Federal Democratic Republic of Ethiopia
Ministry of Health

BIOMEDICAL EDUCATION FOR

Pharmacy and Medical Equipment Management Directorate

January,2018

Addis Ababa

Forward

Modern health care services are very much dependent on the use of proper medical equipment for diagnosis and treatment. The majority of these devices and equipment are manufactured in developed countries and needs skilled man power to manage and use them lifelong. Because they are applied on human being they need rigorous care and handling for the sake of patient safety and utilize them effectively and efficiently. Even with normal and careful use, they are subject to malfunction.

It is important to take good care of them and employ timely preventive maintenance to keep them working last long and decrease downtime. The proper handling and maintenance of these devices can be achieved by deploying the well trained and competent biomedical Equipment Engineers/ Technicians to the respective health facilities. In line with this, it is also important to provide continuous on job training to build their capacity and introduce them to a new technology. Therefore, this training package is developed to provide TOT for biomedical education training provider institute instructors as well as professional who are working at health facilities to fill their Knowledge, attitude and skill gaps on some selected Laboratory equipment.

I would like to take this opportunity to thank all who participated in the revision and development of this training manual.

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List of acronyms and abbreviations

PPE	Personal Protective Equipment
LED	Light Emitting Diode
AD	Active Duty
JIT	Jimma University Institute of Technology
AAIT	Addis Ababa University Institute of Technology
AAT PC	Addis Ababa TegbareidPolytechnique College
STD	Sexually Transmitted Disease
HBC	Human Bridge College
KPTC	KombolchaPolytechnique College
HTM	Healthcare Technology Management
BSC	Biological Safety Cabinet
GTP	Growth and Transformation Plan
PPE	Personal Protective Equipment

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Introduction to the Manual

The Federal Ministry of Health's Growth and Transformation Plan (GTP) indicates that by 2018, 16 specialized governmental hospitals, 80 general hospitals, 800 primary hospitals, and 3,200 health centers will be established. Additionally, there are more than 200 private hospitals and diagnostic centers operating in the country. The FMOH reports that these healthcare facilities will need 4,000 newly trained biomedical equipment technicians and 600 biomedical engineers. Ensuring that existing technicians and engineers are equipped with adequate skills is also a challenge. Ethiopia lacks systems to manage the lifecycle of emerging healthcare technologies and medical equipment, but has developed a plan to address this.

The current biomedical engineering programs at JIT and AAIT, and the vocational biomedical Technician program at AATPC, HBC, KPC and other newly merging regional TVET Colleges are tasked with producing technicians and engineers to meet the very high demands for trained professionals throughout Ethiopia. Program gaps include a lack of adequate hands-on, practical training opportunities and laboratory/ industrial skills for students, and an acute shortage of academically/industrially/vocationally trained faculty and staff. The existing faculty and staff lack access to modern biomedical training equipment, modern training methodologies, as well as evidence-based information on biomedical equipment that is in line with international standards and best practices. This deprives students/trainees of standardized protocols and training in devices maintenance and management and leads to an unstructured career path for students.

The HRH Project through its close working relation with those institutes has made discussions with teaching staff's and biomedical departments to gather the information regarding the training demand and discussed with the FMoH, HR directorate and decided to develop these standard training packages for the purpose of conducting technical update training on some selected medical equipment. The HRH project, Core biomedical Engineers coordinate this training package development activity in collaboration with FMoH technical experts, we hope this will be a good opportunities for faculty, staff, and HTM personnel to fill the skill gap on the selected medical equipment and as a result improves the faculty teaching learning process.

CORE COMPETENCY

The following are the core competency of this training:

- Apply the operation principles of some selected Clinical Laboratory equipment
- Identify the basic components of the selected Clinical Laboratory equipment
- Apply the proper handling and safe use of Clinical Laboratory devices
- Perform appropriate troubleshooting procedures for each equipment
- Perform preventive and corrective maintenance as per the manufacturer manual
- Perform calibration and performance test as demanded

Course syllabus

COURSE DESCRIPTION

This 10 days course is designed to equip trainees/Biomedical professionals with appropriate knowledge, skill and attitude required for maintenance and care of laboratory equipment. It covers basic working principles, purposes, main components, troubleshooting techniques and safety procedures for the selected laboratory equipment.

COURSE GOAL

This course is designed to provide participants with knowledge, skill and attitude necessary for laboratory equipment maintenance activities and to make the biomedical engineers/ technicians effective.

PARTICIPANTS LEARNING OBJECTIVES

After completion of this course participants will be able to:-

- Provide CRC health care services
- Describe uses/purpose of Laboratory equipment
- Identify types of Laboratory equipment
- Explain working principles of Laboratory equipment
- List and define basic parts and components of Laboratory equipment
- Perform the steps for troubleshooting techniques of Laboratory equipment
- Practice maintenance for Laboratory equipment
- Differentiate the types of Laboratory equipment
- Identify performance test procedures in Laboratory equipment
- Approve performance test procedures in Laboratory equipment
- Handle laboratory Equipment with appropriate care
- Follow maintenance report techniques
- Implement safety needed for the equipment and user in Laboratory equipment

TRAINING METHODS

- Brainstorming
- Interactive presentation
- Discussion
- Coaching
- Demonstration
- Video demonstration
- Site visit
- Troubleshooting exercise.
- Illustrated presentation
- Practical sessions
- Case study

TRAINING MATERIALS AND INSTRUMENTS

Participant manual
Facilitator's guide
LCD Projector
PowerPoint presentations
Flip chart and different colour markers
Laptop computer
User and service manual
Tool kits
Multi meter
Personal Protective Equipment (PPE)
Reference manual
And the following laboratory equipment
Microscope
Centrifuge
Refrigerator
Laboratory Incubator
Biological safety cabinet (BSC)
Chemistry analyser

PARTICIPANT SELECTION CRITERIA

Participant for this course should be biomedical engineers/ technicians and registered professional working on medical Equipment maintenance.

FACILITATOR / TRAINER SELECTION CRITERIA

Facilitators of this training manual shall be selected from

TWG of this training manual
Having TOT on clinical laboratory equipment.
Basic training on clinical laboratory equipment maintenance with facilitation skill training and
Having BSc degree in Biomedical Engineering

METHODS OF EVALUATION

A. Course Evaluation

Daily evaluation
End of training evaluation
Participant oral feedback

B. Participants Evaluation

Formative
Pre-test
Group exercises/ demonstration using checklists

Summative

For Basic

- o Knowledge assessment (30 %)
- o Practical assessment (70%)

For TOT

- o Teach back:- 50%
- o Post-test:- 50%

CERTIFICATION CRITERIA

Certificates will be provided to basic training trainees who have scored 70% and above on summative assessment and attended 100% of the course. For TOT trainees, certificate shall be provided to those who have scored 80% and above on summative assessment and attended 100% of the course.

COURSE DURATION

10 days

SUGGESTED CLASS SIZE

20 – 25 participants at a time

4 trainers

TRAINING VENUE

The training will be conducted at the nationally recognized IST centers having appropriate facilities.

Course Schedule

Training Course on Clinical Laboratory Equipment for Biomedical Professionals

Organized by: _____

Venue: _____ Date: _____

Day 1	Time	Activity	Duration	Facilitator	Moderator
Morning	8:30 – 9:15 am	Registration	30 min		
	9:15- 9:25 am	Welcoming /Opening remark	20 min		
	9:25 – 9:35 am	Participants self introduction and expectation	15 min	All participants	All facilitators
	9:35 - 10:30 am	Pre-test	55 min		
	10:30- 10:45 am	**Coffee Break**			
	10:45- 12:30 am	Chapter 1:	1hr 45 min		
	12:30- 1:30	**Lunch**			
Afternoon	1:30- 3:00 pm	Chapter 1 Chapter 2	55 min 35 min		
	3:00 -3:15	**Tea break**			
	3:15-5:30 pm	Chapter 2	2 hrs 15 min		
Day 2	**Time**	**Activity**	**Duration**		
Morning	8:30 – 8:45am	Recap	15 min	All the participants	Facilitators
	8:45 - 10:00am	Chapter 2	1 hr 15 min		
	10:00- 10:15am	**Coffee Break**			
	10:15- 12:30 PM	Chapter 2	1 hr 45 min		
	12:30- 1:30	**Lunch**			
Afternoon	1:30- 3: 00 PM	Chapter 2	1 hr 30 min		
	3:00- 3:15PM	**Coffee Break**			
	3:15- 5:30	Chapter 2	25 min		
		Chapter 3	1 hr 50 min		
Day 3	**Time**	**Activity**	**Duration**		
Morning	8:30 - 8:45am	Recap	15 minutes	Participant	
	8:45 - 10:00	Chapter 3	1 hr 15 min		
	10:00- 10:15	Coffee Break			
	10:15- 12:30	Chapter 3	2 hr 15 min		
	12:30- 1:30	**Lunch**			
Afternoon	1:30 – 3:00	Chapter 3	1 hr 30 min		
	3:00- 3:15	Coffee Break			
	3:15- 5:30	Chapter 4	2 hr 15 min		

Day 4	Time	Activity	Duration		
Morning	8:30 - 8:45	Chapter 4	15 min		
	8:45 - 10:00	Chapter 4	1 hr 15 min		
	10:00- 10:15 am	**Coffee break**			
	10:15- 12:30	Chapter 4	2 hr 15 min		
	12:30- 1:30	**Lunch**			
Afternoon	1:30- 3:00	Chapter 4	1 hr 30 min		
	3:00- 3:45	**Coffee break**			
	3:45- 5:30	Chapter 4	1 hr 45 min		
Day 5	**Time**		**Duration**		
Morning	8:30 - 8:45	Recap	15 min		
	8:45 - 10:00	Chapter 4	1 hr 15 min		
	10:00- 10:15	**Coffee Break**			
	10:15- 12:30	Chapter 4	2 hr 15 min		
	12:30- 1:30	**Lunch**			
Afternoon	1:30- 3:00	Chapter 4	1 hr 30 min		
	3:00 – 3:15	**Coffee Break**			
	3:15- 5:30	Chapter 4	2 hr 15 min		
Day 6	**Time**	**Activity**	**Duration**		
Morning	8:30 - 8:45	Recap	15 min		
	8:45 - 10:00	Chapter 4	1 hr 15		
	10:00- 10:15	Coffee break			
	10:15- 12:30	Chapter 4	2 hrs 15min		
	12:30- 1:30	**Lunch**			
Afternoon	1:30- 3:00	Chapter 4	1 hr 30 min		
	3:00- 3:15	Coffee break			
	3:15- 5:30	Chapter 4	2 hrs 15 min		
Day 7	**Time**	**Activity**	**Duration**		
Morning	8:30 – 8:45	Recap	15 min		
	8:45 – 10:00	Chapter 5	1 hr 15 min		
	10:00 – 10:15	**Coffee break**			
	10:15 – 12:30	Chapter 5	2 hrs 15 min		
	12:30 – 1:30	**Lunch**			
After noon	1:30 – 3:00	Chapter 5	1hr 30 min		
	3:00 – 3:15	**Coffee break**			
	3:15 – 5:30	Chapter 5	2 hrs 15 min		
Day 8	**Time**	**Activity**	**Duration**		

Morning	8:30 – 8:45	Recap	15 min		
	8:45 – 10:00	Chapter 6	1 hr 15 min		
	10:00 – 10:15	**Coffee break**			
	10:15 – 12:30	Chapter 6	2 hrs 15 min		
	12:30 – 1:30	**Lunch**			
Afternoon	1:30 – 3:00	Chapter 6	1 hr 30 min		
	3:00 – 3:15	**Coffee break**			
	3:15 – 5:30	Chapter 6	2 hrs 15 min		
Day 9	**Time**	**Activity**	**Duration**		
Morning	8:30 – 8:45	Recap	15 min		
	8:45 – 10:00	Chapter 6	1 hr 15 min		
	10:00 – 10:15	**Coffee break**			
	10:15 – 12:30	Chapter 6	2 hrs 15 min		
	12:30 – 1:30	**Lunch**			
Afternoon	1:30 – 3:00	Chapter 7	1 hr 30 min		
	3:00 – 3:15	**Coffee break**			
	3:15 – 5:30	Chapter 7	2 hrs 15 min		
Day 10	**Time**	**Activity**	**Duration**		
Morning	8:30 – 8:45	Recap	15 min		
	8:45 – 10:00	Chapter 7	1 hr 15 min		
	10:00 – 10:15	Coffee break			
	10:15 – 12:30	Chapter 7	2 hrs 15 min		
	12:30 – 1:30	**Lunch**			
Afternoon	1:30 – 3:00	Chapter 7	1 hr 30 min		
	3:00 – 3:15	**Coffee break**			
	3:15 – 5:30	Chapter 7	2 hrs 15 min		

Chapter 1:

Caring, Respectful and Companionate Healthcare Service

Time: 160 minutes

CHAPTER DESCRIPTION:

This chapter is designed to equip healthcare professionals and senior management in health facilities to increase core competencies of compassionate, respectful, holistic, scientifically and culturally acceptable care for patients and their families.

CHAPTER OBJECTIVE:

By the end of this chapter the participants will be able to:

Describe Compassionate, respectful and Caring (CRC) healthcare service delivery

ENABLING OBJECTIVES:

By the end of this chapter participants will be able to:

- Describe Compassionate, respectful and caring (CRC)
- List principles of health care Ethics
- Discuss components of compassionate care
- Explain principles of respectful care
- Discuss characteristics of Compassionate leader

CHAPTER OUTLINE

1.1. INTRODUCTION TO COMPASSIONATE, RESPECTFUL AND CARING (CRC)

Individual reflection

What is Compassionate, Respect and Caring (CRC)?

Time Allowed 15 minutes

1.1.1. DEFINITION OF CRC

Compassion (ሩህሩህ)

Is a feeling of deep sympathy and sorrow for the suffering of others accompanied by a strong desire to alleviate the suffering? Therefore, we can say it is being sensitive to the pain or suffering of others and a deep desire to alleviate the suffering.

Respectful (ተገልፃይንየሚያከብር)

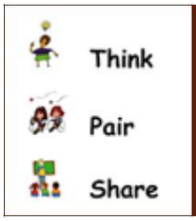
Is the kind of care, in any setting, which supports and promotes, and does not undermine a person's self-respect, regardless of any differences?

Caring (ተንከባካቢ)

Caring is an intensification of the affective dimension of empathy in the context of significant Suffering. It is coupled with effective interventions to alleviate that suffering.

Compassionate, respectful and Caring (CRC) -

Means serving patients, being ethical, living the professional oath, and being a model for young professionals and students. It's a movement that requires champions who identify with their profession and take pride by helping people.



•Why CRC a transformational agenda?

Time Allowed 10 minutes

1.1.2. WHY CRC A TRANSFORMATION AGENDA?

Helping health professionals' to become compassionate and respectful practitioners remains a major challenge for the healthcare. Compassionate and respectful care is not only morally and financially essential, but it is required in many countries through national legislation and/or national health policy. The notion that healthcare services must be expanded beyond the prevention of morbidity or mortality is only one aspect of the agenda. It must encompass respect for patients' basic human rights, including respect for patients' autonomy, dignity, feelings, choices, and preferences. It must include choice of companionship wherever possible.

Taken from the United Nations human rights declaration, 'All human beings are born free and equal in dignity and rights.' The Ethiopian constitution of human rights article 25 and 26 states that the rights to equality and privacy.

In the Ethiopian health system, there are many health professionals who have dedicated their entire career to public service and are respected by the public they serve. However, a significant proportion of health professionals see patients as just 'cases' and do not show compassion. Lack of respect to patients and their families is also a common complaint.

A three-year report of the Ethics Committee and relevant documents in Addis Ababa showed that 39 complaints were related to death of the patient and 15 complaints were about disability. The committee verified that 14 of the 60 claims had an ethical breach and/or negligence and other study also indicated that forwarding bad words, shouting on patients, mistreatment, insulting and hitting of clients are some of unethical practices showed by the health professionals.

STUDIES SHOWED THE NEED FOR CRC

Lack of role models in many health facilities.

Measuring the worth of a profession by how much it pays.

Senior physicians cancel their outpatient clinics without informing their patients.

Elective surgeries get cancelled.

Admitted patients are by default getting the care they need from relatives.

Nurses, for various reasons, have limited their role to providing injections and securing IV lines.

Proper counseling during dispensing of drugs is also becoming a rarity.

The quality of lab tests and the quality assurance process that lab professionals have to take before issuing results is not practiced as expected.

Lack of compassion, respect and care is the common source of grievances in health facilities.

1.1.3. THE BENEFITS OF CRC

Table 1.The benefits and beneficiaries of Compassionate and Respectful Care

Beneficiaries	Who	How
First	Patients	• When health professionals are compassionate, patients are less anxious • Adherence to medical advice and treatment plans • Compassionate care correlates positively with both prevention and disease management. Diabetic patients, for example, demonstrate higher self-management skills when they self-report positive relationships with their providers • Hostile emotional states in patients delay the healing processes • Quality of health professionals –patient communication with increased physical functioning, emotional health and decreased physical symptoms of pain in patients
Second	Health Professionals	• Health care Professionals satisfaction with their relationships with patients can protect against professional stress, burnout, substance abuse and even suicide attempts • Burnout is strongly associated with poorer quality of care, patient dissatisfaction, increased medical errors, lawsuits and decreased expressions of compassion • Participation in a mindful communication associated with short-term and sustained improvement in well-being and attitudes associated with patient care • A major predictor of patient loyalty • When health professionals are compassionate, they achieve earlier and more accurate diagnoses because the patient is better able to reveal information when he or she feels emotionally relaxed and safe • Respect from the client/patients • Health professionals will find their work more meaningful and gratifying
Third	Students	• Good role modeling is essential for students • Increased motivation to be CRC health professionals
Fourth	Health care facilities	• Patient satisfaction will rise • Quality of health care will be improved • Lower malpractice suits • Staff will be more loyal to their hospital or health care system • Patient adherence to treatment will rise • Resources can be conserved • Greater employee satisfaction and reduced employee turnover.

1.1.4. NATIONAL STRATEGY AND APPROACH OF CRC

The development of caring, respectful and compassionate health workers requires a multi-pronged approach in order to make CRC as a culture, self-driven inner motive and a legacy that the current generation of practitioners leaves to their successors.

NATIONAL STRATEGY AND APPROACHES FOR CRC

Reforming the recruitment of students for health science and medicine programs.

Improving the curriculum of the various disciplines.

Ownership and engagement of the leadership at all levels of the system.

Inspirational leadership that aims to create an enabling environment.

National, regional and facility level ambassadors.

An advocacy campaign through mass media will also be launched to project positiveimages of health professionals.

Patients and the general public will also be engaged in this movement.

An annual health professional recognition event will be organized

Putting in place a favorable legislative framework to reinforce CRC which would include regulation on patients' rights and responsibilities (PRR)

Measurement of health care providers on CRC

Comprehensive projects will be designed.

Conducting national assessment related to CRC.

Provision of continuous CRC trainings.

Engagement and ownership of professional associations.

Experience sharing from national and international best practices.

1.2. HEALTHCARE ETHICS

1.2.1. PRINCIPLES OF HEALTH CARE ETHICS

Individual reflection

❖What is ethics?

❖What is health care ethics?

Time: 5 Minutes

Ethics:

Ethics is derived from the Greek word ethos, meaning custom or character. Ethics is the study of morality, which carefully and systematically analyze and reflect moral decisions and behaviors, whether past, present or future. It is a branch of philosophy dealing with standards of conduct and moral judgment. Health care ethics:

It is a set of moral principles, beliefs and values that guide us to make choices about healthcare. The field of health and healthcare raises numerous ethical concerns, including issues of health care delivery, professional integrity, data handling, use of human subjects in research and the application of new techniques.

Ethical principles are the foundations of ethical analysis because they are the viewpoints that guide a decision. There are four fundamental principles of healthcare ethics.

Autonomy
Beneficence
Non-maleficence
Justice

1. AUTONOMY

Autonomy is the promotion of independent choice, self-determination and freedom of action. Autonomy implies independence and ability to be self-directed in one's healthcare. It is the basis of self-determination and entitles the patient to make decisions about what will happen to his or her body.

Case one:
A 49-year-old client with diabetic finding came with right foot second finger gangrene to a hospital. The surgeon decided that the finger should be removed immediately. But the patient refused the procedure.
Question: How should the surgeon handle this case?
Time: 5 Minutes

2. BENEFICENCE

Beneficence is the ethical principle which morally obliges health workers to do positive and rightful things. It is "doing what is best to the patient". In the context of professional-patient relationship the professionals are obliged to always and without exception, favor the wellbeing and interest of their patients.

Case two:
Ms. X was admitted to adult surgical ward with severe excruciating right flank pain with presumptive diagnosis of renal colic. Nurse Y was the duty nurse working that day. The physician who saw her at OPD did not write any order to alleviate the pain.
Question: What should the attending nurse do for Ms. X?
Time: 5 Minutes

3. NON-MALEFICENCE

The principle refers to "avoid doing harm". Patient can be harmed through omitting or committing interventions. When working with clients, healthcare workers must not cause injury or distress to clients. This principle of non-maleficence encourages the avoidance of causing deliberate harm, risk of harm and harm that occurs during the performance of beneficial acts. Non-maleficence also means avoiding harm as consequence of good.

Case Three:
Mr "X" is admitted to internal medicine ward with cardiac failure. The physician admitted Mr "X" and prescribed some medication which should be given regularly by the ward nurse. A nurse in charge of the ward does not give a patient medication timely and appropriately.
Question: What should the ward nurse do for Mr "X"
Time: 5 Minutes

4. JUSTICE

Justice is fair, equitable and appropriate treatment. Justice refers to fair handling and similar standard of care for similar cases; and fair and equitable resource distribution among citizens. It is the basis for treating all clients in an equal and fair way. A just decision is based on client need and fair distribution of resources. It would be unjust to make such decision based on how much he or she likes each client.

Example:

Resource scarcity is the common issue in healthcare settings. For example, there may be only one or two neurosurgeons and many patients on the waitlist who need the expertise of these neurosurgeons. In this case we need to serve patients while promoting the principle of justice in transparent way. Example, the rule of first come first serve could be an appropriate rule.

Justice requires the treatment of all patients equally, irrespective of their sex, education, income or other personal backgrounds.

1.2.2. CONFIDENTIALITY AND INFORMED CONSENT.

CONFIDENTIALITY

Confidentiality in healthcare ethics underlines the importance of respecting the privacy of information revealed by a patient to his or her health care provider, as well the limitation of healthcare providers to disclose information to a third party. The healthcare provider must obtain permission from the patient to make such a disclosure.

The information given confidentially, if disclosed to the third party without the consent of the patient, may harm the patient, violating the principle of non-maleficence. Keeping confidentiality promotes autonomy and benefit of the patient.

THE HIGH VALUE THAT IS PLACED ON CONFIDENTIALITY HAS THREE SOURCES:

Autonomy: personal information should be confidential, and be revealed after getting a consent from the person

- **Respect for others:** human beings deserve respect; one important way of showing respect is by preserving their privacy.

Trust: confidentiality promotes trust between patients and health workers.

THE RIGHT OF PATIENT TO CONFIDENTIALITY

All identifiable information about a patient's health status, medical condition, diagnosis, prognosis and treatment and all other information of a personal kind, must be kept confidential, even after death. Exceptionally, family may have a right of access to information that would inform them of their health risks.

Confidential information can only be disclosed if the patient gives explicit consent or if expressly provided for in the law. Information can be disclosed to other healthcare providers only on a strictly "need to know" basis unless the patient has given explicit consent.

All identifiable patient data must be protected. The protection of the data must be appropriate to the manner of its storage. Human substances from which identifiable data can be derived must also be protected.

EXCEPTIONS TO THE REQUIREMENT TO MAINTAIN CONFIDENTIALITY

Routine breaches of confidentiality occur frequently in many healthcare institutions. Many individuals (physicians, health officers, nurses, laboratory technicians, students, etc) require access to a

patient's health records in order to provide adequate care to that person and, for students, to learn how to practice care provision.

Care providers routinely inform the family members of a deceased person about the cause of death. These breaches of confidentiality are usually justified, but they should be kept to a minimum and those who gain access to confidential information should be made aware of the need not to spread it any further than is necessary for descendants benefit. Where possible, patients should be informed ahead that such a breach might occur.

Many countries have laws for the mandatory reporting of patients who suffer from designated diseases, those deemed not fit to drive and those suspected of child abuse. Care providers should be aware of the legal requirements to be able to disclose patient information. However, legal requirements can conflict with the respect for human rights that underlies healthcare ethics. Therefore, care providers should look carefully at the legal requirement to allow such an infringement on a patient's confidentiality and assure that it is justified.

Case four:
An HIV-positive individual is going to continue to have unprotected Sexual intercourse with his spouse or other partners. **Question:**
How do you manage such an individual?
Discuss situations that breach confidentiality.
Time: 5 Minutes

Ethiopia Council of ministers' regulation 299/2013, Article 77 Professional Confidentiality

INFORMED CONSENT

Informed consent is legal document whereby a patient signs written information with a complete information about the purpose, benefits, risks and other alternatives before he/she receives the care intended. It is a body of shared decision making process, not just an agreement. Patient must obtain and being empowered with adequate information and ensure that he/she participated in their care process.

For consent to be valid, it must be voluntary and informed, and the person consenting must have the capacity to make the decision. These terms are explained below:

A. Voluntary: the decision to either consent or not to consent to treatment must be made by the person him or herself, and must not be influenced by pressure from medical staff, friends or family. This is to promote the autonomy of the patient.

B. Informed: the person must be given all of the information in terms of what the treatment involves, including the benefits and risks, whether there are reasonable alternative treatments and the consequences of not doing the treatment. This will help to avoid harm—patients may harm themselves if they decide based on unwarranted and incorrect information.

C. Capacity: the person must be capable of giving consent, which means they understand the information given to them, and they can use it to make an informed decision.

GENERAL PRINCIPLE OF INFORMED CONSENT

Should be given by a patient before any medical treatment is carried out.The ethical and legal rationale behind this is to respect the patient's autonomy and their right to control his or her life. The basic idea of personal autonomy is that everyone's actions and decisions are his or her own.

The principles include:

Information for patients

Timing of consent process

Health Professionals responsibility for seeking consent

Decision making for incompetent patients

Refusal of treatment

Ethiopia Council of minister's regulation 299/2013, Article 52. Patient's informed consent

1.2.3. PREVENTIVE ETHICS IN THE ASPECT OF CRC

WHAT IS PREVENTIVE ETHICS?

Preventive Ethics is a systematic application of ethical principles and values to identify and handle ethical quality gaps, dilemmas, challenges and errors to appropriately and fairly. It could be carried out by an individual or groups in the health care organization to identify prioritize and systematic address quality gaps at the system level.

WHY IS PREVENTIVE ETHICS IMPORTANT FOR CRC HEALTHCARE WORKERS?

First and foremost, the CRC health workforce, patients, families and the community at large should have a common understanding that the experience of illness and the practice of medicine lead to situations where important values and principles come to conflict and ethical dilemmas and challenges arise everywhere. Moreover, the CRC health worker should always understand the context in which She/he operates (like the services, the clients, the providers, values, norms, principles, culture, religions, socio-economic-geographic…) as the way in which ethical dilemmas are handled vary from case to case and place to place.

Preventive ethics helps the CRC health workforce to predict, identify, analyze, synthesize and manage ethical dilemmas, challenges and errors to make the appropriate and fair decisions. Hence, preventive ethics enhances honesty and transparency between healthcare workers, patients, families and relevant others to make a deliberated joint decision. Moreover, it inspires mutual understanding and trust amongst the healthcare provider, recipient and the community at large.

Preventive ethics brings all efforts together productively and leads to the satisfaction of clients, providers and the community even if when the decisions are sometimes painful and outcomes are negative.

1.2.4. ETHICS AND LAW AS ENABLERS OF CRC

THE RELATION BETWEEN ETHICS AND LAW

Individual reflection

What is the relationship between ethics and law?

Time: 5 Minutes

ETHICS as discussed in the previous sessions, is considered as a standard of behavior and a concept of right and wrong beyond what the legal consideration is in any given situation.

LAW is defined as a rule of conduct or action prescribed or formally recognized as binding or enforced by a controlling authority. Law is composed of a system of rules that govern a society with the intention of maintaining social order, upholding justice and preventing harm to individuals and property. Law systems

are often based on ethical principles and are enforced by the police and Criminal justice systems, such as the court system.

Ethics and law support one another to guide individual actions; how to interact with clients and colleagues to work in harmony for optimum outcome; provision of competent and dignified care or benefits of clients/ patients. Ethics serves as fundamental source of law in any legal system; and Healthcare ethics is closely related to law. Though ethics and law are similar, they are not identical.

Often, ethics prescribes higher standards of behavior than prescribed by law; and sometimes what is legal may not be ethical and health professionals will be hard pressed to choose between the two. Moreover, laws differ significantly from one country to another while ethics is applicable across national boundaries.

The responsibilities of healthcare professionals and the rights and responsibilities of the patient is stipulated in legal documents of EFMHACA like regulation 299/2013, directives and health facility standards.

1.3. PRINCIPLES AND STANDARDS OF COMPASSIONATE CARE

1.3.1. QUALITIES OF COMPASSIONATE CARE

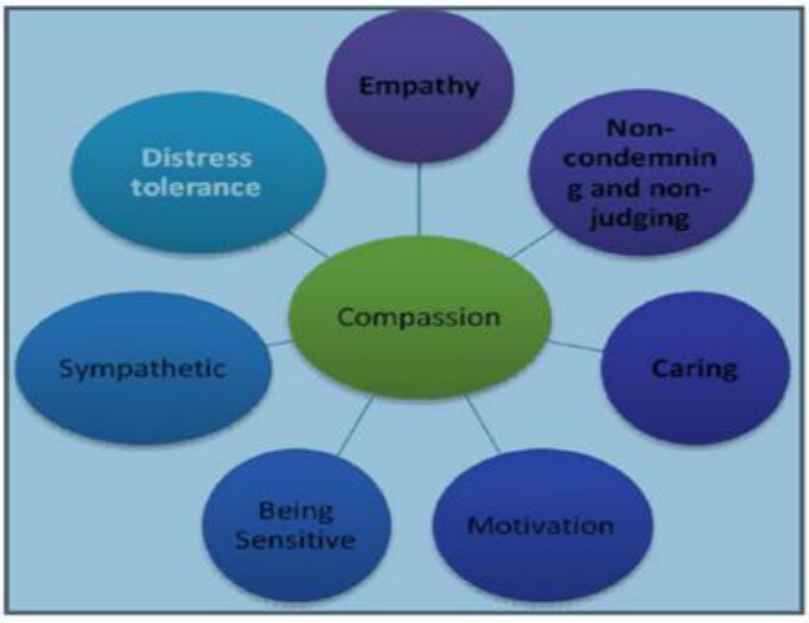
Compassion can be defined as: “sensitivity to the suffering of self and others with a deep wish and commitment to relieve the suffering”.

Developing more compassion can be a way to balance emotions to increase the well-being of patients, healthcare professionals and facilitation of healthcare delivery. For patients, compassion can help prevent health problems and speed-up recovery. Compassion can improve staff efficiency by enhancing cooperation between individuals and teams and between patient and healthcare professionals.

Individual reflection

Can compassion be trained and learned? Time Allowed: 5 Minutes

Qualities of Compassionate Care



Role play on qualities of compassionate care:
Instructions:
One participant will take the role of a healthcare provider and another participant will take the role of a mother [with limited mobility] of a sick child with a feeding problem. Other participants should observe and note the discussion.

Roles
Healthcare provider
A mother (with limited mobility) of a sick child:

Situation:
A mother with limited mobility brings her 3-month-old baby girl with cough and fever to the outpatient clinic. The healthcare provider seemed tired. By the time the mother enters the examination room, he was talking with his subordinate about last night's football game. He had already noticed her but did not let her to sit. Her child was crying and she was trying to quiet her.
All of a sudden the healthcare provider shouted loudly at the mother to quiet her child or they would have to leave.

While waiting and calming her child, the mother told the healthcare provider that her child is very sick and needs an urgent care. While facing to his friend, the healthcare provider told the mother that he would see her child in five minutes.

After waiting for 10 minutes, the healthcare provider started to examine the child and felt sad about the condition of the child; apologized to her for having let her wait so long. The healthcare provider evaluated the child gently, gave the child a proper treatment, reassured the mother, and the child went home better.

Discussion Questions
Did the health provider demonstrate the characteristics of compassion?
If not, what are the areas /conversation that show poor characteristics of compassion?

If yes, what are the areas /conversation that show good characteristics of compassion?

Time allowed: 30 minutes

1.3.2. ELEMENTS OF COMPASSIONATE CARE

According to researches the key elements of compassionate care has categories, each contains theme and subthemes.

Virtue: It is described as ‘‘good or noble qualities embodied in the character of the health care provider

Relational space: is defined as the context and content of a compassionate encounter where the person suffering is aware of and is engaged by, the virtues of the health care provider.

THE CATEGORY OF RELATIONAL SPACE COMPRISED TWO THEMES.

Patient awareness which describes the extent to which patients intuitively knew or initially sensed health care provider capacity for compassion.

Engaged care giving which refers to tangible indicators of health care provider compassion in the clinical encounter that established and continued to define the health care provider-patient relationship over time.

Virtuous Response: It is the "Enactment of a virtue toward a person in suffering,'' and it is both an individual category and an overarching principle of care that functions as a catalyst to the three core categories of compassionate care giving: ''seeking to understand, relational communicating, and attending to needs'' The category of virtuous response contain three broad themes within it:

Knowing the person refers to the extent to which healthcare providers approached their patients as persons and view their health issues and suffering from this point of view.

Seeing the person as priority involves healthcare providers' ability to priorities patient needs, setting aside their own assumptions and healthcare system priorities in the process.

Beneficence refers to healthcare providers wanting the best for the patient, informing the three more targeted core categories of compassionate care giving.

Seeking to Understand: refers to healthcare providers trying to know the patient as a person and his or her unique needs.

The need to understand a person's desires and tailor his or her care is identified by most patients as a fundamental feature of compassion.

Seeking to Understand the Person.

Seeking to Understand the needs of the Person

Relational Communication: isan important element of compassion identified by patients consisting of verbal and nonverbal displays conveyed by the healthcare provider's engagement with the person suffering.

There are four specific themes and associated subthemes that convey compassion within clinical communication:

Demeanor (''being'')

Affect (''feeling for'')

Behaviors (''doing for'')

Engagement (''being with'')

ATTENDING TO NEEDS

It refers to ''a timely and receptive desire to actively engage in and address a person's multi-factorial suffering''. Attending to patients' needs has three interrelated themes:

Compassion-Related Needs: refers to the dimensions of suffering that patient feel compassion: physical, emotional, spiritual, familial and financial.

Timely refers to addressing suffering in a ‘‘timely’’ manner.

Action refers to the initiation and engagement of a dynamic and tangible process aimed at alleviating suffering. Compassion is more action.

1.3.3. PRINCIPLES OF COMPASSIONATE CARE

Individual reflection

What are the principles of compassionate care?

Time Allowed: 5 Minutes

The universal principles of compassion will help us know one another in a more meaningful way where we discover one another respectfully. They create the conditions that allow a person who is suffering to experience the healing power of compassion.

Attention: is the focus of healthcare provider. Being aware will allow the healthcare provider to focus on what is wrong with a patient; or what matters most to the patient.

Acknowledgement: is the principle of what the healthcare professional says. The report of the examination or reflection on the patient’s message. Positive messages of acknowledgment are buoyant; they let someone know that you appreciate them as a unique individual.

Affection: is how healthcare providers affect or touch people. Human contact has the ability to touch someone’s life. It is the quality of your connection, mainly through warmth, comfort, kindness and humor. Affection brings joy and healing.

Acceptance: is the principle of being with mystery – how you stand at the edge of your understanding or at the beginning of a new experience, and regard what is beyond with equanimity. It is the quality of your presence in the face of the unknown, in the silence. Like the sun in the north at midnight, acceptance welcomes the mysteries of life and is at peace with whom we are and where we are, right now. It is the spirit of Shalom.

•The principle of acceptance is: being at peace with the way things are allows them to change.

1.3.4. THREATS TO COMPASSIONATE CARE

There are factors preventing compassion and compassionate behavior for individual members of staff, teams and units and health facility. Most research discusses compassion at the individual level. In general, the most common threats for compassionate care are:

Compassionate fatigue: Physical, emotional and spiritual fatigue or exhaustion resulting from care giving that causes and a decline in the caregivers’ ability to experience joy or feel and care for others.

A form of burnout, a kind of “secondary victimization” what is transmitted by clients or patients to care givers through empathetic listening.

Unbalanced focus between biomedical model (clinical training) and person: Effective clinical care is clearly fundamentally important, but human aspects of medicine and care must also be valued in training and in terms of how to be a good healthcare professional.

Stress, depression and burnout:

Self-reported stress of health service staff is reported greater than that of the general working population.

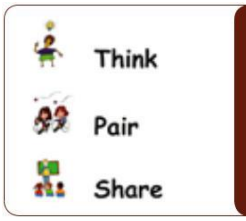
Burnout (or occupation burnout) is a psychological term referring to general exhaustion and lack of interest or motivation to work.

Overall health facility context: Attention by senior managers and health facility boards to achieve financial balance that affects priorities and behaviors of staff in health facility.

ADDRESSING THREATS OF COMPASSION
Overcoming compassion fatigue
Developing an inner compassionate self
Compassion to yourself
Teaching compassion to professionals through, training and education
Dealing with staff stress and burnout
Dealing with wider health facility context

1.4. RESPECTFUL CARE

1.4.1. DEFINITION OF CONCEPTS OF RESPECTFUL AND DIGNIFIED CARE



Can you share us your experience with regard to respect and dignity in the health care setting?

What does respectful care mean to you?

Time Allowed: 10 minutes

Definition of Dignity (ልእልና)

The word dignity originates from two Latin words: ‘dignitus’ which means merit and ‘dignus’ meaning worth. It is defined from two perspectives:

Dignity is a quality of the way we treat others.

Dignity is a quality of a person’s inner self.

Types of Dignity

There are four types of dignity: dignity of human being, personal identity, merit and moral status.

1. Dignity of human being

This type of dignity is based on the principle of humanity and the universal worth of human beings their inalienable rights-which can never be taken away.

2. Dignity of personal identity

This form of dignity is related to personal feelings of self-respect and personal identity, which also provides the basis for relationships with other people.

3. Dignity of merit

This is related to a person’s status in a society.

4. Dignity of moral status

This is a variation of dignity of merit, where some people have a personal status because of the way they perceived and respected by others. (N.B. Refer to Hand-out 3.1 for details.)

Attributes of Dignity

There are four attributes of dignity:

Respect: self-respect, respect for others, respect for people, confidentiality, self-belief and believe in others

Autonomy: having choice, giving choice, making decisions, competence, rights, needs, and independence

Empowerment: Feeling of being important and valuable, self-esteem, self-worth, modesty and pride

Communication (may be verbal or non-verbal): explaining and understanding information, feeling comfort, and giving time to the patients / families

Definition of Respect (አክብሮት)

It is a term which is intimately related to dignity

It is probably the most important action verb used to describe how dignity works in practice.

THE ACTION MEANINGS OF THE WORD RESPECT ARE:
Pay attention to
Honoring
Avoiding damage e.g. insulting, injuring
Not interfering with or interrupting
Treating with consideration
Not offending

People can vary by their skills, educational background, gender, age, ethnicity, and experiences. But, as human being, all are entitled to get dignified and respectful care. Every human being must respect others and get respect from others. Therefore, dignity is brought to life by respecting people:

Rights and freedoms

Capabilities and limits

Personal space

Privacy and modesty

Culture

Individuals believes of self-worth

Personal merits

Reputation

Habits and values

DIGNITY AND RESPECT IN THE HEALTH CARE SETTING

Treating clients with dignity implies treating them with courtesy and kindness, but it also means:

Respecting their rights

Giving them freedom of choice

Listening and taking into consideration what they say and

•Respecting their wishes and decisions, even if one disagrees.

Treating clients with dignity implies being sensitive to clients' needs and doing one's best for them, but it also means:

Involving them in decision making

Respecting their individuality

Allowing them to do what they can for themselves and

Giving them privacy and their own personal space

1.4.2. PRINCIPLES OF RESPECTFUL CARE

Individual reflection

Think of a person who gave you the most respectful care/service.

- Describe the situation?
- What are the qualities of that person?
- What did you value most?

Time: 5 Minutes

The principles of respectful care guide actions and responsibility of care providers in ensuring dignified care for their service users. Dignified care has seven core principles.

Recognize diversity and uniqueness of individuals

Uphold responsibility to shape care

Meaningful conversation

Recognize the care environment

Recognize factors affecting dignity

Value workplace culture

Challenge dignity barriers

1.4.3. CHARACTERISTICS OF DISRESPECTFUL CARE

The situation where you received disrespectful care?

Describe the incident?

What was your reaction?

Time: 5 Minutes

THE SEVEN CATEGORIES OF DISRESPECT AND ABUSE

Category	example
Physical Abuse	Slapping, pinching, kicking, slapping, pushing, beating,
Non-consented care	Absence of informed consent or patient communication, forced procedures
Non-confidential care	Lack of privacy (e.g. Laboring in public or disclosure of patient information
Non-dignified care	Intentional humiliation, rough treatment shouting, blaming, treating to withhold services laughed at patients, provider did not introduce themselves, patients not called by their names throughout the interaction.

Discrimination based on specific patient attributes	Discrimination based on ethnicity, age, language, economic status, education level, etc.
Abandonment of care	Women left alone during labor and birth Failure of providers to monitor patients and intervene when needed
Detention in facilities	Detention of patients/family in facility after delivery, usually due to failure to pay

1.4.4. FACTORS AFFECTING RESPECTFUL CARE PROVISION

Individual reflection

What do you think hinders you from providing respectful care in your health facility?

What are the factors that facilitates provision of respectful care in your health facilities?

Time: 5 Minutes

Different Factors have a significant impact on hindering or facilitating the provision of respectful careservice. These factors can be broadly classified in to three major groups; Health care environment, staff attitude & behavior and patient factors

Positive attributes of the physical environment which helped health professional to provide dignified care are related to aspects maintaining physical and informational privacy and dignity, aesthetically pleasing surroundings and single sex accommodation, toilet and washing facilities. Aspect of the environment that maintain physical and informational privacy are listed below

Environmental privacy (for example curtains, doors, screens and adequate separate rooms for intimate procedures or confidential discussions (auditory privacy).

Privacy of the body: covering body, minimizing time exposed, privacy during undressing and clothing are some of the enabling factors to ensure bodily privacy done by health professionals.

Aesthetic aspects of the physical environment (for example space, color, furnishing, décor, managing smells); and the provision of accommodation, toilet and washing facilities

Managing peoples in the environment: such as other patients, family and ward visitors/public contribute positively to maintain dignity in the health

Adequate mix and proficient Staffing: adequately staffed with appropriate number and skill mix, as high workload affects staff interactions, and have strong leaders who are committed to patient dignity.

Physical environment which hinders health professional form providing respectful care are related to the overall health care system, lack of privacy, restricted access to facility /service and lack of resources. Aspect of the environment that hinders the provision of respectful care are listed below,

The healthcare System: Shortage of staff, unrealistic expectations, poorly educated staff, ‘quick fix’ attitude, low wage, pay ‘lip service’ to dignity, low motivation, lack of respect among professionals, normalization/tolerance of disrespectful care, lack of role model, management bureaucracy and unbalanced staff patient ratio and skill mix.

Lack of privacy: Lack of available single rooms, bath rooms and toilets without nonfunctional locks, use of single rooms only for infectious cases and lack of curtains or screens

Restricted access to facility/service: Badly designed rooms, inadequate facilities (e.g. toilets, bath rooms), Cupboards with drawers that does not open, toilet and bath rooms shared between male and females.

• Lack of resource: Run out of hospital, gowns and pyjamas, Lack of medical equipment and supplies

The A, B, C, of respectful health care, is a tool designed to consider the attitudes and behaviors of health care providers

–ATTITUDE

Ask yourself:

How would I be feeling if I was this person?

Why do I think and feel this way?

•Are my attitudes affecting the care I provide and, if so, how?

•Are my personal beliefs, values, and life experiences influencing my attitude?

ACTION TO BE TAKEN

Reflect on these questions as part of your everyday practice.

•Discuss provider attitudes and assumptions and how they can influence the care of patients with the care team.

•Challenge and question your attitudes and assumptions as they might affect patient care

• Help to create a culture that questions if and

B- BEHAVIOR

• Introduce yourself. Take time to put the patient at ease and appreciate their circumstances.

Be completely present. Always include respect and kindness.

Use language the patient/family can understand

C-COMMUNICATION

Communication revolving around the patient's needs.

Patient centered communication with defined boundaries

TEN MECHANISMS TO MITIGATE THREATS TO RESPECTFUL CARE -

Support clients with same respect you would want for yourself or a member of your family

Have a zero tolerance of all forms of disrespect

Respect clients' right to privacy

Maintain the maximum possible level of independence, choice, and control

Treat each client as an individual by offering personalized care

Assist clients to maintain confidence and a positive self esteem

Act to alleviate clients' loneliness and isolation

Listen and support clients to express their needs and wants

Ensure client feel able to complain without fear of retribution

Engage with family members and care givers as care partners?

1.5. COMPASSIONATE LEADER

1.5.1. QUALITY OF COMPASSIONATE LEADERSHIP

Group exercise

Discuss in a group of 4-5 and share your experience to the larger group.

What does it mean for you to lead, and manage?

Can you give an example of a leader whom you know in your professional or personal life? What makes him or her good leader for you?

Do you know of any individuals in high positions or authority who demonstrate compassionate, respectful and caring practices when they deal with their staff and clients?

Duration: 20 minutes

BRIEF DESCRIPTION OF LEADERSHIP THEORIES

Introduces transactional, transformational, and servant leadership theories. It will also provide a better understanding of qualities of CRC leaders, which will enable participants to provide better service and increase awareness of CRC leadership.

Transformational leaders: lead employees by aligning employee goals with their goals. Thus, employees working for transformational leaders start focusing on the company's well-being rather than on what is best for them as individual employees.

Transactional leaders: ensure that employees demonstrate the right behaviors because the leader provides resources in exchange.

Servant Leadership: defines the leader's role as serving the needs of others. According to this approach, the primary mission of the leader is to develop employees and help them reach their goals. Servant leaders put their employees first, understand their personal needs and desires empower them and help them develop their careers.

CHARACTERISTICS OF COMPASSIONATE LEADERS

'In-tune' feeling: Their actions abide by their words – and they always have the time to engage with others.

Manage their moods: They know feelings affect others and they use positive emotions to inspire, not infect others with negative feelings.

Put people before procedures: They are willing to set aside or change rules and regulations for the greater good.

Show sincere, heartfelt consideration: They genuinely care for the well-being of others and have a humane side that puts other people's needs before theirs.

Are mindful: They are aware of their own feelings and their impact on others. They are also attentive and sympathetic to the needs of others.

Are hopeful: They move others passionately and purposefully with a shared vision that focuses on positive feeling of hope.

Courage to say what they feel: They communicate their feelings, fears, even doubts which builds trust with their employees.

Engage others in frank, open dialogue: They speak honestly with humility, respect and conviction, and make it safe for others to do the same.

Connective and receptive: They seem to know what other people are thinking and feeling.

Take positive and affirming action: They carry out compassion. They do not just talk about it; they make a promise, act on it and keep it.

WHAT DOES COMPASSIONATE LEADERSHIP DO FOR THE ORGANIZATION?

Positively affects sufferers, clients, employees

Increases people's capacity for empathy and compassion

Promotes positive relationships

Decreases the prevalence of toxic viral negative emotions and behavior

Increases optimism and hope

Builds resilience and energy levels

Counteracts the negative effects of judgment and bias

SELF-EVALUATION OF COMPASSIONATE BEHAVIOR

Good leaders can evaluate their own behavior using different methodologies. The self-assessment of compassionate leaders should be conducted every six months to enhance self-compassion through mindfulness.

Mindfulness begins with self-awareness: knowing yourself enables you to make choices how you respond to people and situations. Deeper knowledge about yourself enables you to be consistent, to present yourself authentically. You will learn and practice different ways to develop mindfulness and explore how it can contribute to developing compassionate leadership practices through:

Enhancing attention and concentration

Increasing creativity and flexibility

Working efficiently in complex systems and uncertain environments

Creating meaning and purpose

Making effective and balanced decisions

Responding effectively to difference and conflict

Acting with compassion and kindness

Enhancing relationships and partnerships

Enabling genuine and courageous action

Working ethically and wisely

Developing cultural intelligence

1.5.2. SYSTEMS THINKING FOR CRC

Group activity in healthcare system thinking

Discuss in a group of 4-5 and share your experience to the larger group.

- Discuss concepts of Health System and how it relates with your Health Facility /Hospital and Health Center/ functions.
- Take your Health Facility/Hospital and Health Center/ and list the various department/core processes/support processes. Using a systems thinking approach, discuss how they interact with each other?
- Take in to account the CRC concepts and identify gaps you may have experienced in your facilities?

Duration: 20 minutes

System: A system is a set of interacting or interdependent components forming an integrated whole.

Health System: A health system consists of all the organizations, institutions, resources and people whose primary purpose is to improve health.

Fully functional health system: A point which various management systems and subsystems are connected and integrated to provide the best possible health services to all the intended beneficiaries of those services.

Management systems: The various components of the overall health system that managers use to plan organize and keep track of resources. Management systems are run by people living in different contexts.

INTEGRATE CRC INTO EXISTING SYSTEM

Integration of new initiatives into existing system has paramount importance in expediting the process of implementation and ensuring sustainability of CRC in a health system. Integration can be done using “AIDED” model.

Assess: Understand the capacity of the unit structure, especially in regards to the availability of resources, as well as human resource; also to assess the level of human capability when integrating and sustaining the CRC by determining the level of support the unit requires before or after carrying out CRC.

Innovate: Design and package the CRC to fit with the existing quality of unit structure and their environmental context to spread the CRC throughout the hospital departments.

Develop: Build upon existing knowledge of main stakeholders and opinion leaders by encouraging hospital policies, organizational culture, and infrastructure to support the implementation of principles of CRC.

Engage: Use existing roles and resources within the hospital units to introduce, translate, and integrate CRC principles into each employee’s routine practices.

Devolve: Capitalize on existing organizational network of index user groups to release and spread the innovation to new user groups.

1.5.3. ORGANIZATIONAL CULTURE

Organizational culture consists of the values and assumptions shared within an organization. Organizational culture directs everyone in the organization toward the “right way” to do things. It frames and shapes the decisions and actions of managers and other employees. As this definition points out, organizational culture consists of two main components: shared values and assumptions.

Shared Values: are conscious perceptions about what is good or bad, right or wrong. Values tell us what we “ought” to do. They serve as a moral guidance that directs our motivation and potentially our decisions and actions.

Assumptions: are unconscious perceptions or beliefs that have worked so well in the past that they are considered the correct way to think and act toward problems and opportunities.

Five key systems influence the hospital’s effective performance with respect to improving the safety and quality of patient care, as well as sustaining these improvements. The systems are:

Using data

Planning

Communicating

Changing performance

Staffing

LEADERS CREATE AND MAINTAIN A CULTURE OF SAFETY AND QUALITY THROUGHOUT THE HOSPITAL. RATIONALE

CRC thrives in an environment that supports teamwork and respect for other people, regardless of their position in the organization.

Leaders demonstrate their commitment to CRC and set expectations for those who work in the organization. Leaders evaluate the culture on a regular basis.

Leaders encourage teamwork and create structures, processes, and programs that allow this positive culture to flourish. Disruptive behavior that intimidates others and affects morale or staff turnover can be harmful to patient care.

Leaders must address disruptive behavior of individuals working at all levels of the organization, including management, clinical and administrative staff, licensed independent practitioners, and governing body members.

CREATING AN ORGANIZATIONAL CULTURE OF EMPOWERING EMPLOYEES FOR CRC

Having empowered employees is the aim of many leaders. Literature has reported that creating an organizational culture will empower employees to increase customer satisfaction levels, as well as to improve employee morale and productivity.

Employee empowerment encourages communication, participation in shared decision-making and enabling physicians and staff to reach their full potential by creating and optimal healing environment.

There are many different ways to build employee empowerment and engagement, but all share six fundamental actions to promote CRC on the part of leadership:

Share information and communication: Sharing information with employees is important because it not only helps to build trust; it gives employees important information to allow them to make the best possible decisions in critical situations when providing CRC services.

Create clear goals and objectives: Inspire employees to embrace the mission or changes of the organization by appealing to their innate desire to help patients and provide an efficient CRC service. Great leaders share important information in a structured and consistent manner.

Teach, accept and encourage: If you empower employees to make decisions that will help keep customers happy, then you have to be willing to allow them to make mistakes and learn from those mistakes.

Reward Self-Improvement: Create an environment that celebrates both successes and failures. A good leader celebrates successes; and employees who take risks for the benefits of patients/client; also, a good leader will assist employees to develop a plan for growth and reward them as they advance.

Support a learning environment: Listen to the voice of physicians, nurses and other staff to understand key barriers, issues, and opportunities to allow them to have a voice in crafting solutions for CRC challenges.

Create a clear role of autonomy: Enable frontline workers to execute change by supplying resources (education, funding, access to other skill sets within the health facility, etc.) and removing obstacles themselves.

1.5.4. LEADING CRC HEALTH TEAMS

Group activity

Discuss in a group of 4-5 and share your experience to the larger group.

What principles do you think of when implementing CRC?

Do you think there are differences between your current “leading” style and leading based on CRC? If yes, list the differences.

Duration: 10 minutes

Health facility leaders have intersecting roles as public servants, providers of health care, and managers of both healthcare professionals and other staff.

As public servants, health facility leaders are specifically responsible for maintaining the public trust, placing duty above self-interest and managing resources responsibly

As healthcare providers, health facility leaders have a fiduciary obligation to meet the healthcare needs of individual patients in the context of an equitable, safe, effective, accessible and compassionate health care delivery system.

As managers, leaders are responsible for creating a workplace culture based on integrity, accountability, fairness and respect.

ETHICAL HEALTHCARE LEADERS APPLY AT LEAST THE FOLLOWING SIX SPECIFIC BEHAVIORAL TRAITS:

Ethically conscious: Have an appreciation for the ethical dimensions and implications of one’s daily actions and decisions or, as described by author John Worthily, the “ethics of the ordinary” (reference?).

Ethically committed: Be completely devoted to doing the right thing.

Ethically competent: Demonstrate what Rush worth M. Kidder, president and founder of the Institute for Global Ethics, calls “ethical fitness,” or having the knowledge and understanding required to make ethically sound decisions (reference).

Ethically courageous: Act upon these competencies even when the action may not be accepted with enthusiasm or endorsement.

Ethically consistent: Establish and maintain a high ethical standard without making or rationalizing inconvenient exceptions. This means being able to resist pressures to accommodate and justify change inaction or a decision that is ethically flawed.

Ethically candid: Be open and forthright about the complexity of reconciling conflicting values; be willing to ask uncomfortable questions and be an active, not a passive, advocate of ethical analysis and ethical conduct.

PROBLEM-SOLVING IN HEALTHCARE

Steps of Scientific Problem Solving Skills

Define the problem

Set the overall objective

Conduct a root cause analysis

Generate alternative interventions

Perform comparative analysis of alternatives

Select the best intervention

Develop implementation plan and implement plan

Develop evaluation plan and evaluate

BEST PRACTICE IDENTIFICATION

Criteria to select best practices

New/Novel idea- not much practiced in other hospitals in Ethiopia

Effectiveness: has brought empirical change to the implementation of CRC specifically to patient satisfaction and quality of service provision. The practice must work and achieve results that are measurable.

Relevant/impact: improved CRC and quality of patient experience (Explain the relevance of the innovation using a clear baseline and current performance of CRC)

Diffusible: implemented at low cost in other facilities or implemented innovation in other hospitals.

Sustainable: Innovation is easy to understand, easy to communicate and works for long time.

Political commitment: The proposed practice must have support from the relevant national or local authorities.

Ethical soundness: The practice must respect the current rules of ethics for dealing with human populations.

By definition, “Best Practices” should be “new/novel”, “effectiveness” and “relevance”.

MONITORING AND EVALUATION OF CRC HEALTH TEAM

Potential focus areas where leaders focus to evaluate their CRC staff

Quality of work: Provide accuracy and thorough CRC service

Communication and interpersonal skills: listening, persuasion and empathy to clients/patients and teamwork and cooperation in implementing CRC

Planning, administration and organization: setting objectives, and prioritizing CRC practice

CRC knowledge: knowledge-base training, mentoring, modeling and coaching

Attitude: dedication, loyalty, reliability, flexibility, initiative, and energy towards implementing CRC

Ethics: diversity, sustainability, honesty, integrity, fairness and professionalism

Creative thinking: innovation, receptiveness, problem solving and originality

Self-development and growth: learning, education, advancement, skill-building and career planning

1.6 SUMMARY

Dignity of human being is the basis for healthcare delivery

Clients should be treated as human being not as cases

Disrespect and abuse is a problem in Ethiopia.

Zero Tolerance to Disrespectful care shall be a motto for all health workers in the health facilities.

Improving the knowledge of ethics is important to boost the ethical behavior in practice

Chapter 2:
MICROSCOPE

Time: 8 hrs

CHAPTER DESCRIPTION:

This chapter is designed to provide participants with the necessary knowledge, skills and attitude required for laboratory equipment maintenance for biomedical engineers and technicians. It covers basic working principles, purposes, main components, troubleshooting techniques and safety procedures for Clinical microscope

CHAPTER OBJECTIVE:

At the end of this chapter participants will be able to identify faults and maintain Microscope

ENABLING OBJECTIVES:

By the end of this chapter participants will be able to:

- Describe uses/purpose of microscope
- Identify types of microscope
- Explain working principles of microscope
- List and define basic parts and components of microscope
- Perform the steps for troubleshooting techniques of microscope
- Practice and differentiate the types of maintenance for microscope
- Identify and approve performance test procedures in microscope
- Handle microscope with appropriate care
- Implement safety needed for the equipment and user in for microscope

CHAPTER OUTLINE

2.1. INTRODUCTION

Individual activity

Explain the purpose of laboratory in the hospital

List some Laboratory Equipment

Time:10 min

A microscope is an instrument designed to make fine details visible. It is used to see objects that are too small for naked eye. The microscope must accomplish three tasks that are produce a magnified image of the specimen (magnification), separate the details in the image (resolution), and render the details visible to the eye, camera, or other imaging device (contrast).

2.2. PURPOSE/USE OF MICROSCOPE

The main purpose of microscope is to view objects that are not visible to the naked eye. Laboratory microscope uses to diagnose diseases like malaria, roundworms, tuberculosis, dysentery, crypto sporidium giardia.

2.3. TYPES OF MICROSCOPE

Microscope can be classified based on purpose for which it is intended, Image making physical principles, area of application and versatility.
Basically microscope classified as follows:

2.3.1. LIGHT MICROSCOPES

2.3.1.1 Simple Microscope:

A simple glass magnifier is used. (Convex lenses (thicker in the center than the periphery)). The specimen or object could be focused by use of the magnifier placed between the object and the eye.

2.3.1.2 Compound microscope:

It is type of microscope which most widely used. It consisted of two convex lenses aligned in series i.e.an object glass (objective) closer to the object or specimen, and an eyepiece (ocular) closer to the observer's eye with means of adjusting the position of the specimen and the microscope lenses.
The compound microscope achieves a two-stage magnification. The objective projects a magnified image into the body tube of the microscope and the eyepiece further magnifies the image projected by the objective (more of how this is done later).Can magnify up to 2000x

2.3.1.3 Dissection or Stereo Microscope:

It is type of light microscope contains lens in different angles that provides a three dimensional viewing of objects for complete diagnosis. Typically uses light reflected from the surface of an object rather than transmitted through it. It doesn't have very strong magnifying power like the compound microscope, but can be very useful in studying of dissection parts of living organisms. It is used mainly in the field of medical science including forensics, sorting, and microsurgery.

2.3.2. ELECTRON MICROSCOPE

These types are the most advanced types of microscopes used in modern science. They use beams of electrons rather than light to create an image of the specimen. The electron microscopes are powered by a beam of electron that strikes any objects that comes to its path to magnify. They are applicable used to observe very small objects like viruses, DNA, parts of cells.

2.3.2.1 Transmission Electron Microscope (TEM):

Transmission microscopes are used for studying cells and tiny slices of microorganisms like viruses. They are more powerful and can magnify up to 250,000X.

2.3.2.2 Scanning Electron Microscope (SEM):

They have lower magnifying power than TEM but can provide 3 dimensional viewing of objects. SEM has no lenses or eyepieces and can magnify up to 100,000X

2.3.3. FLUORESCENCE MICROSCOPE:

A fluorescence microscope is an optical microscope that uses fluorescence and phosphorescence instead of, or in addition to, reflection and absorption to study properties of organic or inorganic substances. Fluorescence Microscopy is a special form of light microscopy. It uses fluorescence to highlight structures in fixed and living biological specimens instead of using absorption, phase or interference effects.

2.3.4 DARK FIELD MICROSCOPE

In optical microscopy, dark field describes an illumination technique used to enhance the contrast in unstained samples. It works by illuminating the sample with light that will not be collected by the objective lens, and thus will not form part of the image.

2.4. WORKING PRINCIPLE OF LIGHT MICROSCOPY

Visible light is focused through a specimen by a condenser lens and then it is passed through two more lenses placed at either end of a light-tight tube. The latter two lenses each magnify the image.

A mirror at the bottom of the microscope reflects light rays up to the object through a hole in the stage. Objective lenses magnify the image which is made even larger when it is seen through the eyepiece lenses.

2.5. BASIC PARTS/ COMPONENTS AND FUNCTIONS OF MICROSCOPE

Group activity
In a group of five
Discuss the Basic components of microscope and their funct
Time: 5 min

2.5.1. OPTICAL COMPONENTS:

OBJECTIVE: The most important optical component of the microscope. Its basic function is to gather the light passing through the specimen and then to project an accurate, real, inverted IMAGE of the specimen up into the body of the microscope.

EYEPIECE: A second important optical component. Its basic function is to “look at” the focused, magnified real image projected by the objective (and tube lens in infinity-corrected systems) and magnify that image a second time as a virtual image.

SUBSTAGE CONDENSER: The third important optical component. Its basic function is to gather the light coming from the light source and to concentrate that light in a collection of parallel beams (from every azimuth) onto the specimen.

COLLECTOR LENS: The base of the microscope contains a COLLECTOR LENS. Placed in front of the light source. Its function is to project an image of the light source onto the plane of the condenser's aperture diaphragm.

FIRST SURFACE MIRROR: Found in the base of the microscope, under the condenser. Its function is to reflect the light coming from the lamp up into the sub stage condenser.

TUBE LENS: Found at the lowest part of the observation tubes (binocular or trinocular)Its function is to gather the parallel rays of light projected by the objective (in infinity-corrected systems) and bring those rays to focus at the plane of the fixed diaphragm of the eyepiece. In the instruments of some manufacturers, the tube lens is built into the body of the microscope itself.

2.5.2. MECHANICAL/ELECTRICAL COMPONENTS

ARMS: Supports the body tube. Used to carry the microscope.

BASE: It houses the electrical components for operating and controlling the intensity of the lamp

STAGE: The stage has an opening for passing the light. The specimen is placed on top of the stage and held in place by a specimen holder. Attached to the stage are concentric X-Y control knobs which move the specimen forward /back or left/right.

COURSE and FINE FOCUSING KNOBS: These raise or lower the stage in larger/ smaller increments to bring the specimen into focus.

NOSEPIECE: It may be fixed or removable for holding the objectives of various magnifications.

OBSERVATION TUBES: Either binocular or tri-nocular, are attached to the stand above the nosepiece. The bottom of the observation tube holds a special lens called the TUBE LENS. The tube lens has the function of gathering the parallel beams projected by the objective and bringing the image to focus at the level of the eyepiece diaphragm (intermediate image plane).

2.6. SAFETY

Think pair-share

What are the safety procedures that should be followed when operating microscope?

Time: 5min.

1. Wear Protective Clothing

Before you begin using a microscope, put on protective clothing. This includes a lab coat, a pair of safety glasses and a pair of disposable gloves. The slides you are examining under the microscope could contain dangerous chemicals or biological material so, it is important to protect all parts of your body.

2. Carry with Two Hands

To prevent damage to the microscope and to protect yourself from injury, always carry the microscope with two hands. Place one hand on the arm of the microscope and place the other hand underneath the base of the microscope. This method will give the microscope the most support. If you are walking with it, always hold it up high to avoid hitting tables or chairs. If you are not careful with the microscope and

hit something, you could cause small pieces of the microscope to break off and create a tripping hazard.

3. Do Not Touch the Lens

Never touch the lens of the microscope with your bare hands. This could damage the functioning of the microscope. Instead, use a special lens paper to clean it. You may also use a soft cloth dipped in a small amount of isopropyl alcohol to clean the lens, according to the Utah State Office of Education.

4. Do Not Look into the Light

If you are using a microscope with a mirror, never use direct sunlight as a light source. This could cause eye damage when looking into the microscope. If you are using a microscope with a light, do not look directly into the light. This could cause eye damage as well. Also, remember to turn off the light of the microscope when it is not in use.

5. Be Cautious Handling Slides

Always be careful when handling glass slides and cover slips. If the slide or cover slip breaks, use protective gloves to clean up the broken glasses. This will help prevent cuts and contamination from slide contents. Dispose of the glass in a designated sharps container in the laboratory.

6. Storing

Protect optical parts of the microscope from dust, dirt and Fungus

Store the microscope under a protective cover

Always cover the microscope with the supplied dust cover when not in use

Store in a dry place

In humid or moist environments, it is advisable to store the microscope in a waterproof container with a drying agent

Do not touch the optical lens with bare fingers

Do not store the microscope in direct sunlight. Sunlight can influence the quality of the specimen imaging.

7. Electrical safety

Never disassemble the microscope as doing so may cause electric shock or damage to the microscope

Allow the halogen bulbs to cool before touching. Halogen bulbs become extremely hot and may cause burns if touched.

To avoid electric shock or damage to the instrument, unplug the microscope before replacing the bulb.

Use only the prescribed halogen or fluorescent bulb.

Turn off and unplug the microscope before moving.

2.7. TROUBLESHOOTING

Learning activity

Before beginning troubleshooting and maintenance of microscope prepare and consider the following:

- **Ask the end users and clients about the problem**
- **Collect operational and maintenance manual**
- **Refer the past record history of the equipment end users**
- **Wear Personal Protective Equipment**
- **Prepare the necessary tool kits, and measuring instrument**

Troubleshooting

Connect the power cord to the socket out let
Check that the light intensity knob is at the minimum level
Make the power supply ON.
Gradually maximize the light intensity knob
Check loose components or parts and damaged wires
Smell if burnt insulation occur

If the bulb does not give light:

Disconnect the power cord from the socket outlet
Check the main power supply with multi meter
Check the power cord function with continuity test techniques
Check if the fuse is burn out
Check if the bulb is burn out
Check the circuit board components fails

2.8. REPAIR

Fix the problems which encountered in power cord.

2.8.1 Replacing the fuse:

Unplug the microscope from power source
Replace the burnt fuse as recommended

2.8.2. Replacing the bulb:

Unplug the microscope from power source
Find location of bulb
Follow manufacturer's instructions to remove the bulb
Use tissue paper or an appropriate device to remove the bulb from the microscope
Check the model number on the bulb to ensure the use of correct replacement bulb.
Replace the bulb by holding it with lens paper or an appropriate device.
Never touch the bulb with your fingers.

2.8.3 Replacing circuit board components:

Replace individual components if possible
If not possible replace the entire circuit board

2.8.4 If poor Image Quality encountered

Clean objective and lens
Clean scope thoroughly
Check oil, replace if any contamination or haze is visible
Ensure the slide is thoroughly dry before applying oil

2.8.5 If Uneven Illumination encountered:

Ensure nosepiece is rotated to position where it clicks into place.
Centre condenser
Adjust Kohler illumination: correctly focus the lamp to achieve a uniform level of brightness in the field of view.
Check to see bulb is correct model

2.8.6 If Constant Refocusing occurs:

Be sure slide is flat on stage
Clean stage and underside of slide
Be sure microscope is on flat and levelled surface

2.8.7 Surging or Flickering Light occurs:

Loose plug or connection
Clean bulb contacts (Unplug from power source)
Assure halogen pins are in full contact
Bulb needs replacement
Check to see if cord is damaged - Replace, if any wear and tear is visible.
If voltage supply is erratic, use a voltage stabilizer

2.8.8 If excessive contrast in the image occur:

Check the diaphragm's iris of the condenser is not fully closed.
Open the iris of the diaphragm slightly.

Table 1. Properly analysed troubleshooting techniques

PROBLEM	PROBABLE CAUSE	SOLUTION
The lighting system is not producing uniform light.	The electrical system shows voltage errors.	Check and repair the electrical system. Connect the microscope through a voltage stabilizer.
	The microscope's connector to the wall outlet is slack.	Connect the plug to the outlet. If any of the elements are defective, replace it.
	The bulb is badly installed and is not making good contact.	Reinstall the bulb.
	There are metal or black specks on the bulb's surface.	Replace the light bulb.

The sample is poorly illuminated.	The diaphragm's iris is almost closed.	Open the diaphragm's iris until the lighting is adequate.
	The condenser is very far (very low).	Bring the condenser closer.
	The condenser's lenses show dust or fungal growth.	Clean the condenser. Remove the dust with a brush. Remove the fungi with a lens cleaning solution.
There is excessive contrast in the image.	The diaphragm's iris of the condenser is almost closed.	Open the iris of the diaphragm slightly.
The image is slightly too clear and shiny.	The diaphragm's iris of the condenser is very open.	Close the diaphragm's iris slightly.

Table 2.The table below shows the general maintenance inspection list
Check the electrical, mechanical and optical performance.

		Check Date: ….. Checking by: …..
Check point	Check contents	Result
1.Electrical unit	1) When the power switch is turned ON, the lamp is lit and the brightness can be varied by adjacent knob.	YES NO
2.Course/fine focus adjustment knob	1) The course/fine focus adjustment knob is smoothly moved without any stress or unevenness.	YES NO
	2) The tension of course/fine focus adjustment knob can be adjusted by the adjacent ring.	YES NO
	3) The upper limit is changed by turning the stopper on the upper side.	YES NO
3.Stage	1) the plane stage should not fall spontaneously	YES NO
	2) A specimen is held securely by the specimen holder	YES NO
	3) The X/Y movement of mechanical stage is smooth without unevenness, backlash or slipping.	YES NO
4.Observation tube	1) The inter-pupillary distance can be operated smoothly in working range.	YES NO
	2) When changing the inter-pupilary distance, the displacement of optical axis is not apparent.	YES NO
	3) The dioptre adjustment ring is moved smoothly in working range.	YES NO
	4) The optical axis of left side coincides with that of right side.	YES NO

5.Revolving nosepiece	1) The revolving nosepiece can be rotated smoothly and stop at the click position.	YES	NO
6.condenser	1) The vertical movement of condenser is smooth.	YES	NO
7.visibility (observation)	1)Observation image is normal without flares/ghosts//uneven illumination.	YES	NO
	2) Dust and dirt are not noticeable in observation.	YES	NO

2.9. RECORD HISTORY

A service or maintenance history provides a record of the work done on each individual item over time, and keeps the records all in one place. This provides a reference where the specific problems of a machine or item/area can emerge.

The information is required as follows: (See more on Annex)

The complete service or maintenance history is required in the maintenance workshop. Because technicians can see what the recurring problems are with equipment and what work has already been done on the machine.

Key facts from the service history need to be linked to the equipment inventory.

2.10. PREVENTIVE MAINTENANCE

Group activity

In a group of five Discuss the preventive maintenances that should be performed for the microscope on regular basis

Time:5 min.

2.10.1 CLEANING MATERIALS AND PROCEDURE

2.10.1.1 CLEANING SOLUTIONS AND SOLVENTS:

Refer to manufacturer's guide to select appropriate organic solvent

Use Ethyl ether-alcohol or alcohol or lens cleaner solution for cleaning of lenses.(unless you get the manufacturers guide)

2.10.1.2 CLEANING MATERIALS:

Use Lint-free cotton gauze pads

Use Lint-free cotton swabs

Use Lens paper and blower

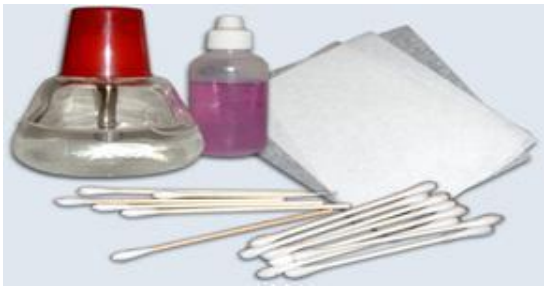


Figure 1 cleaning Materials

2.10.1.3 CLEANING PROCESS:

a. Eyepiece

Check removing dust before wiping lens.
Clean with a cotton swab moistened with lens cleaning solution.
Clean in a circular motion inside out.
Wipe with dry lens paper.
Repeat cleaning and drying if required.

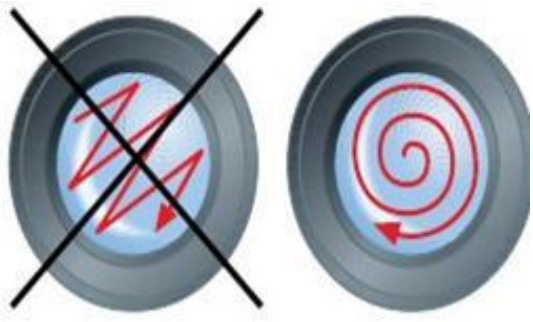


Figure 2 cleaning an eye piece

Objectives

You can objectives while attached to microscope
Moisten the lens paper with the cleaning solution
Wipe gently the objective in circular motion from inside out
Wipe with dry lens cleaning paper

Microscope Stage

Wipe the microscope stage using the cleaning solution on a soft cloth.
Thoroughly dry the stage.
Repeat above steps, if required.

The Microscope Body

Unplug the microscope from power source
Moisten the cotton pad with a cleaning agent
Wipe the microscope body to remove dust, dirt, and oil
Repeat the above steps if required

The Condenser and Auxiliary Lenses

Unplug the microscope from power source.
Clean using lint-free cotton swabs moistened with lens cleaning solution.
Wipe with dry swabs.

2.11. SUMMARY

Microscope is used to see objects that are too small for naked eye.

Laboratory microscope uses to diagnose diseases like malaria, roundworms, tuberculosis, dysentery, crypto sporidium giardia

Microscope can be basically classified as: Light Microscope(simple , compound, dissection or stereo), Electron microscope(TEM, SEM), Florescence microscope and dark field microscope

Basic components of microscope can be listed as optical components(objective, condenser, eyepiece, collector lens, first surface mirror and tube lens) & mechanical components(arm, base, stage, course and fine adjustment knobs, nose piece& observation tubes)

When operating microscope, we have to make sure that we followed all the safety procedures.

During troubleshooting and maintenance of microscope we have to prepare operational and maintenance manual and all the necessary tools and follow all the stapes according to the manual

Chapter 3:
CENTRIFUGE

Time: 7 hrs

CHAPTER DESCRIPTION:

This chapter is designed for participants to provide the necessary knowledge, skills and attitude required for laboratory equipment maintenance for biomedical engineers and technicians. It covers basic working principles, purposes, and main components, troubleshooting techniques and safety procedures for Clinical Centrifuge.

CHAPTER OBJECTIVE:

At the end of this chapter participants will acquire basic knowledge and skills about centrifuge maintenance

ENABLING OBJECTIVES:

By the end of this chapter participants will be able to:

- Describe uses/purpose of centrifuge
- Identify types of centrifuge
- Explain working principles of centrifuge
- List basic parts and components of centrifuge
- Perform the steps for troubleshooting techniques of centrifuge •Practice the types of maintenance for centrifuge
- Identify performance test procedures in centrifuge
- Handle centrifuge with appropriate care
- Implement safety needed for the equipment and user for centrifuge

CHAPTER OUTLINE

3.1. INTRODUCTION

Think pair-share

Discuss the purpose of Centrifuge machine clinical laborat

List some

List the types of centrifuge and their functions Time:5 min

In a solution, particles whose density is higher than that of the solvent sink (sediment), and particles that are lighter than it float to the top. The greater the difference in density, the faster they move. If there is no difference in density (isopycnic conditions), the particles stay steady.

To take advantage of even tiny differences in density to sepa¬rate various particles in a solution, gravity can be replaced with the much more powerful “centrifu¬gal force” provided by a centrifuge. This technique plays crucial role in biochemistry or biotechno¬logy as it is non-dispensable part of one or the other step in every method involved in biological study right from the separation of cell organelles to complex experiments involving separation of sub-cellular fractions.

Centrifugation is a procedure that involves the use of centrifugal force for the sedimentation of mixture with a centrifuge used in industry and laboratory settings. A centrifuge is designed to use the centrifugal force generated in rotational movements to separate the constitutive elements of a mixture.

3.2. PURPOSE/USE OF CENTRIFUGE

The main purpose of laboratory centrifuge is for separating particles from a solution according to their size, shape, and density, viscosity of the medium and rotor speed.

Centrifuges are necessary equipment in most laboratories and meet application needs ranging from clinical and blood banking; microbiology; tissue culture; molecular biology and genomics; drug discovery; and proteomics.

3.3. TYPES OF CENTRIFUGES AND THEIR USES

There are various types of centrifuges, depending on the size and the sample capacity.
They vary widely in speed and capacity work by the sedimentation principle, where the centripetal acceleration is used to separate substances of greater and lesser density. There are four major types of centrifuges.

3.3.1 Small Bench Centrifuges:

They are used to collect small amount of material that rap¬idly sediment like yeast cells, erythrocytes etc. They have maxi¬mum relative centrifugal field of 3000-7000 g.

3.3.2 Large Capacity Refrigerated Centrifuges:

They have refrigerated rotor chamber and have capacity to change rotor chambers for varying size. They can go up to maximum of 6500 g and use to sediment or collect the substances that sediment rapidly like erythrocytes, yeast cell, nuclei and chloroplast.

3.3.3 High Speed Refrigerated Centrifuges:

They can generate speed of about 60000g and are used to collect micro-organism, cellular debris, larger cellular organelles and proteins precipitated by ammonium sulphate.

3.3.4 Ultra Centrifuges:

1. Preparative ultracentrifuge:
It can produce relative centrifugal force of about 600000g and its chamber is refriger¬ated, sealed and evacuated. It is employed for separation of macromolecules/ligand binding kinetic studies, separation of various lipoprotein fractions from plasma and de-protonation of physiological fluids for amino acid analysis.

2. Analytical ultracentrifuge:
It is capable of operating at 500000 g. Three kinds of optical systems are available in analytical ultracentrifuges: a light absorption system, and the alternative Schlieren system and Rayleigh inter ferometric system, all of which detect changes in the refractive index of the solution.

3.4 WORKING PRINCIPLE OF CENTRIFUGE

Individual reflection
Explain working principle of
Centrifuge Time:10 min

A centrifuge is a piece of equipment, generally driven by an electric motor that puts an object in rotation around a fixed axis, applying a force perpendicular to the axis to separate substances of different densities.

Centrifuges represent a practical application of Newton's law of motion. When a body of mass [m] turns around a central point [O], it is subjected to a centripetal force [N] directed towards the rotation axis with a magnitude N = m **ω**2R, where

Is effective mass of sedimenting particle [R]

is the distance of migrating particles and

[**ω**] is the angular velocity of rotation.

When the system spins at a speed of **ω** radians per second, the samples are subjected to the centrifugal force Fp of the same magnitude as N, but in an opposite direction. The relationship between the centrifugal acceleration [**ω**2r] to a given radius [r] and the force of gravity [g] is known as the relative centrifugal field or [RCF].

RCF = rω2/g

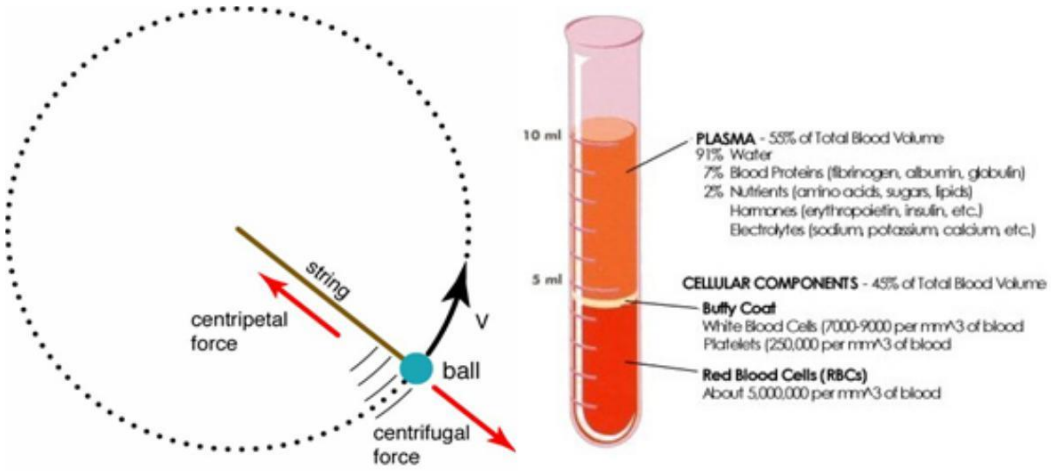


Figure 3 operating principle of laboratory centrifuge

3.5 BASIC PARTS/ COMPONENTS AND FUNCTIONS CENTRIFUGE

The electric/electronic control:

- On and off control
- Operation time control (timer)
- Rotation speed control (in some centrifuges)
- Temperature control (in refrigerated centrifuges),
- Vibration control (safety mechanism) and
- Brake system.

Base: It is the bottom part of the centrifuge.

Lid/cover: part of centrifuge used to close during operation. It creates interlocking with the parts of the machine.

Electric motor: It is the heart of the machine which governs the rotor to rotate at a maximum speed.

Rotor: It is the rotating part used to create the centrifugal force in the machine.

3.6 DESIGN AND TYPES OF ROTORS

1. Swinging Bucket Rotors:

The swinging bucket rotor has buckets that start off in a vertical position but during acceleration of the rotor swing out to a horizontal position so that during centrifugation the tube and hence the solution in the tube, is aligned perpendicular to the axis of rotation and parallel to the applied centrifugal field, the tube returning to its original position during deceleration of the rotor.

2. Fixed Angle Rotors:

In fixed angles the tubes are located in holes in the rotor body set at a fixed an¬gle between 14° and 40° to the vertical. Under the influence of centrifugal field, particles move radially outward and have only a short distance to travel before col¬liding with, and precipitating on, the outer wall of the centrifuge tube. A region of high concentration is formed that has a density greater than surrounding medium, with the result that the precipitate sinks and collects as a small compact pellet at the outermost point of the tube.

3. Vertical Tube Rotors:

They are considered as zero angles fixed angle rotors in which the tubes are aligned vertically in the body of the rotors at all times.

3.7 SAFETY

Think pair-share what are the safety procedures that needs to be followed when operating centrifuge machine

Time:5 min

The majority of all centrifuge accidents result from user error. To avoid injury, workers should follow the manufacturer's operating instructions for each make and model of centrifuge that they use.

3.7.1 Safe Procedures for Centrifugation

1. General

Before centrifugation

Well trained operators are responsible for proper operations procedures, review the user manual.

Use only rotors compatible with the centrifuge. Check the expiration date for ultracentrifuge rotors.

Check tubes, bottles, and rotors for cracks and deformities before each use.

Make sure that the rotor, tubes, and spindle are dry and clean.

Examine O-rings and replace if worn, cracked, or missing.

Never overfill centrifuge tubes (don't exceed ¾ full).

Always cap tubes before centrifugation.

Always balance buckets, tubes, and rotors properly.

Check that the rotor is seated on the drive correctly, close the lid on the centrifuge, and secure it.

When using swinging bucket rotors, make sure that all buckets are hooked correctly and move freely.

During centrifugation

- Keep the lid closed at all times during operation. Never open a centrifuge until the rotor has stopped.
- Do not exceed safe rotor speed.
- The operator should not leave the centrifuge until full operating speed is attained and the machine appears to be running safely without vibration.
- Stop the centrifuge immediately if an unusual condition (noise or vibration) begins and check load balances.

After centrifugation

- Allow the centrifuge to come to a complete stop before opening.
- Wear gloves to remove rotor and samples, see Glove Selection and Use.
- Check inside of centrifuge for possible spills and leaks, clean centrifuge and rotor thoroughly if necessary.
- Wash hands after removing gloves.

Hazards /Risks

- Mechanical failure of rotor parts (often violent)
- Small differences in mass of the load can result in a large force imbalance when the rotor is at high speed.
- This force imbalance strains the spindle and may result in damage to centrifuge or personal injury.
- Centrifuge rotors should never be touched while the rotors are moving, because a spinning rotor can cause serious injury.
- Fire or explosion
- Sample leaks causing aerosols, corrosion and contamination

Emergency Situations

The following events are considered an emergency:

- If there is a spill in the centrifuge
- If centrifuge malfunctions

- If there is rotor failure
- If there is tube breakage

Other safety:

- Never clean rotors and associated parts with abrasive wire brushes.
- Store the rotor upside down in a dry place, with lids or plugs removed, to prevent condensation.
- Remove adapters after use and inspect for corrosion.
- Inspect rotor regularly. Remove rotors from use that show any sign of defect, and report it to a manufacturer's representative for inspection.

3.8. TROUBLESHOOTING

Learning activity

Before beginning troubleshooting and maintenance of centrifuge prepare and consider the following:

- **Ask the end users and clients about the problem**
- **Collect operational and maintenance manual**
- **Refer the past record history of the equipment end users**
- **Wear Personal Protective Equipment**
- **Prepare the necessary tool kits, and measuring instrument**

Troubleshooting

Connect the power cord to the socket outlet and supplying power.
Install balanced test tubes
Select the working speed and time
Close the lid cover and run the cycle.

After doing so the substance will be separated depending on the differences in their relative density.

If the main switch is ON but the centrifuge is not functioning.

Disconnect the power cord from the socket outlet.
Check the main power supply with multi meter.
Check the power cord functionality with continuity test techniques.
Check if the fuse is burn out.
Check the circuit board component fails.

If Severe vibrations occurred:

Balance the rotor's load: Fill all the opposite tubes with the same level of liquid of same density and distribute the weight of the opposite tubes symmetrically.
Select a rotation outside of the critical speed range.
Check the rotor is properly mounted.
Check proper lubrication is done in the rotor.

If the tubes leak:

Confirm the covers are properly secured.
Confirm the tubes are filled at the optimum level.

4. If the tubes are cracked or broken:

•Be sure that the tube is working at recommended temperature.

•Check that the tube is working out of service time.

3.9. REPAIR

3.9.1 Fix the above listed problems based on the error cods described in the manufacturer service manual.

Table 3.1.Check list for testing the equipment

		Check Date: Checking by:
Check point	Check contents	result
1.The electric/ electronic control:	1) Time control (timer) properly set	YES NO
	2) RPM properly set	
2.Sample holder (tube)	1) compatible with the rotor	YES NO
	2) Balanced in proper way	YES NO
3.Rotor	1)rotate as the manufacturer recommendation	YES NO
	2)test with tachometer the exact RPM value	YES NO

3.9.2. History Recording and reporting

A service or maintenance history provides a record of the work done on each individual item over time, and keeps the records all in one place. This provides a reference where the specific problems of a machine or item/area can emerge.

The information required are as follows: (see Annex)

The complete service or maintenance history is required in the maintenance workshop. Because technicians can see what the recurring problems are with equipment and what work has already been done on the machine.

Key facts from the service history need to be linked to the equipment inventor

3.10. PREVENTIVE MAINTENANCE

The main types of preventive maintenance in centrifuge are cleaning, inspection and lubrication.

The following should be considered when preventive maintenance is implemented in laboratory centrifuge.

•Lubricate and clean motor.

• Clean case.

•Inspect power cords and plugs.

•Inspect controls and switches.

•Ensure appropriate menu settings for proper use.

•Ensure tightness of rotor.

•Check lights and indicators.

•Verify that alarms are operating properly.

•Ensure interlock is functioning.

If refrigerated, ensure temperature reading is working.

Replace/repair gaskets, seals, and vacuum pump (if applicable).

3.11. Summary

•Centrifuge is used for separating particles from a solution according to their size, shape, and density.

•Centrifuge can basically classify as: Bench top centrifuges, refrigerated Centrifuges and ultra-Centrifuges.

•Basic components of centrifuge can be listed as: The electric/electronic control, Base, Lid/cover, Electric motor and Rotor:

•When operating centrifuge, we have to make sure that we followed all the safety procedures.

•During troubleshooting and maintenance of centrifuge we have to prepare operational and maintenance manual and all the necessary tools and follow all the stapes according to the manual

Chapter 3:
REFRIGERATOR

Time: 24hrs

CHAPTER DESCRIPTION:

This chapter is designed for participants to develop the necessary knowledge, skills and attitude in laboratory equipment maintenance for biomedical engineers and technicians. It covers basic working principles, purposes, and main components, troubleshooting techniques and safety procedures for refrigeration system.

CHAPTER OBJECTIVE:

At the end of this chapter participants will develop basic knowledge, skill and attitude about refrigerator maintenance

ENABLING OBJECTIVES:

By the end of this chapter participants will be able to:

- Describe uses/purpose of Refrigerator in clinical laboratory
- Explain working principles of Refrigerator
- List basic parts and components of Refrigerator
- Perform the steps for troubleshooting techniques for Refrigerator
- Practice the types of maintenance for Refrigerator
- Handle Refrigerator with appropriate care
- Implement safety needed for the equipment and user for Refrigerator

CHAPTER OUTLINE

4.1. INTRODUCTION

Group activity

In a group of five, discuss The uses of refrigerators in clinical laboratory

Time : 5 mins

This module will provide the technician/engineer with the ability to understand the causes of main operational problems presented by vapor compression refrigeration or air conditioning systems. It is important to understand how to avoid them through the adoption of good practices, and to be aware of the main precautions which should be taken when servicing installations and systems.

Methods and techniques that are used when working on systems, primarily during servicing exercises, are discussed. In particular, this includes the consideration of system cleanliness (moisture, acid, non-condensable), and the means for overcoming these problems, such as proper evacuation methods and system purging. To avoid such issues in the first place demands appropriate procedures associated with tightness testing (“leak testing”) and refrigerant charging, which are described.

Technicians have the important role of making the operation of RAC systems the most energy efficient and decreasing refrigerant emissions. This can only be achieved by the adoption of good practices. The section starts with the evaluation of the problems due to the presence of moisture and contaminants in the system, and how to avoid them through purging and evacuation, charging, and leak testing. The important measurement instruments and tools necessary to achieve good servicing practices are included.

Cold Chain Equipment Maintenance System in Ethiopia and Challenges

Group activity

In a group of five

Discuss about the challenges of cold chain equipment Maintenance in Ethiopia

Time: 5mins

Cold chain equipment’s are expected to be maintained at all level by trained technicians, which are trained as a user, mid-level technician or senior level. But due to different reasons cold chain equipment maintenance system is not strong. Some of the challenges in cold chain equipment are:

- No records of essential data of equipment’s used in cold chain
- Non-functionality of equipment due to minor problems
- Lack of information about the actual status of the cold chain equipment
- Lack of knowledge of spare parts management
- No annual cold chain plan
- No cold chain emergency plan (lack of planning for emergencies resulting in organizations not having effective cold chain systems during responses).
- No regular monitoring and super vision of cold chain maintenance

4.2.PURPOSE/USE OF REFRIGERATOR/COLD CHAIN

The Cold chain management

The cold chain system is a means for storing and transporting vaccines in a potent state from the manufacturer of the vaccine and blood products to the person being immunized and transfused. The cold chain system comprises three major elements:

Personnel who use and maintain the equipment and provide the health service

Equipment for safe storage and transportation of vaccine

Procedures to manage the programs and control the distribution and use of vaccine

Maintenance of the cold chain requires vaccines and diluents to be:

- •Collected from the manufacturer or an airport as soon as they are available;
- •Transported between 2ºC and 8ºC from the airport and from one store to another;
- •Stored at the correct temperature(seeFigure3A) in primary /central and intermediate vaccine stores and in health facilities;
- •Transported between 2ºC and 8ºC to outreach sites and during mobile sessions; •Kept between 2ºC and 8ºC range during immunization sessions;
- •Keptbetween2ºCand 8ºCduring return to health facilities from outreach sites.

After vaccines reach the health facility you must:

- •Keep them between 2ºCand 8ºCin your health facility refrigerator.
- •Carry them to the immunization session in a vaccine carrier with conditioned or cool/chilled water packs.
- •Keep the vaccines cool using a foam pad in the vaccine carrier while you immunize the children

4.3. WORKING PRINCIPLES AND TYPES OF REFRIGERATOR /COLD CHAIN EQUIPMENT

Individual reflection

1, what are the two common refrigeration systems?

2, List some compression type equipment

Time 5min.

The equipment's for storage of vaccines must have recommended temperature conditions for vaccine storage round the year. There are different equipment of different capacity for storage of vaccines at different levels. Some of the equipment are dependent on electric or kerosene or gas supply to maintain there commended temperature, while others can maintain the desired temperature range even in the absence of power supply for a specific time period.

There are two common refrigeration systems known as compression and absorption refrigeration.

Compression refrigeration system

Compression refrigeration uses compressors to drive the cooling process. The compressor is powered by electricity. The source of electricity could be from the mains or, if it is solar unit, from solar energy. This system is the most efficient compared to abruption systems. Some of the compression type equipment are: Cold rooms, Freezers, Deep Freezers (MF314, MF214, MF114, etc), Icepack freezers

(TFW800,etc),ILR(TCW3000,MK304,MK314, MK204, MK414, TCW300, TCW1990, etc.).Some equipment can be used as freezers or ILR interchangeably (TCW300)by switching to freezing or cold storage.

Cold Rooms and freezer rooms

These are used for bulk storage of vaccines at national and regional/zonal stores. They maintain a temperature (+2oC to +8oC cold rooms) & (-25oCto-15oC freezer rooms).They are available in different sizes. These are used for storage of large quantities of vaccines. They have two identical coolingunitsandstandbygeneratorsetswithautomaticormanualstartandstopfacilities.They are also provided with temperature recorder and alarm systems.

Figure 4. Cold room

Deep Freezers

Deep Freezers with top opening lids have been supplied under the immunization programme. The cabinet temperature is maintained between-15oto-25oC.This is used for storing of OPV and also for freezing ice packs. In case of power failure, it can maintain the cabinet temperature in the rangeof-15o to-25oC for 18&26 hours at ambient temperatures of 42oC and 32oC respectively, if not opened. The deep freezers have vaccine storage capacity and ice pack freezing capacity. These are available in different sizes (large and small).

Example: **Deep Freezer: Model MF314- vaccinestoragecapacity264litters or 380icepacks. Ice Lined Refrigerator (ILR)**

These type of refrigerators are top opening and they can hold the cold air inside better than a refrigerator with a front opening. Where there is no electric power for 24 hrs, it can keep vaccine safe only with as little as 8 hours continuous electricity supply in a 24-hour period. It is available in different sizes. For example;

ILR-ModelMK304ofvaccinestoragecapacity105litersor26000to30000dosesofmixed antigen.

Inside the ILR there is a lining of water containers (ice packs or tubes) fitted all around the walls and held in place by frame. When the refrigerator is functioning the water in the containers freezes and if the electricity supply fails, then the ice lining maintains the inside temperature of the refrigerator at a safe level for vaccines. Therefore the temperature is maintained in ILR for much longer duration than in deep freezers and ILR scan keep vaccine safe.

Solar Refrigerators (Solar-powered equipment)

1. Solar refrigerators with battery

A solar refrigerator operates on the same principle as normal compression refrigerators but in corporate low voltage (12 or 24V) DC compressors and motors, rather than mains voltage AC types. A photovoltaic refrigerator has higher levels of insulation around the storage compartments to maximize energy efficiency, a battery or number of batteries depending up on the size of panel for electricity

storage, a battery charge regulator and a controller that converts the power from the battery to DC form required by the compressor motor.

2 Direct Drive Solar refrigerators

Ordinary solar fridges are expensive and require heavy lead-acid batteries which tend to deteriorate, especially in hot climates, or are misused for other purposes. In addition, the batteries require maintenance, must be replaced approximately every three to five years, and must bed is posed of as hazardous wastes possibly resulting in lead pollution. These problems and the resulting higher costs have been an obstacle for the use of solar powered refrigerators in developing areas. Currently there are direct drive solar (DD solar) refrigerators which are functioning without battery.

Absorption type refrigerators

Group activity

In a group of three

What is the difference between compression and absorption type refrigeration?

Time 3min

The absorption system is unique in refrigeration since it involves no moving parts. Continuous absorption types of refrigerators have four main sections: the boiler (generator), the condenser, the evaporator and the absorber.

The four sections are connected by steel tubes. The entire system is welded together. The necessary heat for generation is obtained by using a gas burner, kerosene burner or electric heating element at the boiler (generator).

The system is charged with ammonia, water and hydrogen. The amount of the combined solution is ata pressure which will allow the ammonia to condense at room temperature.

It is important that

Understand that the entire cycle is carried out entirely by gravity flow of the refrigerant.

The unit remains in a level, upright position.

The heat generated in the absorber be removed and that the heat removed by the condenser be carried away by the surrounding atmosphere.

Example of some of the absorption type refrigerators in Ethiopia are: SIBIRV170KE, RCW50KE, Zero PR265KE,etc.

Temperature monitoring devices

Introduction

Temperature of refrigerators/freezers used for storage of vaccines must be recorded twice daily. A break in the cold chain is indicated if temperature rises above+8oC or falls below+2oC in the Refrigerators; and above-20oC in the Deep Freezer.

The Refrigerators and Deep freezers each should have separate thermometer and temperature record book.

The serial numbers of refrigerators and deep freezers should be indicated at the top of the temperature record book and should be available near the equipment and every supervisory visit should be documented in the record.

The thermometer or fridge-tag should be kept in between the freeze sensitive vaccine inside the basket of the refrigerators.

The recording of the temperature is done in order to:

Record that vaccines were not exposed to temperatures above+8oCelsius and below+2oC.

Check that the equipment is working properly.

You must be careful and ensure that the temperature in therefrigeratorsdoesnotriseabove+8oC. Also you must check that the temperature does not fall below+2oC as it damages the T series of vaccines. Adjust the thermostat switch in different seasons to maintain the inside temperature of the equipment well with in the prescribed range. Do the shake test for T-series vaccines if temperature falls below 2oC. The temperature records should be used to take action to shift vaccines to cold boxes or other refrigerators when temperature warrants.

Remember

•Keep one thermometer in every unit.

•Designate a staff member to record the temperature twice a day.

•Keep the booklet of 12 monthly temperature recording forms on the top of each unit and check daily to see that the temperature record is maintained.

1, Vaccine vial monitors (VVM)

A vaccine vial monitor (VVM) is a label that changes colour when the vaccine vial has been exposed to heat over a period of time. Before opening a vial, the status of the VVM must be checked to see whether the vaccine has been damaged by heat.

Manufacturers attach VVMs to vials of most vaccines. The VVM is printed on the vial label or cap. It looks like a square inside a circle. As the vaccine vial is exposed to more heat, the square becomes darker. Use only vials with inner squares that are lighter in colour than the outside circle.

Vials with VVMs in which the inner square has begun to darken but is still lighter than the outer circle should be used before the vials with a lighter inner square.

2, Dial Thermometers

Dial thermometers have been provided to record the temperature in the refrigerators/Freezers.
It has dial with moving needle to show the temperature of vaccine within therangeof-50oC to+50oC.

3, Alcohol Stem Thermometers

Alcoholic thermometers are much sensitive and accurate than dial thermometers.
They can record temperatures from-50oCto+50oC and can be used for refrigerators and deep freezers.

4, Freeze Indicator (Freeze tag)

It is also an electronic device to monitor vaccines exposed to less than 0oC. It contains an electronic temperature measuring circuit with associated LCD display. If the indicator is exposed to a temperature below -0.50C for more than 60 minutes the display will change from “good” status in to the “alarm” status.

Figure 5. Freeze tag, Stem thermometer, Dial thermometer

5, Cold Chain Monitor Card (CCM)

A vaccine cold chain monitor is a card with an indicator strip that changes colour when vaccines are exposed to temperatures that are too high. The vaccine cold chain card is used to estimate the length of time that vaccine has been exposed to high temperatures.

Manufacturers pack these monitors with vaccines supplied by WHO and UNICEF

Usually the cold chain monitor is only used for large shipments of vaccine.

The same card should remain at all times with the same batch of vaccine.

The change in color is cumulative and relates to heat exposure over the

Whole life of the shipment and not to a specific point in the cold chain.

Figure 6. CCM Card

6, Electronic Data Logger (Fridge-Tag)

Features of Fridge-Tag

The electronic data loggers are also being introduced to monitor the temperature of refrigerator. It is an electronic device placed with the vaccine which records the vaccine temperature for 30 days. It has an alarm system and as soon as the temperature of the equipment storing the vaccine crosses the safe range alarm alerts the handlers. This device assists in temperature monitoring through following features:

It shows temperature of refrigerator in digital LCD screen at all the time

It indicates if there was any alarming situation during the past 30days. The device shows“ω (Alarm)”on LCD screen if there was any alarming situation in past 30 days. The alarming situation is when the temperature went above +8 Degree Celsius over a consecutive period of ten hours or temperature drops down below-0.5Degree Celsius for a consecutive period of 60 minutes.

It shows the duration of temperature violation for every alarming situation happened in past 30 days. To see the duration of temperature violation, device is equipped with a “Read” button which guides the user through the history of past30daysstarting from “today” till “30daysago”.

It shows a “ω(OK)” sign if there has been no violation of temperature in past 30days.

It has a shelf life of two years from the date of activation of device. The devise once activated, can not be stopped through-out its operational life. Hence, it provides round the clock monitoring of refrigerators without any need of intervention of user for two years of time.

It has been specifically designed to be used with refrigerators and cold rooms that are required to maintain the temperature between+2 to+8 Degree Celsius.

4.4. BASIC PARTS OF COLD CHAIN EQUIPMENT AND MAINTENANCE

Think pair-share

Discuss about the preventive maintenance that should be performed to cold chain equipment

Time: 3min

Maintenance of cold chain equipment refers to all technical activities that ensure smooth running of the equipment. The most faults/breakdown of cold chain equipment area result of poor care and preventive maintenance. A good maintenance should aim to reduce running cost and extension of lifespan of the equipment.

Cold chain maintenance contribute to country EPI goals, such as,

- Ensuring quality and potent vaccines.
- Ensuring increase in vaccination coverage.
- Ensuring reduction of vaccine wastage.
- Reducing vaccine cost.

Well maintained cold chain equipment will improve the quality of service &ensure the extension life span of equipment &reduction operational cost of equipment.

Type of maintenances

Maintenance can be categorized in to two groups:

- Preventive maintenance
- Corrective maintenance

Preventive maintenance

Preventative maintenance is defined as a defensive measure to reduce the equipment down time and energy use. This allows the system to operate at maximum effectiveness.

Preventive maintenance means regularly inspecting of the equipment (cold room, refrigerator& generator) to see which parts are beginning to wear. These should be replaced before they wear any more. Sometimes parts must be repaired before they breakdown. This process minimizes the number of times the system has to be stopped for major repair.

A preventive maintenance is done before the breakdown, and can be categorized in to two groups:

- Systematic preventive maintenance
- Conditional preventive maintenance

Systematic preventive maintenance: Conducted on systematic manner after some use of (time, cycle, and km) even if the equipment is still performing well.

Conditional preventive maintenance: which is to verify and control certain parameters to detect anomalies for corrective action as necessary.

Corrective maintenance

Covers all activities under taken after equipment break down is urgent and costly, can be categorized in to two groups:

Palliative maintenance

Curative maintenance (repaired)

Palliative maintenance: To ensure functionality of the equipment for the moment until full scale repair can be arranged.

Curative maintenance (repair): intervention to ensure normal functioning of the equipment through full scale repair.

If the planned preventive maintenance regime is effective, emergency repairs should not be needed. However it is absolutely essential that the performance of refrigeration equipment and controls is monitored on a daily basis and that the equipment is repaired as soon as there is any sign of a defect. Use troubleshooting guides to identify the likely cause of the problem and try to repair, but if the problem is out of your capacity call immediately to the emergency repairs.

If emergency repairs are a frequent occurrence, this is an indication that the routine preventive maintenance is not working.

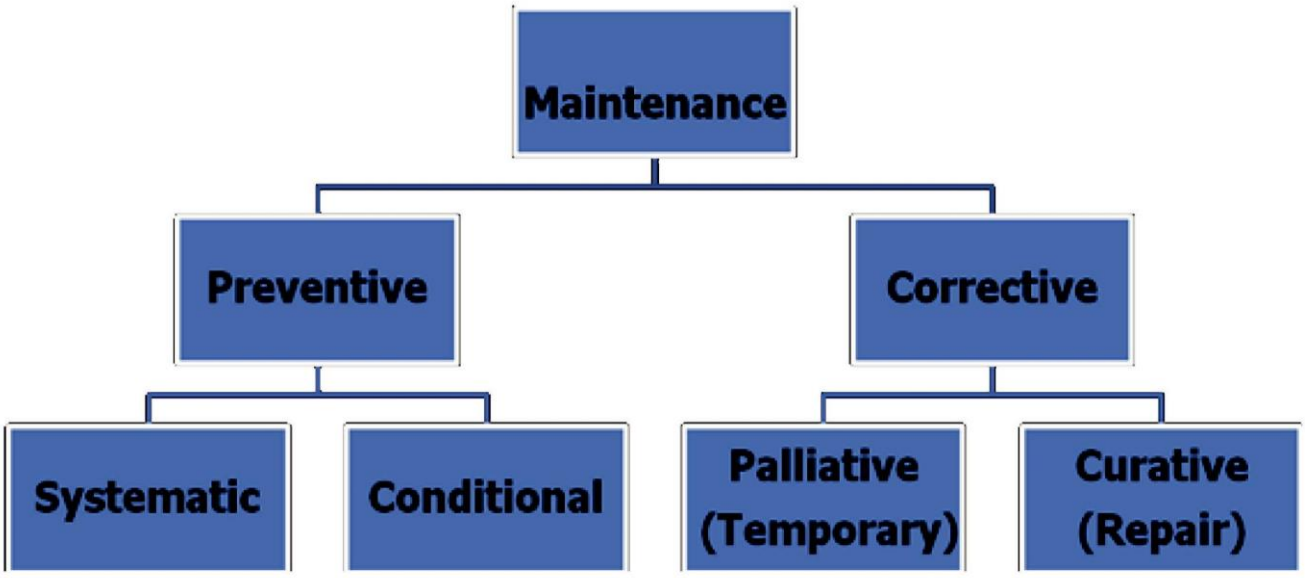


Figure 7. Block diagram for maintenance cycle

Refrigerants

Until recently the chlorofluorocarbon (CFC) gases R11 and R12 were very widely used as insulation foaming agents and refrigerants. However, CFCs cause severe damage to the earth's ozone layer and contribute significantly to global warming. The Montreal Protocol 14 called for the cessationofCFCconsumptionby1January1996in industrializedcountriesandby1January 2010in developing countries. Hydro chlorofluorocarbon (HCFC) refrigerants, e.g. R22 and R502, are still allowed as transitional substances even though they also contribute, albeit to a lesser extent, to ozone depletion and global warming. HCFCs are to be phased out worldwide by2040. Their use should be avoided wherever possible. The hydro fluorocarbon (HFC) gas R134a is acommonreplacementforR12insmallrefrigeratorsand freezers, as are hydrocarbons such as butane (R600) and is obutene (R600a). For safety reasons, WHO/V&B has decided not to recommend the use of flammable gases such as R600 and R600a in cold chain equipment.

Cold store manufacturers select refrigerants to suit the specified operating temperatures. R134aisoften used for+4°Ccoldroomsbutisnotsuitable for-20°Cfreezerrooms. Various alternative gases are available for this purpose, e.g. the blended gasR404a. Some industrialized countries, notably the United Kingdom and the USA, continue to allow the export of equipment that uses R12,which is also being reclaimed and recycled in many countries, and simple tools are available for this purpose. Recycling should be encouraged where it is possible and applicable, because it ensures that equipment can continue to be used. Recycling also helps to reduce and delay the release of CFCs in to the atmosphere. The skills and tools needed to handle several different refrigerants may not be available. Refrigerator technicians' toolkits, suitable for equipment containing CFC 12, are listed in the WHO/UNICEF Product information sheets. If possible, select refrigerators, freezers and cold rooms that use the same refrigerant. How to avoid contamination with incompatible refrigerants

Label equipment. Fix a permanent label on the front of every appliance indicating the type of refrigerant it contains.

Label salvaged components. Label every reusable component salvaged from old refrigeration circuits. The label must indicate the refrigerant used in the equipment from which the component was obtained. Salvaged components must only be used in equipment that uses the same refrigerant.

Provide the correct tools and spare parts. Provide all service engineers with the correct tools and spare parts for the equipment for which they are responsible.

Refrigeration system and maintenance

In general refrigeration is defined as any process of heat removal. More specifically, refrigeration is defined as that branch of science which deals with the process of reducing and maintaining the temperature of a space of material below the temperature of the surrounding.

In mechanical refrigeration, constant cooling is achieved by the circulation of a refrigerant in a closed system, in which it evaporates to a gas and then condenses back again to a liquid in a continuous cycle. If no leakage occurs, the refrigerant lasts indefinitely throughout the entire life of the system. All that is required to maintain cooling is a constant supply of energy, or power, and a method of dissipating waste heat. There are two common EPI refrigeration systems known as vapour compression and absorption refrigeration.

Absorption refrigeration system and maintenance

An absorption system makes use of the ability of one substance to absorb relatively large volumes of the vapour of another substance, usually a liquid. The absorbent has the ability to absorb large quantities of vapour when cold and give then up when heated. Due to this fact, the working fluid in absorption type refrigeration system is always at wo-component solution one of which serves as refrigerant and the other as absorbent. The component of this mixture must have different boiling temperature.

Oneofthefirstandstillthemostwidelyusedabsorptionrefrigerationsystemtoday,is the system using water as absorbent and ammonia as refrigerant.

Characteristics of absorption refrigeration system

- The control of heat transfer processes is less precise than electrical control, and it takes much longertoproduceadesiredtemperaturechangewithinanabsorptionrefrigerator.
- Maintaining precise and stable temperatures requires user attention at least twice daily.

Absorption systems rely on heat transfer, chemical processes, and gravity flow of fluids rather than on electrical or mechanical power.

Absorption refrigeration is driven by heat, either from an electric element, a bottled gas flame. or a kerosene wick burner.

Absorption refrigeration should only be used when a reliable power source for a vapor-compression system is unavailable, or when it can be shown that costs of absorption systems are lower than vapor-compression alternatives and the absorption system can provide an equivalent degree of cooling for the vaccines.

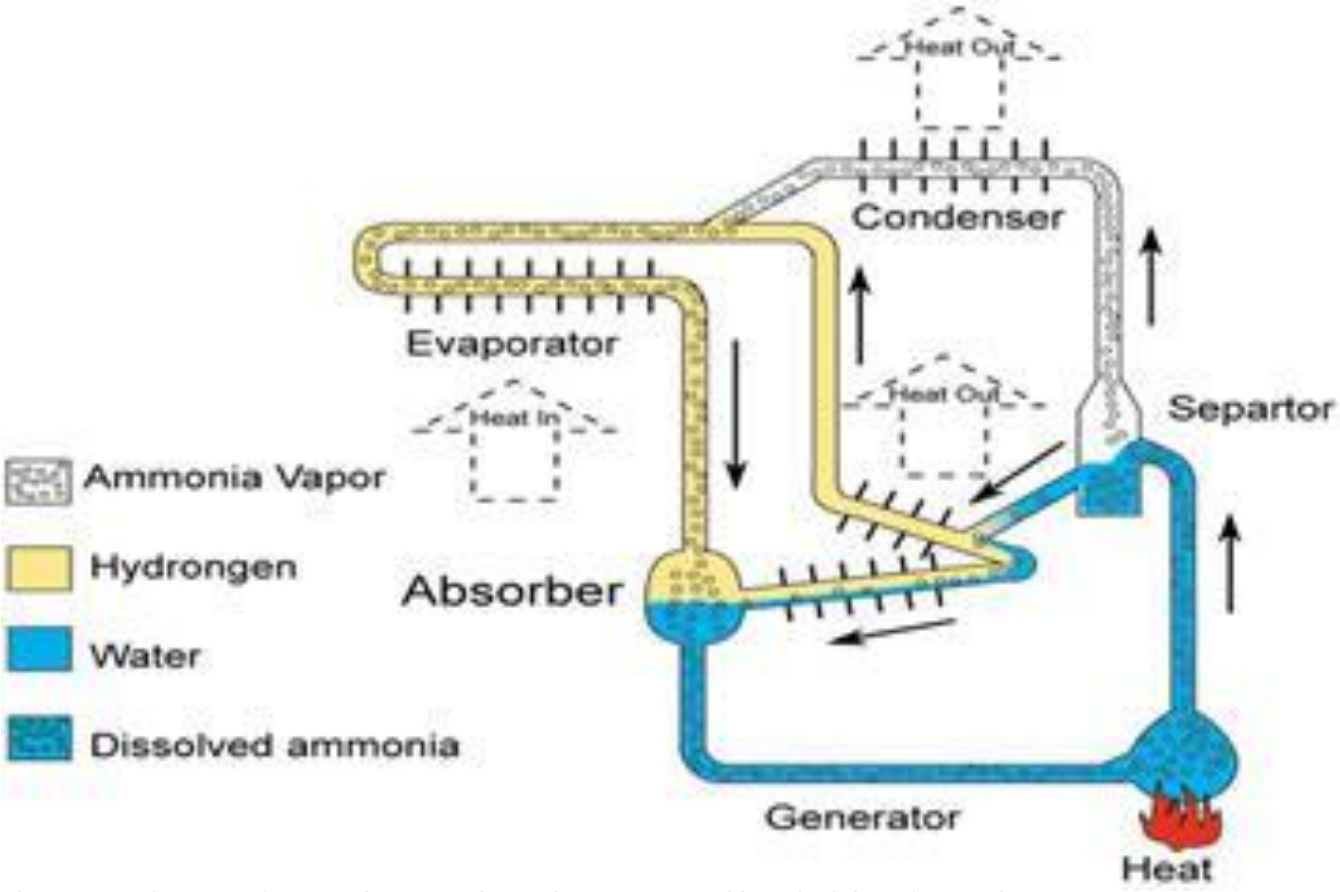


Figure 8.Basic parts of ammonia water absorption system and its principles of operation

With the application of heat at the generator, ammonia vapour is driven from the solution. This hot vapour rises into the separator and a portion of the water condenses and flows by gravity into the absorber. The hot ammonia vapour continues to rise into the condenser where it gives up it sheat to the surrounding air and condenses into a liquid. The liquid ammonia enters by gravity into the evaporator, where it is mixed with hydrogen gas. Circulation of hydrogen gas causes a reduction in pressure within the evaporator. The low pressure causes the ammonia liquid to boiling to a gas (evaporating) and absorbing heat in the Process (refrigerating effect). The mixture of hydrogen/ammonia vapour that's carrying the absorbed heat is now drawn by gravity into-the absorber. Because the water from the separator has a greater affinity for ammonia, it separates from the hydrogen as the hydrogen gas being very light rises and returns to the generator to start the cycle again. Absorption refrigeration is driven by heat from electric element, gas flame, or Kerosene wick burner

Absorption Refrigeration System Important notes

The equipment can be operated using either kerosene or electricity.

The device will not function and might be damaged if it is operated with both energy supplies being selected simultaneously

To avoid the risk of fire, use only pure top-grade kerosene. Do not use petrol, diesel or mixed fuels.

For operation with electrical energy, the required voltage must be checked with the data given on the name plate

Widely used types of Absorption refrigerators in Ethiopia are:
Domestic: RCW42KE; RCW50KE
SIBIR: V170KE; V110KE,V24KE, S2325 KE,
etc Note: - KE: - kerosene& electric operation
Installation and operation

Installation instruction

The device should be checked immediately after delivery for damage which might have occurred during transportation. In case you suspect any refrigerator damages, not if your supervisor before unpacking. Remove accessories from the box and examine to ensure they are complete. Parts include, filler funnel, brush, burner, wick cleaner, spring, (burner mirror and aluminium partitions- for RCW50KE only).

The device should be cleaned properly before setting it in to operation. For this, use only lukewarm water and a mild cleaning agent. abrasive or caustic cleaning agents, steel wool, scouring sponges, or chemical cleaning agents should not be used under any circumstances. After the cleaning is finished, the device should be dried properly.

Ensure that the device is placed in a cool location, away from heat sources, and not be exposed to direct sun light. The room must be ventilated properly. The device must not be exposed to air draught conditions. The unit covering, i.e. the venting slots and the chimney opening must not be blocked.

Lower the distance holder at the rear side of the device. Make sure that, due to the air circulation required, a minimum distance of 10cm is provided between the device and any wall located next to the device. If the device is placed near to a wooden wall or a cardboard wall, a minimum safety distance of 50cm must be realized. Clearances to roof at least 400mm (for SIBIR refrigerators) Check that the door seals properly against the cabinet. To ensure proper function, the device must be standing properly. Use a water level to check and to correct if necessary.

Installation of the isolation inserts (onlyforRCW50KE)

Two aluminium and 2 water isolating inserts are included with the delivery. The use of these isolating inserts is subject to the ambient temperature.

Use the water isolation inserts at ambient temperatures up to+32°C.

Use the aluminium isolation inserts at ambient temperatures higher than +32°C (up to +43°C at maximum).

The isolation inserts must be pushed into the slot on the left and right side of the freezer section. Two isolation inserts must always be installed. If only one isolation insert is installed, the temperature in the cooling section without an isolation insert will become too cold.

The plastic isolation inserts must be filled up to the indicated maximum level with cold, clean water before starting operation. Do not fill the isolation inserts completely! The upper section must be kept free

Instruction for operation with electrical energy

Stop kerosene operation! The device will not function and might be damaged if it is operated with both energy supplies being selected simultaneously.

Refer to the nameplate (rear side of box) to check whether the available mains supply corresponds to the required operating voltage of the device (220V, 240V, or 120V).

The mains cable has to be provided, corresponding to the local regulations, with an earthed mains plug.

Connect the mains plug to the socket.

Turn the electrical thermostat switch clockwise to position “2” (ambient temperatures+32°C).

The LED “POWEROK” lights up. Use the thermometer to check for the temperature of the cooling section afterabout24hours. For storage of vaccines the temperature should be within a rangebetween+2°C and+8°C.

Adjust the temperature as required using the electrical thermostats witch(increased setting= increased cooling capacity).

Turn the thermostat switch counter-clockwise to position “0” and unplug the mains cable to switch off the device when it is operated with alternating current.

INSTRUCTION FOR OPERATION ON KEROSENE

Filling the tank

Use only pure top-grade kerosene.

Use the funnel provided to fill the tank. To ensure the tank remains free from dirt, the kerosene should be poured in through a sieve, filter paper or a clean cloth.

Fill the tank up to the ‘MAX’ mark. For SIBIR refrigerators, the level indicator shows the

Kerosene level

Wipe the tank carefully in case fuel has been spilled.

Close the tank using the red shutter cap and push 3/4of the way on to the tank plate.

Installing and lighting the burner

The‘Aladdin32’keroseneburnerconsistsof the following parts: Burner glass; Burner gallery; Burner insert; Burnerring,including2lockingnuts;Wickcleaner/clipper;Wickholder;Wick; Burner housing and Spring

After unpacking the burner proceed as follows:
1. Push the spring on to the burner housing (Smaller diameter facing upwards).

Figure 9. Disassemble the burner

2. The wick cleaner is located below in the burner housing. Keep in a safe place after removal.

Figure 10. Cleaning the wick

3. Position the burner glass securely on the burner gallery.

Figure 11.reassemble the burner gallery

4. Detach the burner gallery, together with burner glass, by turning anticlockwise.

Figure 12. Burner detachment

Screw the wick out, turn the burner round and dip the upper end of the wick in to the kerosene for a few minutes.

Figure 13. Deep the burner wick in to kerosene

6. Twist the wick out so that it is approximately 2mm over the edge of the burner.

Figure 14. Re-assembly of burner

Position the burner up right on the tank.

The ends of the wick must reach the bottom of the tank inlet.

Leave the burner in this position for approximately five minutes to enable the wick to absorb the kerosene from the tank.

Then light the burner and leave it burning for several minutes until the wick is burning all around.

Figure 15. Lightening the burner

10. Attach the burner gallery, together with the burner glass, and place clock wise in position.

Figure 16. Place the burner in position

CAUTION: THE BURNER IS HOT.

11. Press the burner down wards onto the spring while carefully pushing the tank onto the tank plate.

Figure 17. Place the tanker in position

12.Release the burner carefully when it is positioned under the chimney pipe.
13.Ensure that the burner glass is exactly under the flange and is closed tightly.

Adjusting the burner flame

The optimum adjustment must be set to achieve maximum performance from the equipment. The burner must be burning on a completely blue flame.

To adjust the flame, screw out the wick until small light tips appear above the flame. See MAX (Fig:- 17- A, B & C)

Figure 18. Adjusting the burner for proper flame

• To adjust the MIN settings turn the wick back slowly until the light tips disappear.

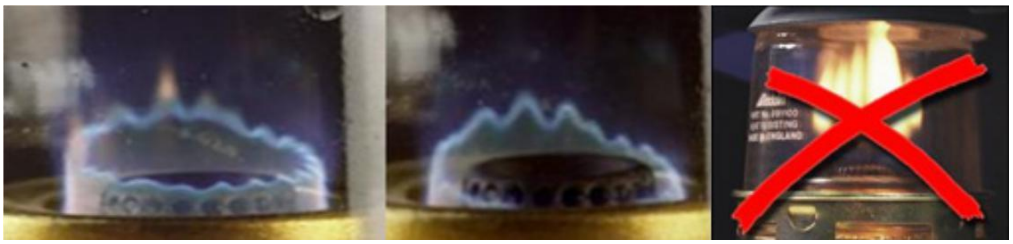


Figure 19. Adjusting the minimum and maximum setting of flame Figure 20. Wrong yellow flame

• Do not operate the burner on a large yellow flame under any circumstances. (Fig:- 19)

This causes the flame to give off smoke and the unit to overheat. Performance is impaired as a result. Kerosene consumption also increases considerably.

A yellow flame always indicates in correct oxygen supply. There can be several main causes: Oburner glass sealing–pervious flange

Oburner glass is resting in securely on the burner gallery

Owick is too far out or burned too low (soot particles)

okerosene supply interrupted or insufficient kerosene in the

tank odraught (flickering flame)

oburner installed incorrectly or dirty.

The flame must be re adjusted after the burner has been in operation for approximately30 minutes and after 1hour

•Check the refrigeration compartment temperature after approximately 24 hours by using the thermometer.

For the storage of Vaccines the temperature must be between+2and+8°C (green area on the thermometer).
If necessary, regulate the temperature by adjusting the flame (smaller flame=lower cooling capacity).

SWITCHING OFF WHEN OPERATING ON KEROSENE

Turn the wick back, press the burner on to the spring and push the tank out. Blow the flame out. Please refer to the procedure for the cooling of products.
e.g. Vaccine cooling

Install the isolation inserts in to the device (ForRCW50KE).

After setting in to operation the device will have to operate for a minimum of24hours, until thetemperaturesuitableforthestorageofvaccinesisreached.Toavoidafurtherextension of that period, the device must be operated empty, i.e. without icepacks, and without vaccines.

Use the thermometer enclosed to check the temperature of the cooling section after about 24 hours. For storage of vaccines the temperature should be with in arrange between +2°C and+8°C.

Do not store any vaccines, until the device is performing a stable operation at the required operating temperature.

Observe the temperature continually and, if necessary, rectify using the thermostat button

o (When operating on electricity) or by adjusting the flame(when operating on kerosene).

• Check and record the temperature on a daily basis while equipment is in operation.

USEFUL NOTES:

Store your vaccines such that air can circulate between the individual packages.

Keep the device tidy inside. Thus, you can avoid unnecessarily extended opening periods.

Open the lid of the device just as often and just as long as absolutely necessary, in order to prevent the unit from humidity penetrating into the interior.

CLEANING

The refrigerator should be cleaned inside and outside before it is set in to operation and after wards at regular intervals.

Use luke warm water with a mild cleaning agent. Abrasive or caustic cleaning agents, steel wool, scouring sponges, or chemical cleaning agents should not be used under any circumstances.

After the cleaning is finished, the device should be dried properly. The interior section of the refrigerator must be free of water and humidity.

If the device is to be taken out of operation for a longer period, the inner and outer containers should be cleaned and the lid should be left open a small gap, to avoid unpleasant smells.

LIGHTING KOSMOS BURNER–YELLOW FLAME

Remove the lamp glass with its sealing ring (pull carefully upwards).

Adjust thewicktoabout1mm (1/32inch) above the wick guide.

Light the wick and allow the flame to travel around the wick.

Turn the flam every low. It should now be even. If it is not, the wick should be pressed down where the flame is high. Use a wire or screwdriver.

Replace the lamp glass with insert carefully

Push the tank in to the tank holder underneath the cabinet at the rear of the refrigerator.

SLIDE THE TANK CAREFULLY FOR WARDS AGAINST THE GUIDE PIN.

Carefully lift the tank by means of the lever arm and check that the guide pin enters the hole in the bracket on the left side of the burner.

Make sure that these a ling ring seals properly against the chimney. There must be no gap between the chimney and the sealing ring.

Adjust the flame to medium flame, and leave the refrigerator running for 3–4hours.

For further adjustment.

Never let the flame get smoky. If it does, turn down the flame.

Never turn the flame to maximum until the chimney heated for 3–4 hours.

First time using the refrigerator, smoke will appear due to paint residues in the chimney
Regulating the temperature KOSMOS burner– Yellow flame

For good temperature control, the burner should be lit constantly. The refrigerator temperature depends on the flame size. It is regulated by the control knob.

High flame gives a colder refrigerator. Low flame gives a warmer refrigerator.

DAY/NIGHT REGULATOR (SIBIR170/110 KE)

In low ambient temperature (for example at night in some climates) the refrigerator may be too cold. By moving the lever (at the top of the refrigerator) to the “moon” position, the flue baffle inside the chimney willbeliftedupabout320mm (11⁄2inches),which reduces the efficiency of the cooling unit.

During day, when it is hot, the lever should be moved to the “sun” position. The flue baffle will return to normal and the refrigerator will operate normally.

ROUTINE PREVENTIVE MAINTENANCE

Group Activity

In a group of five

Discuss what are the routine preventive maintenances that should be performed daily, weekly and monthly basis?

DAILY

Check and note the cool-room temperature using the thermometer/fridge-tag.

If the temperature does not correspond to the level required, rectify using the thermostat but to nor by adjusting the flame. Should this fail, refer to chapter entitled

'Error location'.

When equipment is operating with kerosene, check the colour of the flame. The flame must be blue and the burner must not give off any smoke. (The tank contents may make it impossible to set a blue flame).

Examine the tank contents. To ensure the burner is able to operate properly, the kerosene level in the burner inlet should not fall below5mm.

Store the vaccines away in their corrector der to enable air to circulate freely between the individual packages.

Remove any residual liquid from the inner container immediately.

WEEKLY

Check for the ice layer on the evaporator. If the ice layer is thicker than 1cm, the device must be defrosted.

Frost forming rapidly (in just a few days) could be result of poor door sealing

Clean the lid sealing and verify that the lid is locking tightly

When operating on kerosene:

Examine the wick. The end of the wick must be straight and clean. Trim using the wick cleaner/ clipper, if necessary.

Examine the ventilation holes in the burner housing. These must remain free.

Examine to ensure the burner is free from soot.

Clean the burner glass.

Examine to ensure the end of the wick reaches the bottom of the tank inlet.

Clean the chimney using the brush provided. (Refer to chapter entitled 'Cleaning the chimney').

- Examine the tank. The ventilation bore in the tank cap and the kerosene inlet opening in the burner inlet must remain free.

MONTHLY

Use a soft brush to free the unit from dust.

Clean the device inside and out side. Use lukewarm water with a mild cleaning agent. Abrasive or caustic cleaning agents, steel wool, scouring sponges, or chemical cleaning agents should not be used under any circumstances. After the cleaning is finished, the device should be dried properly.

Clean the lid sealing/door gasket.

Check the hinges and locking for tight fastening and verify that the lid is locking tightly.

CHECKING THE DOOR SEAL

Place a thin paper strip against the cabinet front.

Close the door.

Pull the paper strip, if it moves easily or falls away by itself:

Find the place where the rubber gasket doesn't seal tightly, then…

Place a pad of paper or sticking plaster between the rubber

Gasket and the inside of the door in order to make the gasket seal tightly

If you cannot make the door seal tightly, order anew door.

DEFORESTING

Due to the humidity of the ambient air, a layer office will form gradually on the evaporator. As a result of the unit construction, that ice layer will at first format the left side of the evaporator. If the ice layer is thicker than 1cm, the cooling capacity of the device will be impaired. In such a case the device must be defrosted.

Remove the medical products (vaccine, blood,), Ice packs and isolation inserts. Store them in another pre-cooled refrigerator/cold box.

Switch off the device-if operated electrically, unplug the device; if operated with kerosene, blow out the burner flame.

Open the lid/door and wait until the ice has completely melted.

- Do not make at tempts to remove the ice layer using a knife or other tool

After defrosting the interior of the device must be completely and

Properly cleaned and dried. Do not use any heating devices to dry the device.

CLEANING THE CHIMNEY

Switch off from kerosene operation. Turn the wick back, press the burner on to the spring and pull the tank out. Blow the flameout and wait until the chimney has cooled down.

Lay a sheet of paper down onto the tank plate under the chimney.

Pull out the flue baffle.

Clean the chimney using the brush provided until no more particles of soot fall on to the paper.

Remove the paper and push the tank back together with the burner.

CLEANING/CLIPPING THE WICK

If a blue flame can no longer be set, the wick must be cleaned or clipped.

Switch off kerosene operation. Turn back the wick, press the burner on to the spring and pull the tank out. Blowout the flame.

Wait several minutes until the burner has cooled down.

Remove burner gallery, glass and insert.

Position the wick cleaner on the burner ring with the hollow side facing down wards.

Press the wick cleaner down wards and turn clock wise. At the same time slowly turn the wick up wards. As soon as the wick touches the cleaner, black carbon particles will appear in the wick cleaner's openings. Continue this process until no more black particles appear.

Then clean the burner thoroughly and ensure the wick is still positioned up right over the burner ring.

Refit the burner insert, light the burner and position the gallery and glass.

Push the tank back and adjust the flame. Readjust the flame after approximately 30 minutes and after 1hour.

CLEANING THE BURNER/REPLACING THE WICK

Switch off kerosene operation. Turn back the wick, press the burner onto the spring and pull the tank out. Blow out the flame.

Wait several minutes until the burner has cooled down.

Remove burner gallery, glass and insert. Clean or clip the wick

Unscrew the two nuts on the burner ring and remove the ring.

Pull the wick and its holder out of the burner housing.

Remove particles of dust and soot from the burner gallery, insert, ring and housing using a needle or a soft brush. Then wash the parts in clean kerosene and dry thoroughly.

Clean the burner glass using a soft cloth.

If you wish to replace the wick, remove the holder from the old wick and position on the new one.

Insert the ends of the wick into the openings in the burner housing from above. The teeth on the wick holder must be on the same side as the small toothed wheel in the housing.

Pull the ends of the wick down wards until the toothed wheel inter locks with the teeth.

TURN THE SCREW IN THE HOUSING ANTICLOCKWISE TO INTRODUCE THE WICK.

Positiontheburnerringandtightenthetwolockingnuts.Ensurethatthetwonutsare positioned under the housing's flange.

Refit the burner insert.

When using a new wick, screw out slightly, turn burner round and dip the upper end of the wick into the kerosene for a few minutes.

Screw the wick out so that it is approximately2mm over the edge of the burner ring. Position the burner on the tank. The ends of the wick must reach the bottom of the tank in let. Leave the burner in this position for approximately five minutes to enable the wick to absorb the kerosene from the tank.

Then light the burner.

- The wick must burn all around.

Position the burner gallery and turn clockwise to fix in his position.
Insert the burner glass carefully into the gallery.

Press the burner down wards on to the spring and push the tank backwards on to the tank plate.

Release the burner carefully when it is positioned under the chimney pipe. Ensure the burner glass is positioned exactly underneath the flange and closes tightly.

CLEANING AND TRIMMING THE WICK–KOSMOS BURNER

For removal of the tank.

Remove the lamp glass with insert.

Clean the wick surface with your fingers in order to get it even and free from carbon.

If not possible to use fingers, trim with a raz or blade.

Blow the wick and burner clean.

Assemble the burner and fit it in to the tank.

REPLACING THE WICK – KOSMOS BURNER

Remove the tank.

Remove the lamp glass with insert.

Lift the burner from the tank.

Turn the wick down wards and pull it out.

Un pack a new, dry and clean wick.

Insert the new wick, red end first, at the bottom of the burner.

Push the wick in until it reaches the cogwheel.

Figure 21. Inserting the new wick

Turn the cog wheel shaft clock wise until the wick end comes out at the burner top.

9.Pull the wick back and forth through the burn era few times.

Turn the wick until itis 2–3mm above the top of the wick guide.

Unscrew the gallery.

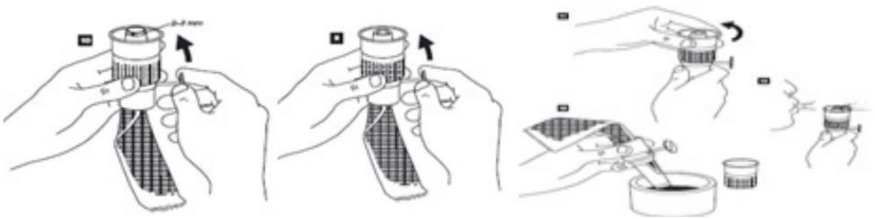


Figure 22.Adjusting the proper wick height in mm& soaking the wick

Dip the wick in kerosene a few seconds.

Light the wick and allow the flame to burn until it goes out by itself.

Blow the ashes away and the wick should now be even all the way around the wick guide. If not, repeat the procedure.

CLEANING THE TANK

Extinguish the flame and pull the tank out.

Remove the burner and tank cap.

Screw off the burner shield.

Wash the tank with kerosene. Do not reuse this kerosene after wards!

Clean the burner shield, dry carefully and reinstall.

Examine the ventilation opening in the tank cap. This opening must remain free.

Refill the tank and close tightly.

Wipe the tank all around and examine for any possible damage.

Reinsert the burner and light. Push the tank onto the tank plate in the way described above.

CLEANING THE REFRIGERATOR

It is advisable to clean the refrigerator inside when defrosting.

Use warm (not hot)water and mild house hold detergent.

3. Never use scouring powder, steel wool or similar.

Do not forget to clean the door gasket.

Before starting the refrigerator again, wipe all parts completely dry.

Put the vaccine back as quickly as possible.

Clean the external parts with a soft brush or a piece of cloth. In particular, the cooling unit should be kept clean for best performance.

CORRECTIVE MAINTENANCE

Activities to be performed before repairs:

Where it takes more than two hours to repair your appliance, remove all vaccines and icepacks and store them in another pre-cooled appliance.

Remove the plug from the socket (for electrical refrigerators).

Stop kerosene operation and remove the tank with the burner (for kerosene refrigerators).

For almost all repairs, the cover of the cooling unit has to be removed

Checking the thermostat and heater

Pull out the plug from the wall socket.

Remove the plastic cover on the thermostat.

Remove electrical cables from the thermostat.

By-pass the thermostat by connecting the cables using tape or sticking plaster.

Make sure to insulate the metal ends completely.

Push the plug into the wall socket and put the refrigerator on test for at least 3–4 hours.

If the refrigerator gets cold the thermostat should be replaced.

If the cooling unit does not get warm, replace the heater.

When finished, do not forget to put the wires back on the thermostat.

Do not attempt this procedure without the proper knowledge electrical components

Replacing the heating element (forRCW50/42KE)

Dismantle the cooling unit cover.

The heating element is on the inside of the cooker insulation in the heating pipe.

Lift up the cooker insulation and press it down in the direction of the arrow until it opens.

Remove the cooker insulation

Undo the heater's connecting flex from the terminal block and remove the cable clip from the back wall of the appliance.

Unscrew the heater's fastening screw from the heating pipe.

Remove the heating element with the flexes.

To insert the new heating element, proceed in reverse order.

Replacing the electrical thermostat (For RCW50KE)

Dismantle the cooling unit cover(forRCW50/42KE).

Unscrew the evaporator cover's two fastening screws on the inside of the appliance.

Pull up the evaporator cover carefully.

The capillary tube for the electro thermostat is under the evaporator cover. Straighten the capillary tube carefully and pull it backwards through the opening in the back wall of the appliance.

Unscrew the fitting elbow.

Undo the heater's fastening clamp so that the fitting elbow can be moved freely.

Take off the thermostat button.

Pull the entire fitting elbow carefully back out of the appliance.

Undo the control panel from the fitting elbow.(Using a screw driver, bend the plastic catch back carefully.)

Unscrew the thermostat's fastening nut.

Mark and disconnect the wires on the thermostat.

To install a new thermostat, proceed in reverse order.

NB: The capillary tube may not be bent with sharp edges and may not be placed on a heat source (e.g. the cooling unit).

Replacing the thermometer (For RCW50KE)

Dismantle the fastening clamp in the inside container.

Take off the transparent PVC hose.

Remove the sealing compound from the duct at the back of the appliance and store it in a safe place.

Pull the capillary tube out of the back wall of the appliance and straighten it.

Lift the thermometer out of the appliance.

To install the new thermometer, proceed in reverse order. When removing the capillary tube, ensure it is not bent with sharp edges.

The duct at the back of the appliance must be sealed with sealing compound.

Replacing the thermostat (For SIBIRKE)

Remove the plug from the wall socket.

Remove the capillary tube end at the cooling element and pull it careful y out from the rear of the cabinet

Remove the plastic cover and the wires from the thermostat.

Remove fastening screws or nuts and pull the thermostat out.

Fit the new thermostat.

Connect the wires and replace the plastic cover.

Reattach the capillary tube.

Plug into the wall socket.

BECAREFULNOT TOBREAKTHECAPILLARYTUBE!

Make sure that the capillary tube makes contact with the cooling element only where it is to be fastened.

Replacing the heater (For SIBIRKE)

Remove the plug from the wall socket.

Remove the terminal cover and loosen the heater cables.

Look for a small cover on the boiler case and remove it.

Lift the heater and take it out.

Insert the new heater in to the heater tube.

Make sure that the glass wool is put back around the heater and fit the cover again.

Connect the cables and fit the terminal cover in reverse order.

Put the refrigerator on test.

Troubleshooting chart for kerosene operated refrigerated

Problem	Probable Cause	Remedy
Refrigerator not cooling at all	1.Flamenotburning 2.Thesize of the flame not proper 3.Ventilation around the cooling unit not sufficient 4.Refrigerator not correctly levelled 5.Try electrical operation if possible	1. Light the burner if it does not stay alight clean the burner and wick 2. Check and adjust the flame. 3.Checkand arrange the cooling unit for ventilation. 4. Check and level the refrigerator 5.Ifit is working on electrical repeat starting procedure on kerosene. If itis not working on electrical too replace the cooling unit

Refrigerator Not cold enough	1. Flame not correctly adjusted 2. Evaporator frosted 3. Over loaded Refrigerator 4. Door not closing properly 5. Air circulation inside and around the refrigerator is not good 6. Refrigerator not correctly levelled 7. Dust on condenser or blocked condenser 8. Flue baffle not in position 9.Flueand baffle not clean 10.Dirt on kerosene tank. 11.Burnernotclean 12Wicknot clean and not level 13. Lamp glass insert do not have good sealing.	1. Check and adjust the correct flame size 2. Defrost the evaporator 3. Takeout some load 4. Check door gasket or adjust door 5. Improve installation and re arrange vaccine for good air circulation 6. Check and level the refrigerator 7. Clean condenser or remove blockage 8. Check and hang flue baffle in position 9. Clean the flue and baffle 10. Clean the tank and refill 11. Clean the burner 12. Trim the wick or replace 13. Adjust tank position to give good sealing
Refrigerator Too cold	1. Flue baffle not in position 2. Flame size too high	1. Lift the flue baffle in position. 2. Turn flame down

COMPRESSION REFRIGERATION SYSTEM

Individual Activity

Discuss about the principal parts of compression refrigeration and their functions

Time: 5min

In general refrigeration is defined as any process of heat removal. More specifically, refrigeration is defined as that branch of science which deals with the process of reducing and maintaining the temperature of a space of material below the temperature of the surrounding Compression refrigeration are driven by electricity and cannot operate on gas or kerosene. The compressor provides powerful cooling, approximately four times more than absorption refrigeration for the same input of electrical energy.

Wherever there is more than 8 hours of electricity per 24 hours, the compression refrigeration is preferred to the absorption refrigerator as its thermostat ensures correct internal temperatures in most conditions and less maintenance is required.

Vapour-compression refrigeration has the advantages of control and response time over absorption refrigeration for all small refrigeration applications, including vaccine storage. Absorption refrigeration should only be used when a reliable power source for a vapour-compression system is unavailable, or when it can be shown that costs of absorption systems are lower than vapour-compression alternatives and the absorption system can provide an equivalent degree of cooling for the vaccines.

The compression cycle is so named because it is the compressor which changes the refrigerant vapour from low pressure to high pressure. This pumping causes the transfer of heat energy from the inside of the cabinet to outside. Since the compression machine transfers heat from one place to another, it may also be called a heat pump.

Ice-lined refrigerators maintain temperatures below +8 0C even with 16 hours electricity failure per 24 hours, day after day. Ice-lined refrigerators are strongly recommended zonal, regional and central levels, since electricity supplies are rarely perfect and standby electricity supplies are not practical. An internal lining of water filled tubes or packs that surround the vaccine storage area provide the cooling. In order to freeze this water lining with a limited number of hours when power is available (8 hour), the compressor has to operate extensively and, occasionally, the vaccine storage area in the bottom of the appliance falls below 0 oC. Freeze sensitive vaccines should, therefore NOT be stored within 20 cm of the base of these models. Some models have a mark inside the cabinet, which indicates areas potentially dangerous for the storage of these vaccines.

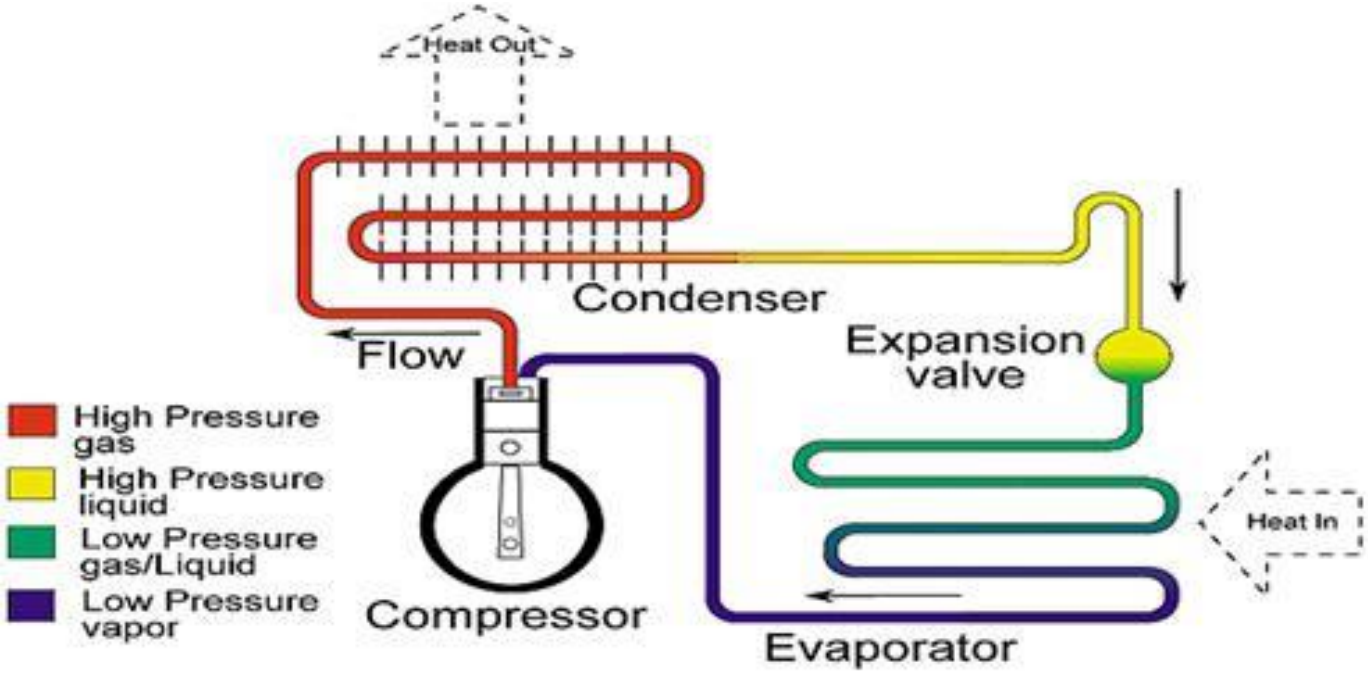


Figure 23. Schematic diagram for compression process, parts and their functions

THE COMPRESSION CYCLE

A thorough understanding of the cycle of operation of a refrigerator is necessary before a correct diagnosis of any service problems can be made. Thus, only by a thorough study of the fundamentals will one be able to master the field of refrigeration.

A cycle, by definition, is an interval or period of time occupied by one round or course of events in the same order or series. The word cycle, as applied here, means a series of operations in which heat is first absorbed by the refrigerant, changing it form liquid to a gas. And then the gas is compressed and forced into the condenser where the heat is absorbed by the circulating air, thus bringing the refrigerant back to its original or liquid state.

The compressor pumps refrigerant through the entire system. It draws cool refrigerant gas in through the suction line from the evaporator coils. At the same time, it compresses the gas and pumps it in to the discharge line. The compressed gas sharply rises in temperature and enters the condenser.

The condenser performs a function similar to that of the radiator in an automobile; that is, the condenser is the cooling coil for the hot refrigerant gas. In the condenser, the heat is expelled into the room air outside the cabinet. During this process, the refrigerant gas gives up the heat it removed from inside the cabinet and changes into a liquid state.

As the hot refrigerant liquid leaves the condenser to enter the capillary tube, a filter-drier removes any moisture or impurities.

The capillary tube is carefully calibrated in length and inside diameter to mete the exact amount of liquid refrigerant flow required for each unit. A predetermined length of the capillary tube is usually soldered along the exterior of the suction line, forming a heat exchanger, which helps to cool the hot liquid refrigerant in the capillary tube.

As the refrigerant leaves the capillary tube and enter the larger tubing of the humid plate and evaporator, the sudden increase in tubing diameter forms a low-pressure area and the temperature of the refrigerant drops rapidly as it changes to a mixture of liquid and gas. In the process of passing through the evaporator. The refrigerant absorbs heat from the storage area and is gradually changed from a liquid and gas mixture to a gas.

The low-pressure refrigerant gas leaving the evaporator coil now enters the accumulator, which is a large cylinder designed to trap any refrigerant liquid that may not have changed to gas in the evaporator. Since it is impossible to compress a liquid. The accumulator prevents any liquid form returning to the compressor.

As the refrigerant gas leaves the accumulator, it returns to the compressor through the suction line, which is part of the heat exchanger, thus completing the cycle.

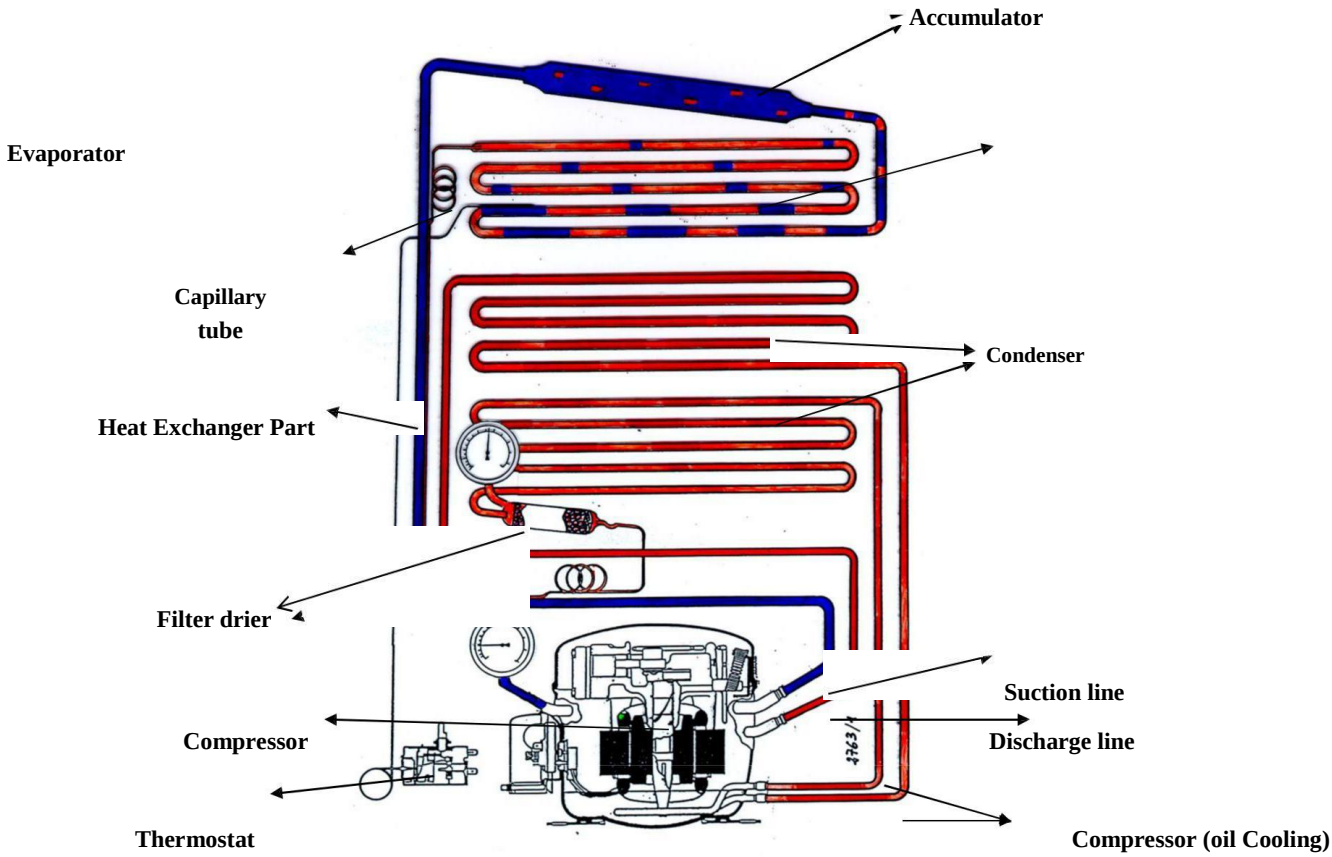


Figure 24. Schematic diagram for compression refrigeration system

PRINCIPAL PARTS OF COMPRESSION REFRIGERATION AND THEIR FUNCTIONS 1. Compressor

Compressor is machines that take refrigerant vapour flowing from the evaporator and compress it causing arise in temperature to take place. Compressors are also responsible for keeping the refrigerant circulating throughout the system, so that the hot vapour from the Compressor is passed to the condenser, where it cools and flows back to the evaporator. Hermetic compressor: The unit employ an electric motor and compressor assembly which are mounted on the same rotor shaft. This has the advantage that no Coupling has to be supplied between the motor and the compressor which are contained in a totally closed steel shell. Such containers are said to be hermetically sealed, and is called a hermetic compressor the hermetic sealing is achieved by welding.

Hermetic compressor is commonly used on domestic refrigerators

Figure 25. Compressor

2 Condenser

The condenser is that part of a refrigeration system in which the super-heated vapour traveling along the discharge line from the compressor is condensed or (liquefied). Inside the condenser the hot refrigerant vapour cools as heat transfers by conduction through the metal walls. Outside the wall is the condensing medium, which can be either air or water. Condenser fall into three main groups: Air-cooled, Water-cooled, end evaporative. In air-cooled types, the air-condensing medium removes heat from the outside of the condenser walls by convection. This convection can be either of the natural type in which air in contact with the walls is heated, rises and is replaced by cold air, or else it can be forced by a fan.

Types of condenser

Skin-type condenser: - with coils attached to the outside or inside of the foamed cabinet casing (Natural air contact cooling)

Wire: Condenser, generally attached to the rear of cabinet (Natural air contact cooling)

Finned condenser: - mounted on the same base Plate as the compressor, (Fan forced cooling)

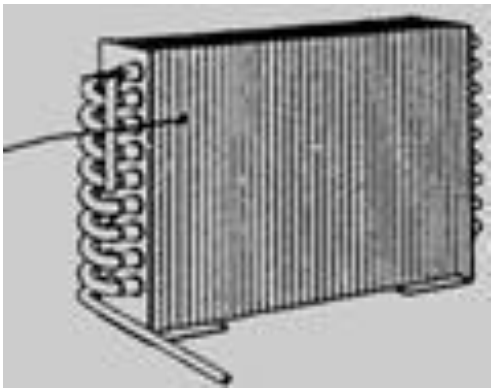


Figure 26. Condenser

3. Water cooled condenser: -

Is annular construction with a tube with in the outer tube. The cooling water flows through the inner pipe and the refrigerant circulates through the outer pipe. In this configuration, some additional heat is transferred from the refrigerant to the ambient air surrounding the condenser.

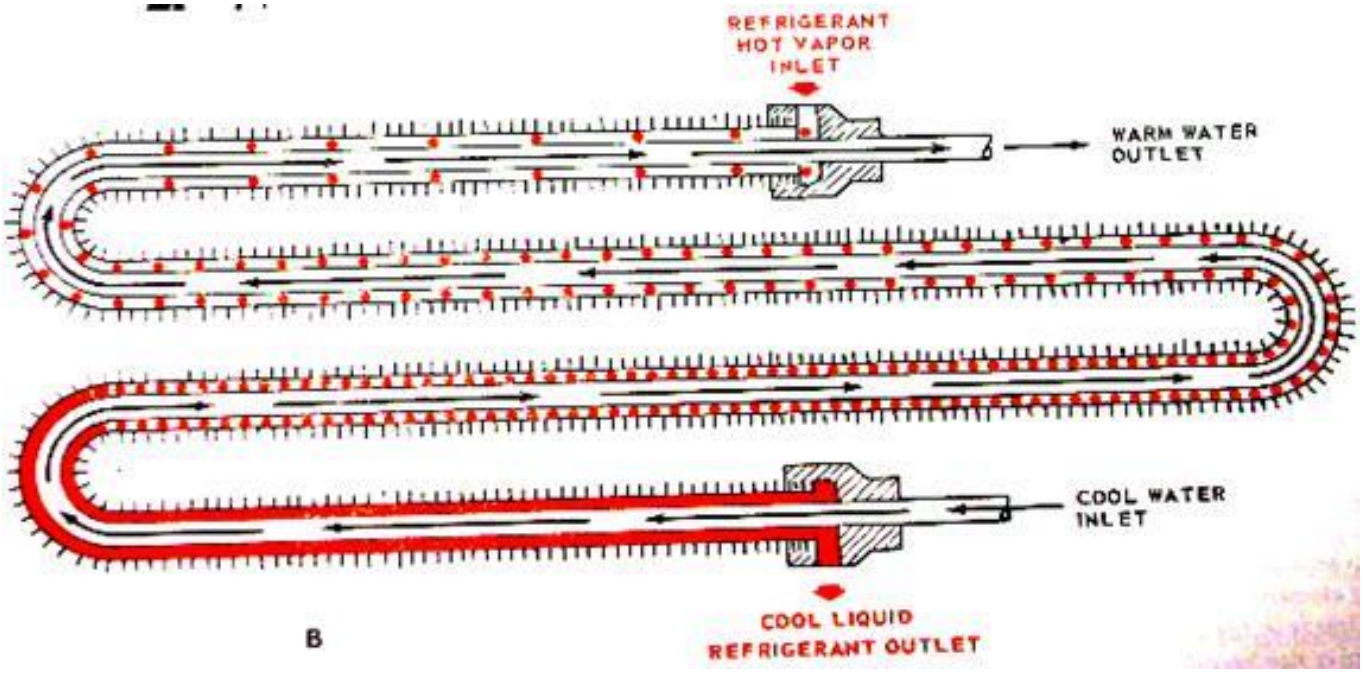


Figure 27. Water cooled condenser

3 Filter drier

The function of the filter-drier is to remove moisture and impurities from the refrigeration system. The drying and purifying agent is usually silica-gel.

The drier consists of a tubular container filled with a silica-gel (desiccant), which is a water-absorbing substance. The drier is mounted between the condenser and the capillary tube.

It is important that refrigerant is dry and therefore contains no water. Moisture in refrigeration system can cause acids to be formed and these can corrode and weaken the metal that make up the pipes and other parts. Sludge, which blocks the system, can also be a problem. Moisture can also cause Ice to form in throttling valves.

Note:-

Owing to the danger of explosion a drier must not be removed by the application of heat unless it has been emptied of it contents.

a drier must always be kept sealed when in storage.

A drier must be fitted in a vertical or inclined position with the capillary tube downwards.

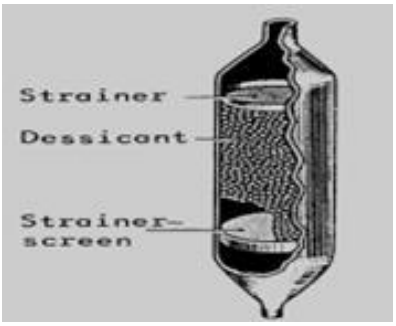


Figure 28. Filter dyer

4 Capillary tube

Silica-gel- ( )

The capillary tube is essentially an expansion device used as a part of the refrigerant circuit. It consists normally of a miniature tube; the length of the capillary tube depends on the size of the compressor and the kind of the refrigerant used. That section where the capillary tube and suction line are brazed together is called the heat exchanger. In more recent refrigeration systems the capillary tube is located inside the suction line the resin of capillary tube is fixed to the suction line, is the cool suction line reduces the temperature of the refrigerant before it enters the evaporator.

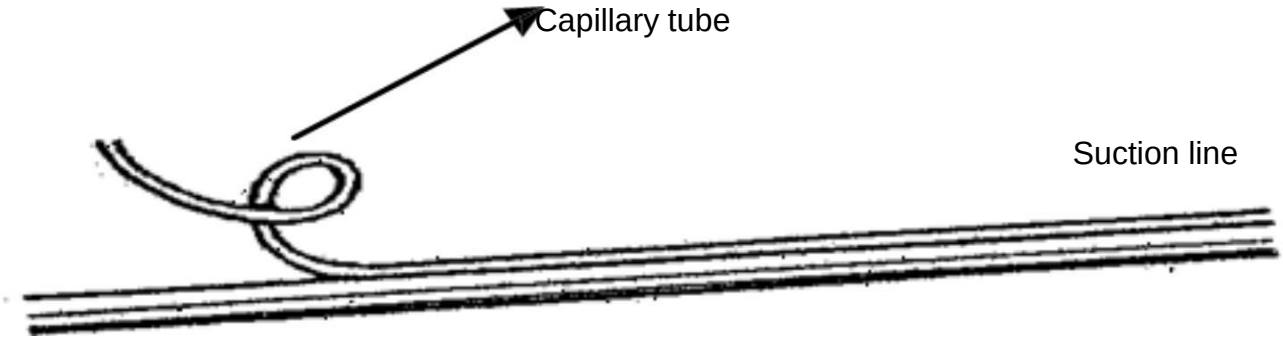


Figure 29. Capillary Tube

5 Evaporator

The function of the evaporator is to absorb heat from the refrigerator cabinet, the heat being introduced by food placed in the refrigerator, insulation loss, and door openings.

In operation, when the refrigerant leaves the capillary tube and enters the larger tubing of the evaporator, the sudden increase in tubing diameter forms a

Low-pressure area and the temperature of the refrigerant drops rapidly as it changes to a mixture of liquid and gas. This cold mixture passes through the evaporator. In the process of passing through the evaporator tubing, the refrigerant will absorb heat from the products to rage area and will gradually change from a liquid and gas mixture to a gas.

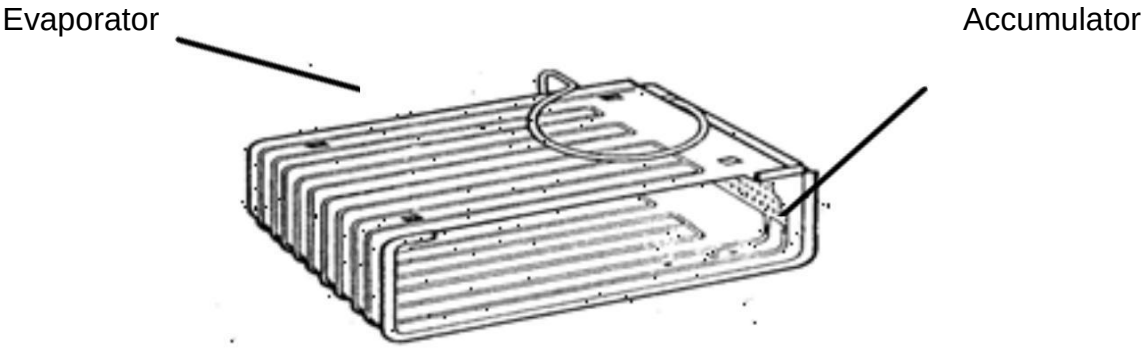


Figure 30. Evaporator

A common type of evaporator fitted in refrigerators or freezers consists of two sheets of aluminium pressed together with channels blown out between them (Roll bond).

6 Accumulator

TheAccumulatorisalargecylindricalvesseldesignedtotrapanyrefrigerantliquidthatmaynot have changed to gas in the evaporator. In this manner any liquid refrigerant remaining in the Low side of the system is prevented from entering the suction line to the compressor. As a rule the accumulator consists of a tubular container with an appreciably larger diameter than the suction line. It may also be integral with an evaporator in the form of corrugation incorporating a number of channels connected in parallel (Roll bond).

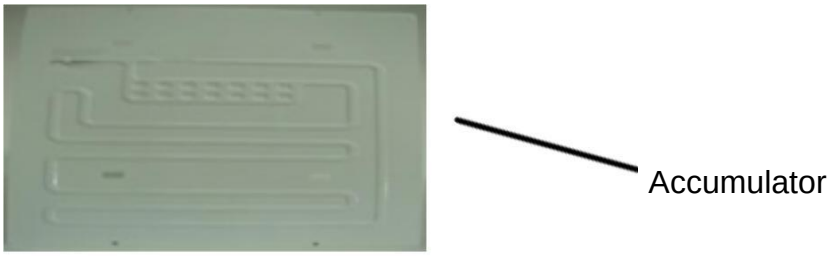


Figure 31. Liquid accumulator

The accumulator is located on the outlet side of the evaporator and its purpose is to vaporize any remaining liquid that may have passed the evaporator. This prevents refrigerant in the liquid state from entering the suction line and causing frost or condensation to form on it. A refrigeration system consists principally of a high-pressure side and a Low-pressure side.

7 High-Pressure side

The high-pressure side of the system is the side containing the high-pressure refrigerant. It consists of the condenser, capillary tube, and compressor.

8 Low-Pressure side

The Low-pressure side is that part of the system where the refrigerant is in a gaseous state at low temperature and pressure. It consists of the evaporator and Suction line. The low-and high-pressure side of a refrigeration system is shown in the figure.

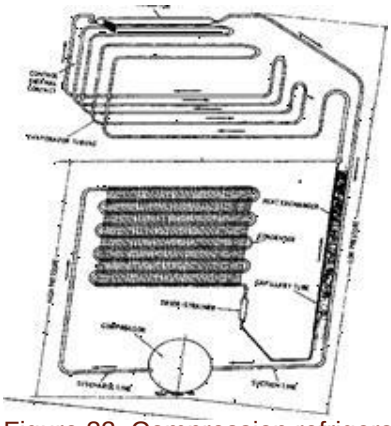


Figure 32. Compression refrigeration High & Low pressure side

Main mechanical domestic refrigerator parts, in mechanical diagram with low- and high-pressure sides of refrigeration system .Principal electrical parts of the domestic refrigeration system and their functions

9 Starting relay

Electrical device which connects and/or dis connects starting winding of electrical motor. When the compressor is switched on a heavy surge of current passes through solenoid (A), causing contact (B) to move up and close the starting winding circuit. When the motor starts, current drops and the strength of the magnetic field in solenoid (A) weakens, allowing contact (B) to drop down to its position of rest. The motor then continues on its main or running winding only.

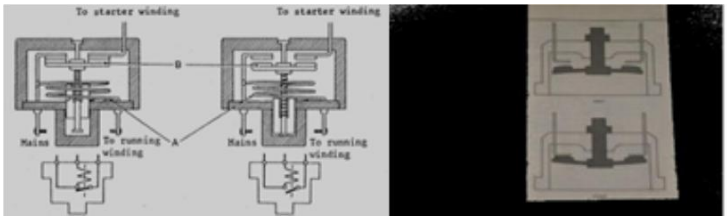


Figure 33. Schematic diagram of starting relays

10 Over load protector

Thermal overload protection for hermetic motors

All hermetic motor-compressor should be equipped with some type of thermal device which will protect the motor against overheating regardless of the cause. Not only to motor over current but also to overheating resulting from high discharge temperature and other such causes.

Figure 34. Open and Closed type of overload relays

11 Thermostat

The thermostat is used to regulate the running periods of the compressor

so that the desired temperature is maintained inside the refrigerator or freezer.

12 Capacitor

The starting capacitor is which gives the compressor a high starting torque. Capacitor: -A capacitor consists in its simplest form of two parallel metal plates. Inmostcasesthetwoplatesarekeptseparatebyapieceofinsulatingmaterial, known a dielectric and the capacitor is rolled up to form a cylinder.

Figure 35. Capacitor

13 Condenser Fan

Condenser fan is an electric fan motor, blow air over the condenser pipes, the hot compressed vapour refrigerant passes through the condenser pipes causes to cold and Condenses.

Figure 36. Condenser and its surrounding, physical photo

14 Condenser cooling fan

The condenser cooling fan (when used) is connected in parallel with the compressor. Therefore, if the compressor operates but the fan dose not, the fan is either defective or is disconnected.

An excessive fan noise complaint may arise if one of the fan blades has been bent out of alignment .If any irregularity is noted, replace the fan blade. Another cause of excessive fan noise maybe, loose fan-bracket mounting screws.

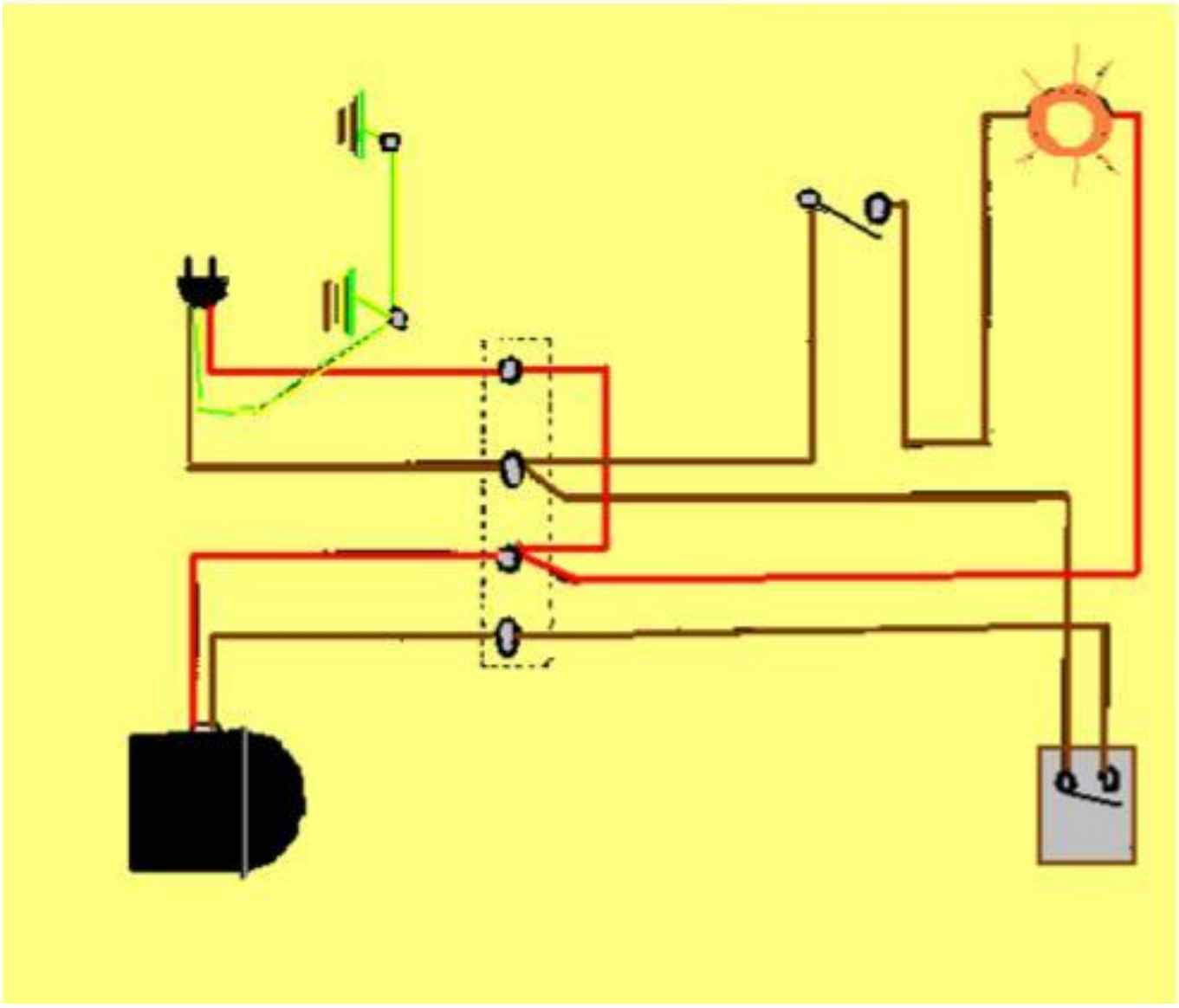
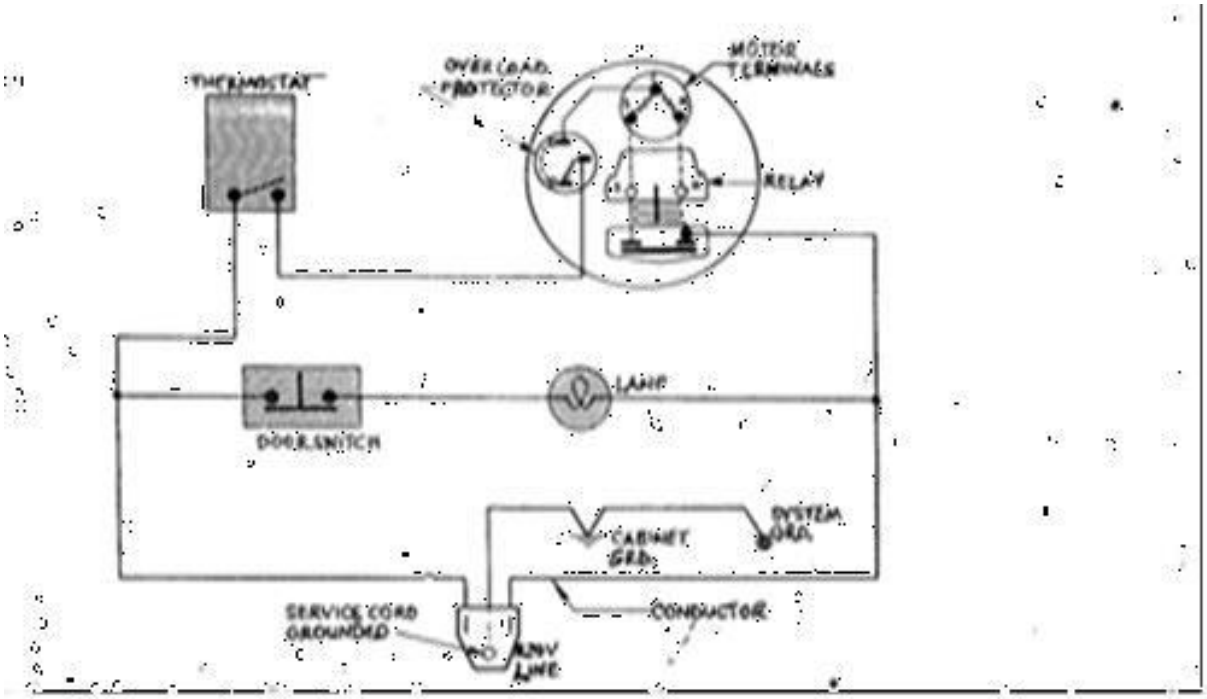


Figure 37. Basic refrigeration electrical control circuit diagram, physical & Schematic



Measuring and test equipment and tool kits for refrigeration works

To perform an effective and efficient maintenance work on refrigeration, a service or maintenance man should have:

- Toolkit
- Measuring equipment, and
- Test equipment

Toolkit

Cutting and joining of copper tubing, evacuating and charging refrigerant are the major works in conducting installation and repair work of cold rooms and refrigerators (Compression or photovoltaic). In order to accomplish this work, a toolkit containing the following major items is necessary.

- Tube (pipe) cutter
- Pinch-off (crimping) tool
- Pipe reamer (inner, outer)
- Flaring tool
- Swaging tool
- Bending tool (pipe bender)
- Quick coupler
- Brazing torch acetylene or propane (includes torch handle, regulator, nozzle and connecting hose)
- System analyser

Apart from the above major items, common hand tools like files (different size &shapes), hammer (ball pin), canter punch, chisel, hacksaw, screwdrivers, pliers, hand vice, adjustable wrench, Allen wrench(set), tape measure, thermometer, etc. are necessary.

Properties of Refrigerator Pipe

All refrigerator works use a special type of soft, clean copper pipe. Copper pipe we use for repair work of refrigerators is supplied in coils or roles of about 6m (20ft) long. All dirt and moisture has been removed from the inside of this pipe where the ends have then been sealed to keep the inside clean.

Generally copper pipe used for refrigeration is soft, so that can be bent and joined easily. Materials that are soft are easily damaged. Always handle the pipe carefully when taking a length of pipe from the coil; when cutting, bending and brazing. Always use refrigeration quality pipe. Any other pipe will damage the refrigerator cooling system.

How to handle a pipe

As mentioned above pipe for refrigerator is supplied in the form of coil. To remove a piece of pipe from the coil, you should unroll the pipe, cut off the length of a pipe you need and then seal the open end to prevent dirt contaminating the rest of the coil then roll the end of the pipe back. Never pull the pipe side way from the coil. This will damage the pipe.

Use of major tools in cutting and joining copper tubing

Tube (pipe) cutter

As the name states, tube cutter (pipe cutter) is used for cutting copper pipe keeping the cut absolutely square, and prevent the formation of burrs and scarf. Avoid hacksaws when possible as it forms burrs go into the rest inside of the pipe. But if forced to use hacksaw, work with the cut end of the tubing held down, so that any scarf or dust does not slide into the pipeline.

How to cut a pipe

Carefully measure the length of pipe needed and mark on the outside (where you are going to cut) with the edge of a file.

Place the pipe between the bottom rollers and the top cutting wheel (see the drawing).

Position the pipe so that the cutting wheel is in line with the mark that you made with the life.

Tighten the hand screw until the cutting wheel just touches the outside of the pipe.

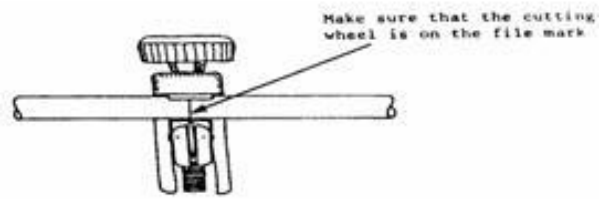


Figure 38. Tube cutter

Pipe cutter in position on the pipe

Turn the pipe cutter slowly around the pipe so that the cutting wheel cuts gradually into the outside.

Turn the hand screw to increase the pressure of the cutting wheel and then turn the cutter around the pipe again.

Continue the cutting by gradually increasing the pressure of the cutting wheel. Work slowly and carefully. Do not use too much pressure or you may damage the pipe.

Pinch-off (crimping) tool

It is a device for sealing the end of a pipe in a coil, compressor (after charging & testing process is completed). By turning the handle clockwise will force the pipe end to be squeezed hardly.

Pipe reamer (inner & outer)

It is used to remove all rough edges from the end of a pipe. It is a one piece both edges shaped to ream the inner or outer side of a pipe end Hold the open end of the pipe to be reamed down (so that the piece of copper will not get inside the pipe). Turn the reaming tool until all rough edges have been removed from the inside of the pipe.

Flaring Tool

In refrigeration work joining of copper tubes is done either by flare fitting or by brazing (soldering). Flare fitting is done by making the end of the pipe opened out wards to form a cone shape edge that fits a flared nipple and tightened by a flared nut. The tool used for flaring pipe is called a flaring tool.

A pipe-flaring tool has the following parts

Block: Uses to tighten the pipe to be flared. It has holes of different diameters (usually 5 holes) to fit different sizes of pipe. It has screws & Thumb nuts fitted on both end of the block for holding tight the pipe on the block.

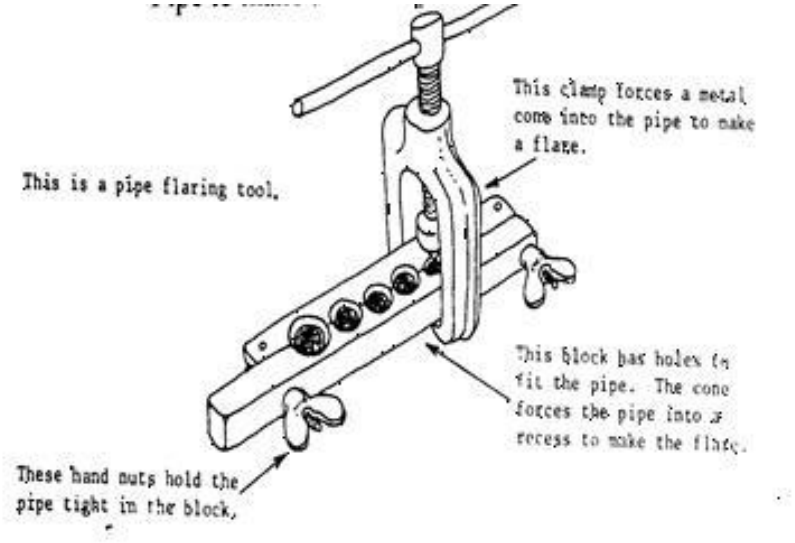


Figure 39. Set of flaring tool

b) Clamp (yoke) & cone: The clamp uses for forcing the metal cone into the pipe to make a flare.

How to make a flare on the end of the pipe

Make sure that the end of the pipe is free of rough edges before flaring.
Place the pipe into a hole where it fits properly. Make sure that you have:

a. Placed the flare nut on the pipe;

b. Chosen the correct size hole in the flaring tool to fit the pipe; there are5 holes to fit different sizes of pipe.

Position the pipe so that the end is a bit high above the top plate of the flaring block. The distance is calculated as “pipe diameter divided by3mm”.

Tighten the thumbnuts at each end of the block.

Fit the yoke to the flaring block.

Remove the flared pipe from the block.

Examine the flare. If it has a crack at end, the cone was screwed down too quickly. If so cut off the end and make another.

Make surethattheflareisacorrectsize.Itshouldjustfitinsidetheflarenut.If it is too loose, cut off the flare and start again. Repeat until the flare is the correct size for the flare nut, (not too loose or not too tight).

Swaging Tool

To joint wo-pieces of pipe of the same size (diameter) together by brazing (soldering), one must be made larger so that the other fits inside. Making the end of a pipe larger is called swaging. The tool use for swaging the end of a pipe is called swaging tool.

Parts of Swaging Tools

Swaging Block:-usestotightenthepipetobeswaged.Ithasholestofitthepipe.(Similarto that of flaring block)

Clamp (Yoke):-uses for forcing the punch in to the end of the tube.

Steel punches:-they are of different diameters to fit the pipe size and uses to Enlarge the inside diameter of the end of a pipe.

How to swage the end of a pipe

Place the pipe in one of the holes of the block. Make sure that you have chosen the correct size hole to fit the pipe.

Position the pipe so that the end is “the outside diameter of the pipe plus 3mm “above the top of the swaging block.

Tighten the thumb nuts at each end of the swaging block.

Choose the punch of the right size to swage out the end of the pipe so that other piece fits inside.

Oil the punch, fit the clamp and punch on to the swaging block, then force the punch into the pipe. Now the punch will open out the end of the pipe.

Remove the pipe from the swaging block. Now another piece of pipe can be fitted into the swaged end.

If the pipe does not fit easily into the swaged end, use reaming tool or emery close to clean the inside of the swage or outside of the pipe to be fitted.

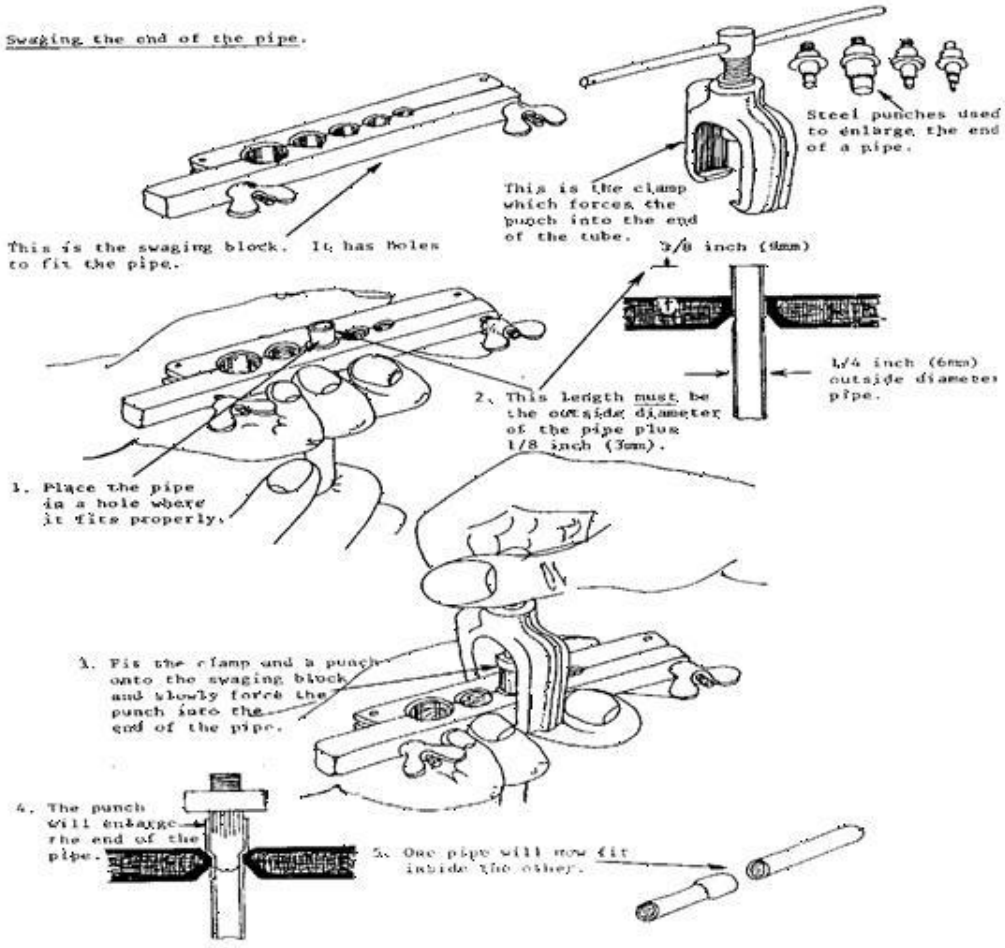


Figure 41. Swaging procedure

Bending tool

Refrigerator pipe is soft and can be bent by hand, but because it is soft it can be easily damaged when bending. We have to use a bending tool for making a smooth curve (bend)of a pipe without damaging it. Bending spring (external &internal) or Lever type tube bender are tools used for bending pipe. Each will help not only to make a better-Looking, but to prevent tubing at the inside radius of the bend being distorted, collapsing and forming a restriction, or reaching to bend stresses by the formation of hairline cracks which will later be the source of refrigerant leaks.

How to bend the pipe

A/Using spring

There is different size of springs that fits the outer or inner diameter of a pipe.

Choose the correct spring that fits the pipe to be bent and push it in to the outside or inside of the pipe. This helps the pipe to bend evenly.

Bend the pipe a little at a time, using your thumbs.

Do not try to complete the bend with one movement. This will cause the pipe to buckle.

Do not make a sharp bend in the pipe. If the pipe diameter is 1/4inch (6mm), the sharpest bend that can be made without risk of damaging the pipe is about 1 inch (2.5cm) radius.

Pipe that cracks, splits, wrinkles, or flattens during bending must not be used. It causes refrigerant leak.

Bend the pipe so that it fits on to the connection easily.

Using a lever-type tube bender

There are different diameter holes sectioned in half arcs, aligned in the base and the lever part of the tool. Choose the correct size that fits the outside of the pipe and insert the pipe and bend using the lever. The above restriction also works on this procedure.

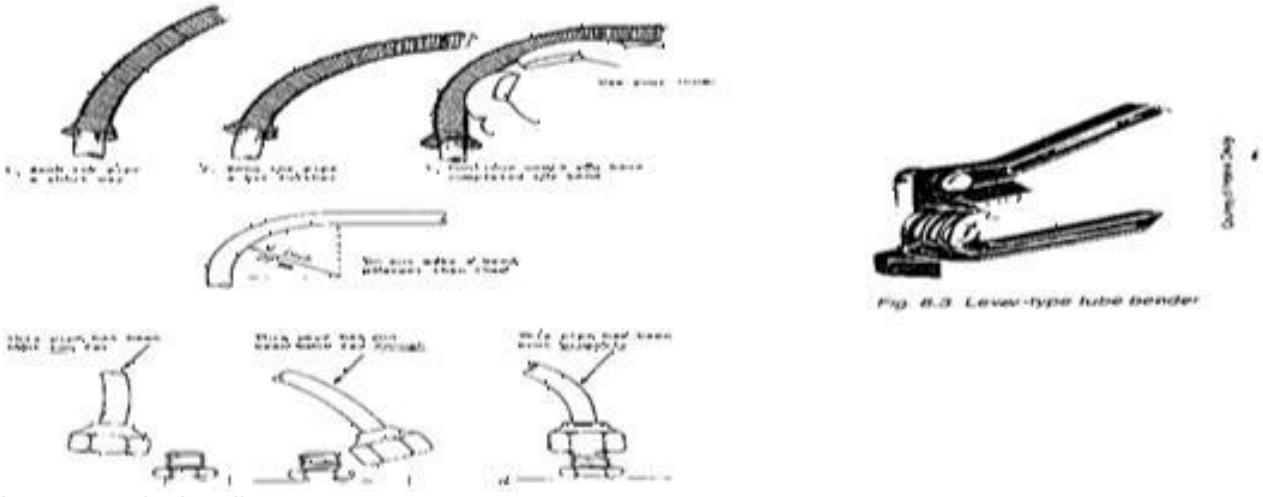


Figure 42. Tube bending

SYSTEM ANALYSER (MANIFOLD)

A system Analyser is the most important instrument in a refrigeration maintenance work. It helps the maintenance man to:

Evacuate the system

Charge refrigerant to the system

Measure the low & high pressure value of the system

Analyser leakage of refrigerant from the system and etc

Blue hose(for low pressure)

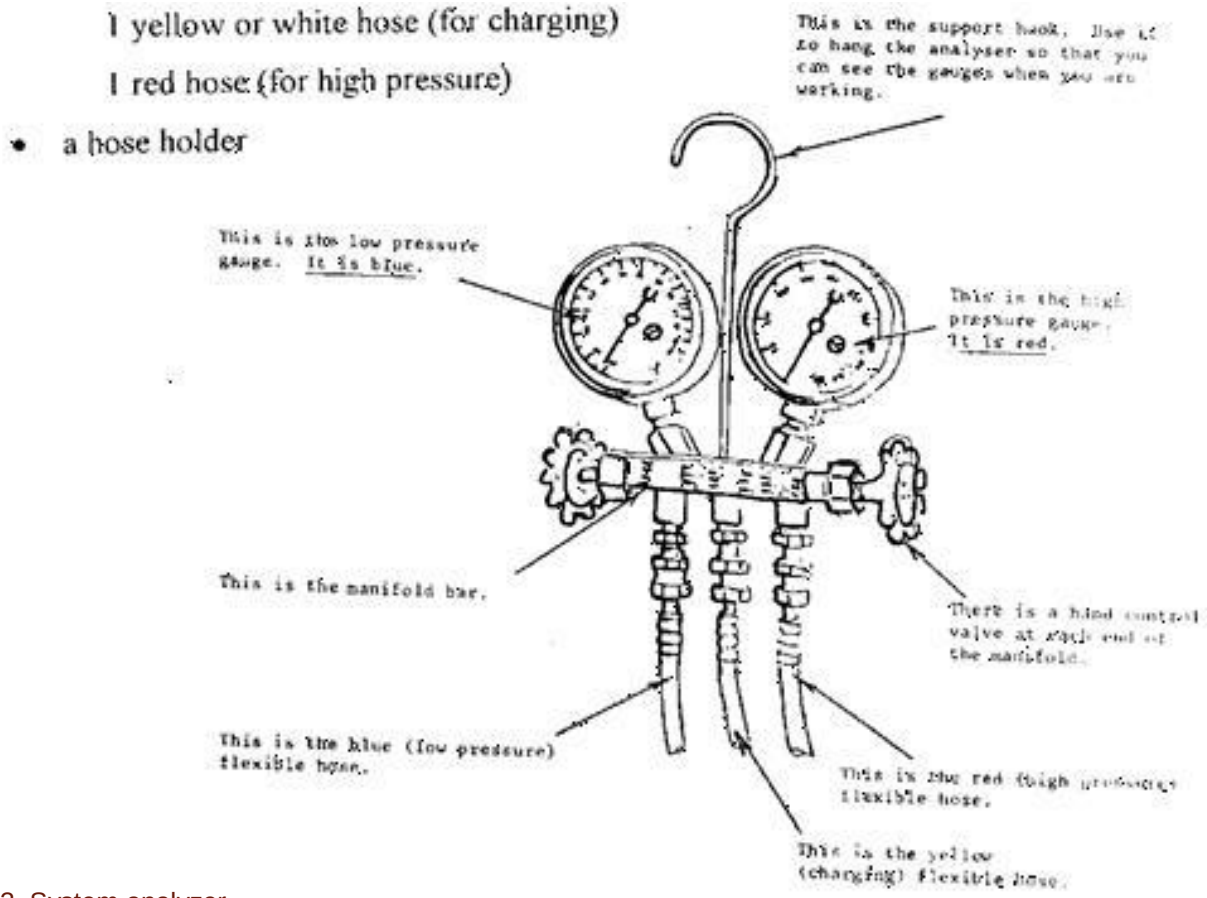


Figure 43. System analyzer

How to assemble the analyser

Connect the hose holder and support hook on to the back of the manifold. The hook must be able to move, so that the service man can hang the analyser in a convenient surface.

Connect the blue (low pressure) gauge tightly in to the left connection. Position the gauge facing towards you.

Connect the red (high pressure) gauge tightly in to the right connection. Position the gauge as above.

Connect the blue (low pressure) hose tightly on to the thread on the left side of the manifold (in the same direction as the blue gauge).

Connect the red(high pressure)hose tightly on to the thread on the right side of the manifold(in the same direction as the red gauge)

Connect the yellow or white (charging)hose in the middle of the manifold.

Do not use any tools for tightening hose connections. “Hand tight” gives a leak tight connection.

Test for leakage in gauges

After assembly of the system analyser, test for leaks on each gauge shall be made using the following procedures:

- Observe that the needles of each gauge are pointing exactly at zero, if not, open the front cover of the gauge and gently turn the adjusting screw on the dial until the needle is pointing to zero.
- Fully close both control valves
- Connect the blue hose to a refrigerant cylinder and fill it with a little gas; carry out the leak test below the blue gauge
- Repeat for the red gauge
- If you find a leak, seal the connection using thread-sealing tape (Teflon tape); test for leak again.

How to set valves on the system analyser

Closing or opening of control valves (both at a time or individual)enables the system analyser to analyse different procedures in a refrigeration system, such as:-

- Measuring system pressure
- Charging refrigerant to the system
- drawing a vacuum from the system

N.B. The pressure in the suction pipe is shown on the blue gauge.

The pressure in the delivery pipe is shown on the red gauge.

QUICK COUPLER

Brazing torch acetylene or propane (includes torch handle, regulator, nozzle and connecting hose)

Measuring Equipment

Voltmeter (Avo-meter)

It is a test and also measuring instrument having a number of different ranges for identifying:-

- Whether a components are functional or faulty
- Whether a line in the circuit has continuity or is broken (open) (as test equipment)
- For measuring voltage, current and resistance (as a measuring equipment).

It is also known as circuit analyser, a vo-meter (ampere-volt-ohms meter) or multi-meter and is constructed either in analogue or digital system.

Figure 44. Digital multimeter

CLAMP-ON AMMETER

This is an essential item, to measure the power drawn by the motor or a complete appliance without interrupting the electric circuit. The probes clip over any conductor in any convenient position. If can be combined with voltmeter and/or an ohmmeter.

Figure 45. Clam -on ammeter

REPAIRING VAPOUR COMPRESSION REFRIGERATION SYSTEM

Type of problems

Cut and break the service tube to release all refrigerant from the system.

Heat the connection to the drier with the blow torch or remove it by cutting the pipe.

When the brazing material l malts, remove the filter drier

Take the following precautions when replacing the filter drier

Do not damage the pipe connected to drier. It must be perfectly round.

Do not allow any pieces of dirt, copper or brazing material to get inside this pipe.

Use a small flame only. Overheating can cause damage.

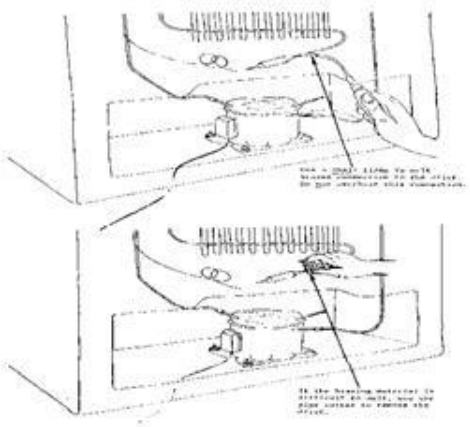


Figure 47. Replacing the filter dryer

FITTING THE CAPILLARY TUBE IN THE DRIER

Clean inside and outside, the end of the condenser pipe and outside of the capillary tube.

Fit the drier inside the condenser pipe and the capillary tube into the open two ends of the drier

Braze the drier to the condenser pipe and the capillary tube; Make a strong joint that will not leak.

Then:-

Test for leaks

Evacuate the system

Re- charge the system

Switch on the refrigerator and test that it is fully charged by any of the following methods

Normal system pressures

Normal compressor running amps

Make sure that the refrigerator is cooling and cutting in and out properly on the thermostat.

Re- crimps and brazes the open end of the service tube.

TAKE THE FOLLOWING PRECAUTIONS:

Use a small flame and do not let the drier get hot.

Do not let any brazing material or flux get inside the pipe.

REMOVING AND FITTING FAULTY COMPRESSOR

- Unplug the refrigerator
- Remove the cover of the compressor terminal

box •Remove the electrical connection

- Examine carefully the connection inside the terminal box
- Cut and break the service tube to release all refrigerant from the system.
- Mark where the suction and delivery pipes have to be cut on the faulty compressor (allow sufficient pipe for connection to the replacement compressor).
- Clean the outside of the pipes before cutting.
- Use the miniature pipe cutter to cut each pipe. Do not allow any dirt or pieces of metal to get inside the pipes. Cover the open ends of the cut pipes with adhesive tape so that Moisture and dirt cannot get inside.

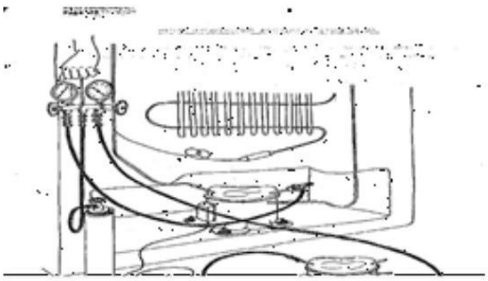


Figure 49. Remove the filter dryer

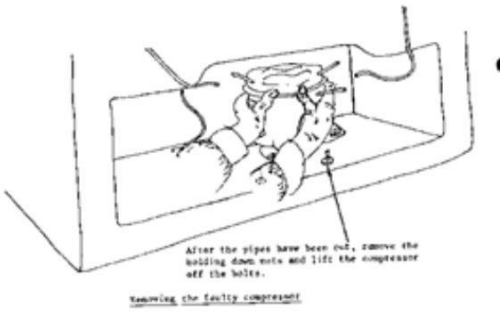


Figure 50. Remove faulty compressor

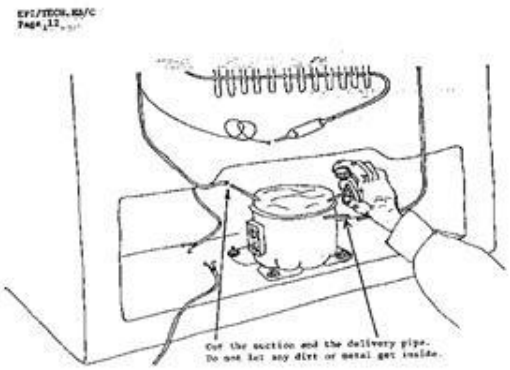


Figure 51. Fit the replacement compressor

C) Fit the replacement compressor

- •Position the replacement compressor and bolt it.
- •Braze the suction and delivery pipes to the compressor.
- •Fit a replacement drier.
- •Test for leaks.
- •Re-connect the electrical wires to the terminal box.
- •Evacuate the system.
- •Re-charge the system
- •Switch on the refrigerator and test that it is fully charged by any of the following methods:
  - o Normal system pressures.
  - o Normal compressor running amps.
  - o Loss of refrigerant test.
- •Re-crimp and braze the open end of the process tube.
- •Make sure that the refrigerator is cooling and cutting in and out properly on the thermostat.

4.5. TROUBLE SHOOTING COMPRESSION REFRIGERATOR

Trouble	Common cause	Remedy
1. Unit will not run.	-Blown fuse. -Low Voltage. -Broken temperature control. -Broken relay. -Broken overload. -Defective service cord. -Broken timer. -Broken compressor.	-Replace fuse. -Check outlet with voltmeter should check 220v plus or minus10%. -(Check the thermostat) Jumper across terminals of control. If unit runs and connections area ll tight, replace control. -Check relay, replace if necessary. -Check overload , replace if necessary -Check with test light at unit; if no circuit and current is indicated at outlet , replace or repair. -Check well, and replace if necessary. -Check compressor, replace if necessary.
2. refrigerator section too cold, No frost	-Refrigerator section air flow control Knob turned to coldest position. -Airflow control broken or remains open	-Turn control knob to warmer position. -Replace control or remove obstruction.
3.Freezer section too cold. (nofrost refrigerator)	-Cold control knob improperly set. -Cold control capillary not properly clamped to evaporator. -Brokencoldcontrol.	-Turn knob to warmer position. -Tighten clamp or reposition. -Check control replace if necessary.

4.Unitrunsallthe	-Not enough air circulation around Cabinet or air circulation is restricted. -Poor door seal. -Undercharge or overcharge -Room temperature too warm. -Cold control. -Excessive door openings.	-Relocate cabinet or provide proper clearances around cabinets-remove restriction. -Check and make necessary adjustments. -Check, evacuate and re–charge with proper charge. -Ventilate room as much as possible. -Check control; if it allows unit to operate all the time, replace control. -Use instruct customer.
5.Noisyoperation.	-Loose flooring or floor not firm. -Cabinet not level. -Tubing contacting cabinet or other tubing. -Drip trey vibrating. -Compressor ,condenser or fan motor not tighten.	-Tighten flooring or brace floor. Level cabinet -Move tubing. -Move treys–place on Styro foam pad if necessary. -Check ;and tray to tight all parts, if the problem is in the internal mechanical part of the compressor or fan Replace if necessary.
6. Refrigerator not cooling at all	1.Electric power cut off 2.Fuse blown/circuit breaker open the line 3.Heating element not working 4.Thermostat doesn't cut in not correctly leveled 5.Refrigerator	1.Check and connect line 2.Check and replace fuse/close circuit breaker/ 3.Check and replace heating element 4.Check and replace thermostat 5.Level the refrigerator
7. Refrigerator too cold .	1. Thermostat knob not in proper position 2 Thermostat sensor (capillary tube) end not fitted properly to evaporator 3. Faulty thermostat	1 Put the thermostat knob to the warmest position. 2. Fasten the sensor (capillary tube) end properly to the evaporator 3. Check and replace thermostat
8. Refrigerator not cold enough	1. Control knob not in coldest position 2. Evaporator frosted 3. Door not closing properly 4. Low air flow in side and around the refrigerator 5. Over loaded refrigerator 6. Refrigerator not level 7. Dust on condenser	1. Turn the control knob to coldest position 2. Deforest it 3. Check door gasket or adjust do or 4. Improve installation and rearrange vaccine 5. Take some load out 6. Level the refrigerator 7. Clean condenser

KEY ELEMENTS OF MAINTENANCE SYSTEM

Inventory of the refrigerators and maintenance toolkits

The inventory of cold chain equipment helps to improve planning for cold chain and update the information on the status of the equipment.

The objective of the inventory

To verify physical quantities of the cold chain equipment.
To obtain information on each equipment (age, origin, location)
To observe the status of equipment (functional status, need repair ,spare part)
Provide information for better planning &implementation of vaccination activities

DATA TO BE COLLECTED

Equipment location (health centre or clinic, district health centre or hospital, etc.)

Type, make, serial number and model of equipment

Age or year of installation (for status of efficiency)

Functional status of equipment (working well, needs repair, out of order,etc.)

Movement of equipment from one facility/department to another.

Origin or supplier of equipment

Source of energy used

Capacity (storage volume, ice making)

Other technical characteristics (e.g. power consumption, voltage)

Basic information of cold chain equipment (refrigerators/Cold rooms) can be found at the back or inside of the equipment.

SPARE PART MANAGEMENT

The spare parts management is very important for good maintenance system orders, placement

To order/request spare parts, should know the type & Quantity needed.

Which spare part should be placed where & by whom?

RECORDING AND REPORTING CLOD CHAIN EQUIPMENT MAINTENANCE ACTIVITIES

Efficient recording & reporting system contributes greatly to reduce the “down time “of the equipment. It is desirable for efficient maintenance that there cording &reporting should be direct from “who wants the service” to “who will provide the service” with intimation to the other officers concerned.

REFRIGERATORS MAINTENANCE RECORDING &REPORTING SYSTEM

The care and preventive maintenance form should be completed for routine maintenance of the equipment carried out by the cold room users/managers of each cold store.

All maintenance and calibration should be recorded & reported, together with any follow-up action taken, since this is part of the quality system.

These meticulous records of the maintenance, servicing and repair of all cold chain equipment will be useful in identifying whether or not the equipment has consistently performed to expectations.

The selection of equipment in the future may depend on this, and it is therefore important for senior technicians to ensure that the users/managers of each cold store maintain such equipment records.

What to record:

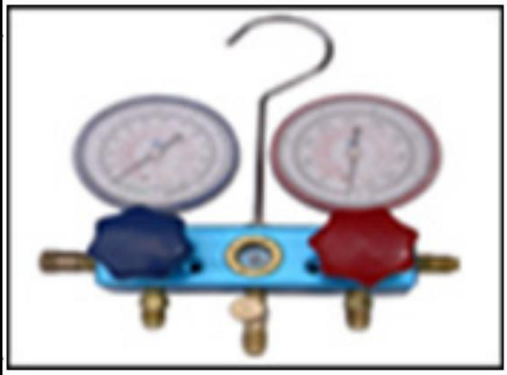
All refrigerator available should be recorded by type ,model, location, year of installation, etc.

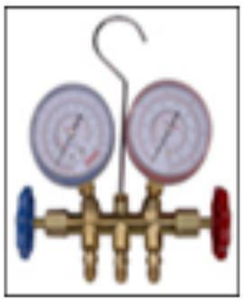
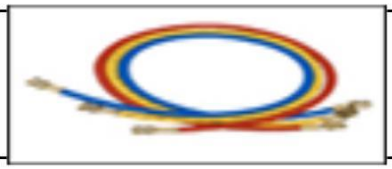
All spare parts by type and model.

all maintained cold chain equipment by type, date, technician conducted the maintenance, spare parts used, etc.

What and when to report

All conducted preventive and curative cold chain equipment maintenance activities, including number, type and model of equipment maintained and spare parts used should reported to the next level in Monthly, Quarterly and Annual basis.

SN	Description of the item	Picture
	Set of screwdriver	
2	Test light	
3	Flat nose plier	
4	Long nose plier	
5	Side cutter	
6	Adjustable wrench(10 inch)	
7	Adjustable wrench (6 inch)	
8	Tapemeasure5meter	
	Metallic tool box	
	Tubing toolkit Swaging tool Flaring tool Pipe reamer (inner & outer) Cutting tool Bending	
	Clampmeter	
	Set of brazing tool kit (Oxyacetylene) Oxygen cylinder Acetylene cylinder Oxygen gage Acetylene gage Oxyacetylene hose Torch	 
	Air Blower 220 V ~50/60Hzmin450Watt	

	System analyser (Manifold) With charging hose	 
	Vaccumpump1/4 hp	
	Refrigerant leak detector (Electronic)	
	Drillingmachine500wØ Max16-18 mm	
	Set of open wrench(07- 22'')	
	Set of socket wrench(05- 14'')	
	Set of exagonale key (8 or 12 pcs)	
	Caliper	
	Soldering iron	
	Thermometer with sensor	
	Vise-grip/Locking(tubing) pinch-off tool 7"/175mm	
	Inspection mirror/dentist mirror	
	Safety goggles	
2 7	Battery hydrometer	

ADDITIONAL WAYS TO SAVE:

If the freezer is empty, or mostly empty, fill the space with containers full of water. It requires less energy to cool a smaller space than a larger one. Not only will this help with energy efficiency, but you'll also have ice ready if there's a power outage or your fridge stops working.

Set the temperature of the fridgeto3°C(37°F)andthefreezerto-16°C(3°F).Colder temperatures waste energy and are not necessary to prevent food spoilage. Keeping the temperatures just5°C(9°F) colder than the recommended levels can increase fridgeenergyusebyasmuchas25%.

If your fridge has dials instead of temperature selectors, the recommended temperatures (see above) will usually correspond to a medium setting on the dial. To check that the internal temperature is correct, place a weather thermometer inside the fridge/freezer and adjust the dial accordingly.

4.6. SUMMARY

The cold chain system is a means for storing and transporting vaccines in a potent state from the manufacturer of the vaccine and blood products to the person being immunized and transfused.

Deep freezers are used to preserve laboratory samples for long time.

There are two common refrigeration systems known as compression and absorption refrigeration.

Basic components of the refrigerator systems can be listed as compressor, evaporators and condensers

When operating refrigerator systems, we have to make sure that we followed all the safety procedures.

Chapter 4:
LABORAORY INCUBATOR

Time: 7hrs

CHAPTER DESCRIPTION:

This chapter is designed for participants to develop the necessary knowledge, skills and attitude in laboratory equipment maintenance for biomedical engineers and technicians. It covers basic working principles, purposes, and main components, troubleshooting techniques and safety procedures for Laboratory Incubators

CHAPTER OBJECTIVE:

At the end of this chapter participants will be able to develop basic knowledge, skill and attitude about Laboratory incubator maintenance.

ENABLING OBJECTIVES:

After completion of this chapter the participants will be able to:

- Describe uses/purpose of laboratory incubator
- Identify types of laboratory incubator
- Explain working principles of laboratory incubator
- List basic parts and components of laboratory incubator
- Perform the steps for troubleshooting techniques of laboratory incubator •Practice the types of maintenance for laboratory incubator
- Identify performance test procedures in laboratory incubator
- Handle laboratory incubator with appropriate care
- Implement safety needed for the equipment and user for laboratory incubator

CHAPTER OUTLINE

5.1. INTRODUCTION

Think pair share

Discuss the purpose of incubators in clinical laboratory Time : 3min.

The word incubator comes from the Latin word incubare which means to brood. The incubator is designed as a chamber of controlled temperature, atmosphere and humidity for the purpose of maintaining live organisms in an environment suitable for their growth. Among its most common uses are incubation of bacteriological, viral, microbiological and cellular cultures; determination of the biochemical demand for oxygen (BOD) and biological storage. Incubators vary in complexity and design. Some only control temperature while others control the atmospheric composition as well. Some have the capacity to achieve temperature conditions below room temperature with refrigeration systems. Depending on the design and specifications, incubators control temperatures from -10 °C and go up to 75 °C or slightly more. Some incubators have CO2 injection for achieving special atmospheric conditions at which the growth of diverse species of organisms and cells is favoured.

5.2. OPERATING PRINCIPLES

Group activity

In a group of five

Explain the working principle of laboratory incubator Time : 5 min

The incubator uses diverse means of heat transference and environmental control to achieve conditions for specialized laboratory procedures. In general, these have a system of electrical resistors controlled by thermostats or microprocessors. As for the heat transference systems, the incubators use conduction and natural or forced convection.

5.2.1. CO2 PRINCIPLE OF OPERATION

The microprocessor CO2 control system interprets the information from the CO2 sensor, displays the CO2 concentration directly on the digital display, reads the set point and controls the percentage of CO2 in the incubator chamber. The infrared (IR) sensor operates under the principle that a certain frequency of infrared light is absorbed by CO2. The more CO2 present in the chamber the more light is absorbed. The IR sensor is only sensitive to CO2, so its accuracy is consistent no matter what the conditions are in the incubator.

5.3. MAIN PARAMETERS OF CO2 INCUBATORS

Individual Activity

List the main components of co2 incubator Time : 3min

There are five parameters which contribute to the optimum growing conditions.

Precise temperature control
Precise CO2 control
Humidity
Reliability (Electronic control system)
Sterility

PRECISE TEMPERATURE CONTROL

Water-jacketed CO2 incubators utilize water in water jacket to minimize heat loses. Heaters warm the water in the jacket to create a stable environment in the chamber. The water jacket also serves as an insulation from the effects of ambient conditions. The temperature control system monitors the temperature of the jacket water by using proportional control, it controls the water temperature to maintain the chamber temperature set point. Water has a high capacity to hold heat and it is the ideal medium to surround the chamber in order to obtain a temperature uniformity.

PRECISE CO2 CONTROL: -

Infra Red CO2 Sensor is a solid state gas analyzer for Carbon dioxide gas concentration. CO2 concentration is detected by sensing thermal conductivity deviation. Gases in the chamber comprises of oxygen, Nitrogen water vapor and Carbon dioxide. As the ratio of Nitrogen and Oxygen is always constant they do not have an effect on the measurement of CO2 concentration, but the variation of water vapor as doors are frequently opened and closed would change the thermal conductivity of the chamber. Infra-Red CO2 Sensor utilizes Infra-Red light for analyses of CO2 concentration. This analyzer consists of an optical set incorporating Infra-Red Source, sample cell, and Infra-Red light Detector.

HUMIDITY: -

humidification of the part is achieved through a process of water evaporation from a water reservoir placed within the chamber. When the chamber is sealed a constant level of water in the humidifier pan on the chamber floor can effectively evaporate to produce humidity at 95% R.H .or better. Note constant level of water and relative position is very important.

INCUBATOR CONTROL ELECTRONICS: -

It is a microprocessor based and serves for the precise control requirements of the chambers environment, providing optimum programmable condition for culture growth.

SETTING TEMPERATURE AND CO2 CONCENTRATION AND KEY LOCK

The MOD key is used to change the set points of temperature and CO2. Not that the set points preset before shipment are 370C and 5% Co2. When the power is ON, The display shows current measurement reading for temperature and CO2 in the chamber. Pressing the mode key switches the display to set points. The first time the MODE key is pressed, the temperature set point is highlighted by the flashing LED. The temperature set point can then be increased or decreased using the UP and DOWN keys. With anther press of the mode key the CO2 set point flashes and can likewise be changed. When the MODE key is pressed again the temperature display shows lock, and the CO2 concentration display shows off. When the UP key then pressed the display changes to lock on, and lock lamp lights. It is then impossible to set the set points control and adjustments and CO2concentrator ON/OFF key and power off key are also disabled. When the down key is pressed, lock off is displayed, the key lock is released and lock lamp goes out. When the mode key is pressed again, the display returns to the current temperature and CO2 Readings. The values in the following steps are given as an example.

Table 4. Setting up description and display key

NO.	SET UP	KEY	DISPLAY
1	With power on display shows in-chamber readings		36.5 o C 4.5
2.	Press the MODE key and both displays change to set point readouts. Temperature set point.	MODE	MODE o C 5.0
3	To change the set point 37.5oC press the UP key to increase to that value	△	37.5 o C 5.0
4	Press the MODE key again and the CO2 set point flashes	MODE	37.5 o C 5.0
5	To change the set point to 4.5%, press the DOEN key to decrease to that value	▽	37.5 o C 4.5
6	After setting the current-ration, press the MODE key again LOCK OFF flashes on the display	MODE	LOC OFF
7.	Select the key lock. Press the UP key to lock operation. LOCK ON flashes on the display, and lock lamp light up.	△	o C LOC OFF %
8	Press the MODE key again and the display changes back to the current temperature and CO2 readings.	MODE	37.5 o C OFF %

MAIN ELECTRIC AND ELECTRONICS PARTS AND THEIR FUNCTIONS

PARTS	FUNCTIONS
1. CO2 Sensor	Measures CO2 density concentration in the Chamber.
2. Temperature Sensor	Measuring of chamber temperature
3. over heat protection Sensor	For over heat protection Circuit.
4. Ambient temperature Sensor	Measuring ambient temperature.
5. CO2 Sensor Box temperature Sensor	Controls CO2 Sensor box Temp.
6. Air Pump	CO2 gas sampling and zero adjustment
7. Fan Motor	Air circulation in the chamber.
8. Power transformer	Power supply to the micro board.
9 Heaters	Heating different parts of the equipment
10. Solenoid Valve	Controls CO2 gas feed.
11. Power Switch	Power supply
12. Noise Filter	Protects from switching noise
13. Switching Transformer	Power supply to CO2 and Micro board

STERILITY:- All internal parts are made of stainless steel which provides an easily cleanable (for decontamination). Inert surface that does not in itself promote biological growth.

CALIBRATING MAIN TEMPERATURE CONTROLLER

Most of the incubators have option for calibration. This can be done by following user manual of the incubators. During main temperature calibration it is important that the door not be opened for any reason, and the temperature has been stable at set point for several hours. Compare the reference thermometer with the digital display. If there is an unacceptable difference put the display into calibrate mode by pressing both the UP and DOWN arrow pads at the same time until the two outside decimal points begin to flash (this depends on the type of the incubators) .While the decimal points are flashing the display can be changed to match the reference thermometer by pushing the UP or DOWN arrow pads. If no adjustments are made within five (5) seconds the display will default back to displaying the temperature in the chamber. After the display has re stabilized and maintained set point for several hours, check the actual temperature again. If the reference thermometer does not match the display, repeat the calibration.

CALIBRATING CO2 CONTROLLER

During CO2 calibration it is important that the door not be opened for any reason and the CO2 has been stabile for several hours. Using a Fyrite gas analyzer, measure the actual CO2% within the chamber via the sample port on the left side of the unit. If there is an unacceptable difference between the display and the Fyrite put the display into calibration mode by pressing both the UP and DOWN arrow pads at the same time until the decimal points begin to flash(this depends on the type of incubator). While the decimal points are flashing the display can be changed to match the Fyrite by pushing the UP or DOWN arrow pads. If no adjustments are made within five (5) seconds the display will default back to displaying the CO2% in the chamber. After the display has re stabilized and maintained set point for several hours, check the actual CO2% again. If the Fyrite does not match the display, repeat the calibration.

MAINTENANCE AND OPERATION

The general operation and routine maintenance for incubators are featured next. The specific procedures must be followed according to the recommendation of each manufacturer.

5.4. SAFETY RECOMMENDATIONS FOR OPERATION

Think-Pair-Share

Discuss the safety procedures that needs to be followed when operating laboratory incubator

Time : 5 min

Do not use an incubator in the presence of flammable or combustible materials as components inside of this equipment could act as ignition sources during operation.

Avoid spilling acid solutions inside the incubator. These cause the incubation chamber material to deteriorate. Whenever possible, try to use substances whose pH is neutral. Avoid incubating substances generating corrosive vapours.

Avoid placing receptacles on the lower cover which protects the resistive heating elements.

Use personal protective elements when using the incubator: safety eyeglasses, gloves, tongs for placing and removing containers.

Avoid staying in front of an open incubator. Some substances emit vapours that should not be inhaled.

Calibrate the incubator where it is installed to establish its uniformity and stability.

Verify the operational temperature of the incubator in the morning and evening hours, with certified calibrated instruments (thermometer, thermocouple, etc.).

Register in the appropriate document or form each excursion detected in the incubator (i.e. temperature, humidity or CO2 level) and any corrective action necessary.

Daily:Verify that the temperature in the incubator does not vary more than one degree centigrade (+/– 1 °C). Record temperature.

Add a non-volatile microbial inhibiting agent if water is needed inside the incubator to maintain a certain level of humidity.

CLEANING RECOMMENDATIONS

Clean cell culture or bacterial incubators regularly, at least every 14 daysand after any infectious material spill, using appropriate disinfectants.

- Disconnect the incubator before initiating the cleaning processes.
- Use non-abrasive cleaning agents: a piece of cloth dampened with mild detergent for leaning easily reached interior and exterior surfaces.
- Avoid contact between cleaning agents and electric elements.
- Wait until the incubator is dry (free of humidity) before connecting it again.

5.5. PREVENTIVE/ROUTINE MAINTENANCE

Group Activity

In a group of five discuss

What preventive maintenance we need to perform for laboratory incubator?

A well installed and operated incubator has few maintenance demands and many years can elapse before it requires any technical intervention. When any maintenance activity is performed, it must be done according to the manufacturer's recommendations. The routine maintenance presented next must be carried out only by approved personnel with technical training on the incubator that are aware of the risks run in this type of activity. These routines focus on verifying the conditions and correct functioning of the following components:

The door gasket. This is generally made of a silicone base for which several years of use are guaranteed. In order to substitute the gasket, it is necessary to dismount the door and remove the mechanisms that fasten it to the door. In general, the gasket is mounted in a groove. The new gasket must have the same specifications as the original. Its mounting is done using the gasket's housing on the door and the fastening mechanism which can be as simple as a set of screws in some incubators.

Heating elements (system of resistors). The heating elements are generally located in the lower part of the incubator. In order to substitute them, it is necessary to dismount the panels and the lower covers of the incubator. In some incubators, the doors need to be dismounted as well (the exterior, metal, the interior, glass). Once the protective covers are removed, the resistors and the temperature sensor systems are disconnected and substituted by new ones with the same specifications as the originals. All removed elements are then reassembled, and a calibration is performed.

Cooling ventilator. In case of damage, this component must be substituted by a ventilator with the same characteristics as the original. To install, the compartment in which it is housed must be opened. In some incubators, it is necessary to dismount the doors and some protective panels. Once this is done, the damaged ventilator is disconnected and replaced by the new one, verifying that the air blows in the right direction.

All dismounted elements are then reassembled. For replacing the components mentioned below, proceed similarly as described for the previous components. It is very important to use replacement parts with the same specifications as the originals. Internal circulation ventilator, Electronic control, Electronic components, Thermo couples, Glass door (internal), Handle, Body of the incubator (internal and external elements).

5.6. TROUBLESHOOTING

The common situations presented in the following table must be resolved by approved personnel with specialized training in incubator operation and maintenance. Special cases must be treated according to the manufacturers' recommendations.

TROUBLESHOOTING TABLE

Standard incubator

PROBLEM	PROBABLE CAUSE	SOLUTION
The incubator does not function.	There is no power in the electrical feed network.	Check the condition of the electrical connection.
	The on/off switch is in the off position.	Place the switch to the ON position.
	The electrical feed cable is defective.	Check the cable or replace it.
The incubator displays heating errors.	The temperature control is defective.	Check and adjust or replace the temperature control.
	The heating resistor is defective.	Replace the resistor with a spare one with the same characteristics as the original.
	The heating resistor connection is defective.	Clean connection points. Adjust the connection.
	The electric thermocouple is defective.	Replace the electric thermocouple.
	The temperature selected is lower than room temperature.	Check the incubator's specification. Only refrigerated incubators can operate in these conditions. Normally the ambient temperature is lower than that of the incubator.
	The relay is defective.	Replace the relay.
	The door gasket(s) is/are defective.	Change the door gasket(s).
The alarm remains on and the temperature is higher than that selected.	The temperature selected was changed to a lower value than the maximum limit of the alarm.	Wait until the temperature of the incubator goes down to the selected temperature.
	The temperature control is defective.	Replace the temperature control.
	The relay is defective.	Replace the relay.
The screen continually shows an error sign. Usually the LED displays the letters EEE.	The alarm diode is flashing.	Allow the incubator to cool until it stabilizes at the selected operational temperature.

Low temperature incubator

PROBLEM	PROBABLE CAUSE	SOLUTION
The incubator control does not function.	The switch is turned off.	Turn on the main switch.
	There is no electrical feed.	Verify the electrical feed circuit.
The temperature readings are erratic. (It is higher or lower than selected).	There is an accumulation of frost around the evaporator.	Defrost according to the procedure defined by the manufacturer.
		Reduce the cooling temperature.
The temperature in the incubation chamber is uniform, but higher than selected.	There is an accumulation of frost around the evaporator.	Defrost according to the procedure defined by the manufacturer.
	The flow of air in the interior is blocked by samples.	Reorganize the content of the incubator to allow the air to flow.
The temperature is higher or lower than selected.	The temperature control could require calibration.	Calibrate according to the procedure defined by the manufacturer.
The control is disconnected while in operation.	The voltage line is inadequate.	Verify the voltage line, this must not vary by more than 5% of the specified voltage indicated on the plate.
		The electrical connection is defective.
The compressor does not function although the cooling LED is on.	The thermal protector of the compressor is open.	Verify the voltage; it must not vary by more than 5% of the voltage specified on the plate.
Temperature readings are higher than those selected and set off the alarm over 40 °C.	The cooling relay is defective.	Replace the cooling relay.
	The compressor is defective.	Replace the compressor. Load the refrigerant and calibrate (this is a specialized procedure which requires special tools).

INCUBATOR REPAIR/MAINTENANCE SKILL GUIDE

Rate the performance of each step observed by using the following rating scale

Needs improvement

Performed correctly but no improvement

Proficiently performed: task efficiently and precisely performed in proper sequence

Table 5. Incubator maintenance skill leaning check list

LEARNING GUIDE FOR INCUBATOR MAINTENANCE SKILL				
Task	Cases			
Gathering information and maintenance preparation				
Ask the user about the failure and past maintenance history				
Get ready the necessary test tools , maintenance toolkit , spar part , service manual ,user manual,SOP and PPE				
Put on the necessary personal protective equipment				
Troubleshooting and repair				
Unload and disinfect the incubator				
Look for any components or parts damage , listen for any abnormal sound and sense for abnormal smell				
Power on the Incubator and take measurement by using appropriate testing tools				
Repair the damaged part by following the service manual				
GENERAL MAINTENANCE & CLEANING (PERFORMED PERIODICALLY)				
Do the following preventive maintenance on quarterly bases				
Clean Exterior: Use a mild detergent and single distilled water as needed.				
Clean Stainless Steel Interior: Wipe down with an appropriate disinfectant such as 70% Isopropyl Alcohol or equivalent non-corrosive disinfectant as necessary. Do not use and Chlorinated or Halogen materials on Stainless Steel.				
For Water Pan: Use only single distilled water. Clean pan and change water on a weekly basis. A small amount of Copper Sulfate can be added to the water pan to prevent bacteria growth from occurring.				
Replace gas supply line filters (CO2& N2): every fifth tank or when the filter is visibly discoloured.				
For Air Inlet Filter: Replace every 3 to 6 months or when the filter is visibly discoloured.				

PREVENTATIVE MAINTENANCE & CALIBRATION (PERFORMED AT MINIMUM EVERY 6 MONTHS):				
Perform Preventative Maintenance, Check Incubator and Adjust or Correct as Needed: Gas or water leaks. Tubing cracks and tight connections. Door switch functionality. All displays & indicator lights working normally. Tank switch functionality (if applicable) Chamber contamination or condensation. Pressure settings on gas regulators. Operation of all motors, fan, pumps and heaters. Ability of Incubator to recover to correct gas % within specified time. CO2 sensor and heater operation. Inspect all filters for discoloration and integrity, replace as needed. Ensure water level in water jacket is full (if applicable) Inner & outer doors functioning & sealing properly All caps in place; (i.e. side access port, RH reservoir & CO2 sample port) Perform Calibration Chamber temperature calibration. CO2 calibration. Perimeter and door calibration (if condensation is noted on doors and walls) RH calibration (if applicable) O2 calibration (if applicable)				
Record the maintenance work by using standard maintenance log book				

Maintenance inspection Checklist

Table 6. Incubator maintenance inspection checklist

Name of the laboratory _____Instrument's Model_____ serial no._____ Year_____, Month_____, and Date_____

S/No	Checklist	√=correct, X= not correct					
1	Check power supply with all circuitries for accurate out puts and insulations						
2	Checking of Temperature reading with standard thermo meter						
3	Carbon dioxide concentration test by using fyrite						
4	Humidification test by hygrometer						
5	Checking of Condensation						
6	Functionality of alarm/ signal indicators performance tests						
7	Observation of water leakage						
8	Checking of level of water in the jacket						
9	Motor or fans performance test (rpm)						

Checked By: Name_____ Signature_____

Approved By: Name_____ Signature_____

Remark: _____

5.7. SUMMARY

Incubator is used for incubation of bacteriological, viral, microbiological and cellular cultures

Incubator can be classified as normal incubator, co2 incubator, refrigerated incubators and shaker incubators.

When operating incubator, we have to make sure that we followed all the safety procedures.

During troubleshooting and maintenance of incubator we have to prepare operational and maintenance manual and all the necessary tools and follow all the stapes according to the manual

Chapter 6:
BIOLOGICAL SAFETY CABINET (BSC)

Time: 10 hrs

CHAPTER DESCRIPTION:

This chapter is designed for participants to develop the necessary knowledge, skills and attitude in laboratory equipment maintenance for biomedical engineers and technicians. It covers basic working principles, purposes, and main components, troubleshooting techniques and safety procedures for Biosafety Cabinet.

CHAPTER OBJECTIVE:

At the end of this chapter participants will be able to develop basic knowledge, skill and attitude about Biosafety Cabinet maintenance.

ENABLING OBJECTIVES:

After completion of this chapter the participants be able to:

- Describe uses/purpose of Biosafety Cabinet
- Identify types of Biosafety Cabinet
- Explain working principles of Biosafety Cabinet
- List basic parts and components of Biosafety Cabinet
- Perform the steps for troubleshooting techniques of Biosafety Cabinet •Practice the types of maintenance for Biosafety Cabinet
- Identify performance test procedures in Biosafety Cabinet •Handle Biosafety Cabinet with appropriate care
- Implement safety needed for the equipment and user for Biosafety Cabinet

CHAPTER OUTLINE

6.1. INTRODUCTION

Think-Pair-Share

Discuss the purpose of Biological safety cabinet in clinical laboratory

Time: 5 mins

This equipment is designed for controlling aerosols and micro particles associated with managing potentially toxic or infectious biological material in laboratories in activities such as agitation, centrifugation, pipetting, and opening of pressurized containers. Safety cabinets have been designed to protect the user, the environment and the sample manipulated using appropriate ventilation conditions. They are also known as laminar flow cabinets and/or biosafety cabinets.

6.2. PURPOSES OF THE BIOLOGICAL SAFETY CABINET

The biological safety cabinet is used for the following:

To protect the worker from risks associated with the management of potentially infectious biological material.

To protect the sample being analysed from becoming contaminated.

To protect the environment. The cabinets are used for routine work related to pathogens (parasites, bacteria, virus, fungus), cell culture and under very precise conditions, the management of toxic agents.

6.3. OPERATION PRINCIPLES

Group activity

In a group of three

1. Discuss the operating principle of Biosafety cabinet

The biological safety cabinet is a chamber generally constructed of steel. It has a front glass window of adjustable height, a ventilation system with an electrical motor, a ventilator and a set of ducts which while functioning, generate a negative pressure condition inside the cabinet. This forces the air to flow from inside the cabinet through the front opening to generate a curtain of air protecting the operator. Internally, the air is conducted through a series of grids and ducts to be finally treated in HEPA1 filters. Depending on the design of the cabinet, the air is recycled inside the laboratory or extracted and renewed in diverse proportions. The air flow, which in Class II cabinets moves from the filter towards the work surface, is laminar. Summary of the existing type of cabinets and their principal characteristics is presented next.

6.4. TYPES OF BIOLOGICAL SAFETY CABINETS

Individual Reflection

What are the types of biosafety cabinet Time : 3min

CLASS I BSC: The Class I Biological Safety Cabinet is a negative-pressure, ventilated cabinet usually operated with an open front and a minimum face velocity at the work opening of at least 75 linear feet per minute (lfpm). All of the air from the cabinet is exhausted through a HEPA filter either into the laboratory or to the outside.

The Class I BSC is designed for general microbiological research with low and moderate-risk agents, and is useful for containment of mixers, blenders, and other equipment. These cabinets are not appropriate for handling research materials that are vulnerable to airborne contamination, since the inward flow of unfiltered air from the laboratory can carry microbial contaminants into the cabinet.

The Class I BSC can also be used with an installed front closure panel without gloves, which will increase the inward flow velocity to approximately 150 lfpm. If such equipped cabinets are ducted to the outside exhaust, they may be used for toxic or radiolabelled materials used as an adjunct to microbiological research.

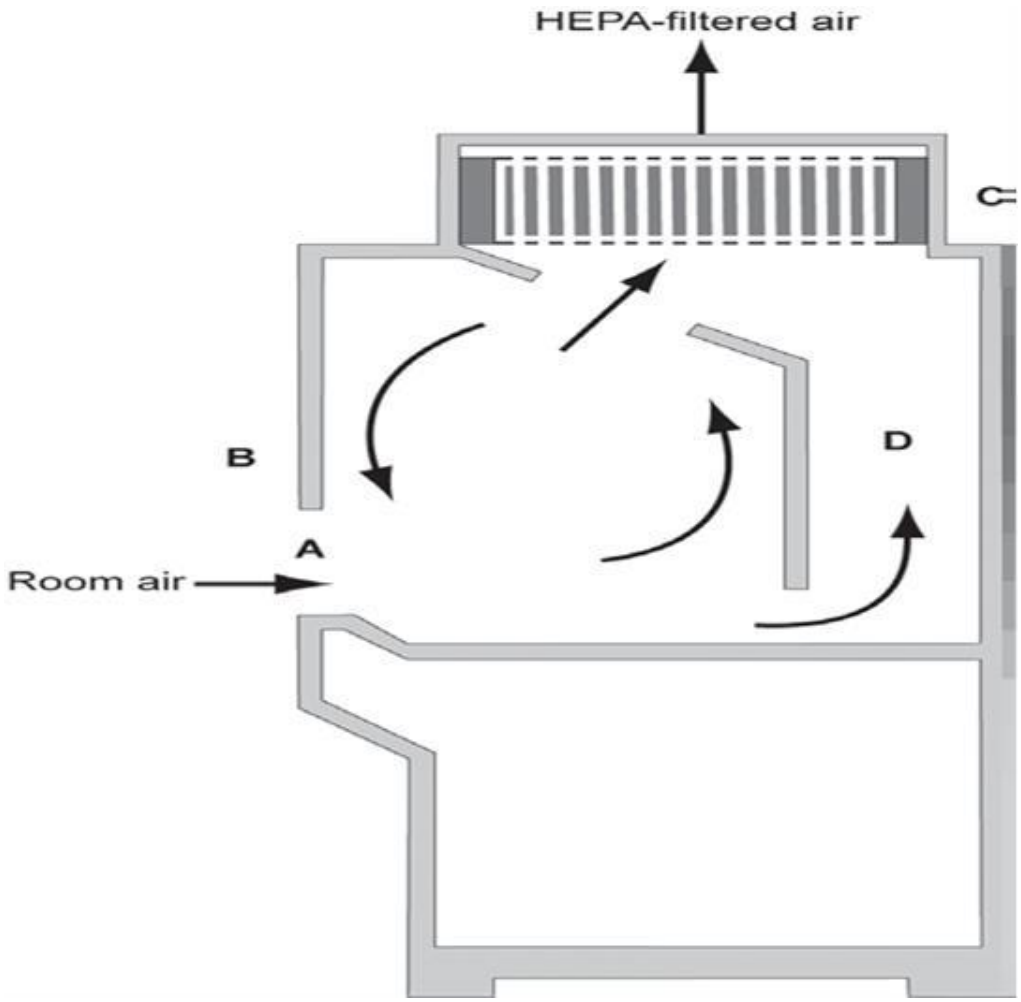


Figure 52. Class 1 Biological Safety Cabinet

CLASS II BIOLOGICAL SAFETY CABINET (BSC): is designed with inward air flow at a velocity to protect personnel (75-100 lfpm), HEPA-filtered downward vertical laminar airflow for product protection, and HEPA-filtered exhaust air for environmental protection. Design, construction, and performance standards for Class II BSCs, as well as a list of products that meet these standards, have been developed by and are available from the National Sanitation Foundation International.

Class II BSCs are classified into two types (A and B) based on construction, air flow velocities and patterns, and exhaust systems. Basically, Type A1 and A2 cabinets are suitable for microbiological research in the absence or very small amounts of volatile or toxic chemicals and radionuclides, since air is recirculated within the cabinet. Type A cabinets may be exhausted into the laboratory or to the

outdoors via a “thimble” connection to the building exhaust system. Type B cabinets are further sub-typed into types B1 and B2. A comparison of the design features and applications are presented. Type B cabinets are hard-ducted to the building exhaust system and contain negative pressure plena. These features, plus a face velocity of 100 lfpm, allow work to be done with toxic chemicals or radionuclides.

It is imperative that Class I and II biological safety cabinets be tested and certified in situ at the time of installation within the laboratory, at any time the BSC is moved, and at least annually thereafter. Certification at locations other than the final site may attest to the performance capability of the individual cabinet or model but does not supersede the critical certification prior to use in the laboratory. As with any other piece of laboratory equipment, personnel must be trained in the proper use of the biological safety cabinets. Of particular note are activities that may disrupt the inward directional airflow. Repeated insertion and withdrawal of the workers’ arms into and out of the work chamber, opening and closing doors to the laboratory or isolation cubicle, improper placement or operation of materials or equipment within the work chamber, or brisk walking past the BSC while it is in use have been demonstrated to cause the escape of aerosolized particles from within the cabinet. Class I and

cabinets should be located away from traffic patterns and doors. Air flow from fans, room air supply louvers and other air moving devices can disrupt the airflow pattern at the face of the cabinet. Strict adherence to recommended practices for the use of BSCs and their proper placement in the laboratory are as important in attaining the maximum containment capability of the equipment as is the mechanical performance of the equipment itself.

All Class II cabinets are designed for work involving microorganisms assigned to biosafety levels 1, 2 and

Class II cabinets provide the microbe-free work environment necessary for cell culture propagation, and also may be used for the formulation of non-volatile antineoplastic or chemotherapeutic drugs.

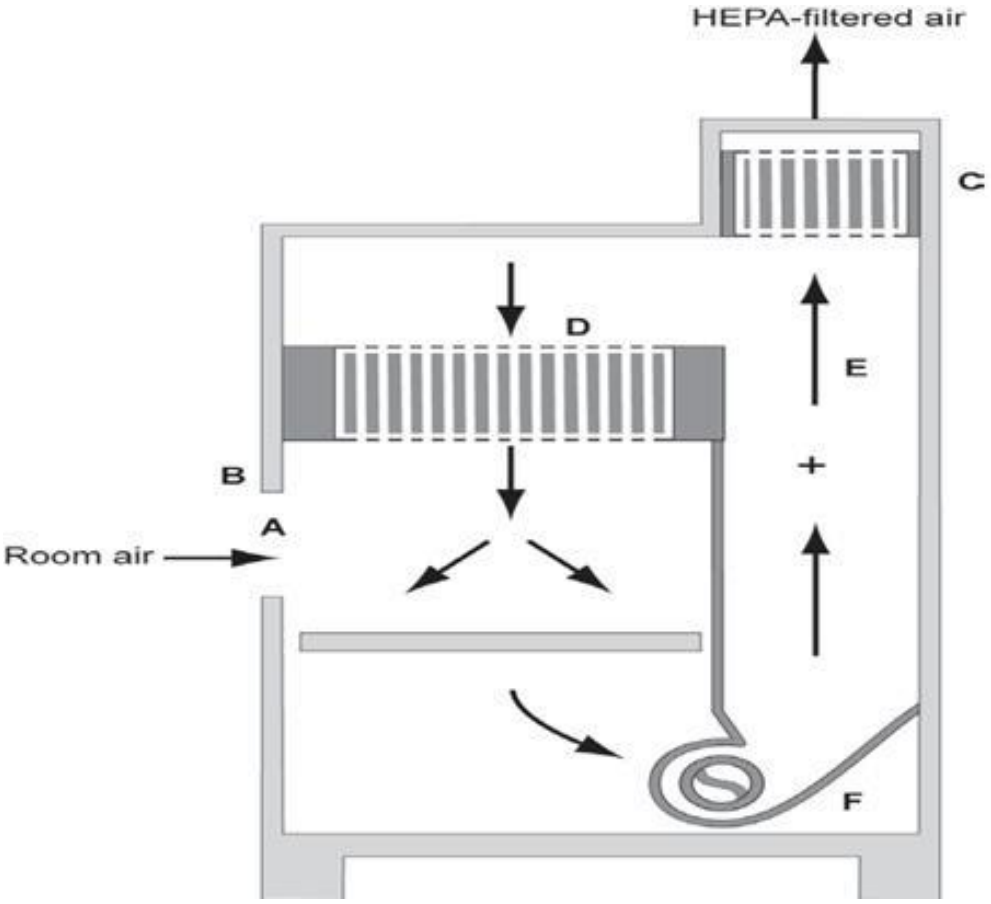


Figure 53. Class II Type A Biological Safety Cabinet

CLASS II, TYPE B1: The cabinets supply blowers draw room air (plus a portion of the cabinet’s re-circulated air) through the front grille and then through the supply HEPA filters located immediately below the work surface. This particulate-free air flows upward through a plenum at each side of the

cabinet and then downward to the work area through a backpressure plate. In some cabinets there is an additional supply HEPA filter to remove particulates that may be generated by the blower/motor system. Room air is drawn through the face opening of the cabinet at a minimum inflow velocity of 100 lfpm. As with the Type A cabinet, there is a split in the down-flowing air stream just above the work surface. In the Type B cabinet, approximately 70 percent of the down flow air exits through the rear grille, passes through the exhaust HEPA filter, and is discharged from the building. The remaining 30 percent of the down flow air is drawn through the front grille. Since the air, which flows to the rear grille, is discharged into the exhaust system, activities that may generate hazardous chemical vapors or particulates should be conducted towards the rear of the cabinet.

Type B1 cabinets must be hard-ducted, preferably to their own dedicated exhaust system, or to a properly designed laboratory building exhaust.

Laboratory exhaust systems should be located at the terminal end of the ductwork. A failure in the building exhaust system may not be apparent to the user, as the supply blowers in the cabinet will continue to operate. A pressure-independent monitor should be installed to sound an alarm and shut off the BSC supply fan, should failure in exhaust airflow occur. Since this feature is not supplied by all cabinet manufacturers, it is prudent to install a sensor in the exhaust system as necessary. To maintain critical operations, laboratories using Type B BSCs should connect the exhaust blower to the emergency power supply.

CLASS II, TYPE B2 BSC: -This BSC is a total-exhaust cabinet; no air is re-circulated within it. This cabinet provides simultaneous primary biological and chemical containment. The supply blower draws in room air or outside air at the top of the cabinet, passes it through a HEPA filter and down into the work area of the cabinet. The building or cabinet exhaust system draws air through both the rear and front grilles, capturing the supply air plus the additional amount of room air needed to produce a minimum calculated or measured inflow face velocity of 100 lfpm. All air entering this cabinet is exhausted, and passes through a HEPA filter (and perhaps some other air-cleaning device such as a carbon filter) prior to discharge to the outside. Exhausting as much as 1200 cubic feet per minute of conditioned room air makes this cabinet expensive to operate.

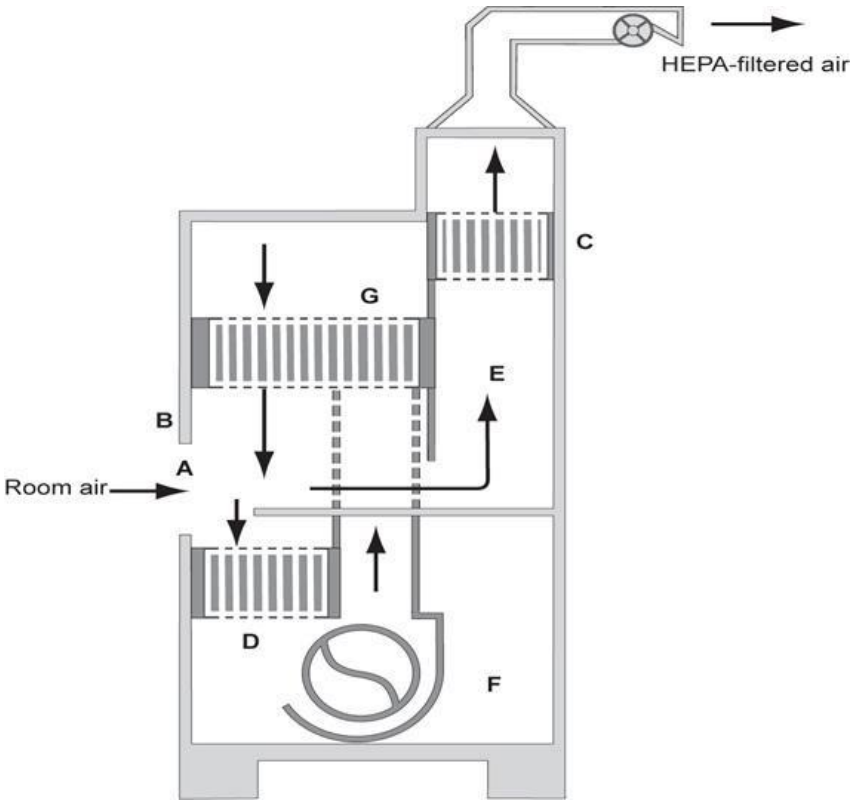


Figure 54. Class II Type B1 Biological Safety Cabinet

CLASS III: The Class III biological safety cabinet was designed for work with biosafety level 4 microbiological agents, and provides maximum protection to the environment and the worker. It is a gas-tight enclosure with a non-opening view window. Access for passage of materials into the cabinet is through a dunk tank (that is accessible through the cabinet floor) or double-door pass-through box (such as an autoclave) that can be decontaminated between uses. Reversing that process allows for safe removal of materials from the Class III biosafety cabinet. Both supply and exhaust air are HEPA filtered. Exhaust air must pass through two HEPA filters, or a HEPA filter and an air incinerator, before discharge to the outdoors. Airflow is maintained by a dedicated independent exhaust system exterior to the cabinet, which keeps the cabinet under negative pressure (usually about 0.5 inches of water pressure).

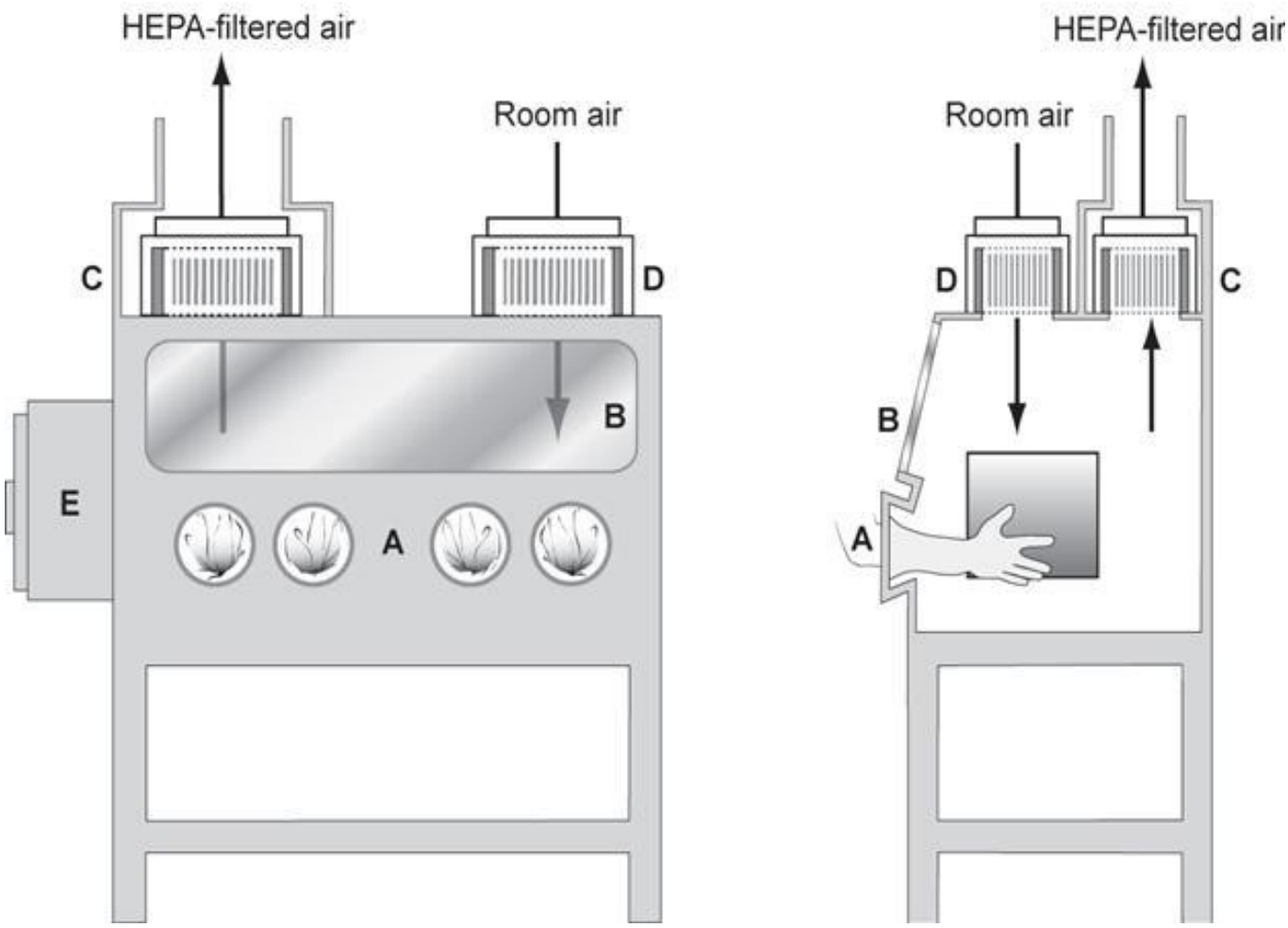


Figure 55. Type III biological Safety Cabinet

Performance Testing BSCs in the Field

Class II BSCs are the primary containment devices that protect the worker, product and environment from exposure to microbiological agents. BSC operation, as specified by NSF/ANSI Standard 49—2007, needs to be verified at the time of installation and, as a minimum, annually thereafter. The purpose and acceptance level of the operational tests ensure the balance of inflow and exhaust air, the distribution of air onto the work surface, and the integrity of the cabinet and the filters. Other tests check electrical and physical features of the BSC.

A. DOWN FLOW VELOCITY PROFILE TEST: This test is performed to measure the velocity of air moving through the cabinet workspace, and is to be performed on all Class II BSCs.

B. INFLOW VELOCITY TEST: This test is performed to determine the calculated or directly measured velocity through the work access opening, to verify the nominal set point average inflow velocity and to calculate the exhaust airflow volume rate.

C. AIRFLOW SMOKE PATTERNS TEST: This test is performed to determine if: 1) the airflow along the entire perimeter of the work access opening is inward; 2) if airflow within the work area is downward with no dead spots or refluxing; 3) if ambient air passes onto or over the work surface; and 4) if there is no escape to the outside of the cabinet at the sides and top of the window. The smoke test is an indicator of airflow direction, not velocity.

D.HEPA FILTER LEAK TEST: This test is performed to determine the integrity of supply and exhaust HEPA filters, filter housing and filter mounting frames while the cabinet is operated at the nominal set point velocities. An aerosol in the form of generated particulates of dioctylphthalate (DOP) or an accepted alternative (e.g., poly alpha olefin (PAO), di (2-ethylhexyl) sebecate, and polyethylene glycol and medical grade light mineral oil) is required for leak-testing HEPA filters and their seals. The aerosol is generated on the intake side of the filter and particles passing through the filter or around the seal are measured with a photometer on the discharge side. This test is suitable for ascertaining the integrity of all HEPA filters.

E. CABINET INTEGRITY TEST (A1 CABINETS ONLY): This pressure holding test is performed to determine if exterior surfaces of all plenums, welds, gaskets and plenum penetrations or seals are free of leaks. In the field, it need only be performed on Type A1 cabinets at the time of initial installation when the BSC is in a free-standing position (all four sides are easily accessible) in the room in which it will be used, after a cabinet has been relocated to a new location, and again after removal of access panels to plenums for repairs or a filter change. This test may also be performed on fully installed cabinets. Cabinet integrity can also be checked using the bubble test; liquid soap can be spread along welds, gaskets and penetrations to visualize air leaks that may occur.

F. ELECTRICAL LEAKAGE AND GROUND CIRCUIT RESISTANCE AND POLARITY TESTS: Electrical testing has been taken out of NSF/ANSI 49 Standard—2007 for new cabinets certified under this Standard. This responsibility has been turned over to UL. All new cabinets must meet UL 61010A-1 in order to be certified by NSF. These safety tests are performed to determine if a potential shock hazard exists by measuring the electrical leakage, polarity, ground fault interrupter function and ground circuit resistance to the cabinet connection. An electrical technician other than the field certification personnel may perform the tests at the same time the other field certification tests are conducted. The polarity of electrical outlets is checked (Table 3, E). The ground fault circuit interrupter should trip when approximately five mill amperes (mA) is applied.

G. LIGHTING INTENSITY TEST: This test is performed to measure the light intensity on the work surface of the cabinet as an aid in minimizing cabinet operator fatigue.

H. VIBRATION TEST: This test is performed to determine the amount of vibration in an operating cabinet as a guide to satisfactory mechanical performance, as an aid in minimizing cabinet operator fatigue and to prevent damage to delicate tissue culture specimens.

I. NOISE LEVEL TEST: This test is performed to measure the noise levels produced by the cabinets, as a guide to satisfactory mechanical performance and an aid in minimizing cabinet operator fatigue.

J.UV LAMP TEST: A few BSCs have UV lamps. When used, they must be tested periodically to ensure that their energy output is sufficient to kill microorganisms. The surface on the bulb should be cleaned with 70% ethanol prior to performing this test. Five minutes after the lamp has been turned on, the sensor of the UV meter is placed in the centre of the work surface. The radiation output should not be less than 40 microwatts per square centimetre at a wavelength of 254 nano meters (nm).

6.5. BIOLOGICAL SAFETY CABINET COMPONENTS

Group Activity

In a group of five discuss

What are the main components of BSC and their functions Time : 4 min

6.6.1. CABINET PRESSURE PLENUMS

The cabinet work area is surrounded by negative pressure and all external seals are under negative pressure. The supply plenum only contains room air at a positive pressure.

6.6.2. CABINET HEPA/ULPA FILTERS

The HEPA or ULPA biosafety cabinet filters used in this cabinet have been tested by the manufacturer for minimum particle collection efficiency under the latest version of IEST-RP-CC034. Each biosafety cabinet filter is integrity tested for leaks greater than 0.01% of the upstream aerosol concentration as stated in the latest version of IEST-RP-CC034.

6.6.3. EASY FILTER ACCESS

For convenience and ease of service, all filters are front accessible. The supply filter is located behind the dress panel in the front of the cabinet. The exhaust filters are located below the work surface. Only qualified technicians should replace filters.

6.6.4. ONE-PIECE INTERIOR WALL CONSTRUCTION

The interior side and rear work area walls are constructed from a single piece of 16-gauge stainless steel. It has smooth coved corners to help prevent build-up of contaminants and aid in clean-up.

6.6.5. FRONT ACCESS HIGH VELOCITY AIR SLOTS

At the intersection of both sidewalls and front access opening there are high velocity air slots. The purpose of the slots is to capture any particulate traveling near the sidewalls and access opening.

6.7.6. ALL-METAL PLENUMS

The plenums are constructed entirely of either carbon or stainless steel in order to provide strength, durability, air-tightness and resistance to deterioration.

6.7.7. REMOVABLE RECESSED STAINLESS STEEL WORK SURFACE

The work surface is constructed of corrosion resistant 16-gauge type 304 stainless steel, with a satin finish that diminishes light reflection. It is recessed to retain spills and can be removed along with its supports to gain access to the drain pan and exhaust filters.

6.7.8. DRAIN PAN

The drain pan is designed with smooth coved surfaces in all four bottom corners to facilitate cleaning and disinfection. Drainage is provided by a 1/2” diameter stainless steel ball valve located at the bottom of the drain pan.

6.7.9. VIEW SCREEN

The cabinet’s sliding view screen is 1/4” [6.35mm] safety plate glass. The view screen may be opened to 21” [533.4 mm] (without armrest) for placing of large items in the work area, and may be fully closed for system shutdown or UV light operation.

Note: the armrest must be properly re-installed prior to

6.7.10. WORK AREA LIGHTING

The work area is illuminated by two external fluorescent lamps which provide a minimum of 100 foot-candles of light at the work surface.

6.7.11. ELECTRONIC BALLAST

The BSC features solid-state electronic ballasts for the fluorescent and UV lights (Optional). These ballasts increase reliability, efficiency, and service life with lower heat output.

6.7.12. GROUND FAULT CIRCUIT INTERRUPTER

The outlets on the cabinet are protected by a ground fault circuit interrupter (GFCI). The GFCI is designed to protect the operator from some electrical hazards. If the GFCI detects a hazardous condition, it will automatically cut off electricity to all the outlets. The button in the canter of the GFCI outlet, typically the left hand outlet, will pop out. To reset the GFCI, correct the cause of the problem, and then press the reset button on the GFCI.

6.7.13. ADJUSTABLE CABINET HEIGHT

The channel stand has adjustable legs and leg levellers. The legs provide 6" [152.4mm] of height adjustment and the leg leveller provides an additional 2.5" [63.5mm] of height adjustment. The standard configuration has a cable port located in the cabinet's right side wall. This provides a way of introducing power and data cables or siphoning tubes into the work area of the cabinet without having to go through the front view screen access opening. An optional cable port may be added to the cabinet's left side Cable ports wall. Plugs are provided for use when the ports are not being used or the cabinet is being decontaminated.

6.7.14. UV LIGHT (OPTIONAL)

The optional ultraviolet (germicidal) lamp is permanently installed in the work area rear wall. See "Ultraviolet Germicidal Lamp" in Section III, Proper Cabinet Use. Fume Hood Configuration (Optional) The optional Fume Hood Configuration allows the use of the BSC models to be used as a general purpose Fume Hood.

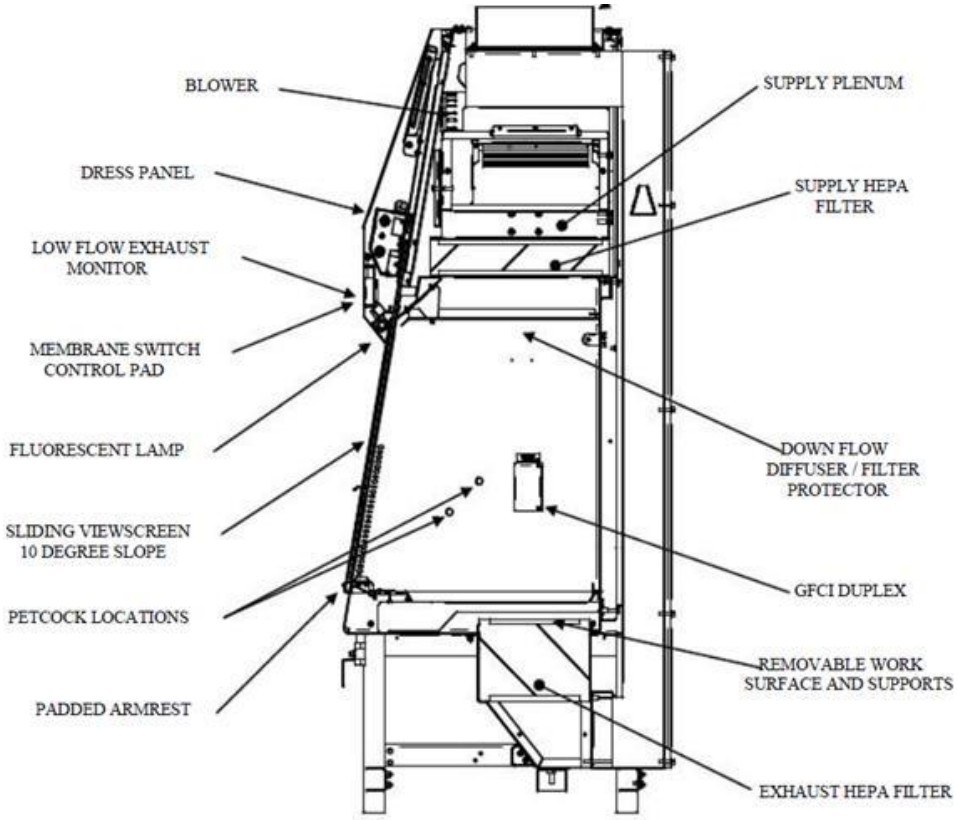


Figure 56. Components of biological safety cabinet

6.6. MAINTENANCE AND TROUBLESHOOTING

Think-Pair-Share

What preventive maintenance we need to perform for BSC on weekly, monthly and annual basis?

Time : 6min

6.7.1. PREVENTIVE MAINTENANCE

WARNING: The maintenance of internal components must only be done by trained and qualified personnel. In order to carry out maintenance on the internal components, decontamination must be done previously. Personal protection must be worn to perform the routines.

General maintenance required for the biological safety cabinet is for the most part simple to perform. The routines and frequencies are shown below:

WEEKLY

- Decontaminate the work surface and the interior surfaces of the cabinet with 70% ethanol.
- Clean the front glass door and the surface of the ultraviolet lamp, using a domestic cleaning solution.
- Verify the precision of the manometer's reading, indicating any fall in pressure flowing through the HEPA filter. Register the date and the reading in the cabinet 'slog book.

MONTHLY

- Clean the exterior surfaces, especially the front and the upper part using a piece of damp cloth in order to remove the dust.
- Disinfect the surface of the lower compartment with 70% Ethanol or a suitable disinfecting solution.
- Verify the state of the service valves.
- Do the tasks due on a weekly basis.

ANNUALLY

- Carry out the certification process according to established outlines in the NSF 49 regulation
- Check the intensity of the UV lamp with a radiometer Substitute it if necessary
- Test the state of the fluorescent lamp. Substitute it if necessary
- Perform the tasks due on a monthly basis

REMOVAL OF THE WORK SURFACE

For the removal of the work surface the following procedures required:

- Decontaminate the surface before removing it.
- Loosen and remove the attachment screws located on the front part of the work surface.
- Loosen, but do not remove the attachment screws located on the back part.
- Raise the front end and remove it, pulling it towards the front part of the cabinet.
- Decontaminate the interior part of the work surface.
- To assemble it, perform the activities described in steps 2, 3 and 4 in reverse order.

CHANGING OF THE ULTRAVIOLET LAMP

In order to change the ultraviolet lamp, the manufacturers 'instructions must be followed. In general, the following procedures are done:

Turn on the cabinet and leave it working for 5 minutes.

Raise the front window to its maximum position.

Decontaminate the interior surfaces and the UV lamp.

Disconnect the electrical feed to the cabinet.

Disconnect the UV tube from its connectors turning it 90 degrees. Next, install a spare part with the same characteristics as the original. Some manufacturers have installed the lamps on a plate located in the front of the cabinet, which is necessary to unscrew and lift so that the assembly of the lamp is kept visible. Once this is done, the lamp can be substituted as indicated above.

Table 7. BSC Troubleshooting chart

TROUBLESHOOTING TABLE[1]		
PROBLEM	PROBABLE CAUSE	SOLUTION
Neither the light nor the ventilation system in the cabinet works.	The cabinet is disconnected from the electrical outlet.	Verify that the cabinet is connected to an electrical outlet and that the cable is well connected to the cabinet's electrical box.
	There is no electrical feed in the connection.	Confirm that the electrical outlet is energized and that the circuit breaker is not deactivated (thermo magnetic protection). Restart switches.
The cabinet's ventilator is functioning but the light does not.	The lamp is defective.	Replace the lamp. Use one with the same characteristics of the original
	The lamp is badly connected.	Check the lamps connection. Adjust to the correct position.
	The thermo magnetic protection of the service breaker is activated.	Reconnect the circuit breaker.
	The lamp's wire is disconnected.	Check the lamp's wire.
	The lamp's ballast is defective.	Replace the ballast.
The ventilator is not blowing but the light is coming on.	The front window is closed.	Open the window until it reaches the work position.
	The ventilator's motor is defective.	Replace the motor ventilator set.
	The ventilator's motor is disconnected.	Check the motor's connections.
The manometer indicates an increase in the fall of pressure through the filter.	Retention of particles in the HEPA filter has increased.	Normal process during the useful life of the filter.
	There is blockage in the grids or return slots.	Verify that the grids are not obstructed by equipment or material.
	The extraction pipe is obstructed.	Test that there are no existing blockages or restrictions in the extraction pipe.
	There is a blockage or restriction under the work surface.	Verify that the pipe below the work surface is free of obstructions.
There is contamination in the samples manipulated in the cabinet.	Work procedures are inadequate.	Check that the cabinet is being used according to procedures and good practices.
	Restrictions in the return slots or blockage of the extraction duct.	Test the return and extraction system to see if they are free from obstructions.
	The cabinet's external factors affect its flow patterns on the inside and cause contamination.	Verify the installation of the cabinet and the procedures that are being carried out.
	The HEPA filter is defective.	Replace the HEPA filter and certify the cabinet.

BSC Maintenance skill Check list

Rate the performance of each step observed by using the following rating scale

Needs improvement

Performed correctly but no improvement

Proficiently performed: task efficiently and precisely performed in proper sequence

Table 8. BSC maintenance skill Check list

Task	Cases			
GATHERING INFORMATION AND MAINTENANCE PREPARATION				
Ask the user about the failure and past maintenance history				
Get ready the necessary test tools , maintenance toolkit , spar part , service manual ,user manual ,SOP and PPE				
Put on the necessary personal protective equipment				
Troubleshooting				
Unload and disinfect the Biological safety cabinet				
Look for any components or parts damage , listen for any abnormal sound and sense for abnormal smell				
Power on the BSC and take measurement by using appropriate testing tools				
Repair				
Follow the following step to correct the air flow unbalance				
Take the inflow air velocity by using the anemometer and check if the reading is the range of manufacturer recommendation				
If the front of the BSC is directed to the door or the window close the door or window and again take the inflow air velocity				
See for the blockage of the front and back grille and remove if there is any blockage of the grill and again take the reading of inflow air velocity				
Look the BSC if it has the damper and if it has the damper open it to increase inflow air velocity				
Increase the motor speed by turning the potential meter to the clockwise/counter clock wise direction according to the manufacturer recommendation				
Follow the following steps to replace Ultraviolet lamp				
Turn on the cabinet and leave it working for 5 minutes.				
Raise the front window to its maximum position.				
Decontaminate the interior surfaces and the UV lamp.				
Disconnect the electrical feed to the cabinet.				
Disconnect the UV tube from its connectors turning it 90 degrees. next, install a spare part with the same characteristics as the original				
PREVENTIVE MAINTENANCE				

Do the following preventive maintenance on quarterly bases				
Clean and disinfect all BSCs on a quarterly basis.				
Remove panel and grill from the BSC and set aside.				
Disinfect all surfaces of the BSC thoroughly by spraying/wetting with an appropriate amount of a hospital disinfectant and allow to stand for the label-specified contact time before wiping.				
Disinfect panel and grill thoroughly by spraying/wetting with an appropriate amount of a hospital disinfectant and allow to stand for the label-specified contact time before wiping.				
Replace the panel and grill, and properly secure.				
Clean the ultraviolet lamps in the BSC with a lint-free cloth dampened by using alcohol Check list for the proper functioning of BSC				
Do the Airflow Smoke Patterns Test				
Smoke pattern down flow test .Does smoke show smooth downward flow with no dead spots or reflux (upward flow)?				
View screen retention test. Does the smoke shows a smooth downward flow with no dead spots or reflux? Does smoke escapes from the cabinet?				
Work Opening Edge Retention Test. Does smoke refluxed out of the cabinet once drawn in, or smoke billow over the work surface or penetrate onto it?				
Sash/window seal test. Does smoke escapes from the cabinet?				
Record the maintenance work by using standard maintenance log book				

6.7. SUMMARY

The biological safety cabinet is used for to protect the worker from risks associated with the potentially infectious, protect the sample contamination and to protect the environment work related to pathogens

Biological safety cabinet can be basically classified as: class 1,class 2 and class 3

Basic components of BSC can be listed as HEPA filter, motor, Cabinet pressure plenums, removable recessed stainless steel work surface, Drain pan, View screen

When operating BSC, we have to make sure that we followed all the safety procedures.

Chapter 7:
CLINICAL CHEMISTRY ANALYZER

Time: 12 hrs

CHAPTER DESCRIPTION:

This chapter is designed for participants to develop the necessary knowledge, skills and attitude in laboratory equipment maintenance for biomedical engineers and technicians. It covers basic working principles, purposes, and main components, troubleshooting techniques and safety procedures for clinical chemistry analyser.

CHAPTER OBJECTIVE:

At the end of this chapter participants will be able to develop basic knowledge, skill and attitude about clinical chemistry machine.

ENABLING OBJECTIVES:

After completion of this chapter the participants be able to:

- Describe uses/purpose of clinical chemistry
- Identify types of clinical chemistry
- Explain working principles of clinical chemistry
- List basic parts and components of clinical chemistry
- Perform the steps for troubleshooting techniques of clinical chemistry •Practice the types of maintenance for clinical chemistry
- Identify performance test procedures in clinical chemistry
- Handle clinical chemistry with appropriate care
- Implement safety needed for the equipment and user for clinical chemistry

CHAPTER OUTLINE

7.1. INTRODUCTION TO CHEMISTRY ANALYSER

Think-Pair-Share

What are the applications of chemistry analyser

machine Time: 6min

Chemistry analyzers measure the concentration of analyte in blood or other bodily fluids based on specific chemical reactions by photometry. This unit gives introduction to Chemistry Analyzers. Clinical applications of the analyzer and types of Chemistry Analyzers will be discussed.

7.2. APPLICATION OF CHEMISTRY ANALYSER

Applications of Chemistry Analyzers vary from clinical diagnostic, drug abuse monitoring to forensic testing, etc.

Generally Chemistry Analyzers are used to perform tests on whole blood, serum, plasma, or urine samples to determine concentrations of analytes (e.g., cholesterol, electrolytes, glucose, calcium), to provide certain hematology values (e.g., hemoglobin concentrations, prothrombin times), and to assay certain therapeutic drugs (e.g., theophylline), which helps diagnose and treat numerous diseases, including diabetes, cancer, HIV, STD, hepatitis, kidney conditions, fertility, and thyroid problems.

7.3. TYPES OF CHEMISTRY ANALYSER

Individual reflection

List some common types of chemistry

machine Time : 3min

Chemistry analyzers comprise among others, dry chemistry analyzers using sample-impregnated dipsticks onto which chemical reactions are detected, and wet chemistry analyzers testing analyses in solution. Various models of chemistry analyzers are available, some designed to measure a single analytes, e.g. glucometers, hemoglobin meters; others to measure up to more than ten.

Chemistry analyzers can be bench top devices or placed on a cart; other systems require floor space.

Common types of Chemistry Analyzers are described below.

DRY CHEMISTRY ANALYZER

A dry chemistry analyzer is a reflectance photometer. Reflectance photometry quantifies the intensity of a chemical or biochemical reaction generating color on a surface (e.g., slide, test strip, dipstick or test patch). Light is emitted at a specific wavelength onto the test strip by the instrument's light source (e.g. light emitting diodes or LEDs). The colored product absorbs that wavelength of light.

WET CHEMISTRY ANALYZER

The wet chemistry analyzer is basically a photometer. As opposed to a spectrophotometer, it does not have a prism or transmission grating. One of several or a single color filter is used to measure the absorption of light in liquid samples according to the Beer- Lambert law. The wet chemistry analyzer

generally uses a light source such as a halogen lamp with filters. More recent models use a single LED or several LEDs at specific wavelengths. Tests performed on wet chemistry analyzers are based on the production of a colored compound of the analyte with specific reacting reagents. The color is directly proportional to the concentration of analyte(s) in solution. Typically, measurements are performed between 304 and 670 nm or with additional filters. Some instruments have the capacity to perform kinetic measurement through time.

7.4. WORKING PRINCIPLES OF CHEMISTRY ANALYSER

Group Activity
In a group of five
Explain the working principle of chemistry machine Time 5 min

INTRODUCTION

Chemistry analyzers adopt photometry principles to determine concentration of particles or cells in a given sample. This section describes the working principles of chemistry machine.

7.4.1. PHOTOMETER

The light absorption laws rule the performance of spectrophotometers. The amount of light radiation that passes through a homogeneous absorbing medium is defined as transmittance, T, where:

T=И_0

I0=incident light radiation intensity

I = transmitted light radiation intensity

The absorbance, A, (or extinction, E) is defined as:

A=logω(1⁄T)=logω(И_0)

The Lambert-Beer law states the relation between absorbance, concentration of a compound absorbing light and sample thickness:

A= ωcd

= molar extinction coefficient of the compound absorbing light at a certain (ω) wavelength. c = molar concentration of the compound absorbing light

d = optical path of the radiation into the solution

The absorbing spectrum of a compound is represented by a graph where the absorbed light (= absorbance) is related with the wavelength. For a colored solution, the graph will show one or more absorbance peaks. These may be in the visible part of the spectrum (400-700 nm) as in the ultraviolet (200-400 nm) region.

WORKING PRINCIPLES

Chemistry analyzers are based upon the photometry principles.

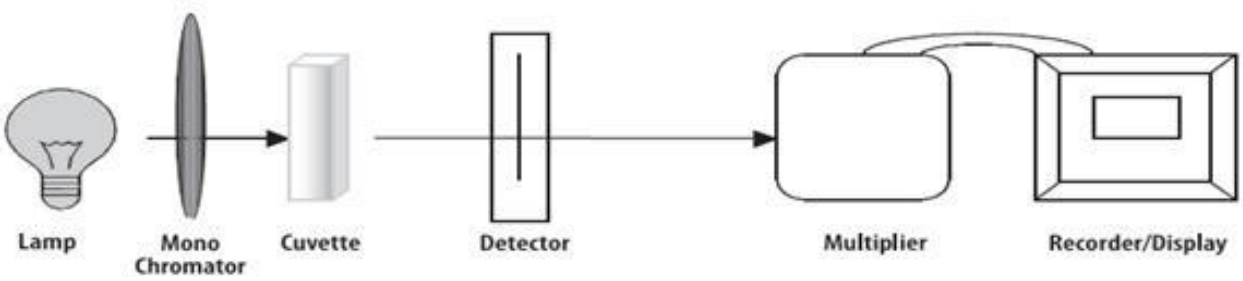


Figure 57. Schematic diagram for photometry

DRY CHEMISTRY ANALYSER

A dry chemistry analyzer is a reflectance photometer. Reflectance photometry quantifies the intensity of a chemical or biochemical reaction generating color on a surface (e.g., slide, test strip, dipstick or test patch). Light is emitted at a specific wavelength onto the test strip by the instrument's light source (e.g. light emitting diodes or LEDs). The colored product absorbs that wavelength of light.

The more analyte in the sample, the more product (color) and the less the light is reflected. The instrument's detector measures the reflectance of this colorimetric enzymatic or chemical reaction on the test dipstick or strip and converts it into an electronic signal. This signal is translated into the corresponding concentration of analyte in the bodily fluid tested and the concentration is then printed and/or shown on a LED digital display.

WET CHEMISTRY ANALYZER

The wet chemistry analyzer is basically a photometer. As opposed to a spectrophotometer, it does not have a prism or transmission grating. One of several or a single color filter is used to measure the absorption of light in liquid samples according to the Beer- Lambert law. The wet chemistry analyzer generally uses a light source such as a halogen lamp with filters. More recent models use a single LED or several LEDs at specific wavelengths. Tests performed on wet chemistry analyzers are based on the production of a colored compound of the analyte with specific reacting reagents. The color is directly proportional to the concentration of analyte(s) in solution. Typically, measurements are performed between 304 and 670 nm or with additional filters. Some instruments have the capacity to perform kinetic measurement through time.

A light beam is sent through a cuvette that contains the solution that has to be read. The exiting light beam is transmitted to a photometer containing interference filters of different wavelengths. The signal is amplified and then processed by the specific electronics and by the computer. The program then makes all the necessary calculations and controls, so that it can finally present the concentration of the compound in the sample and the any irregularities found in the reaction. The general principle upon which the photometry in clinical chemistry is based is the following:

- The increasing or the decreasing of the color intensity in a specific solution is proportional to the searched compound concentration. Generally speaking, when a sample is added to a specific reagent, it starts a reaction carried out by specific enzymes or substrates.
- This reaction causes the increasing (or decreasing) of the solution color inside the cuvette. During the reaction process, the instrument "reads" it by means of its absorbance.
- The final data processing is done with reference to a calibration or a theoretical factor, so as to give at the end the concentration of the compound into the sample.

Light emitted from the LED becomes monochromatic light of a certain wavelength after passing through an optical fiber (Five different types of optical filters are provided, and the optimum wavelength is selected for each test item). Monochromatic light is separated and transmitted to the photometry section of each channel by ten optical fibers.

In each photometry section, the monochromatic light transmitted by the optical fibers is irradiated on the reagent fields, which has a color reaction after sampling. Its reflected light is read with 2 photodiodes, and the system calculates measurement results by end-point assay (EPA) or reaction-rate assay (RRA).

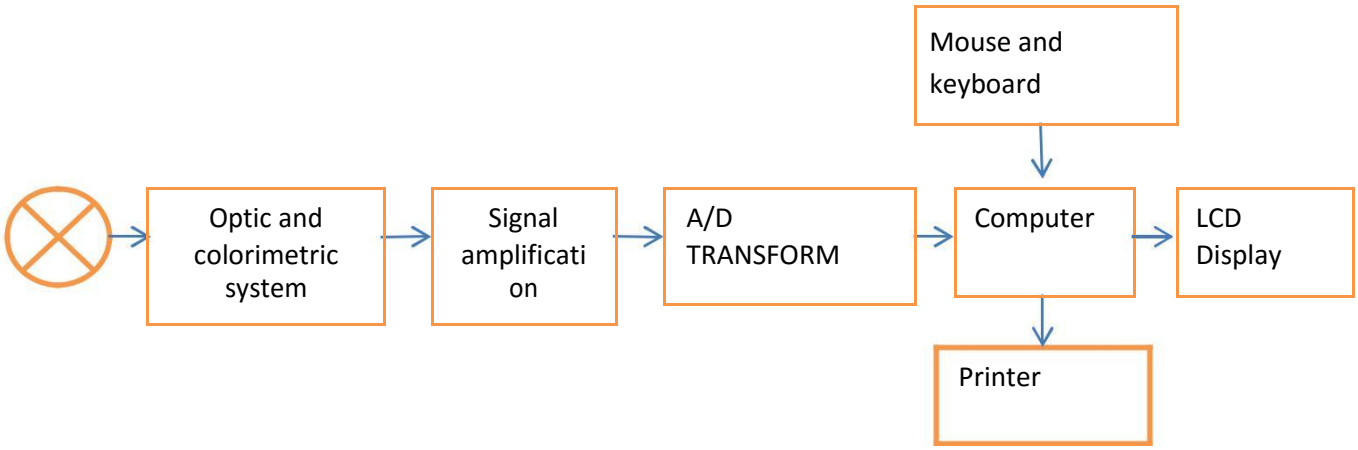


Figure 58. Block diagram for chemistry analyzer main components

7.5. MAIN COMPONENTS OF CHEMISTRY ANALYSERS

Think-Pair-share

Discuss about the main components of chemistry analyser and their functions

Time : 6 min

Components of Chemistry Analyzers vary according to manufacturers. This section describes components common to most types of analyzer models.

PROBE UNIT

Probe unit includes the probe, which aspirates sample from the sample tube or reagent from the reagent bottle and then dispenses the sample or reagent into reaction cuvette; and also aspirates the sample from the sample tube. The probe also has the function of detecting liquid level, protecting the probe against collision in the vertical direction and tracking liquid level. What's more, the probe is also able to limit its mechanical motion and lock itself when the power failure occurs.

The general workflow of the probe assembly is from wash pool to sample aspirating position, and then to reaction disk dispensing position and ISE dispensing position.

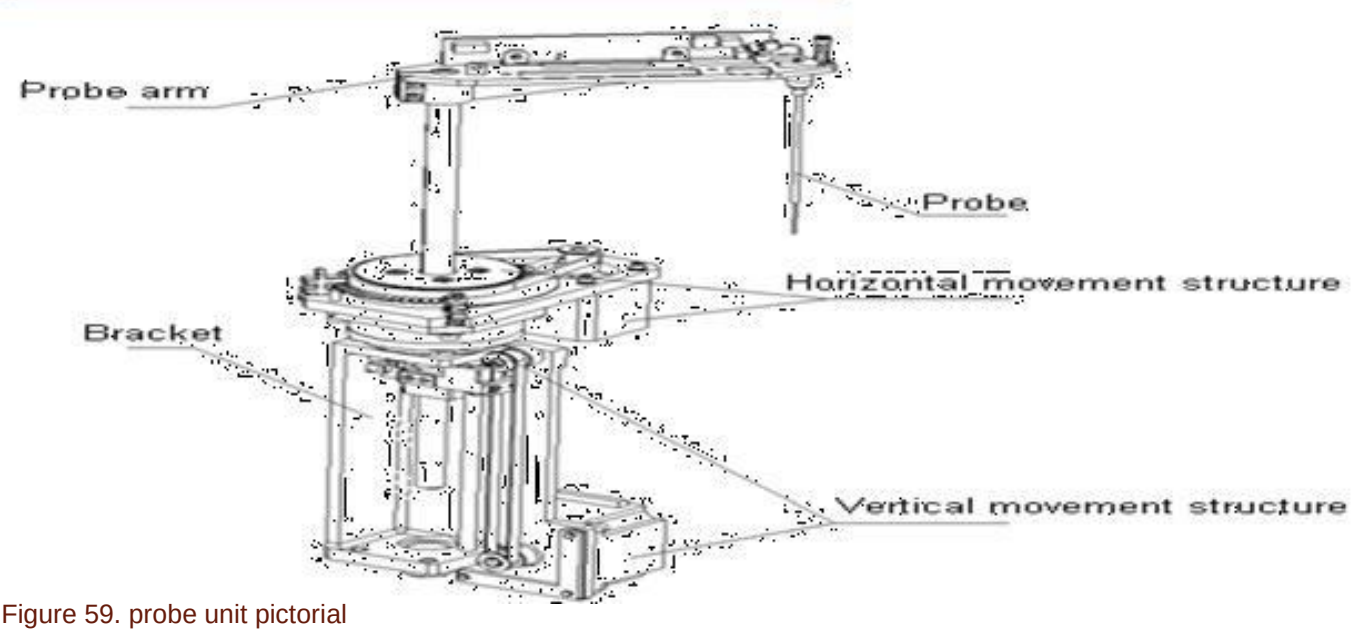


Figure 59. probe unit pictorial

SAMPLE/REAGENT DISK UNIT

The sample/reagent disk unit holds the sample tubes and reagent bottles and carries them to the specified position for aspirating sample or reagent. At the same time it is capable of refrigerating so as to keep the reagent stable and prevent it from volatilization.

Holding sample tubes: Sample containers (tube, micro tube, etc.) are placed on the sample/reagent disk unit, and then the sample probe unit aspirates sample and dispenses them into reaction cuvette.

Holding reagent bottles: Reagent bottles are placed on the sample/reagent disk unit, and then the sample probe unit aspirates reagent and dispenses them into reaction cuvette.

Programmed feeding: The sample/reagent disk unit carries specified sample tubes or reagent bottles to the aspirating position for aspirating according to the programmed period. The sample/ reagent disk is driven by the drive assembly.

4.Reagent refrigerating: The sample/reagent disk unit is capable of refrigerating and keeping the reagents at 4-15° C for 24 hours a day so that the reagents are always stable and not volatilized.

REACTION DISK UNIT

The reaction disk unit holds reaction cuvettes and rotates clockwise, carrying the cuvettes to specified position for sample/reagent dispensing and stirring. The reagents and the sample react in reaction cuvette. Also the reaction disk unit provides a constant-temperature environment for the reaction.

MIXING UNIT

The mixing unit is equipped with a mixing bar, which is used to stir the liquid in cuvettes. Additionally, the mixing unit has a specified mechanical position and is able to lock itself when power failure occurs.

The working position of the mixing bar: the wash well and the stirring position.

PHOTOMETRIC UNIT

Chemistry analyzer is a typical instrument which features in optics mechanics, electronics and arithmetic. The photometer is one of the key components of the instrument and determines directly the precision and accuracy of measurement of the system.

The light source irradiates directly the cuvette in the photometer. A combined light passes through an optical interference filter and turns to a monochromatic light. The monochromatic light passes through the cuvette and is received by the photoelectric detector and then is converted into an electrical signal by the photoelectric detector. The microprocessor calculates the concentration of the solution in the cuvette by contrasting the optical intension of the light before and after passing through the solution. The multiple monochromatic wavelengths in the photometer system are obtained by utilizing the filter

wheel. Rotate the filter of a specific wavelength to the light path while performing the colorimetric measurement.

FLUID SYSTEM

The fluid system mainly consists of sampling system and washing system. The sampling system consists of syringe module and probe module. The functions of individual module are listed as below:

Syringe module: drive the transportation of the reagent or sample and assure the precision of the sampling of reagent/sample.

Probe module; A single probe is used to aspirate and dispense the reagent and sample in the fluid system.

Pump/valve module: supply water to wash the inside and outside of the probe and the mixing bar in a specified mode. The assembly consists of the interior pump, exterior pump, and solenoid valve and restrictor ring.

Wash-pool module: consists of two same wells, to wash the probe and the mixing bar correspondingly.

7.6. MAINTENANCE OF CHEMISTRY ANALYSER, HARD WARE

Group Activity

In a group of five, discuss

What are the safety procedures that needs to be followed when operating chemistry machine

Time: 3min

SAFETY PRECAUTIONS

To ensure the safe operation and troubleshooting of the analyzer, and the safety of the operator, follow the precautions listed below.

Wear PPE before starting any maintenance procedure.

Do not remove or install a circuit board, connect or disconnect any plug or cable while the power cord is connected.

Observe procedures pertaining to safe handling of biological hazards while performing system maintenance or repair.

The instrument status must be in Standby/OFF position before attempting to clean any part of the instrument.

Keep clear of all mechanical assemblies when booting up the system

PREPARATION FOR MAINTENANCE

Prior to starting maintenance procedure you should prepare items required for the task. As there are numerous models available, it is recommended that you bring all the basic maintenance toolkits. In

addition you will need Personal Protective Equipment (PPE) to avoid any biological hazard during the task.
You will also need maintenance logbook for recording the task executed.
In general, before starting maintenance

- Prepare the necessary maintenance toolkits
- Collect analyzer manuals (user and service manuals)
- Collect equipment past records
- Collect equipment error codes, if any
- Wear personal protective equipment

GENERAL TROUBLESHOOTING STRATEGIES

Excellent problem cleaning and eliminating skills root from deep understanding about the instrument and experience accumulated day by day.

Generally, Logical troubleshooting may be divided into three steps:

Problem Identification: Involves identifying parts/areas that are functioning normally and parts with problem. Once the problems have been identified, classification of the problems follows.

Problem classification: Analyzer problems are generally divided into three categories:

- Hardware component related,
- Software computer programs related
- Measurement related to sample analysis

Trouble clearing: Involves correction of the problems

OBSERVATION

The first step in any kind of troubleshooting is general observation of the equipment. Start from the outside of the equipment while power is not connected and,

- Inspect any loose electrical connection
- Inspect any loose fluidic connection
- Inspect for any damaged parts such as probes, panels and etc.
- Check if there are empty water, detergent or reagent containers
- Check whether there are full waste containers
- Inspect fluidic connectors for blockage from dirt or twisting
- Check the positions of fluid containers (they should be placed below the analyzing unit)

After observing the analyzer from the outside and if there are no problems found connect the analyzer to power source and try to start the analyzer. While analyzer is on

- Check for any abnormal sound coming from the analyzer’s mechanical part.
- Check for any abnormal odor (burning smell or any other)

GENERAL TROUBLESHOOTING TECHNIQUES

These instructions are general guidelines for troubleshooting chemistry analyzers. Since there are numerous models available, always refer to the instruction manual from the manufacturer and follow the steps recommended.

If there is no light passing through the system, or if its intensity is not constant, change the bulb.

If there is light in the system but no display response, change the photocell.

Always replace blown fuses and bulbs according to the manufacturer's instructions.

If the equipment is faulty, consult a qualified biomedical engineer.

If the chemistry analyzer fails to switch on, check the electric socket outlet. Plug and check the fuse or the battery terminals.

Main problems addresses by using general troubleshooting mechanisms are:

Test problems with:

- Reagents
- Samples, controls, standards
- Operating errors
- Instrument errors

Instrument problems:

- Electrical/electronic problems
- Mechanical problems
- Operating error

Computer problems:

- Incorrect parameters, faulty test parameter data, faulty calibrator data
- Faulty system parameter on disk or disk load problems
- Operating error

Facility problems:

- Heat
- Humidity
- Power supply
- Water supply
- Drain

Most of the analyzers today come with separate computer for operation. Manufacturer's software on the computer not only helps to operate the analyzer but also have maintenance functions. The operating software can provide

Status of the equipment and its parts

Level of fluid containers connected to the analyzer

Error messages and suggested solutions

Preventive maintenance procedures such as cleaning parts

Since every brand has its own operating software it is necessary to refer to the operating manual of the manufacturer of the specific equipment to perform maintenance using the software.

CHEMISTRY ANALYSER TROUBLESHOOTING CHART

PROBLEM	PROBABLE CAUSE	SOLUTION
Analyzer does not start	ON/OFF switch (Power) is in OFF position	Move the switch to the on position.
	There is no electric energy in the feed outlet.	Verify the general electric feed. Test that some safety
mechanism has not miss-fitted.	The electric feed cable is not well connected.	Connect cable firmly
The command buttons do not respond.	The initialization of the equipment during start-up is incomplete. An incorrect command was activated, during startup.	Turn off the equipment and switch on again.
Flow cell is dirty. Flow cell leaks	Cleaning not frequent enough or not thorough enough.	Soaking the flow cell with cleanser.
	Bad flow cell quality or poor maintenance.	Replacing the flow cell.
Flow cell is clogged.	Serums not good enough or cleaning not frequent enough..	Soaking or pressurized washing
Problem regarding light source	Aged lamp excessive service time, decreased illumination, fog in lamp, or damaged lamp	Replacing the lamp.
Bubble in probe	The tube between sample probe and flow cell is damaged or not connected well	The tube is too long or too short. Is the connection of the tube in normal state?
The aspiration of flow cell is not constant.	Aspiration in sample probe may be blocked	Check if the reaction disk isn't damaged and install it securely
No liquid in flow probe	The aspiration tube is too long or too short A section of aspiration tube is aging	Check the connections of aspiration probe, flow cell inlet, etc. Replace the Aspiration tube
Bad repeatability of result	The reaction disk is dirty, There is bubble in the probe The aspiration probe isn't connected well The reaction liquid is polluted	Replace the Reaction disk Clean Flow cell Check the aspiration of the probe Replace the bulb of the photometer
Leakage of liquid occurs to the bottom of the analyzer	Waste outlet tube not well connected to container Overflow from waste bottle	Check waste connection Check whether waste bottle is full and dispose waste

CORRECTIVE MAINTENANCE OF COMMON FAILURES

Replacing the Lamp

Tungsten-halogen lamp is the common type of lamp used as the light source in the optical system of chemistry analyzers. The most common problem of these lamps is drop of intensity of light produced due to aging. It is necessary to replace it after the intensity drops below a certain degree. It is necessary to check the operating software to get intensity and frequency of light produced by the lamp.

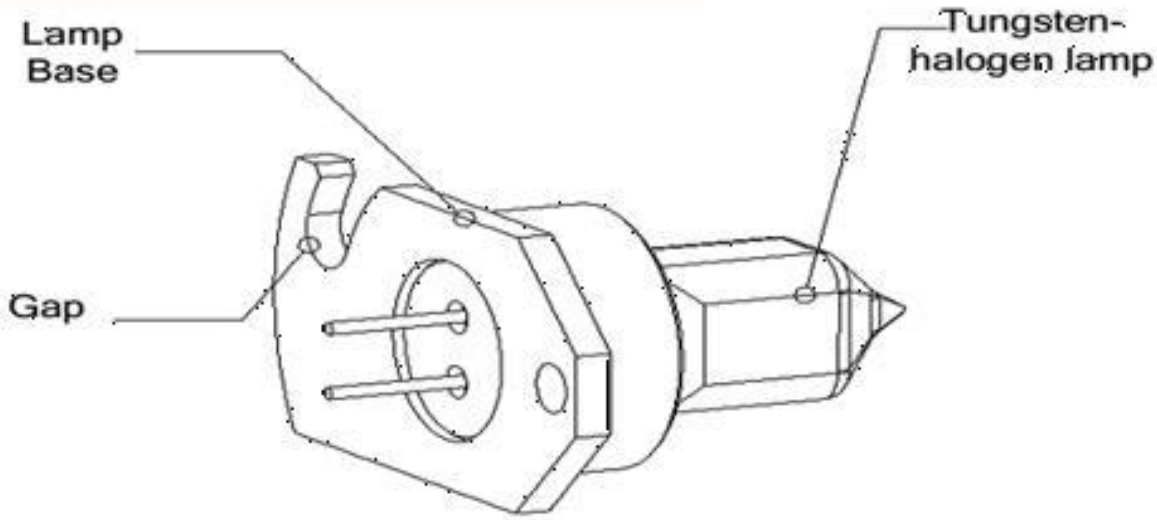


Figure 60. Light assembly structure

STEPS TO REPLACE THE LAMP

The lamp assembly should be replaced as a whole. The assembly should not be disassembled.

Check the software to see the intensity has dropped below the critical point.

Place the Main Power to OFF. Wait at least 15 minutes until the lamp and its housing cools down.

Open the table panel (panel enclosing the lamp assembly).

Remove the lamp assembly altogether.

Place the new lamp assembly into the porcelain socket.

Place the lamp base part with gap to the hole of the light source. When the lamp base reaches half of the depth, rotate it clockwise until the restraining screw is fixed.

After the lamp assembly is assembled and the socket is fixed, install the table panel.

Place the Power back to ON.

Log on the operating software (or test and maintenance software if available) by entering username and password.

Wait 20 minutes until the light source is stable, and then enter the Maintenance screen and click New Lamp.

Check the air blank AD (Background value) after executing New Lamp. The replacement is successful when the value of all channels is below 65535. If the background is above 65535, the background overflows and it is necessary to adjust the gain.

The photometric performance of the system should be checked after replacement of the lamp assembly.

PRECAUTIONS WHILE REPLACING THE LAMP

Do not touch the lamp before it cools down, or you may get burned. Do not start the procedure until it has cooled down.

Wear white clear cotton gloves while replacing the lamp. Don’t pinch the bulb of the lamp so that the lamp will not be contaminated or broken.

Check the installation of the light base and the porcelain socket after replacement.

REPLACING THE FILTER

It is necessary to replace the filter when it is damaged or aged.
Steps to replace the Filter Assembly
The steps of replacing filters are as follows.

Turn the Power to OFF.

Remove the rear panel and the table panels of the analyzing unit.

Pull out the porcelain socket, the cooling fan of the optical module, the sensor and the motor cable socket.

REMOVE THE LIGHT SOURCE ASSEMBLY.

Remove the dustproof cover and then the plate.

Use the fixture to cover the filters and then unscrew the screws fixing the filter by using the cross-head screwdriver. It is necessary to use the fixture to protect the filters from being scratched. If the fixture is not available handle the filter properly to avoid scratches.

Push the filter out with cotton swabs.

Refer to the analyzer manual to find out filter installation holes and their respective filter wavelengths.

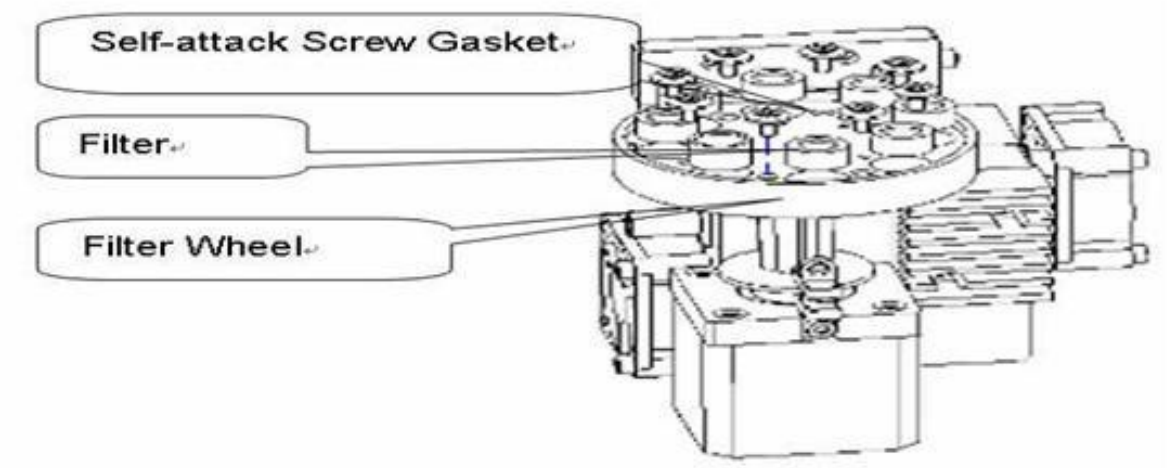


Figure 61. Filter Assembly

Install the filter to the filter wheel hole with the right order and direction. Cover the filter with the fixture and tighten the screws on the filter

Install dustproof cover.

Install the optical module back.

Pull out the porcelain socket, the cooling fan of the optical module, the filter wheel home position sensor cable and the motor cable socket.

Turn on the power, and check the movement of the filter wheel. Install the front plate and the back panel when the lamp is turned on.

Confirm the photoelectric performance after replacement.

PRECAUTIONS WHILE REPLACING THE FILTER

Wear white clear cotton gloves while operating.

Do not get the filter damaged while screwing the screws.

Press the filter gently into the installation hole on the filter wheel.

If there is dirty on the surface of the filter, clean it with ethanol-soaked defatted cotton.

Check the rotation of the filter wheel.

UNCLOGGING SAMPLE PROBE

Biological analysis using Chemistry Analyzer is performed on bodily fluids like urine, blood and etc. Clogging of the sample due to dirt from the surrounding environment or contamination from objects from the samples causes abnormal fluid flow inside the sample probe which affects the overall performance of the system.

Here are the steps to remove, unclog and reinstall the sample probe.
Steps to Remove the Sample Probe

Turn the Power to OFF.

Remove the sample/reagent disk.

Pull the probe arm to the highest point by hand. Rotate the probe arm to move the probe to a position above the sample/reagent compartment and convenient to operate.

Grab the lower part of the arm cover with two hands and pull them slightly outwards and remove the cover upward from the arm base.

While holding the probe's fluid connector with one hand and the tubing connector with the other, rotate the tubing connector counter-clockwise until it disconnects from the probe.

Press the circuit board with one hand and disconnect the probe's circuit connector from the board with the other hand.

Take out the spring inside the probe

PRECAUTIONS WHILE REMOVING THE SAMPLE PROBE

The probe tip is sharp and can cause puncture wounds. To prevent injury, exercise caution when working around the probe.

Wear gloves and lab coat and, if necessary, goggles.

To avoid of dropping water from the unplugged fluid connector, please wipe off the water with clear gauze when necessary.

Store the removed probe in a safe place where it will neither endanger people working around the area nor be damaged.

Exercise caution when disconnecting the connector. Excessive force may damage the connector and/or the circuit board.

Please wear the glove to protect the circuit boards or release the charge first when you handle the circuit boards.

Store the removed probe in a safe place where it will neither endanger people working around the area nor be damaged.

Exercise caution when pulling the probe away from the arm.

A bent or damaged probe will lead to unreliable test results and should be replaced immediately.

STEPS TO UNCLOG THE SAMPLE PROBE

Place a container like beaker below the sample probe.

Connect the unclogging device to the tubing connector.

Use a single-use syringe to aspirate the wash solution, remove the needle and connect the syringe to the other end of the unclogging device.

Push the syringe plunger slowly until there comes liquid out of the sample probe tip.

If no liquid comes out of the sample probe tip, insert a needle into the sample probe tip and push the syringe plunger.

Leave the sample probe soaked with wash solution for about 10 minutes.

Push and pull the syringe plunger for several times until liquid comes out of the probe tip evenly.

Use the syringe to aspirate deionized water and rinse the sample probe for at least 3 times.

Remove the unclogging device and the syringe, and then connect the tubing connector.

Remove the container.

PRECAUTIONS WHILE UNCLOGGING SAMPLE PROBE

The probe tip is sharp and can cause puncture wounds. To prevent injury, exercise caution when working around the probe.

Wear gloves and lab coat and, if necessary, goggles.

Dispose of the used needle in accordance with the national guidelines for biohazard waste disposal.

A bent or damaged probe will lead to unreliable test results and should be replaced immediately.

STEPS TO INSTALL THE SAMPLE PROBE

Turn the Power to OFF.

Insert the probe back into the hole on probe arm, and align the hole on probe plate to the rotor inside the arm.

Sleeve the spring on the rotor and screw the retaining screws to secure.

Pinch the probe by the part near the probe arm.

Gently push the probe upward and then release the probe to see if the spring can move freely. If there is problem on the movement of the spring, check for errors and start over the above steps after fixing the errors. If the spring can move with the desired freedom proceed to the next steps.

Connect the probe’s circuit connector back to the circuit board.

Ensure the gasket is inside the probe.

Attach the probe’s fluid connector back to the tubing connector.

Turn the Analyzing Unit power ON while ensuring that the sample probe is not attaching any conducting object, such as hands.

Follow the manufacturer specific steps to calibrate the sample probe. This is done manually in most cases.

Install the cover back to the probe arm. Check the marks inside the probe arm cover to see the orientation of the cover.

Pull the probe arm to its highest point and rotate it to move the probe to a position above the wash pool.

Load the sample/reagent disk.

PRECAUTIONS WHILE INSTALLING THE SAMPLE PROBE

The probe tip is sharp and can cause puncture wounds. To prevent injury, exercise caution when working around the probe.

Wear gloves and lab coat and, if necessary, goggles.

Exercise caution when connecting the probe. Excessive force may bend the probe.

REPLACING THE PROBE

If the probe is bent or damaged, it must be replaced immediately. Use of faulty probes leads to unreliable test results.

Steps to replace the Probe

Follow the procedure given below to replace the damaged or bent probe.

Remove the probe following steps discussed in last section (Removing Sample probe)

Install the probe by following the procedure in last section (Installing probe)

REPLACING THE MIXING BAR

If the mixing bar is damaged, it must be replaced immediately. Follow the procedures discussed below to replace the damaged mixing bar.

Steps to replace the Mixing Bar

Turn the Power to OFF.

Gently pull the bar arm to a position convenient to operate.

Remove the damaged mixing bar

Install the new mixing bar at the position as the old one.

After replacing the bar, visually check whether the bar is vertical to the bar arm. If not, try reinstalling the bar.

Pull the bar arm to its highest point and rotate it to move the bar to a position above its wash pool.

PRECAUTIONS WHILE REPLACING THE MIXING BAR

Wear gloves and lab coat and, if necessary, goggles.

Dispose of the damaged mixing bar in accordance with the national guidelines for biohazard waste disposal.

Concentrate your force in the direction of the axis on the bar arm, while pulling out the bar. Biased force may damage the bar and/or the axis.

REPLACING THE PLUNGER ASSEMBLY OF THE SYRINGE

Most of Chemistry Analyzer manufacturers set maximum lifetime (usage time before replacement) for the Syringe plunger assembly used in their analyzer. The lifetime can be set in terms of number of tests performed using the plunger (e.g. 100,000 tests) or the period/duration of usage (e.g. three months). You can find the maximum lifetime of the plunger assembly in the service manual of the analyzer. Once the plunger has been used for the specified period it has to be replaced with a new one. Damaged Syringe plunger assembly also needs to be replaced immediately.

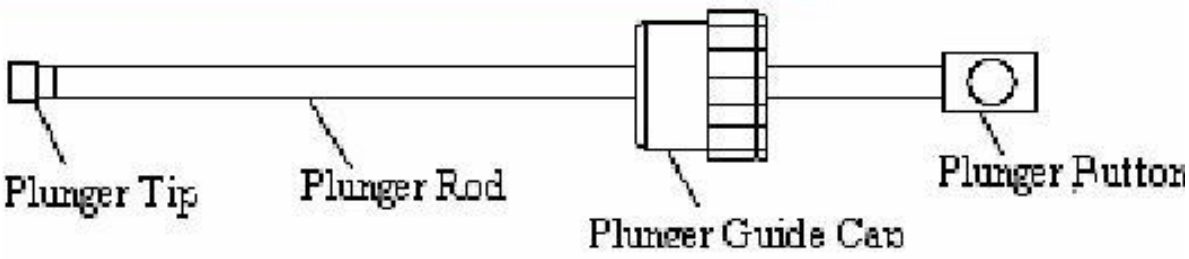


Figure 62. Plunger Assembly

Steps to replace the Plunger Assembly of the Syringe

Place the Power to OFF.

Unscrew the screws on the syringe cover and remove the cover.

Prepare a new plunger assembly and soak the plunger tip in deionized water to eliminate bubbles.

Remove the syringe from the holder.

Unscrew the plunger guide cap and pinch the plunger button to gently pull the plunger assembly from the syringe.

Pinch the new plunger assembly by the plunger button and carefully insert the plunger tip into the syringe and push it all the way to the end. Screw the plunger guide cap until secure.

Immerse the syringe connector into deionized water. Pinch the plunger button, pull it to aspirate half syringe of deionized water and then push it to expel the deionized water and the air from the syringe.

Grab the Tee with one hand and the syringe connector with the other hand. Screw the syringe into the Tee until secure.

Place the syringe on the holder. Install space bars and fix the retaining screws.

Place the Power back to ON.

Check for proper syringe aspiration and dispensing using the operation software

PRECAUTIONS WHILE REPLACING THE PLUNGER ASSEMBLY OF THE SYRINGE

The probe tip is sharp and can cause puncture wounds. To prevent injury, exercise caution when working around the probe.

In case your skin contacts the sample, control or calibrator, follow laboratory safety procedure and consult a doctor.

Exercise caution when installing the plunger assembly. Excessive force may crack the syringe.

REMOVING AIR BUBBLES

If there are bubbles observed during the process, they may be caused by the air leak between the syringe and the Tee. Uninstall the syringe and re-install it. If the bubbles are found again, follow the following procedures to remove the bubbles.

Steps to remove air bubbles

Turn the Power to OFF.

Remove the Syringe cover

Remove the screws and space bars, and remove the syringe from the holder.

Pull the plunger gently outwards until you cannot proceed any more, and then push it quickly. Repeat this pull-push operation until the air bubbles are removed from the syringe.

Place the syringe on the holder. Install space bars and fix retaining screws. Precautions while removing air bubbles

To prevent infection, always wear gloves, goggles and protective clothing when doing the maintenance.

Be sure not to push the plunger to the end tip; otherwise the syringe may be damaged.

7.7. PREVENTIVE MAINTENANCE

Individual reflection

What preventive maintenance we need to perform for chemistry machine on daily, monthly and annual basis?

Time : 3min

Some chemistry analyzers require minimal maintenance and automatically perform self-calibration routines. The guidelines below are general procedures applicable to most instruments. Always carefully follow the manufacturer's instructions for calibration, regular servicing and maintenance of the analyzer. Daily PM

Any spill on, or around the instrument should be cleaned immediately.

At the end of the day, disconnect the power source by switching OFF at the wall socket if applicable and removing the plug or disconnecting the battery terminals.

For dry chemistry analyzers: Do not leave test strips in the instrument. Regularly clean the window or compartment where test strips are inserted and keep it closed. Use a soft, clean damp swab.

For wet chemistry analyzers: Keep the sample chamber empty and closed when not in use.

Cover the instrument after use.

Store appropriately away from dust

Check reagent levels and refill if needed

Check water tanker and refill

Check detergent tanker and refill

Check waste containers and refill if needed

MONTHLY PM

The window and/or front surface of the photo detector should be inspected and cleaned with lens tissue.

CLEANING DUST FILTERS

To clean fan filters, perform the following the steps

•Grasp and pull both fan covers from one side of instrument and remove filters •Remove filter from the left side of the instrument

•Wash filters with deionized water or pressurized air to remove all the dirt •Use paper towels or lint-free tissues to dry the filter. •Reinsert filters into their positions

SIX MONTHS PM

Inspect the instrument visually to verify the integrity of its components according to the manufacturer's specifications.

Verify that the buttons or control switches and mechanical closures are mounted firmly and that their labels are clear.

Ensure that all the accessories are clean and intact.

Check the adjustment and condition of nuts, bolts and screws.

Make sure the electrical connections do not have cracks or ruptures. Test that they are joined correctly.

Verify that cables securing devices and terminals are free from dust, grime or corrosion.

Verify that cables are not showing signs of splicing or of being worn out.

Examine that the grounding system (internal and external) is meeting the electric code requirements.

Make sure the circuit switches, fuse box and indicators are free from dust, corrosion and grime.

Check lamp alignment if recommended by the manufacturer

YEARLY PM

Check the installation location for safety of the electrical (for instruments using main power only) and the physical infrastructures.

For instruments using main power

- o Check that the voltage is appropriate and does not vary more than 5% from the voltage in the equipment specifications.

Check that the polarity of the outlet is correct.

Check that there is sufficient space around the instrument for the connecting cables and for adequate ventilation.

Test the integrity of the counter and its cleanliness.

Verify that the instrument is away from equipment generating vibrations and direct solar radiation.

Check that there is no excessive humidity, high temperature or dust.

Ensure that there is no source of smoke, gas or corrosive emissions nearby.

MAINTENANCE REPORTING

You should always record any maintenance task done on equipment for future use. You should use the standard maintenance recording format of the facility where the equipment is located, if it is available. In case where there is no format available you can use the one provided here.

7.8 SUMMARY

Chemistry analysers are used to measure the concentration of analyte in blood or other bodily fluids based on specific chemical reactions by photometry.
Applications of Chemistry Analysers vary from clinical diagnostic, drug abuse monitoring to forensic testing.

- Dry and wet chemistry are Common types of chemistry analysers.

Basic components of chemistry analysers can be listed as probe unit, sample/reagent disk unit, reaction disk unit, mixing unit, photometric unit, fluid system
When operating chemistry analysers we have to make sure that we followed all the safety procedures.

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Logical troubleshooting of scientific instruments, by Robert l. Morris, PE, CCE

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Annex 1:

Trainee's check list, Microscope

Learner's name:			
Trainer's name:			
Course Title:	Light microscope		
Learning Objective:	To build maintenance capability of Biomedical Engineers/Technicians.		
Date of assessment:			
Venue of assessment:			
During the demonstration of knowledge, skills and attitude, the learner has:		Yes	No
1.Correct handling of microscope Demonstrated			
2. Mechanical and electrical parts of microscope Identified			
3. The required hand tools, Instruments and materials Prepared			
4. Preventive maintenance procedure to demonstrate:			
A. The eyepiece and objective lens properly removed ----------			
B. Cleaned the eyepiece and objective lens according to the manufacturers			
instruction_____			
5. Corrective maintenance procedure demonstrate:			
A. The power supply parts of the microscope Identified ----------			
B. The input and output voltage checked ----------			
C. Old illumination bulb and replaced ----------			
B. Quality image created as the procedure ----------			
D. Adjusted the Inclination of the Illumination Part ----------			
1. Followed OSH policies and procedures in performing the activities			
The learner's demonstration was:		Satisfactory	Not Satisfactory
Learner's signature:	Date:		
Trainer's signature:	Date:		

Annex 2:

Trainee's check list, centrifuge

Learner's name:			
Trainer's name:			
Course Title:	Centrifuge		
Learning Objective:	To develop maintenance capably of Biomedical Engineers/Technicians.		
Date of assessment:			
Venue of assessment:			
During the demonstration of knowledge, skills and attitude, the learner has:		Yes	No
1.Correct handling of centrifuge demonstrated			
2. Mechanical and electrical parts of centrifuge Identified			
3. The required hand tools, Instruments and materials Prepared			
4. Preventive maintenance procedure to demonstrate:			
a. Properly lubricate and clean the moving part _____			
b. Checked for properly settings of speed and time _____			
c. Check for proper functioning interlock system _____			
d. State of the brushes is checked			
5. Corrective maintenance procedure demonstrate:			
a. Identified the power supply parts of the centrifuge _____			
b. Check the input and output voltage _____			
c. Check for any vibration _____			
d. The actual rotation speed against selected ones are checked using photo tachometer			
6.Followed OSH policies and procedures in performing the activities			
The learner's demonstration was:		Satisfactory	Not Satisfactory
Learner's signature:	Date:		
Trainer's signature:	Date:		

Annex 3:

Trainee's check list, Refrigerator

Learner's name:			
Trainer's name:			
Course Title:	Refrigerator		
Learning Objective:	To develop maintenance capably of Biomedical Engineers/Technicians.		
Date of assessment:			
Venue of assessment:			
During the demonstration of knowledge, skills and attitude, the learner has:		Yes	No
1.Check for correct placing of refrigerator			
2. Identified the Mechanical and electrical parts refrigerator			
3. Prepare the required hand tools, instruments and materials			
4. Preventive maintenance procedure to demonstrate: a. Ensured daily recording of temperature and temperature set points b. Checked for properly settings temperature _____ c. Show how to defrosting the referigirator _____ d. Check Fans and motors working conditions_____ e. Check for the compressors sound condition f. Check the Condition of door/lid gaskets g. Alarm indicators and other electrical components h. Demonstrate how to clean the dust from the refrigerator			
5. Corrective maintenance procedure demonstrate: a. Rectify the problem of the refrigerator (The facilitator should make some problem on the machine) b. Demonstrate how to refill refrigerate gas			
6.Followed OSH policies and procedures in performing the activities			
The learner's demonstration was:		Satisfactory	Not Satisfactory
Learner's signature:	Date:		
Trainer's signature:	Date:		

Annex 4:

MAINTENANCE REPORT WRITING FORM

Facility:	
Date:	
Department:	
Equipment name:	
Order number:	
Fault description:	
Action taken:	
Spare(s) used:	
Maintenance result	
Remark:	

Maintenance performed by:_____ Date: _____Signature_____

Maintenance approved by:_____Date:_____Signature_____

Equipment returned to:

Name: _____ Date:_____ Sign:_____

Annex 5:

Format for order of spare parts

Requisition of spare parts should clearly show type or model of spare parts and type or model of equipment which spare parts requested for.
Finally requested and collected spare parts should be recorded by type of equipment requested and stored properly.

Region: _____ Zone: _____ Vaccine: _____ Store: _____

	Spareparts/Consumable						
No	Type of equipment	Name	Model	Unitof measurement	Quantity available	Total spare parts/ consumable required	Remarks

Format for Maintenance record registration in cold store/cold room,refrigerator

Region: _____ Zone: _____ Vaccine Store Name: _____ Vaccine Store: _____

SN	Date Reported	Reported by	Model	Type of maintenance	Description of problem	Description of maintenance	Spare used	Date of maintained	Remark

Inspected by: _____

Date: _____

Signature: _____

Annex 6:

Basic tool kit and electric test equipment

Measuring and titling of electrical components, cleaning& titling the mechanical of refrigerators & cold rooms is the major works in conducting preventive and repair work of cold rooms and refrigerators. To perform an effective and efficient maintenance work on refrigeration, a service or preventive maintenance man/technician should have the following toolkit and electric test equipment.

Tool kits requirementfor senior technicians

Annex 7:

Role and responsibilities of technicians

Conduct preventive maintenance of cold rooms & refrigerators in the cold store

Conducting inventory of cold chain equipment/materials & Identifying functional and not functional cold chain equipment with the possible reasons

Keeping proper document of cold chain equipment/materials.

Keeping proper stock of cold chain materials and spare parts

Conducting training of cold chain management for health workers

Conducting supportive supervision on cold chain and vaccine management regularly.

Ensuring the availability of the necessary cold chain materials

Ensuringthattherearead equateandpotentvaccinesavailableatcoldstoreandhealth facilities

Establishing proper reporting systems on cold chain management activities

Control and monitoring of the cold room and vaccine refrigerators temperature;

Arrangement of vaccines, diluents and icepacks accordingly

Recordingandreportingtemperaturemonitoring,maintenanceactivitiesandavailablespare parts

For maintenance to be effective every technician/user should know:-

Basic maintenance toolkits required

Required and available spare parts.

Annex 8:

Trainee's check list, Laboratory Incubator

Learner's name:			
Trainer's name:			
Course Title:	Maintaining laboratory incubators Equipment		
Learning Objective:	To develop the capacity of Biomedical Engineers/Technicians to maintain Operation Microscope		
Date of assessment:			
Venue of assessment:			
During the demonstration of knowledge, skills and attitude, the learner has:			
1.Describe the purpose of Incubator		Yes	No
2.Demonstrate calibration of laboratory incubator		o	o
3.Explain the different part of Laboratory incubator		o	o
4.Identified mechanical and electrical parts of laboratory incubator		o	o
4. Demonstrated preventive maintenance procedure		o	o
Cleaned the Incubator according to the manufacturers instruction		o	o
Check the Functionality of alarm/ signal indicators performance tests		o	o
Observation of water leakage		o	o
Checking of level of water in the jacket		o	o
Carbon dioxide concentration test by using fyrite		o	o
Checking of Temperature reading with standard thermo meter		o	o
Humidification test by hygrometer		o	o
5.Demonstrate corrective maintenance procedure:		o	o
Identified the power supply parts of the Incubator ----------		o	o
Checked the input and output voltage ----------		o	o
Dismantle the main components and re assemble----------		o	o
Followed OSH policies and procedures in performing the activities			
The learner's demonstration was:		Satisfactory o	Not Satisfactory o
Learner's signature:	Date:		
Trainer's signature:	Date:		

Annex 9:

Trainee's check list, Biological safety cabinet

S/No	Checklist	√=correct, ×=not correct	
1	Disinfected and cabinet is cleaned and		
2	Read the pressure display of the BSCs		
3	Smoke pattern airflow test		
4	Down flow air velocity Test		
5	Inflow air by smoke test		
6	Sash retention test by smoke test		
7	Check UV light		
8	Label major parts of BSCs		
9	Check internal socket of BSCs		
10	Demonstrate functioning of fans observation		
11	Check for Alarm displays		

Annex 10:

Trainee's check list, Chemistry machine

Learner's name:			
Trainer's name:			
Course Title:	Maintaining laboratory chemistry analyzers		
Learning Objective:	To develop the capacity of Biomedical Engineers/Technicians to maintain Operation Microscope		
Date of assessment:			
Venue of assessment:			
During the demonstration of knowledge, skills and attitude, the learner has:			
1.Describe the purpose of Clinical chemistry analyzers		Yes	No
2.Demonstrate how to run sample and calibrator on clinical chemistry analyzers		o	o
3.Explain the different part of chemistry analyzers		o	o
4. Identified optical , fluidics and electrical parts of chemistry analyzers		o	o
5. Demonstrated preventive maintenance procedure		o	o
Restart the analyzers and ensure for the proper initialization		o	o
Check the alignment of the moving part and adjust if there is problem by following manual		o	o
Perform daily cleaning		o	o
Checking the flow cell temperature reading		o	o
Observation for the diluter group and clean if there is any blockage		o	o
Checking the tightness of all the solenoid valve		o	o
Perform the weekly preventive maintenance following the manual		o	o
5. Demonstrate corrective maintenance procedure Rectify the problem of the analyzers (The facilitator should make some problem on the machine)		o	o
6 Followed OSH policies and procedures in performing the activities		o	o
The learner's demonstration was:		Satisfactory o	Not Satisfactory o
Learner's signature:	Date:		
Trainer's signature:	Date:		

Annex 11:

Trainer evaluation check list

Y	N	Details
		Use a vacuum or broom to remove dust build-up from the fridge coils. Depending on the model, the coils will either be located behind the fridge or underneath the fridge: Remove the grill at the bottom front of the fridge to access coils located underneath. Pull the fridge out from the wall to access the coils located behind the fridge.
		Inspect the door seals to see if there are any areas that are cracked or otherwise damaged. Close the fridge door on a small piece of paper.If you can pull it out easily, the seal is not effective and you should consider replacingit. If the door seal is in good shape, clean it with warm soapy water and then wipe it dry.
		Most fridges rely on a drain hole and drip pan to remove condensation. Remove any food particles and mineral deposits from the drain hole according to the instructions in the owner's manual. After wards, clean the drain pan.
		Make sure there is atleast 8cm (3inches) of airspace between the back of the fridge and the wall and at least 2.5cm (1inch) of space on both sides to allow for good air circulation. This does not apply to zero-clearance or front-vented fridges.
		Place a carpenter's level on top of the fridge to verify that the fridge is level both front-to-back and side-to-side. If necessary, adjust the fridge feet. A level fridge ensures proper door movement and ice maker operation.
		Sometimes even frost-free fridges need to be defrosted.If applicable, unplug the fridge and allow the freezer to defrost on its own. Do not try to remove the ice with a knife as this can damage the fridge.
		Consult the fridge owner's manual to see if there are any additional maintenance items recommended for the model.

Annex 12:

Check list for training evaluation

please indicate your agreement base on the following scale: 1=poor, 2=fair, 3=good, 4=very good, 5=excellent							
S. No	Parameters	Result					
1	**ABOUT THE TRAINING**	1	2	3	4	5	
1.1	The training objectives set were made clear at the beginning of each activity.						
1.2	The training objectives have been achieved.						
1.3	The presentations were helpful for the participants' learning.						
1.4	The methods of training used during the training were appropriate.						
1.5	Training materials were consistent with the training objectives.						
1.6	Training materials were adequate						
1.7	The training flowed in such a way that learning was improved						
1.8	Time provided during the training was adequate						
2	**ABOUT THE PARTICIPANTS**						
2.1	Most participants were active in the discussion						
2.2	Most participants enhanced my learning process						
2.3	There was good collaboration in my group						
2.4	Most of the participants were open to new ideas						
2.5	I have had the opportunity to ask questions						
2.6	I learned new things in the training						
2.7	I shall be able to use the skills I have gained for improving my performance						
2.8	My expectations were met						
ABOUT THE FACILITATORS							
3.1	Good knowledge of the topic						
3.2	Enough content presentation						
3.3	Address Objective in discussing topics						
3.4	Immediate response to changes in situation based on participants' needs						
3.5	Appropriate teaching methodologies						
3.6	Effective in motivating participants						
3.7	Skilled in relating with participants						
3.8	There was good time management						
3.9	Comments, insights, lessons learned on the whole training including how to improve future training						

Appendex 13:

Incubator logbook

Temperature required:	36 ± 1 °C (acceptable variation)

Trimester (3 months period):				Year:				
Month	Temp. °C	Operator (initials)	Month	Temp. °C	Operator (initials)	Month	Temp. °C	Operator (initials)
1			1			1		
2			2			2		
3			3			3		
4			4			4		
5			5			5		
6			6			6		
7			7			7		
8			8			8		
9			9			9		
10			10			10		
11			11			11		
12			12			12		
13			13			13		
14			14			14		
15			15			15		
16			16			16		
17			17			17		
18			18			18		
19			19			19		
20			20			20		
21			21			21		
22			22			22		
23			23			23		
24			24			24		
25			25			25		

Annex 13:

Biological Safety cabinet daily recorded sheet

Safety check must be completed each time cabinet is switched on for use.

Site ----------

Month: ----------

Operator	Date	Visual Alarm	Sound Alarm	Airflow	Sample