
Republic of Zambia

# Upgrading Guidelines/Information of Health Facilities and Utilities

Ministry of Health

Republic of Zambia

March 2016

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Supported by Health Capital Investment Support Project (2015-2016, Extension Phase)
Japan International Cooperation Agency (JICA)

# FOREWORD

The Ministry of Health together with its partners realizes that efficient and effective delivery of clinical care is highly dependent on the availability of appropriately upgraded environment, which is in well facilitated space. Such facilities and utilities should always be properly designed, built, and maintained, so as to ensure efficient treatment in clean and safe from infection.

The main challenges in achieving this include the lack of, appropriate holistic and futuristic management plans, human resource for facility/utility management and maintenance, adequate budget funds for renovation/maintenance activities at all levels which means daily and long-term of facility maintenance plans and executions.

It is against this background that the Ministry with its partners Health Capital Investment Support Project (HCISP) through Japan International Co-operation Agency (JICA) embarked on drafting the “Upgrading Guidelines/Information of Health Facilities and Utilities”. It is hoped that the guidelines will help to standardise design of medical facilities and utilities country wide and result in efficient and effective establishment of these life-saving function.

It is expected that these guidelines will result in a planned and coordinated approach to new or renovated hospital design; dissemination and compliance with the established development policy and enhance capacities for medical service in higher level, through appropriate understanding, planning, design, construction, renovation, and maintenance of health facilities and utilities.

Dr.Peter Mwaba
**Permanent Secretary**
**Ministry of Health**

## ACKNOWLEDGMENTS

**The directorate of Policy and Planning would like to thank Ministry of Health in acknowledging all individuals and cooperating partners that made it possible for development and finalization of "Upgrading Guidelines/Information of Health Facilities and Utilities".**

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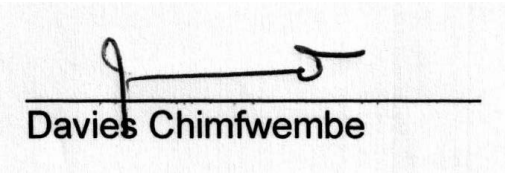


**Director, Policy and Planning**

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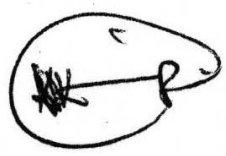


Dr. Kennedy Lishimpi

**Director, Clinical Care and Diagnostic Services**

Part A: Upgrading Guidelines for 2nd and 3rd Level Hospitals

Part B: Information for Health Facility Utility Planning

# Part A

# Information for Health Facility Utility Planning

# Part A

## Upgrading Guidelines for 2nd and 3rd Level Hospitals

- Table of Contents –

HOSPITAL PREMISES
(PHYSICAL FACILITY STANDARDS)

### Basic description



### Critical Parts of Hospital

Keys of Upgrading

## CHAPTER : PREMISES (PHYSICAL FACILITY STANDARDS)

### 1. Location of Provincial and National level Hospitals

1.1. Premises shall be located in a safe area with special attention to:

a) Size and shape of the site, topography, drainage, soil conditions, utilities available, natural features, orientation of the site (north, south, east, west), vegetation, trees and plantings
b) Availability of water (preferably year-round), power
c) Cost of acquiring the site and ownership of the site
d) Current or planned roads nearby and closeness to a village or community center (market or school), Ease of access for the population to be served
e) Potential methods of waste disposal
f) Cultural factors that may adversely affect utilization (for example, a site near a burial ground)
g) Risk of floods or earthquakes
h) The amount of room for expansion

1.2. The hospital should not be in same building with living premises, hotel, bar/restaurant, petrol stations, hair salon and other entertainment activities.

### 2. Construction Requirements

2.1. Layout

2.1.1. The site plan (layout) should establish the basis for both current and future development.

2.1.2. It must show all current and possible future elements including: compass points, direction of prevailing winds, property boundaries, scale, topography and contour lines, existing trees, rock outcroppings, streams, and other bodies of water, structures already on or adjacent to the site, roadways, paths, direction to the nearest village or community centre, traffic routes for vehicles and people on the site, parking and delivery areas, direction of future expansion, locations of ablution areas, water supply and sanitation, covered walkways and drainage of surface water.

2.1.3. The surrounding of the hospital must provide a suitable landscaping scheme to ensure that the outdoor spaces become pleasant areas for patients to view from their beds and in which patients, visitors and staff may relax.

2.1.4. Cultural consideration for layout in the land should be considered. Mortuary must have convenient access, while need to keep proper distance from residential facilities and inpatients wards.

2.2. Parking Area

2.2.1. The hospital should have adequate parking for bicycles, motor cycles, and motor vehicles within the hospital, including provisions for disability friendly parking.

2.2.2. The parking should have proper zoning for staff, visitors, outpatients, and emergency and

delivery vehicles. Emergency, delivery and service vehicles should be provided with a separate parking near the emergency unit and service areas respectively.

2.2.3. All parking should be located away from inpatient areas so as to reduce noise and air pollution;

2.2.4. All parking areas, for staff and visitors, should be well–lit and secured.

2.2.5. Effective turning vision and adequate signage should be provided.

2.3. Communication

Hospital should provide for effective and efficient system of communications to provide appropriate health services or support health service provision over a distance. The following are some areas to be included.

2.3.1. **Telephone system:** Efficient telephone system both internal and external (fixed or mobile telephone, radio call) should be provided to cater for administration and patient services.

2.3.2. **Information technology:** The hospital should take advantage of convenience and effectiveness of information technology; therefore it should procure and install information technology system (email, websites).

2.3.3. **Nurse Call System:** Nurse call system should be provided to allow patients to call for assistance at each bed position, in patient's toilets, bathrooms, showers and other appropriate treatment areas.

2.3.4. **Alarms:** Availability of alarm system interfaces to be used in cases of emergency should be considered.

2.4. Construction Materials

Selection of construction materials should draw attention to all relevant laws, regulations, rules, codes, standards and other guidelines applicable to Zambia public works and the health sector. Premises should be constructed from long-lasting materials free of health hazards (e.g., asbestos, lead-based paint) in order to provide a solid and sound shelter as specified in the specific area.

2.5. Ventilation, Air Conditioning, and Lighting

2.5.1. All rooms shall have sufficient number and appropriate size of windows to allow natural light and ventilation where applicable, in accordance with Public Health Act and Guidelines for Environmental Infection Control in Health-Care Facilities by CDC (Centers of Disease Control and Prevention).

2.5.2. When installed, Heating, Ventilating and Air-conditioning (HVAC) systems should meet the requirement to the Guidelines by CDC and should achieve the following minimum conditions:

a) Provide specific required temperatures and a relative humidity of 50-60%,
b) Provide minimal acceptable ventilation rates as required in specific areas,
c) The ventilation system should be designed and balanced to provide the pressure relationships as required in the specific department/ area of use.
d) The ventilation systems serving sensitive areas, like operating theatres, delivery rooms, nurseries and sterile rooms, must be equipped with at least two filter beds in which case air supply and air exhaust systems must be operated mechanically.

2.5.3. All areas shall be adequately illuminated by either natural or artificial light to facilitate activities and safe movement corresponding with the purposes of each area.

2.5.4. Natural ventilation is encouraged unless where mechanically controlled air is required. For efficient environment, device for shade against straight sunlight should be considered.

2.6. Surfaces

2.6.1. **Floors:** Floor coverings must be easy to clean and resistant to disinfection procedures. This applies to all areas in patient care environments. Treatment Areas should not be carpeted. In both Patient and Treatment Areas, the flooring should be easily cleaned and in good repair. Floors in areas used for food preparation or food assembly should be water resistant and greaseproof to comply with Food and Drugs Act cap 303. Floor surfaces, including joints in tiles in such areas, should be resistant to food acids (epoxy grout). In all areas subject to frequent wet cleaning methods, floor materials should not be physically affected by germicidal cleaning solutions. In areas where frequent traffic flow of people, trolleys and stretchers, floors shall wear resistant and non-slippery.

2.6.2. **Skirting:** Wall bases in Kitchens, Operating and Bathing Rooms, Clean and Dirty Utility Rooms, CSSD areas and other areas subject to frequent wet cleaning methods should be made integral with the floor, tightly sealed against the wall, and constructed without voids.

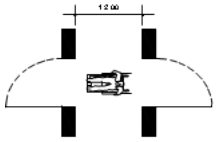
2.6.3. **Walls:** Other than special treatments included as feature face work in public or staff relaxation areas, wall finishes should be able to scrub, and in the immediate vicinity of plumbing fixtures, should be smooth and water-resistant. Interior design/color in all areas where patient observation is critical, colors shall be chosen that do not alter the observer's perception of skin color.

2.6.4. **Ceiling:** All exposed ceilings and ceiling structures in areas occupied by patients or staff, and in food preparation or food storage areas, should be finished so as to be non porous and readily cleanable with equipment routinely used in daily housekeeping activities. Ceilings in operating and delivery rooms, postnatal, and sterile processing rooms should be monolithic from wall to wall without fissures, open joints, or crevices that may retain or permit passage of dirt particles. The minimum clear ceiling height in occupied areas, corridors shall be 3000mm and maintenance corridors and outside walkway shall be 2600mm. minimum ceiling heights for operating rooms with ceilings mounted equipment shall be 3000mm. MRI, CT Scan and X-rays ceilings should abide with Radiation Protection Agency and manufacture specifications.

2.6.5. **Openings:** Openings comprising of doors, windows and vents are located in the building to provide for physical access to and escape from a building, create views to the outside, admit daylight, and facilitate natural ventilation. Design, size and position of openings in a building are the factors that should be considered during the design.

2.6.6. **Doors Size:** In general, clear door openings to rooms which may be accessed by stretchers (including wheeled bed stretchers), wheelchairs or handicapped persons (including employees), shall be of a minimum size of 1000 mm. Clear door openings in corridors shall suit the requirements of traffic and equipment movement and shall be greater than 1200mm. The minimum dimensions of clear door openings to inpatient bedrooms in new areas shall be 1200mm wide and 2000mm high, to ensure clearance for the movement of beds.

***Construction:*** Doors shall be constructed to meet the following minimum criteria: All corridors doors should have a minimum width that will be specified depending on the use, and associated equipment;




Corridor Width

To facilitate mopping, doorjambs should have sanitary stops 200mm above floor level or top of the doors.

If the locking system is not electromagnetically controlled, exterior doors shall be provided with door locks that are controlled by a key from the outside and they should also allow egress from inside by turning the lever handle.

At stairways, doors and hardware for exit doors shall lead directly to the exterior. For interior doors shall be provided with inside and outside door handles free at all times.

Doors to patients' wards and/or observation rooms shall not be lockable from inside the ward; clear door openings in corridors shall suit the requirements of traffic and equipment movement but shall not be less than 1200mm. Consideration must be given to the size of furniture and special equipment that is to be delivered via these access ways. All doors in corridors shall be able to swing in the direction of the egress.

Glazed panels shall be provided in doors where visual observation for reasons of safety, security or patient observation is required, but in fire doors the size must comply with the Town and Country Planning Act cap. 283. Rooms which contain baths, showers and/or water closets shall be equipped with doors and hardware which will permit emergency access from the outside, also provide privacy and should have fittings for disabled

2.6.7. **Windows:** Window sills for patients' wards shall be a minimum height above the finished floor level (900mm) according to Public Health Acts, and they allow for outside view even when lying down level. For effective ventilation, highest part of opening shall be higher than 2000mm above finished floor level. Windows should be able to open and be provided for ease of washing from within the building and letting in ventilation in non-air conditioned spaces. Provide insect screen. All rooms regularly occupied by patients or staff should have glazed windows to achieve external views, and where

possible, they should be provided with natural light and ventilation. In psychiatric units, windows shall be glazed with laminated tempered or wired glass: the glass shall have a minimum thickness of 11mm; where applicable, mosquito screens shall be provided to all windows.

2.6.8. **Corridor:** In areas where regular trolley and stretcher movement is expected, the minimum corridor width shall be 2100mm. The optimum corridor width is 2350mm. Stretcher-guard must be provided. Handrails are desirable, while they must be reliably strong and clean all the time.

2.6.9. **Lightning Protection:** All buildings must be equipped with adequate lightning protection as provided by The Town and Country Planning Act.

2.6.10. Maintenance: All premises and installations should be in a good state of maintenance and a life cycle costing that allows good operation. Maintenance should be a key factor in the design of any health capital investment project. When planning premises and equipment the following factors should consider:

a) During planning for procurements of equipment and plant, adequate spare parts should be included for 3 years maintenance and service. Further service contracts with suppliers should be proposed and funded where possible.
b) Small workshops and maintenance stores should be provided at all facilities.
c) Every hospital should have maintenance register, and should keep record of maintenance after construction finish.

2.6.11. **Water Supply:** The hospital must be provided with an adequate, clean and safe water supply suitable for consumption, ablution, and engineering purposes. Alternative sources of water like harvesting rainwater and wells should be considered. All service rooms must have water points in relation to patient number with accessories for hand-washing with elbow operated taps as stipulated in Guideline for Environmental Infection Control in Health-Care Facilities by CDC.

2.6.12. **Storage facilities:** Hospital shall have adequate and secure storage facility for pharmaceutical, food, and equipment and supplies.

2.6.13. **Ablution Facilities:** Toilets and bathrooms should be adequate according to the number of patients/clients. The doors must have the door opening outwards with non-slippery floor. Special consideration should be given to disability friendly facilities.

2.6.14. User-Friendly Features for Physically Challenged
All areas of the premises shall comply with Persons with Disability Act No. 6, (2012) which stipulates the minimum requirements for user friendly facilities for physically challenged:

- The toilets for physically challenged people shall have following minimum requirements:
  - At least one separate unisex with a maximum travel distance of 40 meters
  - Adapted toilets shall be installed with an effective emergency alert to users

- Support rails to facilitate lifting and stability

- The flooring shall be of slip resistant material.
- For access, the facility shall provide for wheeled movement by providing ramps and lifts for all the main traffic of patients. Ramp shall be 1/10 slope or less, flat landing space within every 1000mm altitude.

## 3. Premises for Provincial, Specialized and National Referral Hospitals

3.1. Functional Relationship shall be considered between other level hospitals and between departments in the hospital.

3.2. Hospitals should have enough rooms according to the specifications given in these standards and/or requirement for medical activities.

## 4. Infection Prevention and Control

4.1. The Hospital shall conform to the requirement or standards in relate with Guideline for Environmental Infection Control in Health-Care Facilities by CDC. Premises should be designed to prevent spread of Infection (communicable diseases) through various routes.

4.2. Healthcare facilities should provide for respiratory hygiene/cough etiquette in waiting and service provision areas for patients and visitors: Design of traffic flow and activity pattern should regulate the flow of visitors, patients and staff in order to prevent disease transmission in healthcare facilities.

4.3. Special units (Theatres, Labour Ward, ICU, CSSD, Laboratory) should be divided into unrestricted, Transition, Semi restricted, and Restricted zones defined by the activities performed.

4.4. Isolation rooms should be provided to separate immune-compromised or infectious patients from other patients. Personal Protective Equipment (PPE) Bays should be provided immediately outside all Isolation Rooms.

4.5. Hand hygiene facilities (hand washing, hand rub and surgical hand scrubbing) should be provided to prevent hand-borne infections.

4.6. To achieve infection control, the design should facilitate: prevention of patients/clients from nosocomial infections (hospital-acquired or healthcare related infections), Protection of healthcare providers (HPs) from occupational infections, Protection of communities from infectious diseases and prevention of environmental pollution.

4.7. On the issue of highly contagious diseases the hospital should have adequate knowledge of such a disease, way of handling the affected and have the authority of

implementing/facilitating action of all the necessary treatment/containment processes. The Provincial, Specialized and National level hospitals are expected to provide technical support to lower level facilities.

## 5. Safety and Security for Provincial, Specialized and National Referral Hospitals

5.1. Security System

5.1.1. The hospital should provide Security services including : Access control and tracking systems, Door intercommunication systems, Duress systems, Intrusion detection systems, Parking control systems, Safes and strong rooms, Security staff location, Security information systems, Security lighting, Security hardware, barriers, screens and fencing, Video surveillance systems, ability to observe Waiting Areas, design of reception counters, choice of glazing, location of security office, location and installation of duress alarms in high risk areas and where staff may work alone in isolation, location and installation of CCTV systems, design of waiting rooms, provision of escape routes, location of service panels and resistance of building materials to assault. Escape gates/exits should be provided for emergency evacuation. Reference assembly point should be identified labeled and be known by all staff.

5.2. Fire Safety

5.2.1. Health facility's premises, services and equipment shall be designed and constructed in accordance with the requirements outlined in the Town and Country Planning Act cap. 283. The guidelines address and cover the following design elements in health facilities:

5.2.2. Compartmentalization; Egress (in/outlet); Fire and smoke barriers/doors; Fire resistant construction; Fire detection and alarm systems; Fire suppression systems (automatic and manual)

5.2.3. Electrical protection; Emergency lighting; Brigade access; Building clearances, and other fire safety related design should be considered. Where possible the hospital should be insured against fire.

5.3. Occupational Health and Safety

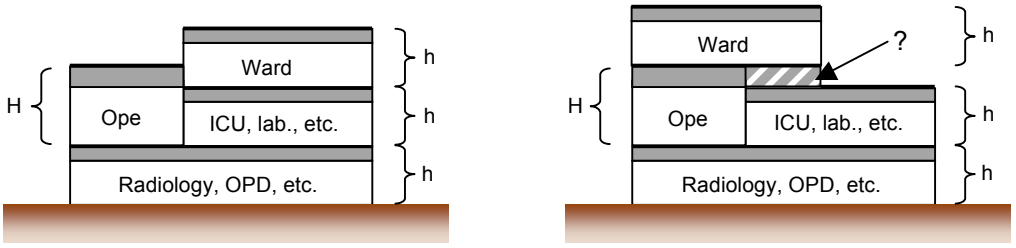
5.3.1. Premises should fully be in compliance with the Occupational Health and Safety Act N.36 - 2010, the designers shall take liability to the design and installation of specific equipment recommended in the guidelines for use at workplaces of the Provincial, Specialized and National Referral Hospitals. Special attention has to be given to ensure safety against ionizing energy and highly contagious diseases likely to be encountered in these hospitals. The Occupational Health and Safety Act of 2010 should be consulted.

## 6. Bio-clean Zoning and Operation Theaters

### 6.1 Theater department location of hospital-building

To explain operation department design, starting with location is proper in relate with master plan of whole hospital premises. (Refer standards for Master Plan)

As a room structure with shadowless lights, ceiling height of theater shall be 3.0m. Besides special air-condition makes structure higher than other rooms in hospital. Therefore, if hospital is multi-story, easier to design theaters on top floor.




Floor height for operation theater needs H=4.5m or more, while general hospital rooms is possible about h=4.0m. Not only considering department connection on each floor, but also space relation on elevation should be considered.

□Normally number of operation theatres in general hospital is about one theater per 50 to 70 beds, which depend on how to separate usage of cases.

### 6.2 Interior finish of operation rooms.

Interior materials of operation theatres are specified below table.

| | Features | Example materials |
|---|---|---|
| Floor | Smooth and flat<br>Waterproof surface<br>(Waterproof basement)<br>Heavy-duty covering<br>Chemical-resistant | Vinyl sheet for theater-use (3rd, 2nd level)<br>(1st level hospital: desirable with seamless heavy-duty vinyl sheet, tiles thick and antibacterial finish, terrazzo if keep it carefully clean) |
| Baseboard | Easy to clean corners | Roll up floor sheet<br>Sanitary material (R-shaped, stainless) |
| Wall | Smooth and flat finish<br>Avoid overhang & dust<br>Shockproof base & finish<br>Chemical-resistant<br>Relaxing colors | Steel or medical panel with proper coating (3rd, 2nd)<br>Tiles with proper surface (2nd, 1st level) |
| Ceiling | Flat finishing | |
| Doors | Operation without hand<br>Flat frame with wall | Automatic door with foot/arm button(3rd, 2nd)<br>Tight door with kickboard, push board |

□Size of general (minimum) operation theater is 40 to 45 $m^2$; while operation with more monitors, more equipment, or transfer cases with extra body needs bigger theater for contain those mentioned elements.

### 6.3 Clean air Standards and Operation Theaters

ISO standards of clean air depends on numbers of 0.1μ-particles per $1m^3$ to specify performance of filter. Higher efficiency filter is used for bio-clean room.

Door to enter Class 1 zone is from Class 2 zone. Door to enter Class 2 zone is from Class 3 zone.

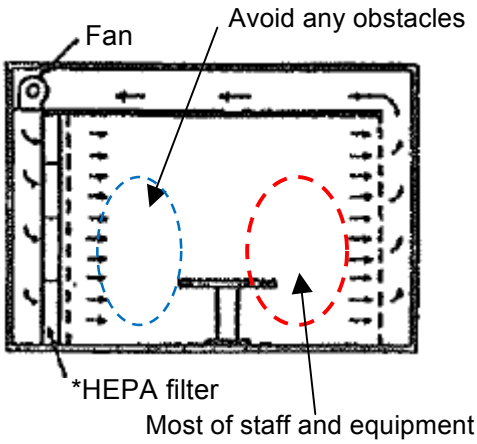
Air conditioning zone should be divided as following table.

| Level | Particles/$m^3$ air | Description summary | Type of rooms |
|---|---|---|---|
| Class 1 | $10=10^1$<br>$100=10^2$<br>$(1,000=10^3)$ | Laminar airflow room by high-efficiency particulate air filter (□**HEPA filter**) | Bio-clean operation theater<br>Compromised patient's bedroom |
| Class 2 | $1,000=10^3$<br>$10,000=10^4$ | Air-condition with **High-efficiency filter** | General operation theater |
| Class 3 | | Complete air-conditioned and clean environment | Premature room<br>Cystoscope room<br>Angiography($3^{rd}$)<br>Operation hall (hand wash)<br>NICU, ICU, CCU($3^{rd}$)<br>Delivery room |
| Class 4 | | Suitable cleanness for patients to avoid dirt. Where complete air-conditioned, considered about location of intake and exhausted of zoning. | Wards<br>Newborn nursery<br>Artificial dialysis room<br>Examination room<br>Emergency (exam/treatment)<br>Waiting room<br>X-ray<br>CT scan($2^{nd}$, $3^{rd}$)<br>Endoscope (digestive apparatus)<br>Physiotherapy room<br>General laboratory<br>Central sterilizing supply dept.<br>Recovery area after operation<br>Dispensary, pharmacy |
| Class 5 | Hazardous/ infectious material | Negative pressure to prevent leakage | RI (radio isotope) area<br>Bacteria laboratory<br>Pathology laboratory<br>Isolation wards & treatment<br>Endoscope (bronchium)<br>Prosectorium |
| | Odor and dirt | Negative pressure for non-proliferation | Patients' toilet<br>Dirty linen<br>Sanitary room<br>Mortuary |

□**HEPA filter: High Efficiency Particulate Air filter**

### 6.4 Design for 3rd level hospital theaters

Laminar airflow room for class 1 clean room
*Only class1 theaters need HEPA filter
Class2 theatres use high-efficiency filter

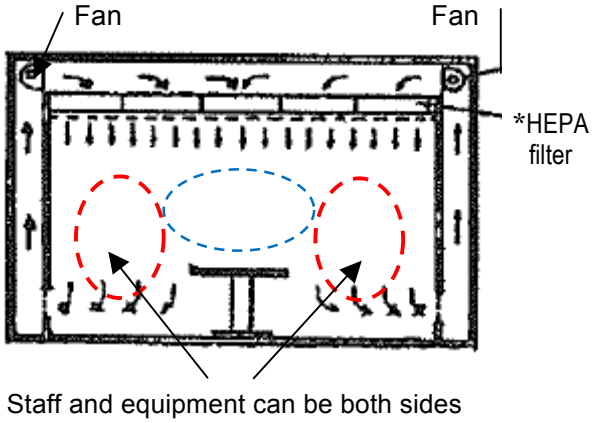


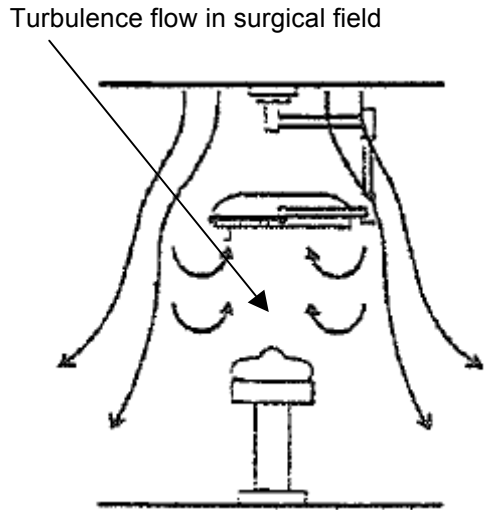

1. Horizontal airflow type

Operation
staff and

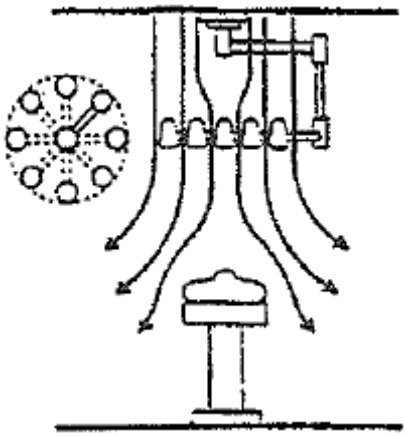
equipment should avoid disturbing clean air to the patient. Therefore, location of equipment and staff formation will be restricted. Otherwise, standing origin side of airflow has risk of clean environment in surgical field.

2. Vertical airflow type
Compare to horizontal type, more flexibly equipment and staff can stand during operation.
On the other hand, design and installation of lighting must be well considered not to disturb laminar flow. Shape of lighting valves (and its combination) shall not be big horizontal plate which create turbulence flow. Contemporary shadowless lights made with LED become smaller, so they do not disturb laminar flow.




Old big plate type shadowless light in the middle




Small or split type of shadowless light

### 6.5 Zoning types of clean rooms and traffic system

There are some variation of class 2 and class 3 clean zoning in operation theater area.

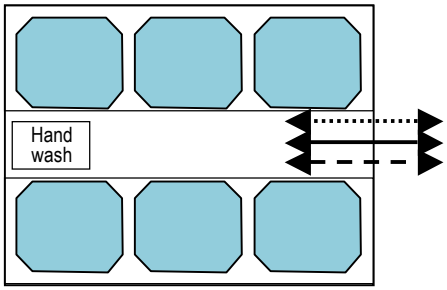



Fig. 1

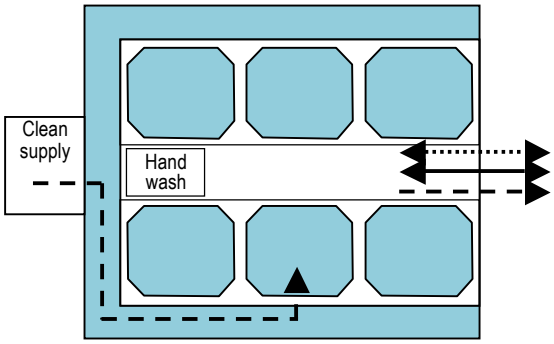



Fig. 2

Fig.1: Central hall type

Only this type, clean supply and dirty collection of equipment take same route. Easier to built, while rigorous maintenance is required.

Fig.2: Clean supply corridor type

Other than theaters, requires more class 2 clean area, which costs more to maintain.

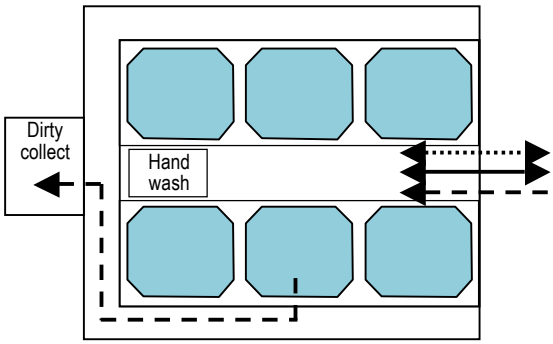



Fig. 3

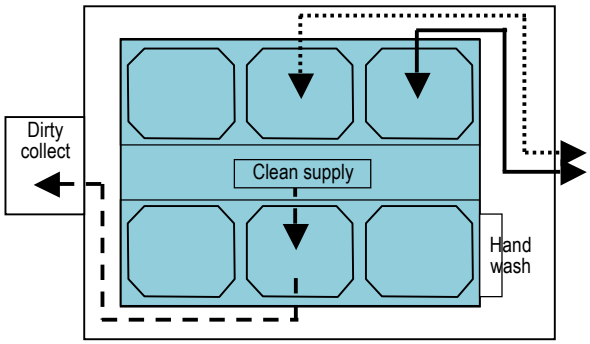



Fig. 4

Fig.3: Dirty collection corridor type

Similar to most common types in big hospitals in Zambia.

Fig.4: Clean supply hall type

Other than theaters, requires more class 2 clean area, which costs more to maintain.

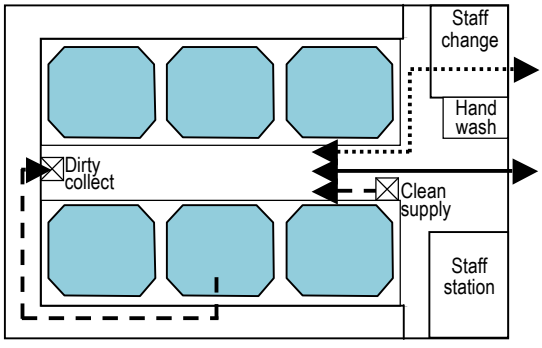
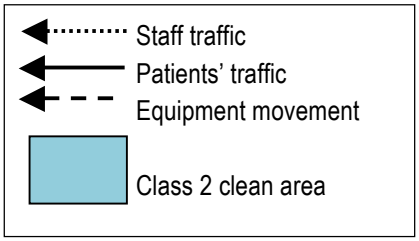



Fig. 5

Fig.5: Dirty corridor type with equipment lifts

Small elevators for equipment are required, which cost more and strict maintenance.



**6.6 Example Checklist** for 300-bed size hospital **theater** design

*Timing of Basic Design stage

**Stage 1** = before basic design(BD), **Stage 2** = early stage, **Stage 3** = middle of BD, **Stage 4**=after BD

Stage 2

1. Required (/expected) rooms, their numbers and sizes.
2. What among above rooms will possibly expand in the future.
3. Clean and dirty circuit system
4. Expected frequency of operation in each theater
5. Location where equipment set-up
6. Necessity of bio-clean theatre
7. Necessity of day-surgery theater and its location
8. Independent infectious theater

Stage 3

1. Transfer method onto operation table
2. Numbers of operation staff's hand wash sink taps

Stage 4

1. Types of operation tables.

**Items to be checked**

Concept: Safe and efficient service shall be provided with proper facilities, equipment, and staffing as acute hospital.

Staff structure and service policy:

Having app. 8 theaters equipped various types of surgery with some future adjustment.

Considerate location for safe and efficient transfer from emergency room.

Patient's traffic coming in and going out are separated each other.

CSSD management office will control clean supply and dirty collection.

| Main rooms | No. | Size ($m^2$) | Conditions & remarks |
|---|---|---|---|
| General theater | 4 | 42(6by7) | 1 has switch to negative pressure for infection |
| Large theater | 1 | 56(7by8) | |
| Large theater | 1 | 56(7by8) | With sealed (Pb 2mm) for later conversion to hybrid theater |
| Bio-clean theater | 1 | 50(7by7) | Class 1 bio-clean theater with Class 2 front chamber |
| Operation hall | 1 | 177 | |
| Large equipment | 2 | 40 | Store |
| Staff station | 1 | 17 | |
| Anesthetist office | 1 | 29 | Max 10 specialists |
| Conference | 1 | 9 | |
| Day surgery change | 1 | 7 | 2 changing space and 1 toilet for patients |
| Staff lounge | 1 | 18 | |
| Staff changing | 2 | 16 | For male and female, shower, 30 persons |
| Staff Toilet | 3 | 2 | Connected to change rooms |
| Family waiting | 3 | 13 | Separate room for privacy |
| Family toilet | 1 | 2 | |
| Family meeting | 1 | 9 | |
| Solid waste | 1 | 9 | |
| Pharmacy store | 1 | 23 | Sharing with ICU dept. |

Exclusive department office to be considered for operation schedule and maintenance.
Room for patient's family for waiting operation and conference after operation.
To provide high level service, medical human resources will be cultivated in the field.
Facility conditions:
For traffic after operation, the department locate podium below ward on tower (higher floors).

**6.7 Example Checklist** for 300-bed size hospital **CSSD** (Central Sterilize & Supply Department) design

*Timing of Basic Design stage
**Stage 1** = before basic design(BD), **Stage 2** = early stage, **Stage 3** = middle of BD, **Stage 4**=after BD

Stage 2

1. Required rooms, their numbers and sizes.
2. What among above rooms will possibly expand in the future.
3. Numbers and types of autoclaves (autoclave, Ethylene Oxide Gas sterilizer, etc.)

Stage 3

1. Type and storing amount of disposable material, methods of supply

**Items to be checked**

Example of Regional Hospital's central sterilization & supply department
For clean control, traffic to/from theaters to be separated clean supply and dirty collect.
Locate same level of theaters for compact traffic
Ventilation and air pressure of rooms are considered 3 levels for dirty, middle, clean.
Smooth circulation of operation equipment with CSSD.
Locations shall be considered efficient operational traffic between theaters and laboratories.

| Main rooms | No. | Size ($m^2$) | Conditions & remarks |
|---|---|---|---|
| Washing room | 1 | 35 | |
| Setting/sterilizing | 1 | 53 | |
| Wagon pool, store | 1 | 72 | |
| Front chamber | 1 | 4 | Clean supply to wards |
| Clean store | 1 | 13 | |
| Store (general) | 1 | 8 | |

## 7. Emergency Care Access and Flow

### 7.1 Flow in 2nd level (=Provincial level) to 3rd level (=life saving) emergency medical care center

For fatal emergency case of injury or sickness, there is not enough time to transport longer distance if they want to save the patient's life. Therefore emergency function of hospital should be important in Provincial level.

Emergency medical care center should be able to process as below quickly and smoothly 24 hours a day, 7days a week. The care should be done as following stages.

★1. Accept patient/ambulance → ★2. examine → ★3. diagnosis → ★4. treat/operation → ★5. hospitalization

★Stage 1.

Doctor and staff on duty/call should be assigned 24h a day, 7 days a week.

Emergency entrance should be designed properly: ambulance bay for smooth access of stretcher from ambulance to hospital building, with shower nearby when patient need to be cleaned soon after coming in. Canopy of ambulance bay must be high enough, since some types of ambulance have antenna high above from the roof.

★Stage 2.

Examination of emergency patient provincially covered is generally listed as below.

Radiology: X-ray, CT scan (desirable for 2nd level, where manufacture support available)

Laboratory: High speed blood and urinal test within an hour

★Stage 3. & 4.

Staff availability by duty system and information network should be established.

Most serious case needs operation, which shall be done class 2 level theater.

★Stage 5.

Recovery, ICU, ward

For desirable provincial level of emergency care, 2nd level hospital shall provide best possible opportunity of lifesaving care before the patient's condition gets too late. Therefore, together with patient transfer system and staff preparation, hospital should have some important conditions to upgrade as following.

★Proper (separate) emergency entrance with ambulance bay

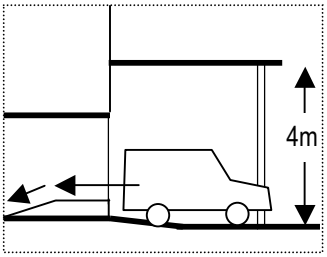
Canopy clearance shall be no lower than 4m for biggest ambulance access.

Bay has dock with higher floor for easy stretcher transfer from ambulance without steps.

★Emergency department for process of treatment and recovery

★Easy access for patients to radiology (x-ray, CT), for staff service to laboratory and blood bank

★Operation and ICU; Beds for emergency case should always be prepared in emergency or in other wards



### 7.2 Generally large hospital has following entrance(access)

| | Access | Traffic | Remarks |
|---|---|---|---|
| 1. | Main entrance | Patients, visitors | Often in common with OPD |
| 2. | OPD entrance | Out patients | Big capacity, easy direction |
| 3. | Inpatients entrance/exit | Inpatients,<br>Their visitors | Easy direction for visitors<br>Near hospitalization office |
| 4. | Overtime entrance | Emergency patients | Often in common with inpatients' access |
| 5. | Emergency entrance | Patient by ambulance,<br>Walk-in patients (able to share) | Near overtime entrance<br>With □Ambulance bay |
| 6. | Staff entrance | Staff | Independency for smooth traffic |
| 7. | Mortuary access | Body and family | Independent access |
| 8. | Service entrance | Supplies | Large size, handling space |
| 9. | Food entrance | Meal ingredients | Better separate from service |
| 10. | Solid waste exit | Waste | Desirably independent exit |
| 11. | Hazardous waste exit | Hazardous waste disposers | If special disposer business required |

Emergency entrance has its own reception which can supervise both ambulance bay and walk in entrance. Ambulance bay has canopy big enough covering working area of ambulance and high enough vehicles and their antennas. Size and specifications of ambulances in the area should be referred when designing.

### 7.3 Room requirement for (life-saving) emergency center

1. Ambulance bay with canopy and wind guard, heliport for 3rd level
2. Quick patient-assessment with walk-in patients to guide proper reception.
3. Reception and office of emergency information
4. Waiting room (with toilets) for patients and their family
5. Family meeting room (both general and infectious. Part of office, if privacy protected and access controlled)
6. Staff changing room (male and female)
7. Lockers for patients with toilet (or support patients travel with his/her belongings nearby and secured)
8. Staff station and pantry
9. Examination/treatment room (minimum for medical and surgical. occasionally pediatrics, ENT, eye, ObGyn)
10. Conference room
11. Staff lounge (doctors and nurses)
12. Duty room with toilet
13. Observation room
14. Clean supply preparation (equipment, medicine, sterilized items, linen) rooms with clean corridor
15. Resuscitative room (medical, surgical, brain-neurological, orthopedics
16. Laboratory, x-ray room (small function inside or convenient access to each department)
17. Equipment store (including power charger if necessary)
18. Others: equipment cleaning room, sluice, medical waste treatment, dead-on-arrival/brought-in-death exam (explain to family), mortuary, isolation ward, warm bathroom, elevator (for stretcher, medical staff, visitors, supply), ICU and CCU, infectious zoning, burn units

**7.4 About Burn unit (usually in ICU area after emergency acceptance and treatment)**

Burn unit with air fluidized supporting system (air-bed) shall have normal patient's bed and shower space large enough to take shower with stretcher.

7.4.1 Principles of burn care

a. Reducing necessity for movement within the unit of staff, patients, waste material,
   Allocate zones of patient condition (acute, non-acute, infected) within the ward
   Equip each zone with all the patient-care requirements for daily routine
   (therapy, hygiene, staff areas, etc.)
   Organize routine traffic route not to have contact between various zones
   Keep immunosuppressed patients isolated (possibly in single rooms)

b. Inserting pressurized air-locks between rooms with different asepsis requirements to provide barrier against airborne micro-organisms.

7.4.2 Patient bedroom

a. For non-acute (no immunological problem) patients
   A room with two beds with WC and shower

b. For acute or septic patients (at high immunological risk)
   A single room to limit patient's transfer and consequent dispersal organisms
   WC with sluice disposal in each room
   Hydrotherapy tub room (between two single rooms through air-lock each side)
   Filter/ante-room (separate for each room, between corridor and bedroom,
   acting as air-lock to the tub room)

c. Other methodology in bedroom design
   Patient's lift hanging from the ceiling through shower space to each bed
   (easier for patient and staff)
   Air condition should control humidity as well as temperature and cleanness.

**7.5 Example Checklist** for 300-bed size hospital **Emergency/casualty department** design

*Timing of Basic Design stage

**Stage 1** = before basic design(BD), **Stage 2** = early stage, **Stage 3** = middle of BD, **Stage 4**=after BD

Stage 1

1. Emergency role level to treat in the region
2. Heliport requirement: if necessary, location either ground level or rooftop

Stage 2

1. Required rooms, their numbers and sizes.
2. What among above rooms will possibly expand in the future.
3. Numbers of night-beds exclusive for emergency dept.
4. Whether emergency ward is operated exclusively or not
5. HBO: if hyperbaric oxygen therapy required, its location

**Items to be checked (Example of Provincial Hospital's emergency department)**

Concept: Staffing exclusive Medical Doctor focusing on emergency care, the hospital would like to enhance emergency care of the region.

Staff structure and service policy:

Having emergency-ward, the emergency room doctor will initial consultation and treatment. When the patient needs consecutive care, the doctor will contact with related specialist doctors for hospital treatment.

Emergency OPD shall locate convenient area with related departments in order to deal with urgent examinations and operations.

Emergency for perinatal and pediatric patients, consolidate information network in the region and prepare smooth acceptance of patients.

Contribute human resource cultivation of emergency medical care field in the region.

Facility conditions:

Direct access with elevator from ambulance bay to emergency treatment room

Access route from the street to ambulance bay is away from general hospital traffic

Locate convenient relation with laboratories and next to radiology

Route to operation theatres and emergency ward shall be convenient

| Main rooms | No. | Size ($m^2$) | Conditions & remarks |
|---|---|---|---|
| Initial consultation | 1 | 75 | Large room with 4 exam-bed with isolator |
| Waiting bay | 1 | 41 | |
| Staff station | 1 | 14 | Viewable to initial consultation and recovery |
| Examination | 3 | 11 | Specialized in walk-in patients |
| Treatment | 1 | 17 | For emergency surgery & infection control |
| Recovery | 1 | 57 | For 7 beds |
| Decontamination | 1 | 31 | Area beside entrance with ambulance bay |
| Equipment store | 1 | 7 | Access from initial consultation room |
| Sluice | 1 | 7 | From initial consultation with good ventilation |
| Department office | 1 | 13 | Locate walk-in entrance |
| Patients' toilet | 1 | 5 | Consider disable-use |
| Duty room | 2 | - | Single-bed-rooms near the department |
| Staff toilet | 2 | 3 | M, F |

## 8. Intensive Care Unit (ICU) guideline

### 8.0 Human resource precondition

1. Doctor: One or more ICU certified doctors works inside of ICU area 24hrs.
2. Nurse: One nurse per two patients work 24hrs. One per 1.5 patients desirable.
3. Biomedical equipment technician: Certified ICU. Desirable exclusively.
4. Pharmacist: Desirable one exclusively in ICU zone.
5. Clerk: Desirable who specializes in ICU.

### 8.1 Floor plan for ICU

ICU Department floor consists of 1)bed unit 2)medication/supervision 3)information management 4)staff conference 5)equipment 6)supply 7)duty 8)clinical laboratory 9)education 10)hall way. Layout should be considered traffic of patients and staff.

### 8.2 Room size

#### 8.2.0 Total area, ceiling height, and column span

One of total ICU area's indicator is 75m$^2$ per bed. If special function hospital, floor requirement becomes larger than 75m$^2$. Ceiling height above bed area shall desirably be 2.8 to 3.0m. In order to avoid columns' restriction of medical activity layout, large hall structure or 7.2m (or longer) column span for normal reinforced concrete structure is desirable.

#### 8.2.1 Bedroom

An ICU department should have minimum 4 beds. Definition of bedroom here is bed and surrounding area occupied by one patient. Each bedroom is recommended to be 20m$^2$ or more. Bed distance is recommended at least 3.6m by center to center. Independent compartment should be 20 to 25% in general, but it varies because of consideration of patient's numbers and severity level and type, staff system, infection prevention, patient's privacy, etc. Independent compartment is desirable 25m$^2$ or more. Isolation bedroom should have front chamber for infection prevention. (Certified "Special Function Hospital" shall have more than above.)

#### 8.2.2 Staff station

Size depends on the case.

#### 8.2.3 Equipment store

Exclusive equipment store is required for ICU department. Size shall be no less than 10m$^2$ per bed in total. If 10 beds in ICU, its equipment store shall be 100m$^2$ or more.

#### 8.2.4 Hallway (corridors)

The internal width shall desirably be 2.4m, since considering traffic of patients, medicine, medical equipment, solid waste, etc.

#### 8.2.5 Other rooms

Other than above rooms, sizes shall be considered case by case with the following rooms. Doctor's office, doctor's lounge, Department Head's office, nurse office, nurse lounge, Nurse Head's office, technician's office, changing room, information office, laboratory, dispensary, sluice, wash and sterilizing, linen, duty room, toilet, shower room, interview room, conference, family lounge, pantry, etc.

### 8.3 Design conditions of rooms

#### 8.3.1 Bedroom area

Floor load shall be 1 tonnage per square meter.

Piping system has minimum outlets as 2 oxygen's, 1 air, and 2 suction's per bed. More outlets are

required, depending on main patients tendencies. If certified enough for “special function hospital”, 4 oxygen’s, 2 air’s, and 3 suction’s are desirable.

Where volatile anesthetic or nitrogen monoxide can be used, installation of exhausted ventilation for surplus gas is desirable.

For time management, calendar and clock must be installed. Bedroom always need to have window to outside. The blind shall be installed there.

Independent unit needs video camera to observe patient’s condition.

**8.3.2 Staff station**

Desirable location of staff station has shortest trip to every bed and direct view to all the bedroom area. The station shall be equipped with biological information monitor, other imaging tools of patient’s monitoring system, hospital information system terminal, nurse call terminal, medical records, film viewer, telephone, facsimile, photo copy machine, intercommunication system, etc. Pharmacy and dispensary are recommended to be separate from the staff station.

Power and numbers of electric outlet and their location, water outlet should be thoroughly discussed to make decision in proper design stage.

**8.3.3 Equipment store**

Inside of ICU department, equipment store is necessary for maintenance and reservation of medical equipment used for examination or treatment. For maintenance, medical piping and electric power outlet should be installed there. The store has space for clean and stand-by equipment.

Its entrance has to have enough size opening to let all those equipment brought smoothly through. Installing information computer is desirable for maintenance management.

**8.3.4 Doctors’ office, nurses’ office**

The office is where medical staff spend time for paperwork, research, education, etc. Intercommunication system is necessary to contact with staff station all the time. Telephone, facsimile, hospital information line, internet line should be installed. Capacity of electric power supply and numbers of outlets shall be considered with staff numbers and how they will use.

If drinking and eating are allowed, sanitary control must be strict.

**8.3.5 Doctor lounge, nurse lounge**

The lounge is where medical staff will take a break and relax. Doctors and nurses should be better to have their own lounge separately. Intercommunication system is necessary to contact with staff station all the time. Water supply is necessary as well.

Telephone and internet line shall be installed. Capacity of electric power supply and numbers of outlets shall be considered with staff numbers and how they will use.

**8.3.6 Department Head’s office, Nurse Head’s office**

In terms of management, those offices need to be inside of the department. Intercommunication system, telephone line, internet line, electric outlets shall be installed.

**8.3.7 Changing room**

Necessary to be inside area of the department. Size of changing room depends on numbers of users (both male and female). Toilet and shower shall be contained.

**8.3.8 Information office**

Information system servers of patients’ biological information monitor will be installed in the office. Independent telephone line shall be installed because of system maintenance. The office access need to be locked for security reason.

**8.3.9 Laboratory**

When ICU-internal and emergency laboratory test is required (mainly ABG: Arteriole Blood Gas),

they will use equipment in this laboratory. Water supply, medical sewage, and power supply are necessary. Capacity of electric power supply and numbers of outlets depend on equipment used there.

**8.3.10 Dispensary**

Desirable to set own dispensary in the department. Medicine cabinet, dosage counter, clean bench shall be installed. Water supply, ventilation, power supply, telephone line, hospital information line need to be installed.

**8.3.11 Sluice, wash and sterilizing room**

Medical sewage system, water (& hot water) supply, ventilation, power supply (voltage to be consider) are necessary.

**8.3.12 Doctor duty room**

Duty room should be in the department area. Convenience for both gender, rooms shall be plural. Numbers of bed shall be considered about working cycle related with type of diseases.

Internal telephone line, intercommunication system to staff station need to be installed. Water (& hot water) supply is necessary.

**8.3.13 Toilet and shower**

Staff toilet is necessary in the department. Containing shower is desirable. In some cases, shower room is planned for both staff and patients' disinfection and washing.

**8.3.14 Interview room (family explanation)**

Explanation and informed consent procedure to patient's family are done in this room. Therefore, it should better be in the department. Installation of information related outlets, film viewer, etc. make explanation easier.

**8.3.15 Conference**

Desirable to be inside of the department, because clinical conference and treatment policies are discussed there. Staff education also take place.

Hospital information outlet, biological information monitor system outlet need to be installed. Besides, other meeting equipment such as film viewer, computer, video player & monitor, projector, are considered.

**8.3.16 Family lounge**

Family lounge should be planned either inside or near the department. The environment should be well arranged for family privacy. Access should be controlled by view of security staff.

As a communication methods, direct contact to staff station is necessary. If pay phone is nearby, it is more convenient.

**8.4 Location in relate with other departments, traffic network**

**8.4.1 Location in relate with other departments**

ICU department has close connection to Emergency Dept., Operation Theater, Recovery room, Radiology Dept., General Ward, Blood Transfusion Dept., Laboratory. Therefore distance to above sections should not be long. Positional relation (both horizontal and vertical) to those sections depends on medical services. The priority should be determined by target illnesses, traffic network of patients & medical staff, supply procurement, etc. For the connection of sharing portable x-ray, having own monitor is desirable.

**8.4.2 Access/entrance of ICU department**

Access routes of medical staff, patients, their families shall be separated each other.

Intercommunication device to staff should be installed for visitors.

### 8.4.3 Patients' transfer and supply delivery

Careful consideration is required about traffic network balancing with convenience and patients' privacy. Supply routes between ICU and anther department are desirably separated from other sections'.

### 8.5 Privacy and amenity, environment

Designing interior colors and noise as well as natural surroundings shall be well considered in order to reduce stress of patients, families, visitors, and staff.

### 8.6 Example Checklist for 300-bed size hospital ICU/HDU design

Concept: Facilitating ICU (HCU, CCU, SCU, NICU), serious disease shall be in highly special care environment with sufficient staff.

Staff structure and service policy:

Contain CCU and SCU specific for coronary disease and stroke.

(NICU will be staffed with doctors and nurses specializing in newborn infant disease.)

Nursing support of co-medicals and managerial support of medical clerks will assure medical doctors commitment of their own field.

Located close to emergency department for safety and efficiency.

Collect and cultivate human resource with sufficient level.

Facility conditions:

Smooth traffic of patients from operation is considered. NICU should be near Delivery.

ICU, CCU, SCU, HCU(HDU) will be in a row and flexible to medical needs.

Family access must be proper circumstance.

Negative air-pressure room shall be installed for infectious case.

| Main rooms | No. | Size ($m^2$) | Conditions & remarks |
|---|---|---|---|
| ICU | 2 | 21 | 2 units. 20$m^2$ per bed. One switch negative-P. |
| CCU | 2 | 21 | 2 units. 20$m^2$ per bed. |
| SCU | 3 | 22 | 3 units. 20$m^2$ per bed. |
| HCU(one-bed) | 4 | 21 | 2 units are 12$m^2$, other 2 units 15$m^2$ per bed for ICU conversion. One has switch to negative-P. |
| HCU(4-bed) | 1 | 40 | 8$m^2$ per bed. |
| Staff station | 3 | 82 | Separate to each nursing unit |
| Hall | 1 | | |
| Sluice | 1 | 8 | Proper ventilation |
| Equipment store | 1 | 8 | |
| Linen store | 1 | 6 | |
| Drip preparation | 1 | 9 | For drip infusion |
| Conference | 1 | 16 | |
| Pharmacy store | 1 | 23 | Sharing with theater department |
| Patients' toilet | 1 | 4 | Wheelchair considered |
| Staff toilet | 2 | 2 | Each gender. Sharing with emergency ward. |
| Doctor's duty room | 2 | 11 | Unit bath in each room |
| Nurse's duty room | 1 | 11 | Sharing with emergency ward. |
| Staff lounge | 1 | 12 | Sharing with emergency ward. |

## 9. Dialysis Center

### 9.1 Artificial dialysis environment

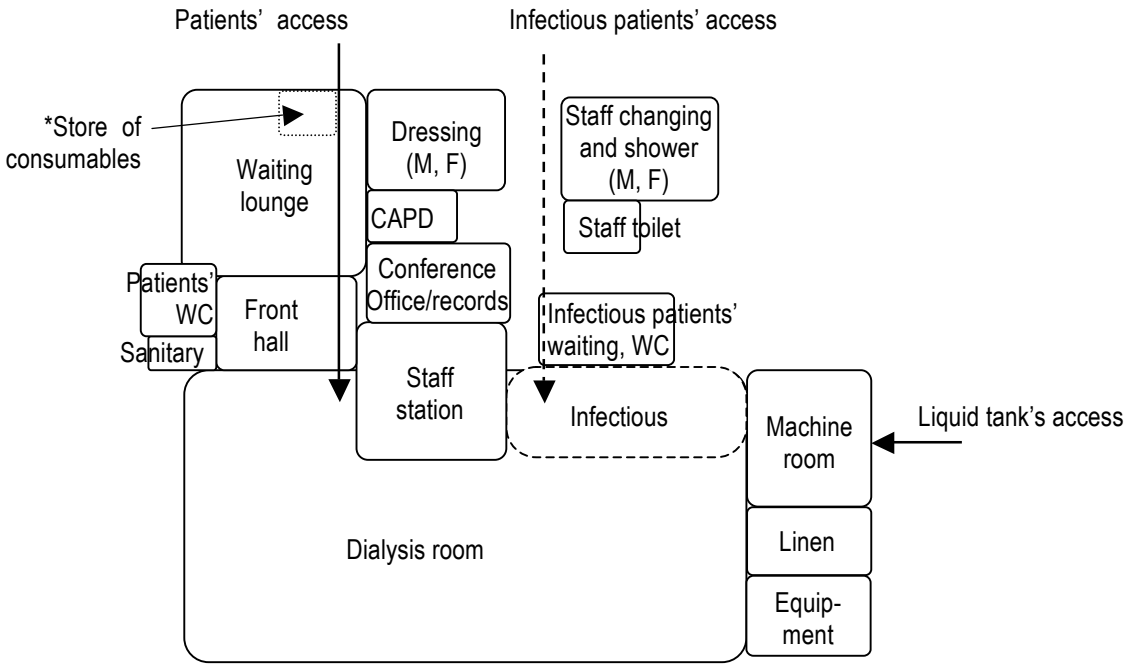
Patients normally come through OPD, after shunt was created in operation theatre, and start coming dialysis center. The access should be easy to find.

Separate access for infectious patients is desirable to prepared.

Because of large and heavy machines such as dialysis liquid supply machine, the way of bringing-in and carrying-out should be designed big enough to the machines get through and floor is durable enough to support the weight.

### 9.2 Artificial dialysis zone shall contain the following rooms:

Waiting lounge and/or Front hall (for clean-air keeping and weighing patients before and after)
Dressing room(with locker)
CAPD exam/treatment room (CAPD: Continuous Ambulatory Peritoneal Dialysis)
Conference
Patients' toilet
Sanitary room
Staff station (Including reception corner)
Dialysis room
Machine room
Equipment storage room
Linen storage
Staff toilet and changing room (M, F, with shower and lockers)




(example) Zoning diagram of dialysis center

### 9.3 Conditions of main rooms

#### 9.3.1 Dialysis room

a. Big simple-shaped room for easy observation

All the patients should be observed easily from the staff station during dialysis.

If containing beds for infectious patients, the zone is separated with its own access and toilet.

b. Distance between dialysis beds

Concerning wheelchair/stretcher access and infectious prevention, more than 1m space between two beds next to each other. Case of parent accompany, some beds are 1.2m in between.

Dialysis usually takes 5 to 6 hours with bed-head artificial kidney dialysis machine. For patients' amenity, amusement such as TV set or back-ground music system can be used.

c. Beds shall be set in a simple row.

In order to keep pipes in clean condition with smooth flow of dialysis liquid, piping route should not have tight turn or many curves. Therefore, beds should be lined as simple as possible.

d. Piping pits below floor level should be waterproof.

Structural floor should be designed lower than finishing level, because piping pit should be created lower level than floor level for smooth movement of patients and equipment. The design of piping pit should be waterproof, since dialysis liquid shouldn't be leaked.

#### 9.3.2 Staff station (nurse station)

a. Open counter style

All the patients should be easy to observe from the staff station during dialysis.

b. Contents

Staff station has reception near entry area and check each patient when coming in.

Meeting table, intercom station, whiteboard, X-ray viewer, terminal computer, monitor

#### 9.3.3 Waiting lounge and/or Front hall

When patients come and change their clothes, they need lounge to wait for all the members of the dialysis course ready.

Direct connection to dressing room, patient's toilet (wheelchair accessible), and sanitary room (treat liquid after dialysis).

Weight scales shall be sets near entry of the dialysis room.

#### 9.3.4 *Store of consumables

The store shall provide specific medicine with checking receipt of required patients at the entrance.

If management system takes different way, it is not necessary to have this store.

### 9.3.5 Dressing room

Separate room for each sex depends on numbers and social situation.

Locker/safety-box should be installed enough for each gender patients.

### 9.3.6 CAPD exam/treatment room

Consultation, exam/treatment room for patients of Continuous Ambulatory Peritoneal Dialysis.

The room shall have bed, sink, hand wash.

### 9.3.7 Conference room

Desk and chairs (User's numbers are depends on hospital. Teaching hospital might have 20 persons'.)

### 9.3.8 Machine room

Room for the machine of dialysis liquid supply. Access rout must be heavy duty and the structure must be strong enough for the weight.

For daily access of heavy liquid, easy access of outside is necessary.

Considering enough space for machine maintenance and renewal.

Floor should be waterproof.

### 9.3.9 Linen storage

Distinguish clean and dirty linen with strict clean management. It should locate easy access from dialysis room.

### 9.3.10 General

Because of daily big group and heavy liquid access, dialysis center is usually designed on ground floor of hospital.

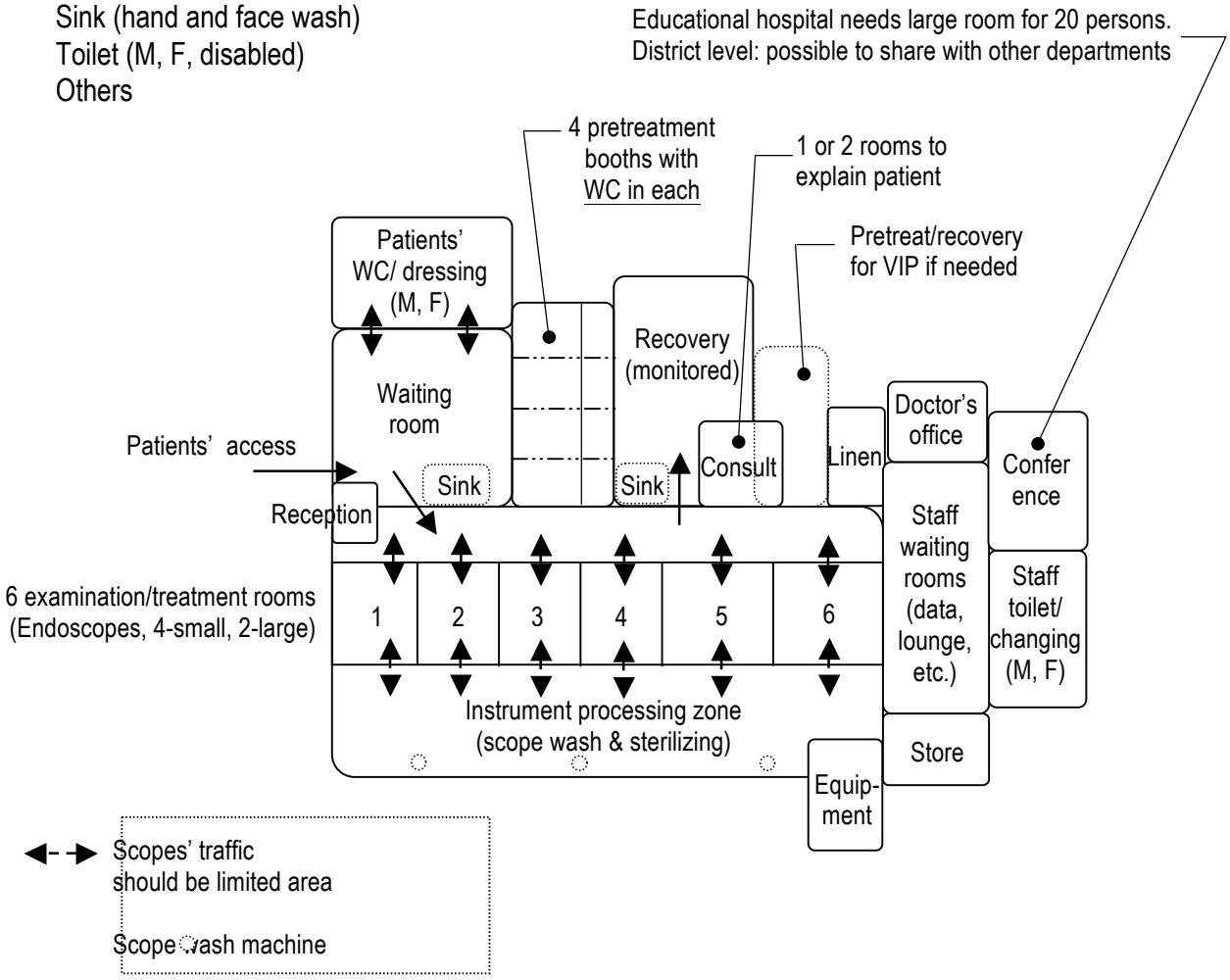
## 10. Endoscope environment

### 10.0 Future expansion of endoscopy

Endoscopy examination is not only effective to find digestive organ cancer, but also less damage to patient's body in its treatment/cutting process compare to traditional surgical operation. Therefore, it becomes popular all over the world. As its future expanding medical care method, creating sufficient environment is important to prevent infection.

### 10.1 Endoscope zone shall contain the following rooms:

Reception
Waiting room(patient holding room, sofa, patients' locker)
Preparation booths(booth with toilet, connect to waiting room, near exam/treatment)
Examination/treatment room
Instrument processing (scope wash & sterilizing) room
Recovery room (patient's beds and curtain for each bed)
Dressing room
Pretreatment room
Data room
Conference room
Sink (hand and face wash)
Toilet (M, F, disabled)
Others




(Example of 6 examination-room Educational Hospital)
Zoning diagram of endoscope area

### 10.2 Critical conditions of main rooms

#### 10.2.1 Instrument processing (scope wash & sterilizing) room

a. Keep away from patients' traffic.

In order to avoid cross-infection, dirty parts of equipment and staff with dirt should keep their traffic away from patients.

Inside of the room should be big enough to wash/sterilize for restored condition.

Space for workbench, lighting, electric outlet, water supply, air compressor, sink for cleaning, sterilizer/disinfector, ultrasonic cleaner for treatment equipment, dirty-tank, scope cabinet.

b. Separate traffic of clean scopes and dirty scopes.

In order to avoid infection, clean scopes going out to storage and dirty scopes back from treatment room have to move separated route each other.

c. Traffic between exam/treatment and instrument processing room should be short.

Used scope and other tools should be clean as soon as possible. Above two kinds of rooms are independent each other, but closely related.

d. Plain flat floor

Floor should be easy to clean, durable material to protect seamless surface.

e. Ventilation

Scope wash & sterilizing room should be independently and adequately ventilated area, because antiseptics used there is strong and with toxicity for staff's exposure and environment. Since some major antiseptics is heavier than air as vapor, exhaust opening should locate low position and near sterilizer's lid effectively. Waste disposal of the antiseptics shall depend on standard of each antiseptic drug.

f. Washing sink should be wide and deep enough.

Scope wash sink should be wide enough no need to bend scopes, and deep enough not to spit water around. Height should be considered about staff's comfort for continuous work.

g. Water outlet for scope wash needs temperature and amount control.

Water temperature should be controllable around 40 degree. Shower head type is not desirable for scope wash.

Water shouldn't contain more than 0.1ppm Chlorine (as drinkable standard).

h. Water outlet with dirty sink should be automatic/arm-operation.

Dirty sink for waste out of body shall be convenient located and desirably with automatic sensor or arm-operation type to avoid infection through fingers. Desirably outlet for water, soap, and dryer.

i. The room should be class 4

Not open clean air with equal pressure, ventilated 6times/hour, flesh air 2 times/hour.

#### 10.2.2 Examination/treatment room

a. The room should have adequate space

Considering expected activities in each hospital case, such as stretcher traffic and medical equipment should have enough space. 4m × 5m is minimum size of examination room. Big hospital that can have educational Endoscope Center with several examination rooms needs 2 of them as large (5m × 6m) size.

b. Suction machines shall be prepared 2 per one bed.

Treatment, gastrostomy, hemostasis requires long time and extra suction machine should be necessary for oral suction. Therefore 2 suction machines shall be set for each bed.

c. Electric cables for endoscope should be wiring under floor or ceiling level.

For the patient's safety and to avoid risk of disconnecting, electric wire should not run on the floor. Besides, floor is easy to clean without electric wire.

d. Hand-wash sink for staff shall be desirably with automatic sensor or arm-operation type.
Staff hand-wash sink should be locate convenient place inside of the room for hand-wash soon after taking off gloves, as well as less infectious position with automatic water outlet or arm-operation type.
Desirably water, soap, and dryer.

e. Computer and monitor for scope shall be set in each examination/treatment room.

f. Air-conditioning system can be operated by each examination/treatment room.

**10.2.3 Pretreatment room and waiting room**

a. The capacity of the numbers of patients
Preparation takes longer than examination or treatment. Pretreatment/waiting area needs 3 to 4 times capacity of treatment room numbers. During waiting time, patients need to go toilet and gargle at sink sometimes. Some preparing patients need to go toilet very frequently, therefore individual booths with toilet of its own should be prepared. For 6 examination-room size, at least 4 booths are recommendable. If hospital have VIP patient who needs special privacy, independent pretreatment/recovery room shall be installed for proper access to examination/treatment room.

b. Condition of the space
The floor should be flat and the surface is easier material to keep clean. Patients can wait on sofa close distance to lavatory and toilets with enough not to wait. If some cases they required tougher preparation, they should stay individual compartment with toilet for personal privacy.

**10.2.4 Recovery room**

a. The capacity of the numbers of patients
When patients were sedated or possible to vomit, they need to stay monitored about an hour on recovery bed. Since each such patient spends longer time than treatment, recovery beds' numbers are 2 times of treatment rooms or more.

b. Condition of the space
The floor should be flat and the surface is easier material to keep clean. Create compartment with curtain of each recovery bed for gender and personal privacy.

**10.2.5 Lavatory (hand and face wash)**

Lavatory sink should locate near examination/treatment room, because patients need to gargle mouth soon after treatment. Sink design should be less spatter type.

**10.2.6 Toilet:** Easier design to keep clean, with hand-wash sink nearby to avoid infection through door-handle.

**10.2.7 General environment**

a. Beds and pillows should have waterproof surface and be easy to clean.
Blood, bodily fluid, and water tend to make pollution on the surface. Therefore, beds and pillows should have waterproof surface with one-time-use paper-sheet. Handrail of the bed should be clean with ethanol in each use.

b. Endoscope system, keyboard, mouse, etc. should be clean with ethanol some times.

Above tools which can be touched by infected hands during treatment should be cleaned by ethanol. If the material is fragile by ethanol, soap or general antiseptic drug as alternative.

c. Blood and body fluid should be always treated as infectious possibility.

All liquid spat from body onto floor and walls should be wiped away and sterilized with ethanol or 0.1%sodium hypochlorite.

### 10.2.8 Types of Scope

There are various types of endoscope for medical use both in endoscope zone and operation theaters as following.

a. Endoscopy Department

Laryngendoscopy, bronchoscopy, upper gastrointestinal endoscopy, duodenoscopy, small-bowel endoscopy, large intestine endoscopy, capsule endoscopy, cholangioscopy, colonoscopy

b. Operation theater

Thoracoscopy, celoscopy, abdominoscopy, cystoscpoy, arthroscopy, microendoscopy, angioscopy, epiduroscopy

## 11. Others

### 11.1 Planning and Designing Points of Modern Hospitals for Higher Level

**Functional structure of general hospitals**

Hospital usually have 5 functional blocks and departments as below list and table.

1. OPD: Patients by visiting basis
2. Medication: Examination/treatment
3. IPD: Patients by hospital stay
4. Administration: Hospital management
5. Service: Supply and procurement

| Block | | Departments | |
|---|---|---|---|
| 1 | Outpatient Block | Outpatient Department (OPD) | |
| | | Emergency (casualty) Department | |
| 2 | Medication Block | Examination | Laboratory test |
| | | | Physiological test |
| | | | Endoscope test |
| | | Radiology | Radiation diagnosis |
| | | | Nuclear diagnosis |
| | | | Radiation treatment |
| | | Operation Department | |
| | | Intensive Care Unit (3rd level) | |
| | | Delivery Department | |
| | | Rehabilitation Department | |
| | | Dialysis Department (3rd level) | |
| 3 | Inpatients' Blocks | Ward / High Dependent Unit (2nd level) | |
| 4 | Administrative Block | Management | Director/managers' rooms |
| | | | Medical Professions Office |
| | | | Medical Management Office |
| | | | Duty room |
| | | | Meeting rooms |
| | | | Medical records |
| | | | Library |
| | | | Staff locker room |
| 5 | Service Department | Pharmacy | |
| | | Central sterilizing & supply department | |
| | | Kitchen and Landry | |
| | | SPD (Supply Processing & Distribution) room | |

For designing higher level hospital, communication with medical staff to take out their opinions will be more important, because the relation and activity network between departments will be changing as the medical technology's progress. Other than hospital organization, some buildings or rooms are established separated by donor or independent funds while operation is done by hospital staff or the donor. Communication is important to understanding management and security for how to combine into design.

## 11.2 Establish Master Plan of Reconstruction for Modernization and Upgrading

Tendency of historical hospital's upgrading is not only to modernize high-technology facilities, but also to centralize building for compact and functional medical activity traffic. Most important thing for modernize hospital should be to make it compact and functional in its buildings as well.

There is a typical example of modernize historical hospital shown as sequence of figures.

**Step 1** For the firstly demolished building group [ ], acquire space by proper part of renovation of remaining buildings. If space cannot be created enough, temporary buildings should be built.

After rooms are created, move functions to new space and demolish empty buildings. For smooth traffic, temporary route shall be created sometimes.

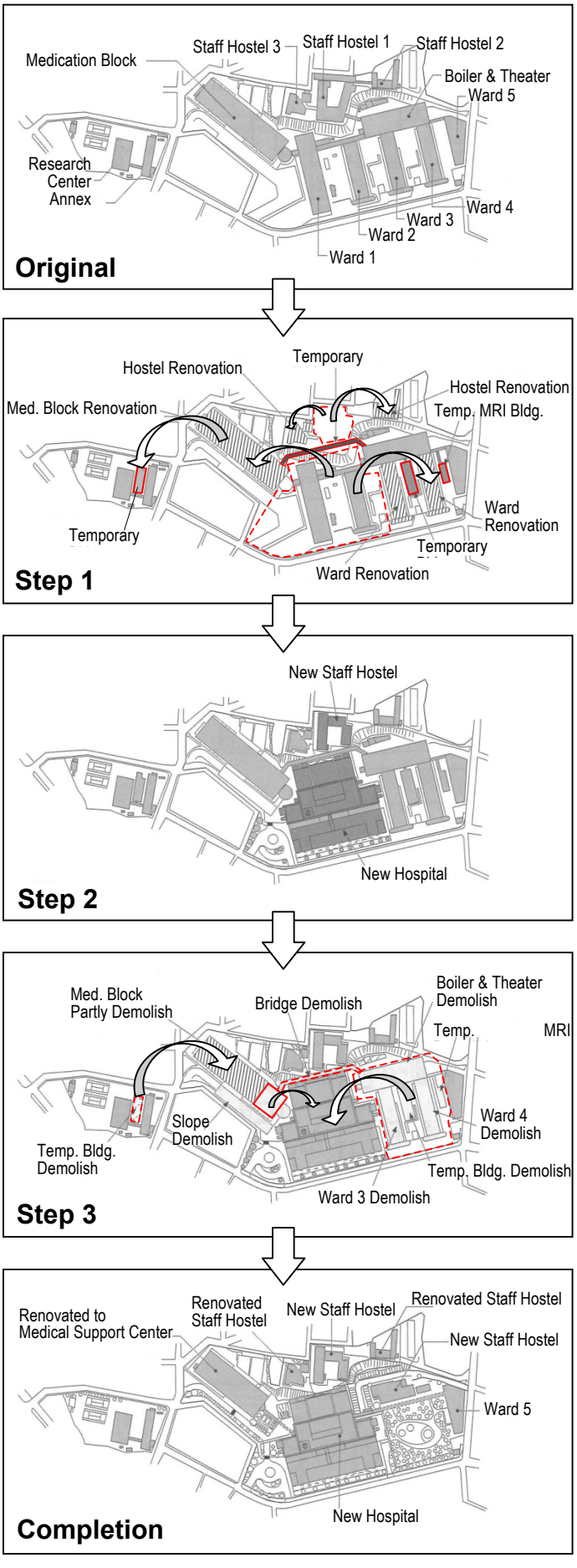
**Step 2** Level land of space after demolished buildings, construct new and modern design hospital, which is usually compacted functions with higher rise building.

**Step 3** Above mentioned reason, new hospital has more capacity than original buildings that stood there. Therefore more area on the site can move into new hospital building, which create some more empty rooms in original buildings to be demolished.

In this stage, emptied temporary buildings can be demolished as well.

**Completion** After demolishing original buildings that were planned so, this area should be designed open space such as park or vehicle parking to keep away from further construction of any buildings. This open space is very important to provide the first step in the future, when next upgrading is required in half to one centuries.

Creating such a Master Plan is important to upgrading historical old hospitals to compact & functional modern hospitals.



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# Part B

# Information for Health Facility Utility Planning

## Part B

## Information for Health Facility Utility Planning

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# 1. Sources of Water and Water Supply System

**(1) Source / Collection of Water**

This consists of the intake where the water is drawn from the source of supply, the receiving reservoirs; the transmission line, of the conduit pipe through which it flows; and the pumping machinery to raise the water from one level to another until it reaches the purifying system.

When there is existing water network and water supply of sufficient pressure, it should be connected to purifying system or water treatment plant of adequate capacity before distributing the water to hospital intake. To ensure sufficient water pressure is available to hospital, a reservoir tank and water pumping system can be considered.

When there is no existing water network in the area, planners and designers should look for the nearest, appropriate and uncontaminated body of ground or surface water, such as natural spring, flowing river, lake or reservoir. Using such sources, a simple system of filtration through gravel and sand can be established, and a naturally-aerated collecting and storage pond can be dug. In the absence of a spring or river, a shallow tube-well (borehole) may be dug or drilled, fitted with a hand pump or a deep-well fitted with a hand pump or power engine-driven pump. Experience indicates that water extracted from a depth of up to about 25m is generally potable and safe. Deeper wells yield more water and usually of better quality, but more powerful pumps and longer piping system are needed. An elevated water tank can be used to store the water collected. Whether the water source is a spring, a river or a well, a piped conveyance and distribution system supported by a forced pumping needs to be used when it is not possible to do it by gravity.

**(2) Water Treatment System**

This consists of settling basin(s), where settleable (particulate) solids are removed; coagulation and flocculation where chemicals are added to aid removal of small suspended solids that cannot be removed by gravity; filtration where flacs are removed; ion exchange and membrane filters in which hardness is removed; and disinfection usually by chlorine where disease-causing organisms are killed/removed.

The type of filtration system and technology to be used is a function of the quality of the water source, the level of contaminants and the economy of operation and maintenance of the system.

Water quality shall be easily checked to determine its suitability for consumption meeting safety standards.

Depending on the needs, filtration designs can be qualified for consumption, cooking , and the like, and for cleaning, washing, and for toilet.

**(3) Water Supply/Distribution System**

This consists of the distribution reservoirs, in which the treated water is stored, and the network of pipes that convey the water to the points of consumption. Normally, storage facilities are provided to store a 36-hour (3-day) supply capacity for 200-250-beds capacity hospital.

In a simple gravity system, the force of gravity moves the water from the source of the treatment system to the points of consumption. The pressure required in the system for ordinary use is 34.3 N/ $cm^2$ (3.5 kg/$cm^2$), for fire protection without the aid of fire engines, however, the pressure required is 68.6 N/ $cm^2$ (7.0 kg/$cm^2$).

When using elevated water tank, it must be coupled by a reservoir tank system for storage before pumping the stored water to the tank via a simple filtration system. The reservoir tank must be cleaned, disinfected and maintained periodically, as well as its filtration system.

In the same vein, when using direct supply from ground water, a cistern system should also be used coupled by adequate capacity pressure tank after filtration system.

An alternate water source must be considered if the normal water source is disrupted for more than 3 days.

**(4) Water Reserving at Site (Collection System)**

This consists of the intake where the water is drawn from the source of supply, the receiving reservoirs; the transmission line, of the conduit pipe through which it flows; and the pumping machinery to raise the water from one level to another until it reaches the purifying system.

Where piped transmission line is not available, rainwater harvesting can be considered in some cases. The rainwater reservoir must be of adequate capacity to supply hospital needs at least during dry season. Rainwater should not only be accessible for use but also secured from outside contamination.

**(5) Volume of Water**

The minimum water requirement is about 50 litres per person per day for hospital use. Normally, however, the water requirement is 115 litres per person per day. An additional volume of about 30 litres per person per day should be added to this basic volume in the computations for watering lawns and as a stand-by for fire protection.

# 2. Health Care Waste Management

## 2.1 Classification of Health Care Waste

Incineration is the common disposal method of Health Care Waste (HCW) in Zambia. This is because incineration of HCW offers the benefits of sterilization, reduction in volume and rendering the waste unrecognizable. However, in recent years, public acceptance of incineration has been declining and environmental regulations of incineration are becoming increasingly more stringent. Further, there are methods of treatment and disposal of HCW that are non-incineration based. MoH is in the process of upgrading Health Facilities from one level to another. It is therefore, anticipated that there will be unprecedented increase in generation of HCW. Health Care Waste Management (HCWM) will also include specialized methods of segregation, storage, collection, pre-treatment, transportation and disposal of cancer and veterinary waste.

According to WHO, HCW is classified into five main categories. These include:

A. Non-risk HCW

B. HCW requiring special attention.

C. Infectious and highly infectious waste.

D. Other hazardous waste

E. Radioactive waste

This classification is shown in the diagram below.

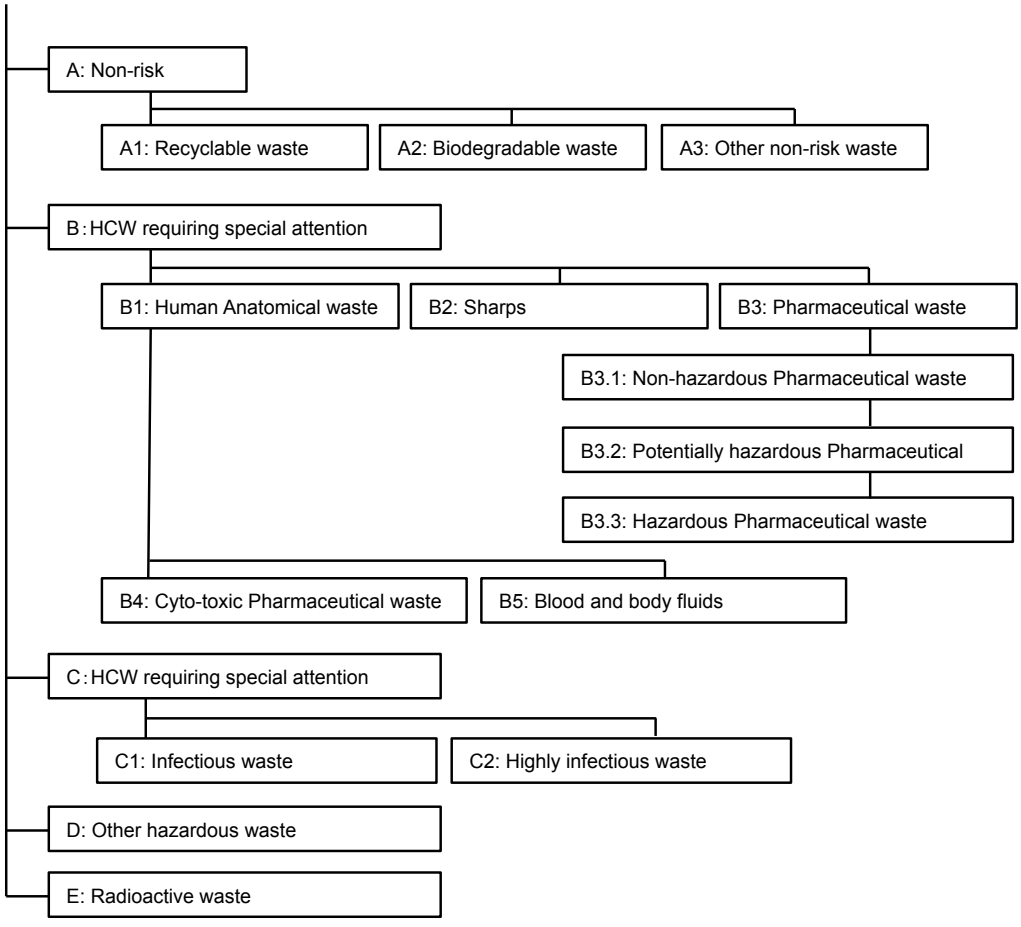



**Figure 2.1: Classification of Health Care Waste, WHO, 2002**

**(1) Non-risk HCW**

Non-risk HCW includes all the waste that has not been infected such as general office waste, packaging or leftover food. They are similar to normal household or municipal waste and can be managed by the municipal waste services. They represent between 75% to 90% of the total amount of HCW generated by HCF (WHO, 2009). These fall in three categories:

**A1: Recyclable waste**

It includes paper, cardboard, non-contaminated plastic or metal, cans or glass that can be recycled.

**A2: Biodegradable HCW**

This waste comprises putriscible or compostable materials e.g. leftover food or garden waste.

**A3: Other non-risk waste**

These include all the non-risk waste that do not belong to categories A1 and A2.

**(2) Biomedical and health care waste requiring special attention**

**B1: Pathological and anatomical waste**

This category of waste comprises infectious pathological and anatomical waste e.g body parts, organs, tissues and blood bags. This waste may not be infectious unless the status is known, it is treated as though it were (WHO, 2003) . This excludes animal parts that are duly certified for human consumption arising from food processing plants.

**Examples of such wastes**: tissue waste, removed organs, amputated body parts, placentas, etc.

**B2: Sharps**

Sharps are all objects and materials that are closely linked with health-care activities and pose a potential risk of injury and infection due to their puncture or cut property. For this reason, sharps are considered as one of the most hazardous waste generated in the Health Care Facilities (HCF) and they must be managed with the utmost care.

**Examples of such wastes**: all types of needles, broken glassware, ampoules, scalpel blades, lancets, vials without content

**B3: Pharmaceutical waste**

The term "pharmaceutical" embraces a multitude of active ingredients and types of preparations. The spectrum ranges from teas through heavy metal containing disinfectants to highly specific medicines. Waste management therefore requires the use of a differentiated approach. This category of waste comprises expired pharmaceuticals or pharmaceuticals that are unusable for other reasons (e.g. call-back campaign). Pharmaceutical wastes are divided into three classes. Their management occurs in a class-specific manner (see below).

**B3.1: Non-hazardous pharmaceutical waste**

This class includes pharmaceuticals such as camomile tea or cough syrup that pose no hazard during intermediate storage, collection, transportation and disposal. , and .They are not considered hazardous wastes and should be managed jointly with municipal waste.

**B3.2: Potentially hazardous pharmaceutical waste**

This class embraces pharmaceuticals that pose a potential hazard when used improperly by unauthorised persons. They are considered as hazardous wastes and their management must take place in an appropriate waste disposal facility.

**B3.3: Hazardous pharmaceutical waste**

Class B3.3 pharmaceutical waste comprises heavy metal containing and unidentifiable pharmaceuticals as well as heavy metal containing disinfectants, which owing to their composition require special management. They must be considered as hazardous wastes and their management must take place in an appropriate waste disposal facility.

**B4: Cytotoxic pharmaceutical waste**

Cytotoxic pharmaceutical wastes are wastes that can arise by use (administration to patients), manufacture and preparation of pharmaceuticals with a cytotoxic (antineoplastic) effect. These chemical substances can be subdivided into six main groups: alkylated substances, antimetabolites, antibiotics, plant alkaloids, hormones, and others. A potential health risk to persons who handle cytotoxic pharmaceuticals results above all from the mutagenic, carcinogenic and teratogenic properties of these substances. Consequently, these wastes pose a hazard, and the measures to be taken must also include those required by occupational health and safety provisions.

**Examples of such wastes**: Discernible liquid residues of cytotoxic concentrates, post-expiration-date cytotoxic pharmaceuticals and materials proven to be visibly contaminated by cytotoxic pharmaceuticals must be disposed of as cytotoxic pharmaceutical waste.

**B5: Blood and body fluids waste**

It includes wastes that are not categorised as infectious waste but are contaminated with human or animal blood, secretions and excretions. It is warranted to assume that these wastes might be contaminated with pathogens.

**Examples of such wastes**: Dressing material, swabs, syringes without needle, infusion equipment without spike, bandages, and waste from postmortem activities and among many other clinical wastes.

**(3) Infectious waste**

Infectiousness is one of the hazard characteristic listed in annex II of the Basel Convention and defined under class H6.2. Special requirements regarding the management of infectious wastes must be imposed whenever waste is known or – based on medical experience – expected to be contaminated by causative agents of diseases and when this contamination gives cause for concern that the disease might spread. In this category two groups can be considered depending on the degree of infectiousness that is expected.

**C1: Infectious waste**

This class comprises all biomedical and health-care waste known or clinically assessed by a medical practitioner or veterinary surgeon to have the potential of transmitting infectious agents to humans or animals. Waste of this kind is typically generated in the following places: isolation wards of hospitals; dialysis wards or centres caring for patients infected with hepatitis viruses (yellow dialysis); pathology departments; operating theatres; medical and animal health practices and laboratories which mainly treat patients suffering from the diseases specified above. It includes:

- Discarded materials or equipment contaminated with blood and its derivatives, other body fluids or excreta from clinically confirmed infected patients, postmorten activities or animals with hazardous communicable diseases. Contaminated waste from patients known to have blood-borne infections undergoing haemodialysis (e.g. dialysis equipment such as tubing and filters, disposable sheets, linen, aprons, gloves or laboratory coats contaminated with blood);
- Carcasses as well as litter and animal faeces from animal test laboratories, if transmission of diseases is to be expected.

**Examples of such wastes**: Blood from patients contaminated with HIV, viral hepatitis, brucellosis, Q fever. Faeces from patients infected with typhoid fever, enteritis, cholera. Respiratory tract secretions from patients infected with TB, anthrax, rabies, poliomyelitis, etc.

**C2: Highly infectious waste**

It includes:

- All microbiological cultures in which a multiplication of pathogens of any kind has occurred. They are generated in institutes working in the fields of hygiene, microbiology and virology as well as in medical laboratories, medical and animal health practices and similar establishments;
- Laboratory waste (cultures and stocks with any viable biological agents artificially cultivated to significantly elevated numbers, including dishes and devices used to transfer, inoculate and mix cultures of infectious agents and infected animals from laboratories).

**Examples of such wastes**: Sputum cultures of TB laboratories, contaminated blood clots and glassware material generated in the medical analysis laboratories, high concentrated microbiological cultures carried out in medical analysis laboratories.

**(4) Other hazardous waste**

This category of waste is not exclusive to the health-care sector. They include: gaseous, liquid and solid chemicals, waste with high contents of heavy metals such as batteries, pressurized containers, etc.

Chemical waste consists of discarded chemicals that are generated during disinfecting procedures or cleaning processes. Not all of them are hazardous but some have toxic, corrosive, flammable, reactive, explosive, shock sensitive, cyto- or genotoxic properties. They must be used and disposed of according to the specifications provided with each type of chemical.

Waste with high contents of heavy metals and derivatives are potentially highly toxic. They are considered as a sub-group of chemical waste but should be treated specifically.

Pressurised containers consist of full or emptied containers or aerosol cans with pressurised liquids, gas or powdered materials.

**Examples of such wastes**: thermometers, blood-pressure gauges, photographic fixing and developing solutions in X-ray departments, halogenated or non-halogenated solvents, organic and in-organic chemicals.

**(5) Radioactive HCW**

Radioactive waste includes liquids, gases and solids contaminated with radionuclides whose ionizing radiations have genotoxic effects. The ionizing radiations of interest in medicine include X- and γ-rays as well as α- and β- particles. An

important difference between these types of radiations is that X-rays are emitted from X-ray tubes only when generating equipment is switched on whereas γrays, α- and β- particles emit radiations continuously.

The type of radioactive material used in health-care facilities results in low level radioactive waste. It concerns mainly therapeutic and imaging investigation activities where Cobalt (60Co), Technetium (99mTc), iodine (131I) and iridium (192Ir) are most commonly used.

**Examples of such wastes**: Radioactive waste includes solid, liquid and gaseous waste contaminated with radionuclides generated from in vitro analysis of body tissue and fluid, in vivo body organ imaging and tumour location, and investigative and therapeutical procedures.

## 2.2 Laws and Regulations related to the Health Care Waste

### (1) Legal and regulatory framework

The current Zambian legal provision regarding management of HCW are provided according to the sector of application and control as listed below:

#### 1) The Public Health Act, Cap 295 of 1995

The Public Health Act Cap 295, part IX deals with control of infectious diseases, sanitation and housing. This Act places responsibility on local authorities to take measures and maintain their areas in a clean and sanitary condition. It also prevents the occurrence of nuisances and aspires to remedy them or other conditions liable to be injurious or dangerous to health. In addition, Section 67 defines a nuisance as one which includes any accumulation or deposit of refuse which is offensive or which is injurious or dangerous to health.

It is instructive that the provisions in Public Health Act do not explicitly deal with health care waste. However, these provisions address the conditions which render premises dangerous to health. There are circumstances in which the danger to health arises from the handling of infectious health care waste, in which case the provisions of the Public Health Act can be used.

#### 2) The Environmental Management Act No. 12 of 2011

The principal law on Environmental Management is EMA No. 12 of 2011 of the Laws of Zambia. The Act empowers ZEMA:

- To give specific or general directions to local authorities regarding collection and disposal of waste.
- To formulate and provide standards and regulations for the sound management of waste.

#### 3) Environmental Management (licensing) Regulation (Statutory Instruments No. 112 of 2013)

Part IV of this Statutory Instrument has been promulgated to amplify the provisions of the EMA. These regulations control and monitor the generation, collection, storage, transportation, pre-treatment, treatment, disposal, and trans-boundary movement of hazardous waste.

In these regulations hazardous waste includes:

- Waste from pharmaceuticals
- Waste from clinics and other related wastes (medical, veterinary, investigations and research). It excludes office and kitchen wastes and has the following characteristics:

**a) Infectious substances**

These are substances or wastes containing viable micro-organisms or their toxins which are known or suspected to be capable of causing disease in humans and animals.

**b) Toxic (Delayed or chronic)**

These are substances or waste which, if inhaled. Ingested or penetrate the skin, may cause delayed or chronic effects, including carcinogenicity.

The Fifth and Sixth Schedules prescribe the type of waste which is regulated and includes the following:

- **Waste Streams**: Clinical waste from hospitals, health centres, clinics and includes pharmaceutical waste.

Part III of SI 112 of 2013 governs the reclamation, reuse, recovery, recycling, transport, disposal and trans-boundary movement of industrial, commercial, domestic waste which is non-hazardous.

**4) Medicines and Allied Substances Act No. 3 of 2013**

This Act provides for licensing of Medicines and allied substances Act in relation to the registration of Pharmacists, Agro veterinary shops and health shops. The provisions of these guidelines describe a series of steps that need to be followed in order to dispose unwanted pharmaceuticals. The steps required include; identification of pharmaceutical waste, sorting of pharmaceutical waste by category, filling the relevant forms to seeking authority from ZEMA and the Director General among other persons for disposal of such waste.

**5) Ionizing Radiation Protection Act No.19, of 2011**

The Ionizing Radiation protection No.19, of 2011, aims to control the; import, export, possession and use of radioactive substances and irradiating apparatus. Under this Act, a license is required to handle any radioactive substances or irradiating apparatus from the Radiation Protection Authority. The Act mandates the method of disposal of radioactive waste products, transportation of radioactive materials, storage, use and maximum working hours that employees are expected to work with radioactive materials. Under this Act also, institutions generating this category of waste shall be expected to apply for a license from the same Authority.

**6) Local Government Act, Cap 281 of 1991**

This Act provides for the establishment of city, municipal, district, township councils or management boards and Local Government Service Commission and defines their functions and powers including the acquisition of land.
Section 61 defines the functions of Local Authorities as read in Second Schedule No. 51 which states that Local Authority should establish and maintain sanitary services for the removal and destruction of, or otherwise dealing with all kinds of refuse and effluent, and compel the use of such services. Second schedule No. 52 states that Local Authorities shall establish and maintain drains, sewers and works for the disposal of sewage and refuse. The statutory instrument No.100 of 2011, addresses the issue of the municipal solid waste.

**7) National Strategic Plan for Infection Prevention**

The mission statement of this plan is to ensure safety of health workers, patients, and the community and to maintain a safe environment through the promotion of safe injection practices and proper management of medical waste.
The policy objectives spell out the need to advocate for support and implementation of proper management of medical waste among others. Some of the guiding principles for the implementation of this policy include:

- The need for environmental protection through appropriate waste disposal methods.
- Minimization of risks to patients, health workers, communities and the environment through application of safer injection devices and sharps waste disposal methods.
- Strengthening of the necessary human resource capacity through training and sensitization for safe waste disposal.
- Develop logistic system that will address the sustained supplies and equipment of HCWM. This will require a commensurate investment to comply with HCWM requirement.

Therefore, a unique strategy is recommended for the advocacy of best waste management practices through behaviour change with communication as a key element in the strategy.

**8) International Conventions**

**a) The Stockholm convention on Persistent Organic Pollutants**

The Stockholm Convention is an international environmental Treaty, signed in 2001 and became effective in May 2004. It aims to eliminate or restrict the production and use of Persistent Organic Pollutants (POPs). Key elements of the Convention include the requirement that developed countries provide new and additional financial resources and measures to eliminate production and use of intentionally produced POPs, eliminate unintentionally produced POPs where feasible, and manage and dispose of POPs wastes in an environmentally sound manner.

**b) The Basel Convention**

The Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and Disposal is an international Treaty that was designed to reduce the movements of hazardous waste between nations, and specifically to prevent transfer of hazardous waste from developed to less developed countries (LDCs). It does not, however, address the movement of radioactive waste. The Convention is also intended to minimize the amount and toxicity of wastes generated, to ensure their environmentally sound management as closely as possible to the source of generation, and to assist LDCs in environmentally sound management of the hazardous and other wastes they generate.

In addition to conditions on the import and export of the above wastes, there are stringent requirements for notice, consent and tracking for movement of wastes across national boundaries. It is worth to note that the convention places a general prohibition on the exportation or importation of wastes between parties and non-parties.

**c) Minamata convention 1**

This is a new multilateral environmental agreement that addresses specific human activities that are contributing directly to mercury pollution. This convention was as result of deaths of many people in Minamata in Japan who had been exposed to Mercury from the mines which accumulated in the fish in the Minamata bay.

The convention resolved the following:

- Reduce the use of clinical thermometers and BP machines and other detecting devices
- Reduction in mercury mining
- Vaccines which use mercury as preservatives
- Reduce the use of mercury batteries
- Phase out mercury manufacturing and processes i.e. soaps, cosmetics, dental filings
- Safe storage and disposal of all mercury related products after their removal from the market
- Phase out or control mercury air emissions from coal fired power plants, industrial boilers, cement production etc.

**9) Auditor General's Report Findings**

The 2009 General Auditor's report on medical waste management in the health institutions revealed serious weaknesses in the prevailing HCWM practices. It was observed that the following areas were not handled according to available laws of

Zambia and the regulations; generation, handling, storage and transportation to the final disposal point. Notable findings included the following:

a) Most Health facilities did not maintain records of the quantities of waste generated contrary to ministry policy, legislation or regulations.
b) Colour coding and labelling not followed by some Health institutions.
c) Transportation and disposal not done according to ZEMA guidelines.
d) Improper and ineffective treatment of HCW
e) Lack of HCWMP
f) Most Health facilities did not orient members of staff in HCWM

**10) Health Care Waste Handling Practices**

**a) The Practice of Waste Segregation**

The key to minimization and effective management of HCW is identification and segregation of the waste. It ensures that the correct disposal procedures are taken, personnel safety is maintained, environmental harm is minimized and recycling consumes the least resources. Segregation of HCW should be done according to the following categories; infectious or clinical waste (hazardous waste), non-infectious or general waste, highly infectious waste, and sharps. Segregating waste according to type minimizes the costs of HCW collection and treatment. Correct and efficient segregation will only be achieved through rigorous training and education of employees, supervisors and managers. Staff must also be aware of the rationale for segregation as well as colour codes for containers and bags used for different types of wastes.
For effective HCWM the following shall be the HCW segregation practices:

i. Segregation shall be carried out by the health care worker or any other person generating waste. This shall be done as close to the point of generation as possible. (i.e. in all clinical areas, traditional health practices and home based care environments)
ii. HCW receptacles shall be readily available at the point of generation, located away from patient areas to avoid cross infections;
   · Be safe and guarantee the absence of infectious microorganism in the domestic waste flow;
   · Be well understood and well known by the medical and other health staff of the HCFs;
   · Be regularly monitored to ensure that the procedures are respected.
iii. Suitable HCW receptacles of appropriate size and number, to accommodate the different waste types being generated, shall be used.
iv. The personnel involved in HCW management shall ensure that the waste bags are removed and sealed when they are not more than three-quarters full. The preferred method of sealing shall involve a plastic sealing tag of the self-locking type and stapling shall never be encouraged.
v. Health care providers and any other personnel shall not sort through waste by correcting errors of segregation. If general and hazardous waste are accidentally mixed, the mixture should be treated as hazardous HCW.
vi. Segregation system shall be uniformly applied throughout the whole country and shall be maintained throughout the entire waste stream up to disposal;
   · Be simple to implement for the medical and other health workers and applied uniformly throughout the country or facility.

**b) Packaging**

In general, the waste shall be packaged in sealed bags or receptacles to prevent spilling during handling and transportation. The bags or containers shall be resistant to their content (puncture-proof for sharps, resistance to chemicals reaction) and to normal conditions of handling and transportation such as vibration and changes in temperature, humidity or pressure (resulting from altitude).

**c) Colour coding**

For effective HCWM the following shall be the HCW colour coding practices:

i. Colour coding for the bin liners shall always correspond or match with the waste containers both at the internal and external storage sites. Colour coding will reduce the risks of cross contamination and occupation health hazards and enhance identification of types of HCW.
ii. Bins and bin-liners, containers and bio-hazard bags shall be either black or brown and yellow to reinforce the separation of types of waste. See annex 9 for colour coding guide.

**d) Labelling**

Labelling is important in order to:

i. Identify the source of HCW or date of generation in case of an accident or improper segregation of the waste.
ii. Ensure that the workers responsible for HCW management handle the different types of wastes safely.
iii. Ensure that each staff member feels more responsible for what they put into the bag/receptacle
iv. Ensure that segregation is done properly
v. Ensure that Medical Departments gather data on the amount of waste produced in each department.

**11) Storage, Collection and Transportation of HCW**

**a) Storage**

Storage is classified into internal and external. Consideration for storage must be based on the classification or type of waste being dealt with and the potential risk of infection to health-care workers and waste disposal staff.

**i. Internal (Primary) Storage**

Internal storage is the temporary placement of waste at the point of generation before transfer to external storage points. A storage location for the HCW should be designated inside the HCF. The waste in the bin-liners or containers should be stored in a separate area, room or building appropriate to the quantity of waste produced bearing in mind the frequency of collection.

Segregation of hazardous waste from general waste should be maintained in storage. They should be planned periodic cleaning and disinfection of temporary storage areas and the containers. The storage time for HCW before it's transferred to external storage facilities should ensure that during cold/rain season 48 hours and during hot season 24 hours.

**ii. External (Secondary) Storage**

External storage refers to the transit point where waste is stored after removal from primary storage to the time it is collected and transported for treatment and final disposal. These are locations in special areas or in the grounds of a HCF

where larger containers are used to store waste until it goes for final disposal either on or off-site. The external storage is usually situated within the HCF. The frequency of removal of waste stored depends on the volume and nature of waste generated.

For effective HCWM the following shall be the HCW external storage practices:

- To ensure that waste is kept separated, the central storage receptacles for each colour coded bags shall be placed in similarly colour coded receptacles.
- There shall be one or more external storage points for hazardous and non-hazardous waste depending on the layout and size of each HCF.
- The external storage point(s) for the hazardous and non-hazardous waste shall be geographically separate at a HCF.
- Waste from the separate external storage points for general waste and potentially infectious waste shall go to different final disposal facilities.
- Facilities for external storage shall be sited away from the kitchen, laundry, ward etc. but within the precincts of the facility and shall be easily accessible to collection vehicles;
- The facility shall be enclosed and surrounded by an impervious wall of appropriate height and provided with a gate and lock;
- The walls and floors shall be smooth, without cracks, impervious, easy to clean and disinfect
- The site shall be spacious, well ventilated and lit;
- All loading and unloading of waste shall take place within the designated collection area around the storage point;
- Larger volume waste bins should be available at the external storage facility to receive waste containers from the internal storage points.

These bins shall be marked for ease of identification of content and the markings must correspond with the colour code used for polythene bags in internal storage;

- HCW shall not be compressed during storage;
- Waste bins shall be washed and disinfected each time they are emptied;
- The storage area shall have water supply for cleaning purposes; waste water from the storage area must be drained into septic tanks, soak ways and municipal sewer system and must not be allowed to drain off into storm water drainage or streams;

Adequate spill kit and protective clothing such as gloves, overall, nose masks etc.; must be provided at the storage sites. The kit sites must include absorbent materials, disinfectant, buckets, and shovels for staff to clean up any spills and must be easily accessible.

- Provision shall be made for wash/room facilities for those who handle these waste e.g. basins, shower, water and soap/detergents etc.;
- External storage facilities must meet certain basic standards for the type of waste stored e.g. the temperature of refrigeration of body parts must be such as to prevent further decomposition or multiplication of pathogens;
- Only authorised persons shall have access to external storage area.

- Bio-hazard symbols (as indicated in annex for symbols) and other warning signs shall be conspicuously posted on the door to prevent people from unnecessarily gaining access to the area

**iii. Waste storage, treatment and disposal of cytotoxic waste**

Cytotoxic waste should be managed separately from other types of special waste and from other waste generated in a clinical setting that are not assessed or classified as hazardous waste.

Cytotoxic waste should be transported to a dedicated, secure storage are await collection for disposal and treatment. Bins should be sealed or otherwise secure prior to waste collection and not re-open while on-site. Waste treatment must render the cytotoxic waste non-infectious and unrecognizable. Currently, thermal destruction treatment (1,100oC or higher) is the only acceptable technology for treating cytotoxic waste. If the waste consists of a mixture of cytotoxic and other waste, it should be incinerated at the temperature recommended for cytotoxic waste.

**iv. Radioactive waste**

Radioactive waste should be stored in containers that prevent dispersion, behind lead shielding. Waste that is to be stored during radioactive decay should be labelled with the type of radionuclide, the date, and details of required storage conditions. Further information is provided in the National guidelines.

**a) Collection of health care waste**

For effective HCWM the following shall be the HCW collection practices:

- Collection and transportation of HCW from HCFs shall be integrated into the general waste management plan of the local authority.
- At the institutional level, all HCW shall be sorted on site before collection and transportation. This will bring about easy identification of content of containers thus preventing careless handling and the risk of secondary infection.
- There shall be a fixed schedule for the collection of waste bags and containers from each medical department. This is to ensure the regular removal of waste from each location and to ensure coordination between medical staff and cleaning or housekeeping staff. The minimum frequency of waste removal should be once a day and preferably at least once per working shift.
- No bags shall be removed without labelling indicating the point of generation (hospital and ward) and content;
- Health care workers shall immediately replace the bags or containers with new ones of the same type.
- There shall be separate schedules and separate collection times for different colour coded containers. Separate trolleys shall be used for different types of waste. This is to avoid increased possibilities of wastes becoming mixed and being transported along inappropriate disposal routes.
- The use of closed wheeled trolleys with lids is recommended and shall not be used for any other purpose. The use of wheeled trolleys, containers that are user friendly (easy to load, no sharp edges and easy to clean) is recommended for transportation within the healthcare establishment.
- Vehicles shall be disinfected and cleaned daily or at the end of each haulage with an appropriate disinfectant at an appropriate site where wastewater will be properly disposed off.
- Waste ducts that convey sacks of waste by gravity shall not be used, as they tend to scatter wastes at the exits of the chutes, and are subject to fouling by the wastes, leading to nuisances such as smell and insects.

- Carts and vehicles used to transport the waste shall be carefully designed so that they are stable, quiet in operation, and so that transportation can be achieved with the minimum of effort and inconvenience.
- Trolleys or carts shall be large enough so that waste is not piled up on them in an unsafe way.
- Waste bags shall not be hand carried around the HCF, since it increases the risk of injury to the legs, arms and torso from incorrectly disposed of sharps or other items.
- Where the facility is not equipped to carry out on-site treatment and disposal of HCW the institution shall appoint a waste management contractor licensed by ZEMA to collect and transport its wastes to a designated site for treatment and final disposal. Wastes from HCFs shall be packaged and transported separately based on the adopted colour codes.

**b) Transportation of Health Care Waste**

The general requirements for the transportation of HCW shall observe the following HCW transportation practices:

- It shall only be done by accredited waste management contractors and certified by the local authority and ZEMA.
- All necessary care must be taken to prevent odour nuisance to the neighbourhoods during transportation.
- Where hazardous wastes and other wastes have been mixed, they must be considered hazardous and managed as such.
- HCW must be transported directly to the disposal or treatment site within the shortest possible time.
- Vehicles used for transportation of HCW must be so constructed as to prevent the scattering of packaged wastes, odour nuisance, and must be leak proof.
- The transportation shall be undertaken according to approved times on approved routes and in approved vehicles with approved bio-hazard labels.
- The transporter shall provide for security of the vehicle and an emergency procedure plan.
- Waste must not be compacted or subjected to any other treatment that could cause bags or containers to rapture.
- Labels shall be firmly attached to containers so that they do not become detached during transportation and handling.
- Specific routes shall be planned through the HCF to minimize the passage of loaded carts through patient care and other clean areas.
- Vehicles and trolleys used for moving HCW through the HCF should be designed to prevent spills, and should be made of materials able to withstand exposure to common cleaning agents. These shall not be used to transport any other materials other than HCW.

They should have the following attributes:

- Easy loading and offloading;
- No sharp edges, which could damage waste bags or containers during loading ad offloading;
- Easy to clean.
- The vehicles and trolleys should be cleaned regularly and as soon as possible if the waste material leaks or spills in order to prevent odour and minimize infection.
- The facility's infection prevention (IP) committee or other appointed person should be consulted about the frequency of cleaning and the type of cleaning agent to be used.

**c) Transportation of Radioactive Waste Containers**

The requirements for the transportation of radioactive wastes shall observe the following radioactive HCW transportation practices:

- Radioactive waste containers must be brightly coloured (yellow) and shall be marked 'Radioactive Waste'.
- All radioactive waste packages or containers should have labels bearing the radiation symbol on them.
- The label should be completed and signed by the officer in charge of waste management in the organization.
- The printing on the labels should be permanent and legible for the entire storage period.
- Radioactive waste should be adequately packaged and contained for transport to ensure safety, not only of those involved in the transport operation, but also for those who could be affected as a result of transport operations in accordance with the International Atomic Energy Agency (IAEA) Regulations for the Safe Transport of Radioactive Material. (Requirements, 1996, Safety Standards Series ST-1, IAEA, Vienna).
- Drivers transporting radioactive material have to be suitably trained and carry contingency plans on the vehicle detailing action to be taken in the event of an accident.
- Radioactive waste material shall be managed in accordance with the Ionising Radiation Act number 16 of 2005), as read with the Ionising Radiation Protection Regulations and Part IX of EPPCA.
- The containers should bear the International Radioactive Symbol to distinguish it from containers meant to receive other types of waste.

**Table 2.1: Summary of Types of Treatment and Disposal of HCW**

| Method | Advantages | Disadvantages |
|---|---|---|
| **Double chamber/rotary kiln incineration** | - Elimination of health risks due to the complete destruction of the waste<br>- Fully destroys microorganisms and sharps<br>- Reduces volume and weight of waste<br>- Destroys all types of organic waste (liquids, pharmaceuticals, and other solids) | - High investment and operation costs<br>- Requires skilled staff to operate<br>- Emit toxic flue gases<br>- Generates residues that need safe land-filling |
| **Single chamber or drum/brick incineration** | - Good disinfection efficiency<br>- Reduces volume and weight of waste<br>- No need for highly trained operators | - Emission of atmospheric pollutants<br>- Need for periodic removal of slag and soot<br>- Inefficient in destroying thermally resistant chemicals and drugs<br>- No destruction of sharps |
| **Autoclaving** | - Relatively simple to operate | - Relatively expensive to install and operate<br>- Requires boiler and stack emissions controls<br>- Relatively high maintenance costs<br>- Generates contaminated wastewater that needs treatment |
| **Microwave irradiation** | - The shredding process reduces the volume of the waste | - Cannot be used to treat pharmaceutical and cytotoxic waste<br>- Skilled operators required<br>- Chemicals used are themselves hazardous and require special precautions when used |

| Method | Advantages | Disadvantages |
|---|---|---|
| **Chemical disinfection** | - The shredding process reduces the volume of the waste | - Cannot be used to treat pharmaceutical and cytotoxic waste<br>- Skilled operators required<br>- Chemicals used are themselves hazardous and require special precautions when used |
| **Encapsulation** | - Simple, low cost and safe<br>- May be used for sharp<br>- Reduces the risk of scavenger gaining access to the waste | - Generates hazardous waste water that needs treatment |
| **Inertisation** | - Simple, low cost and safe<br>- May be used for pharmaceutical waste | - Not applicable to infectious waste |
| **Refuse pit** | - Simple to operate | - Practically for limited periods of time and amount of waste<br>- Possibility of groundwater pollution |

**d) Shredding**

Shredders cut sharps into small pieces. This technology requires a worker skilled in the operation and maintenance of heavy-duty, rotating equipment. Simple shredders can be made from a manually operated grain mill. Due to the presence of workers during operation, only disinfected needles and syringes should be processed.

## 2.3 Technologies for Treatment and Disposal of Health Care Weste (HCW)

The following Factors should be used in the Selection of Treatment Methods:

- Types and quantities of waste for treatment and disposal
- Capability of the healthcare facility to handle the waste quantity
- Technological capabilities and requirements
- Availability of treatment options and technologies
- Capacity of systems.
- Treatment efficiency (microbial inactivation efficacy)
- Occupational health and safety factors
- Environmental releases
- Volume and/or mass reduction
- Installation requirements
- Space available for equipment
- Operation and maintenance requirements
- Infrastructure requirements
- Skills needed for operating the technology
- Location and surroundings of the treatment and disposal sites
- Options available for final disposal
- Public acceptability
- Regulatory requirements
- Capital cost of the equipment
- Operating and maintenance costs of the equipment
- Other costs including costs of shipping, customs duties, installation, commissioning /decommissioning, transport and disposal of residues.

**(1) Assessment of Waste Parameters for Incineration**

Specific waste parameters should be assessed at the planning stage to determine the most suitable type and size of incinerator:

- Current extent of waste production and type of health care waste;
- Volume of waste;
- Estimated future waste production;
- All the physical parameters that determine the suitability of waste for incineration, such as low heating values and low moisture content.

**Table 2.2: Refers to Categories of Health Care Weste Management**

| Type of Health Institution | Recommended technology at various levels |
|---|---|
| **Private health care facilities** | - This will depend on the level and location of the institution i.e. clinic, health centre/ hospital and rural/urban setting |
| **Health Post** | - Land disposal with safe burying with provision and use of liners to prevent ground water contamination<br>- Where there is electricity, free-burn incinerators are recommended. |
| **Health Centre (Rural)** | - Brick incinerator<br>- Where there is electricity, free-burn incinerators are recommended. |
| **Health Centre (Urban)** | - Chemical disinfection<br>- Rotary kiln<br>- Incinerator<br>- Where there is electricity, free-burn incinerators and recommend |
| **First Level (District Hospital)** | - As for Urban Health Centr |
| Second Level (General Hospital) | - Pyrolytic incinerator<br>- Chemical disinfection<br>- Wet thermal or steam treatment<br>- Free-burn Incineration |
| **Third Level (Central Hospital)** | - Land disposal with safe burying with provision of liners to prevent ground water contamination<br>- Pyrolytic incinerator<br>- Chemical disinfection<br>- Wet thermal or steam<br>- Treatment disinfector<br>- Microwave irradiation for teaching hospital<br>- One waste collection<br>- Vehicle per institution |
| **National Reference: (University Teaching Hospital), Regional: (centralized) waste disposal sites (Lusaka and Copperbelt provinces)** | - As for third level, except the number of units will be twice those at level three<br>- Two waste collection vehicles<br>- Free-burn Incineration<br>- Three at each station of either Pyrolytic incinerator or incinerator 350 to 1000 LA wood / coal fired.<br>- Four waste collection and two utility vehicles per station<br>- Free-burn Incineration |

**(2) Incineration Technology**

There are two main types of incinerators: auto-combustion incinerators and fuel-assisted incinerators. It is important to consider the factors outlined above when determining which of the two is most appropriate for the intended use scenario.

Some types of waste have enough heat value to support their own combustion (auto-combustion), and additional fuel such as wood or kerosene is only necessary for the initial ignition. In other cases, the heat value of the waste is too low and additional fuel is required to maintain combustion (fuel-assisted). The composition of the waste to be destroyed as well as the design of the incinerator must be considered when selecting the appropriate incinerator type. For low-income countries it is often necessary that incinerator designs are selected which support auto-combustion in order to reduce the operational costs.

Wastes containing halogens, phosphorus, sulphur, or nitrogen can generate noxious by-products when burnt, thus they require a more sophisticated technology than do wastes which only contain carbon, hydrogen, and oxygen. Therefore, the choice of incinerators and their potential gas-cleaning system will depend on the waste itself. Some wastes are not suitable at all for incineration (such as highly explosive and/or radioactive materials).

**1) Understanding Incinerator Performance**

**a) Combustion 101**

Good combustion requires the right combination of carbon and oxygen. The important factors of oxygen supply in an incinerator design are:

i) Air inlets must be the right size and in the correct location to allow a good mixture of air (oxygen) with the waste (gasses).

ii) Chimney diameter and length must be carefully designed (not too short and not too long) in order to control draught/draft.

iii) Incinerator itself should be located away from obstacles like buildings and trees.

iv) Ashes and other residues that block the free passage of air (oxygen) must be removed routinely.

An incinerator, when operated, should have low or zero visible emissions and should not emit solid particulate matter from the stack. Thick black smoke should never be emitted; if it is, this is a sign that the incineration or combustion is either inadequate or is not being operated properly. Usually, black smokes indicates combustion at low temperatures denoting production of pollutants, such as carbon monoxide (CO), carbon dioxide (CO2) and Sulfur Dioxide (SO2).

**b) Auto-combustion incinerators**

In an auto-combustion system, the incinerator is preheated using dry wood and/or other agricultural residues (e.g., coconut shells, charcoal, etc.). At some point, the waste itself generates the heat for continued combustion during the waste disposal process. Auto-combustion incinerators are substantially cheaper to operate than fuel-assisted incinerators, however auto-combustion incinerators are not suited to destroy placenta or anatomic waste unless anatomic waste is interspersed with safety boxes, dry wood, or charcoal in a ratio of 1 kilogram of anatomic waste to 3 kilograms or more of plastic, wood or charcoal.

Auto-combustion incinerators are able to destroy non-sharps infectious waste if the ratio by weight of safety boxes, wood, or charcoal to non-sharps waste is 2:1 or greater. In consideration of the amount of plastic waste generated by injections, it is important that incinerator technologies which can destroy 50 to 100 percent plastic in the waste load without causing damage to the refractory materials are selected. It is important that metalwork in the incinerator is stainless steel or cast iron if incinerator equipment is expected to be operational for more than three years without replacement.

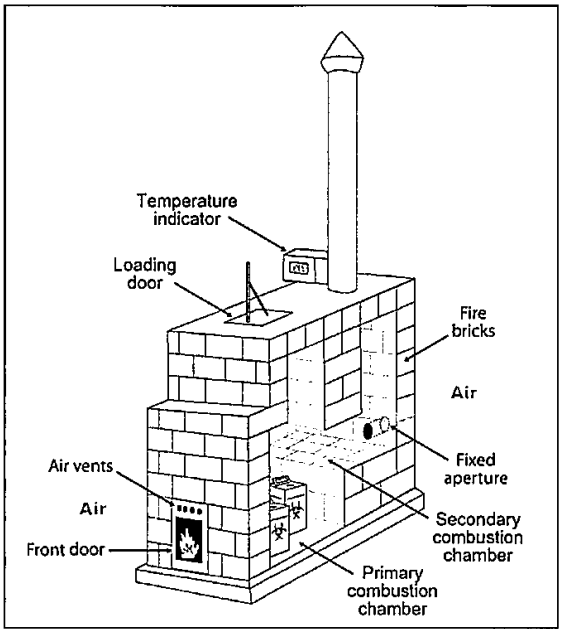



**Figure 2.2: Standard Components of a Small-scale Incinerator**

**c) Fuel-assisted incinerators**

Fuel-assisted incinerators require a fossil fuel (diesel or gas) and a continuous electrical power supply to operate. Fuel-assisted incinerators are sometimes prone to damage if an electrical power failure occurs during operation.

The better-designed fuel-assisted incinerators control the fuel supply in order to maintain constant combustion temperatures and to economize on fuel consumption. Fuel is injected into both the primary and secondary chambers, along with auxiliary air through blowers.

Most fuel-assisted incinerators with a capacity to destroy 100 to 150 kilograms of waste per day consume 5 to 8 liters per hour of fuel (4 to 6.5 kilograms of gas). It is important to note that some fuel-assisted incinerators cannot destroy more than 15 to 25 percent of plastic per load because of the high caloric value of plastics and the damage that can be caused to the refractory lining.

**d) Temperature**

An incinerator should operate in the temperature range of 800° to 1,200°C when medical waste is incinerated. Toxic fumes including furans and dioxins are emitted at temperatures below 600°C if polyvinyl chloride or certain other materials are incinerated.

**e) Residence time**

The gas-residence period should not be less than one second. The gas residence period is the amount of time that the gases take to travel through the incinerator. The gases should travel through the incinerator as slowly as possible, a process that greatly reduces the toxicity of the fumes emitted.

**f) Fuel to waste ratio**

In principle, all products containing enough carbon, hydrogen, and oxygen will burn well as long as there is a low water (moisture) content. The different heating values of products found in health care waste can be expressed in British thermal units per kilogram (btu/kg).

Some types of waste have enough heat value to support their own combustion (auto-combustion), and additional fuel such as wood or kerosene is only necessary for the initial ignition. The heat value of other types of waste will be too low for auto-combustion and will require additional fuel in order to maintain combustion (fuel-assisted.) The composition of the waste to be destroyed must be considered when selecting an incinerator.

**g) Lifecycle**

An incinerator should be corrosion resistant. An auto-combustion system should have a 5-year lifecycle; a fuel-assisted system should have a 10-year lifecycle.

The stack height of an incinerator must be superior to 4 meters so that the stack emissions are not in contact with operators or others in the immediate proximity. Any incinerator selected should be purchased complete with sufficient consumable parts (i.e., fuel filters, burner nozzles, etc.) and replacement parts (i.e., grates, refractory liners, temperatures sensors, etc.) to ensure operation of the incinerator for its planned life cycle.

**2) Selecting an Appropriate Incinerator**

The following are key steps to follow when selecting the appropriate incinerator for health care waste management (HCWM) to meet country and programmatic needs. Whether selecting one incinerator for one health facility or selecting several for a country, following the steps below will help ensure that the appropriate technologies are procured to meet the HCWM system needs.

When planning for a large-scale procurement of multiple units, the selection process will take considerable effort but is a necessity when investing a large amount of money into the system. Even when procuring one incinerator, following these steps will take time. This guidebook provides general information about each step in the procurement process and the questions that need to be addressed in order to guide country-level planning and decision-making. A resource developed by PATH, Planning for Safe Syringe Disposal, may be a useful reference for this process. This document can be found at http://www.path.org/files/TS_syringe_disposal_plan.pdf.

***Key steps to selecting an incinerator design***

1. *Determine your health system needs for HCWM treatment and disposal solutions.*
2. *Assess the infrastructure of the area.*
3. *Determine availability of local resources to support construction and operation.*
4. *Assess policy environment.*
5. *Develop cost estimates.*
6. *Identify lead candidate incinerator designs and determine which units to procure.*

**a) Key steps for selecting an incinerator design**

**- Determine your health system needs for HCWM treatment and disposal solutions.**

In order to determine what type of incineration technology would best fit your health system needs, it is important to undertake the following:

- Map existing HCWM infrastructure. Where is the closest functioning incinerator or other treatment facility? Is transport of HCW possible? Will other facilities be interested in bringing health care waste (HCW) to this facility for disposal? If an incinerator does not exist, what is the best location to situate a centralized incinerator in a service area?
- Characterize waste. What types of HCW are produced in your facility/service area? What types require treatment by incineration?

- Quantify waste. How many safety boxes and bags of infectious waste are filled each day in your facility/service area? What other waste will need to be incinerated? Is there an effective segregation system in place already to minimize quantities of waste that require treatment?

**- Assess the infrastructure of the area.**

- What condition are the roads near the facilities where incinerators are needed?
- Is power available?
- Is there land available on facility grounds to construct an incinerator (including an ash pit)?

**- Determine availability of local resources to support construction and operation.**

- Determine availability of skilled engineers for installation. Are there skilled engineers to manage proper construction and provide ongoing support once the unit is installed?
- Determine availability of quality materials. If constructing a unit such as a De Montfort and the project proposes procuring materials locally, are quality refractory bricks available? What about high-quality metal components?

**- Assess policy environment.**

- Determine if incineration technologies meet current environmental standards/polices.
- Determine if existing HCWM practices are aligned with national guidelines.
- Determine if facility placement and incinerator technologies are aligned with current national HCWM planning efforts.
- Document attitudes and public awareness about incineration.

**- Develop cost estimates.**

For each of the candidate incineration technologies, document all of the predicted costs including capital, operation, and maintenance costs. Be sure to include transport costs if planning to use a centralized approach. More detail on cost considerations are included below.

**- Identify lead candidate incinerator designs and determine which unit(s) to procure.**

Based on the information gathered through the steps outlined above, conduct an analysis to determine which incinerator technologies meet the health system needs and budgets. Again, multiple types of incinerators may need to be purchased depending on the HCWM system needs.

**b) Budgeting for capital, operational, and recurrent costs**

**- Fuel costs**

A regular supply of fuel—whether for auto-combustion incinerators, fuel-assisted incinerators, or transportation of waste—is essential. Likewise, a system of monitoring and control of the use of fuels is equally important. Adequate budgetary provisions for fuel supply is essential. Facilities equipped with incineration equipment are encouraged to serve as a disposal facility for other facilities nearby on an as-needed basis for a fee. This would increase the waste throughput of the disposal unit, render its investment more economical, and cost-share its operation with other facilities.

Fuels used for auto-combustion incinerators are typically dry wood, charcoal, or coconut husks. Agricultural residues such as straw, corn husks, etc. do not generate sufficient heat to be used effectively as preheating and booster fuels. Fuel

used in fuel-assisted incinerators is typically fuel oil, waste vegetable oil, liquefied petroleum gas, compressed natural gas, and methane, as well as electricity to power pumps, spark igniters, and control circuitry. Special attention should be paid when selecting fuel-assisted incinerators to ensure that the financial implications of installation, maintenance, and operation are fully understood and budgeted.

***Lessons learned: incinerator selection in Haiti***

*In Haiti, US$1M in funding was received from donors and used to purchase 17 diesel-electric incinerators and 20 biomass-assisted incinerators.*

*The original technical specification was not followed by the donor agency and consequently one of the models chosen was inadequate for incineration of safety boxes due to design of the grate system. The second model had no temperature gauge and required additional biomass to be added throughout the burn cycle.*

*The civil work expenses for the installations were 4 times the capital cost of the incinerators: a US$5,000 incinerator cost US$25,000 installed. Once the incinerators were installed, it was determined the country would need more than US$300,000 annual to cover fuel costs to operate the diesel-electric incinerators.*

**- Lifecycle costs**

The destruction capacity over the estimated life of the system is also important and is critical in the determination of life-cycle costs. Procurement agencies frequently select equipment based upon the equipment capital investment costs. True equipment costs relate to the life-cycle costs and not just their capital cost.

Life-cycle costs include: accessories; shipping and insurance; electrical; civil and mechanical works associated with the installation; installation; cost of associated civil works such as ash pit, needle pit, placenta pit, rinsing station, protective enclosures; fuel supply and electricity through the period of operation; salaries of operators; supervisory and management time; training of operators and supervisors; service; and maintenance and spare parts. All of these cost elements should be taken into consideration when comparing the costs of incinerators.

**- Comparing costs**

The table below is an illustrative example of how costs/capacity could be compared side by side including installation costs and life-cycle costs. Note that when considering the purchase of a WDU kit vs. installing a De Montfort-style locally manufactured unit, determine the availability of high-quality materials (including refractory bricks and metal parts) as well as skilled engineers to ensure the design is appropriate and the unit is installed correctly.

**Table 2.3: Comparison of installed small-scale, auto-combustion incinerators currently in use.**

| Characteristics | CREATE* waste disposal unit (WDU) | De Montfort-style locally manufactured unit |
|---|---|---|
| Materials | $5,000 | $2,000 |
| Installation (including labor) | $4,500 | $4,000 |
| Days required to install | 9 | 18 |
| Annual maintenance costs | $150 | $1,000 |
| Average life span (year) | 5 - 10 | 2 - 3 |
| Capacity (day) | 20 - 30 kg/day | 15 - 20 kg/day |

*CREATE= Centre for Renewable Energy, Appropriate Technology, and Environment. **All amounts are in US dollars

**(3) Non Incineration Treatment Options**

The following basic processes are used for the non- incineration treatment of hazardous healthcare wastes, particularly sharps, infectious and pathological waste:

**1) Low heat Thermal**

Low-heat thermal processes use thermal energy at elevated temperatures (100ºC and 180ºC) high enough to destroy pathogens, but not sufficient to cause combustion or pyrolysis of waste. The treatment processes take place in two environments – moist or dry environment. In the former, steam is used to disinfect waste, commonly performed in an autoclave or other steam-based system; also referred to as a wet thermal process whilst in the later heat is used without the addition of water or steam.

**2) Chemical**

Chemical Treatment Processes use chemical disinfectants such as dissolved chlorine dioxide, bleach (sodium hypochlorite), peracetic acid, lime solution, ozone gas, or dry inorganic chemicals. This process often involves shredding, grinding, or mixing to increase exposure of waste to the chemical agent and the treatment usually results in disinfection rather than sterilization. For liquid systems, wastes may go through a dewatering stage to remove and recycle the disinfectant.

**3) Biological**

Specifically refers to the degradation of organic matter through processes occurring in nature. Examples include composting, vermiculture (digestion of organic wastes through the actions of worms), bio digestion, and natural decomposition through burial of cadavers, tissues and anatomical parts. In some cases, enzymes may be added to speed up decomposition of organic waste. Composting and vermiculture methods have been successfully used for placenta and hospital kitchen waste.

**4) Mechanical**

This method generally supplements other treatment methods and includes shredding, grinding, mixing, and compaction which reduce waste volume. This method is unable to destroy pathogens. The advantage of this method is that the rate of heat transfer is improved and the waste has more surface area for treatment

**5) Inertisation (Stabilisation)**

This process involves mixing waste with a mixture containing lime, cement and water in order to minimize the risk of toxic substances contained in the waste migrating into surface water or underground water. The mixture can be transported in liquid state to landfill. It is a suitable technology for disposing of pharmaceuticals and incineration ashes with a high metal content.

**6) Shredding**

Shredders cut sharps into small pieces. This technology requires a worker skilled in the operation and maintenance of heavy-duty, rotating equipment. Simple shredders can be made from a manually operated grain mill. Due to the presence of workers during operation, only disinfected needles and syringes should be processed.

**7) Non Incineration**

Non-incineration technologies are used to disinfect infectious health-care waste, while avoiding the formation and release of dioxins and furans (C4H4O). Depending on the waste being treated, alternative treatment technologies may also render health-care waste unrecognizable, reduce its volume, eliminate the physical hazards of sharps, decompose pathological or anatomical waste and/or degrade chemotherapeutic waste. The current plan proposes to introduce the non-incineration of HCW under the UNDP project title “Reducing Unintended Persistent Organic Pollutants (UPOP) and Mercury from Releases from Health Sector in Africa”. The technology will be piloted in two level one health facilities in order to assess social and ethical acceptability. Results from the pilot project will provide policy direction and further guidelines.

## 2.4 Health Care Wastewater Management

**(1) Classification of Wastewater**

The laws governing the disposal of wastewater vary from country to country. These may be amplified by national sanitation codes, rules and regulations and local ordinances. Normally, wastewater is subjected to at least some preliminary treatment, such as screening, to separate the larger floating solids from the liquid waste, which is then passed through a sedimentation tank to remove settleable suspended matter. The effluent from the process is then treated further using secondary treatment processes such as trickling filter, activated sludge, rotating biological disk, etc. before it is discharged into a body of water, on natural land, on prepared land, or on specially constructed filter beds of sand and gravel.

1) Household Wastewater
   Human wastewater, Non-fecal wastewater, Kitchen wastewater, Bath/Shower wastewater,
   Laundry wastewater
2) Medical Wastewater
   Thin Wastewater with Acidic, Alkaline and Heavy Metal
   - By carters (But other than listed here, those fall under household waste water)
3) Film Processing Fluids
   Film developing fluid, fixing fluid
   - Stored in the collection tank, then collected by the carters.
4) Hospital liquid wastes, e.g. laboratory waste, hemodialysis (nephrology) treatment waste, surgical, nephrology and ward waste, pathological waste, radiological and other toxic wastes, should be treated before it is discharge to community sewage system.

**(2) Drain Pattern**

Raw wastewater contains both organic and inorganic matter. In order to determine the most effective and least expensive method of disposal, the raw wastewater should be analyzed for its chemical, biological and physical properties. In planning and designing a hospital, the following recommendation should be considered:

**1) Dialysis related Wastewater**

Cleaning of the interior of Hemodialysis Machine requires using chemicals, such as acetic acid and sodium hypochlorite. In this case, the drainage becomes less acidic or alkaline, there is a possibility that the hydrogen ion concentration (pH) exceeds the exclusion criteria. In particular, when acid wastewater is drained in the sewer, it will cause adverse effect on sanitary chamber or main sewer. Therefore, it is required to install treatment stage of wastewater by the exclusion facilities. [Exclusion Criteria: hydrogen ion concentration (pH) of less than 9 but more than 5]

**2) Chemicals Used in Laboratory (Clinical Tests)**

In clinical testing, variety of chemicals will be used. Some of these chemicals contained controlled substances among them. Those chemicals should be collected and required to undergo neutralization treatment before going to sewer.

**Table 2.4: Laboratory Chemicals which affect to People's Health**

| | |
|---|---|
| Cadmium and its compounds | 1,1,1- trichloroethane |
| Cyanide | 1,1,2- trichloroethane |
| Organophosphorus compound | Trichlorethylene |
| Lead and its compounds | Tetrachlorethylene |
| Hexavalent chromium compound | 1,3- dichloropropene |
| Hiso & its compounds | Thiuram |
| Mercury& alkyl mercury and other mercury compounds | Simazine |
| Polychlorinated biphenyls | Thiobencarb |
| Dichloromethane | Benzene |
| Carbon tetrachloride | Selenium and its compounds |
| 1,2- Dichloroethane | Boron and its compounds |
| 1,1- Dichloroethylene | Fluorine and its compounds |
| Cis -1,2-Dichloroethylene | Dioxins |

**Table 2.5: Laboratory Chemicals which affect to the Living Environment**

| | |
|---|---|
| Phenols | Iron and its compounds (soluble) |
| Copper and its compounds | Manganese and its compounds (soluble) |
| Zinc and its compounds | Chromium and its compounds |

In performing clinical testing, first, check if it contains controlled substances in the chemicals used. If the controlled substance is included, please go to the proper collection and disposal of the waste after use. As for the draining of acidic or alkaline waste neutralization process is required. It should be noted that although not a controlled substance, for the organic solvents such as toluene, xylene, and chloroform, if are not eliminated in the sewer, it can have an adverse effect on the sewage treatment. These chemicals cannot be treated in the sewage treatment plant and it will flow to the sea and / or rivers as ordinary waste. Therefore, it is required to collect these chemicals before disposal of waste. Likewise, related instruments should be treated as much as possible.

**3) Detergent**

In the detergent and bleach specific for dishwashers and washing machines for the kitchen, there are those of alkaline. In addition, some toilet detergents are alkaline and acidic. These detergents are used in large quantities and, because there is a possibility that the hydrogen ion concentration of the wastewater exceeds the exclusion criteria, one can either change to those used during the middle ages, and / or perform the neutralization treatment.
[Exclusion criteria: hydrogen ion concentration (pH) of less than 9 but more than 5]

**4) Mercury Thermometers, Mercury Sphygmomanometer, Dental Amalgam**

Mercury thermometers, mercury sphygmomanometer, and the amalgam for filling in dental treatment, contains mercury. Shaping the amalgam by cutting especially in dental filling, mercury might be included in the waste going to the drainage. These mercury, sedimentation, deposits, should be sent to a processor as industrial waste collector.

[Exclusion criteria: mercury and alkyl mercury and other mercury compounds 0.005 mg / ℓ or less]

**5) Sterilizing Material**

The sterilizing materials are those that contained controlled substances, such as phenols. Phenols are used in small amount so as not to exceed the exclusion criteria. To ensure such please do the necessary measures.

[Exclusion Criteria: The following phenols 5 mg / ℓ ]

Examples of bactericidal disinfectant containing phenols:

- Phenol
- Cresol soap solution
- Sterilizing agent containing triclosan
- Disinfectant, including chloroxylenol

**6) High Temperature Disability**

Drainage from the high-pressure steam sterilization equipment, kitchen dishwasher and sterilizer of medical instrument are at very high temperature. The frequent high temperature drainage flows can potentially damage the sewer pipe. From possible damage due to high temperature exposure to high temperature drain steam flow.

[Exclusion criteria: a temperature of less than 45 °C]

**7) Infectious Wastewater**

If the drainage and waste associated with medical care of infected patients have been released to the untreated public sewer the process of sterilization or the like is necessary to prevent infection by eating and splashes.

- In septic tanks, in which raw wastewater flowing in is contained for a period of time to allow bacteria to act on it, helps in its decomposition and render it relatively inoffensive. The treated wastewater is disposed of by percolation in the ground, or infiltration well or a trench field. The suitability of the ground for this purpose should first be established by percolation tests.
- Oxidation pond(s), in which the wastewater is exposed to the sun in simple ponds or ponds equipped with mechanical aerators, depending on the condition and quantity of the wastewater to be treated.

## 2.5 Health Care Waste Management Organization

In order to facilitate the development and implementation of an appropriate waste management system, an effective organization should be established and an in-house waste management plan formulated by each health care establishment. Such a waste management plan specifies not only the duties and function of each member of the waste management organization, but also detailed descriptions of the generation, segregation, handling, storage, transport and treatment/disposal of waste within the health care establishment as well as procedures for contracting off-site transport and disposal services, and for responding to emergencies.

Periodic review of waste management practices by both the regulatory agency and health care establishments should be carried out to improve the protection of health of the workers and the general public, and enhance the cost-effectiveness of the waste management systems.

Respective District Medical Offices (DMOs) are requested to collect sharps, as well as particular wastes that cannot be disposed, handled and managed at health facilities level regularly.

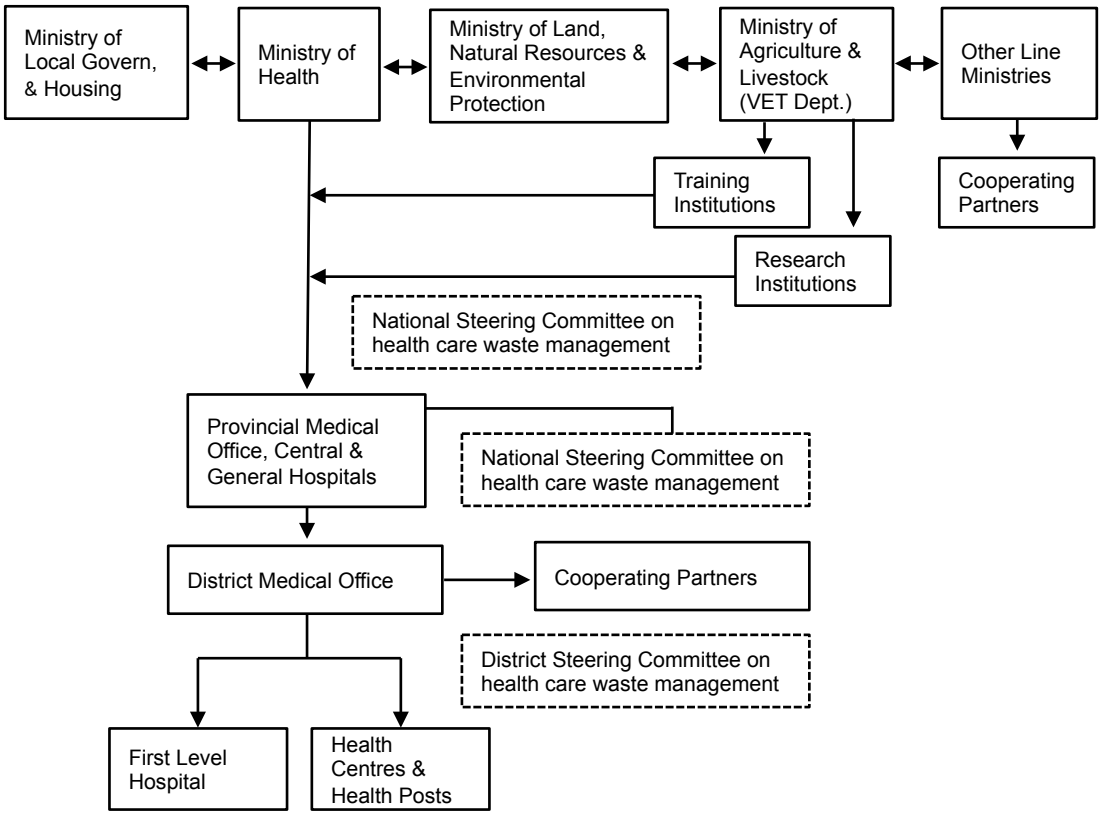



**Figure 2.3: Organogram for Health Care Weste Management**

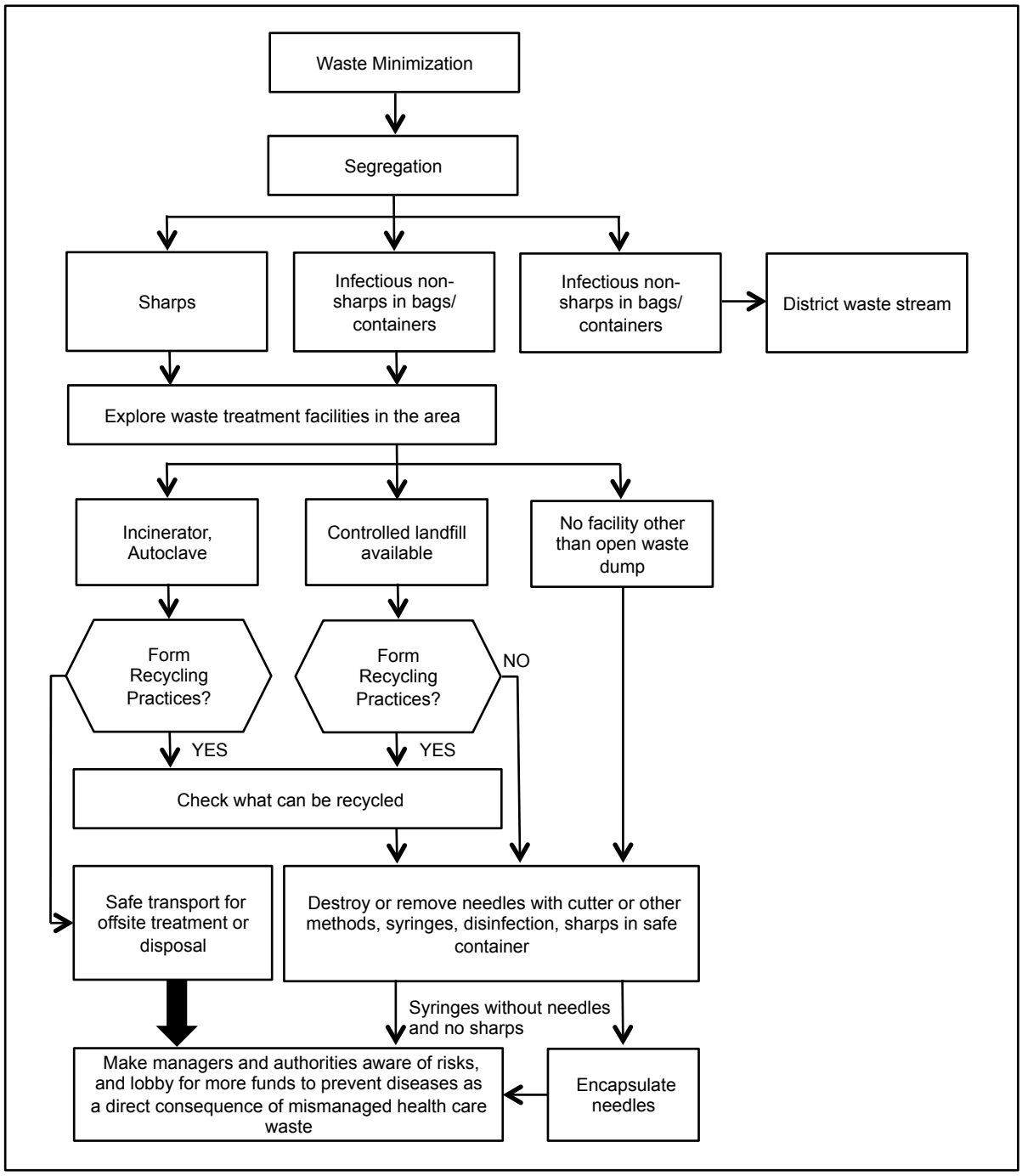


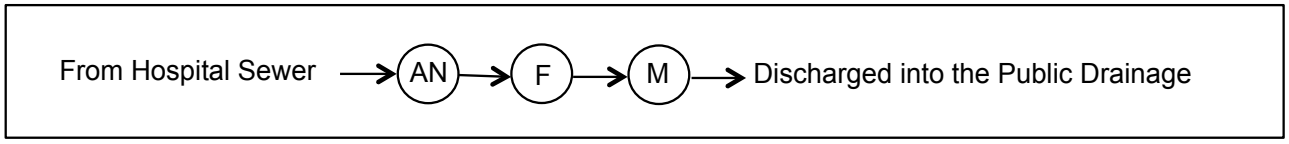

**Figure 2.4: Areas without Access to a Legally Approved Modern Waste Treatment Facility**

## 2.6 Sewage Treatment System

**(1) Introduction**

Wastewater Stabilization Ponds (WSP) or facultative ponds or lagoons are used to treat hospital wastewater, especially hospitals that are located in remote areas. Sewage treatment systems in this type, targets hospitals that are located in remote area.

WSP systems consist of single series of anaerobic, facultative and maturation ponds, or several series in parallel. The pond system can be used alone but they are also used in combination with each other. Figure 2.1 shows pond combinations which are commonly used in the country.




AN= Anaerobic Pond, F= Facultative Pond, M= Maturation Pond

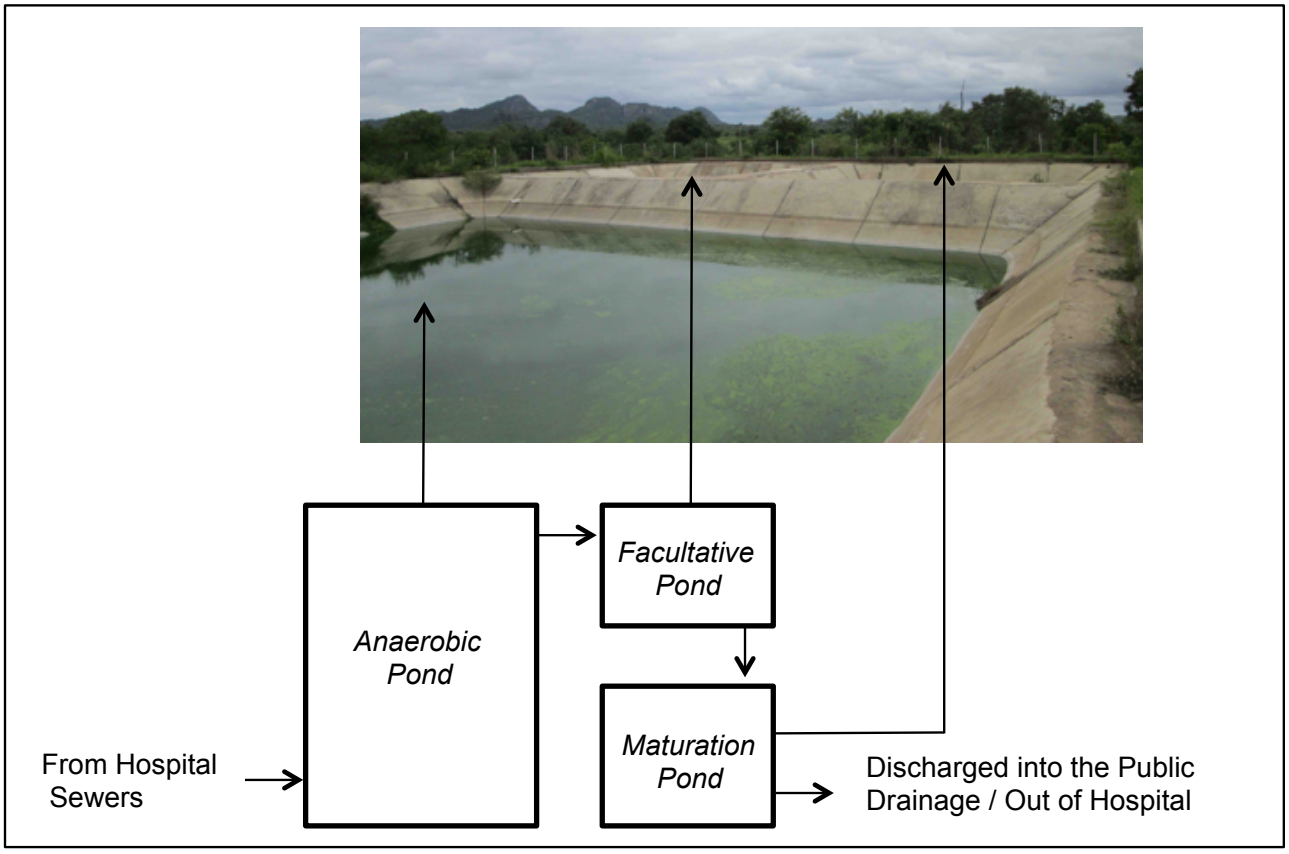



Photo: Chadiza District Hospital

**Figure 2.5: Stabilization Pond Configurations**

Anaerobic and facultative ponds are mainly designed for Biological Oxygen Demand (BOD) removal and maturation ponds mainly for pathogen removal. In many cases anaerobic ponds and facultative ponds are enough for waste water treatment but depending on the destination of effluent the maturation ponds are provided for further polishing purposes.

In some cases facultative ponds are provided without anaerobic ponds. In general maturation ponds are required only

when the treated waste water is to be used for unrestricted irrigation and has to comply therefore with the WHO guideline of <1,000 faecal coliforms per 100 ml, and when stronger waste water (BOD>150 mg/l) are to be treated prior to surface water discharge.

Restricted irrigation refers to the irrigation of industrial crops, such as cotton and sunflower, and food crops that are processed or cooked prior to consumption, such as wheat, potatoes and many other vegetables. Unrestricted irrigation covers food crops eaten uncooked, such as salad crops.

Usually there are odour problems associated with the anaerobic ponds but its inclusion substantially reduces the land area required for facultative ponds. Odour problem can be reduced if properly taken into account during the design stage.

**(2) Advantages and Disadvantages of WSP**

The advantages of WSP include:

- Simplicity in design and construction
- Low production of biological sludge
- Low capital, operation and maintenance cost
- High treatment efficiency if properly designed
- Robust and relatively reliable
- Less sensitive to shock loading

The disadvantages of WSP include:

- Large land requirement for the ponds
- Sludge accumulation will be higher in cold climates due to reduced microbial activity
- Mosquitoes and other insects can breed if vegetation is not controlled
- If not designed properly may cause odour problem
- Difficult to control or predict ammonia levels in effluent

A comparison of WSP with other technologies is given in Table 2.3.

**(3) Type of WSP**

The ponds are classified as:

- Anaerobic ponds
- Facultative ponds
- Maturation ponds

Anaerobic, facultative and maturation pond are more commonly adopted and are generally not aided by any mechanical devices. These three are described in detail. The design features are presented in Table 2.7.

**Table 2.6: Advantages and Disadvantages of Various Wastewater Swage Treatment Systems**

| | Criteria | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|---|
| Plant | BOD removal | 2 | 2 | 2 | 2 | 1 | 1 | 1 |
| Performance | SS removal | 2 | 1 | 1 | 1 | 1 | 2 | 2 |
| | FC removal | 3 | 3 | 2 | 3 | 2 | 1 | 1 |
| | Helminth removal | 3 | 1 | 3 | 3 | 2 | 2 | 1 |
| | Virus removal | 3 | 1 | 3 | 3 | 2 | 1 | 1 |
| Economic | Construction simplicity & cost | 3 | 3 | 3 | 3 | 2 | 2 | 1 |
| Factors | Land requirement | 3 | 1 | 1 | 1 | 1 | 2 | 3 |
| | Operational simplicity | 1 | 3 | 3 | 3 | 2 | 3 | 1 |
| | Maintenance costs | 3 | 3 | 3 | 3 | 3 | 3 | 1 |
| | Energy demand | 3 | 3 | 3 | 3 | 3 | 3 | 1 |
| | Sludge removal costs | 3 | 2 | 2 | 3 | 3 | 2 | 1 |

A: Package Plant B: Activated Sludge Plant C: EAAS D: Biological Filter

E: Oxidation Ditch F: Aerated Lagoons **G: WSP System**

BOD: Biological oxygen demand, FC: Faecal coliform, SS: Suspended solids.

WSP: Wastewater Stabilization ponds, EAAS: Extended aeration activated sludge.

**Statements: Good: 1, Fair: 2, Poor: 3**

### (4) Anaerobic Ponds

In anaerobic ponds large concentration of organic and inorganic solids in waste water is stabilized and the biological activity occurs in the absence of oxygen and in the process produce methane gas and sulphur containing malodorus gases. The anaerobic ponds are the smallest of the series and are used as a primary treatment process and not necessarily to produce the high effluent quality. The Biological Oxygen Demand (BOD) and solids concentration in the raw wastewater are reduced by sedimentation and anaerobic digestion. Since anaerobic pond is devoid of oxygen, it functions much like open septic tanks. Anaerobic digestion occurs in the sludge at the bottom of the pond which results in converting organic load to methane and carbon dioxide and releasing some soluble by-products into the water column (eg. Organic acids, ammonia). Anaerobic treatment is more suited to waste water with high BOD and SS (Suspended solids) from agricultural and food processing wastewater.

A properly designed anaerobic pond can achieve around 60% BOD removal at 20°C and one-day hydraulic retention time is sufficient for waste water with a BOD of up to 300 mg/l and temperature higher than 20 °C (Mara, 2003).

At temperature below 15°C, the digestion processes slows down and the dominant process is thought to be sedimentation. Anaerobic ponds are usually more than 2m deep for sludge storage capacity. The hydraulic retention time depends on the volumetric BOD loading required ($g/m^3.d$) and can be up to 20 days. They reduce the problems associated with sludge accumulation and solids feedback in a following facultative pond. The high efficiency of BOD removal combined with the partial mineralisation of organics experienced in an anaerobic pond allows for smaller subsequent ponds thereby reducing the overall land requirements. The major problem of anaerobic ponds are the odour and the increase in ammonia and sulphide concentrations caused by the anaerobic processes. Besides BOD, Chemical Oxygen Demand (COD) and Suspended Solids (SS) removal, anaerobic pond is efficient in the removal of Vibrio cholera due to their high sulphide concentrations. WSP

system can constructed without anaerobic ponds but their provision not only stabilizes the organic concentrations of wastewater but also reduces the land area required for the facultative ponds.

**(5) Facultative Ponds (Secondary Facultative Ponds)**

Facultative pond are either primary facultative ponds that receive raw wastewater or secondary facultative ponds that receive settled waste water effluent from anaerobic ponds. They are designed for BOD removal on the basis of a relatively low surface loading (100-400 kg BOD/ha d at temperature between 20°C and 25°C) to permit the development of a healthy algal population as the oxygen for BOD removal by the pond bacteria is mostly generated by algal photosynthetic pond. The water layer near the facultative pond surface contains dissolved oxygen due to atmospheric re-aeration and algal respiration, a condition suitable for aerobic and facultative organisms. The sludge deposits at the bottom of the pond support anaerobic organisms while the intermediate anoxic layer, termed as facultative zone ranges from aerobic near to top to anaerobic at the bottom. These layers may persist for long periods due to temperature-induced water density variations. Inversions can occur in the spring and fall when the surface water layer may have a higher density than lower layer due to temperature fluctuations. This higher density water sinks during these unstable periods, creates turbidity, and produces objectionable odours.

The presence of algae in the aerobic and facultative zones is essential for the successful performance of facultative ponds. In sunlight, the algal cells utilise $CO_2$ from the water and release $O_2$ produced during photosynthesis. The oxygen, produced by algae and surface reaeration, is used by aerobic and facultative bacteria to stabilize organic material in the upper layer of water. As a result of the photosynthetic activities of the pond algae, there is a diurnal variation in the concentration of dissolved oxygen. After sunrise, the dissolved oxygen level gradually rises, in response to photosynthetic activity, to a maximum in the mid-afternoon, after which it falls to a minimum during the night when photosynthesis ceases and respiratory activity consumes oxygen. The position of the oxypause (the depth at which the dissolved oxygen concentration reaches zero) similarly changes, as dose the pH since at peak algal activity carbonate and bicarbonate ions react to provide more carbon dioxide for the algae, so leaving an excess of hydroxyl ions with the result that the pH can rise to above favourable for ammonia removal via volatilization.

Anaerobic fermentation occurs at the bottom layer of the lagoon. In cold climates, oxygenation and fermentation reaction rates are significantly reduced during the winter and early spring and effluent quality may be reduced to the equivalent of primary effluent when an ice cover persists on the water surface. Figure 2.6 and Figure 2.7 shows the schematic representation and mutual relationships within the WSP systems of treatment.

**Table 2.7: Design Features and Expected Performance for Aquatic Treatment Units**

| Technology | Treatment Goal | Climate Needs | Detention Time (Days) | Depth (m) | Organic Loading (kg/ha.day) | Effluent Characteristics (mg/l) |
|---|---|---|---|---|---|---|
| Oxidation pond | Secondary | Warm | 10-40 | 1-1.5 | 40-120 | BOD=20-40<br>TSS= 80-140 |
| Facultative pond | Secondary, Polishing | None | 25-180 | 1.5-2.5 | 22-67 | BOD=30-40<br>TSS=40-100 |
| Partial mixed Aerated pond | Secondary, storage, polishing | None | 7-20 | 2-6 | 50-200 | BOD=30-40<br>TSS=30-60 |

| Technology | Treatment Goal | Climate Needs | Detention Time (Days) | Depth (m) | Organic Loading (kg/ha.day) | Effluent Characteristics (mg/l) |
|---|---|---|---|---|---|---|
| Storage pond, HCR pond | Secondary, storage, polishing | None | 100-200 | 3-5 | 22-67 | BOD=30-40<br>TSS=10-40 |
| Root zone Treatment, Hyacinth pond | Secondary | None | 30-50 | <1.5 | <30 | BOD<30<br>TSS<30 |

**HCR**: Hydrograph-controlled release, **BOD**: Biological Oxygen Demand, **TSS**: Total Suspended Solids (check the water quality)

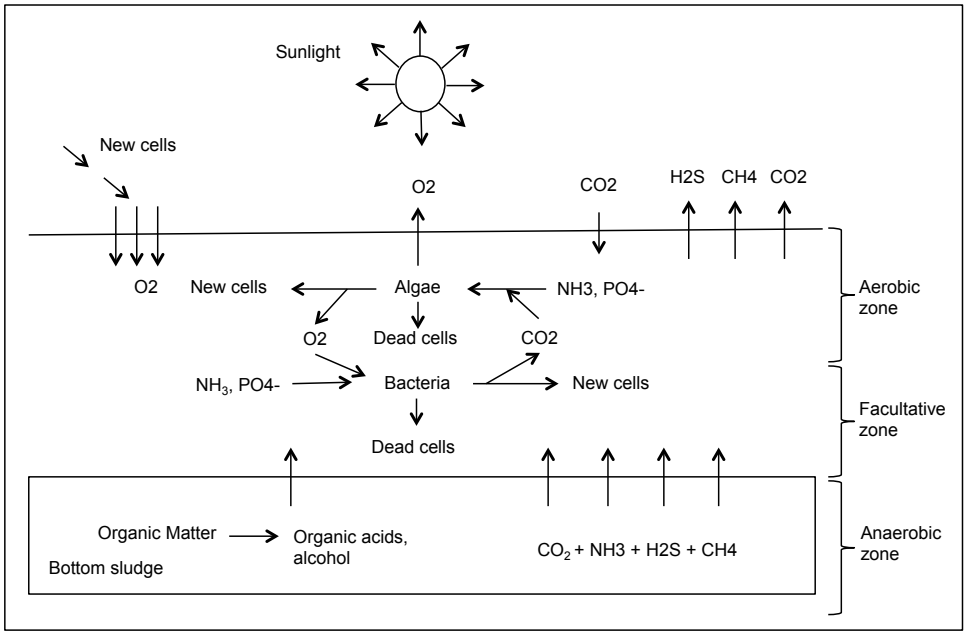



***Figure 2.6: Schematic Representation of Facultative Ponds***

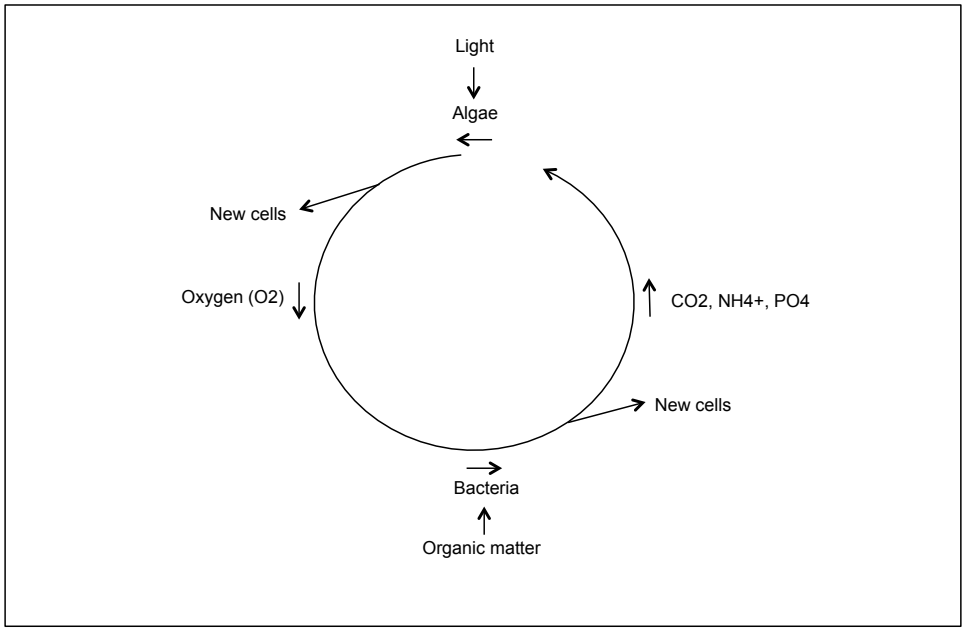



***Figure 2.7: Mutual Relationship between Pond Algae and Bacteria***

# 3. Electric Power Supply (Electricity)

### 3.1 Power Receiving and Transforming Facilities

Followings are to be considered when electrical power planning for the health facilities:

(1) Receiving Voltage

1) 3∅, 11 kV, power capacity which would be contracted with ZESCO (Zambian Electricity Supply Corporation)

2) Transformer Capacity (it should be considered following elements and respective capacities

Single phase: ********** kVA, Three phase: ********** kVA

Emergency for single phase: ********** kVA, Emergency for three phase: ********** kVA

3) Power Transformer Bank (Low Voltage Switchgear)

4) Capacity (depending on the demand load of the hospital)

5) Equipment (Specifications of Breaker and Transformer)

- Low voltage switchgear, isolation transformers for ICUs and OTs, insulation against EMF
- Properly designed grounding system of low impedance for proper operation of electronic medical devices and safety.

(2) Capacity of the electrical power required by the health facilities are influenced by the bed capacities, and characteristics of the health facilities, such as X-ray machine, Kitchen Machinery, Laundry Machinery, etc. which provides general / central medical services, or specialized medical services, and distribution of clinical and medical departments in the health facilities.

### 3.2 Consideration of Electric Power Supply Capacity for District Level Facilities

According to the estimation of electricity power supply to District Health Facilities, such as Health Posts, Health Centers, Zonal Health Centers and First Referral Level Hospitals are calculated based on the functions which would be serviced in the respective health facilities. The function of respective health facilities are shows in the Table 3.1.

**Table 3.1: Characteristics of Medical Services by type of Health Facilities**

| Functional Spaces | Health Post | Health Center | Zonal Health Center | L1 Hospital* |
|---|---|---|---|---|
| 1. Outpatient | ✓ | ✓ | ✓ | ✓ |
| 2. Outpatient (Dental) | | ✓ | ✓ | ✓ |
| 3. Casualty | | | | ✓ |
| 4. Wards | ✓ | ✓ | ✓ | ✓ |
| 5. Maternity | ✓ | ✓ | ✓ | ✓ |
| 6. Pharmacy | ✓ | ✓ | ✓ | ✓ |
| 7. Laboratory | ✓ | ✓ | ✓ | ✓ |
| 8. Environmental Unit | ✓ | ✓ | ✓ | ✓ |
| 9. Kitchen | | | ✓ | ✓ |
| 10. Laundry | | | ✓ | ✓ |
| 11. Mortuary | | | ✓ | ✓ |

| Functional Spaces | Health Post | Health Center | Zonal Health Center | L1 Hospital* |
|---|---|---|---|---|
| 12. Operating Theatre | | | | ✓ |
| 13. Medical Imaging | | | | ✓ |
| | | | | |
| Total Area of Functional Spaces | 80 – 100 sq.m. | 130 – 150 sq.m. | 1,500 – 2,000 sq.m. | 2,500 – 4,500 sq.m. |
| Required Power Supply | 30 – 50 kVA | 30 – 50 kVA | 100 – 150 kVA | 200 – 350 kVA |

- L1 Hospital - First Referral Hospital at District Level
- Floor spaces were calculated functional Human Resources (HR) Units, such as Outpatient and Maternity, so on.
- Electricity power supply capacity was calculated based on the existing medical equipment and facility utilities which would be incorporated into the health facilities.

**Source of Information**: District Health Facilities, WHO 1998, and Equipment Planning and Monitoring Tool Procedures Manual, MoH Zambia, 2008

### 3.3 Electric and Electronic Engineering

Electric power is supplied to hospitals by public or private utility companies. In either case, hospital should have a back-up generator for use in the case of breakdown, at least for emergency, delivery and operating rooms, selected corridors and exits, and stairs. In addition, battery or automatic generators may be used.

The following is a checklist of these electrical components that should be brought in at a very early stage of the designing process. Consultation should also take place with the local power supply company and with any necessary government authorities regarding the mode and system of supplying high- and low-tension power to the hospital.

(1) Power supply

| | |
|---|---|
| - Main incomer (size) | - Tariffs and metering |
| - Maximum capacity | - Agreements with supplying authority |
| - Supply voltage | - Alterations to existing supply |

(2) General description

- General description of any existing system (mains and essential service
- Technical data on existing installation (maximum capacity, assessed connected loads and measured maximum site demand, cable types, protection methods and discrimination/distinction)
- General description of new system (with load estimates for both essential and non-essential supplied

(3) Local distribution

- General labeling of sub-main and sub-circuit system (routes, board locations and area of coverage)
- Cable types and sub-main load estimates
- Installation and wiring methods
- Protection methods and discrimination/distinction

(4) Earthing

- Method adopted for earthing system

(5) Sub-stations

- Type and accessibility
- Transformer and switch-gear ratings and type
- Capacity for increased load, provision for expansion
- Lightning arrester

(6) Stand-by generator (Weather proof)

| | |
|---|---|
| - Type and ratings | - Auto transfer switch |
| - Capacity for increased load | - Battery indicator |
| - Controls and alarms | - Sound proof |
| - Faulty indicator | - Main incomer |
| - Fuel type and stored quantity | - Start and stop bottom |
| - Provisions for maintenance, including access | - Prepare approved base |

(7) Distribution boards

- General description
- Sub-main or sub-circuit protection for 3-phase fault and line -to-grounf fault
- Breaker rating
- Capacity for increased load
- Services supplied (assessed loads and area covered)
- Balance the circuit

(8) Special safety and earthing

- Area, location and classifications
- Medical procedures carried out and equipment used
- Type of protection chosen, with justification

(9) General power

- Known major equipment, with assessed loads (e.g., kitchen and laundry equipment, autoclave, medical services plant, medical equipment))
- Typical location and numbers of plug sockets, including number per circuit
- Connections to essential supply, with load estimate
- Hazardous areas and provisions proposed

(10) Interior lighting

- Area classifications

- Illumination level per room
- Anti-glare design
- Types of fittings (surface, suspended, concealed)
- Lamp type and colour
- System data: mounting height
- Estimated connected load and load per circuit
- Connections to essential services with estimated loads

(11) Exterior lighting
- Areas served and purpose
- Type of fitting
- Control and wiring method, including routes

(12) Lightning protection
- Need
- Design criteria
- Description of proposed design

(13) Communications
- Justification for each type of area
- Type of system
- Areas served
- Wiring method

Other features and safety considerations, like call systems, intercommunication systems, fire alarm systems and other special installations may be included as required in the design and computations for the total electric power requirements.

### 3. 4 Back-Up Power Supply

Hospital should have a reliable alternative source of power, in addition to the normal electrical service, for emergency lighting, for operation of essential equipment, and for the safety of its occupants. The alternative source should be from:
- A generator, when the normal service is supplied from one or more central transmission lines, or
- An emergency generating set or a central transmission line, when the normal supply is generated on the premises.

The emergency generator set with ATS (Automatic transfer Switch), including the prime mover, recommended circuits to which power should be provided are:

(1) Lighting
- All exits, including exit signs, stairways and corridors
- Surgical, obstetrics and emergency room operating light
- Laboratory, recovery room, intensive care units (ICU), nursing station, labour room

- One or two lifts, if needed for emergency
- Telephone operator's room
- Critical areas and administrative offices
- Use of energy saving LED lamps especially for OT and ER

(2) Equipment
- Alarm system, including fire alarm
- Blood bank refrigerator
- Vaccine and cold chains
- Sewerage or sump lift pump, if installed
- Operating, recovery, ICU and delivery rooms
- One electrical sterilizer

(3) Heating, cooling and ventilation system
- Operating, delivery/labour, recovery, ICU

The capacity of the emergency generating set should be 50-60% of the normal electrical load of the hospital, to maintain the minimum level of services.

The emergency electrical system should be so controlled that, after interruption of the normal electric power, the generator brings full voltage and frequency within 10 seconds to all the emergency lighting and equipment listed above. Lights powered by storage batteries can be provided to augment the emergency lighting during the period of transfer switching, immediately following the interruption of normal service; howeverm these should not be used to substitute for the generator set.

### 3.5 Uninterruptible Power Supply (UPS)

- Covered Department

  Operating Theatre, Emergency
- Required Specifications

  25 kVA, 15 minutes; the battery backup for the UPS should be capable of maintaining the critical load during power outages (Generator takes over stand by power supply, when 15 minutes has elapsed.)

### 3.6 Solar Photovoltaic (PV) Power Supply

**(1) Photovoltaic Systems (Stand-Alone System)**

Photovoltaic systems convert sunlight directly into electrical energy. The electricity generated by a system travels through an inverter and then into a building. Some systems also have batteries to provide backup electricity. The system could be either grid connected or off-grid. When grid-connected systems generate more electricity than the building uses, the surplus electricity enters the grid. When the system produces less than the building uses (such as in the evening or when it is cloudy), the utility company grid provides electricity to the building. PV modules have no moving parts, typically require little maintenance other than occasional rinsing and can last over 25 years. PV system costs depend on the system's type and size. An average panel produces 300W with a minimum price of $250.

The Stand-Alone System is termed a “separate system” by the electric utility. However, a “separate system” in the utility’s terminology can exist in a hospital that also has utility power as long as they are completely separated.

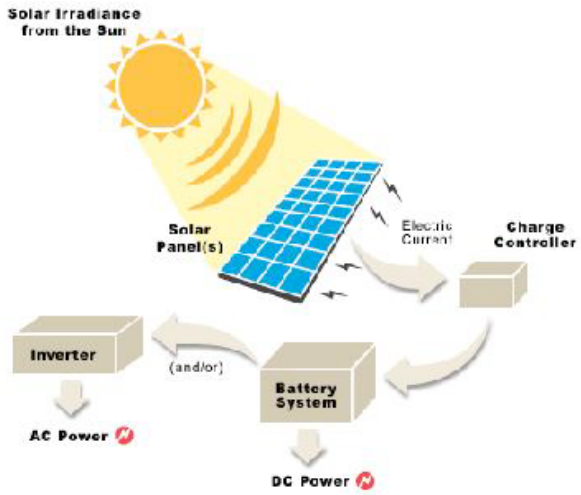



**Figure 3.1: PV solar system**

**(2) Basic Electrical Power Supply for Rural Areas**

Followings are examples which PV power supply were introduced into the remote areas:

Solar power systems provide the basic electrical power for households in rural areas. Environmentally friendly power can now be used to power lights, refrigerators and communications devices – even far away from the power grid

- PV Power: 3.69 kWp (k watt peak) polycrystalline modules
- Surface: 40 m., rooftop
- Battery bank: 750 Ah

**(3) Solar Hybrid Systems**

**A combination of different energy sources for large consumers**

It is possible to increase system availability and/or lower the initial investment costs by combining different energy sources (e.g. solar energy, small wind turbines or diesel generators). Such combination of energy sources is particularly beneficial for clients with higher consumption such as local commercial centers, hotels, schools and hospitals. It can be integrated into existing pure diesel generator sites with solar modules in order to achieve less fuel consumption. These systems can be monitored locally and remotely.

- PV Power: 4.1 kWp polycrystalline modules
- Surface: 42 m., rooftop
- Battery: 550 Ah / 48 V, lead gel

**(4) PV Subsystems (Inverters, Controller, and Wiring)**

**- Inverters**

Conventional appliances and equipment and utility-supplied power use alternating current (AC) power and PV systems produce direct current (DC) power. Inverters are required to convert the power from the PVs from DC to AC. Recently produced inverters are reliable and efficient. They are also a major cost for the project starting at over $1,000 for a size that will accommodate a residence.

For practical reasons, including electrical code compliance and financing, it is best to have a conventional (AC) electrical distribution system in the house. This will permit the use of appliances, equipment, and lighting that is commonly available.

**- Charge Controllers**

Regulate the voltage entering batteries to avoid overcharging the batteries. Available in different capacities and must be selected to match the system. Prevents losses of power back through the panels at night.

**- Wiring**

Some direct current (DC) equipment may be desirable to operate in a home. DC appliances and equipment, although initially more costly than their AC counterparts, will use less power to operate. In some cases, such as pumps, the DC motors are much more efficient. When DC wiring is going to be used in a home, a heavier wire is required. Generally, #10 wire is best for direct current applications but larger wire may be necessary if the wire runs are quite long. Tables are available in the manuals offered by companies listed in the Resources section.

Electrical code requirements will apply to PV installations in regards to having fused disconnects, load centers, and proper grounding.

Inverted power (AC) is wired normally as per code.

**(5) Mounting PV Panels**

PV arrays must be placed to receive the most sunlight. At our latitude (Lusaka, Zambia), a 15-degree slope to the panels with a north orientation was long thought to be best. However, in recent years this has been amended: it is now considered better to orient the panels toward the sun's position at 4pm to 5pm, when electricity demands are often highest. Some power providers charge more for electricity consumed during peak periods. The goal is to avoid more of the air pollution that comes from gas-fired generators at conventional power plants by reducing the demand at peak use times. More westerly-facing panels generate about 20 percent less power overall, but can boost energy production by 50 percent or more between the hours of 2 p.m. and 8 p.m.

A steeper slope will help offset the shorter winter day by bringing the panels closer to perpendicular to the lower winter sun.

There are several ways to mount the panels – fixed, fixed with adjustable tilt angles, manual tracking, passive tracking, and active trackers. All of these mounting approaches can be placed on the ground or on a roof except for some active trackers which are pole mounted and thus more suited for a ground mount.

Fixed mounts are the least costly and lowest energy producing mounting systems. A metal frame suited for outdoor conditions is best. PV panels will substantially outlive the best wood racks.

The fixed mount with adjustable tilt angles and manual tracking mounts will require manually changing the angle of the PV panels either several times a day (manual tracking) and/or seasonal adjustments to keep the panels as close to perpendicular as possible to the sun (tilt angle adjustments).

Trackers are useful if the site is appropriate. There needs to be no obstacles in the east and west that will block the sun since the trackers will orient the PV panels to face the sun from early morning to late afternoon. Passive trackers are typically freon activated to track the sun from east to west only (there is no automatic tilt angle change). Active trackers draw a very small amount of power from the PV panels (as low as one watt) and mechanically track from east to west and adjust to the proper tilt angle. The passive trackers will increase the panels output from 40-50%. Active trackers will improve panel output by as much as 60%. However, it is important to realize that the largest gains for the trackers occurs during the longest days of summer. There are not large gains in the winter

**(6) Batteries**

Batteries are the best method of storing energy from a PV system for the periods when the sun is not shining. (This is for stand-alone or non -grid connected systems.) The information from calculating the daily load will be needed for determining the battery sizing.

**1) Steps for Sizing the Battery Bank:**

- Divide the “Daily Energy Use” (derived from using the Chart on page 6) by the voltage of the battery (typically 12 volts). The result is amp-hours which is the common manner of measuring battery capacity. For example, if the “Daily Energy Use” is 2,000 (watt-hours), divide 2,000 by 12 to get 167 (amp-hours).
- Multiply the daily amp-hours by the number of days that you want to have power in storage in case the sun is not shining adequately. Three to five days is recommended. For this example, we will choose four days. Multiply 167 amp-hours per day times 4 days to get 668 amp-hours.
- Batteries should not be discharged excessively. A deep cycle lead-acid battery (the main battery option) will last longest if it is discharged only 50%. By dividing the total amp-hours from Step 2 (668) by .50, the optimal battery capacity is determined; 668/.50 = 1336 amp-hours at 12 volts.

**2) Selecting Batteries**

Car batteries are not suitable for PV applications as they cannot handle the deep discharges that can occur with PV systems. ”RV” or “marine” batteries can handle a deeper discharge than car or starter batteries and can be used in a beginning system. They will last 2 to 3 years.

Gell cell sealed batteries can be used in limited conditions, but also will not handle deep discharges. Because they are sealed, they are suited to marine applications.

Deep cycle batteries are available for golf carts, and include Industrial Chloride batteries. These batteries are the best choice for PV systems as they can be discharged 80%. The golf cart batteries will last 3-5 years. There are some larger capacity deep cycle batteries that will last 7-10 years. Industrial Chloride batteries will last 15-20 years.

Non lead-based batteries such as nickel-cadmium or nickel-iron batteries are costly but can last a very long time if they are not discharged excessively. A new type of nickel-cadmium battery, fiber-nickel-cadmium, has outstanding longevity at a 25% discharge rate. Nickel-cadmium (NiCad) batteries have different operating and maintenance characteristics than lead-acid batteries that must be considered. For example, it is difficult to measure the depth of discharge that is occurring with a NiCad battery since its output is constant right up to the last moments before being completely discharged. Check with the suppliers in the Resources section about the operation and maintenance characteristics of the NiCad batteries they offer.

For large systems, the best battery choices will be the “true” deep cycle types. Caution in using batteries must be observed along with recognition of their characteristics in response to temperature changes (lead-acid batteries operate less efficiently in cold temperatures) and ventilation requirements.

### 3.7 Solar Water Heater

#### (1) Solar Water Heating Systems

There are two types of active solar water heating systems:

**- Direct circulation systems**

Pumps circulate household water through the collectors and into the home. They work well in climates where it rarely freezes.

**- Indirect circulation systems**

Pumps circulate a non-freezing, heat-transfer fluid through the collectors and a heat exchanger. This heats the water that then flows into the home. They are popular in climates prone to freezing temperatures.

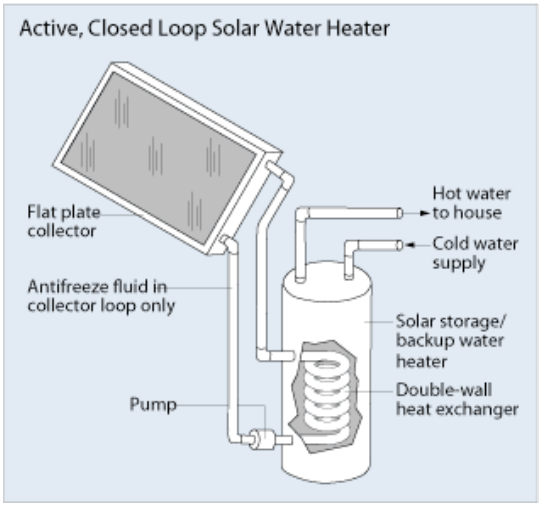



**Figure 3.2: Closed Loop Solar Water Heater, Active**

#### (2) Passive Solar Water Heating Systems

Passive solar water heating systems are typically less expensive than active systems, but they're usually not as efficient. However, passive systems can be more reliable and may last longer. There are two basic types of passive systems:

**- Integral collector-storage passive systems**

These work best in areas where temperatures rarely fall below freezing. They also work well in households with significant daytime and evening hot water needs.

**- Thermosyphon systems**

Water flows through the system when warm water rises as cooler water sinks. The collector must be installed below the storage tank so that warm water will rise into the tank. These systems are reliable, but contractors must pay careful attention to the roof design because of the heavy storage tank. They are usually more expensive than integral collector-storage passive systems.

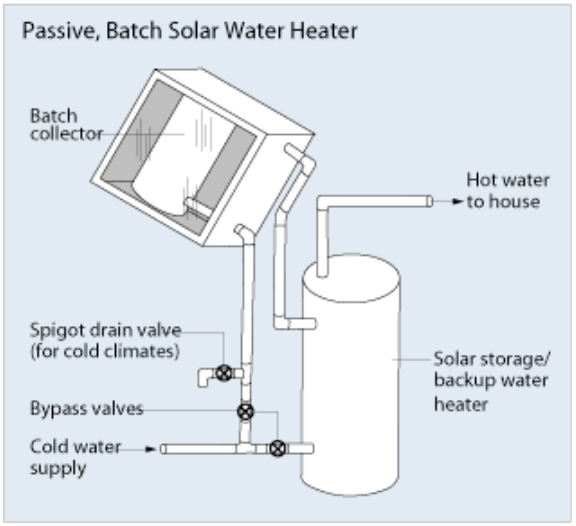



**Figure 3.3: Batch Solar Water Heater, Passive**

**(3) Storage Tanks and Solar Collectors**

Most solar water heaters require a well-insulated storage tank. Solar storage tanks have an additional outlet and inlet connected to and from the collector. In two-tank systems, the solar water heater preheats water before it enters the conventional water heater. In one-tank systems, the back-up heater is combined with the solar storage in one tank.

Three types of solar collectors are used for residential applications:

**- Flat-plate collector**

Glazed flat-plate collectors are insulated, weatherproofed boxes that contain a dark absorber plate under one or more glass or plastic (polymer) covers. Unglazed flat-plate collectors -- typically used for solar pool heating -- have a dark absorber plate, made of metal or polymer, without a cover or enclosure.

**- Integral collector-storage systems**

Also known as integral collector-storage (ICS) or batch systems, they feature one or more black tanks or tubes in an insulated, glazed box. Cold water first passes through the solar collector, which preheats the water. The water then continues on to the conventional backup water heater, providing a reliable source of hot water. They should be installed only in mild-freeze climates because the outdoor pipes could freeze in severe, cold weather.

**- Evacuated-tube solar collectors**

They feature parallel rows of transparent glass tubes. Each tube contains a glass outer tube and metal absorber tube attached to a fin. The fin's coating absorbs solar energy but inhibits radiative heat loss. These collectors are used more frequently for U.S. Solar water heating systems almost always require a backup system for cloudy days and times of increased demand. Conventional storage water heaters usually provide backup and may already be part of the solar system package. A backup system may also be part of the solar collector, such as rooftop tanks with thermosyphon systems. Since an integral-collector storage system already stores hot water in addition to collecting solar heat, it may be packaged with a tankless or demand-type water heater for backup.

**(4) Selecting a Solar Water Heater**

Before you purchase and install a solar water heating system, you want to do the following:

- Estimate the cost and energy efficiency of a solar water heating system
- Evaluate your site's solar resource
- Determine the correct system size
- Investigate local codes, covenants, and regulations.

Also understand the various components needed for solar water heating systems, including the following:

- Heat exchangers for solar water heating systems
- Heat-transfer fluids for solar water heating systems

**(5) Installing and Maintaining the System**

The proper installation of solar water heaters depends on many factors. These factors include solar resource, climate, local building code requirements, and safety issues; therefore, it's best to have a qualified solar thermal systems contractor install your system.

After installation, properly maintaining your system will keep it running smoothly. Passive systems don't require much maintenance. For active systems, discuss the maintenance requirements with your system provider, and consult the system's owner's manual. Plumbing and other conventional water heating components require the same maintenance as conventional systems. Glazing may need to be cleaned in dry climates where rainwater doesn't provide a natural rinse.

Regular maintenance on simple systems can be as infrequent as every 3 - 5 years, preferably by a solar contractor. Systems with electrical components usually require a replacement part or two after 10 years. Learn more about solar water heating system maintenance and repair.

When screening potential contractors for installation and/or maintenance, ask the following questions:

- Does your company have experience installing and maintaining solar water heating systems?

  Choose a company that has experience installing the type of system you want and servicing the applications you select.
- How many years of experience does your company have with solar heating installation and maintenance?

  The more experience the better. Request a list of past customers who can provide references.
- Is your company licensed or certified?

  Having a valid plumber's and/or solar contractor's license is required in some states. Contact your city and county for more information. Confirm licensing with your state's contractor licensing board. The licensing board can also tell you about any complaints against state-licensed contractors.

# 4. Heating, Ventilating and Air-conditioning Systems

### 4.1 General Description

Maintaining a pleasant temperature, about 22°C, is the design target for heating and air-conditioning systems. Higher or lower temperatures may be attained in specific areas through independent units to suit individual requirements.

Heating and air-conditioning and ventilation systems are related both in physical installation and in their function in the hospital departments. Air conditioning differs from ventilation in that the temperature and humidity of the air are controlled in the former. It is expensive to provide, operate and maintain, however, and it should be installed only in areas where it is essential, such as in operating theatres. Whenever possible, therefore, hospital design should minimize or eliminate the need for air-conditioning and mechanical ventilation by providing occupied spaces with adequate windows, cross-ventilated where possible, and by using internal areas for specific purposes, such as operating theatres, darkrooms and storerooms. Careful afternoon to siting and design to take advantage of any cooling breezes and use of trees to shade the building can help in optimizing natural conditions.

The ventilation of a hospital is dictated by health, comfort and safety standards. In areas where excessive heat or moisture is generated, or where objectionable odours, dust or toxic gases are present in the atmosphere, afresh air supply and exhaust system must be provided. Electric fans can be used to augment the system as and where necessary.

Ventilation associated with kitchen, laundry and refrigeration equipment must be designed by qualified engineers in coordination with the users. Special care must be taken in designing extraction systems over cooking installations to avoid the exhaust fumes should be accessible and should be cleaned regularly.

### 4.2 Technical Requirements

Heating, ventilating and air-conditioning systems should meet the following guidelines:

(1) They should provide the temperatures shown in Table 4.1 and a relative humidity of 50-60%.

**Table 4.1 Temperatures to be provided in the facilities**

| Area | Temperature (°C) |
|---|---|
| Operating Theatre | 21 – 25 |
| Recovery Room | 23 – 24 |
| Delivery Room | 21 – 25 |
| Nursery | 25 – 27 |
| Intensive Care Unit | 25 – 27 |
| Imaging Department | 21 – 25 |
| Hemodialysis Unit | 21 – 25 |
| Laboratory Department | 21 – 25 |

(2) All air supply and air exhaust systems must be operated mechanically. Fans serving exhaust systems should be located at the discharge end of the system. Minimal acceptable ventilation rates in the major areas should be as shown in Table 4.2.

(3) The ventilation system should be designed and balanced to provide the pressure relationships shown in Table 4.2.

(4) The ventilation systems serving sensitive areas, like operating theatres, delivery room, nurseries, and sterile rooms, must be equipped with at least two filter beds. The exhaust from all laboratory hoods in which infections or radioactive materials are handled must have filters with 99% efficiency.

**Table 4.2: Ventilation System**

| Area | Pressure in relation to other areas | Minimum total no. of air change per hour | Re-circulated within room |
|---|---|---|---|
| Operating theatre | + | 12 | No |
| Emergency operating room | + | 12 | No |
| Delivery room | + | 12 | No |
| Nursery | + | 12 | No |
| Recovery room | 0 | 6 | No |
| Intensive care unit | + | 6 | No |
| Wards | 0 | 2 | Optional |
| Patient area corridor | 0 | 4 | Optional |
| Isolation room | 0 | 6 | No |
| Treatment room | 0 | 6 | No |
| X-ray (fluoroscopy) room | - | 6 | No |
| X-ray (treatment) room | 0 | 6 | Optional |
| Physical therapy room | - | 6 | Optional |
| Sterilizing room | - | 10 | No |
| Laboratory, general | - | 6 | Optional |
| Laboratory, media transfer | + | 4 | No |
| Anaesthesia storage room | 0 | 8 | No |
| Storage | - | 5 | No |
| Toilet | - | 15 | No |

Remark: Waiting Area - It is recommended 20 to 30 $m^3$ / hours per person

(5) All filter frames must be durable and provide an airtight fit with the enclosing ducts. All joints between segments and the enclosing ducts should be gasket or sealed to provide a positive seal against air leakage.

(6) Ducts that penetrate structures to protect against X-ray radiation should not impair its effectiveness. Ducts that pass through fire walls must be provided with automatic fire door on both sides of the wall.

(7) Duct linings, coverings, vapour barriers and the adhesives used for applying them must have a flame-spread classification of not more than 25 and a smoke-developed rating of not more than 50. Acoustic lining materials should not be used inside duct systems serving sensitive areas, such as operating theatres, nurseries and isolation rooms.

(8) Cold-air ducts should be insulated whenever necessary to maintain the efficiency of the system and to minimize condensation.

### 4.3 Operating Theatres

The classification of air cleanness is defined by NASA and shown to the Table 5.3. The other classifications of air cleanness are lead by calculation. According to the NASA classification, cleanness of air can be shown both of number of particles in the air, or number of bacteria in the air.

If we introduced high-end air filter, it can be able to get the cleanness of class 100 easily.

**Table 4.3: Classification of Air Cleanness classified by NASA**

| NASA Classification | Number of particles equal to and larger than 0.5 μm / $ft^3$ (l), or [1.640 μm / $m^3$] | Number of particles equal to and larger than 5 μm / $ft^3$ (l), or [16.404 μm / $m^3$] | Number of bacteria in the air / $ft^3$ (l), or [ / $m^3$] | Number of falling bacteria in the air, / $ft^3$ (l) / week, or [ / $m^3$ / week] |
|---|---|---|---|---|
| 100 (3.5) | 100 (3.5) | … | 0.1 (0.0035) [0.328 (0.01148)] | 1,200 (12,900) [3,937 (42,322)] |
| 10,000 (350) | 10,000 (350) | 65 (2.3) | 0.5 (0.0176) [1.640 (0.05774)] | 6,000 (64,600) [19,685 (211,942)] |
| 100,000 (3,500) | 100,000 (3,500) | 700 (25) | 2.5 (0.0884) [8.202 (0.29002)] | 30,000 (323,000) [98,425 (1,059,711)] |

It can be classified air conditioning with Introduction of the high-end air filter shows to the followings:

(1) Layer Flow Type: Vertical layer flow, Horizontal layer flow
(2) Non Layer Flow Type: Fixed flow, None Fixed flow

### 4.4 General Wards and Other Departments

(1) General Wards

Natural Ventilation, Window type Air Conditioner, Central Ventilation

(2) Intensive Care Unit (ICU), Coronary Care Unit (CCU), etc.

(3) Laboratory, Emergency, Hemodialysis Unit

(4) Operating Theatre, Central Sterilizing Supply Department (CSSD)

Excessive air-conditioning can have negative effect on skins, drying it out and can also cause dehydration.

Capacity: Rule of Thumb

1. Room Air-conditioning Unit: 0.5-2 TR (Tons of Refrigeration) for area not more than 1,000 sq.ft. (304.8000$m^3$)
2. Packaged unit integral air-cooled condenser: 3-50 T for maximum area 1,000 - 10,000 sq.ft. (304.8000 - 3048.000$m^2$)
3. Split type with outdoor air-cooled condenser: 0.5-50 TR for 100 - 1,000 sq.ft. (30.48000 - 304.8000$m^2$)
4. Central air-conditioning chilled water system with air-cooled condenser: 20-400 TR for area 4,000 sq.ft. (1,219.200 $m^2$) and higher

5. Central air-conditioning chilled water system with outdoor water cooled condenser: 20-2,000TR, for area 4,000 sq.ft. (1,219.200 $m^2$), and higher

Reduce capacity by 10% if area is heavily shaded

Increase capacity by 10% for sunny areas

Add 600 BTU (British Thermal Unit) / Hr for each additional person if area is occupied routinely by more than 2 people

Add 1,000 BTU/Hr for every 15 sq.ft. (4.572000 $m^2$) of glass exposed to sun

Add 3414 BTU/Hr for every 1,000 watts of electronic medical equipment and other electrical appliances

Remark: 12.000BTU = 3.000 kcal/h = 1 TR

# 5. Oxygen Plant

## 5.1 General Information

**What is Oxygen?**

Oxygen gas comprises 21 percent of atmospheric gas. Its symbol is O2. Atomic weight of oxygen is 16 and atomic no. is 8. Oxygen gas is non metallic element. It was apparently first obtained in 1727 by Stephen Hales. Oxygen is colorless, odorless and tasteless.

Oxygen reacts with all elements, but not with inert gases to form compound called oxides. Oxygen support combustion and support flammable materials to burn more rapidly. And this combustion supporting property prefer it for different industrial applications.

## 5.2 Introduction of Air Separation System to Oxygen and Nitrogen

The mechanism of producing oxygen in sufficient quantities for the mining industry can be broken down into three methods of production currently in use. First is the Vacuum Swing Absorption Technology (VSA) plants that are in the 25 Ton's per day (TPD) to approximately 150 TPD. Second and the focus of this section are cryogenic fractional distillation, the standard Air Separation Unit (ASU), that produces volumes from 50 TPD to a single train in excess of 4,000 TPD and purities in the range of 95% to 99.5% pure oxygen (or greater if needed). Third, Ion Transport Membranes (ITM) a new technology that is currently under development that will have applications in the future.

This section will focus in on the opportunities related to the largest commonly used group of the oxygen production methodology for the mining industry the cryogenic ASU. While the ASU is comprised of thousands of parts we will attempt to break the unit down into segments that should provide some around specific areas of an oxygen plant that upgraded can improve production, reduce costs and or improve the reliability.

- The Front end TSA and PSA system
- The Machinery including the expander
- The controls within the system
- Operational procedures

While this is not a complete list of items that should be reviewed when considering improvements to a plant, these general areas will provide some insight as well as some case histories of the benefits that can be obtained from projects in these areas.

## 5.3 Process Introduction of Air Separation

(1) **Air Compressor and Chilling Unit**

The free saturated air is sucked from atmosphere through a highly efficient dry-type suction filter into the first stage of the horizontally balanced opposed, lubricated reciprocating air compressor. Compressed air is chilled to 12°C in a chilling unit or evaporation cooler, compressed air passes through the coils of the chilling unit at a temperature of 12°C to a moisture separator, where the condensed moisture gets removed before entering into Molecular Sieve Battery. Before sending the air to MOLECULAR SIEVE BATTERY, air is passed through an OIL ABSORBER where air becomes oil free.

**(2) Purification of Air (Process Skid)**

Chilled air passes through the Molecular Sieve Battery consisting of Twin Tower packed with molecular sieves to remove moisture and carbon dioxide present in the air.

Molecular Sieve Battery operates on Twin Tower System, when one tower is under production the other tower is regenerated by passing waste nitrogen gas at 200°C through a REACTIVATION HEATER. After interval of 8 to 10 hours, the tower under production gets exhausted and regenerated by similar process before use and, thus the cycle continues. Any dust particle gets filtered in the DUST FILTER before air enters the AIR SEPARATION COLUMN All the equipment are mounted on process skid.

**(3) Air Compressor**

Filter system with steel structure and supports elements. De-dust system with valve| collecting machine| spray equipment| automatic clean and control system. Send the pressure difference signals to PLC by pressure differential transmitter. Instrument and electric control system.

**(4) Air Purification Unit**

**Molecular Sieve Battery on skid**

Complete with 2 nos. vessels Reactivation heater complete with Molecular Sieve designed for process skid mounting.

**Defrost Heater**

Consist of heating coils and heating element 5 kW.

**Gas/Air Lines as per standard Layout**

All pipelines for process air Nitrogen and Oxygen line HP line upto manifold along with short bend elbow socket and other necessary fitting as per our standard layout drawing.

**(5) Air Pre-cooling Unit**

- One condenser
- One evaporator / Water cooler
- One set of Piping and valves
- Instrumentation
- Water Separator

**(6) Air Separation Column (Cold Box)**

Cryogenic type completed with support and connected pipes and internal parts including PLATE FIN heat exchangers condensers and rectification columns.

**(7) Turbo Expander**

The turbo expander is a rotary machine running on gas bearing. This is used to provide cooling for the liquefaction of air at minus 180 to -190 degrees centigrade, including:

1) Expansion turbine body

2) Ventricular joint

3) Inlet filter

4) Silencer

5) Bearing & sealed gas system

- Instrument gas filter
- ET bearing and sealed gas system

**(8) Oxygen Cylinder Filling System**

The oxygen is filled into cylinders by an oxygen filling SYSTEM (PUMP/BOOSTER) .

**(9) Filling Manifold Cylinder Filling Station for Filling Oxygen Gas**

Complete with control valves pressure gauge safety valve & pigtail connections points each.

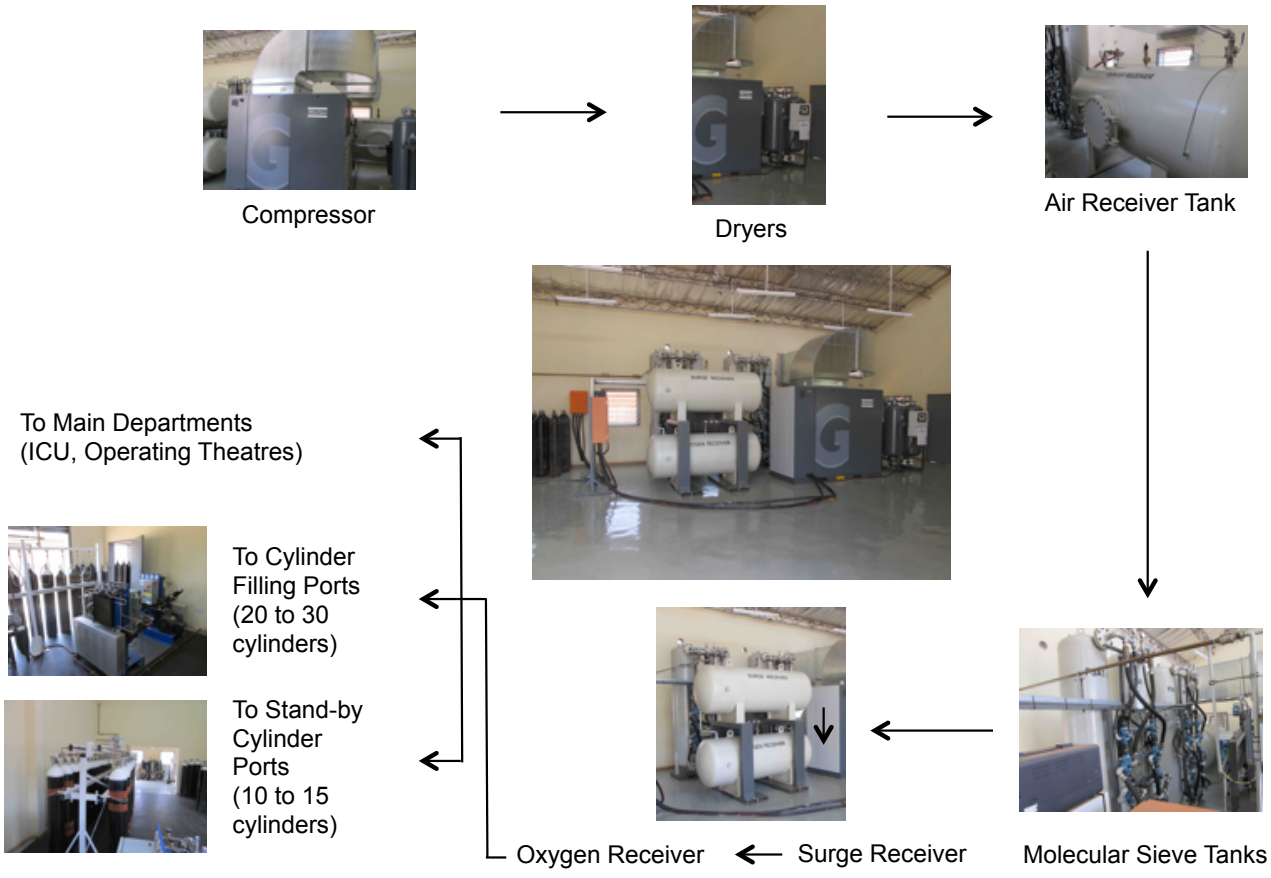



**Figure 5.1: Configuration of the Plant for Producing Oxygen form Atmosphere (Source: UTH, Zambia)**

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