laboratories	500	80	N	A/B
Relatives' Waiting Room	300	80	N/S	B
Seminar Room	300	80	N/S/V	B
General Treatment Areas				
Dialysis	500	80	N/V	B
General Storage Areas	200	80	N/AL	—

Room/Function	Illuminance (Lux)	Colour Rendering Index (%)	Recommended Lighting Control Method*	Lighting Grade (Section 3.16.8,9)
Teaching Areas	300	80	N	—
Administration (Medical Records)	500	80	N	—
Pharmacy	500	80	N	A/B
Morgue				
Autopsy Table	5000	90	N	—
Autopsy Rooms General	500	90	N	—
Body Holding Room	200	80	N	B
General	300	80	Sp	—
Staff Change	100 To 150	80	N	B
Store Room	150	80	N	—
Viewing Room	50/100	80	S/V	B
Waiting Room	200 (Min)	80	N/S	B
Linen Holding Unit				
Linen Store (Linen Department)	100	80	N	—
Pack and Dispatch	300	80	N	A
Pressing	300	80	N	A
Sewing Room	500 (Local)	80	N	A
Laundry	300	80	N	A
Delivery Unit				
Applying Sutures	1000 (Local)	90	N	A
Circulation Space (Day)	100	80	N	B

Room/Function	Illuminance (Lux)	Colour Rendering Index (%)	Recommended Lighting Control Method*	Lighting Grade (Section 3.16.8,9)
Delivery	500	80	N/S	A
Circulation Space (Day)	100	80	N	B
Day	50 To 100	80	N	A
Night	5	80	N	A
Nurseries (Day)	100	80	N	B
Nurseries (Night)	5	80	N	B
Formula Room	300	80	N	B
Special Care Baby Unit	1000 Local	80	N	A
Staff Station				
Day	300	80	N/S	A
Night	30/200	80	N/S	A
Interview	300	80	N	B
Operating Rooms				
Anaesthesia Induction Room	1000 (Local)	80	N	A
Anaesthesia Induction Room	500	80	S	A
Angiography Procedure Room	500	80	S/V	A
Endoscopy Procedure Room	300	80	S/V	B
Operating Room	1000	90	S/V	A
Operating Table/Cavity	10000 to 100000	90	S/V	A

Room/Function	Illuminance (Lux)	Colour Rendering Index (%)	Recommended Lighting Control Method*	Lighting Grade (Section 3.16.8,9)
Recovery – Stage 1	500	90	N/S	A
Scrub	500	80	N	B
Clean Utility	100 To 150	80	N	B
Dirty Utility	100 To 150	80	N	B
Allied Health				
Gymnasium	300	80	N/S	—
Hydrotherapy Pool	200	80	N	A
Physiotherapy	200	80	N/S	—
Rehabilitation	200	80	N/S	B
Ophthalmology				
Consult Room	300	80	S/V	B
Examination of Outer Eye	1000 Local	80	N	—
Reading/Colour Vision Test Screen	300	90	N	—
Vision Test Area	100 (Max)	80	S	—
Outpatient Unit				
Consult/Exam Room	300	80	N	B
Treatment Room	500	80	N	B
Medical Imaging / Interventional Cardiology / Nuclear Medicine				
Angiography	300	80	N/V	A
CT/MRI Scanning Rooms	300	80	N/V	A
ECG	300	80	N/S	A
Electro-Medical	300	80	N/S	A

Room/Function	Illuminance (Lux)	Colour Rendering Index (%)	Recommended Lighting Control Method*	Lighting Grade (Section 3.16.8,9)
Screening - Fluoroscopy	300	80	N/S	A
Isotope Store	300	80	N/S	B
Radiotherapy	100	80	N/V	A
Ultrasound	300	80	N/S	A
Mammography	500	80	N/V	A
X-Ray	300	80	N/S	B
Inpatient Unit				
Children's Play Area	300	80	N/AL	B
Circulation Space	100	80	N/S	B
Circulation Space (Night)	5	80	N/S	B
Treatment Room	1000 (Local)	90	S/V	A
Treatment Room	500 (General)	80	N/S	B
Staff Station				
Day	300	80	N/S	A
Night	30/200	80	N/S	A
Observation/Night Watch	20	80	N/S	B
Observation/Night	1 To 5	80	N/S	B
Mental Health Units	200	80	N/S	B
Patient Bed	300	80	N	B
Corridors (Day)	200	80	N/S/AL	B
Corridors (Night)	50	80	N/S/AL	B

Room/Function	Illuminance (Lux)	Colour Rendering Index (%)	Recommended Lighting Control Method*	Lighting Grade (Section 3.16.8,9)
* LIGHITNG CONTROL N – Conventional On/Off Switching S – Multilevel switching with ability to control the lighting level in the room by selective On / Off switching of groups of luminaires V – Variable lighting output from luminaires AL – Automatic lighting control for energy saving				

Table E.3.3 Recommended Illumination Levels

3.17 System Testing, Commissioning and Operation

Equipment commissioning is an important phase in the project timeline and is critical in confirming that the design parameters are met by the installed system and the system meets the minimum code requirements and commissioned as per manufacturer recommendations.

For medium to large scale healthcare facilities an independent commissioning agent should be employed by the facility owner/client to oversee and integrate the commissioning process.

The following points should be kept in mind while preparing for commissioning of the systems for healthcare facilities.

1. Method Statements
2. Testing and Commissioning plan
3. Testing and commission shall be carried out by respective system manufacture's trained and authorized represented.
4. All testing and commissioning records to be included in the O&M documents. It is highly recommended that an online solution is deployed for O&M documentation for ease of retrieval and reference.

5. Routine testing of backup generators and UPS to be conducted at every 30 days or recommended by the manufacturer (whichever is shorter), and results recorded for verification during DHA inspections.
6. Training on the equipment installed should be conducted by the authorized representatives of original equipment manufacturer.
7. Routine maintained activities shall be carried out as per the respective system manufacturer's recommendation and easily retrievable records are maintained in the facility. Deployment of online software-based facility management solutions incorporating necessary maintenance modules are highly recommended, depending upon the nature of the facility.
8. Refer to DEWA regulation section 1.13 with respect to detailed requirement on routine inspection and maintenance of electrical distribution equipment. These requirements to be strictly adhered to and records shall be available in the facility for routine verification by DHA.
9. All critical system malfunctions to be monitored and all such events to be recorded and archived.