

**State of Kuwait
Ministry of Health
Infection Control Directorate**

**Guidelines for Design of
Operating Theaters
2007**

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Introduction

In the past few years there has been an effort to renovate and build new specialty centers throughout Kuwait. Many of them involving the renovation and expansion of many operating theaters with the addition of new specialties which has created the necessity of national guidelines to build and renovate such facilities.

The number of operating rooms and recovery beds and the sizes of the service areas shall be based on the expected surgical load. In the programme, the size, location, and configuration of the surgical suit and support service departments shall reflect the projected volume of outpatient. This may be achieved by designing either an outpatient surgery facility, or a combined inpatient-outpatient surgical suit.

This design of a standard operating theater would include a reception area, a recovery bay for post operative patients and operating theater suites (according to the needs of the center) with provisions for endoscopy or plaster rooms or other special rooms required.

Facilities include individual theater storage and adequate areas for storing portable equipment such as X-ray machines, and stocks of disposable and sterile goods, offices, staff rest areas, changing rooms, seminar facilities, janitory room, dirty room and clean room.

Lay out of the operating theater

Important design considerations include the mix of inpatient and outpatient operations, patient flow, into and out of the operating room (OR) area, the transportation of supplies and waste materials to and from the OR, and flexibility to allow the incorporation of new technologies.

The operating theater should be zoned into aseptic and clean areas in addition to being separated from the outer areas (*Table 1*). This is to restrict access and maintain unidirectional movement.

An operating room suit design with a sterile core must provide for no cross traffic of staff and supplies from the decontaminated or soiled areas to the sterile or clean areas.

Table (1): Zones of the Operating Theater.

Zone	Barrier	Areas included
Dirty outer zone	Physical	Sluice, storage, waste disposal, outside corridor, changing rooms
Clean	Partial	Supply store, disinfection room, anesthetic room, recovery room.
Sterile core	Physical	Operating Room, sterile preparation.

The use of facilities outside the operating room for soiled / decontaminated processing, clean assembly or sterile processing shall be designed to move the flow of goods and personnel from clean/sterile to dirty without compromising universal precautions or aseptic techniques in both departments.

1. The dirty and outer zone:

This should contain:

- Main access corridor, reception and waiting area.
- An entrance to the changing facilities.
- Accessible area for the removal of waste(janitor area)
- Dirty utility room or soiled work room (sluice)

Main Access corridor, reception and waiting area:

- The entrance to the access corridor shall be electronically controlled allowing only authorized personnel access to the area (code operated or magnetic card).
- **The reception area** shall be a minimum of 52 square meters.
- Cultural issues should be taken into consideration such as separation of the male and female patient in reception areas.
- This area includes the checking of preoperative patients and a waiting area, divided by curtains to provide privacy for the individual patient. Each trolley space shall be serviced with oxygen and suctioning, preferably in wall panels.
- Twelve bed or trolley spaces shall be catered for an 8 theater department, the general rule being 1.5 bed spaces per theater, with the space allowed for the trolley or stretcher shall be a minimum of 2.1 x 1.6 meters with minimum clearance 1.2 meter on the sides of the trolley or stretcher.
- The transfer area shall be a minimum of 22 square meters.
- Provisions shall be made for the isolation of patients with infectious diseases.
- **A control station** should be located to permit visual observation by the nursing staff for all traffic in and out the suit.

Staff clothing change areas:

- Appropriate areas shall be provided for male and female personnel (cleaners, technicians, nurses, and doctors) working within the surgical suit.
- The areas shall contain lockers, showers, toilets, lavatories equipped for hand washing, and space for donning surgical attire.
- Showers are not recommended prior to start of the duty, however they are allowed after duty hours.
- These areas shall be arranged to encourage a one way traffic pattern so that personnel entering from outside the surgical suit can change and move directly into the surgical suit.

Dirty utility room or soiled work room (sluice):

- There shall be room to wash down trolleys, containers for dirty linen, rubbish and dirty instrument.
- The soiled workroom shall contain a flushing rim, drainer, a slop hopper or other provisions for disposal of liquid waste.
- The room shall not have direct connection with operating rooms or other sterile activity rooms.
- The soiled workroom shall contain a hand washing station, with hot and cold mixing faucet.
- The room shall have a work counter and space to separate covered containers for soiled linen and waste.

Janitor area (house keeping):

- House keeping facilities shall be provided for the exclusive use of the surgical suit
- It shall be directly accessible for the suit, shall contain hand washing station, and provision for storage of supplies and house keeping equipment.
- This room shall be separate from the clean workroom.

2. The clean zone:

This contains:

- The sterile supplies store.
- General purpose Storage area (for storage of stretchers, wheelchairs, patient transfer and carrying devices, etc.)
- Medication station.
- Anesthesia room.
- Sub-sterile area
- Recovery area.
- Scrubbing area.
- A clean corridor
- Clean utility room.
- Rest area and lounge for staff.

The sterile supplies store:

- Sterile supplies store: storage space for sterile and clean supplies should be adequate for the functional plan. The space should be moisture and temperature controlled and free from cross traffic.

General Purpose Store:

- Equipment storage room(for equipment and supplies): each surgical suit shall provide sufficient storage area to keep its corridor width free of equipment and supplies but not less than a total of 13.9 square meters or 4.65 square meters per operating room, which ever is greater.
- Storage areas for portable X-ray equipment, stretchers, fracture tables, warming devices auxiliary lamps etc. these areas shall be out of corridors and traffic.

Medication station:

- Provisions shall be made for storage and distribution of the drugs and routine medications used in the theater. This may be done from a medicine preparation room or unit.
- If used, a medicine preparation room or unit shall be under visual control of the nursing staff.
- It shall contain a work counter, sink, refrigerator and double locked storage for controlled substances.
- Hand washing station shall be provided.

Anesthesia room:

- There shall be built in cupboards and work benches, with a fitted stainless steel sink and drains. Racks that are enclosed in cupboards with glass panels shall be provided for anesthetic tubing and storage for equipment.
- Safety drug cupboards shall be installed and service panels fitted to the wall.
- All surfaces shall be hard wearing and washable. Wood must not be used.
- Free standing equipment shall include anesthetic machine, monitor, and defibrillator.
- The anesthesia work room for cleaning, testing, and storing anesthesia equipment shall contain work counters, sinks, and racks for cylinders.
- Provisions shall be made for separate storage of clean and soiled items.
- In new construction, depending on the functional and programs, the anesthesia work room should provide space for anesthesia case carts, and other anesthesia equipments.
- The room shall be a minimum of 12 - 16 square meter

Sub-sterile area:

It acts as a service area between 2 or more operating or procedure rooms and should be equipped with flash sterilizer (for immediate or emergency use only), warming cabinet, sterile supply storage area and hand washing station.

Recovery Area:

- Recovery area shall be a minimum of 110 square meters
- This area works on 1.5-2 beds per theater and includes nursing stations, and clean utility area of 10 square meters and a dirty utility room of 10 square meters.
- Each bed or recovery space shall be 2.40 square meters.
- Each bed space shall be cubical with curtains and shall have service pendants or wall panels at the head of each bed.
- Services shall include suction, oxygen, air and electricity points.
- A monitor shall be available for each bed and access to defibrillators and respirators.
- There shall be hand washing basin between two trolleys
- There shall be an examination light over each bed space.
- There shall be two sets of exit doors, one set leaving to the main hospital wards, and the other set directly into the intensive care unit.
- The connecting door to the intensive care unit should be through the clean corridor, passing through a changing room where personnel are required to change into clean surgical attire before entering the operating theater

Scrubbing area:

- Scrub room shall be approximately 9.25 square meters. Facilities must include a scrub sink for at least 3 people, with hands free operable controls. There shall be a glove and gown bench or trolley separated from the sink.
- Scrub position shall be provided near the entrance to each operating room.
- Scrub facilities should be arranged to minimize incidental splatter on near by personnel, medical equipment or supply carts.
- View windows at scrub stations permitting observation of room interiors should be provided.

Scrub sinks:

- Scrub sink used for surgical scrubbing must be of cleanable and disinfectable material such as stainless steel.
- The sink should have rounded corners to allow easy cleaning and prevent accumulation of water and bacteria.
- Hands free operation is a must, for example elbow operated or electronic sensors.
- High side panels to control splash are preferred.
- The water source should be at high enough level not to come in contact with the scrubbing person's arm during the procedure of scrubbing and not far from the edge so that the scrubbing person does not lean on the edge of the sink and contaminate his clothing.
- Knee operated sinks are not preferred because of the contact with the surgeon's clothing.
- Surgical scrub solution shall be dispensed with hands free apparatus.
- Scrubbing up room shall have a clearly identified timer or clock for timing of the scrubbing procedure. This may also be an electronic timer.
- Course filters shall be installed to filter the water used in scrubbing room

Clean work room (Clean utility room):

- This room should not be used for food preparation
- A clean work room is required when clean materials are assembled within the surgical suit prior to use
- It shall contain a work counter, a hand washing station and storage facilities for clean supplies

Rest area , lounge for staff, report preparation area, and toilet facilities:

- Separate or combined lounge for male and female staff shall be provided. Lounge shall be designed to minimize the need to leave the suit and to provide convenient access to the recovery room.
- These lounges may contain furniture for rest, area for food and drinks preparation, T V, computer, fridge and toilet with hand washing facilities.
- The furniture should be easily washable and non dust forming or collecting. Wooden furniture is not allowed inside the theater suit.
- Report preparation area shall be provided and shall be accessible from the lounge area.
- **A supervisor's offices or stations and teaching areas:** the number of these offices depends on the functional program of the operative suite.

Other Service Areas:

- **Medical gas storage facilities** should provide additional separate storage of reserve gas cylinders necessary to complete at least one day procedures and must comply with rules of national fire authority
- **Area for preparation and examination of frozen sections**, it may be a part of general laboratory if immediate results are obtainable without unnecessary delay in completion of surgery
- **Area for refrigerated blood bank storage** that meet standards of blood banking
- **Area for refrigeration facilities for harvested organs**
- **Area for pathology specimens** storage prior transport
- **Ice machine** should be provided from self dispensing ice makers to provide ice for treatment and patient use.

3. Sterile Core:

- The restricted area of the operating suit includes: operating and procedure rooms
- In this area surgical attire and hair coverings are required.
- Masks are required where open sterile supplies or scrubbed persons may be located
- Signs shall clearly indicate the surgical attire required in each area.

Measurements:

- The operating theater should be a quadrangular room with a minimum clear area of 36 square meters, 6 x 6 meters, exclusive of fixed or wall mounted cabinets and built in shelves, with a minimum 6meters clear dimension between fixed cabinet and built in shelves and a system for emergency communication with the surgical suit control station. Ceiling height should be a minimum of 3.2 meters. In addition 1-2 feet of ceiling height may be needed if radiology equipment is to be permanently mounted.
- Theater may be larger depending on the requirement; rooms for cardiovascular, orthopedic, neurological and other special procedures that require additional personnel and/or large equipment, when included this room shall have in addition to the above a minimum clear are of 56 square meters with a minimum of 6 meter clear dimension exclusive of fixed or wall mounted cabinets and built in shelves.
- When open heart surgery is performed an additional room in the restricted area of the surgical suit preferably adjoining this operating room shall be designated as a pump room where extracorporeal pumps, supplies and accessories are stored and serviced.
- When complex orthopedic and neurosurgical surgeries are performed, additional room shall be in the restricted area of the surgical suit. Preferably adjoining the specialty operating room which shall be designated as equipment storage room for the large equipment used to support these procedures.
- Endoscopy theaters and plaster rooms may be smaller than the standard size. There shall be provision for an operating table, shadowless theater light surface pendants, panels and at least 4 fitted X-ray film illuminators. There shall be room for the various pieces of mobile equipment required such as trolleys, swab racks, and kick buckets, and machinery such as diathermy, ECG monitors, defibrillators, and mobile X-ray machines

- Provision shall be made for appropriate clear space, mechanical facilities and electrical connections to accommodate the special functions of the above mentioned rooms.

General issues:

- Glass fronted cupboards for storing various small items required during surgery for example, needles and dressing tapes, shall be built into the walls. This prevents dust collecting on top of cupboards which are wall mounted. Non glare, see through glass doors of cupboards shall be trimmed with stainless steel , which make the door lie flush with the wall when closed. There shall be a minimum of joints in the frame and the cupboard shall be designed to ensure adequate cleaning.
- All storage shall be at a height which is easily accessible.
- X-ray screens and service pendants shall be built into the wall so that they are flush, to insure ease and efficiency of cleaning and minimize the risk of dust collection and infection.
- There shall be provision for two X-ray electrical sockets and 6 twin electrical outlets in addition to service pendants and service wall panels
- Windows must not be built in the sterile area but only in the dirty zone and should contain a filter for not allowing insect inside the theatre
- It is advisable to consider future medical advances when designing an operating theater although it is considered less cumbersome to have equipment built into the walls, to lessen the problem of dust collection and infection, items such as monitors should be free standing, as development in their efficiency may make them smaller and more compact.

Specific requirements

Walls:

- Walls are to be painted with seamless coating material which is bacteriostatic and can tolerate washing with detergents and disinfectants without deterioration of surface bonding (Epoxy - acrylic resin)
- Walls in operative rooms (instead of painting) could be covered with full height 1.5 mm thick flexible vinyl sheeting welded to antistatic floor with round skirting level
- Walls in anesthesia, scrubbing and recovery rooms (instead of painting) may be coated with flexible vinyl up to the level of 1.2 meters.
- Walls must be smooth without cracks, seams, open joints, crevices or dividers which harbor dust, insects or bacteria and all cut edges should be tapered to the wall to prevent collection of dust
- Walls must be scratch resistant , withstanding wear and tear with fixed smooth trolley height wall protectors along corridors and exit areas
- Wall surfaces should be hard and resist impact, impermeable , stain proof and easy to clean
- Around sinks and washbasins there should be ceramic tile splash back adequately bonded with smooth water proof type of grout
- Walls penetrated by pipes ,ducts and conduits should be tightly sealed to minimize entry of insects and rodents

Floors:

- Throughout the operating theater suite (the theater, anesthesia room, scrubbing-up room and recovery room). The flooring should be 2-5 mm thick flexible, antistatic vinyl sheet. Welded at the seams, to provide a safe continuous water proof surface.
- The antistatic vinyl sheeting should be covered up the wall, to form a 100-150 mm skirting.
- All corners shall be rounded slightly to prevent the harboring of dust and bacteria, and there shall be no cracks or crevices at the seams or at the walls, which may allow pests such as ants and cockroaches into these clean areas.

Ceiling:

- Ceiling shall be smooth, nonporous, scrubbable, non-perforated, without cervices or seams and capable of withstanding harsh chemicals
- Ceiling shall be easily cleanable, non-friable and monolithic.
- Cracks or perforations in these ceilings are not allowed.
- The minimum ceiling height shall be 2.4 meters, with the following exceptions:
 - 1-Ceiling in operating, delivery rooms and other rooms containing ceiling mounted surgical light fixtures shall be of sufficient height to accommodate the equipments or fixtures and their normal movement (see measurements for OR, page 10)
 - 2- Ceiling in corridors, storage rooms and toilet rooms shall be not less than 2.35 meters.
- Equipment rooms and similar spaces where impact noise may be generated shall not be located directly over delivery and operating suit.

Doors:

- There shall be double door from the anesthetic room into the theater, and from the theater through the exit lobby, at least 1.5 meter in width
- Other doors to and from the dirty utility rooms and the scrub up room shall be a minimum of 1 meter in width.
- Doors should NOT be manufactures of wooden material.
- All doors shall have a small, high window and shall be electronically operated.
- Doors should be made of washable material which can tolerate washing with detergents and disinfectants.

Illumination:

- Operating and delivery rooms shall have general lighting in addition to special lighting units provided at surgical and obstetrical tables.
- General lighting and special lighting shall be on separate circuits.
- Lighting should be bright and evenly light spaces.
- Lamps should render colors natural.
- Lamp surfaces should be easy to clean and not collect dust.
- Fixtures should limit glare or any other undesirable reflections and direct view of lamps.

Operating room lights:

- Optimal illumination in the surgical field is essential, especially during precise surgical procedures .A wide range of surgical lights are available and should be closely matched to the needs of the procedures to be performed. Specific considerations include the intensity of the light, the size of the illuminated field ,the production of heat and shadows, and the maneuverability of the lamps .
- A common model consists of a single lamp placed in the center of a concave reflective shell, each aligned at a slightly different angle to widen the illuminated area and minimize shadows. The diameter, shape, and composition of the concave reflective surface determine the focus depth, as well as the shadows and glare produced . Models equipped with focus adjustment to help sharpen the intensity of the illumination are available.
- In addition to field size and illumination, maneuverability is a vital consideration. Ceiling-mounted tract lighting provides the greatest range of motion, with as much as 360degrees flexibility and it fully illuminates the head and feet. Ceiling-mounted fixed units are most commonly used. They should be situated over the table to illuminate the largest field possible. All lights should be equipped with handles to allow the staff to position them during the procedure. These handles should be capable of being sterilized. Disposable sterile handle covers are available from most manufacturers.
- The range of movement over the operating table shall consist of a diameter of 3.5 meters, with the center of the table as the center of the circle. The normal height from the ground shall be 2.06 meters, but shall also be capable of a height not less than 1.5 meters. The light shall be capable of a 360 degree rotation .It shall be completely stable when positioned.
- The light shall have focus and dimming control, but it is preferable for the dimmer not to be positioned on the light.
- It shall be possible for a failsafe mechanism to be incorporated into the theater light, so that if one lamp fails then there is a second lamp which gives sufficient light to continue work. This second lamp shall give a minimum of 50% intensity of the first lamp.
- A tungsten lamp of at least 24 volts is usual .The light shall not cause shadows and shall be sufficient to see clearly into a deep wound. The intensity of the light shall be between 1000 and 3000 lumens/sq foot, according to the personal preference of the surgeon.
- The external surfaces of surgical luminaries shall be antistatic, and not attract dust particles. The theater light and the fittings shall be capable of easy cleaning and maintenance.
- The luminaries shall not be capable of transmitting heat in a down ward direction, which may dry the tissues in the wound and over heat the surgical team. Provision shall be made for the heat generated by the lamps to be expelled over from the center of the operating field.

Table (2): recommended illumination levels in each room

	I luminance (Foot-candles)
Surgical suite	
Operating room , general	150-200
Operating table	Task lighting as required
Scrub general	75
Clean up room, instruments	50
Anesthesia storage	30
Sub-sterile room	30
Toilets/ bathing	
General(Includes water closets , shower/tub)	30
Night lighting	3
Utility room (clean and soiled)	
General	30
Work counter	50
Stairways	20
Storage rooms	20
Obstetric delivery suite	
Scrub , general	75
Operating room	150-200
Delivery table	Task lighting as required
Post-delivery recovery area	75
Sub-sterilizing room	30
Janitor closet	20
Locker rooms	20
Corridors	
Day	20
Night	10

Air supply:

The air supply to each operating theater suit should be independent, so that it can be switched off and maintained without affecting the entire theater complex. If this is not feasible, each unit should supply no more than two separate suits.

Types of air supply:

Air is supplied to the operating theater by:

1- Plenum *Ventilation (conventional):*

This is the most frequently used system in general purpose operating rooms.

2- Laminar flow ventilation:

The laminar flow is usually used in specialized orthopedic units and cardiothoracic units, often in conjunction with sophisticated closed. This system is unidirectional and delivers air flows over the operating table of 300 air changes per hour and a bacterial count of 10 (BCP) or less per cubic meter at wound site. Laminar flow may be delivered vertically or horizontally; the former is preferable.

Design features :

- **Air changes**
 - Maintenance of 20 -24 changes per hour, of which at least 5 should be fresh air from outside. Approximately 80% of the air in the room is recycled through a canopy over the operating table and passes through a 5 μ m filter.

- **Filtration**
 - Filter all air with prefilter followed by final filter (two – stage filtering). Air is drawn in from the atmosphere and passes through a 5 μ m filter to 95 percent efficiency coarse filter to remove dust and debris is installed after the atmospheric air has been drawn into the air handling unit (AHU).
 - Before the air is delivered to the operating site it passes through a high efficiency particulate air (HEPA) filter with a 0.3 μ m filter and a 99.97% efficiency which removes bacterial contamination.
 - The air is introduced at the ceiling and exhausted near the floor.
 - Exhaust system in the corridors and the sluice room then removes the air to the atmosphere outside. Regular service and maintenance of the ventilation plant is essential, the filter should be changed at least twice per year or more as determined by the atmospheric conditions e.g. high dust or pollution.

- **Flow**
 - There should not be reversal of air flows when exits are opened nor any leakage through the seals around the doors and windows when they are closed.

- **Pressure**
 - Differential pressure shall be a minimum of 2.5 Pa between different areas in the OT to ensure air flow as recommended in Table 3..

Table (3): Recommended specifications of Air Supply in different areas of the OT.

Area designation	Air movement relationship to adjacent area	Minimum air change of outdoor air per hour	Minimum total air change per hour	All air exhausted to outdoors	Re-circulated by means of room units	Relative humidity %	Design temperature
Operating rooms/ delivery room	Out	3	20	-	No	50-65	20-23C 68-73F
Recovery room	-	2	12	-	No	50-65	21-24C 70-75F
Critical and intensive care	-	2	12	-	No	50-65	21-24C 70-75F
Anesthesia Gas storage	In	-	15	Yes	No	-	-
Janitor room	In	-	10	Yes	No	-	-
Bathroom	In	-	10	-	-	-	24C 75F
Clean linen storage	Out	-	2	-	-	-	-
Dirty corridor/ dirty room	In	-	10	Yes	No	-	-

If any maintenance activities involving the air supply system in the operating theater, the infection control department should be informed and any work in the theater area should only resumed with the permission of infection control department after the collection of the appropriate environmental samples.

- **Temperature and humidity:**

- Temperature and humidity control is essential with an air conditioning unit attached to a monitoring system to carefully regulate both temperature and humidity.
 - It is preferred to have a system with the facility to print out and record the parameters in the sterile core.
 - Special air conditioning and voltage regulation shall be provided.
 - Temperature shall be maintained between 20-23 degree centigrade (68-73 F) in the operating room with relative humidity should have a minimum 50% - 65% with 55% being the average recommended . The higher the humidity the higher the chance of a electronic sparks developing.
 - Humidifiers shall not permit the growth and multiplication of microorganisms.
- The operating room should 1°C cooler then the outer area

Scavenging system:

- A scavenging system captures and exhausts waste gases to minimize the exposure of the operating room staff to harmful anesthetic agents. Scavenging systems remove gas by a vacuum or a passive exhaust system or both. Vacuum scavengers use the suction from an operating room vacuum wall outlet or a dedicated vacuum system. To prevent positive or negative pressure in the vacuum system from affecting the pressure in the patient circuits, manifold-type vacuum scavengers use one or more positive or negative pressure relief valves in an interface with the anesthesia system. In contrast, open – type vacuum scavengers have vacuum ports that are open to the atmosphere through some type of reservoir; such units do not require valves for pressure relief. Passive exhaust scavengers can vent into a hospital ventilation system (if the system is the non-re-circulating type) or, preferably, into a dedicated exhaust system. The slight pressure of the waste gas discharge from the anesthesia machine forces gas through large-bore tubing and into the disposal system or directly into the atmosphere.
- The NIOSH (National Institute of Occupational Safety and Health) recommended exposure limit (REL) for N₂O is 25 ppm as a time-weighted average (TWA) during the period of anesthetic administration .This REL is intended to prevent decreases in mental performance, audiovisual ability, and manual dexterity during exposures to N₂O.
- N₂O should be monitored when the anesthetic equipment is installed and every 3 months thereafter
- Connection ports with different-diameter hoses for N₂O and O₂ should be used to reduce the possibility of incorrectly connecting the gas delivery and scavenging hoses.
- All rubber hoses, connections, tubing, and breathing bags should be checked daily and replaced when damaged or when recommended by the manufacturer
- The scavenging system exhaust rates (flow rates) shall be approximately 50 liters per minute (L/min) to minimize leakage of N₂O.

Gas and suction system:

- Gas and suction outlets should be self sealed when not in use
- Outlets from different gases should have non interchangeable connections , for fear of giving wrong gas during anesthesia
- Filters on air and gas supplies should be capable of removing all particles larger than 5 microns
- Standardizing the position of gas outlets throughout the hospital to ensure that accidents cannot occur so outlets should supply oxygen, air, suction and nitrous oxide provided in that order from left to right
- Portable anesthesia machine should provide 1 oxygen, 1 air, 1 suction and one nitrous oxide gas outlet in the anesthetic room
- There must be 3 suction outlets per room for operative rooms and 3 outlet per bed in recovery room

Water supply:

- Hot and cold water supply at sufficient pressure should be piped to most areas of theater to operate all fixtures and equipments during maximum demand
- Hot water should be at maximum temp 65 degree centigrade
- Supply capacity for hot and cold water piping should be determined on the basis of fixture units using recognized engineering standards
- Each water service main , branch main , riser and branch to a group of fixtures ,should have valves and stop valves should provide for each fixture and appropriate panel for access should be provided at all valves where required
- Filtered water may be provided for drinking
- Drainage system for water sinks should be adequate and efficient
- General piping requirements: from inert material, clean joining, no erosions, not enhancing microorganism growth, smooth with no cracks or crevices , non porous, and have no dead legs (should have continues flow)
- Common piping materials:
 - 1- stainless steel
 - 2- aluminum
 - 3- PVC or CPVC

Drainage system:

- Drainage piping shall not be installed within the ceiling or exposed in operating, delivery rooms, central services, and electronic data processing area.
- Floor drains are not to be installed in operating and delivery rooms.

Communication:

- Telephones can be positioned in anesthesia or laying up room and telephone should be silent and have light indicator for urgent messages
- Ringing phones or telecom are permitted in offices ,rest area, reception area, nurse station at recovery bay
- Telecom can be installed for communication between operating theater and laboratory, reception and other rooms

Electricity:

- Service pendants for electricity may be used for plugging in the anesthetic machine, monitoring equipment or to provide power for the diathermy.
- It is much safer for wiring to be plugged in at a height, to prevent personnel tripping over the wires and disconnecting vital equipment.
- All electrical points shall be capable of giving sufficient power for many varieties of machinery.
- Transformers shall be provided to protect the delicate machinery from sudden surges of power.
- All electrical points in the operating theatre suite shall be serviced by the emergency power system. There shall be no more than 10 second transfer of power supply.

Safety requirements

Fire Alarm:

- A single state fire alarm system shall be provided throughout the building.
- The fire alarm system shall be designed and installed in accordance with the requirements of National Fire Standard
- Heat detectors shall be installed in the following areas:
 - I. Storage rooms,
 - II. Mechanical equipment and service rooms,
 - III. Janitor closets.
- Smoke detectors shall be installed in corridors, at top of each exit stair shaft, in every holding room
- Smoke alarms shall be installed with permanent connections to an electrical circuit and shall have no disconnect switches between the over-current device and the smoke alarm.
- It is not recommended to have water sprinklers in the theatre suite itself. Automatic heat sensing devices may be used, but in low occupancy areas such as stores, smoke detectors should be installed.
- Fire alarm signals shall be audible only at the reception desks and offices. Fire panels in the other areas shall have flashing lights and the location of the fire on the panel.
- If electromagnetic doors are used in the theatre suite, then there must be an automatic release for manual door opening.

Portable Fire Extinguishers:

- Multi-purpose fire extinguishers 5 Kg or equivalent capacity shall be provided and so located that the travel distance to an extinguisher does not exceed 15 m.
- Fire extinguishers shall be located so that they are not unduly exposed to fire hazards and where possible, at or near the exits from the building or room, and shall be mounted by means of wall attachments.
- Fire extinguishers shall be installed in accordance with the requirements of the National Fire Standards.

Emergency lighting:

- Power for emergency lighting systems shall be provided from either :
 - I. A generator, “Emergency Electrical Power Supply for Buildings or
 - II. Batteries “Unit Equipment for Emergency Lighting.”.
- The emergency lighting shall be provided to average levels of at least 10 lx at floor level in exits, corridors, principal routes providing access to exits, generator rooms, holding rooms, and traditional healing rooms.
- The emergency lighting system shall be provided to continuously supply power in the event that the regular power supply is interrupted and be so designed and installed that upon failure of the regular power it will assume the electrical load automatically for a period of not less than one hour.

Exit signs:

- Must have an illuminated sign with ‘EXIT’ above the door.
- Fire exits are located at the end of the main corridor leading to the outside.
- A continuous illuminated exit sign shall be provided in means of way out, over every exit door and over every way out from rooms with an occupant load greater than 30.

Emergency exit doors:

- As any other facility, emergency exit doors should be available in the operation theater for any possible emergency evacuation. However, during non- emergency situation, these doors must remain closed at all times. These doors are directly connected to the outside so they are in the dirty or outer zone.
- No emergency doors should be situated near the sterile operating theaters.
- All exit doors shall open in the direction of exit travel.
- Exit doors shall be clearly identifiable and no hangings or draperies shall be placed over emergency exit doors to conceal or obscure any exit.

References:

- Guidelines for design and construction of hospitals & health care facilities . AIA (American Institute of Architects), the facility guidelines institute, with assistance from US department of health and human services, 3rd edition Aug. 2002
- Standard specification for design of operating theaters and Intensive Care Unit. Directorate of Infection Control, Ministry of Health, Kuwait 2001.
- Fire safety requirements for health stations, health centers and nursing stations. Technical Committee of Health Care Facilities, Government of Canada Sep. 1999 (last modified Sep. 2003). Available from www.hrsdc.gc.ca/asp/gateway.asp
- Effective energy-efficient lighting for healthcare, Small commercial lighting program in New York State. Available from <http://sclp.lightingresearch.or/healthcareresources.asp>
- Controlling exposures to nitrous oxide during anesthesia administration, Anesthetic gases guidelines for work place exposures. NIOSH (National Institute of Safety and Occupational Health, USA) May, 2000.
- Plumbing design for health care facilities ,American Society of Plumbing Engineers , ASPE Plumbing engineering Design Hand book, volume 3. Available from www.ASPE.org/ASPE_publications
- Anesthesia gas scavenging system, Article by Carl Lawes , Available from www.ebme.co.uk.
- Introduction to scavenging, Anesthesia UK (An educational site with training resources for Anesthetic professionals) www.frca.co.uk
- Hospital Infection Control setting up with minimal resources, Shaheen Mehtar, Oxford University Press, 1992.
- General Principles of OR Design and Construction, ACS Surgery: Principles and Practice. Available from www.medscape.com/viewarticle/503005_2