Biomedical equipment servicing level -IV

Based on May, 2011 Version 2 OS and Feb, 2021 Version 1 Curriculum

Module Title: Finding and Repairing Faults in Measuring and Analysis Systems

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Instruction Sheet

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Identifying, obtaining and understanding OHS procedures for a given work area.
- Following OHS risk control measures and procedures
- Obtaining the nature of the fault from documentation
- Advising is sought from the work supervisor to ensure the work
- Establishing sources of materials that may be required for the work
- Obtaining tools, equipment and testing devices needed to carry out the work

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, **upon completion of this Learning Guide, you will be able to**:

- Identify, obtain and understand OHS procedures for a given work area.
- Follow OHS risk control measures and procedures
- Obtain the nature of the fault from documentation
- Advise is sought from the work supervisor to ensure the work
- Establish sources of materials that may be required for the work
- Obtain tools, equipment and testing devices needed to carry out the work

Learning Instructions

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 4.
3. Read the information written in the information “Sheet 1, Sheet 2, Sheet 3, Sheet 4, Sheet 5 and Sheet 6.

4. Accomplish the “Self-check 1, Self-check 2, Self-check 3, Self-check 4, Self-check 5 and Self-check 6” **in page 9, 21, and 23** respectively.

Information Sheet-1	**Identifying, obtaining and understanding OHS procedures for a given work area**

Understanding OHS policy

Occupational health and safety (OHS) is the term used to describe the laws and processes that help to protect employees from death, disease and injury while at work. The purpose of the Health and Safety policies and procedures is to guide and direct all employees to work safely and prevent injury, to themselves and others. Ultimate goal is to eliminate or minimize hazards that can cause accidents.

Obtaining and identifying OHS procedure at workplace

One of your most important responsibilities is to protect your Health and Safety as well as that of your co-workers. What the law requires Workplaces under the jurisdiction are governed by your provincial legislation. The legislation places duties on owners, employers, workers, suppliers, the self-employed and contractors, to establish and maintain safe and healthy working conditions. Your officials are responsible for monitoring compliance.

You are responsible to:

- Protect your own Health and Safety and that of your co-workers;
- Not initiate or participate in the harassment of another worker;
- Co-operate with your supervisor and anyone else with duties under the legislation.

Legislation gives you three rights:

- The right to know the hazards at work and how to control them;
- The right to participate in Occupational Health and Safety;
- The right to refuse work which you believe to be unusually dangerous.

You may not be punished for using these rights. An employer can be required to legally justify any action taken against a worker who is active in Health and Safety.

Note: Refer ''Install advanced Biomedical equipment module, LO2, Information sheet 2 page no.27-30''

For radiation emitting devices it is necessary to identify and follow the OHS procedures.

A radiological emergency is an emergency in which there is, or is perceived to be, a hazard due to radiation exposure from a source may include the following

- Medical symptoms of radiation exposure;
- Loss or theft of a dangerous radioactive source;
- Public radioactive contamination/exposure;
- A transport emergency involving radioactive materials;
- Detection of elevated radiation levels;
- Presence of a radiological dispersal device (RDD)

Any source of radiation has the potential to give a radiation dose through external or internal routes as follows:

External routes: Individuals can be exposed to radiation from radioactive material in the environment:

- Directly from a radioactive source or from radioactive material deposited on the ground or other surfaces;
- Dispersion of a radioactive material in gaseous or vapor form in the atmosphere.

Internal routes: Individuals can be exposed to radiation from radioactive material within the body by:

- Inhaling radioactive material in the atmosphere from the incident or re-suspended from the ground;
- Ingesting food/water that has been contaminated with radioactive material;
- Absorbing radioactive contamination through the skin or open wounds into the body.

Health effects from exposure to radiation include one or more of the following:

- Short-term effects such as skin burns or acute radiation syndrome at high doses of radiation;
- Long-term effects such as an increased risk of certain types of cancer reported at doses above 100 mSv;

- Psychological effects even where little or no radiation exposure has occurred.

In exceptional situations such as in nuclear and radiological emergency operations, informed emergency workers may volunteer to take actions where there is a probability of receiving doses that might exceed 50 mSv (the occupational dose limit for workers in a single year). The only situations in which this is applicable are listed as follows;

- No emergency worker is subject to an exposure in an emergency in excess of 50 mSv other than:

  (a) For the purpose of saving life or preventing serious injury;

  (b) If undertaking actions intended to avert a large collective dose; or

  (c) If undertaking actions to prevent the development of catastrophic conditions.
- When undertaking intervention under these circumstances, all reasonable efforts shall be made to keep doses to workers below twice the maximum single-year dose limit, except for life-saving actions, in which every effort shall be made to keep doses below 10 times the maximum single-year dose limit in order to avoid deterministic effects on health. In addition, workers undertaking actions in which their doses may approach or exceed 10 times the maximum single-year dose limit shall do so only when the benefits to others clearly outweigh their own risk.

Safety procedure following OHS for MRI machine

This guidance and advice document overviews safety issues in Magnetic Resonance Imaging (MRI). The MRI Responsible Person:

- has day to day responsibility for MRI safety in the MRI Centre;
- shall be required to have training in, and have good working knowledge of, MRI training and safety;
- shall be delegated as **Responsible Person** by Chief Executive or General Manager;
- may effectively be Clinical Director, Head of Department or Superintendent Radiographer in an MRI department;

The Authorized Person:

- Shall be on a certified list to be given access to controlled area;
- Shall be one of the MRI Centre personnel, including the MR Operator
- Must have read and understood the MRI Centre safety training materials, and have completed and passed a screening questionnaire annually;
- Shall be one of certain external users with access to scanner rooms, such as engineers, researchers, research assistants, cleaning and maintenance staff;
- Must have an appropriate record of their MR training which is kept by the Responsible Person;
- Shall satisfy him/her at all times that they conform to the requirements of the screening process.

Controlled Areas

The static magnetic field and the shielding define the controlled areas. Typically, MR departments will define two controlled areas the controlled area and the inner controlled area.

Controlled Area

- The controlled area is where the static magnetic field, B0, may exceed 0.5 mT2 (often referred to as the 5 Gauss line: 5 Gauss = 0.5mT). The controlled area will incorporate the inner controlled area, the control room and typically, preparation room, patient changing rooms and reporting rooms.
- Ideally the limit of the 0.5mT line should be marked out on the floor as a safety guide for staff.

Note: Access should be restricted to the controlled area by a permanently locked door, ideally with a keypad entry.

Inner Controlled Area

- The inner controlled area is where the static magnetic field may exceed 3mT. This is typically the scan room itself and this area should be clearly marked and access controlled by means of a lockable door.

Note: Due to the hazards of the static magnetic field described in this section, resuscitation of patients should take place outside the inner controlled area. Local rules should outline specific procedures to reflect this.

Bio-effects

The interaction of the static magnetic field (B0) with the body and its functions may result in the creation of electrical potentials, currents generated by body movements and the possible displacement of naturally generated currents within the body by B0. Electrical potentials and related effects during physical movements within static magnetic field gradients may induce sensations of vertigo, nausea, phosphenes and a metallic taste in the mouth.

Note: "*The Biological Effects most likely to occur are the production of vertigo-like sensations and these acute effects are associated with movement in the static field. The sensitivity to these effects varies considerably between individuals. Patients and volunteers should be moved slowly into the scanner, to avoid the possibility of vertigo and nausea.*

Mechanically, electrically and magnetically operated devices may malfunction in the presence of a strong magnetic field. This malfunction may not be obvious at the time of examination but may subsequently have serious consequences.

Examples include:

- cardiac pacemakers
- cochlear implants
- programmable hydrocephalus shunts
- implanted neuro-stimulation systems
- implanted drug infusion pumps

Non-active devices:

There is a risk that implanted ferro-magnetic devices will undergo attractive forces such that they can dislodge, causing serious injury or discomfort to the person concerned. Such devices will be labeled as MR unsafe, MR conditional or MR safe.

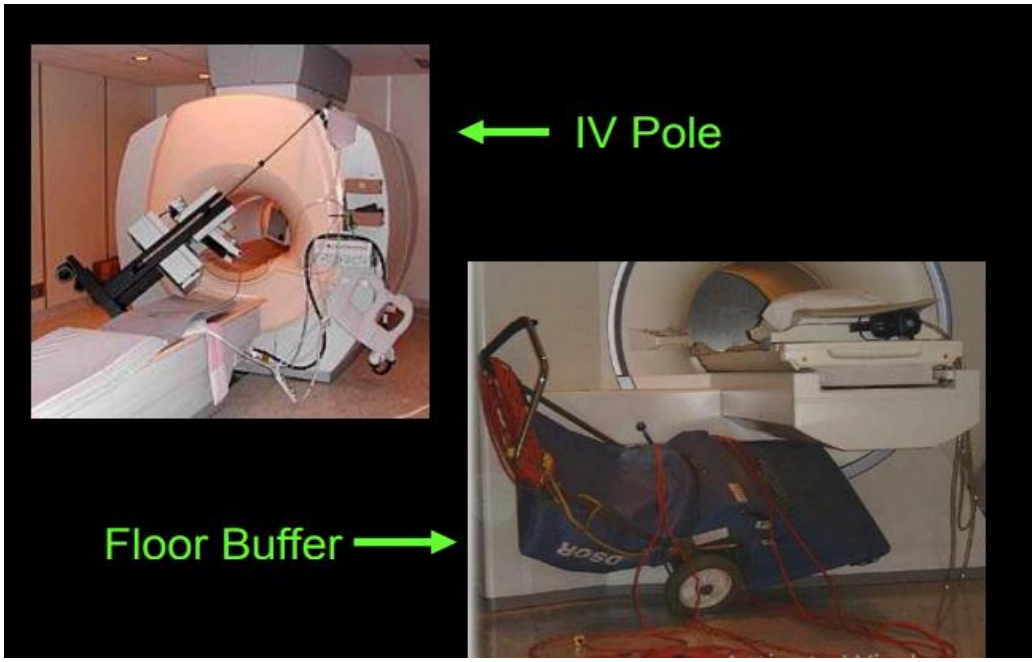

Figure 1.MRI Accident

Safety consideration for departments;

It is recommended that all staff working in MR units should have as a minimum:

- Knowledge and understanding of the threats posed by the static magnetic field;

- Understanding of the environment and controlled area;
- Awareness of MR authorized personnel;
- Understanding of the screening process and access rights;
- Knowledge and understanding of emergency procedures within the scan room;
- Understanding of the nature of a magnet quench and when a system may need to be quenched by the operator;
- Understanding of the labeling system for MR equipment;
- Understanding of the requirement for hearing protection and correct positioning;
- Understanding of the correct use and positioning of the coils and cables and ancillary equipment

Figure 2.Safety notice

Self-Check -1	**Multiple choice**

1. For ionizing radiation emitting device radiation protection standard protocol should include?

A. Warning notice indicator B. radiation effect description C. door safety interlock D. all

2. MRI room safety protocol include
   A. ferromagnetic material inhibition to come with
   B. zonal restriction and marking
   C. avoiding internal implants D. all
3. Obtaining and identifying the OHS policy and procedures is responsibility of___.
   A. workers B. Employers C. safety and quality officers D. all

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 6 points**
You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = _____
Rating: _____

Name: _____ Date: _____

Information Sheet-2	**Following OHS risk control measures and procedures**

Following OHS policy

Occupational health and safety (OHS) is the term used to describe the laws and processes that help to protect employees from death, disease and injury while at work. The purpose of the Health and Safety policies and procedures is to guide and direct all

employees to work safely and prevent injury, to themselves and others. Ultimate goal is to eliminate or minimize hazards that can cause accidents.

One of your most important responsibilities is to protect your Health and Safety as well as that of your co-workers. What the law requires Workplaces under the jurisdiction are governed by your provincial legislation. The legislation places duties on owners, employers, workers, suppliers, the self-employed and contractors, to establish and maintain safe and healthy working conditions. Your officials are responsible for monitoring compliance.

You are responsible to:

- Protect your own Health and Safety and that of your co-workers;
- Not initiate or participate in the harassment of another worker;
- Co-operate with your supervisor and anyone else with duties under the legislation.

Legislation gives you three rights:

- The right to know the hazards at work and how to control them;
- The right to participate in Occupational Health and Safety;
- The right to refuse work which you believe to be unusually dangerous.

You may not be punished for using these rights. An employer can be required to legally justify any action taken against a worker who is active in Health and Safety.

What is hazard?

The Occupational Health and Safety Regulation 2001 define a hazard as ‘anything (including work practices or procedures) that has the potential to harm the health or safety of a person’.

Hazard: is also a situation or thing that has the potential to harm a person.

Hazards at work may include: noisy machinery, a moving forklift, chemicals, electricity, working at heights, a repetitive job, violence at the workplace etc…

Risk: is the possibility that harm (death, injury or illness) might occur when exposed to a hazard.

Hazards can be grouped into five broad areas:

- Physical hazard:- e.g. noise, radiation, light, vibration

- Chemical hazard:- e.g. poisons, dusts
- Biological:- e.g. viruses, bacterial infection , parasites
- Mechanical/ electrical hazard: - e.g. Trips and falls, tools, electrical equipment (micro or macro shock).
- Psychological hazard: - e.g. fatigue, violence.

Hazards can arise from work environment, use of machinery and substances, poor work design inappropriate systems and procedures

Risk management

Risk management is a proactive process that helps you responds to change and facilitate continuous improvement in your business. It should be planned, systematic and cover all reasonably foreseeable hazards and associated risks.

It involves four steps to set out hazards;

Identify hazards – find out what could cause harm.

Assess risks if necessary – understand the nature of the harm that could be caused by the hazard, how serious the harm could be and the likelihood of it happening.

Control risks – implement the most effective control measure that is reasonably practicable in the circumstances.

Review control measures-to ensure they are working as planned.

Step1 – How to identify hazard

Identifying hazards in the workplace involves finding things and situations that could potentially cause harm to people. We can find hazards by;

- Inspect the work place
- Consult your workers
- Review available information's

Step 2 – How to assess risk

A risk assessment involves considering what could happen if someone is exposed to a hazard and the likelihood of it happening. A risk assessment can help you determine:

- How severe a risk is
- Whether any existing control measures are effective
- What action you should take to control the risk

- Wow urgently the action needs to be taken

STEP 3 – How to control risks

The most important step in managing risks involves eliminating them so far as is reasonably practicable, or if that is not possible, minimizing the risks so far as is reasonably practicable. The ways of controlling risks are ranked from the highest level of protection and reliability to the lowest as shown in Figure below

Figure 3.Risk level

LEVEL-1 Control measures

You must always aim to eliminate a hazard, which is the most effective control. If this is not reasonably practicable, you must minimize the risk by working through the other alternatives in the hierarchy. The best way to do this is by, firstly, not introducing the hazard into the workplace. For example, you can eliminate the risk of a fall from height by doing the work at ground level.

LEVEL- 2 control measures

If it is not reasonably practicable to eliminate the hazards and associated risks, you should minimize the risks using one or more of the following approaches:

Substitute the hazard with something safer

For instance, replace solvent-based paints with water-based ones.

Isolate the hazard from people

This involves physically separating the source of harm from people by distance or using barriers. For instance, use remote control systems to operate machinery; store chemicals in a fume cabinet.

Use engineering controls

An engineering control is a control measure that is physical in nature, including a mechanical device or process. For instance, use mechanical devices such as trolleys to move heavy loads; place guards around moving parts of machinery; install residual current devices (electrical safety switches); set work rates on a production line to reduce fatigue.

LEVEL- 3 control measures

These control measures do not control the hazard at the source. They rely on human behavior and supervision, and used on their own, tend to be least effective in minimizing risks.

Ultrasound machine (Philips HD3) safety and risk management

This equipment has been verified by a recognized third-party testing agency as a Class I device with Type BF and Type CF isolated patient-applied parts and Type B accessories. For maximum safety observe the following:

- Do not connect the ultrasound system to the same circuit used for life-support devices.
- Shock hazards may exist if this system, including all externally mounted recording and monitoring devices is not properly grounded. Protection against electrical shock is provided by grounding the chassis with a three-wire cable and plug.
- The system must be plugged into a grounded outlet. The grounding wire must not be removed or defeated.
- To avoid risks of electrical shock and fire hazards, inspect the system power cord and plug on a regular basis. Ensure that they are not damaged in any way.

- Do not remove the protective covers on the system; hazardous voltages are present inside.
- Cabinet panels must be in place while the system is in use. All internal adjustments and replacements must be made by a qualified Philips Ultrasound field service engineer.
- Do not operate this system in the presence of flammable gases or anesthetics. Explosion can result from electrical ignition.
- To avoid risk of electrical shock hazards, always disconnect the system from the wall outlet before cleaning the system
- To avoid risk of electrical shock hazards, always inspect transducers before use: Check the face, housing, and cable before use.
- Do not use if the face is cracked, chipped, or torn; the housing is damaged; or the cable is abraded.
- To avoid risk of electrical shock, do not use any transducer that has been immersed beyond the specified cleaning or disinfection level.
- All patient-contact devices, such as transducers, pencil probes, and ECG leads must be removed from the patient contact prior to application of a high-voltage defibrillation pulse.
- Connection of optional devices not supplied by Philips Ultrasound could result in electrical shock. When such optional devices are connected to your ultrasound system, ensure that the total system earth leakage current does not exceed 300mA
- Avoid placing the system in an environment that may produce electrostatic discharges (ESD) that could affect the ultrasound system performance. (Electrostatic discharges can cause the ECG heart rate display to increase by 10% to 15% for a few seconds after the discharge, even though the ECG heart rate display returns to normal within a few seconds.
- Avoid placing the system in an environment that may produce electromagnetic interference (EMI) that could impact the diagnosis of a patient

Mechanical Safety during Installation

Although the system is designed to be mobile, remember that it is very heavy, and that you must take precautions when moving it. The physical aspects of this system present a hazard that can cause injury, property damage, or equipment damage if the following information is ignored:

- Before moving the system, be sure to power it off, remove any loose equipment from the top of the system, disconnect the system power cord, and disconnect all external devices. Move and secure external devices away from the system.
- Make sure the control top is locked, to prevent its up/down movement and unlock the caster locks before moving the system. Push with the handle at the front of the cart. After the system is in position, engage the caster locks to immobilize the system.
- Be aware of the casters as well as the extremities of the system when moving it. The system is heavy enough in any configuration that it can cause injury to you or others. Exercise additional caution when going up or down inclines.
- When attempting to overcome an obstacle, do not push the system with enough force to cause it to tip over. Do not exceed 10 degrees of incline.
- Never park the system on an incline. For transport, make sure the control top is locked and secure the system so that it cannot roll or tip. Engage the caster locks and use wheel chocks and restraining straps.
- Do not attempt to hold the system in place manually. Never strap or secure the system at any point on the control top or monitor.

Self-Check -2	**Multiple choice**

1. _____ is the term used to describe the laws and processes that help to protect employees from death, disease and injury while at work.

A. OHS B. hazards C. Risk management D. all

2. Protection against electrical shock is provided by grounding the chassis with a _____ cable and plug.

A. Two wire B. Three wire C. four wire D. five wire

3. To avoid risk of electrical shock, do not use any transducer that;
   A. Has been immersed beyond the specified cleaning or disinfection level.
   B. Cracked at its head
   C. A&B
   D. None
4. Which one is highest health and safety levels for risk control
   A. Level 1 B. Level 2 C. Level 3 D. Level 4

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 6 points**

You can ask your teacher for the copy of the correct answers.

Answer Sheet

Score = _____
Rating: _____

Name: _____ Date: _____

Information Sheet-3	**Obtaining the nature of the fault from documentation**

Nature of faults

One can access nature of the fault from different materials like service manual, installation manual, operator manual and also from recorded equipment history file. By using those documents you can easily and effectively find the fault and understand nature of the faults. Device use environments and device users are changing. Increasingly, devices are being moved from exclusive use in specialized healthcare settings, such as hospitals, into community care and home-use as well. As a result, in addition to the new environmental challenges that may be presented, devices may have

to be managed by untrained and unskilled users whose medical condition may further compromise their ability to operate the device safely and effectively.

Devices /equipment themselves are changing greatly. In addition to the changes in the workplace environment, people working in healthcare establishments are facing the need to operate devices of greater complexity, which creates further challenges to safe and efficient operation. Users and society in general, are becoming less tolerant towards poor design. Furthermore, by increasingly transferring much of the effort in diagnosis, monitoring and treatment of patients from the clinician to the device, medical devices are becoming more safety-critical in healthcare treatment. These factors and the ever-growing issue of product liability, place even greater emphasis on manufacturers to design fit-for purpose devices.

Medical device related faults/errors

Medical errors, which may also be referred to as adverse incidents or adverse events, occur in the context of medical treatment. They result when a correct action is not undertaken or where an incorrect action is performed. It can be seen that medical errors may result from device-related errors or from non-device-related errors.

Device-related errors occur when a medical error is associated with a medical device. These may be due to errors on the part of the device manufacturer (manufacturer-related errors) or may be caused by inappropriate practice in use (user errors). Manufacturer-related errors may be caused by manufacturing errors or device design errors. User errors may be caused by other factors. These types of error are defined below.

- Manufacturing errors occur during the device manufacturing process and result when the device specification .Such errors may arise, for example, due to inappropriate device sterilization practice or a failure to manufacture the device within the required dimensional tolerances.

- Device design errors occur when the device specification is inappropriate. These may include, for example, designing a device which is insufficiently robust to withstand the full range of use conditions or designing one which fails to fulfill its basic performance requirements.
- User errors occur when the user is at fault. These may be caused by: psychological factors such as tiredness or stress, physical factors such as insufficient dexterity or poor eyesight, training-related factors such as insufficient or incorrect training, and also negligence.

Causes of faults

Equipment failures occur due to various causes which include the following; Improper storage and transportation, Initial failure, Inappropriate handling, Inadequate maintenance, Environmental stress, Random failure, Inappropriate repair technique and Wear-out failure. The World Health Organization (WHO) estimates that 50% to 80% of such equipment remains non-functional and the most commonly cited reasons are poor maintenance culture and lack of highly trained technicians. According to statistics on medical equipment failures from WHO about 80% of all medical equipment failure cases are caused by preventable factors and failures due to inadequate maintenance alone account for about 60% of all the medical equipment performance cases [2]. In addition to this, failures due to inappropriate handling, environmental stress and wear-out account for about 20% of all the failure cases. There are several types of maintenance practices that are carried out on medical equipment. These include Inspection, Predictive Maintenance, Preventive Maintenance, and Repair/Corrective Maintenance. Investigating causes of equipment failure involves logical troubleshooting using wide-range knowledge of operating principles of the equipment, structure of the equipment, and understanding of the electronic circuits of the equipment.

Self-Check -3	**Multiple choice**

1. Fault can be arises from

   A. Manufacturer defect B. User error C. Environmental factor D. all
2. At which step error may occur if the manufactured device is perfect in other country / region

A. Specification preparation B. purchasing the equipment C. Installation phase D. A&C

3. Which is used for finding faults
   A. Service manual B. installation manual C. User manual D. all

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 6 points**

You can ask your teacher for the copy of the correct answers.

Answer Sheet

Score = _____
Rating: _____

Name: _____ Date: _____

Information Sheet-4	**Advising is sought from the work supervisor to ensure the work**

Supervisor guidance at work place

The supervisor in this case is one who has experience in maintaining and fault finding in his past career. The supervisor expected to know and understand the subject matter of the problem faced or fault of the equipment. Purpose of supervisor to see the work;

- Planning, scheduling, supervising the work
- To minimize errors
- To share experience and easily find the faults
- To reduce risk/hazards
- Motivate the worker on site
- Organize the necessary tools and testing devices
- Apply his/her critical thinking on problem occurred
- Provide guiding materials like manuals for maintenance and troubleshooting, installing , performance checking and any other reference regarding the work
- Communicate the experts for more complex tasks

The supervisor should have ability to read, analyze, and interpret technical things and legal documents. This may include the following;

- Ability to respond to common inquiries or complaints

- Ability to write clearly and concisely to give direction and information and document work needed and/or completed
- Ability to understand electrical wiring diagram, system flow diagram
- Ability to apply concepts such as fractions, percentages, ratios, and proportions to practical situations
- Ability to define problems, collect data, establish facts, and draw valid conclusions
- Ability to interpret an extensive variety of technical instructions in mathematical or diagram form and deal with several abstract and concrete variables
- Basic computer skills including working knowledge of Microsoft Word and Excel

Supervision during installation of advanced medical equipment

The work place supervisor should have to see the installation process in between the work to guide the installer/technician for better accomplishment of the work. As we have discussed in the above section the supervisor going to see the work is expected have adequate knowledge and skill regarding the subject matter of the work. During the installation process the supervisor see the workers and give advice regarding installation procedure, safety notes, necessary materials usage etc…

The supervisor may help to correct fault of the workers by seeing;

- Misaligned parts and mechanical parts
- Faulty cable and wire connection
- Faulty site for the machine installation
- Incorrect or missed accessories or parts

Supervision during Maintenance of advanced medical equipment

During the maintenance procedure the supervisor helps to maintenance team by sharing the past experience and skill to find the problem of the faulty equipment. During maintenance the problem can be;

- Single electrical components ex. Resistor, fuse, Transistor, contactor, breaker, switch, capacitor, inductor etc…
- Whole PCB board ex. Ultrasound image processor board, Ultrasound signals amplifier board, display board, x-rays time control board etc…

- Machinery parts ex. Motor compressor, high voltage transformer, water purification system, etc…
- Reagents quality for laboratory devices
- Environmental factors like ambient temperature, altitude, pressure, humidity

Regarding the above listed problem the supervisors easily guide the maintainer to fix the problem easily with in short time.

Self-Check -4	**Multiple choice**

1. Which is role of supervisor

A. plan the work schedule B. perform the task fully C. delay the work D. stressing the workers

2. No matter for the supervisor to know the subject matter of the work.

   A. True B. False

3. Supervisor skill is used to ___.

   A. Reduce errors and save time B. increase work load C. increase cost D. all

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 6 points**

You can ask your teacher for the copy of the correct answers.

Answer Sheet

Score = _____
Rating: _____

Name: _____ Date: _____

Information Sheet-5	Establishing sources of materials that may be required for the work

Establishing source of materials

Materials required for fault finding and repairing the fault are varying depending on the specific equipment. In general the necessary source material for finding fault and repair the advanced medical equipment relays on equipment service manual, operator manual. For modern system specifically the fault indicating errors /error codes can be generated on the device to trace the system easily. Following the error code you can exactly access the faulty part.

X-ray machine fault indicator material guide

The material should include the following;

- General precautions
  - ✓ Before removing any covers, or testing any wires or connections, ensure the system is switched off, and unplugged from the power point.
  - ✓ Mobile high-frequency generators may be battery operated. The batteries in these are connected in series, and may have a total voltage of up to 240 V DC. Refer to the operating or installation manuals for the position of the battery isolation switch, and ensure this is switched off before removing any covers.
  - ✓ If the power plug has loose connections, have an electrician check the plug. The plug may be assembled incorrectly.
  - ✓ Use radiation PPE and other electrical shock safety devices
- Visual inspection of the control panel, power off
  - ✓ Check all knobs and switches. Where knobs have a pointer attached, check that the pointer aligns correctly at all positions of the indicated scale.
  - ✓ Where controls have had extra labels attached, are these labels still relevant? If so, are they in good condition?

- ✓ Older X-ray mobiles often have analogue meters instead of digital displays.
- ✓ With power switched off, the meter needle should be on the ‘zero’ calibration mark.

- Mechanical and electrical inspection, power off
  - ✓ Look for any loose panels or sections.
  - ✓ Pay particular attention to the mounting of the collimator.
  - ✓ With a screwdriver, check for possible loose screws, particularly with the tube support arm and the vertical bearing tracks.
  - ✓ With the X-ray tube set to minimum height, check the vertical suspension wire rope for possible broken strands.
  - ✓ Check the action of the tube-stand bearings. Are there any visible gaps between the bearings and the track surface? Also are there any ‘clunking’ noises or ‘jerking’ when moved, which can indicate damaged bearings. Spray the tube stand tracks and bearings with a light aerosol lubricant. Wipe down afterward, so only a very small film is left on the tube stand tracks.
  - ✓ Check for possible loose lock handles, and ensure manually operated locks have an adequate range of adjustment.
  - ✓ Ensure the mobile brakes operate in a positive fashion when the hand is released from the handle, and that they are fully released while the mobile is travelling.
  - ✓ Pay particular attention to the cabling from the X-ray tube and tube stand. All movements of the system should not cause any stress or pulling of the cables.
  - ✓ Inspect the HT cables for any sign of damage to the safety earth shield at the X-ray tube cable ends. Ensure the cable ends are firmly inserted into the X-ray tube, and the securing ring nut is not loose.

- ✓ Where there is evidence of twisting or pulling on the HT cables, particularly at the X-ray tube end, investigate means of providing additional support. If necessary, discuss with the service department.
- ✓ Examine carefully all plugs and sockets attached to cable ends. The outer insulation of cables should not be pulled out from the cable clamp.
- ✓ Check the condition of the power cable. If necessary, remove the plug cover, and ensure terminations are tight, and no connections are stretched or have broken strands.

Self-Check -5	**Multiple choice**

1. Source material that specifically used for maintaining fault of the is___.
   A. Service manual B. Installation manual C. operational manual D. brochures
2. What is safety guide instruction for x ray machine
   A. Ensure the power is ON before touching the electrical parts
   B. Enter gently to the room
   C. Use radiation protection lead
   D. Ignore warning notice and indicators

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 6 points**

You can ask your teacher for the copy of the correct answers.

Answer Sheet

Score = _____
Rating: _____

Name: _____ Date: _____

Information Sheet-6	**Obtaining tools, equipment and testing devices needed to carry out the work**

There are a lot of tools, equipment and testing devices used for finding and repairing the fault occurred during maintenance measurement and system analysis. These are different screw drivers that used to open the system and looking for faulty section, measuring and testing device example; digital multi-meter, radiation measuring device, electrical safety tester etc…

Screwdriver: The screwdriver is a tooling agent that can be manual or power and it is used for screwing and unscrewing screws. Its shaft is made up of tough steel to resist twisting and bending. A simple screwdriver consists of a handle and a shaft that ends with a tip and for the user, it puts into the screw head before turning the handle. A simple form of the screwdriver has been replaced in many workplaces and homes with a Power Drill because they are quicker easier and can drill holes too.

Figure 4 .different type of screw driver

Note: For additional information refer *"LG #01, LO#01, information sheet 2"*

Wrench: A wrench is a tool specially designed to tighten or loosen nuts, bolts, studs, and pipes. Wrenches are made from steel alloy to prevent breakage. There are many different types of wrenches. Each type has its own use. By using the proper wrench for the task to be done, you will not break the wrench, damage the equipment, or cause personal injury.

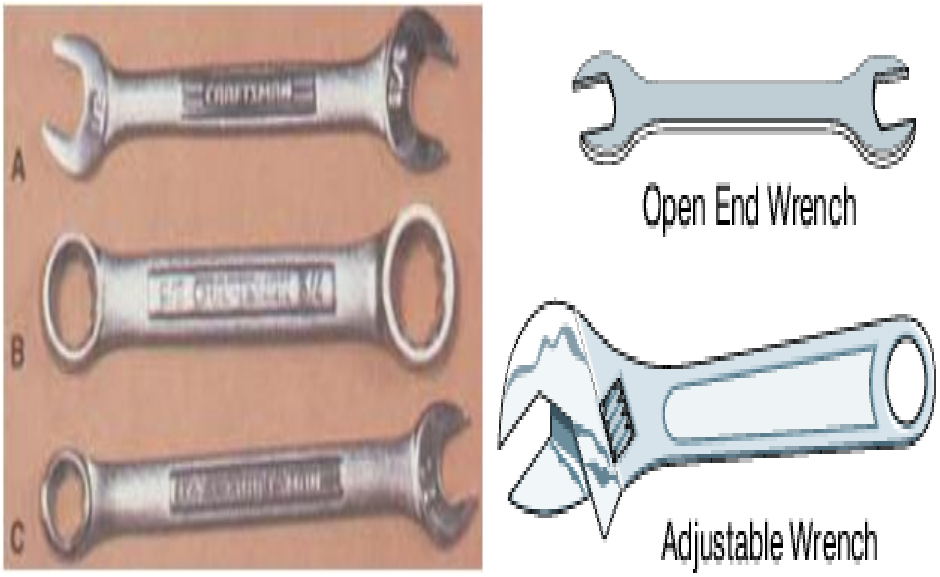

Figure 5.wrench tool

Digital multi-meter: it is used to find fault regarding power output system and circuit measurement and analysis system. Every electrical medical device requires this testing tool to perform accurate measurement and electrical system error detection. The measurements are output current, output voltage with-in the system, system continuity test, IC test etc…

Table 1.Description of modern multi-meter

Symbols	Measurement Functions	Descriptions
$V\sim$ V_{AC}	AC Voltage	Measures amount of AC Electrical Pressure
$V\overline{\overline{\overline{\ }}}$ V_{DC}	DC Voltage	Measures amount of DC Electrical Pressure
mV	Milli Volts	.00V or 1/1000V
A	Amperes	Measures amount of electron flow
mA	Milli Amperes	.001 or 1/1000A
µA	Micro Amperes	.000001A or 1/1,000,000A
Ω	Ohms	Measurement of resistance to the flow of electron
	Diode	Device used to control direction of electron flow
	Audible Continuity	Audible indication of continuity for low resistance
	Capacitance	Device used to store electrical potential
HZ	Hertz	Measurement of Frequency or number of cycles per/sec
°F	Degrees Fahrenheit	Temperature measurement
°C	Degrees Celsius	Temperature measurement

Oscilloscope

An oscilloscope, or scope for short, is an electronic test instrument that is used to observe an electronic signal, typically voltage, as a function of time. In other words it is a voltage versus time plotter. Oscilloscopes come in two basic types, analogue or digital, and support various features and functions useful for measuring and testing electronic circuits. An oscilloscope is a key piece of test equipment for any electronics designer.

- **Parts of an Oscilloscope**

Internally, an oscilloscope is a fairly complex piece of electronic equipment. Fortunately, its operation is simplified through the use of various features and knowing its internal workings is not key to its use. Despite this, as a good designer, it is important to understand the correct operation of test equipment and any affect it may have on the circuit under test

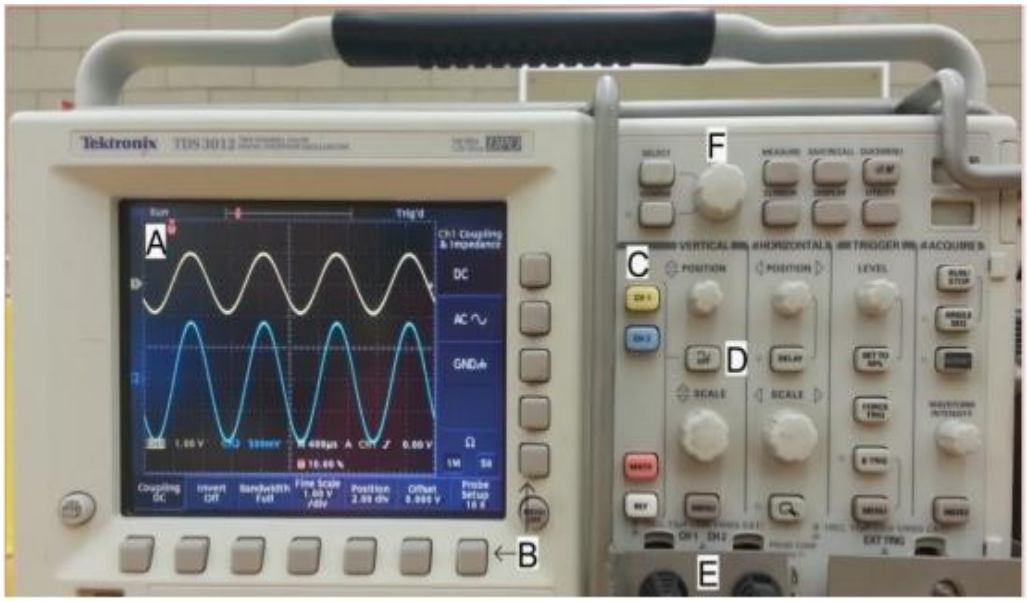

Figure 6.Oscilloscope features

- ✓ **Display:** The main feature of an oscilloscope is its display. Analogue versions of oscilloscopes use Cathode Ray Tube (CRT) displays, while digital scopes use LCD (or similar) screens

- ✓ **Probes**: The voltage signals that are to be measured must be transferred to the oscilloscope. This is done using oscilloscope probes. Probes are specially designed to minimize noise and interference, while also creating a known load effect on the circuit (so it can be accounted for). Some probes also have protective features to prevent any damage a signal may cause to the oscilloscope (such as overvoltage).

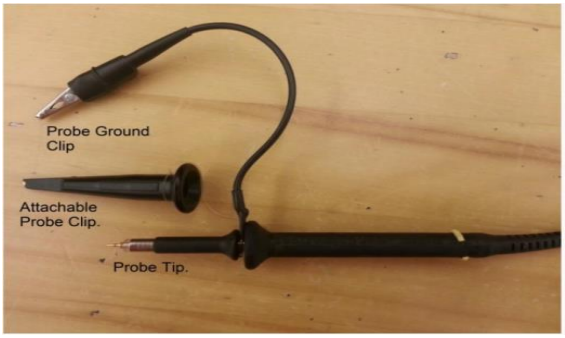

Figure 7.probes

The probing end can consist of either a sharp point as shown on above figure 7, which can be held against a pin, pad, or other conductor, or a small clip, convenient for attaching the probe to a wire or other small circuit feature. In addition, a grounding clip is located at the end of a small wire on the probe. The grounding clip is connected, through the oscilloscope, to chassis ground (in other words, the clip is always at the reference voltage and cannot be used to measure signals), and should be attached to the ground or common signal of the circuit to be measured. Note the probe is relatively heavy and can generally NOT be supported by the circuit features it may be attached to. Take care when attaching clips

- ✓ **Channels:** An oscilloscope channel generally refers to the input of a signal (kind of like tuning in a TV channel, except that you can see more than one channel at a time on a scope). It can also refer to the path of the signal through the oscilloscope. An oscilloscope can have 1 or more channels, and it is common to have 2 or 4. Having multiple channels allows for the simultaneous measurement of multiple signals, making comparisons and other functions easier. Each channel typically has its own set of controls or a common set that is toggled.
- ✓ **Controls:** The controls of an oscilloscope can be used to adjust almost any aspect of the scope from display parameters to advanced mathematical functions. The controls themselves consist of dials, toggles, buttons, and switches as seen in Figure 7.

Signal Generator

The signal generator is exactly what its name implies: a generator of signals used as a stimulus for electronic measurements. Most circuits require some type of input signal whose amplitude varies over time. The signal may be a true bipolar AC signal (with peaks oscillating above and below a ground reference point) or it may vary over a range of DC offset voltages, either positive or negative. It may be a sine wave or other analog function, a digital pulse, a binary pattern or a purely arbitrary wave shape.

The signal generator can provide “ideal” waveforms or it may add known, repeatable amounts and types of distortion (or errors) to the signal it delivers. This characteristic is one of the signal generator’s greatest virtues, since it is often impossible to create predictable distortion exactly when and where it’s needed using only the circuit itself.

Waveform Characteristics

Wave forms have many characteristics but their key properties pertain to amplitude, frequency, and phase:

Amplitude: A measure of the voltage “strength” of the waveform. Amplitude is constantly changing in an AC signal. Signal generators allow you to set a voltage range, for example, —3 to +3 volts. This will produce a signal that fluctuates between the two voltage values, with the rate of change dependent upon both the wave shape and the frequency.

Frequency: The rate at which full waveform cycles occur. Frequency is measured in Hertz (Hz), formerly known as cycles per second. Frequency is inversely related to the period (or wavelength) of the waveform, which is a measure of the distance between two similar peaks on adjacent waves. Higher frequencies have shorter periods.

Phase: In theory, the placement of a waveform cycle relative to a 0 degree point. In practice, phase is the time placement of a cycle relative to a reference waveform or point in time

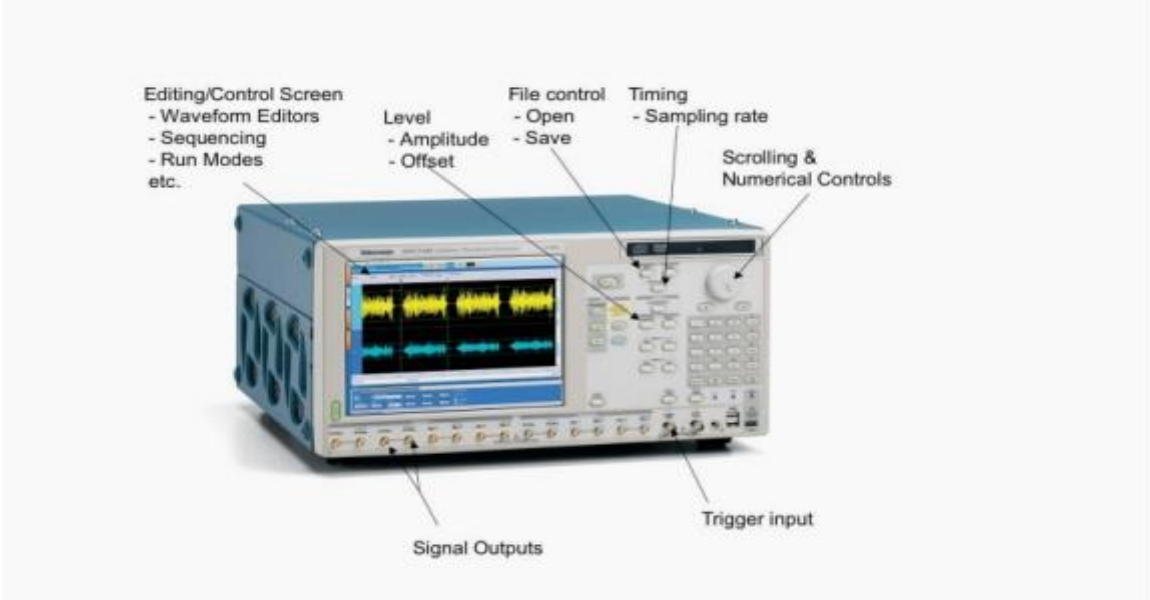

Figure 8.Signal generator

Radiation testing device

For radiation emitting medical device like X-ray machine, CT scanner, Lithotripter (if using x-ray source) and others may require radiation testing during fault finding by radiation detector/ analyzer. By using the analyzer you may know x-ray dose, exposure time, and proportional kilo voltage.

Figure 9.Radiation testing equipment

Note: For additional information refer "LG #01, LO#01, information sheet 2"

Self-Check -6	Multiple choice

1. Tools and devices are not mandatory for detecting faults exactly

   A. True B. False

2. Which device is not required for x ray machine fault finding

   A. Digital multi-meter B. X-ray tester C. electrical safety tester D. CBC readent

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 6 points**

You can ask your teacher for the copy of the correct answers.

Answer Sheet

Score = _____
Rating: _____

Name: _____ Date: _____

LG #37	LO#2: Find and repair faults

Instruction Sheet

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Following OHS risk control measures and procedures
- Determining the need to test or measure live.
- Checking apparatus.
- Approaching Fault finding methodically
- Dismantling equipment components.
- Rechecking faulty components.
- Readjusting or replace faulty components.
- Testing effectiveness of the repaired components.
- Reassembling apparatus tested and prepared for return to customer.

- Dealing with unexpected situations safely.
- Carrying out fault finding and repair activities.

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, **upon completion of this Learning Guide, you will be able to**:

- Follow OHS risk control measures and procedures
- Determine the need to test or measure live.
- Check apparatus.
- Approach Fault finding methodically
- Dismantle equipment components.
- Recheck faulty components.
- Readjust or replace faulty components.
- Test effectiveness of the repaired components.
- Reassemble apparatus tested and prepared for return to customer.
- Deal with unexpected situations safely.
- Carry out fault finding and repair activities.

Learning Instructions

5. Read the specific objectives of this Learning Guide.
6. Follow the instructions described below 3 to 4.
7. Read the information written in the information “Sheet 1, Sheet 2, Sheet 3, Sheet 4, Sheet 5, Sheet 7, Sheet 8, Sheet 9, Sheet 10, and Sheet 11.
8. Accomplish the “Sheet 1, Sheet 2, Sheet 3, Sheet 4, Sheet 5, Sheet 7, Sheet 8, Sheet 9, Sheet 10, and Sheet 11.” **in page 9, 21, and 23** respectively.

Information Sheet-1	Determining the need to test or measure live

Why we need live measurement?

Live measure is the first step to be checked during fault finding especially when the faulty equipment show sign like;

- Complete shutdown of the equipment
- Partially functioning
- The machine start working and shutdown after a while
- When the machine have no any indicator the line voltage is arrived the equipment
- Power protection components are blown frequently ex. Fuse
- Main breaker or sub breaker are trips
- There is a macro shock

Live measurements are mostly by digital multi-meter by making the system ON to get exactly the voltage value. The following picture shows for single phase measurement;

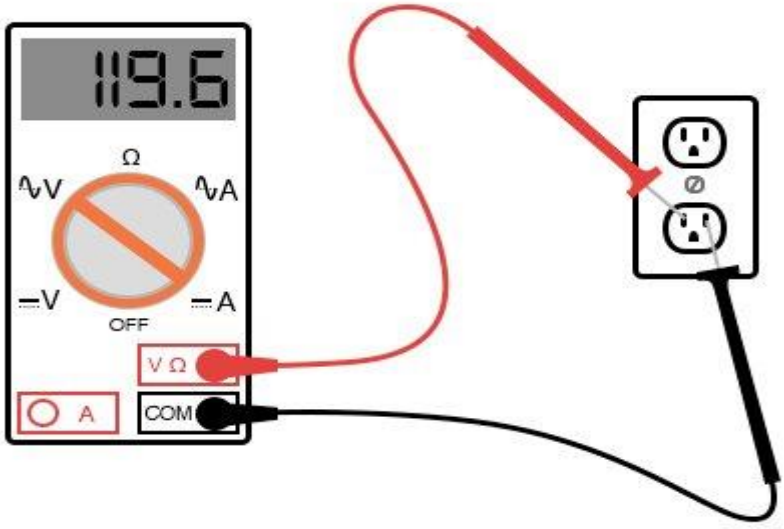

Figure 10. Voltage Measurement

For three phase measurement you do similarly but you expect higher value (380-420 v Ac) from line to line measures and 220-240vAc from neutral to each line.

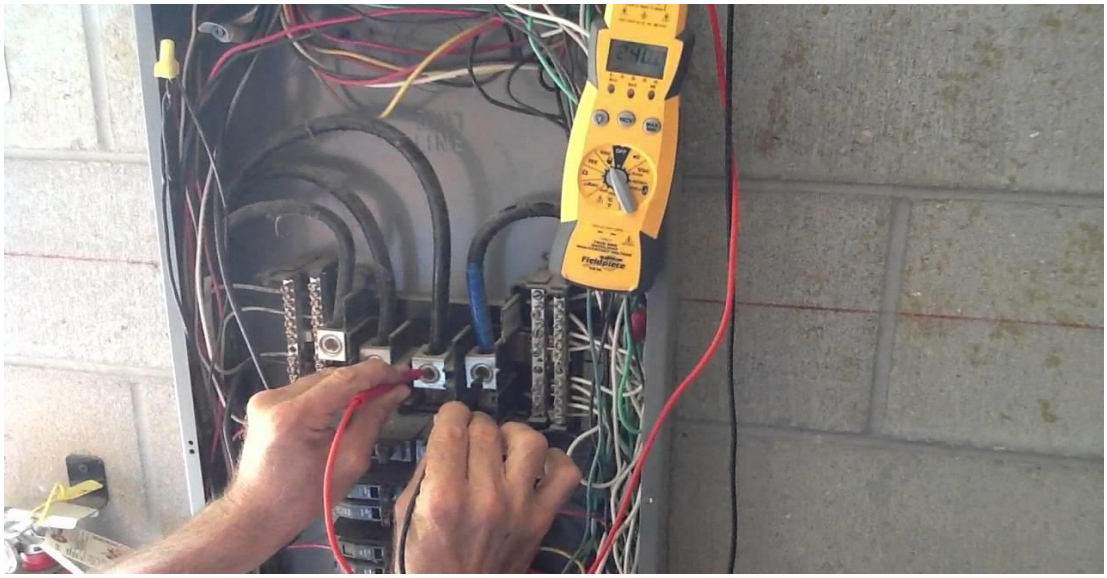

Figure 11.Three phase voltage measurements

You can also measure the live values for component level fault tracing using oscilloscope on the faulty system and also you can look for the output signal for the components.

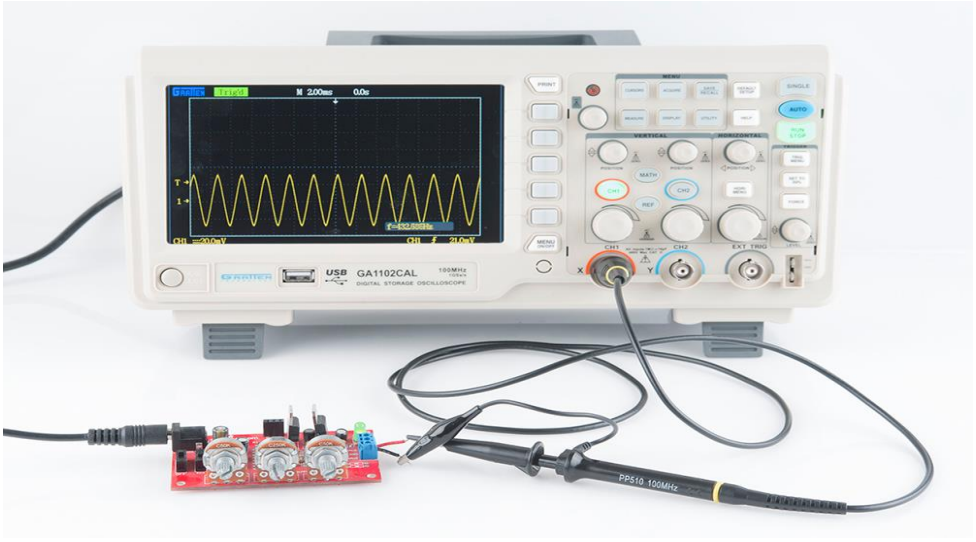

Figure 12.Oscilloscope use for live measurement

Self-Check -1	**True or False**

1. Measuring input voltage prior to opening up the faulty device is advised.

2. Oscilloscope can provide more information than digital multi-meter measurement.
3. You can read 380 VDC when you put your multi-meter probe between neutral and line

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 6 points**

You can ask your teacher for the copy of the correct answers.

Answer Sheet

Score = _____
Rating: _____

Name: _____ Date: _____

Information Sheet-2	**Checking apparatus.**

Checking of the machine requires prior knowledge regarding how the machine was works normally and its working principle. If it is new to check the machine is faulty of not follow the instruction below;

- Acquire operational or service manual of the machine
- If you get difficulty the manual download it from internet by the machine model and brand
- If you still get difficulty contact supplier for assistance
- Once you get manual read correctly all the procedures
- Read carefully parameters to be set and safety, warning notice to be followed
- After you get necessary information ;
  - ✓ Read the power rating nameplate
  - ✓ Plug the power socket
  - ✓ Torn ON the machine
  - ✓ Wait for a moment after it get ready
  - ✓ Observe the error message is not displayed

- ✓ If you get any error reading refer back to the manual
- ✓ Use logical thinking to visualize the problem

Checking ultrasound machine faulty

Machine failures have been defined as the inability to carry out its normal functionality. Failure analysis generally included consultation at three levels of personnel. First, sonographers provided detailed information how the problems were observed and whether there were any warning signs about the failure. Second, vendor engineers would diagnose the faulty. Third, if component has to be replaced, vendor engineers would provide the underlying causes of the failure after the machine was disassembled and then repaired. Physicists would carry out functional tests of the system after replacement. All the failure and associated solution documentation written in the study period were retrieved, categorized, and then analyzed. Failure categorized into different categories, namely software, hardware, and US probe. Software category included failures related to the system software such as software corruption or system reboot. Hardware failures were subcategorized into input, core, and output. Input hardware failures included all sensing equipment, such as barcode scanner, and all keyboard command keys. Core hardware failures included the computer central processing unit, disc storage, batteries, and cables. Output hardware failures observed on monitor, image artifacts as observed on hardcopy, different subcategories of physical, defects of the probe itself, black shadows arising from the probe, sheath/shell, general defects, and cable and signal loss.

Self-Check -2	**Short answer**

1. Write steps to check the apparatus.
2. List 3 things to check for ultrasound machine.

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 6 points**

You can ask your teacher for the copy of the correct answers.

Answer Sheet

Score = _____
Rating: _____

Name: _____ Date: _____

Information Sheet-3	Approaching fault finding methodically.

Method of approaching the fault

Trouble-shooting is primarily conducted to find the faults in a given machines. Trouble-shooting is a procedure of observation, then making suitable tests to either eliminate, or confirm, a suspect section of equipment. As the area under examination is reduced by further tests, it becomes easier to locate the actual problem. With any trouble-shooting technique, it is not necessary to approach a problem from any specific direction or set of rules. Rather, you should first observe, consider a possibility and then devise a test to check that assumption. Consider which items are quick or easy to check. This can save time if first carried out. When a problem occurs, record how the equipment was used just before the problem occurred. This allows a similar procedure to be used as a test, in case the symptoms of the recorded problem are not easily reproduced. During the process of locating the cause of a problem, record the tests or checks made, and the

results. This will provide a valuable record if it becomes necessary to ask advice from the service department.

Typical x-ray machine problems

- Operator error
- Equipment incorrectly calibrated
- Faulty connecting plugs, sockets, or cables
- A safety interlock is preventing equipment operation
- Electrical or electronic failure
- High-tension cable or X-ray tube failure
- Mechanical problems
- Alignment adjustments

Observation of a problem

This is important, especially at the time a problem occurs. Possibilities that may be observed are:

- Is there an operator error?
- A burning smell?
- Where does it come from?
- Is there an increase in temperature? For example:
  - ✓ The X-ray tube housing has become very hot to touch
  - ✓ A lock coil, in the area where a burning smell is observed, is very hot to touch
- Unusual sound. What sort of sound? Where from?
- Absence of sound. For example:
  - ✓ No anode rotation noise from the X-ray tube.
  - ✓ Ventilation fans are quiet
- Wrong mechanical operation. Look for obstructions, or loose sections. For example:
  - ✓ An indicator knob on a control panel has slipped into a wrong position.
  - ✓ A film is jammed in the processor.

- Visual observation. For example:
  - ✓ Appearance of the film immediately as it leaves the processor.
  - ✓ Smoke rising from equipment, or a HT cable end.

Equipment manuals

Should be referred to whenever there is a problem. The operation manuals often include a section on fault or problem symptoms, as do the installation or service manuals. The spare parts illustrations can help find the physical positions of parts, such as locating a fuse in equipment.

If during maintenance or other events manuals appear to be missing, replacements should be obtained as soon as possible. Quite often, service engineers attending your equipment will also require these manuals. If not available, this could lead to delays in correcting a problem.

Request for assistance

When requesting advice from the service department, the following information may be required.

- Hospital name, address, fax, and phone number
- Who to contact at the hospital when discussing the problem
- Include the department and phone number.
- Department and room number for equipment location.
- Make and model number of equipment.
- Descriptions of the problem include any symptoms.
- What tests have been made and the results.
- Any conclusions that were made regarding the cause of the problem, or what will be needed to correct the problem.

Using radiation detector to approach the problem

By measuring output radiation of x-ray machine you can easily identify the direction of your fault finding. For example;

- If KV set and measured is deviating too much you can trace high voltage side of the generator easily

- If the exposure time is too long or short than expected duration you can easily find fault across the timer circuit
- If the mA measure is deviating from expected values you can trace the low voltage side of the generator easily

Self-Check -3	**Multiple choice**

1. How can you approach the anode motor of x ray machine is not working?

   A. By looking collimator B. by hearing the sound C. by seeing smoke D. all

2. Which approach is leading you to find the fault easily and timely?

   A. By tracing each parts B. using operator /service manual C. check the parts randomly D. read the whole contents regarding the machine

3. _____ is a procedure of observation, then making suitable tests to confirm a suspect section of equipment.

   A. Repair B. PPM C. troubleshooting D. testing

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 6 points**

You can ask your teacher for the copy of the correct answers.

Answer Sheet

Score = _____
Rating: _____

Name: _____ Date: _____

Information Sheet-4	**Dismantling equipment components**

Dismantling ultrasound machine

To disassemble the machine to find fault and do repair the following chart clearly indicate the way to dismantling safely.

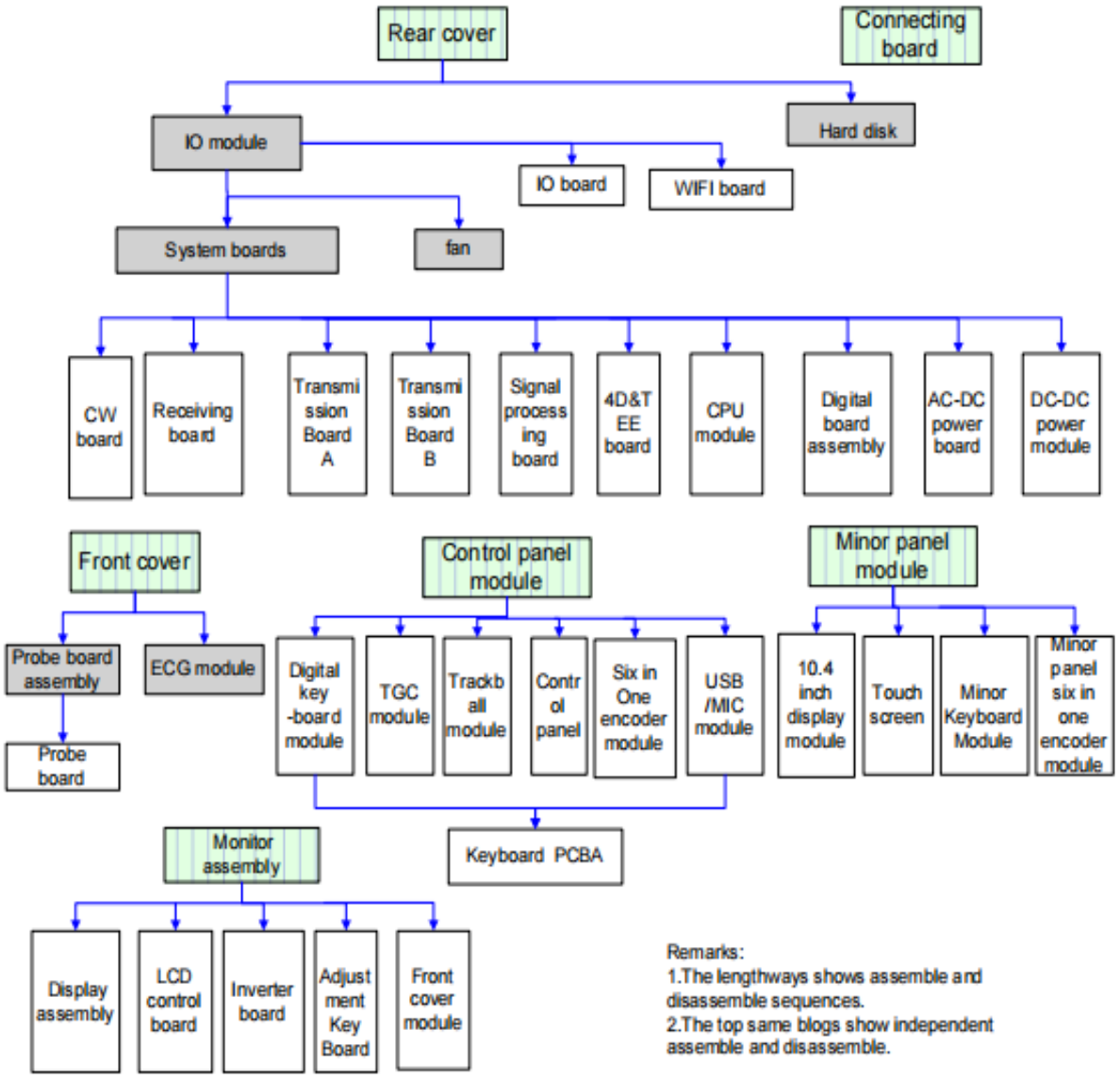

Figure 13.Disassembling procedures

Removing the power supply: Hold the buckles of power wire and pull out power input assembly in the horizontal direction. Remove one screw and four plugs of cable as follows, and then power input module could be removed. Unscrew the M4x8 screws (2 pcs) fixing the power input assembly.

Figure 14.Unscrew power supply

Remove Probe Board Assembly

Step1: Hold the position as marked in the below figure by index finger and move it outward to remove covers of the printer and the storage box.

Figure 15.Cover removal

Step2: Remove 2 M4×8 screws which are fixed on the base of main unit rack below the footswitch board.

Figure 16.removing screw

Step 3: Pull out the footswitch board module in the direction marked below

Step 4: Pull out the plugs (t2 pcs at each side) that are filled in the left and right lateral sides and then remove the M4X8 screws (2 pcs at each side) which are installed on the rack of two sides.

Figure 17.removing probe receptacle

Step 5: Unscrew 8 M4X12 screws fixing probe board assembly and pull it out.

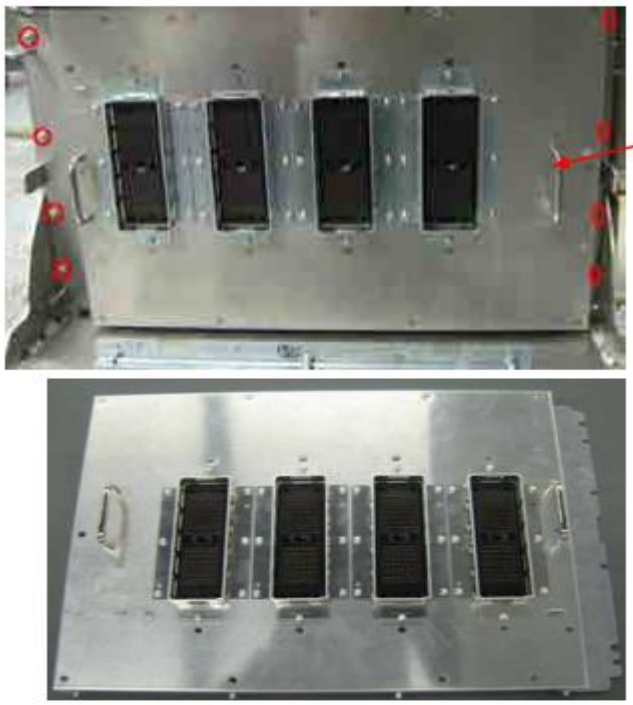

Figure 18.taking out the receptacle

Self-Check -4	**True/false**

1. For dismantling the parts you can start from outer cover.
2. Step assembling back should does not matter is missed.
3. Use appropriate tools may affect the dismantling procedures.

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 6 points**

You can ask your teacher for the copy of the correct answers.

Answer Sheet

Score = _____
Rating: _____

Name: _____ Date: _____

Information Sheet-5	Rechecking faulty components

Rechecking the faulty components is the process followed dismantling to properly testing the parts get faulty. The may follows the following procedures;

- Preparing necessary tools to recheck
- Placing the parts to rechecked separately
- Use different testing devices and read manual, datasheet.

The rechecked parts for x-ray machine

- The generator hands switch cable.
- The connecting cable to the collimator
- The fluoroscopy footswitch for a fluoroscopy table
- Plugs or sockets used with mobile or portable X-ray equipment
- Power plugs
- Plugs or sockets for tomographic attachments.
- Cables, which are pulled or twisted.

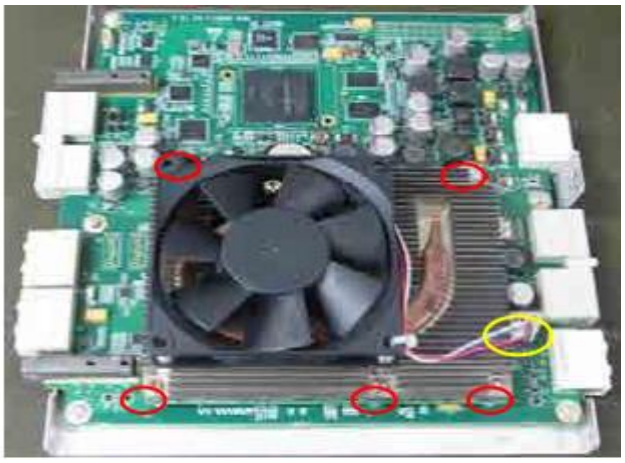

Figure 19.rechecking the fans for main board

For diagnostic ultrasound machine you may recheck the following;

- Ultrasound probe
- Ultrasound printer
- Image quality ex. Artifact
- All functional keys
- Power button
- Power cable

Self-Check -5	**Multiple choice**

1. For x ray machine you can recheck

A. Hand switch B. collimator C.A&B

2. For ultrasound machine _____rechecked

A. Ultrasound probe B. peripherals C. image artifact D. all

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 6 points**

You can ask your teacher for the copy of the correct answers.

Score = _____
Rating: _____

Answer Sheet

Name: _____ Date: _____

Information Sheet-6	**Readjusting or replace faulty components.**

Readjusting the faulty components

Readjusting the faulty components can be

- Increasing or decreasing the parameter of set values
- Adjusting rheostat or potentiometer
- Adjusting tightening the cables
- Tightening the loosen screw

Fuse replacement

Some glass fuses can visually show if they are open circuit by metal deposited on the glass. If the failure is a small break in the wire, this is not easy to see. Fuses may have fine wire, again not easy to see, so it may appear open circuit, but still be in good condition. A continuity test with a multi-meter is the only reliable way of verifying if a fuse is good or open circuit. The meter is set to the low ohms range. If the meter shows no indication when the probes are attached to the fuse, the fuse is open circuit. Do not try to test a fuse with a meter while it is still connected in the equipment, this can give a false result.

The physical location of fuses will vary greatly depending on the manufacturer and model of equipment. Electrical regulations in many countries require a fuse to be protected from access without using a tool. Where fingers may be able to unscrew the cap of a fuse holder, a protective cover must first be removed. Possible fuse locations are for X-ray generator can vary. There will not be any external access fuses. Most fuses will be located in the control cabinet, and a panel will need to be removed to gain access. In some cases, there may be additional fuses under a cover at the HT transformer. In some installations miniature circuit breakers may be fitted instead of fuses. These have a reset switch, or button, mounted on top of the device. Mobile or portable X-ray generators can have external access fuses mounted on a rear panel. Otherwise internal access to the equipment is required.

Same other faulty components will be replaced. During replacing parts consider the following key point;

- Specification of parts should be replace can match the faulty parts or components like power rating , fitting length width
- Data sheet for IC should read and properly replace
- Take care during soldering and de-soldering the components on the board
- Use hot gun or other de-soldering devices
- The pin should be match
- The cable length should be match
- Color coding should be followed

Self-Check -6	Multiple choice

1. During replacing parts consider_____.

   A. Size of the parts B. power rating of the parts C.A&B

2. For board part replacement use

   A. Hot gun B. soldering iron C. manual cracking

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 6 points**

You can ask your teacher for the copy of the correct answers.

Answer Sheet

Score = _____
Rating: _____

Name: _____ Date: _____

Information Sheet-7	Testing effectiveness of the repaired components

The effectiveness of the repaired parts can be tested by:

- Using output analyzer
- Using oscilloscope

- Turning ON the machine and looking for image quality, test result output
- Operational time
- Error message
- Faulty alarm
- Performing self-test

Self-Check -7	**True /false**

1. The repaired parts can be checked its effectiveness by multi-meter only.
2. It is possible to test the repaired parts from its output.

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 6 points**

You can ask your teacher for the copy of the correct answers.

Answer Sheet

Score = _____
Rating: _____

Name: _____ Date: _____

Information Sheet-8	**Reassembling apparatus tested and prepared for return to customer.**

This is the step following the repair and testing the faulty components or parts during the work. Unless you reassemble the equipment safely and properly following the instruction the equipment encounter faulty again due to different factors. For proper reassembling of the machine do the following;

- Collect all screws and nuts
- Use proper screw driver
- Start reassembling from the inner parts

- Remember the fitting and washers
- Undo the dismantling procedure followed

Self-Check -8	True /false

1. Reassembling is the reverse of disassembling procedure.
2. It does not matter if the reassembling procedures are missed.

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 6 points**

You can ask your teacher for the copy of the correct answers.

Answer Sheet

Score = _____
Rating: _____

Name: _____ Date: _____

Information Sheet-9	Dealing with unexpected situations safely

In recent years, we have seen an increase in the use of embedded systems in large distributed systems, often designed and optimized for critical real-time controls. These systems of systems often include multiple end-to-end application streams and share heterogeneous, constrained resources. Unlike most non-distributed, static, closed embedded systems, these systems operate in highly dynamic environments and need to be able to react in real-time to changes in missions, conditions and operating environments. Today more and more of these mission-critical distributed real-time embedded (DRE) systems are becoming Quality of Service (QoS) enabled, thus providing predictable, adaptable, and managed behaviors. Due to the dynamic and distributed nature of DRE systems, unplanned events can occur that could significantly impact the behavior and performance of these systems. Examples of unplanned events are significantly less than expected available resources, system failures, unexpected

service demands, and events completely outside the system scope which have unanticipated side effects on its operation. With potentially large numbers of unplanned events in DRE systems, designing adaptation strategies to handle these is challenging. In order to effectively manage unplanned events in DRE systems, we first need to clearly define what unplanned events are and how they differ from planned events. A planned event often has known signatures that we can probe for or monitor and is expected to happen during the operation of the system, even if it is “abnormal” behavior. When it happens, we know exactly what to do and we often know the cause(s) of the event. Unplanned events, on the other hand, are not expected to happen during the normal operation and are unpredictable, and we don’t know when, where, and how they will happen. Thus these events have to be dealt with as they occur and cannot be specified in pre-planned mission requirements. While these events often do not have clear signatures, they can have adverse effects on the system and have symptoms that are detectable. However, each event can have multiple symptoms and each symptom can have multiple causes. We can further divide unplanned events into two subtypes: unpredictable events and unexpected events, based on whether we can provide remedies to maintain acceptable system posture. Unpredictable events are those that we can envision might happen, or are possible, but that we cannot predict, when, where, and how they will manifest. For unpredictable events, key symptoms of the events can lead us to the causes and, therefore, the right remedies to bring the system back to normal operation. Unexpected events, however, are those that cannot even be envisioned. For unexpected events, we either cannot identify the key symptoms to monitor or we don’t know how to further probe for their causes. Thus we would not be able to handle these events in a meaningful, predictable way. The point here is that we can only manage events that we have enough knowledge about, whether it is signatures or symptoms. As we gain more experience about the system and more knowledge about unexpected events, the number of this type of unplanned event should decrease, but likely will never go to zero. Thus, our discussion on QoS management of unplanned events will primarily focus on unpredictable events rather than unexpected events.

Self-Check -9	**True /false**

1. There are two types of unplanned events
2. QoS management of unplanned events will primarily focus on unpredictable events rather than unexpected events.

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 6 points**

You can ask your teacher for the copy of the correct answers.

Answer Sheet

Score = _____
Rating: _____

Name: _____ Date: _____

Information Sheet-10	**Carrying out fault finding and repair activities.**

FAULTS AND FAULT FINDING

Repair of devices working on high frequencies is one of the most difficult problems which modern technology can force us to solve.

Each of them could be the cause of the fault. They do not necessarily look different if they are in a condition of proper working or if they are really faulty.

With our normal senses we can recognize only very minor differences if at all. Burnt resistors, open circuits, spilt condensers, burnt coils and so on, are rather rarely to be found.

In most cases we can only observe effects of faults of which the fact that the loudspeaker is totally dead could be simplest one. Since during fault finding we cannot achieve any development by using our senses, measuring instruments must be applied in order to display the electrical condition in and around the components.

Only this enables us to draw conclusions. The stringing up of such conclusions is defining the method which has to observe all conditions which are important for the operation of the whole device.

Fault finding procedures

Having established the symptoms of a fault it is then necessary to conduct tests to confirm the symptoms and to attempt to determine the location of the fault within the equipment. A sound knowledge of the technical concepts and the operation of the system may assist in locating the fault but sometimes the testing will be extensive and an overall procedure should be adopted

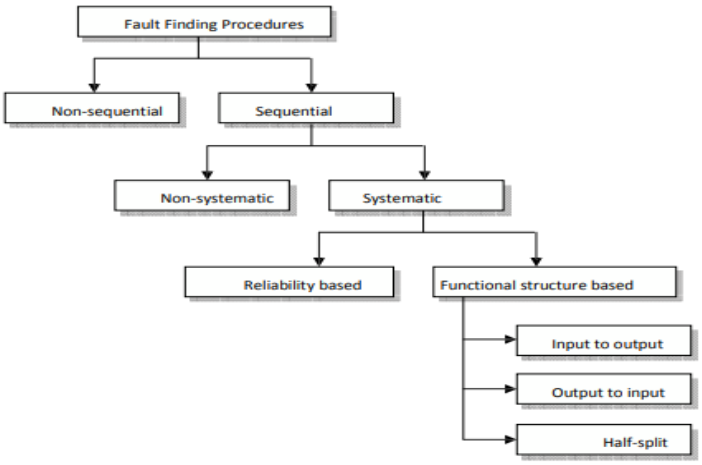

Figure 20. fault finding procedures

Basic Testing Techniques

The Multimeter

Once you have determined the most probably cause of a fault, you must either prove it to be the problem or not. This can sometimes be done by careful inspection but in many cases the fault will be such that you cannot identify the problem component by observation and analysis alone. Here, test instruments can be used to help narrow the problem area and identify the problem component.

Testing Live vs. Dead

One of the first things you must decide is whether the circuit can be alive or must be dead while testing. Performing certain tests while a circuit is alive can be very helpful.

However, some companies have policies that ban (or restrict) testing live circuits while troubleshooting. Before doing any testing make sure you check your company's policy. This module does contain certain techniques used to test a de energized circuit.

Types of Faults

Faults can generally be categorized into either open circuits or short circuits. Open circuits occur when there is a break in the circuitry. This could be a broken wire, loose connection, burned out component, etc. Short circuits occur when two or more components, which should be isolated, come in contact with each other. For example, the insulation on wiring could decay and the conductors short together or short to ground.

Self-Check -10	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Say true for the correct statement and false for wrong statement

1. Repair of devices working on high frequencies is one of the most simple problems which modern technology can force us to solve
2. Short circuits occur when there is a break in the circuitry.
3. Short circuits occur when two or more components, which should be isolated, come in contact with each other

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 6 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Name: _____date

LG #38	LO #3. Completing and reporting fault finding and repair activities

Instruction Sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Following OHS work completion risk control measures and procedures.
- Cleaning work area and make safe.
- Making written justifications for repairs to apparatus.
- Seeking Acceptance that the reported fault(s) have been repaired

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:

- Follow OHS work completion risk control measures and procedures.
- Clean work area and make safe.
- Make written justifications for repairs to apparatus.
- Seeking Acceptance that the reported fault(s) have been repaired

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Read the information written in the “Information Sheets 1”.
3. After reading the information sheet, go to your instructor and get the copy of self-check.
4. Accomplish the “Self-check 1” Self-check 2, Self-check 3, Self-check 4, Self-check 5 in page 8,10,15,18,21,24
5. If you earned a satisfactory evaluation proceed to LO2. However, if your rating is unsatisfactory, see your teacher for further instructions.
6. Submit your accomplished Self-check. This will form part of your training portfolio.

Information Sheet-1	**Following OHS work completion risk control measures and procedures**

Occupational Health and Safety

Occupational Health and Safety occupational Health and Safety or OHS deals with the safety, health and welfare of personnel in work environment. The objective of OHS is to put into practice the programs that will ensure a safe and a healthy working environment. OHS must holistically include not only factory workers, but all other external persons who are affected by the work environment and activities. This includes visitors, vendors, customers and other stakeholders.

Occupational health and safety aims at preventing hazards at the Workplace. Activities at the workplace carry various risks which may lead to accidents, bodily injuries, hearing impairment, circulatory, musculoskeletal and respiratory diseases, stress-related disorders and even cancers. These are undesirable as the legal and moral responsibility is on the Organization's Top Management to provide a work environment that is safe and healthy. Occupational Health and Safety as defined by World Health Organization

The World Health Organization (WHO) defines Occupational Health as below:

"Occupational health deals with all aspects of health and safety in the workplace and has a strong focus on primary prevention of hazards."

Benefits of establishing Occupational Health and Safety

By paying proper attention to the health, safety and welfare of the employees, organizations can benefit in terms of improved employee morale, reduced absenteeism, improved quality and enhanced productivity. These in turn helps in reducing the potential of work-related injuries and illnesses.

It can therefore be said that establishment of a sound health and safety practices helps organisations to sustain business in the long run.

Reasons for Injuries, accidents and ill health in Organizations

- There are various reasons that results in injuries, accidents and ill health in organizations. They are:
- Lack of awareness of safety aspects during work
- Lack of safety and health procedures
- Over exertion due to excessive work load
- Psychological stress and / or personal problems leading to loss of concentration at work
- Slips, trips or falls due to lack of safety planning and infrastructure
- Lack of safety equipment and personal protective equipment (PPE)
- Lack of insistence of regular medical check-ups
- Lack of assessment of work practices that are unsafe and / or spread diseases
- Lack of sanitation and hygiene
- Use of equipment and / or materials that are unsafe and spread diseases

- No learning from “near misses” that could potentially become future accidents
- Failure to identify occupational hazards and conduct risk assessment
- Negligent house-keeping activity
- Absence of a good and sound Occupational Health and Safety Management System
- Industries / Occupations prone to accident and injuries

Even though almost all industries need to avoid accidents, injuries and ill health, there are specific industries that are prone to accidents, injuries and ill health. They are (not limited to) Mining, quarrying, agriculture, oil, gas, chemical, construction, machining, bio technology, etc.

Top Management Commitment towards Occupational Health and Safety

Top Management commitment and involvement in establishing an Occupational Health and Safety Management System is of paramount importance. It is the senior management who can provide a safe and healthy working environment and enforce safety practices in their organization. It is their job to allocate resources and time to ensure planning and implementation of safety methods. Failure on the part of the Top Management to prevent injuries, accidents or ill health could mean legal trouble and emotional problems.

Hence, the Top Management must do the following:

- Establish occupational health and safety committee or team
- Allocate safety resources and equipment
- Allocate manpower resources and finance for the Health and safety initiative
- Establish Occupational Health and Safety policy and objectives
- Ensure that the policy and objectives are communicated and understood within the organization
- Ensure that these OHS objectives are measurable

- Define and assign safety and health responsibilities across the organization structure
- Direct the middle management to monitor safety and health status of employees in their organization

Demand accountability from the lower management levels with regard to safety and health. Enforce safety practices as required by the applicable legislation as well as those deemed necessary for the organization

- Buy equipment with in-built safety features
- Institute employee wellness programs
- Review the effectiveness of the health and safety measures
- Employee Involvement

Involvement of employees in the implementation, maintenance and improvement of health and safety aspects are vitally important because:

Employees are the likely ones who are going to face safety and health related issues

Employees can visualize majority of the safety hazards at the workplace since they work hands-on with the devices and equipment.

Employees can bring in the group knowledge and ideas to deal effectively with health & safety is s only through employee involvement, better participation in health & safety programs can be expected

Self-Check -1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Say true for the correct statement and false for wrong statement

4. All personnel working in laboratories must be trained in safe work practices and hazardous waste disposal.
5. Conductors and cable cores (EELP's Regulation) color code for neutral is white.
6. Control measures are not reasonably practicable to eliminate the hazards and associated risks.
7. Hazards are generally lower in research lab than in routine clinical labs.
8. Risk management is a proactive process that helps you responds to change and facilitate continuous improvement in your business

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 6 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Name: _____date

Information Sheet-2	Cleaning work area and making safe.

Cleaning work area

In the workplace, housekeeping is more than simple floor cleaning, dust removal, and organizing clutter. Housekeeping is crucial to having a safe work environment, helping prevent injuries, improve productivity and morale, and making a positive impression on visitors. This practice goes beyond the traditional office rooms to industrial workplaces, like warehouses and factories, where good housekeeping is more of a challenge with hazardous and flammable materials. Experts say that all workplace safety programs should include housekeeping and that **all** employees play a part. Here are some tips on good housekeeping:

Prevent Slips, Trips, and fall

- Keep floors clean and dry
- Make sure drainage is present where “wet processes” occur
- Report and clean up spills and leaks
- Keep aisles and exits clear
- Consider using mirrors and caution signs for blind spots

Eliminate Fire Hazards

- Keep only necessary amounts of combustible materials in your area
- Store quick burning, flammable materials in designated areas
- Avoid contaminating clothes with flammable liquids
- Hazards in electrical areas should be reported and fixed

Control Dust

- **Never** use just a shop vacuum or dry sweep dust
- Use wet methods or a high efficiency vacuum

Avoid Tracking Material

- Work-area mats should be kept clean and maintained to avoid spreading hazardous materials
- Separate cleaning protocols might be needed for different areas to avoid cross-contamination
- If working with toxic materials, **do not** wear the same clothes home

Prevent Falling Objects

- Use a toe board, toe rail, or net
- Stack boxes and other materials straight up
- Keep heavy objects on the lowest shelf

Clear Clutter

- Keep aisles, stairways, emergency exits, electrical panels, and doors free of clutter
- Purge untidy areas and empty trash receptacles

Store Items Properly

- Store unused materials and equipment out of the way of workers
- Avoid using workspace for storage
- Put everything back where it belongs after use

Use and Inspect Personal Protective Equipment and Tools

- Wear basic PPE when performing house cleaning
- Regularly inspect, clean, and fix tools
- Remove any damaged tools from the work area

Determine Frequency

- All workers should inspect, and clean their workspace and remove unused materials
- Companies should have a mixture between deep cleaning and frequent, light cleaning (i.e. sweeping and cleaning up spills)

Create Written Rules

- Written protocol should specify which cleaners, tools and methods should be used

- Written protocols make the workplace more efficient so that people are aware of and know the proper procedures

Think Long-Term

- Maintain a regular walkthrough inspection schedule
- Keep records, report hazards and train employees to help sustain housekeeping

Self-Check -2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Say true for the correct statement and false for wrong statement

1. In the workplace, housekeeping is more than simple floor cleaning

2. Eliminate Fire Hazards Keep only necessary amounts of combustible materials in your area

3. . Experts say that all workplace safety programs should include housekeeping and that **all** employees play a part.

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 6 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ date

Score = _____

Information Sheet-3	Making written justifications for repairs to apparatus.

Justification is important after medical equipment maintenance is done.
Every repaired parts, systems and apparatus is reported and justified according to the fault analysis procedure that done to capture the maintenance activities

The following are the most important parameter that should justify

- What was the cause of failure?
- What are the steps followed to find the fault
- What is the current status of an equipment or apparatus?
- What is the life expectancy of an equipment after repair

In addition to justifying the maintenance and repair work one should follow the correct procedure of writing justification which includes the following

1. Provide an Overview. A opening overview should briefly summarize what will follow in the **justification** report. ...
2. Describe the Problem. ..
3. Offer a Solution. ...
4. Describe the Role You Will Play. ...
5. Show the Payoff

Self-Check -3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. List the most important parameter that should justified after fault is founded and repair work is done.

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 6 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ date

Score = _____

Information Sheet-4	**Seeking Acceptance that the reported fault(s) have been repaired.**

What is an equipment maintenance log?

The equipment maintenance log is a simple document that contains a list of all actions that have been performed on a certain piece of equipment. It helps keep track of the maintenance history. It generally contains the following two different sections, each containing different types of information:

1. General information

The first section has to do with general information. This information is used to identify the piece of equipment. It most commonly includes:

- Name of equipment
- Model or manufacturer
- Serial number
- Location
- Person responsible for equipment

Some equipment maintenance logs also include the Purchase date and Purchase price in this section.

2. List of maintenance actions

The second section lists all the maintenance actions performed on the equipment. It commonly includes the following fields:

- Date when the action was performed
- Description of the action itself
- Name of the person performing the actions

Lastly, some logs also include a Remarks section. This section is useful in case the person performing the maintenance might have any special notes to add for future reference.

Self-Check -4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. General information that consider during acceptance reporting including maintenance activities performed

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 6 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Name: _____date

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