The Republic of Uganda

MINISTRY OF HEALTH

Health Infrastructure Division

Operation Manual for Regional Medical Equipment Maintenance Workshops and Medical Equipment Maintenance Guidelines

A guide for
Regional Workshop and Hospital Technicians

December 2013

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Foreword

The main mission of the Ministry of Health is to ensure provision of comprehensive Healthcare Services to the Ugandan population and the Government is committed to ensuring efficient, safe and effective Healthcare delivery.

A substantial proportion of the Health Sector budget is spent on acquisition of Medical Equipment.

To ensure that available Medical Equipment safely serves for a long time, it must be managed efficiently. The way in which it is used and maintained may greatly affect its reliability and hence the quality of Healthcare delivered to patients.

Appropriate periodic/preventive and corrective maintenance is key to achieving safe and cost-effective management of medical equipment. It is important therefore that measures are taken to ensure that medical equipment is maintained and cared for by the Healthcare workers in order to maximize the investment made in its acquisition. For effective maintenance to be carried out by the maintenance team, adequate operation and maintenance funds should be budgeted and allocated.

This manual helps to streamline the operations of the Regional Medical Equipment Maintenance Workshops. Additionally, the Maintenance guidelines will facilitate first line Maintenance to be undertaken by both the Users' of the equipment and technicians in a well structured and safe manner.

This manual is an essential reference book for the Regional Medical Workshops to plan, manage and execute basic maintenance using the prepared guidelines; and ensure

adequate and proper maintenance of most common essential Medical Equipment.

I am pleased to write the foreword to this first ever operational workshop manual for RWs in Uganda. I also recommend the use of this manual to our health workers to carry out User Training and first line maintenance in Health Facilities.

I would like to acknowledge and thank JICA for supporting the preparation of this manual and Eng. D.M.K. Katesigwa for providing technical guidance during its drafting.

Special recognition goes to Mr. Naoki Mimuro, Mr. Shigetaka Tojo and Eng. Sitra Mulepo C.S for their dedication and Technical input to produce this manual.

Lastly, I would like to extend my appreciation to the staff of the Health Infrastructure Division, Members of NACME and HI_TWG for their oversight and editorial role during the preparation of this manual.

I have no doubt that this manual will facilitate better maintenance of medical equipment by the RWs in our Health Facilities. .

Dr. Jane Ruth Aceng
Director General Health Services

Acronyms

List of Acronyms

5S	Five steps of Sort, Set, Shine, Standardize and Sustain
AC	Alternating Current
ACHS(HI)	Assistant Commissioner, Health Infrastructure Division, Clinical Services Department
AEO	Assistant Engineering Officer
BP	Blood Pressure
CD4	Cluster of Differentiation 4
CO_2	Carbon Dioxide
CT	Computerized Tomography
CW	Central Medical Equipment Maintenance Workshop
DC	Direct Current
DHOs	District Health Officers
DPA	Disposal Public Asset
ECG	Electrocardiogram
ENT	Ear, Nose and Throat
HC	Health Centre
HGB	Hemoglobin
HID	Health Infrastructure Division
HI_TWG	Health Infrastructure Technical Working Group
HIV	Human Immunodeficiency Virus
HMIS	Health Management Information System
JICA	Japan International Cooperation Agency
LCD	Liquid Crystal Display
LED	Light Emitting Diode
ME	Medical Equipment
MoFPED	Ministry of Finance, Planning and Economic Development
MOH	Ministry of Health

MRI	Magnetic Resonance Imaging
N_2O	Nitrous Oxide
NACME	National Advisory Committee on Medical Equipment
O_2	Oxygen
OPD	Out Patient Department
OT	Operation Theatre
PDU	Procurement and Disposal Unit
PMT	Photo Multiplier Tube
PPDA	Public Procurement and Disposal of Public Assets Authority
PPM	Planned Preventive Maintenance
QI	Quality Improvement
RBC	Red Blood Cell
RF	Radio Frequency
RPM	Rotations Per Minute
RRHs	Regional Referral Hospitals
RWMC	Regional Workshop Management Committee
RWs	Regional Medical Equipment Maintenance Workshops
SpO_2	Saturation of Peripheral Oxygen (Pulse Oximeter Oxygen Saturation)
SVR	Sample Rotary Valve
WBC	White Blood Cell
WIT	Work Improvement Team

Chapter 1: Introduction

1.1 Background

Medical equipment plays an important role in our Health Care system and there are numerous equipment adapted to Health Care. In the health facilities, medical equipment will range from injection needles, centrifuges, stethoscopes, blood pressure machines, to X-Ray Machines, MRI etc. designed to help medical personnel carry out diagnosis and treatment of patients.

Optimal performance of medical equipment is required to ensure safety, accuracy and expected results. To keep medical equipment in good working condition and optimal performance is the function of a medical equipment maintenance unit in a health facility.

The Ministry of Health set up Regional Medical Equipment Maintenance Workshops to carry out medical equipment maintenance in health facilities. In the hospitals, there are different engineering personnel deployed to man hospital maintenance units. They carry out maintenance and repair on medical equipment.

This operation manual is intended to support and guide engineering personnel in the RWs and Hospital maintenance units in the maintenance of basic medical equipment. It will also guide the equipment users and technicians on the operation and working principles of some commonly used equipment.

1.2 Overall Objective

The overall objective of preparing this manual is to define the roles of RWs and other stakeholders; and provide guidelines on medical equipment maintenance management including maintenance planning, budgeting, training and disposal of medical equipment.

1.3 Specific Objectives

The specific objectives of this manual are:

- To define the role and function of RWs and Central Medical Equipment Maintenance Workshop
- To identify and define the roles of various stakeholders
- To streamline the operations of RWs and CW
- To develop maintenance guidelines for commonly used medical equipment in health care facilities.
- To prepare equipment specific Maintenance Guidelines to ensure safety, proper use, care and management of medical equipment.

1.4 Stakeholders in Medical Equipment Management

The following categories of health care workers and providers play a significant role in the maintenance of medical equipment.

- Users of medical equipment

  This category involves doctors, nurses and paramedics whose primary function is to use medical equipment for diagnosis and treatment of patients. Their main role will

be to care for the equipment including reporting equipment failure to the maintenance unit.

- Medical equipment maintenance personnel

  This category includes artisans, technicians and engineers employed by health facilities to offer maintenance services for equipment. Their main role is to identify and isolate the fault, and take remedial action to restore full functionality of the medical equipment.

- Hospital administrative staff

  This category includes the hospital administrators, procurement personnel, accounts personnel and other staff responsible for safe custody of hospital stores. This category is involved in planning, assets/stores management, procurement of spares, and financial management.

- Medical equipment manufacturers and vendors

  The role of this category is to offer spare parts for the equipment they manufacture or sell and offer After Sales Services including contract maintenance services for specialized equipment.

1.5 Definition of Medical Equipment Maintenance

Medical equipment maintenance refers to a set of activities conducted on a medical equipment to keep it in optimum working. It is divided into two major categories namely:

- Planned Preventive Maintenance (PPM)

  This refers to regular safety and performance inspection carried out on medical equipment to evaluate risk and reduce failure so as to enhance its safety, efficiency and reliability.

  It involves cleaning, regular function/safety tests and making sure that any problems are picked up before they cause a breakdown.

  PPM is recommended for most of the medical equipment. It will enhance the efficiency, effectiveness and reliability of medical equipment and must be carried out at appropriate frequency as suggested by the manufacturer or workload.

- Corrective Maintenance (or repair)

  Corrective maintenance is a task performed to identify and rectify a fault on a broken down equipment, machine or system to restore to it to its original operational condition.

The choice of approach for preventive and corrective maintenance depends on the complexity of equipment, equipment usage and/or cost benefit analysis by the in-house trained technician. The majority of equipment in our health care system is basic in nature and can be handled in-house by any technician or artisan at RW level.

For specialized and advanced equipment, the vendor should provide maintenance services through a combination of on-call services and a maintenance contract negotiated at the time of purchase. Maintenance contracting should be reserved for medical equipment for which there is no in-house capacity to maintain or when specialized equipment and technical expertise is needed to be economically viable to develop this capacity in-house.

Chapter 2: Organization Structure for Medical Equipment Maintenance

There is a wide range of medical equipment at different levels of the health care delivery system. The staffs in these Health Facilities are responsible for ensuring that it is used and stored properly and faulty equipment is reported to departments responsible for maintenance.

At the central level, the Unit directly responsible for the management of medical equipment is the Health Infrastructure Division (HID) under the Clinical Services Department. The National Advisory Committee on Medical Equipment is mandated to give appropriate clinical and technical advice to MOH regarding medical equipment.

At District and Health facility levels, the management of medical equipment is the responsibility of the respective Administrative and Technical Departments. The District Health Officers (DHOs) are directly responsible for planning and management of medical equipment in the District Local Governments.

For medical equipment, RWs established under Regional Referral Hospitals (RRHs) carry out medical equipment maintenance; while the HID of the MoH oversees supervision of maintenance activities.

2.1 National Advisory Committee on Medical Equipment (NACME)

The main function of NACME is to review the country's medical equipment needs and determine the appropriate policy framework.

This includes advising on procurement, standardization, maintenance and rehabilitation of medical equipment, bearing in mind cost-effectiveness and appropriateness of technology.

2.2 Health Infrastructure Division (HID)

The division has two major sections with the mandate to formulate policies and guidelines on health infrastructure development and management.

The sections are:

1) Civil Engineering Section
2) Electro-Mechanical Engineering Section

1) Civil Engineering Section

All building and Civil Engineering in the Sector are coordinated by this section. It provides support and supervision of pre-installation works and ensuring that fixed medical equipment is installed safely.

2) Electro-Mechanical Engineering Section

This section encompasses the electrical and mechanical engineering disciplines. The electrical and mechanical engineering professionals are responsible for preparing specifications and ensuring that procured equipment conforms to national and international standards; and that the equipment is appropriate and maintainable.

Some of the activities related to medical equipment in this section include:

i) Supervision and monitoring the management of the complete life cycle of medical equipment and furniture in public health facilities.

ii) Acting as the Secretariat to NACME and take care of the executive work for the committee. Preparation of the standard equipment lists and update of specifications is handled by the Electrical/Mechanical Engineers.

i) Specification and quantification of equipment for procurement in the health sector.

ii) Organizing training from time to time so as to ensure that technicians and engineers keep abreast with the fast changing trends in Biomedical engineering.

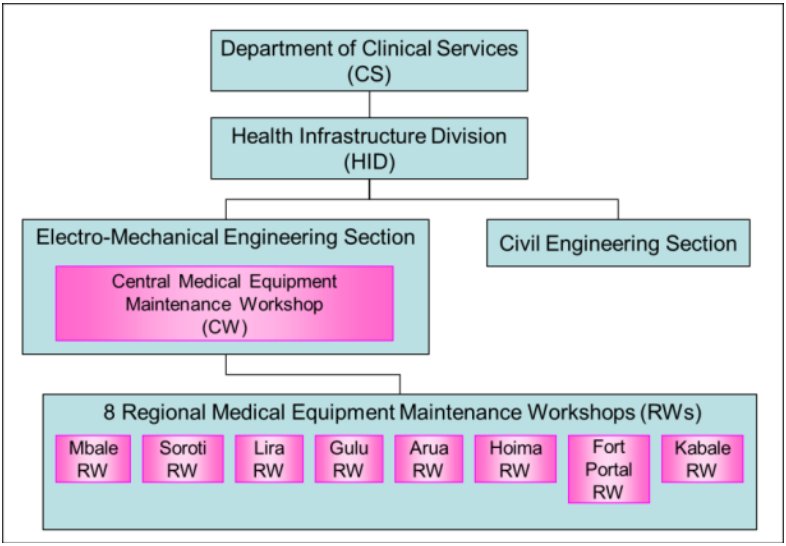

Fig 1 HID Organogram

2.3 Regional Medical Equipment Maintenance Workshops (RWs)

In order to decentralise medical equipment maintenance, the MOH established RWs at RRHs to maintain medical equipment in health facilities under their catchment area.

To date there are nine (9) RWs located at Arua, Lira, Gulu, Soroti, Mbale, Hoima, Fort Portal, Kabale RRHs and Central Medical Equipment Maintenance Workshop, Wabigalo in Kampala.

The Central Medical Equipment Maintenance Workshop (CW) was established under HID and is a referral workshop for all other RWs.

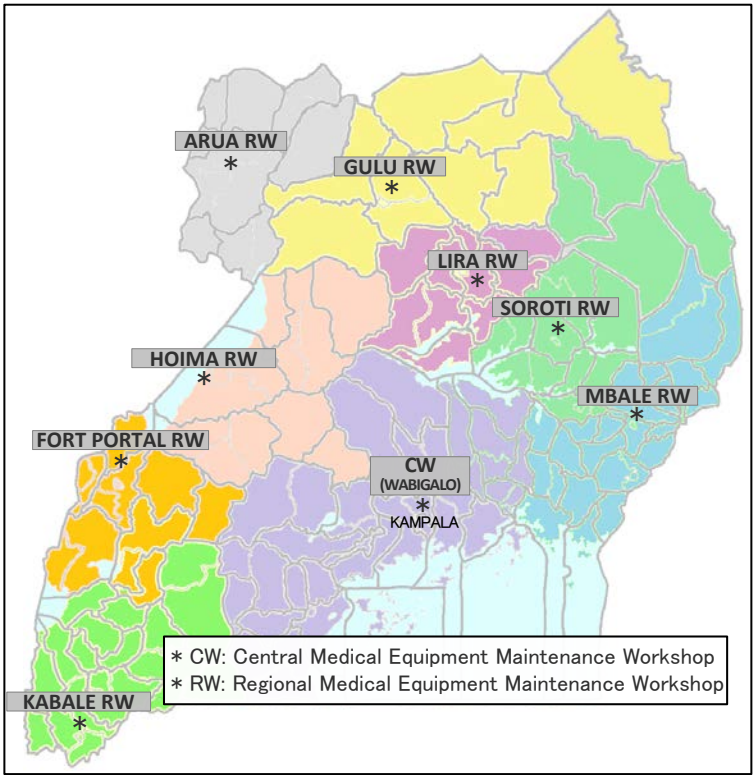

Fig 2 Location and Catchment Areas of RWs

2.4 National Referral Hospitals (NRHs)

At the National Referral Hospital level, the Engineering and Administration Departments are responsible for equipment management. The Hospitals have a fully-fledged Engineering Department that works independent of the RWs.

2.5 Regional Referral Hospitals (RRHs)

At RRHs, the management of medical equipment is the responsibility of the Hospital Administrator and respective RW Manager. While the RWs are part of the Hospitals, they have responsibilities to maintain medical equipment in all the health facilities in their catchment area. This is one of the outreach services of the RRHs.

2.6 District Health Services

At the District level, the management of medical equipment is the responsibility of the DHO and the respective in-charges of the Health Facilities. District Engineers in Local Governments assist the DHO to plan for health infrastructure development and management.

Staffing levels for medical equipment maintenance in Districts is still quite low. There is also a country wide shortage of Biomedical Engineering human resource in both private and public health institutions. The RWs support health facilities in the relevant districts to carry out periodical maintenance and repair of medical equipment.

Chapter 3: Function, Operation and Role of RWs

In line with the 1999 policy recommendations of NACME, a maintenance structure consisting of the CW and RWs was established in Uganda to cater for medical equipment maintenance in Health facilities countrywide.
A RW is established as one of the support services sections under the RRH. In terms of set up, it consists of;

- Workshop building with office space, stores and work area – See Annex 1 for Standard Floor Plan of a RW
- Mobile workshop vehicle
- Tools, Test Equipment and Office Furniture – See Annex-2 for List of Tools, Test Equipment and Furniture
- Staff consisting of Assistant Engineering Officers, Engineering Technicians and Artisans.

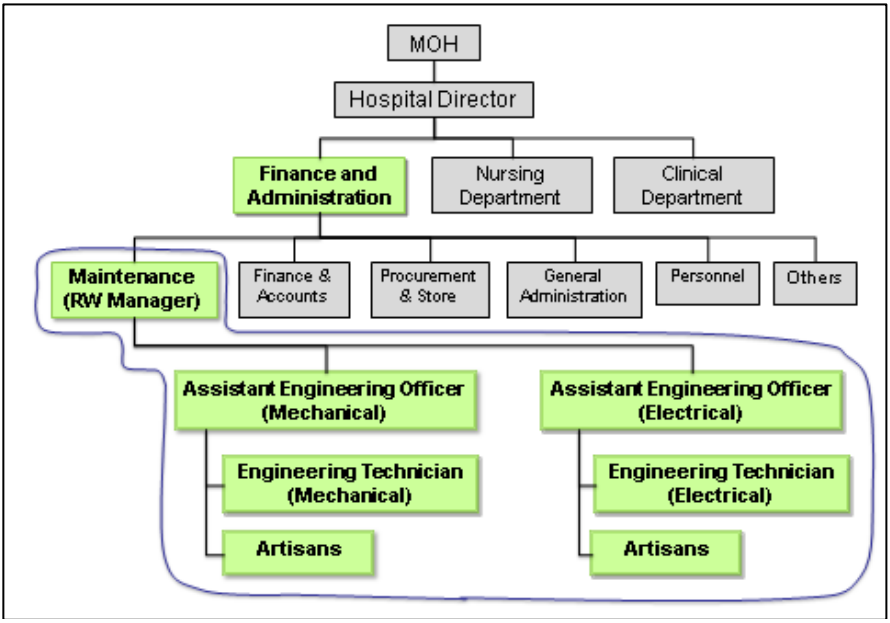

Fig 3 RWs Macro Organogram

Operationally, the teams of technicians from the RW visit Hospitals, DHO's stores and HCIV to carry out equipment maintenance on site. For HCII and HCIII, the faulty medical equipment is delivered to the DHO's stores or HCIV by the In-charge of the HC for the workshop team to carry out maintenance. On a case by case basis, the RW team may visit a HCII or HCIII to repair immovable equipment like a generator, solar system.

3.1 Central Medical Equipment Maintenance Workshop, Wabigalo (CW)

The CW located in Kampala is the RW for Health facilities for the Central region and a referral workshop. It is also acts as a training centre for Hospital based technicians. Other roles and functions of the CW include the following:

i) Supervision of all RWs through the Electro-Mechanical Engineering Section of HID focusing on maintenance and repair activities, review of work plans and budgets; and quarterly reports.

ii) Identification of suitable service providers and guidance on procurement of spare parts.

iii) Plan for capacity development activities for all regional workshops. This involves human resource development, mentorship.

iv) Support other RWs to carry out and update medical equipment inventory.

3.2 Regional Medical Equipment Maintenance Workshops

The RWs are based at the RRH and cater for maintenance of medical equipment in health facilities within the catchment area. While day to day supervision of the operations of RWs is under the Administration of the RRH, each workshop has a RW Management Committee that over sees its operations. The RW Management Committee consists of members from all beneficiary hospitals and the District and Health Sub-District Authorities.

The main functions of RWs include the following:

i) Maintenance of medical equipment in all health facilities in their catchment area.

ii) Medical equipment inventory update in all health facilities in their region.

iii) Advise hospital managers on medical equipment disposal.

iv) Preparation of quarterly equipment maintenance reports for submission to ACHS(HI)

v) Organizing and participating in the Regional Workshop Management Committee (RWMC) Meetings.

vi) Organizing User Training for equipment Users in proper use, handling and first line maintenance.

Chapter 4: Planning, Budgeting and Management of Medical Equipment Maintenance

Lack of medical equipment maintenance results in break down and prolonged down time affects the reliability and quality of health care. Lack of a maintenance policy can result in poor planning, lack of maintenance budgets and thus no spares parts and accessories. Many health facilities suffer because the maintenance requirements are not planned for in advance. This renders much equipment unusable and many devices lie idle because of lack of spares parts or funds.

The staff of the RWs and CW are responsible for planning and budgeting for maintenance activities. For day to day duties, the RW staff are responsible to the Hospital Director and Hospital Administrator. At Ministry level they are supervised by the Senior Engineer (Medical Equipment) based at HID, Wabigalo in Kampala.

The following activities will promote effective maintenance planning and management:

i) Regular medical equipment inventory taking and update

ii) Prepration of annual/quarterly work plans and budgets

iii) Preparation of maintenance schedules

iv) Preparation of maintenance reports including quarterly and annual performance reports

v) Holding regular workshop and regional workshop management committee meetings

4.1 Medical Equipment Inventory Update

The Workshop manager shall endeavor to keep and update an inventory of all medical equipment in each health facility. Proper entry should be made in the inventory database. The inventory record should contain the following details:

i) Name of health facility and date of inventory taking

ii) Equipment Name

iii) Manufacturer (with contact details where possible)

iv) Serial No. of equipment or allocated identification No.

v) Location of equipment in health facility (e.g. OPD, Maternity)

vi) Date/Year of Installation/purchase.

vii) Current maintenance status "Condition A-F"
- see Annex 3

Medical inventory taking should be carried out in August of every year. Inventory update however, should be done when new equipment has been procured, or equipment has been transferred from one location to another.

4.1.1 Inventory taking Rules and Procedure

An accurate inventory is important for proper maintenance planning and scheduling. It should be carried out in good time to inform decision making on equipping gaps, disposal and budgeting. The following methodology shall be followed when carrying out inventory:

- Visit each department and section of the hospital and record available equipment against the user's inventory record if available.
- Carry out a physical count and inquire whether the quantity is adequate.
- Consult the user on operational status (i.e. whether the equipment is operational or not)
- Record all required information as detailed in the Medical Equipment Inventory Form – See Annex 4

The Workshop Manager in consultation with the hospital staff should identify equipment that is due for decommissioning and disposal.

4.2 Work Plan and Budgeting for Medical Equipment Maintenance

In order to plan for maintenance activities the Workshop Manager should prepare a work plan and budget. The work plan should have an itemized summary of planned activities, targets, timelines and intended expenditure on a quarterly basis. The work plan and budget should indicate the proposed source of funding.
Adequate time should be allocated for procurement of goods and services including spare parts. The standard templates for preparation of work plans should be used
– see Annex 5 _ for Template of Work Plan Preparation.

Currently, medical equipment is maintained using resources from the National budget, Local Governments through the health facilities and Development Partners.

4.2.1 Process of Preparation of Annual Work Plans and Budgets

The budgeting process starts in October of every year when the MoFPED sends out a budget call circular.

Each RRH makes an annual work plan and the RW work plan and budget is part of it. The RRH submits the work plan and budget to MOH for onward submission to MoFPED which makes budgetary allocation for various Ministries and/or Departments

During this time, the Workshop Manager should prepare and submit the RW priorities and budget requirements to the Hospital Director for incorporation in the overall work plan for the RRH.

4.2.2 Preparation of RW Annual and Quarterly Budget

Since funds are disbursed to RWs on a quarterly basis; planned activities should be scheduled across the year in a logical manner. Identify routine activities that are repetitive and spread them across each quarter and add other activities that can be carried out in the available time and allocated funds for each quarter. While it is usually normal to divide the annual budget allocation by 4, it is important to critically look at the processes and inputs (i.e. time, human resources and finances) needed to realize planned activities.
The RW budget should provide for the following:

i) Procurement of spare parts and maintenance workshop supplies

ii) Labour cost including outsourced services

iii) Mobile workshop operational costs (i.e. fuel, tyres, servicing and repair)

iv) Subsistence costs while on maintenance trips (i.e. Per diem, lunch allowances)

v) RWMC Meetings

vi) Workshop Managers Meetings

vii) Training for users and workshop technicians

viii) Replacement of essential tools and consumables

ix) Office stationery and supplies

x) Maintenance of office equipment

xi) Payment for telephone, water and electricity bills.

4.2.3 Preparation of Quarterly Maintenance Schedules

As one of the planning tools, each RW will prepare a quarterly maintenance schedule. The maintenance schedule will identify the Health facilities to be visited, allocated time and human resources.

The quarterly schedule shall be prepared after confirming the available funds and prioritized planned activities for the quarter.

The RW manager shall send out the maintenance schedule in good time to allow the Health facility managers plan and mobilize the staff to avail the equipment that needs maintenance.

The maintenance schedule should be followed as much as possible by the RW to ensure efficiency and cost effectiveness.

4.2.4 Budgeting for Emergency Works

There will always be cases of critical equipment breaking down and the RW would be expected to respond immediately. To cater for such incidences, a contingency (10% to15% of the overall quarterly budget allocation) should be provided for in the quarterly work plan to cater for emergency callouts. The contingency funds should be spent on a case by case basis on express approval of the RRH Director; and can be drawn from the petty cash and replenished immediately.

4.3 Management of Medical Equipment Maintenance

In the management of RW operations and Equipment Maintenance, it is important to involve stakeholders especially the Users and Administrators. This will help each player to have a good understanding of WHAT to do, WHEN to do it, WHO is to do what; and to agree on the necessary MEANS to do it.

The following scheduled reports and meetings will provide opportunities for engagement and sharing experiences and challenges of medical equipment management:

- Quarterly reports
- Workshop Managers' meetings
- RWMC meetings
- RW Staff meetings

RWs will implement 5S activities designed to improve the work environment, safety, and work flow. This Manual has a summarized description of 5S implementation steps for the workshop environment and it is attached at Annex 6. The detailed description of 5S implementation can be found in the 5S Hand Book and Implementation Guidelines produced by MOH.

4.3.1 Preparation of Quarterly Reports

The Workshop Manager shall prepare and submit Quarterly Reports to the ACHS(HI) through the Hospital Director every 15th day of the months of April, July, October and January of each year.

The quarterly report shall highlight the overall progress in implementation of planned activities and performance. The quarterly report will contain the following:

- Planned activities and status of implementation
- Summary of medical equipment maintained at each health facility
- Expenditure during the quarter clearly separating expenditure on spare parts, per diem, workshop operational costs (i.e. electricity, water, communication as necessary), labour, and vehicle maintenance,
- Planned activities and expenditure for the next quarter.
- Challenges met
- Conclusion
- Recommendations

A proposed format for preparing quarterly reports is attached at Annex 7 for Quarterly Report General Form

All Job Cards for work carried out in the standard format should be attached – See Annex 8

4.3.2 Workshop Managers' Meetings

The Managers of RWs will always meet to discuss issues relating to Medical Equipment Maintenance and Management of RWs.

- Purpose of meeting

  The Workshop Managers Meeting will be a forum where all the Workshop managers meet and share experiences, challenges and chart a way forward to improve maintenance of medical equipment in their regions.

- Frequency

  The ACHS(HI) through the CW shall organize a Workshop Managers' meeting at least twice a year at the CW or any other RW agreed upon by the members.

- Participants

  The Workshop Managers' meeting will include all RWs Managers, senior staff of CW and the HID responsible for medical equipment management and other stakeholders as shall be deemed fit from time to time (e.g. manufacturers' representatives, equipment vendors, Hospital Administrators).

4.3.3 Regional Workshop Management Committee (RWMC)

In order to bring together all stakeholders, each RW shall hold a RWMC meeting at least twice a year in December and April.

- Purpose

  The RWMC meeting will be a forum where stakeholders come together to share experiences and evaluate the performance of the RW. The work plan, budget and

maintenance schedules will be reviewed and approved for each year and/or quarter. The meeting will be chaired by District/Hospital hosting the meeting while the RW will be secretariat for the meeting.

- Frequency

  The RWMC meeting shall take place at least twice a year to coincide with the review of the quarterly/annual report prepared by the workshop Manager.

- Recommended participants

  The following stakeholders will constitute the RWMC membership:

  - Medical Superintendents/Hospital Administrators of the beneficiary Hospitals
  - DHOs of the beneficiary Districts
  - 25% of the Heads of Health Sub-Districts on a rotational basis
  - Workshop Manager
  - Representative of HID/MOH

- Proposed Agenda for RWMC Meeting

  The following Agenda is proposed for the meeting:

  - Call to order and opening prayer
  - Adoption of Agenda
  - Self-introduction
  - Communication from the Chair
  - Review of minutes of previous meeting and maters arising
  - Report on maintenance activities by the Workshop Manager including quarterly work plan and budget

- Comments and matters arising from the Workshops Managers Report
- Submission of relevant issues from the various participants.
- Comment by a representative of ACHS(HI)
- Issues at Hand and Way Forward

Note: The meeting should always review the proposed work plan, schedule and budget for next quarter/year.

4.3.4 Internal Workshop Staff Meetings at workplace

RWs are manned by a Workshop Manager and other technicians in the RRH. To ensure cohesion and coordination in the RW, the workshop manager will hold regular internal meetings with other staff. The RW Manager will use these meetings to discuss action plans, allocate work and review progress and challenges.

- Frequency

  Internal meetings between the workshop manager and his /her staff should take place on a daily/weekly basis to ensure clarity on the tasks to be performed on a daily, weekly and/or monthly basis.

- Discussion points

  Relevant tasks and timelines should be discussed and agreed upon by all staff members.

- Meeting Minutes and Work Reports

  The Workshop manager will put in place a mechanism to ensure that action points agreed upon in the internal meeting are documented and followed up.

Each staff shall prepare a one page report on the tasks he/she undertook for the day/week and the overall status of the task.

Minutes of all meetings held shall be prepared and filed for future reference. Making of Minutes shall be a shared responsibility by all staff of the workshop on a rotational basis including the workshop manager.

Note:

1. Daily meetings should last not more than 30 Minutes
2. Meetings held on Weekly basis should not last more than 1 hour

Chapter 5: Procurement and Disposal of Goods and Services by RWs

While RWs will get involved in procurement and disposal of medical equipment; this is not their core function. This is the function of the respective Heads of the Health facilities and the Procurement and Disposal Units (PDU). Their role in medical equipment procurement should be limited to;

- Review and/or provision of technical specifications
- Inspection and testing to confirm conformity to contract technical specifications and functionality
- Installation and commissioning
- Recommending medical equipment for decommissioning and disposal based on technical considerations (e.g. age, obsolescence, lack of spare parts, reliability and safety).

For day to day workshop operations, the RWs will be involved in procurement of medical equipment spare parts and maintenance services. In this case, the workshop staff will be involved in procurement processes as a User Department.

5.1 Management of Procurement by RWs

Procurement of spare parts and services by RWs will be guided by the Public Procurement and Disposal of Public Assets Authority (PPDA), the Regulation thereto and guidelines in force. All RW managers need to acquaint themselves with PPDA guidelines and the different procurement methods. Regional workshops will be responsible for planning for spare parts needs (i.e. quantification, specifications and budget), out sourcing maintenance services on a case by case basis and disposal of spare parts that are not useful.

As a User Department, the RW will play the following procurement roles;

i) Determine and quantify workshop requirements
ii) Propose/provide technical specifications for the required supplies
iii) Raise procurement requisitions using the Procurement Form PP 20
iv) Participate in the selection of supplies and service providers
v) Participate in inspection, testing and verification of supplies.

Note:

1. RW staff must exercise high moral and ethical conduct while handling procurement of goods and services
2. No supplies should be used before they are taken on charge in the stores and issued out.

5.1.1 Determination of Spare Parts Needs

Determination of spare parts needs shall be based on demonstrated maintenance needs and requirements for Planned Preventive Maintenance (PPM).

Problem oriented planning and budgeting will be the basis for maintenance planning and scheduling to ensure efficient and cost effective utilization of available resources.

- Medical equipment inventory for each health facility will be analyzed to determine the maintenance condition of the equipment. Repair carried out will always be supported with a Job Card Form – see Annex 8.

- RWs will endeavor to print serialized Job Cards and enforce the preparation of Equipment breakdown Report Forms (HMIS Form 11) by health facilities.
- A list of fast moving spare parts will be prepared and used to determine quarterly requirements. Where possible a list of fast moving spare parts for each equipment will be developed from time to time.

5.1.2 Procedure for Purchasing Spare Parts

Procurement of spare parts and tools shall be in accordance with the PPDA guidelines. The RW will identify and quantify the spare parts requirements, and raise the Procurement requisition to start the procurement process through the PDU.

While the RW would allow the PDU to manage the procurement process, it is advisable for the RW manager to assist the PDU to identify possible suppliers and appropriate procurement method. This is important because of the specialized nature of medical equipment spare parts.

- Some spare parts are manufacturer specific and direct procurement would be the most efficient and cost effective procurement method.
- Also, prequalification of suppliers would help reduce the time needed to identify and place orders. Framework contracts could be entered into with prequalified suppliers.

Whatever procurement method is used, it is important that the process is transparent, fair, efficient and cost effective.

5.1.3 Stores Management by RWs

RWs have stores and must maintain inventory records. Management of all stores (i.e. tools and spare parts) shall be in accordance with standard stores management practices. The RW shall secure and maintain stores "Stock cards", "Stores Requisition Forms" and "Stores Issue Forms".

Stock cards shall be maintained weekly, while monthly stock taking will be carried out for all inventories. No spare part shall be issued out without clearly identifying it (i.e. name, part number and model).

5.2 Disposal of Un-necessary Items

Disposal is part of the procurement process and must be planned for. The life cycle of any equipment ends with disposal; but it is often difficult for users to decide when to decommission and how to dispose of equipment.

The reasons for decommissioning and disposal of equipment will include:

- Wear beyond economic repair
- Damage beyond economic repair
- Unreliability
- Safety
- Clinical or technical obsolescence
- Unavailability of spare parts

- Availability of more cost-effective equipment or clinical procedure or technology

Once items for disposal are identified, the PPDA guidelines and procedure should be followed. The disposal process would include;

A) Identification of items to dispose of

B) Submission of list of items for approval by the Accounting Officer (i.e. Hospital Director and/or Hospital Board).

C) Establishment of a Board of Survey team to approve list of items for disposal.

D) Initiation of disposal process through preparation and submission of disposal requisition DPA Form 120 to the PDU to start the disposal process.

Note: The role of the RW will be advisory as the Accounting Officer/PDU has the mandate to dispose of assets/stores.

Chapter 6: Support Supervision, Monitoring and Evaluation of RWs

The Quality Assurance Department of MOH is responsible for monitoring and evaluation of healthcare services. This is done through the Area Teams which assess and monitor implementation of various policy guidelines, planned activities and performance against Sector indicators.

The Evaluation and Monitoring assessment form for Area Teams includes Health Infrastructure and RW staffs need to provide the information on medical equipment maintenance and its impact on healthcare delivery.

6.1 Support Supervision Policy for RWs

For the RWs, specific support supervision will be conducted by the HID/Clinical Service Department and focus will be put on the following;

- Maintenance planning and budgeting. Evidence based planning and budgeting should be the basis for budget allocation.
- Availability of adequate spare parts. Stock planning and control should ensure that essential medical equipment is well maintained at all times.
- Efficiency and cost effectiveness. Operational costs should be optimized to a minimum level but with high outputs and outcomes.
- Prudent financial management and planning. Maintenance scheduling and resource allocations should be optimized to ensure efficiency and cost effectiveness.
- Equipment down time and response time. The response time to emergency calls for repair of life support equipment should not be more than 24hours. The PPM schedule

should aim at keeping at least 65% of the essential medical equipment in good maintenance condition.

1) Frequency of visits

The HID will carry out support supervision and monitoring of RWs once every quarter.

A standard monitoring sheet has been designed to assess RWs – **see Annex 9 for Support Supervision & Monitoring Sheet.**

Chapter 7: Guidelines for Medical Equipment Maintenance

7.1 Introduction

The main objective for any maintenance system is to ensure prolonged use of available equipment to provide safe and reliable healthcare over its design life.

All RWs shall ensure proper maintenance of medical equipment to sustain the intended healthcare benefits and to preserve capital investments. To achieve this, medical equipment shall be maintained in working order and periodically calibrated to ensure accurate results.

To ensure efficient maintenance of equipment, RWs will plan and budget for maintenance under two main categories:

- Planned Preventive Maintenance
- Breakdown maintenance

7.2 Planned Preventive Maintenance (PPM)

PPM is usually scheduled at specific intervals and includes specific maintenance activities such as lubrication, calibration, cleaning of filters or replacement of spare parts that are expected to wear out after stipulated time or workload (e.g. bearings, tubings).

All RWs shall endeavor to implement PPM and scheduling based on the principle of “Problem oriented maintenance planning and budgeting” to optimize utilization of the limited funds and human resources.

Effective planning for preventive maintenance will involve careful selection of the equipment to be included in the plan. Evidence based decisions must be made while deciding equipment to include in the maintenance schedule in order to reduce costs. Maintenance planning shall always ensure that essential medical equipment for basic diagnosis, infection control, surgery and treatment are kept in good working condition. The overriding considerations will always be safety, efficiency and cost effectiveness.

7.3 Corrective Maintenance Services

Corrective maintenance refers to corrective actions undertaken in the event of breakdown of a piece of equipment. In this case, the equipment is repaired or calibrated after failure.

At all times, medical equipment in use should be free from any fault regardless of how minor the fault is and all repair work should be performed by a competent technician.
The user department should:

1) Record details of the defect
2) Fill-in a "Complaint Form". Refer to Annex 10.
3) Contact the RW technician who should in turn decide whether to carry out the repairs or to contact the maintenance contractor.
4) Ensure that information regarding equipment breakdown is passed to all staff during shift change and the head of the institution.

All equipment breakdown occurring in the wards should be recorded on the Complaint Form mentioned above.

7.4 Maintenance Policy

The choice of implementing Preventive or Corrective Maintenance depends on the complexity of equipment, availability of After Sales service and cost.

Maintenance of medical equipment by the RWs will be based on PPM for all essential medical equipment that can be handled by RWs; and a mix of PPM and Corrective maintenance for medical equipment that need outsourcing the maintenance services.

Equipment maintenance shall be carried out by both In-House trained technicians and Manufacturer's representatives or Vendor.

For specialized and advanced equipment, the RWs will on a case by case basis outsource maintenance services through a combination of on-call services and a maintenance contract negotiated at the time of equipment purchase.

7.5 Levels of Maintenance

For purposes of this Manual, three levels of maintenance will be observed:

Level 1: First-line by the Equipment User

This refers to maintenance activities that can be carried out by the user or health facility based technician. This will include dusting equipment, cleaning filters, checking fuses and checking power supply source without opening the unit and without moving it away from the point of use.

Other first line maintenance activities could include the following:

- Equipment decontamination and sterilization
- Functional checks
- Calibration checks
- Safety checks

Note: First line maintenance may be carried out by Hospital based Technicians too.

Level 2: By Technician

This refers to maintenance carried out by a technician when first-line maintenance cannot rectify a fault or when a regular scheduled check and calibration is due.

Level 3: Specialized Maintenance by Technician/Engineer from Manufacturer's representative/Vendor

This refers to maintenance activities that need higher level technical expertise, troubleshooting techniques and tools.

Equipment such as X-Ray machine, CT Scanners, Ultrasound scanner, Endoscope, Automatic Laboratory Analyzer etc. need specialized engineers and technicians who have been trained to maintain this specific equipment. Additionally, specialized tool/equipment may be required for testing and calibration of such equipment. This caliber of Technicians/Engineers is normally employed by third party companies or vendors representing the manufacturer of the equipment.

This manual focuses on level 1 (user or first-line maintenance) and level 2 (technicians level) maintenance. For purposes of this manual, level 2 maintenance shall be largely provided by the RW technicians except for cases where Maintenance Contracts exist.

7.6 Range of Medical Equipment that can be maintained by WS or Outsourcing

The example medical equipment is shown below;

No	CATEGORY	EQUIPMENT	WS	Out-sourcing
1	General	BP Machine	●	
2		Stethoscope	●	
3		Refrigerator (Electric)	●	
4		Refrigerator (Gas, Kerosene, Solar)	●	
5		Weighing Scales	●	
6		Suction Machines	●	
7		Ultrasonic Nebulizer	●Basic	●
8		Oxygen Concentrator	●	
9		Oxygen Cylinder and Flowmeter	●	
10		Electronics Diagnostic Equipment (General)	●Basic	●
11	Imaging	General X-ray Machine	●Basic	●
12		Ultrasound Scanner	●Basic	●
13	Operating Theatre and Delivery Room	Electrosurgical Unit/ Diathermy	●Basic	●
14		Tables (OT and Delivery), Hydraulic	●	
15		Lamps	●	
16		Anesthesia Machine	●Basic	●
17	Maternity	Infant Incubator	●	
18		Infant Warmer	●	

No	CATEGORY	EQUIPMENT	WS	Out-sourcing
19	Sterilization	Autoclave	●Basic	●
20		Hot Air Oven	●	
21		Disinfector/ Boiler	●	
22	Diagnostics	ECG Machine	●Basic	●
23		Pulse Oximeter	●Basic	●
24	Ophthalmology	Slit lamp	●Basic	●
25	Laboratory	Centrifuge	●Basic	●
26		Microscope	●	
27		Laboratory Incubator	●Basic	●
28		Colorimeter	●Basic	●
29		Hematology Analyzer	●Basic	●
30		CD4 Counter, Flow Cytometry type	●Basic	●
31	Dental	Dental Unit and Dental Chair	●Basic	●
32	Others	Solar System	●Basic	●

7.7 Setting Up a Maintenance System

All RWs will strive to implement PPM and where possible set up a computerized PPM schedule. This will require an up to date medical equipment inventory at all times.

Each RW shall maintain a computerized medical equipment inventory database for each health facility. At the minimum, a Microsoft Excel based database will be maintained by each RW. All relevant information about the equipment must be entered, including its location, serial/identification number, manufacturer

details and maintenance record. A reference number should be engraved on each equipment. Additional information that should be captured includes:

- Whether equipment is maintained in-house, or
- Maintained by external agency or manufacturer

7.7.1 Routine Maintenance Procedures and Work Flow Charts

As much as possible, PPM activities to be conducted on each equipment shall be laid out in a workflow chart or check list. The specific work to be carried out may be based on guidance from the manufacturer's maintenance/service manual.

- The frequency of maintenance shall be based on the manufacturer's recommendation or usage.
- A heavily used equipment must be cleaned and checked more frequently than one which is used less often. Minimum standards must be met to ensure safety and reliability.

7.7.2 Personnel

Maintenance of equipment will be undertaken by a trained biomedical technician/Engineer. In accordance with the approved MOH structure, the following maintenance personnel shall constitute the maintenance team in the RW:

- Assistant Engineering Officer/Engineering Assistant
- Engineering Technician (Electrical and Mechanical)
- Biomedical Engineering Technician (*)
- Artisan (Plumber, Mechanic, Mechanical, Carpentry)

(*) Future cadre in MOH structure

7.7.3 Reminder system

A reminder system will be put in place, so that staff are prompted to carry out tasks when they are due. A card index /sticker/calendar system or a computer programme may be used. Where card/sticker system is adopted, it will be placed on the equipment in such a way that it is visible.

7.7.4 Surveillance

After the programme has been set up, each RW will put in place a periodic surveillance system to ensure that records are legible and that all entries are being made. Copies of Job cards and index cards shall be stored near the equipment.

7.7.5 Standard Maintenance Work Formats

Maintenance records shall be collected and maintained using standardized formats that facilitate easy compilation of important information. The formats will include the following information;

1) Reference ID number as per Inventory
2) Equipment Name
3) Manufacturer
4) Serial Number
5) Date of installation
6) Maintenance Frequency
7) Date of maintenance
8) Date for next Maintenance
9) Cost of maintenance and detail
10) Remarks on Functional status

7.7.6 Special Test Equipment

Each RW will have a range of test equipment and tools to check the correct functioning of medical equipment and its compliance with electrical and other safety standards.

7.7.7 Technical library

Each RW shall maintain a fully stocked technical library with manufacturers' maintenance manuals for various medical equipment and other relevant biomedical engineering literature and publications.

Chapter 8: Periodic maintenance checklist for common equipment

1) Sphygmomanometer [Blood Pressure (BP) Machine]

Function

Blood pressure is an indicator of several diseases as well as of general health. It is an easy screening test using the BP machine. A sphygmomanometer can be used to measure the blood pressure at the high point (systolic) and low point (diastolic) of the cardiac pressure cycle. Pressure is usually measured using a cuff on the upper arm.

How it works

The cuff on the arm is inflated until blood flow in the artery is blocked. As the cuff pressure is decreased slowly, the sounds of blood flow starting again can be detected. The cuff pressure at this point marks the high (systolic) pressure of the cycle. When flow is unobstructed and returns to normal, the sounds of blood flow disappear. The cuff pressure at this point marks the low (diastolic) pressure.

Pressure can be measured using a meter with dial (aneroid type), a mercury column or an electronic display. The sounds are normally detected using a stethoscope, but electronic equipment use an automatic technique with pressure sensors. The two methods do not always give the same results and the stethoscope method is generally more accurate for all types of patient.

Maintenance Checklist

Care and Handling	• Check whether equipment is safely packed • If mercury is spilled, seal unit and send to the technician • Remove all dust and dirt with a damp cloth
Visual checks	• Ensure all parts are present and are tightly fitted • Check that the display is zero when the cuff is deflated • Remove or replace any cracked rubber parts
Function Checks	• Before use, check that the pressure rises and returns to zero • Check correct operation of inflation bulb and valves • Remove any batteries if not in use for more than one month • Inflate to 200 mmHg and check leakage is not faster than 2 mmHg in 10 seconds

Troubleshooting

	Fault	Possible causes	Solution
1	Mercury leakage or mercury NOT at zero level	Mercury leakage or overfilling	Correction to be done by a technician
2	Mercury is dirty	Oxidation of mercury	Cleaning to be carried out by a technician
3	Pressure does NOT increase easily or Pressure increases after inflation	Valve or tube blockage	Remove and clean all valves and tubes. Reassemble and test
4	Aneroid instrument does NOT return to zero	Zero setting has moved	Rotate collar on the base until zero setting is achieved and tighten.
5	Pressure does NOT remain steady	Leakage of air	Isolate leak by closing off parts of tubing. Replace leaking section and retest

2) Stethoscope

Function

A stethoscope is used to listen to sounds within the body. These might be sounds generated by breathing, coughing, blood flow or the stomach. The sounds are picked up and transmitted to the ears of the medical staff for diagnosis.

How it works

A membrane on the stethoscope head picks up the vibrations caused by internal sounds and transmits them to the stethoscope tube. The sounds pass up the tube through the earpiece to the user. The stethoscope head also contains an open bell which is used to pick up lower frequency sounds. The head picks up the sound from a wide area so it sounds loud to the user. Care must therefore be taken not to hit or shout into the stethoscope while in use.

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Maintenance Checklist

Care and Handling	• Check that the equipment is safely packed • Remove any visible dirt • Remove all dust and dirt with a damp cloth Remove earpieces and clean the inside with warm water
Visual checks	• Ensure all parts are present and are tightly fitted • Remove or replace any cracked rubber parts • Replace membrane if broken
Function Checks	• Tap gently before use to check operation • Check tube holder rotates easily within headpiece • Check sound can be heard from both sides of headpiece

Troubleshooting

	Fault	Possible causes	Solution
1	Faint or NO sound heard	Leakage or blockage	Remove all parts and check for leakage and blockage.
2	Tube connector does NOT stay in headpiece	Broken locking mechanism	Repair to be done by a technician
3	Parts damaged or faulty	Broken part	Replace with part taken from other units

3) Refrigerator (Electric and Solar)

Function

A refrigerator is a hospital plant that keeps health facility vaccines, reagents and blood at a required environment (e.g. temperature and humidity).

How it works

An electrical refrigerator can be a compression or absorption type. Compression fridges use electrical power as a source of power and it has four major components;

1- A compressor,
2- A condenser,
3- An Expansion valve/capillary tube,
4- An Evaporator

A compressor has a pump and electrical coil, both inside the housing. The coil gets electrical power to form an electrical field to drive the pump which then pumps the refrigerant in form of gas with a high pressure to the condenser.

The condenser receives the refrigerant, removes heat and condenses refrigerant into a liquid. The liquid refrigerant still at high pressure goes to an expansion valve/capillary tube.

The Expansion valve or capillary tube drops the refrigerant pressure and temperature and this is where cooling starts.

The Evaporator is the cooling part of the refrigerator which evaporates the liquid refrigerant back into gas form and removes heat from the room.

Maintenance Checklist

Care and Handling	• Use a damp cloth to clean the solar panel and fridge body. • Use a damp cloth to clean evaporator after melting ice. Never use a sharp object to remove ice. • Use a brush or dry cloth to clean the condenser. • Use a brush to clean the compressor. • Use a brush to clean the charge regulator.
Visual checks	• Check door rubbers if not damaged. • Check thermometer position in the fridge. • Check room ventilation where the fridge is located. • Check discharge level on the charge regulator. • Check ice formation inside the fridge. • Check dust on solar panels. • Check if solar panels are not shaded.
Function Checks	• Check whether the power source if available. • Check thermostat position inside the fridge. • Check thermometer reading from the fridge. • Check fridge stability on the ground.

Troubleshooting

	Fault	Possible causes	Solution
1	Compressor NOT running.	No power supply. Burnt compressor.	• Check power supply. • Replace the compressor.
2	Compressor running but NOT cooling.	Gas leakage. Weak compressor pump. Chocked drier.	• Braze pipe, charge the fridge. • Replace compressor. • Replace filter drier.
3	Fridge over freezing.	Faulty thermostat. Wrong Thermostat setting.	• Replace thermostat. • Set thermostat properly.
4	Too much ice formation inside fridge.	Evaporator fan not running.	• Replace evaporator fan.

4) Refrigerator (Gas and Kerosene)

Function

The function of a refrigerator is to bring down the room temperature to the required one.

How it works

The absorption system is different from the compression system. It uses heat energy instead of mechanical energy to make a change in the conditions necessary to complete a refrigeration cycle. The system may use butane, kerosene, steam or electrical heating element as a source of heat and ammonia solution as a refrigerant.

The system has few moving parts, small systems have moving parts only in the heat source valves and controls which are used. Larger systems also use circulating pumps and fans as moving parts.

Absorption systems also have 4 major components.1-Generator, 2-Condenser, 3-Absorber/Receiver and 4-Evaporator. In this case the compressor is replaced by a heater and Generator.
Absorption system uses a generator charged with water and ammonia, a heat source usually kerosene flame heats this solution in the generator, the ammonia becomes vaporized and is driven off to the condenser, and the condenser at the top of the system condenses the ammonia vapor into liquid. The liquid flows by gravity into the liquid receiver and then into the evaporator. During the generating cycle, little or no refrigerating effect is taking place. As the system cools, pressure drops causing the liquid ammonia in the evaporator to boil (cooling) and absorb heat from the room, the cycle is complete when vaporized ammonia is absorbed back to the generator.

Maintenance Checklist

Cleaning	• Use a damp cloth to clean the fridge body. • Use a brush to clean the condenser. • Use a brush to clean the generator. • Use a damp cloth to clean the inside of the fridge when it is off and ice is melting.
Visual checks	• Check if gas cylinder is open and there is no leakage. • Check if spirit level is in a better position/leveling. • Check if thermostat probe is in a better position.
Function Checks	• Check if the burner or nozzles are clean and okay. • Check if gas cylinder is open and has gas. • Check if thermostat is functioning well. • Check the level of ice formation on evaporator.

Troubleshooting

	Fault	Possible causes	Solution
1	NOT cooling well.	• Nozzles blocked. • Too much ice formation.	• Clean nozzles. • Carry out manual defrosting.
2	Over cooling.	• Thermostat not cutting off gas or heating element.	• Replace the thermostat.
3	Burning Gas available but NOT cooling.	• Ammonia leakage.	• Braze the pipe and charge the system.
4	Generator heating okay, No leakage but no cooling.	• Bubble formation in the system.	• Turn the system horizontal for at least two days.

5) Weighing Scales

Function

Measuring patient weight is an important part of monitoring health as well as calculating drug and radiation doses. It is therefore vital that scales continue to operate accurately. They can be used for all ages of patient and therefore vary in the range of weights that are measured. They can be arranged for patients to stand on, or can be set up for weighing wheelchair bound patients. For infants, the patient can be suspended in a sling below the scale or placed in a weighing cot on top of the scale.

How it works

Mechanical scales have a spring deflected by patient weight. The spring pushes a pointer along a display or rotates a disc to indicate weight. Electronic scales have a sensor (pressure sensor) that bends under patient weight and the circuitry converts this to displayed digits.

This pressure sensor under strain induces an electric potential which is directly proportional to the applied force (weight).

Baby weighing scale, dial type

Baby weighing scale, spring type

Maintenance Checklist

Care and Handling	• Wipe off dust and replace dust cover after checks • Clear away any dirt or hair on controls and feet • Clean exterior with damp cloth and dry off • Clean off then repaint any exposed or rusted metal
Visual checks	• If bent, cracked or damaged, send for repair • Tighten any loose screws and check parts are fitted tightly
Function Checks	• Check zero at start of day and before each patient • Check reading is accurate using a known weight • Send for repair if inaccurate or sticking • Replace battery if display shows low battery

Troubleshooting

	Fault	Possible causes	Solution
1	Zero point can NOT be set	Scale is not level Zero control broken or internal part jammed	Set scale on level ground and Retest Repair or change parts
2	Movement is stiff or jerky	Dirt lodged inside Internal blockage	Remove any visible dirt or foreign body and reset Lubricate /repair
3	Reading is inaccurate	Zero not properly set Calibration error	Reset to zero Recalibrate
4	Electronic display is blank	Battery / power failed	Replace battery or power supply and retest

6) Suction Machines (Aspirators)

Function

Suction machines (also known as aspirators) are used to remove unwanted fluid from body cavities. They are found in operating theatres, delivery suites, ENT and emergency departments. Smaller specialized suction machines are used in dental departments.

How it works

Suction is generated by a pump. This is normally an electrically powered motor, but manually powered versions are also often found. The pump generates a suction that draws air from a bottle. The reduced pressure in this bottle then draws the fluid from the patient via a tube. The fluid remains in the bottle until disposal is possible. A valve prevents fluid from passing into the motor itself.

Maintenance Checklist

Care and Handling	• Wipe dust off exterior of the equipment and bottle cover. • Wash bottle and patient tubing with sterilizing solution • Wipe round bottle seal with damp cloth, replace if cracked • Remove dirt from wheels / moving parts
Visual Checks	• Check if all fittings & accessories are mounted correctly • Check if filter is clean • Check if parts are fitted and replace any cracked tubes • Check if mains cable has no bare wire and is not damaged
Function Checks	• Check that all switches and vacuum control operate correctly • Check for air and liquid leakage

Troubleshooting

	Fault	Possible causes	Solution
1	Machine is NOT running	No power from mains socket Fuse blown Electrical cable fault	Check power switch is on. Check mains power. Check for leaks or short circuits causing the fuse to blow and correct this. Replace fuse. Try cable on another piece of equipment to rule out internal cable damage
2	Poor fluid flow, pressure gauge low	Tube /seal / bottle leaking or Disconnected Air outlet valve blocked Control valve stuck Internal or control error	Close different tubes by bending. When pressure gauge changes, leakage point has been passed. Replaced damaged tube or seal. Clean outlet valve Operate control valve through full range. Send for repair if it is stuck. Refer to a technician
3	Poor fluid flow, pressure gauge high	Blocked filter or tube	Disconnect each tube one at a time. When air flow is stopped, blockage has been passed. Replace filter or unblock tube.
4	Filter discolored	Floating valve broken	Change filter, clean or replace floating valve
5	Electrical shocks	Wiring fault	Refer to an electrician
6	Manual suction is jammed	Internal slider stuck	Refer to a technician for greasing

7) Ultrasonic Nebulizers

Function

Is a device used to administer medication in the form of a mist inhaled into the lungs. Nebulizers are commonly used for treatment of asthma and other respiratory diseases. The reason for using a nebulizer for medicine to be administered directly to the lungs is that small aerosol droplets can penetrate into the narrow branches of the lower airways. Large droplets would be absorbed by the mouth cavity, where the clinical effect would be low.

How it works

Ultrasonic Nebulizers use ultrasonic power as means to break up medical solutions or suspensions into small droplets, these small droplets are passed for direct inhalation either through the mouthpiece of the device or a hose set. An Ultrasonic Nebulizer uses a small crystal to generate vibrations in the solution that cause droplets to break off.

Maintenance Checklist

Care and Handling	• Clean and sterilize mouthpiece and medicine chamber • Wipe dust from the machine and replace cover after checks
Visual Checks	• Check all parts are present and tightly fitted • Check all moving parts move freely, all holes are unblocked • If mains plug, cable or socket are damaged, replace them • If chamber and tube seals are damaged, replace them.

Function Checks	• Check the whole system functions before use • Before next use, check that there is adequate nebulization. • Check that the compressor fan is working without excessive noise.

Troubleshooting

	Fault	Possible causes	Solution
1	Equipment is NOT working	No power from mains socket/ Blown mains fuse Electrical cable fault	Check power switch is on. Replace fuse with correct current ratings. Check mains power. Try cable on another piece of equipment.
2	Equipment is on but flow is absent	Filter is blocked Pipe is twisted or nebulizer chamber/mouth piece is blocked.	Clean filter Connect pipe properly, clean chamber / mouthpiece
3	Inadequate nebulizing amount	Output adjustment not correctly set. Mouth piece cracked Vibration generator weak	Adjust output as directed in the user manual Replace mouthpiece Replace vibration generator.
4	Electrical shocks	Improper earthing/grounding of the machine. Bare wires touching the body of the machine	Earth the machine appropriately Insulate all live conductors

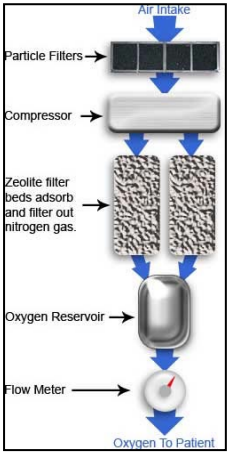
8) Oxygen Concentrators

Function

An oxygen concentrator draws in room air, separates the oxygen from the other gases in the air and delivers the concentrated oxygen to the patient. When set at a rate of two litres per minute, the gas that is delivered by the concentrator is more than 90% oxygen. It is used for situations where bottled gas supply is impractical or expensive, and can be used by patients in the hospital or the home.

How it works

Atmospheric air consists of approximately 80% nitrogen and 20% oxygen. An oxygen concentrator uses air as a source of oxygen by separating these two components. It utilizes the property of zeolite granules to selectively absorb nitrogen from compressed air. Atmospheric air is gathered, filtered and raised to a pressure of 20 psi (138kPa) by a compressor. The compressed air is then introduced into one of the canisters containing zeolite granules where nitrogen is selectively absorbed leaving the residual oxygen available for patient use. After about 20 seconds the supply of compressed air is automatically diverted to the second canister where the process is repeated enabling the output of oxygen to continue uninterrupted. While the pressure in the second canister is at 20 psi (138kPa) the pressure in the first canister is reduced to zero. This allows nitrogen to be released from the zeolite and returned into the atmosphere. The zeolite is then regenerated and ready for the next cycle. By alternating the pressure between the two canisters, a constant supply of oxygen is produced and the zeolite is continually being regenerated. Individual units have an output of up to five litres per minute with an oxygen concentration of up to 95%.



Maintenance Checklist

Care and Handling	• Remove any dust / dirt with a damp cloth and dry off • Fill humidifier bottle up to the level marker with clean distilled water • Wash filter in warm water and dry. Replace if damaged • Clean humidifier bottle thoroughly and dry off
Visual Checks	• Check all screws, connectors, tubes and parts tightly fitted • Replace humidifier bottle if covered with limescale. • Check mains plug, cable or socket for any damage and replace if necessary.

Function Checks	• Check oxygen flow before setting up line to a patient. • Run machine for two min. and check that no alarm goes off. • Check functionality of flow meter. Oxygen flow rate should vary with flow control (see bubbles).

Troubleshooting

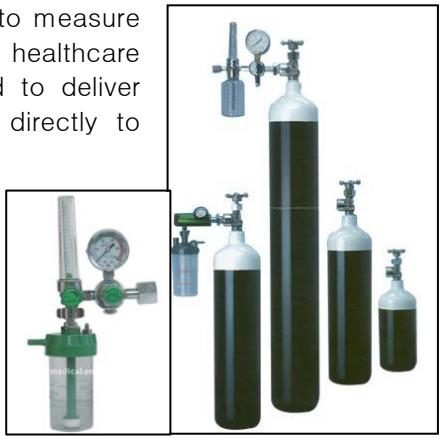
	Fault	Possible causes	Solution
1	Unit NOT operating, power failure alarm sounds	No power from mains socket Concentrator circuit breaker has been set off.	Check mains switch is on and cable inserted. Replace fuse. Press reset button if present
2	Unit NOT operating, no power failure alarm	Alarm battery dead	Replace battery and test as above
3	No oxygen flow	Flow not visible Tubes not connected tightly Water or dirt blocking the oxygen tubing Blocked flow meter or humidifier bottle	Place tube under water and look for bubbles. If bubbles emerge steadily, gas is indeed flowing Check tubing and connectors are fitted tightly Remove tubing, flush through and dry out before replacing Replace meter / bottle or refer to a technician
4	Temperature light or low oxygen alarm is on	Unit over heated or obstructed	Remove any obstruction caused by drapes, bedspread, wall Clean filters. Turn unit off, using standby oxygen system. Restart unit after 30 min.
5	Electric shocks	Wiring fault	Refer to an electrical technician
6	Concentrator is humming but can NOT start	Defective capacitor	Test with a multi-meter and replace
7	Service warning light persists for more than 5 min with or without audible alarm	Dirty filters	Clean or replace the filters

9) Oxygen Cylinders and Flow meters

Function

Medical gases such as oxygen, nitrous oxide etc. are intended for administration to a patient in anaesthesia, therapy or diagnosis. An oxygen cylinder is a cylindrically shaped metal container used to store oxygen that has been compressed to a very high pressure. Oxygen cylinders, which come in different sizes, are usually coloured black with a white top; in some cases, it may be a small cylinder that is entirely black. The black colour helps to differentiate it from other gases that are stored in similar containers. Cylinders are fitted with customized valves (either bull nose or pin index type) with valve guards, which are opened with valve keys.

A flow meter is an instrument used to measure the flow rate of a liquid or a gas. In healthcare facilities, gas flow meters are used to deliver oxygen at a controlled rate either directly to patients or through medical devices. Oxygen flow meters are used on oxygen tanks and oxygen concentrators to measure the amount of oxygen reaching the patient or user. Sometimes bottles are fitted to humidify the oxygen by bubbling it through water.



Maintenance Checklist

Care and Handling	• Ensure delivery tubes and masks are sterile • If humidifier bottle is used, refill with clean water • Clean cylinder, valve and flow meter with a damp cloth
Visual Checks	• Check that the cylinder is the correct type and marked oxygen. • Check all parts are fitted tightly and correctly • Check for leakage: hissing sound or reduction in pressure

Function Checks	• Before use, ensure cylinder is filled & flow is present • Close cylinder valve after each use. • Remove valve dust with brief, fast oxygen flow • Check flow can be varied using flow control

Troubleshooting

	Fault	Possible causes	Solution
1	No oxygen is flowing	Cylinder is empty Flow meter knob or cylinder valve is closed. Faulty regulator	Replace cylinder Open valves, then check flow meter registers flow Close all valves and replace regulator
2	Leakage from cylinder or Flow meter	Cylinder is not connected to regulator properly Faulty or missing washer Flow meter seal damaged or loose Cylinder faulty	Tighten all fittings Replace washer Tighten flow meter Label “Faulty” and return to manufacturer
3	Leakage can NOT be located	Leakage too small to be heard	Apply detergent solution (NOT oily soap) to joints. Bubbles will show at leak point. Clean/replace washer and tighten at that joint.
4	Flow meter ball NOT moving, yet oxygen is flowing	Faulty flow meter	Close all valves, disconnect flow meter and clean inside. Reconnect and test.
5	Pressure gauge does NOT show pressure, yet oxygen is flowing	Faulty pressure gauge	Refer to biomedical technician for Replacement

10) Electronic Diagnostic Equipment (General)

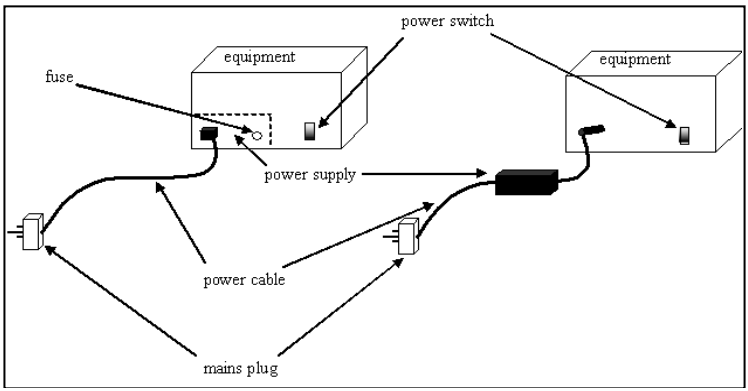
Function

There are many pieces of equipment in a hospital that use electronics for operation. The maintenance of such equipment is a task for specialized and trained staff. However, regular inspection and cleaning will help such equipment last for a long time and operate safely. These are tasks that the equipment user can carry out and should be done regularly, as laid out on the checklists.

The type of equipment that is included in this category are for instance **audiometers, blood gas analyzers, cardiac monitors, cryoprobes, infusion pumps and stimulators.** The steps in this section can also be applied to most laboratory equipment.

How it works

The electrical part of the machine is the most important for safety, and also is the most likely to have problems relating to power supply. The power supply converts the voltage to a lower stable value to make the equipment work and also protects the patient from the mains voltage. Any damage to the power supply, or any liquid spilled into the equipment could result in very serious consequences. The maintenance checklist therefore majors on checking the cables, fuses and power connectors. If a device uses low voltage batteries, it is safer to use. In this case, the user should take care that the batteries are removed if the equipment will not be used for longer than one month, as chemical spillage can occur. Rechargeable batteries must be kept topped up with charge.



General item of electrical equipment, one with internal power supply, the other with external

Maintenance Checklist

Care and Handling	• Wipe dust off exterior and cover equipment when not in use • Remove any tape, paper or foreign body from equipment • Unplug, clean outside of the equipment with a damp cloth and dry off • Clean any filters or covers as directed by in the user manual
Visual Checks	• Check all fittings and accessories are mounted correctly • Check there are no cracks in covers or liquid spillages • Tighten any loose screws and check that all parts are fitted tightly • Check mains plug screws are tight • Check that the mains cable has no bare wire and is not damaged
Function Checks	• Before use, run a brief function check before clinic • Check that adequate supply of printing paper, oil, batteries etc. are available. • Check that all switches operate correctly

Troubleshooting

	Fault	Possible causes	Solution
1	Equipment is NOT running	No power from mains socket	Check power switch is on. Replace fuse with correct voltage and current rating if blown. Check mains power is present at socket using equipment known to be working. Contact electrician for rewiring if power not present.
		Electric cable fault	Try cable on another piece of equipment. Contact electrician for repair if required.
2	Fuse keeps blowing	Part malfunction	Refer to a technician
3	Electrical shocks	Wiring fault	Refer to a technician

11) General X-Ray Machine

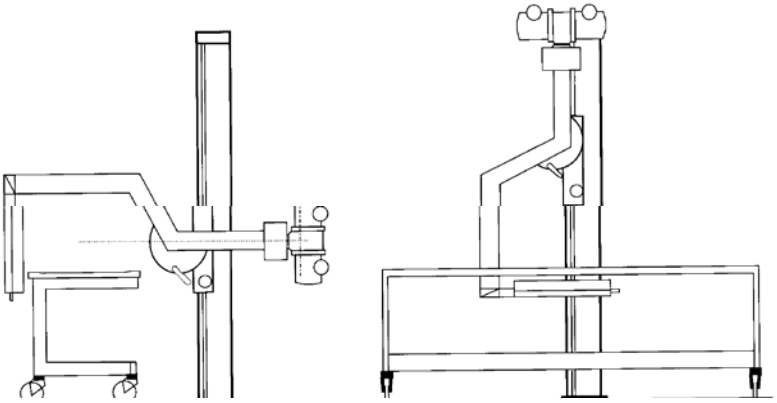
Function

X-Ray machines are used for imaging bones and hard tissues and diagnosing fractures, joint defects, choked lungs etc. Sometimes contrast agents are also used to highlight any defects in the abdomen under X-rays.

How it works

X-rays are high energy electromagnetic waves. The transformer produces a high voltage that directs electrons onto a target in the machine head. X-rays are produced by the target and are directed into beams by a collimator towards the human body. Soft body tissue absorbs less X-rays, i.e., more radiation goes through, whereas bone and other solids prevent most of the X-rays from going through. A photographic film or electronic sensor displays how much X ray has passed through, forming an image of the interior of the body. Bone appears nearly white, because few X-rays strike the corresponding part of the film, leaving it largely unexposed; soft tissue allows much more radiation to pass through, darkening the film in those places.

Users must ensure proper radiation safety protocols and supervision is in place.



(Control panel and transformer not shown)

Maintenance Checklist

Care and Handling	• Remove any items or foreign body from equipment • Clean all dust and dirt from the X-Ray machine and room
Visual Checks	• Check that all parts are present and connected • Check that cables are not twisted and remove from service if any damage is visible • If any plug, cable or socket is damaged, refer to distributor • Check lead aprons for any defects • Check table, cassette holder & grids for smooth movement
Function Checks	• Switch on power and check all indicators function • If machine has not been in use, wear lead apron and check whether exposure indicator lights on switch operates • Check collimator bulb, replace with correct type if needed • Check power supply voltage, and regulation • Check protection earthing for the Equipment • Check that internal earth connections are firm

Troubleshooting

	Fault	Possible causes	Solution
1	X-Ray unit does NOT switch on	Mains power not connected	Check the machine is plugged into the mains socket and that all switches are on. Replace fuse. Check if mains power is present at socket using equipment known to be working. Rewiring by electrician.
2	X-Ray machine NOT exposing, even when power is on.	Safety interlock is on Exposure switch cable problem Internal error	Check safety locks, all switches Check for any loose connection Refer to distributor's technician
3	Poor X-Ray image quality	X-Ray tube problem	Refer to distributor's technician
4	The table does NOT move.	Table motor or cable problem. Safety switch or fuse problem Control circuit problem	Check all cable connections Check relevant fuse or switch Refer to biomedical technician
5	Electrical shocks	Wiring fault	Refer to distributor's technician immediately

12) Ultrasound Scanner

Function

Diagnostic ultrasound machines are used to give images of structures within the body. Other kinds of machines (e.g. therapeutic and lithotripsy) are not dealt with herein. The diagnostic machine probes, which produce the ultrasound, come in a variety of sizes and styles, each type being produced for a particular special use. Some require a large trolley for all the parts of the unit, while the smallest come in a small box with only an audio loudspeaker for output. They may be found in cardiology, maternity, outpatients and radiology departments and will often have a printer attached for recording images. Unlike X-rays, ultrasound poses no danger to the human body.

How it works

The ultrasound probe contains a crystal that sends out bursts of high frequency vibrations that pass through gel and then through the body. Soft tissue and bone reflect echoes back to the probe, while pockets of liquid pass the ultrasound straight through. The echoes are picked up and arranged into an image displayed on a screen. The machine offers a number of processing options for the signal and image and also allows the user to measure physical features displayed on the screen. This requires the machine to incorporate a computer.

Maintenance Checklist

Care and Handling	• Wipe dust off exterior and cover equipment after use • Remove any items or foreign body from equipment • Wipe probe with alcohol-free tissue or cloth • Remove, clean and dry external filter if present

Visual Checks	• Check that all fittings and accessories are mounted correctly • Check that cables are not twisted and probe is safely stored • Check that mains plug screws are tight • Check that mains cable has no bare wire and is not damaged
Function Checks	• If machine has not been in use, run and test briefly

Troubleshooting

	Fault	Possible causes	Solution
1	Equipment is NOT running	No power from mains socket Electrical cable fault	Check power switch is on. Replace fuse. Check mains power is working. Repair or exchange the cable. Try cable on another piece of equipment.
2	Fuse keeps blowing	Power supply or cable fault	Refer to distributor's technician
3	Probe head damaged or noisy	Possible internal fault	Exchange probe.
4	Image quality poor	Gel insufficient Controls set incorrectly Mains voltage is too low	Use more ultrasound gel Check controls for correct positioning and operation (refer to user manual) Use voltage stabilizer
5	Display / computer error	Software fault	Turn machine off and restart. If problem persists, refer to distributor's technician
6	Electrical shocks	Wring problem	Rewiring/repair by a technician

13) Electrosurgical Units (ESU) / Diathermy

Function

Electrosurgery is the application of a high-frequency electric current to biological tissue as a means to cut, coagulate, desiccate, or fulgurate tissue. Its benefits include the ability to make precise cuts with limited blood loss in hospital operating rooms or in outpatient procedures. Cautery, or electrocautery, is the application of heat to tissue to achieve coagulation. Although both methods are sometimes referred to as surgical diathermy, this chapter avoids the term as it may be confused with therapeutic diathermy, which generates lower levels of heat within the body.

How it works

In electrosurgical procedures, the tissue is heated by an alternating electric current being passed through it from a probe. Electrocautery uses heat conduction from an electrically heated probe, much like a soldering iron. Electrosurgery is performed using an electrosurgical generator (also referred to as power supply or waveform generator) and a hand piece including one or several electrodes, sometimes referred to as an RF Knife, or informally by surgeons as a "Bovie knife" after the inventor. Bipolar electrosurgery has the outward and return current passing through the handpiece, whereas monopolar electrosurgery returns the current through a plate normally under the patient. Electrosurgery is commonly used in dermatological, gynaecological, cardiac, plastic, ocular, spine, ENT, orthopedic, urological, neuro- and general surgical procedures as well as certain dental procedures.

Maintenance Checklist

Care and Handling	• Remove any dust / dirt and replace equipment cover • Unplug, clean outside with a damp cloth and dry off
Visual Checks	• Check that all fittings and cables are properly connected • Check there are no signs of spilled liquids or cable damage • Inspect filters, clean or replace if needed. • If any plug, cable or socket is damaged, replace
Function Checks	• Check foot / probe switch smooth operation. • Check returns plate cable disconnection alarm before use.

	• Check proper operation of all controls, indicators and visual displays on the unit. • If not recently used, check operation on wet soap

Troubleshooting

	Fault	Possible causes	Solution
1	Equipment is NOT running	No power from mains socket Electric cable fault	Check power switch is on. Replace fuse. Check mains power. Try cable on another piece of equipment.
2	Equipment is on but shows error signal	Footswitch pedal may have been depressed as unit is turned on or front panel buttons may be stuck. Probe, patient cable or plate malfunction	Note error code and turn unit off. Check footswitch and front panel buttons. Disconnect all foot pedals. Turn on unit again. Check connections and plugs on all cables are tight.
3	Equipment is on but output is absent, weak or intermittent	Power setting is too low Malfunctioning parts Incorrect connection	Adjust power, check manual Check connection or replace parts Check correct probe/footswitch cord are well connected
4	Continuous interference with monitors	Faulty ground connection Poor filtering systems in monitoring device	Check all monitors and power connections. Use separate outlets for each device. Replace monitoring device
5	Monitor interference occurs only when electrosurgery is activated	Metal to Metal sparking Cords and cables are bundled, touching or damaged High power setting	Check all connections are tight. Remove cable cluttering, replace damaged cords Reduce power setting, use blend Mode
6	Pacemaker or internal cardiac defibrillator interference	Equipment activation is causing battery or implant malfunction	Stop procedure immediately, perform emergency care and call implant supplier before restarting procedure
7	Electrical shocks to user	Wiring fault	Refer for rewiring by a technician

14) Tables (for Operating Theaters and Delivery)

Function

Tables are required to hold the patient in a position that is comfortable for both the patient and for medical staff during procedures. They can include dedicated supports for head, arms and legs and often have movable sections to position the patient appropriately. They are made both with wheels and on static platforms and can have movements powered by electric motors, hydraulics or simply manual effort. They can be found in emergency departments, operating theatres and delivery suites.

How it works

Where the table has movement, this will be enabled by unlocking a catch or brake to allow positioning. Wheels have brakes on the rim or axle of the wheel, while locks for moving sections will normally be levers on the main table frame. Care should be taken that the user knows which lever applies to the movement required, as injury to the patient or user may otherwise result. The table will be set at the correct height for patient transfer from a trolley then adjusted for best access for the procedure.

Maintenance Checklist

Care and Handling	• Clean, dry and disinfect table/ underneath/ base • Wipe off any escaped oil or grease from joints
Visual Checks	• Check that all parts are present and tightly fitted • Check that no oil is leaking • Inspect mattress and table for signs of wear • Replace any worn or damaged items

Function Checks	• Check essential movements before use • Check wheel brakes function and wheels rotate • Ensure all moving parts can move, applying grease if needed

Troubleshooting

	Fault	Possible causes	Solution
1	Table can NOT be relocated	Wheels jammed Electric motor not operational (electrically driven table)	Clean wheels, remove obstruction Check power to table Replace fuse if blown If problem persists, refer to technician
2	Table section or body can NOT be moved	Lock or lever is jammed No power to electric table No oil in hydraulic table	Clean jammed part, remove rust and dirt, lightly oil and replace Check correct switch is used Check power and fuses Refill hydraulic oil if needed Check no leakage occurs
3	Oil leakage from hydraulic table	Oil leakage Worn out gasket oil seals.	Locate leak and block it. Clear spillage. Refer to technician.
4	Electric shocks	Wiring fault	Refer to technician immediately

15) Lamps

Function

There are many kinds of sources of light used in medicine. This section deals with large lights for operating theatres or delivery suites, ultraviolet or infrared phototherapy units, ophthalmic slit lamps, handheld and head worn lamps for ENT clinics and domestic torches. However, the principles here will help in the maintenance of any kind of light source.

How it works

Each type of lamp will have a power source with switch and a bulb. Some will also have controls for the brightness or focus of the light, while others will also have lenses to direct the light where required. Some lights operate off mains electricity, while others use batteries instead. Some lights have both, using the batteries for back-up power in case of mains supply failure. Electric bulbs and batteries have limited life and will need regular checking. A stock of spares should be kept of all the correct voltages and wattages (ratings) of parts.

Maintenance Checklist

Care and Handling	• Unplug, clean outside of the lamp r with a damp cloth and dry off. • Clean and sterilize the lamp head handle
Visual Checks	• Check that all lamps are functioning. • Check that there are no cracks in glass / covers or liquid spillages • Tighten any loose screws and check parts are fitted

Function Checks	• Check that switches and focus knob operate correctly • Check working condition of moving parts

Troubleshooting

	Fault	Possible causes	Solution
1	No light or power on visible	No power at mains socket	Check power switch is on. Replace fuse. Check mains power.
		Dead battery	Charge or replace battery
		Blown bulb	Replace bulb with correct voltage and wattage
		Battery leakage	Remove batteries, clean battery terminals and replace with new battery
		Electrical cable fault	Try cable on another piece of equipment.
		Internal wiring fault	Refer to an Electrician
2	Fuse / bulb keeps blowing	Fuse or bulb is wrong rating	Replace with correct rating
		Power supply or cable fault	Refer to an electrician
3	Light can NOT be made bright enough	Dirt on lens or tube	Clean area with dry, clean cotton
		Poor power supply	Check power line or replace Batteries
		Wrong bulb rating	Check bulb rating is correct
		Control malfunction	Refer to an electrician
4	Electrical shocks	Wiring fault	Refer to an electrician

16) Anesthesia Machine

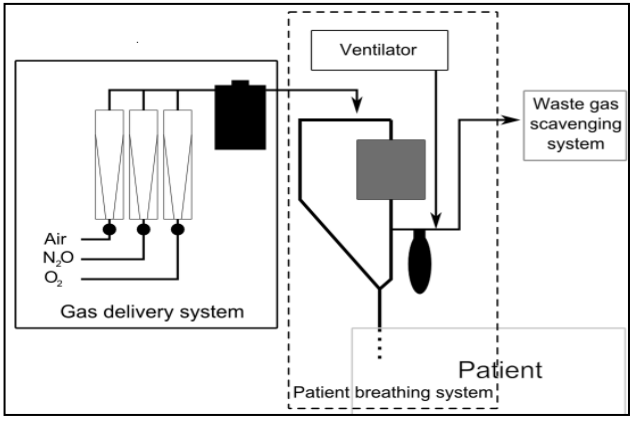
Function

The anesthesia machine is used to support the administration of anaesthesia. The most common type of anesthesia machine is the continuous-flow type, which is designed to provide an accurate and continuous supply of medical gases (such as oxygen and nitrous oxide), mixed with an accurate concentration of unaesthetic vapour (such as halothane or isoflurane), and deliver this to the patient at a safe pressure and flow. Modern machines incorporate ventilator, suction unit and patient monitoring devices.

How it works

Oxygen (O_2), nitrous oxide (N_2O) and sometimes air sources are connected to the machine. Through gas flowmeters (or rotameters), a controlled mixture of these gases along with anaesthetic vapour passes through a vaporizer and is delivered to the patient. Sometimes a ventilator is also connected with the machine for rebreathing thus making it a closed circuit. With ventilators or a re-breathing patient circuit, soda lime canisters are used to absorb the exhaled carbon dioxide and fresh gases are added to the circuit for reuse. Pressure gauges are installed on the anaesthesia machine to monitor gas pressure. Generally, 25% (or 21%) oxygen is always kept in the circuit (delivered to patient) as a safety feature. The device which ensures this minimum oxygen in the circuit is called a hypoxic guard. Some basic machines do not have this feature, but have a nitrous lock which stops the delivery of N_2O in absence of O_2 pressure.

Machines give various alarms to alert operators.



Maintenance Checklist

Care and Handling	• Remove water and waste matter from inside • Clean inside and outside with a damp cloth and dry off
Audio–Visual checks	• If any leak is audible, check with soapy solution • Check all seals, connectors, adapters and parts are tight • Check all moving parts move freely, all holes are unblocked • Check connections for leakage with soap solution & dry off • Check all fittings for proper assembly • Replace soda lime if it has turned blue • Replace any deteriorated hoses and tubing • If seal, plug, cable or socket are damaged, replace
Function Checks	• After use, depressurize system and replace all caps / covers • Before use, check pressure gauges rise and there are no leaks

Troubleshooting

	Fault	Possible causes	Solution
1	Equipment NOT running	No power at mains socket Electric cable fault	Check power switch is on. Replace fuse. Check mains power is present at socket using equipment known to be working. Rewiring if power not present.
2	No Gas output	No O_2 pressure in cylinder / gas supply Check pressure gauges (4 bar or 4 kg/cm2)	Restore gas supply or replace gas cylinders Replace O_2 cylinder and/or N_2O cylinder in case of low pressure.
3	O_2 failure alarm NOT working	Alarm battery is low. Alarm device is not working	Check alarm setting range, alarm on/off, alarm lamp blow out
4	Machine has leaks	Poor seal(commonly occurring around tubing connections, flow valves and O_2/N_2O yokes)Cylinders not seated properly	Clean leaking seal or gasket, replace if broken. Refit cylinders in yokes and retest. If leaks remain, repair by technician.
5	Flow meter fault	Over tightening of the needle valve or sticking of the float / ball	Repair by technician or outsourcing service
6	Electrical shocks	Wiring fault	Rewiring/repair by electrician immediately

17) Infant Incubator

Function

Infant incubators are classified into closed type and open type. An infant incubator is intended to hold a neonate born prematurely or with some disabilities for life support. The closed type of incubator is applied in the case of treatment of neonate jaundice. The open type is often used to facilitate the surgical treatment for neonates who have undergone surgical operation. Humans feature excellent homeostasis of body temperatures. Since homeostasis of neonates is lower, keeping of the body temperature is essential for the neonates. Premature and impaired neonates have further lower homeostasis and thus incubators are indispensable for sustaining their life.

How it works

In practice, incubators cannot be applied in the environment where the outside air temperature exceeds the body temperature. To keep a certain temperature, every incubator is furnished with a heater and a fan motor for air circulation. For the motor, hour meter management is essential.

Note: The hood in the closed type incubators is often made of acrylic material, therefore alcohol and strong chemical agents should not be applied to the hood.

Maintenance Checklist

Cleaning	• Unplug, clean outside with damp cloth and dry off • Clean the access ports and temperature sensor • Wash/replace the air filters, dry thoroughly for reuse • Disinfect water chamber of humidifier
Visual Checks	• Check all fittings and accessories are mounted correctly • Check mains cable has no bare wire and is not damaged • Check doors, cable and tray. Repair if damaged

Function Checks	• Drain off the water tray. Run machine for 30 minutes to dry the tray. Refill tray with sterile water before use. • Check all controls operate correctly • Check the readings of thermometer and oxygen sensors change when breathed upon • Check that batteries are working properly.

Troubleshooting

	Fault	Possible causes	Solution
1	Incubator is NOT running	No power from mains socket Electrical cable fault	Check power switch is on. Replace fuse. Check mains power. Try cable on another piece of equipment. Repair by electrician, if required.
2	Fuse keeps blowing	Power supply or cable fault	Check the Manual and troubleshoot properly
3	Alarms NOT working	Alarm battery dead. Alarm off setting	Replace the battery and recheck. Check alarm setting.
4	Temperature NOT properly controlled	Temperature probe and sensor not working Incubator placed indirect sunlight or near a fan. Fan or air duct problem	Check the temperature probes and sensor connections. Replace the temperature probe or sensor, if required. Move incubator if placed near heat or draught Unblock air duct if obstructed.
5	Incubator NOT heating even when the heater lamp is on.	Heating element problem	If accessible, replace heating element.

18) Infant Warmer

Function

An infant warmer system provides a controlled source of radiant heat for infants and pediatric patients.

How it works

The heater assembly consists of a radiant heater controlled by electronic circuits. A probe is used to monitor the patient's skin temperature. The patient's skin temperature is continuously displayed. Alarms activate to alert the operator of a low or high patient temperature, a skin temperature probe failure, a power failure, equipment failure or a check patient prompt.

Maintenance Checklist

Care and Handling	• Clean the warmer at least once a week or after each patient. • The mattress, X-ray tray, bed and side panels may be cleaned without immersing by using a disinfecting agent safe for use on the materials.
Visual Checks	• For units with casters, check that all casters are in firm contact with the floor and that the warmer is stable and moves freely. • Examine the unit for objects placed on top of the heater assembly.
Function Checks	• Check that all accessories are mounted securely and that the load limits are not exceeded. • Connect the warmer to power source and verify the operation of the control panel. • Check operation of phototherapy warning light.

Troubleshooting

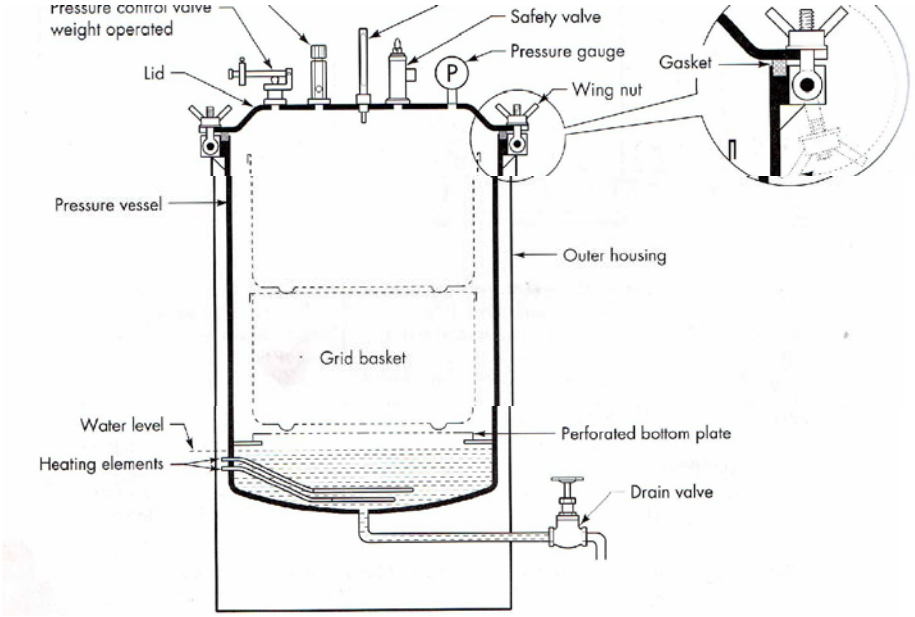
	Fault	Possible causes	Solution
1	Alarm sounding and manual indicator flashing.	Software has detected a fault	Use information mode to obtain error code.
2	Manual indicator flashing accompanied by monotone alarm.	Thermal cut out in head has switched open circuit due to overheating.	Reset thermal cut- out and identify cause.
3	Manual indicator flashing accompanied by rapid pulsing two tone alarm.	Fault in the control or power board.	Replace defective PCB.
4	Power failure	Power switch is off, internal fuses, mains lead and internal harnesses defective.	Switch on power, replace fuse, defective part or PCB.
5	Wrong Skin temperature reading	Skin sensor is damaged, not inserted fully or not the right type.	Replace skin sensor.
6	Unable to provide stable control of skin temperature when in baby/patient mode	Skin sensor is poorly attached to patient or heat path between patient and element is disrupted. Alarm is sounding and mute button is not being pressed.	Attach skin sensor in the correct position and ensure there is no heat path disturbance. Press mute when warmer alarms. This ensures heat is restored to the patient.

19) Autoclaves

Function

Sterilization is the killing of micro-organisms that could harm patients. It can be done by flame or (steam, air, flame or boiling) or by chemical means. Autoclaves use high pressure steam and Sterilizers use boiling water mixed with chemicals to achieve this. Materials are placed inside the unit for a carefully specified length of time. Autoclaves achieve better sterilization than boiling water sterilizers.

Heat is delivered to water either by electricity or flame. This generates high temperature within the chamber. The autoclave also contains high pressure when in use, hence the need for pressure control valves and safety valves. Users must be careful to check how long items need to be kept at the temperature reached.



Maintenance Checklist

Care and Handling	• Remove water and waste matter from inside • Clean outside of equipment and power cord • Drain water reservoir and clean inside of reservoir using vinegar solution
Visual Checks	• Check all screws, connectors& parts are tightly fitted • Check all moving parts move freely • Check internal heating element connections are tight • Replace heating element if covered with lime scale • If plug, cable or socket are damaged, replace • Take care not to damage heater and sensors
Function Checks	• Inspect for defects e.g. cracks, severe pits in the chamber, kinks on tubes. All wires. • Clean and inspect water level sensor, door gasket • Test &inspect all valves e.g. fill, vent, air, repair or replace as needed • Check for leaks during operation • Check for operation of pressure gauges, temp. gauges, LED displays, LCD, and indicator lamps • Leakage current meets the safety standards • Earth lead is tightly secured to equipment

Troubleshooting

	Fault	Possible causes	Solution
1	Equipment NOT heating	No power at mains socket Electric cable fault Damaged heating element	Check power switch is on. Replace fuse. Check mains power socket is working. Rewiring if power not present. Try cable on another piece of equipment. Replace if broken
2	Pressure rises above the marked level	Blocked valve	Clean the pressure regulating valve, safety valve. Pressure vessel may be over filled Retest autoclave under pressure with water only.
3	Steam is constantly escaping	Poor seal	Clean leaky valve and hole, replace if defective. Clean leaking seal or gasket, replace if broken.
4	Electric shocks	Wiring fault	Rewiring/repair by electrician immediately

20) Hot Air Oven

Function

Hot Air Ovens have several functions depending on the set temperature.

In the Laboratory, they can incubate specimens as well as drying slides if set at low temperatures.

Sterilization of water sensitive items like powders, Vaseline, glassware as well as metallic instruments is possible at higher temperatures

How it works

Ovens are basically insulated enclosures in a metal box. They are electrically heated with an air circulating fan. A Thermostat up to 300 centigrade is fitted. A ventilation hole, a timer and a thermometer are also fitted. For the Lab, the thermometer controls the required temperature, with the ventilation hole open to allow steam escape.

During sterilization, the temperature is set high for a longer time to allow complete destruction of bacteria.

Maintenance Checklist

Care and Handling	• Disconnect from power supply prior to cleaning • Clean the exterior case and interior chamber with a moist cleaning cloth • Dry the equipment thoroughly • Remove shelves and immerse in water and clean completely, and then dry shelves thoroughly Never use benzene or paint thinner for cleaning
Visual checks	• Use a properly grounded electrical outlet • Ensure that outside of unit and power cord are clean and not damaged • Ensure that internal chamber is clean

	• Ensure that the Heater element, air inlets, vent outlets, control enclosures, door latches and hinges are clean
Function Checks	• Check that Temperature control sensor is not damaged • Check that circuit breakers & switches are operational • Check predetermined setting and temperatures • Significantly higher temperature could indicate temperature controller is failing

Troubleshooting

	Fault	Possible causes	Solution
1	Erratic temperature	Defective circuit board Dirty sensor	Repair or replace new one Clean the sensor
2	Can NOT heat	Defective circuit board Burnout heater Defective triac Air leakage	Replace new one Replace heater Replace triac Lock door completely or replace door gasket
3	Can NOT power up	Disconnected linkage Mal-functional switch Burnout heater Blew fuse	Connect linkage completely Replace switch Replace heater Replace fuse
4	Failure set temperature	Defective circuit board	Repair or replace new one
5	Unacceptable uniformity	Defective fan	Repair or replace fan or adjust the air vents
6	Temperature fluctuated	Dirty sensor, Burnout electronic parts Defective circuit board	Clean sensor Repair or replace parts Repair or replace circuit board

21) Disinfector/ Boiler

Function

Disinfection kills and reduces some microorganisms but not the resistant bacterial spores. A boiler is used to disinfect medical objects that come in contact with intact skin but not mucous membranes (none critical items). Examples of these items are; suction tubes, dishes and some instruments. Boilers can be electrically operated or non-electric (external heat source).

How it works

It has different parts that help it perform its work effectively. They include; chamber, cover with handle, equipment tray with handles, heating elements, electrical cable (electrical boiler), drain tap, thermal switch (for safety), thermostat (temperature control) and rubber stands. Items to be disinfected first undergo a process of washing, cleaning and rinsing.

Clean items are then immersed into equipment tray, dipped in and properly covered under water and closed. Heat is introduced and water is left to boil at 100 degrees centigrade for twenty (20) minutes before it is switched off. The equipment tray is removed and water is drained out to allow for a fresh procedure to take place.

Maintenance Checklist

Care and Handling	• After every use, wash and clean with vim. • Scrub scale lime deposits and wash with vim. • Change water every after use. • Clean and dry boiler when not in use.
Visual checks	• Check for scaling on element and chamber. • Check for loose nuts on cover and drain tap. Check firmness of electrical connections of top plug and socket.

Function Checks	• Use trouble shooting guide (step by step approach). • Ensure thermostat operates and element heats. • Ensure switches are functional. • Check functionality before next use.

Troubleshooting

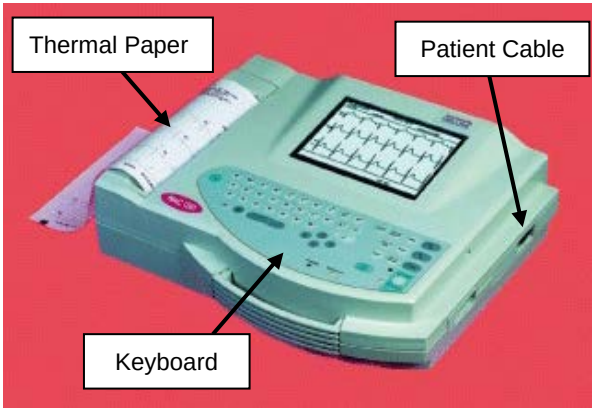
	Fault	Possible causes	Solution
1	Equipment NOT heating	No power at mains socket. Fault on electric cable. Heating element blown. Thermal safety switch tripped.	Replace fuse. Replace power cable. Replace heating element. Reset circuit breaker, switch on mains. Reset safety switch.
2	Water takes long to boil	One element faulty (for more than one element). Scale deposits on the element. Thermostat wrongly set.	Check one of the elements, replace. Remove scale deposits. Adjust thermostat setting.
3	Heating elements keep blowing frequently.	Much scale deposits. Little water in the chamber. Faulty safety switch. Faulty thermostat	De-scale heating element. Always put enough water/user train. Replace safety switch. Replace thermostat.
4	Much steam escapes.	Lid/cover does not close well. Drain valve does not close well. Many items in the boiler chamber	Tighten loose nuts and replace missing ones. Replace drain valve. Reduce on the items/ train user.

22) ECG (Electrocardiogram) Machine

ECG machines are used to monitor the electrical activity of the heart and display it on a small screen or record it on a piece of paper. The recordings are used to diagnose the condition of the heart muscle and its nerve system.

The electrical activity is picked up by means of electrodes placed on the skin. The signal is amplified, processed if necessary and then ECG tracings displayed and printed. Some ECG machines also provide preliminary interpretation of ECG recordings. There are 12 different types of recording displayed depending upon the points from where the recordings are taken

Care must be taken to make the electrode sites clean of dirt before applying electrode jelly. Most problems occur with the patient cables or electrodes.



Maintenance Checklist

Care and Handling	• Clean the Printing head • Clean body of equipment with a damp cloth and dry off
Visual Checks	• Check that battery charge indicator, power indicator and patient cable connector indicators are working • Check that cables are not bent, knotted or damaged • Replace any damaged electrical plugs, sockets or cables

	• Check all knobs, switches and indicators are tightly fitted
Function Checks	• Calibrate machine before use using 1mV pulse • Check that the baseline of the ECG recording is steady • Check the calibration of recordings with ECG a simulator • Check battery power can operate the equipment

Troubleshooting

	Fault	Possible causes	Solution
1	ECG traces have artifacts or base line drift	Improper grounding Patient is tensed up Deep breathing	Try with battery power only. If the recording improves then problem is with grounding. Power the machine from another outlet with proper electrical ground. Relax the patient
2	ECG traces have artifacts in one or more traces, but NOT in all traces	Improper electrode connection with patient or problem with the ECG cable	Check the patient cable. Replace cable if found faulty. Check the electrodes expiration. Check patient skin preparation Check limb electrodes and chest electrodes for damage
3	Paper feed NOT advancing	Incorrect paper loading	Use instructions to reload paper
4	Printing NOT clear or NOT uniform	Printing head problem	Adjust the printing head temperature or position Clean the printing head with head cleaner. If it does not improve, replace printing head. Check the paper roller and replace if not smooth
5	The machine shuts down after a few minutes while on battery power	Problem with battery or charging circuit	Recharge the unit overnight If there is no improvement then replace the battery. If there is still no improvement, refer to a Technician

23) Pulse Oximeter

Function

A pulse oximeter is a device that non-invasively monitors the oxygen saturation of a patient's blood. It measures the amount of oxygen in a patient's arterial blood during operations and diagnosis. This level of oxygen or oxygen saturation is often referred to SpO_2, measured in %, and this is displayed on the pulse oximeter. A pulse oximeter also displays pulse rate.

How it works

The coloured substance in blood, haemoglobin, is a carrier of oxygen and the absorption of light by haemoglobin varies with the amount of oxygenation. Two different kinds of light (one visible, one invisible) are directed through the skin from one side of a probe, and the amount transmitted is measured on the other side. The machine converts the ratio of transmission of the two kinds of light into a % oxygenation. Pulse oximeter probes can be mounted on the finger or ear lobe.

Maintenance Checklist

Care and Handling	• Clean the probe with alcohol wipe after each use • Unplug, clean outside with a damp cloth and dry off
Visual Checks	• Check that all parts are present and connected • Check that cables are not twisted and remove from service if any damage is visible • Tighten any loose parts • If plug, cable or socket are damaged, replace
Function Checks	• Check operation of all lights, indicators and visual displays • Check probe disconnection alarm.

Troubleshooting

	Fault	Possible causes	Solution
1	Equipment is NOT running	No power from mains socket Battery (if present) is discharged Electrical cable fault	Check power switch is on. Replace fuse. Check mains power is present at socket using equipment known to be working. Recharge or replace battery Try cable on another piece of equipment.
2	SpO_2 or pulse rate NOT displayed or unstable	Probe is not mounted correctly Probe not able to read through dirt, nail polish, etc. Patient movement Patient's SpO_2 value is too low to be measured	Connect probe and cable properly Remove grease, dirt, nail polish and clean probe Request patient to remain still Further clinical examination of patient. Recite probe if necessary
3	Probe off displayed on screen	Probe is not connected properly The connection between the probe and oximeter is loose	Connect the sensor Exchange cable
4	"Error "displayed on screen	Faulty probe or control circuit	Refer to user manual and troubleshoot by technician
5	Continuous alarm sounds	Alarm limits set too low or high Power disconnected	Set appropriate alarm limits Connect power cable

24) Slit Lamp

Function

A slit Lamp is used for observing the patient's eye.
The eyelid and anterior segment (cornea, iris, ciliary body, anterior chamber, posterior chamber, crystalline lens, lens, zinn's zonule, anterior vitreous, anterior sclera) is observed in the low magnification.

Posterior segment (posterior sclera, retina, choroid, posterior sclera) is observed in high magnification with Ruby lens.

How it works

By changing the slit width control knob or turning the aperture and slit length control wheel, ideal slit width, slit length and spot size can be achieved.

By turning the illumination unit or operating slit rotation control ring, the desired position of the slit image can be obtained.

Before use, diopter compensation and interpupillary distance adjustments are married out. A focusing test rod is used to establish the proper microscope setting for each use. The test rod is inserted in the hole in chin-rest with the flat surface at the top of test rod facing the microscope.

Maintenance Checklist

Care and Handling	• Remove dust from the mirror and eye piece lens using camel hair brush. Finger marks can be removed if necessary with minimum isopropyl alcohol and a cotton swab. Dry with a facial tissue. • Clean exterior surfaces especially the joystick glide plate by wiping with a soft, dry cloth. Do not use commercial or household cleaners.
Visual checks	• If the glass envelope is blackening, replace the Halogen lamp. .
Function Checks	• Slit width control adjustment – loosen or tighten the small screw at the center of the control to change the amount of force required to turn the knob. Should be tight enough to ensure that the slit does not close spontaneously. • Check the applanation tonometer at 0 g, 2 g and 6 g positions. • See the cone prism through left eyepiece and check whether cone prism is located at the center. If not, adjust the cone position of vertical and horizontal direction. • Slit lamp blades should close without overlapping and open with parallel edges.

Troubleshooting

	Fault	Possible causes	Solution
1	No illumination.	Power cable, switch, fuse, bulb socket or bulb is damaged.	Check and replace damaged part.
2	Slit light is too dim	Bulb is not correctly inserted or Voltage selector setting is incorrect.	Insert bulb correctly, set Voltage selector to the correct position.

25) Centrifuge

Function

Centrifuges are used to fasten the sedimentation of substances in liquids. In medical laboratories specimen may be blood, urine etc. In the centrifuge, test tubes containing specimen are placed into buckets which are then rotated at high speeds or RPM (rotations per minute) for a pre-determined time. The substances in the test tubes are deposited in the order of weight, the heaviest element being the first to settle.

How it works

The brackets holding the buckets are coupled to the shaft of a motor which then rotates the shaft. The motor is normally a universal one with a variable speed mechanism. A timer is also incorporated in the circuit which cuts out power to the motor after a pre-set time by the user elapses. The two parameters being variable make it possible for various time/speed combinations to be applied to a varied range of specimen.

A safety feature is incorporated by the use of door switches. The switch completes the circuit only when the lid is closed to protect fingers from injuries that can be caused by the fast spinning head of the centrifuge.

Some larger centrifuges are equipped with an electrical or mechanical braking system for halting rotation'

Magnetic door locks in conjunction with centrifugal switches ensure that the lid cannot be opened as long as the head is rotating.

Maintenance Checklist

Care and Handling	• Clean the interior of the bowl with disinfectant daily.
Three monthly checks	• Check mountings and replace if necessary • Check for loose bolts and tighten • Check brushes and replace if necessary • Check for corrosion and repaint if necessary • Clean commutator with smooth sand paper

Troubleshooting

	Fault	Possible causes	Solution
1	Powers up but does NOT spin	• Worn out brushes • Dirty commutator	Replace batteries Clean with smooth sand paper and contact spray
		• Check power supply and fuses	Rectify accordingly
2	Noisy vibration	• Imbalance by missing buckets • Worn out bearings	Ensure all buckets are in place Check and replace
3	Speed variation NOT responding	• Check the variable • Resistor contacts	Clean or replace

26) Microscope

Function

Microscopes are indispensable in medical laboratories. They enable the investigation of specimen (blood, urine etc.) for the presence of parasites or other abnormalities.
The microscope is able to achieve this by producing magnified images of specimen examined through it by means of multiple lens arrangement.

How it works

A microscope consists of two lenses (the objective and the eye piece) and a light source with a condenser. Rays from a light source are directed into a condenser which then brings them to a common focus on the specimen. The light rays then pass through the objective and produce a primary image in the focal plane of the eye piece. The eye piece magnifies the primary image and brings it into focus with the retina of the eye.
The objective and eye piece are systems of lenses where the distance from each other is fixed by the mechanical length of the tube. To adjust to form a clear image, either the specimen stage or tube as a whole has to be moved by means of coarse and fine adjustment drives.

The light source of a microscope can be either natural or artificial light.

Maintenance Checklist

Storage	• Should be kept in a dry room at temperature between 5°C to 35°C After use cover it with dust covers
Care and Handling	• Dust can be brushed off with a small paint bush • Clean dirty lenses with lens tissue or soft clean cloth. Breathe on the lens before wiping it. • If the pollution of the lenses is heavy use 2 to 3 drops of xylene on tissue paper • Check all cleaned lenses with a magnifier (inverted eye piece) • Clean oil immersion objective immediately after use with absorbent paper • Clean the body and housing with a soft cloth • Apply petroleum jelly on the rack and pinion when required

Troubleshooting

	Fault	Possible causes	Solution
1	Light source bulb NOT lighting	• Check the bulb • Intensity knob stuck on minimum	Replace if blown Check the knob and rod assembly and clean
		• Check the light circuit fuses	Replace if blown
		• Check the integrity of the transformer	Replace if defective
2	Descending stage	Loose or dirty pinion and rack	Clean, lubricate and tighten the rack
		Check bearings between the stage and limb	Clean and lubricate

27) Laboratory Incubator

Function

Incubator is a device used to grow and maintain microbiological cultures or cell cultures. The incubator maintains optimal temperature, humidity and other conditions such as the carbon dioxide (CO_2) and oxygen content of the atmosphere inside.

The scope of usage of Incubators may vary but the basic requirement of incubator is to provide a controlled temperature environment.

How it works

Laboratory incubators consist of a chamber, heat source, a resettable thermostat and a thermometer. Heat generated is controlled by the thermostat to a desired temperature that is set by the user. The thermometer displays the temperature in the chamber.

Maintenance Checklist

Care and Handling	• Use a smooth cloth soaked in water to clean the surface of the equipment. • Disinfect the machine with an appropriate disinfection solution e.g. Hypochlorite (JIK)
Visual checks	• Make sure the equipment shows no error messages on the controls. • Check whether the door locks properly.
Function Checks	• Check whether the whole system functions before use (e.g. temperature control and display, power supply).

Troubleshooting

	Fault	Possible causes	Solution
1	No display on control panel	No power	The power cord is loose in the socket outlet. Check the outlet for power. Check the circuit breaker on the power panel. In case of tripping, reset it.

			Check that the main power switch on the incubator is turned on. Check for any blown fuses.
2	High temperature alarm flushes	Faulty thermostat	Check if temperature probe is well connected Check whether the thermostat is able to switch on and off
3	Oxidation forming on the interior surfaces	Use of high concentrated detergent.	Clean the interior surface with soft water
4	Temperature display is drifting	Location effect	Check the incubator location.
5	Inside temperature is NOT equal to the display temperature.	Needs calibration Location effect	Verify the calibration procedure. Check the location of the incubator.
6	Temperature NOT controlling at set point	Fault with set point Chambers circulated with cold air	Check the set point Close the doors for a minimum of 30–40 minutes
7	Display on but NO temperature rise	Fault on the Thermostat Fault on the Element	Check thermostat whether it's okay if not replace Check element, if blown replace
8	Temperatures take long to reach the set temperature	Faulty door system	Check the gasket, if damaged replace.

28) Colorimeter

Function

A colorimeter is used to measure the concentration of a substance in the patient's sample by comparing the amount of light it absorbs with that absorbed by a standard sample that contains a known amount of the substance being tested.

A coloured solution of the substance being measured or a coloured derivative of it is produced. Coloured solutions absorb light at given wavelengths in the visible spectrum.

How it works

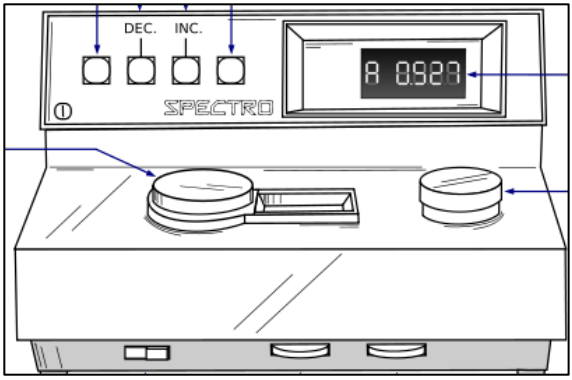
The essential parts of a colorimeter are a light source, an adjustable aperture, colored filters, a cuvette holder, a detector and a data display.

Colored filters are used to select the required wavelength. The usual wavelength range is from 400 to 700 nanometers (nm).

A cuvette which obtains light path of 10 mm size is recommended.

The data display indicates the results as transmittance (a linear scale from 0–100%) or as absorbance (a logarithmic scale from zero to infinity).

To prolong the life of the lamp, switch off the device after use and disconnect from the mains socket at the end of each day.



Maintenance Checklist

Care and Handling	• Clean the equipment with a soft cloth soaked in a mild disinfection reagent • Clean the cuvette holder
Visual checks	• Check the functionality of the bulbs. • Check that there is no mechanical damage • Check that the cuvette is free of scratches and finger marks
Function Checks	• Switch ON/OFF and change the filters smoothly • Check that the correct type of cuvette is in use • Check that the display is functional when switched ON

Troubleshooting

	Fault	Possible causes	Solution
1	The machine does NOT get power	Faulty power out let socket Power cord loosely connected Blown fuses	Check the power socket, if faulty, replace. Fix the power cord. Replace fuses of the same rating.
2	The machine powers but no light	Blown bulb	Replace the bulb of the same rating.
3	The machine is NOT zeroing	Machine is due for calibration Dust accumulation on the light filter	Carry out calibration with a standard medium Clean the filters.

29) Haematology Analyzer

Function

A Haematology analyzer is an automatic multi parameter blood cell counter for in vitro diagnostic use in clinical laboratories. It performs speedy and accurate analysis of parameters in blood and detects the abnormal samples. The instrument displays abnormal analysis data with abnormal marks attached on the LCD screen. Displayed analysis data allows detecting those samples which are outside the tolerance and need further analysis and consideration. Whole blood and pre-diluted blood can be analyzed.

How it works

The white blood cell (WBC) count is measured by the WBC detector block using DC detection method. The red blood cell (RBC) count and platelets are taken by the RBC detector block, also using the DC detection method. The HGB detector block measures the hemoglobin concentration using the non-cyanide hemoglobin method.

Maintenance Checklist

Caring and Handling	• Clean the transducer (TD) chamber and diluted sample line daily(Execute shut down). • Clean the sample rotary valve (SRV) tray weekly. • Clean the waste chamber (rinse sequence) monthly or after every 2500 samples. • Clean the transducer (rinse sequence) monthly or after every 2500 samples. • Clean the sample rotary valve (SRV) every 3 months or after 7500 samples. *SRV* life time is 5 years • Clean the rinse cup as needed. • Clean the WBC/RBC transducer aperture as needed.

Visual checks	• Check trap chamber level daily and discard if necessary. • Auto rinse as needed. • Replace the waste tank as needed.
Function Checks	• Perform a reagent replacement sequence • Auto rinse with background check sequence • Check settings sub-menu for system set up • Perform the waste chamber cleaning sequence • Perform the transducer cleaning sequence • Perform transducer fluid draining sequence (for clog removal) • Check status display 1. Hemoglobin (HGB) convert (real time) 2. Pressure and Vacuum (real time) 3. Unit operation counter • Check paper feed (optional built-in printer)

Troubleshooting

	Fault	Possible causes	Solution
1	Alarm sounds and an error message is displayed.	Pressure or vacuum, is outside range. Air bubbles in the system. Clogging in transducer aperture(s)	Press [HELP] key on keyboard to stop the alarm and change over to the HELP screen that shows what actions to take against the error.

30) CD4 Counter, Flow Cytometer Type

Function

CD4 counter uses flow Cytometry technology that simultaneously measures/counts and analyses multiple characteristics of single cells or particles such as CD4 (One of the lymphocyte).The CD4 count data provides important information for staging and monitoring patients infected with HIV/AIDS. The software provides an automated analysis without operator's intervention. The normal CD4 count is 1,000 cells /mm3 and this count is lower for HIV infected patients.

How it works

The tissue sample is broken up into single cells and held in a test tube, which is placed into the flow cytometer. The liquid containing the cells is drawn up from the test tube and pumped to the flow chamber (flow cell). Cells flow through the flow chamber one at a time very quickly and are presented to one or more light sources (Lasers).

A small laser beam of very bright light hits the cells as they pass through the flow chamber. The pattern of light scattering is dependent on cell size and shape giving relative measurements of these cellular morphological characteristics as cells flow through the beam. Forward scatter measures light scattered in the direction of the laser path and measures the size of the cell. Side scatter measures scattered light at 90 degrees to the laser path and measures the cell granularity.

The light detector processes the light signals and sends the information to the computer. Each type of cell in the immune system has a unique combination of forward and side scatter measurements, allowing count of number of each type of cell.

Filters are used to direct the light emitted by the fluorochromes to the colour detectors. The fluorochromes attached to the cells absorb light and then emit a specific colour of light depending

on the type of fluorochrome. The colour detectors (PMT's) collect the different colours of light emitted by the fluorochromes. The electronics in the cytometer amplify and process the resulting data. They convert analogue data to digital data which is stored in the computer.

This data from the light detector and the colour detectors is analysed from the computer and plotted on histograms.

Maintenance Checklist

Care and Handling	• Unplug, clean external surfaces with a damp cloth with cleaning solution containing alcohol for example 70% ethanol, Deionized water and wipe surfaces with a clean, dry cloth
Visual checks	• Check that all parts are there and correctly fitted • Check that the mains cable has no damage and if damaged replace • Check that the air filter is free of dust and if clogged wash clean with water, dry and reinstall or replace • Check the level of sheath fluid in the reservoir • Check the level of waste in waste reservoir , dispose of if necessary
Function Checks	• Check photo multiplier tube (PMT) voltage adjustment • Check time – delay calibration • Check fluorescence compensation adjustment • Carry out sensitivity testing

Troubleshooting

	Fault	Possible causes	Solution
1	Flow cell NOT filling	No sheath pressure	Check for leaks or cracks in the sheath reservoir. Replace it, if needed. Tighten the sheath cap. Verify the vent valve is in forward
2	No events displayed and status = READY	Communication failure between computer and instrument.	Turn off the computer and instrument; Turn on the instrument, then the computer.
3	No events displayed and status = READY	No sample in the sampler tube	Add sample or install new sample tube
4	Scatter parameters distorted	Air bubble in flow cell Incorrect instrument settings	Prime the fluidics Press PRIME Rerun BD FACSComp
5	Time –delay calibration fails	Empty sheath reservoir. Air in sheath filter Air bubble in the flow cell	Fill the sheath reservoir Vent air from the sheath filter Prime the fluidics
6	Sample tube NOT pressurizing	Fluid mode not in RUN Cracked sample tube Worn Loader seal	Press RUN Replace the sample tube Replace the seal

31) Dental Unit and Dental Chair

Function

Dental unit is intended for diagnostic and therapeutic treatment of dental patients by dentists or health care professionals. Generally, a dental chair refers to the chair for patients while the dental unit consists of the chair, treatment hand pieces, a doctor's table, a light and a cuspidor unit.

How it works

1. Turn the Master ON/OFF toggle to the "ON" position.
2. The hand pieces are automatically activated when removed from their hanger.
3. Depress the Foot Control to operate the activated hand piece. Pressure is shown on the gauge for the hand piece being used.
4. To adjust the pressure to each hand piece, turn the adjustment screw clockwise to decrease pressure or counter-clockwise to increase pressure.
   CAUTION: When adjusting the hand piece pressure, do not over-tighten the screws.
5. To activate water spray, turn the water ON/OFF Toggle to the "ON" position. Flow adjustment to the "wet" hand pieces is controlled by the controls labeled "Flow Control".
6. To release the air of the unit arm, activate the momentary toggle valve and adjust the height of the flex arm to desired position. When desired position is achieved, release the momentary toggle switch to lock the height of the flex arm.
   CAUTION: Do not attempt to adjust the height of the flex are without releasing the air-brake valve. Failure to release the air-brake valve may cause damage.

Maintenance Checklist

Cleaning [Daily]	• Purge the unit with air • Remove hand pieces from the tubing. • Empty the water bottle, then reinstall it (if water bottle is applicable, when using city water, turn off water from the source) • Hold the hand piece tubing and syringe over a pail. Turn the unit on, wait a few moment and then operate the flush toggle, syringe and foot control unit water is purged form the system • Turn unit off • Disinfecting the bottle; Fill the bottle with 100ml disinfectant solution (9 parts tap water & 1 part 5.25% Sodium hypochlorite/ household bleach), shake vigorously and let settle for 10 minutes. Shake again and then rinse twice with water.
Cleaning [Weekly]	• Purge the unit with air • Flush the system with disinfectant solution a. Turn unit off. Empty the water bottle, replacing the water with cleaning solution b. Remove hand pieces from tubing and hold the hand piece tubing and syringe over a pail. c. Turn unit on, wait a few moments and then operate the flush toggle, syringe and foot control unit a continuous stream of solution is running through the system • Allow the disinfectant to remain in the unit for at least 10 to 20 minutes and then flush the system again unit all the solution is used up. • Purge the unit with air; a. Hold the hand piece tubing and syringe over a pail. Turn the unit on, with a few moments and then operate flush toggle, syringe and foot control unit all solution is purged from the system. b. Turn unit off. • Fill with clean water • Turned unit off, remove the empty disinfectant bottle. Replace with clean bottle and water.

	• Disinfectant solution; Use 100ml of disinfectant solution.
Visual checks	• When the compressor is OK, we expect lighting system to be OK.
Function Checks	When the power is on you check • Hand pieces, Air compressor, Foot switch • Check knobs are operational

Troubleshooting

	Fault	Possible causes
1	Hand piece lacks Power	Check regulator adjustment (80psi) Check hand piece pressure adjustment on control block Pinched supply Bad hand piece gasket at connection with tubing Defective hand piece
2	Water coolant does NOT shut off when foot switch is released	Adjust air pressure to 80psi – Water pressure to 40psi Foot control is not exhausting Defective water relay in valve
3	More than one hand piece is operating	Hand piece is not completely in the hanger Improve adjustment of pilot valve in the hanger. Kinked or pinched signal line from the pilot valve.
4	Insufficient water coolant	Adjust coolant flow valve Water filter may be plugged Plugged hand piece Kinked or pinched tubing Improper adjustment of water relay
5	Water coolant is running from hand piece while in holder	Water pressure is too high Air pressure is too low Hand piece holder out of adjustment
6	Water coolant is running continuously	Purge switch is on Water pressure is too high Hand piece holder out of adjustment Improper adjustment of water relay

32) Solar Photovoltaic (PV) System

Function

Solar PV systems generate electricity to operate recommended appliances (e.g. lamps for lighting, ultrasound scanner, oxygen concentrator, suction machine, computer, etc.)

How it works

A solar PV system uses sunlight to generate electricity.. A solar PV system consists of the following main components:

Solar panel/module:

- It receives sunlight and converts it into electricity to charge the battery.

Charge controller (Regulator):

- It controls battery charging and discharging.
- It prevents overcharge (too much current into the battery) of the battery by automatically disconnecting the solar panels when the battery is fully charged.
- It disconnects loads to prevent battery discharge (draining of the battery) beyond safe levels.

Battery:

- It stores electricity generated by the solar panels for use when required..

Inverter:

- It converts the direct current (DC) from the battery into alternating current (AC) and supplies it to operate AC appliances.

AC and DC loads (Appliances):

- These are the AC and DC loads that use electricity.

Other Accessories (Distribution board, Circuit breakers, Cables):

- These are used to interconnect, control and protect different components against damage.

Maintenance Checklist

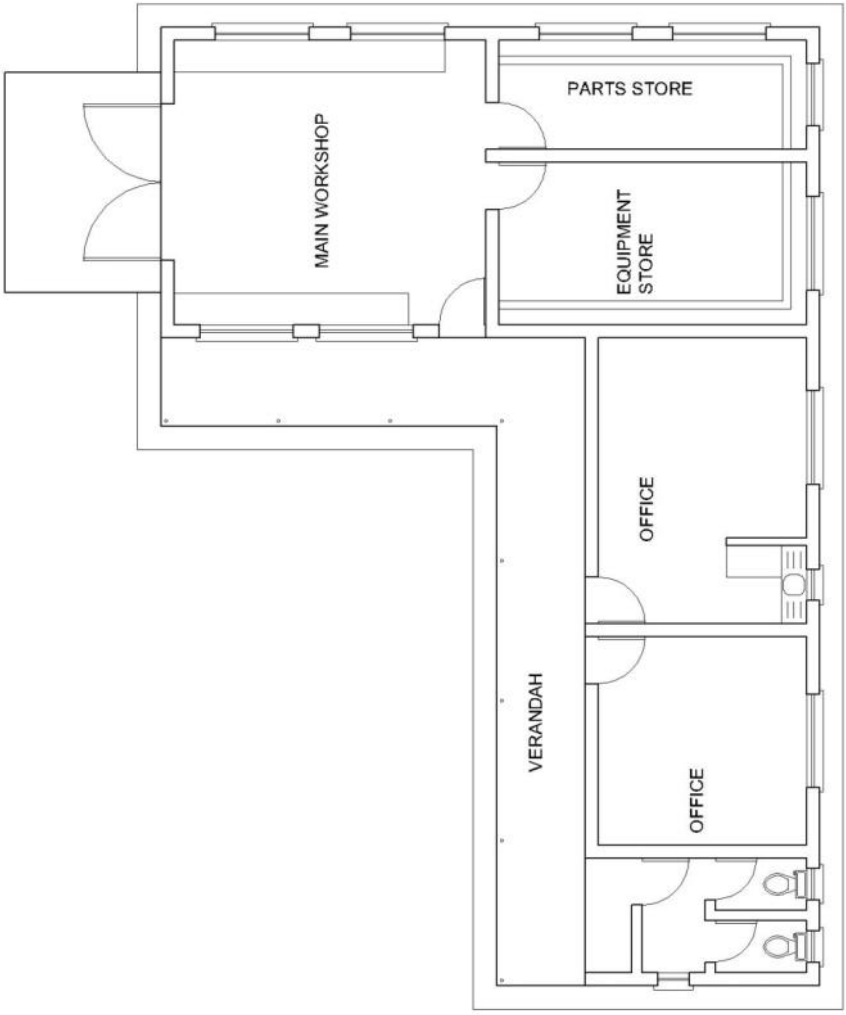
Care and Handling	• Clean the surface of the panels with water and soft cloth to remove any dirt. • Clean the battery terminals of any dust, sulphate deposits and apply a thin layer of Vaseline to avoid corrosion. • Ensure that all the lights are switched off every morning.
Visual checks	• Check that all LED lights are functional • Check that the solar modules are not cracked or shaded. •
Function Checks	• Check that the LED lights (system operation information light and state of charge on battery light) in the morning and evening are green.

Troubleshooting

	Fault	Possible causes	Solution
1	System operation status LED light in Red.	• Fuse is blown. • System not charging or regulator has over heated.	• Replace the fuse. • Check the regulator functionality and ensure solar panels are not shaded or clogged by dirt. •
2	Battery status light in Red	• Low battery charge. • Charge regulator short circuiting	• Disconnect loads and allow the battery enough time to charge and if it fails, replace the battery. • Replace the charge regulator.
3	Both LED lights are green but no power output.	• The inverter could be off. • The circuit breaker could have tripped.	• Switch on the inverter. • Put back the breaker to the on position. • Trace for overload and disconnect.

Annexes

Annex 1: Standard Floor Plan of a Regional Workshop



Annex 2: Recommended WS Tools, Test Equipment and Furniture

No.	Equipment Name	Qt'y
Tools and Test Equipment		
1	Tool Kit, Mechanical (*)	2
2	Tool Kit, Electrician (*)	2
3	Tool Kit, Electronics (*)	2
4	Tool Kit, Medical Equipment (*)	2
5	Tool Kit, Plumber (*)	2
6	Tool Kit, Refrigeration (*)	2
7	Welding machine, heavy duty	1
8	Workshop stool	4
9	Workshop protective wear (pant and shirt)	6
10	Workshop shoes	6
11	Heavy duty gloves	6
12	Automated electrical safety analyzer	1
13	Ultrasound electrical safety transducer leakage current tester	1
14	Portable oxygen analyzer	1
15	2 Drawer work bench with vice No. 5	1
16	Engraving machine, electric, heavy duty	1
17	13mm chuck, reversible, variable speed, Drilling machine, with hammer function, electrical, hand held	1
18	13mm chuck, reversible, 2 speed, Portal drilling machine, cordless with spare battery and charger	1
19	Vice No. 3	1
20	Portable Generator set, 5KVA minimum	1
21	Dual DC regulated power supply	1
22	3 Phase tester	1
23	Mega tester	1
Office Furniture		
24	Office Chair	2
25	Chair	10
26	Desk with lockable drawers	3
27	Photocopier	1
28	Filing cabinet	3
29	6 Persons conference table	1
30	Shelves	3
31	White board 1600cm x 110cm	1

Note: (*) The details of the Kits are described in the following pages.

No. 1/Tool Kit, Mechanical

No.	Description (Tool Kit, Mechanical)	Qt'y
1	Cutter, side, large	1
2	G-clamp	1
3	Pliers, long nose, 170mm	1
4	Screwdriver/tester, Voltage tester	1
5	Box, tool, steel, big, 4 tray, cantilever, 550 x 220 x 215mm (l x w x h)	1
6	Oil can, 125ml, metal with pump	1
7	Hydrometer/battery electrolyte tester	1
8	Brush, steel, hand, 290mm; 37mm; 4 rows	1
9	Chisel and punch set, 6 pc	1
10	File set flat/square/half round/round, coarse and fine, 200mm	1
11	Hacksaw, standard, 470mm	1
12	Hammer, ball pein, 500g/1ib; 350mm	1
13	Hammer, nylon, 280mm; diam:32mm	1
14	Key, hexagon, metric, set, 9pc, 1.5 – 10mm	1
15	Machine, drilling, hand, 2 speed, 1 – 12mm	1
16	Pliers, water pump, standard, 225mm	1
17	Punch, nail, 150 x 5 mm	1
18	Letter punch set, A-Z	1
19	Number punch set, 0-9	1
20	Screwdriver, flat, blade: 3.5mm; shaft:75mm	1
21	Screwdriver, flat, blade: 5.5mm; shaft 100mm	1
22	Screwdriver, flat, blade: 8mm; shaft: 250cm	1
23	Screwdriver, star, No. 1x, Diam: 4 mm; shaft 75mm	1
24	Screwdriver, star, No. 2x, Diam: 6mm; shaft 100mm	1
25	Screwdriver, star, No. 3x., Diam: 8mm; shaft: 150mm	1
26	Spanner, flat, metric, set, 15 pc, 6 – 32mm	1
27	Spanner, ring/flat, metric, set, 16pc, 5 – 25mm	1
28	Spanner, box/socket, metric set, 16 pcs, 6-33mm	1
29	Wrench, self gripping, Max: 50mm	1
30	Wrench, socket, set, large, 10 – 32mm; ½" square drive	1
31	Wrench, chain, diam.: 7 – 2200mm	1
32	Tap and die set, imperial	1
33	Tap and die set, metric	1
34	Wire brush	1
35	Reamer set	1
36	Steel rule, marked, metric: 300mm	1
37	Tape measure, Steel, 3m	1

No. 2/Tool Kit, Electrician

No.	Description (Tool Kit, Electrician)	Qt'y
1	Cutter, side, large, Max. size wire: 2.0mm; L = 210mm	1
2	Multi-meter, basic, digital, Like fluke 11	1
3	Bit, drill, concrete, hammer operated, 3.5/4.5/5.0/6.0 mm, with handle	1
4	Hammer, club, 42 x 42 x 110mm	1
5	Screwdriver, flat, insulated, blade 2.5mm; shaft 75mm	1
6	Screwdriver, flat, insulated, blade 4.0mm; shaft 100mm	1
7	Screwdriver, star, insulated, blade 2.5mm; shaft 75mm	1
8	Screwdriver, star, insulated, blade 4.0mm; shaft 100mm	1
9	Screwdriver/ mains tester, blade 4mm; shaft: 100mm, 100-500V	1
10	Stripper, Wire, Standard, 170mm	1
11	Knife, trimming, retractable blade	1
12	Pen, marking, waterproof, medium	1
13	Tape measure, Steel, 3m	1
14	Box, tool, steel, big, 4 tray, cantilever, 550 x 220 x 215mm (l x w x h)	1
15	Chisel, channeling	1
16	Chisel set complete with floorboard	1
17	Cutter, pipe, 3 – 30mm	1
18	File set flat/square/half round/round, coarse and fine, 200mm	1
19	Hacksaw, Junior	1
20	Hacksaw, standard, 470mm	1
21	Light, torch, rubber coated, 2 batteries LR20, 3V	1
22	Pliers, combination, 203mm / 8"	1
23	Pliers, long nose	1
24	Punch, centre, diam: 6mm; 1 = 115mm	1
25	Reamer, pipe	1
26	Screwdriver, flat, chubby, blade: 5.5mm; shaft: 40mm	1
27	Screwdriver, flat, long, blade: 5.mm; shaft: 200mm	1
28	Screwdriver, flat, screw gripping, blade: 6mm; shaft: 200mm	1
29	Screwdriver, Phillips, chubby, No. 2x Diam: 5.0mm; shaft: 40mm	1
30	Screwdriver, Pazidriv, No. 1, 75mm	1
31	Screwdriver, Pozidriv, No. 2, 100mm	1
32	Spanner, adjustable, medium, 205mm / 8"; jaw:27m	1
33	Spectacles, safety	1
34	Wrench, pipe, small, 229mm / 9"	1
35	Malet Hammer	1
36	Claw Hammer	1
37	Wire brush	2
38	Grip pliers, adjustable, set	1
39	Hygrometer	1
40	Portable hand drill, cordless with rechargeable battery & charger	1
41	Allen keys set (metric & imperial)	1
42	Circlip plier set	1

No. 3/Tool Kit, Electronics

No.	Description (Tool Kit, Electronics)	Qt'y
1	Cutter, side, small size, L=125	1
2	De-soldering tool, standard	1
3	Dispenser, solder	1
4	Iron, soldering, medium, general, 30W / 220V; tip diam: 6mm	1
5	Multi-meter, digital, Like fluke 79 series, Resol: 3.5 digit	1
6	Pliers, long nose, 170mm	1
7	Screwdriver / mains tester, blade: 4mm; shaft: 100mm, 100 – 500V	1
8	Stripper, wire, standard, 170mm	1
9	Tools, trimming, set	1
10	Wick, de-solder	1
11	File, needle, set, 6pcs: 160mm	1
12	Knife, trimming, retractable blade	1
13	Tweezers, 130mm; tips: 1mm	1
14	Box, tool, brief-case type, 500 x 380w x 150h mm	1
15	File, half round, second cut, 150mm	1
16	Hacksaw, Junior	1
17	Hammer, ball pein, 100gr/1 oz	1
18	Key, hexagon, metric, set, 9pc, 1.5 – 10mm	1
19	Key, hexagon, set, imperial, 9pc, 5/64 – 3/8"	1
20	Magnifying glass, pocket type	1
21	Mirror, inspection	1
22	Pliers, combination; 180mm / 7"	1
23	Screwdriver, flat, blade: 3.5mm; shaft 75mm	1
24	Screwdriver, flat, blade: 5.5mm; shaft 100mm	1
25	Screwdriver, flat, blade: 6.5mm; shaft 100mm	1
26	Screwdriver, flat, long shaft, blade: 4.0mm; shaft 250mm	1
27	Screwdriver, flat, screw gripping, blade: 6mm; shaft 200mm	1
28	Screwdriver, Pozidriv. No. 0, 60mm	1
29	Screwdriver, Pozidriv. Long shaft, No. 1, 250mm	1
30	Screwdriver, Pozidriv. Long shaft, No. 2, 250mm	1
31	Screwdrivers, jeweller's, set, crosshead	1
32	Screwdrivers, jeweller's, set, flat blade	1
33	Shears, light duty, L 190 D 4.5	1
34	Spanner, adjustable, small, 155mm / 6", jaw: 20mm	1
35	Spanner, ring/flat, metric, set, 8pc, 8 – 19mm	1
36	Brush, cleaning, 12mm, 260mm	1
37	Snipper set	1
38	Allen key set (metric & imperial)	1
39	Precision screw driver set	1

No. 4/Tool Kit, Medical Equipment

No.	Description (Tool Kit, Medical Equipment)	Qt'y
1	Cutter, side, small size, L=125	1
2	De-soldering tool, standard	1
3	Dispenser, solder	1
4	Iron, soldering, medium, general, 30W / 220V; tip diam: 6mm	1
5	Clamp meter	1
6	Pliers, long nose, 170mm	1
7	Screwdriver / mains tester, blade: 4mm; shaft: 100mm, 100 – 500V	1
8	Stripper, wire, standard, 170mm	1
9	Tools, trimming, set	1
10	File, needle, set, 6pcs: 160mm	1
11	Knife, trimming, retractable blade	1
12	Tweezers, 130mm; tips: 1mm	1
13	Box, tool, brief-case type, 500 x 380w x 150h mm	1
14	File, half round, second cut, 150mm	1
15	Hacksaw, Junior	1
16	Key, hexagon, metric, set, 9pc, 1.5 – 10mm	1
17	Magnifying glass, pocket type	1
18	Mirror, inspection	1
19	Pliers, combination; 180mm / 7"	1
20	Wrench, adjustable, medium, 350mm	1
21	Wrench, adjustable, small, 200mm	1
22	Wrench, socket, medium, 350mm	1
23	Wrench, socket, small, 200mm	1
24	Screwdriver, flat, blade: 3.5mm; shaft 75mm	1
25	Screwdriver, flat, blade: 5.5mm; shaft 100mm	1
26	Screwdriver, flat, blade: 6.5mm; shaft 100mm	1
27	Screwdriver, flat, long shaft, blade: 4.0mm; shaft 250mm	1
28	Screwdriver, flat, screw gripping, blade: 6mm; shaft 200mm	1
29	Screwdriver, Pozidriv. No. 0, 60mm	1
30	Screwdriver, Pozidriv. Long shaft, No. 1, 250mm	1
31	Screwdriver, Pozidriv. Long shaft, No. 2, 250mm	1
32	Screwdrivers, jeweller's, set, crosshead	1
33	Screwdrivers, jeweller's, set, flat blade	1
34	Spanner, adjustable, small, 155mm / 6", jaw: 20mm	1
35	Spanner, ring/flat, metric, set, 8pc, 8 – 19mm	1
36	Brush, cleaning, 12mm, 260mm	1
37	Snipper set	1
38	Allen key set, metric	1
39	Precision screw driver set	1

No. 5/Tool Kit, Plumber

No.	Description (Tool Kit Plumber)	Qt'y
1	Bit, drill, concrete, set, hammer operated, 3.5, 4.5, 5, 6mm; with handle	1
2	Level, Spirit, L = 50cm	1
3	Trowel, pointing, 150mm	1
4	Iron, brazing/soldering, large, 300W / 220V	1
5	Tape measure, steel, 3m	1
6	Box, tool, steel, big, 4 tray, cantilever, 550 x 220 x 215mm (l x w x h)	1
7	Chisel, cold, 16mm x 250mm	1
8	Chisel, floorboard	1
9	Cutter, pipe, 3 – 30mm	1
10	Hacksaw, junior	1
11	Hacksaw, standard, 470mm	1
12	Lamp, soldering, paraffin, 0.5 litre	1
13	Mallet, bossing, 60mm	1
14	Mallet, tinmans, 60mm	1
15	Pliers, combinations, 203mm / 8"	1
16	Pliers, water pump, standard, 225mm	1
17	Rule, s/s, 300mm 25mm wide	1
18	Shears, metal	1
19	Wrench, footprints, 220mm	1
20	Hammer, plumbers' 500gr	1
21	Hook, shave, triangular	1
22	Plumber's bob, with line, 100 gr	1
23	Portal Tripod stand	1
24	Pipe cutter	1
25	Wrench, adjustable, medium, 350mm	1
26	Wrench, adjustable, small, 200mm	1
27	Wrench, socket, medium, 350mm	1
28	Wrench, socket, small, 200mm	1
29	Bit, drill, auger, wood, set, 5pc, 6 – 25mm / 125mm	1
30	Brace, bit, ratchet, 4 jaw, 255mm	1

No. 6/Tool Kit, Refrigeration

No.	Description (Tool Kit, Refrigeration)	Qt'y
1	Leak detector, electronic	1
2	Pressure gauge (for R12 & R134a refrigerants)	1
3	Pipe bender set (1/2", 3/4", 1" …. 2")	1
4	Clamp meter	1
5	Flaring swaging tool	1
6	Ratchet spanner set	1
7	Portal brazing cylinder set	1
8	Blower (dust)	1
9	Digital thermometer	1
10	Portable brazing torch (butane)	1
11	Allen keys (metric & imperial)	1
12	Protective goggles	2
13	Portable gas welding kit	1
14	Silicon gun	1
15	Rivet gun	1
16	Tape measure, steel, 5 m	1
17	Electrical drill, with both hammer & reverse functions	1
18	Cordless portal hand drill, with rechargeable batteries	1
19	Digital clipper	1
20	Screw driver set (flat & screw)	1
21	Vacuum pump	1
22	Circlip pliers	1
23	Electrical clumping tool	1
24	Reamer set	1

Annex 3: Stickers Form, Equipment Condition A–F

CLASSIFICATION OF CONDITION FOR MEDICAL EQUIPMENT BY COLOR CODE

A GOOD AND IN USE	NO PROBLEM
B GOOD BUT NOT IN USE	USER TRAINING NEEDED
C IN USE BUT NEEDS REPAIR	MAINTENANCE NEEDED
D IN USE BUT NEEDS REPLACEMENT (OLD OR OBSOLETE)	PLAN FOR DECOMMISSION -ING/DISPOSAL
E OUT OF ORDER BUT REPAIRABLE	MAINTENANCE NEEDED
F OUT OF ORDER AND SHOULD BE REPLACED (CAN NOT BE REPAIRED, NO SPARE, OLD OR OBSOLETE)	DISPOSE

Annex 4: Medical Equipment Inventory Form

Health Facility:	**Inventory Date:**	**Inspector's Name:**
Adress:	**Hospital Contact:**	**Inspector's Name:**

E.q. Type Key:	ME: Medical Equipment	MF: Medical Furniture	MI: Medical Instrument	HP: Hospital Plant
Condition Key:	A: Good and in use	C: In use but needs repair	E: Out of order but repairable	
	B: Good but NOT in use	D: In use but needs replacement	F: Out of order and should be replaced	

Ref Nr.	Department/ Section	Room	Equipment Name	E.q. Type	Model	Serial No.	Manufacturer	Qty	Product Date	Condition	Comment

Annex 5: Template of Work Plan Preparation

Activity No.	Output Description	Output Indicator(s)	Planned Output Target	Planned Activities to Deliver Outputs	Activity Timing (Q1, Q2, Q3, Q4)	Source of Funding	Responsible officer	Cost Items	Cost per Item (000's)
1	Medical Equipment maintenance improved	Number of technicians and engineers trained	Bio-Medical Engineering training conducted for 10 Engineers/Technicians	Conduct training for technicians in servicing and maintenance of seleced equipment	Q2	GoU	RW Manager	Staff training	30,000
2		Medical Equipment maintenance condition	65% of available medical equipment kept in good condition	Procure assorted medical equipment spare parts	Q2	GoU	RW Manager	Equipment Mainte-nance	300,000
3		Number of equipment maintained	Updated guidelines on health care waste management and disposal	Conduct maintenance visits to target hospitals and HCIVs	Q2, Q3	GoU	RW Manager	Travel inland	3,000
4		Minutes of meetings held	2 meetings per year	Organise and hold RW management committee meetings	Q2, Q4	GoU	Hopital Director	Travel inland	40,000
Total for Activity:									373,000

Annex 6: 5S Activity's Instruction for RWs

1. What is 5S?

5S is a management tool, which originated from the Japanese manufacturing sector. It is used as a basic, fundamental, systematic approach for productivity, quality and safety improvement in all types of organizations.

5S is literally five abbreviations of Japanese terms with five initials of S. There are ***Seiri, Seiton, Seiso, Seiketsu and Shitsuke***. In English, 5Ss were translated as ***Sort, Set, Shine, Standardize and Sustain***. These are explained briefly below:

1. Sort	Remove unused stuff from your venue of work and reduce clutter
2. Set	Organize everything needed in proper order for easy operation
3. Shine	Maintain high standard of cleanness
4. Standardize	Set up the above three So as norms in every section of your place by use of Standard Operating Procedures and checklists
5. Sustain	Train and maintain discipline of the personnel engaged

The five steps of Sort–Set–Shine–Standardize–Sustain are a sequence of activities to improve the work environment to be as convenient and comfortable as possible and thereby also improve service contents with respect to preparedness, standardization and timeliness.

2. Practical hints for five steps

The basic actions and practical hint for implementing5S are shown in the following page. The principal example and practical hints are shown in the following page for every step of 5S.

1S: SORTING / Elimination

Basic actions for sorting

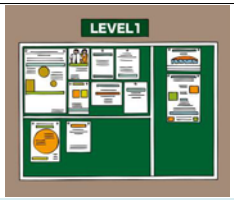
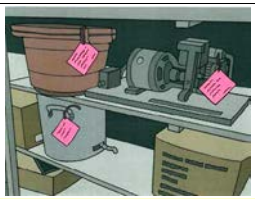
1. Create a chaos free environment. 3. Use “Red Tags.”
2. Clean the walls and notice boards.

How?

- Dispose of unnecessary materials on tables, in drawers, in cabinets and on the floor.
- Remove unnecessary instructions and posters on the walls and on notice boards.
- Attach Red Tags for undecided items for disposal and determine whether the item “may be necessary” or is “unnecessary.”

Hints for actions

- Eliminate all unnecessary items from workplace and reduce clutter.
- Go through all tools, materials, and so forth in the work area.
- Keep only essential items and eliminate what is not required, prioritizing things as per requirements and keeping them in easily-accessible places.
- Everything else should be stored or discarded.

		
Dispose off unnecessary materials on tables, in drawers, in cabinets and on the floor.	The walls and notice boards use X-Y line.	Attach “Red Tags” for undecided items for disposal and determine whether the item “may be necessary” or is “unnecessary.”
		
Good example of chaos free environment at the office desk.	The walls and notice boards use X-Y line.	Remove unnecessary instructions and posters on the wall and on the notice boards.

2S: SETTING/ Material Handling

Basic points for setting material handling

1. Zone/area, clear transport routes; **3. Home for each tool;**
2. Multi-level shelves and containers;

How?

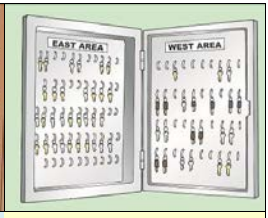
- Secure transport routes without obstacles that are even and not slippery.
- Provide multi-level shelves or storage racks near the work area for medical charts and drugs.
- Provide a "home" for medical equipment and work items and mark their position clearly.
- Use carts, hand-trucks and other wheeled devices when moving materials.

Hints for actions

- Organize everything needed in proper order for ease of operation.
- There should be a place for everything and everything should be in its place.
- The place for each item should be clearly labeled or demarcated.
- Items should be arranged in a manner that promotes efficient work flow, with equipment used most often being the most easily accessible.

Clear transport routes with clear mark.

Provide multi-level shelves or storage racks near the work area for medical drugs.



Provide a "home" for each piece of medical equipment.

Use carts, hand-trucks and other wheeled devices when moving materials.

Secure transport routes without obstacles that are even and not slippery.

Provide multi-level shelves for medical charts in the record unit.

2S: SETTING/ Workstation changes

Basic points for setting workstation changes

1. Easy reach
2. Elbow height
3. Comfortable chairs

How?

- Place frequently used tools, controls and materials within easy reach of workers.
- Adjust the working height for each health care worker at elbow level or slightly below it.
- Allow workers to alternate standing and sitting as much as possible and provide good adjustable chairs with good backrests.

Hints for actions

- Items should be arranged in a manner that promotes efficient work flow, with equipment used most often being the most easily accessible.
- Workers should not have to bend repeatedly to access materials.
- Each tool, part, supply, or piece of equipment should be kept close to where it will be used – in other words, straightening the flow path.

		
Place frequently used tools and materials within easy reach of workers	Adjust the working height for each health care worker at elbow level or slightly below it.	Provide good adjustable chairs with good backrests.
		
Place frequently used tools within easy reach	Adjust the working height for each health care worker at elbow level or slightly below it to reach.	Set necessary equipment nearby worksite for easy to reach.

2S: SETTING/ Labels, signs, color coding

Basic points for setting labels, signs, color cording

1. Labeling
2. Safety signs
3. Color coding/numbering
4. Signboards/mapping

How?

- Make labels, colors and signs easy to see, easy to read and easy to understand.
- Provide clear instructions and information necessary for safe, efficient work.
- Use color coding rules such as for garbage, medical waste and linen by type.
- Use a board with X-Y axis alignment for sharing medical information, a 5-S corner display and a map of work areas for patients.

Hints for actions

- The place for each item should be clearly labeled or demarcated.
- Items should be arranged in a manner that promotes efficient work flow, with equipment used most often being the most easily accessible.

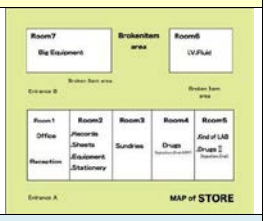
Labels should be easy to read and easy to understand.

Clear instructions for operation of the fire extinguisher.

Numbering rules of medical charts for proper setting,

5S corner display by X-Y axis alignment.

The place for each item should be clearly labeled or demarcated.



A map of work areas for patients.

3S: SHINING/ Regular maintenance and cleanliness

Basic points for Shining

1. Cleanliness
2. Waste bin, cleaning tool
3. Proper maintenance of equipment

How?

- Designate the responsibility for keeping areas clean to staff members and clean regularly.
- Place waste bins and cleaning tools in the appropriate workplace.
- Inspect and maintain medical Instruments, machines and tools regularly.

Hints for actions

- Discuss the placement of waste bins in areas where they are needed at your workplace.
- Regular maintenance keeps your medical equipment productive and safe. Check all machine parts carefully. In particular, special care is needed for rotating parts, detachable guards and electrical wires, etc.
- If you find an inexpensive machine, you should check its safety aspects even more carefully. When accidents occur, costs can be enormous.
- Develop a long-term maintenance plan. For instance, you may check the machine thoroughly every weekend.

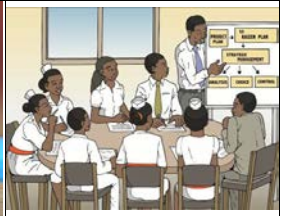
Designate responsibility for keeping the area clean to staff members.

Place waste bins and cleaning tools in the appropriate workplace location.

Inspect and maintain medical instruments, machines and tools regularly.

Cleaning regularly supports daily work tasks.

Place waste bins at every point where HWs undertake procedures.



Discuss establishing a standard of cleanliness with staff members.

4S: STANDARIZE/ Improving quality of care

Basic points for standardizing

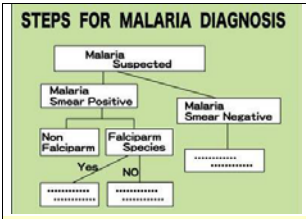
1. Standardized care procedures
2. Procedures of the equipment
3. Ensuring patients' privacy
4. Establishing hand hygiene
5. Reducing patients' waiting time

How?

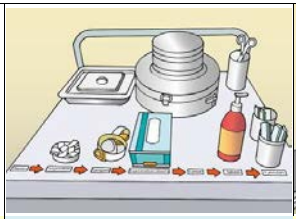
- Establish the protocols of standardized care procedures about each cure and care, such as maternity, vaccination, medical health checkup.
- Display procedures of the equipment and label clearly what operation is meant.
- Use partitions, curtains and other arrangement for protection privacy of persons cared
- Establish hand hygiene procedures and hygienic washing facilities.
- Reducing waiting time for patients at an outpatient room, a laboratory and a pharmacy.

Hints for actions

- Listing basic clinical procedures makes it easy to find necessary standardized care procedures for documentation.
- Labels and signs are needed for clear instruction for procedures.
- Encouraging collection of patients' opinion is essential for improving quality of care.



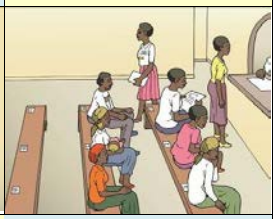
The protocols of standardized malaria diagnosis as a flowchart


Instructions for procedures for the use of equipment with operations clearly labeled.


Curtains for protection privacy of persons cared.


Proper hand hygiene procedures and hygienic washing facilities.

A suggestion box helps improve the quality of care.


Reducing waiting times for patients at outpatient departments, laboratories and pharmacies.

5S: SUSTAIN/ Teamwork

Basic points for sustaining

1. Tool box meeting 3. Work Improvement Team (WIT), 5S Training
2. Record of accidents and injuries

How?

- Hold a brief meeting before beginning work to plan assignments and avoid giving excessive workloads to particular staff members.
- Keep records of medical accidents, occupational injuries and diseases for ensuring both patients and workers' safety.
- Encourage Work Improvement Team (WIT) activities and provide adequate participatory 5S and safety/health improvement training to all workers.

Hints for actions

- Record all accidents, absences, sickness, and other health-related events.
- Plan annual work schedules including sufficient training periods.

Hold a brief meeting before work

Keep records of both medical accidents and occupational injuries

Visit 5S team regularly at the workplace

5S training for all staff members

Holding monthly WIT meetings helps maintain 5S activities

5S facilitators organize engaging 5S workshops.

Annex 7: Quarterly Report General Form

Hoima Medical Equipment Maintenance Workshop Date(D/M/Y) : 10/01/2014

To: Assistant Commissioner, Health Infrastructure, MOH

Thru: Director of Hoima Regional Referral Hospital
CC: All Medical Superintendent and Hospital Administrator of Health Facilities in Hoima Region

Re: Hoima Medical Equipment Maintenance Workshop Quarterly Report

This is a summary report of the activities of Hoima Workshop during October – December 2013.
This report is composed of:

1. Activities carried out during the last quarter.
2. Expenditure during the quarter.
3. Work plan and budget requirement for the pending work.
   - Annex 1: Job Card Records Summary
   - Annex 2: Job Card Record for each health facilities
   - Annex 3: Work Plan for next quarter

1. Report on Maintenance Activities

A number of maintenance activities were carried out in the following health facilities during the period.

RRH	Hoima
GH	Kiboga, Mashindi, Kagadi, Kiryandongo
HC IV	Buliisa, Bwijanga, Kibaale, Kakumiro, Kakindo, Bukomero, Kikuube

Detailed activities are shown in the attached Work Record:

2. Report on Other Activities

Other activities were carried out during the period as described below.

RWCM meeting	Meeting held in Kagadi Hospital.
Inventory update	2 GHs and 3 HC IVs were updated.
5S activities in WS	The spare parts store was cleaned and improved.
User/Tech. training	User training was held for 20 nurses on theater equipment. 2 technicians were trained on Laboratory equipment in Fort Portal.

3. Report on Expenditure

The following table shows all expenditure for the period and details are in Annex 1.

Reference	Description	Amount
Revenue	(Annual work plan allocation for Quarter)	
Annex 1	Spare Parts	
Annex 1	Per diem for engineers/technicians	
Fuel Expenditure	Mileage: 690 km	
Operational cost		
Electricity	Electricity Bill	
Water	Water Bill	
Office stationary	Paper, Toner	
Vehicle	Vehicle Maintenance/Repair	
	RWMC Meeting	
	User Training Seminar	
	Grand Total	

Detailed information on fuel consumption is available on previous quarterly report/work plan.

4. Work Plan and budget requirement for the next quarter

Work plan for the next quarter is attached for perusal. (Annex 2)
The cost of necessary spare parts for pending work is available in the work record. (Annex 1)
Maintenance needs for health facilities is based on the latest health facility equipment inventory update.
The estimated cost of spare parts for the planned activities is indicated in the list.
Any emergency repair shall be handled on a case by case basis.

Total budget requirement for next quarter activities is summarized below.

Reference	Description	Amount
Revenue		
Annex 1	Spare parts	
Annex 3	Per diem for Engineers/Technicians	
Annex 3	Fuel	
Operational Cost		
Past Average	Electricity Bill	
Past Average	Water Bill	
Past Average	Stationary	
Past Average	RWMC Meeting	
Past Average	User Training Seminar	
On plan	Vehicle Maintenance	
	Grand Total	

5. Urgent issues to note:

1) The maintenance money for the 1st quarter was released late.
2) The mobile workshop vehicle has worn out tyres, but budget is not adequate to purchase tyres.
3) The procurement of spare parts has delayed.
4) Solar panels for blood bank refrigerator in **** HC IV were stolen.
5) **** GH generator starting system circuit board needs replacement.

Compiled By

(Name of WS Manager)
Hoima Regional Workshop Manager

Annex 8: Job Card Form

JOB CARD

Job Card Number:

Equipment owner/Health Unit	Department	Room
Equipment Name	Model name	Serial No.
Mnufacturer	Country of origin	Product Date
Complaint Form No.		Sticker on Equipment Year A. B. C. D. E. F
Fault Detected:		
Work done		
Extra work to be done/Advise to the owner(Health Facility)/Findings		

Name of Eng/Tech	Time spent on maintenance Hrs	Contact No.
Name of Eng/Tech	Time spent on maintenance Hrs	Contact No.
Name of Eng/Tech	Time spent on maintenance Hrs	Contact No.

Spare Parts Used and Other Expenses (1)

Any other expenses (Casual Labor etc should be described here

Name	Qty	Unit Price	Total Amount(Ushs)	Source of Spares
1				HP/RWS/Trip Contingency Other(identify)
2				HP/RWS/Trip Contingency Other(identify)
3				HP/RWS/Trip Contingency Other(identify)
4				HP/RWS/Trip Contingency Other(identify)
5				HP/RWS/Trip Contingency Other(identify)
6				HP/RWS/Trip Contingency Other(identify)
Spare Parts GRAND TOTAL				

New equipment sticker,: A,B,C,D,E,F		
Department Personnel avialbale		Comment

Endosed by	Name	Hospital stamp
	Title	
	Signature	Date

Note; (1) Cost of spare parts and other costs are for monitoring maintenancce cost only.

Annex 9: Support Supervision & Monitoring Sheet

Name of RW .....
Name of RW Manager .....
Evaluation Period ..... Date .....
Name of Evaluator .....Designation .....

No.	Areas to be evaluated/ Monitored	Evaluation Criteria	Yes	No
1	MAINTENANCE WORKSHOP	1. Is Workshop Space adquate?		
		2. Are the Workshop premises clean?		
		3. Does the Workshop have basic tools and equipment?		
	Comments on Workshop premises:			
2	MAINTENANCE SERVICES	1.Does the Workshop maintain Inventory?		
		2.Does the Workshop maintain a record of all jobs done?		
		3. Does the w orkshop hold RWMC Meetings?		
		4. Are there Quartely Reports to HI?		
	Comments on Maintenance services:			
3	MINTENANCE PERSONNEL	1. Is the available personnel according to MoH establishment ?		
		2.Does the staff have minimum academic qualifications?		
		3. Does the staff attend regular refresher training?		
	Comments on Maintenance Personnel:			
4	SPARE PARTS	1. Does the Workshop receive regular supplies of spare parts?		
		2. Are spare parts availabel in Uganda		
	Comments on Spare parts:			
5	SUPPORT SUPERVISON	1. Does the Workshop receive Support Supervision from HI?		
		2. Does the RRH monitor the activities of the Workshop?		
		3. In your view , is this Suppor Supervion adquate?		
		4. Is 5S implemented w ell in the Workshop?		
	Comments on Support Supervision:			
6	FINANCING	1. Does the Workshop receive enough funds for maintenance?		
		2. Does the Workshop provide accountabity of funds received?		
		3. In your view , are funds received for maintenance adquate?		
	Comments on Support Financing:			
6	REFERENCE MANUALS	1. Does the Workshop access operation manuals for All equipment?		
		2. Does the Workshop have access to service manuals of major equipment ?		
		3. Is there a technical reference library in the w orkshop?		
	Comments on Refernce Manunuals:			

Annex 10: Complaints Form

Complaints Form

Date _____

Hospital/Health Unit _____ Complaint No. _____

Department _____ Room _____

Name of Equipment Model _____ Serial No. _____

Sticker on the Equipment: A,B,C,D,E,F (to be circled)

Complaint being Reported

_____

_____

_____

_____

Reported by Name _____

Title _____

Date _____

Supported by