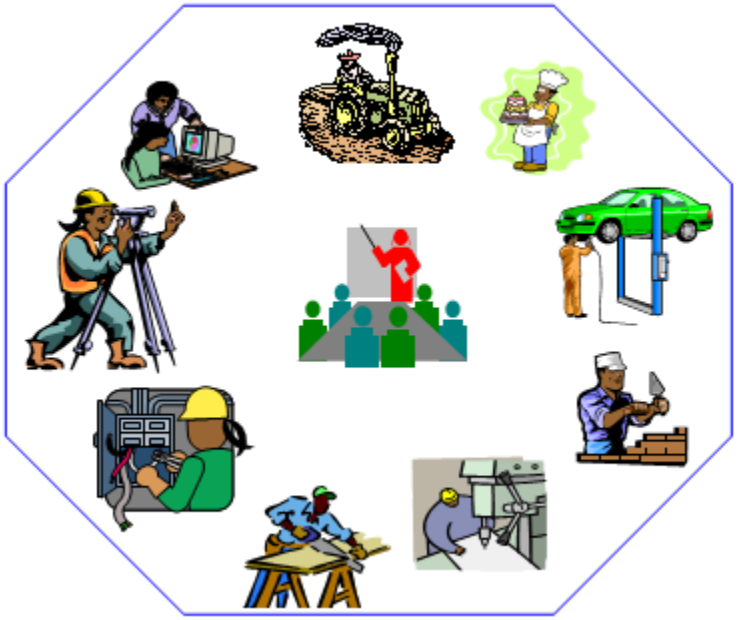
Mechatronics & instrumentation Servicing

Management Level IV

Based on May, 2011 V2 OS and Dec, 2020 V1 Curriculum



Module Title: Diagnosing and Troubleshooting Mechatronics system

LG Code: EEL MIS4 M11 LO (1-4), LG (50-53)

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Bishoftu, Ethiopia

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LG #50	LO # 1. Plan and prepare for diagnosis of faults in Mechatronics systems
Instruction sheet	

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

- Planning and preparing diagnosis of faults.
- Following OH & S policies and procedures.
- Consulting authorized personnel to coordinate the work effectively.
- Obtaining necessary materials.
- Obtaining tools, equipment and testing devices and checking them.
- Checking Mechatronics system.

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:

- Plan and prepare diagnosis of faults.
- Follow OH & S policies and procedures.
- Consult authorized personnel to coordinate the work effectively.
- Obtain necessary materials.
- Obtain tools, equipment and testing devices and check them.
- Check Mechatronics system.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them
4. Accomplish the “Self-checks” which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets
7. Perform “the Learning activity performance test” which is placed following “Operation sheets”
8. If your performance is satisfactory proceed to the next learning guide,
9. If your performance is unsatisfactory, see your trainer for further instructions or go back to “Operation sheets”.

Information Sheet-1	Planning and preparing diagnosis of faults

Planning and preparing a diagnosis plan is generally not difficult to do. But creating a comprehensive diagnosis of faults program that is effective poses some interesting challenges. It would be difficult to appreciate the subtleties of what makes a maintenance plan effective without understanding how the plan forms part of the total maintenance environment

1.1. How do you diagnose faults?

A unit under test (UUT) fails when its observed behavior is different from its expected behavior. Diagnosis consists of locating the physical fault(s) in a structural model of the UUT. The degree of accuracy to which faults can be located is called diagnostic resolution.

Figure1. A unit under test

1.2. Six key steps to approach electrical fault finding

Here are six key points to consider when diagnosing faults in Mechatronics system:

1.2.1. Collect the Evidence

All the evidence collected must be relevant to the problem in hand. If one is in doubt as to whether anything is relevant, then include it. Reject it afterwards at the first opportunity if it clearly is not relevant. The quantity of information collected is unimportant, what matters are that all information collected is relevant. Observe the system running, if you consider it

safe to do so. Use all your senses: smell (burning), hearing (vibration), touch (temperature), sight (for unusual conditions). Refer to any relevant documentation.

1.2.2. Analyze the Evidence

Consider all the evidence collected and, if possible, reject any which after further careful consideration is not relevant. Study the hard core of relevant evidence and – through the process of careful, logical thinking –diagnose the likely fault or at least the area or region of the fault.

1.2.3. Locate the Fault

In a sense this is a continuation of the process of analyses. The areas or regions are systematically reduced in size until a specific part can be identified as being faulty. For example, if a door bell does not ring when it should; it is only by means of a systematic approach that one determines that the bell itself is faulty.

1.2.4. Determination and Removal of the Cause

If the cause of a fault is not removed, the fault will recur even though the fault has been rectified. For instance, a flat bicycle tire might be the result of a puncture (the fault) in the inner tube. If the puncture is repaired (i.e. the fault is removed) this will not be of much use if the cause of the puncture in the first place is not determined and appropriate action taken. The cause of the puncture may be a nail which has penetrated the outer cover. This must be removed.

1.2.5. Rectification of the Fault

This may be a simple task, as in the case referred to above, or it may be a much bigger one. Whatever is the case, it is a specific task based on earlier findings.

1.2.6. Check the System

It is important to ensure that the machine, equipment or system is functioning normally after the cause of the fault and the fault itself has been dealt with. In the case of the puncture, it is easy to confirm that the cause of the fault – and the fault itself – has indeed been dealt with satisfactorily, assuming that the tire remains inflated. With more sophisticated equipment or systems it may necessary to ‘fine-tune’ the system in order to return it to optimum working conditions.

1.3. Benefits of Planning and preparing diagnosis of faults:

Plan and prepare to diagnose faults have many advantages; like improves focus and flexibility, improves action orientation, improves coordination, improves time management and improves control.

Self check -1	Written test

Directions: Answer the following questions.

1. Write six key steps to approach electrical fault finding (1pt. each))
   a. ……
   b. ……
   c. ……
   d. ……
   e. ……
   f. ……

Note: Satisfactory rating –3 and above points, Unsatisfactory - below 3 points

Answer Sheet

Score=_____

Rating:_____

Name:_____Date:_____

Information Sheet-2	Following OH& S policies and procedures

OH&S and state safety laws have helped to provide safe working areas for electricians. Individuals can work safely on electrical equipment with today's safeguards and recommended work practices. In addition, an understanding of the principles of electricity is gained. Ask supervisors when in doubt about a procedure. Report any unsafe conditions, equipment, or work practices as soon as possible.

OHS includes the laws, standards, and programs that are aimed at making the workplace better for workers, along with co-workers, family members, customers, and other stakeholders.

2.1 Environmental Guidelines and Standards

The Ministry of Environment, Forest and Climate (MoEFC) has issued some guidelines and standards which are endorsed by the National Environmental Council. The purpose of these guidelines and directives is to ensure that development projects integrate environmental considerations in the planning process as a precondition for their approval. These include Directive No.1/2008, which was issued to determine projects subject to an Environmental Impact Assessment (EIA). According to this directive, the EIA Proclamation is to be applied to the types of projects listed under the directive. The types of projects subject to EIA in the urban sector include roads, solid waste facilities, Water Supply and Sanitation (WSS) projects and any other project planned to be implemented in or near areas designated as protected. In a similar manner it is indicated that the National Environmental Council has endorsed certain effluent standards for specified industrial sectors. The endorsed effluent standards for the specified 12 industrial sectors are posted on the official website of the Ministry of Environment, Forest and Climate Change MoEFCC, but are not officially published in the same way as directive no.1/2008. As a result, these are widely considered as draft effluent standards for Ethiopia.

2.2 OH& S policies and procedures?

OH& S procedures outline the requirements for complying with both external and internal compliance requirements. Company policies are often published and distributed to workers; ensuring that everyone understands his or her role in following the accepted work procedures.

2.3 Safety Tips

- If you are not sure.....ask.
- Follow instructions and don't take chances.
- Wear your personal safety equipment.
- Never operate equipment you have not been trained for.
- Keep your work area clean.
- Stay clear of forklifts while they are being operated.
- Avoid injury by lifting correctly. If it's heavy ask for help. Max weight to be lifted is 75lbs.
- Make sure the job can be done safely.
- DO NOT unload a truck alone.

2.4 Your Right To Know

The Act requires your employer to provide you with all the information you need to control the hazards you face at work. For example, chemicals at the workplace must be listed. You are entitled to review this list. Your employer must train you to safely handle the chemicals you will work with. If you are inexperienced, you must receive an orientation which includes;

- What to do in a fire or other emergency;
- First aid facilities;
- Prohibited or restricted areas;
- Workplace hazards; and
- Any other information you should know. You must also be supervised closely by a competent supervisor.

2.5 Your Right To Refuse

You have the right to refuse to do work which you believe is unusually dangerous. The unusual danger may be to you or to anyone else. An unusual danger could include such things as:

- a danger which is not normal for your occupation or the job;
- a danger under which you would not normally carry out your job; and/or
- a situation for which you are not properly trained, equipped or experienced.

To exercise this right, use the following guidelines. Once you believe that the work you have been asked to do is unusually dangerous, you should inform your supervisor. Make sure that the supervisor understands that you are refusing to do the disputed job for health and safety reasons. Work with the supervisor to attempt to resolve the problem. If the problem cannot be resolved by the supervisor to your satisfaction, and no worker health

and safety representative or occupational health committee exists at the workplace, your supervisor should phone the Division and ask for advice. You also have the right to contact the Division at any time. The supervisor has the right to assign you to other work (at no loss in pay or benefits) until the matter is resolved.

2.6 Safety Sins by colors

Workplaces are signed to draw attention to hazards or requirements of different areas. Different types of signs in the workplace will be different colors and mean different things.

2..6.1. Mandatory signs

Mandatory signs are ***blue*** and ***white.*** They tell you things that you must do in a work area. They are often used to tell people to wear safety equipment or stick to the walkways.

2.6.2. Caution signs

Caution signs are ***yellow*** and ***black***. They indicate workplace hazards such as forklifts, noise, radiation areas or overhead cranes.

2.6.3. Danger signs

Danger signs are always ***red***, ***black*** and ***white***. They indicate where no-go areas exist, such as high voltage areas or chemical storage areas.

Self check -2	Written test

Directions: - For the following statements, write TRUE if it is correct or write FALSE if it is incorrect on another answer sheet..

1. Mandatory signs are indicated by yellow and black colors.
2. OHS includes the laws, standards, and programs.
3. You have a right to refuse if a danger which is not normal for your occupation or the job.

Note: Satisfactory rating – 2 and above points, Unsatisfactory - below 2 points

Answer Sheet

Score=_____

Rating:_____

Name:_____Date:_____

Information Sheet- 3	Consulting authorized personnel to coordinate the work effectively.

3.1 Consultant

Consultant means any person, including an advisor, who is:

(i) engaged by the Company or an Affiliate to render consulting or advisory services and is compensated for such services, or

(ii) Serving as a member of the board of directors of an Affiliate and is compensated for such services. However, service solely as a Director, or payment of a fee for such service, will not cause a Director to be considered a “Consultant” for purposes of the Plan.

Where a Contractor is responsible under a building or supply contract to maintain plant, equipment and operating systems during the Defects Liability Period, the Consultant shall receive the Contractor’s scheduled report and confirm to the Principal that the Contractor’s advice has been received, certifying that the system is operating to specification and that maintenance has been undertaken in accordance with Operation and Maintenance Manual advice.

3.2 Role of the Maintenance Management Consultant

The mission of the Maintenance Management Consultant is to evaluate and assess maintenance performance –be it technical or organizational -within the corporation, by analyzing requirements and needs, with the aim of measuring and guaranteeing quality and efficacy in this field. He works in different functional areas of a business, ranging from the audits of the maintenance function, development and implementation of a Maintenance Management system, down to the transfer of knowledge (training actions).

An engineering consultant in this area of expertise is therefore expected to master a wide range of skills–project management, auditing, diagnostic techniques, management, benchmarking, information management, among others; he should have sufficient observation capacity and critical analysis capabilities to cope with whatever issues come his way. Since he coordinates most of the consulting work he must be able to break down complex problems in a simple manner, reflecting about concrete problems together with the technical staff of the organization, while bearing in mind that he will have to put the client’s interests first at all times in his decision-making process. Flexibility is fundamental considering that the consultant must mold his behavior in line with his conversation partner.

The master principle to be observed is therefore trustworthiness; the consultant is expected to offer reliable analysis that provides a foundation for each approach.

Now that a picture of the usable referential skills has been given, the main activities of a consultant must be highlighted:

- gathering information related to the Maintenance function performance in the organization;
- developing the action plan for the maintenance consultancy/audit process to be implemented;
- recommending a performance improvement plan for the maintenance function;
- coordinating and assessing the implementation of the maintenance consultancy/audit process, according to the established plan;
- managing information related to the consultancy/audit process;▪Coordinating and/or carrying out training actions;
- Whenever applicable, recommend multifarious investments in the maintenance area;
- Upon project completion, monitoring and assessing as well as developing a final report on the carried out consultancy/audit process.

In short: needs assessment, diagnosis and identification of malfunctions; solution delivery; project implementation and assurance of feasibility in accordance with identified needs; coordination and conduction of training activities; monitoring and assessment.

3.3 Maintenance Management

Gone are the days when the only practiced maintenance within corporations was corrective; interventions would only be carried out when equipment reached its service life limit, when failure occurred or when it approached loss of function. A paradigm shift clearly happened and this scenario no longer reflects nowadays reality. In fact, this idea is reinforced by the acknowledgement on the part of organizations of the importance of maintenance in industry activity. According to Cabral, “Maintenance Management is the frame work of actions directed towards working out and maintaining a balance point in the company’s maintenance level between benefit and cost that maximizes the positive impact of maintenance on the overall business profitability”.

Financial performance alongside other performance indicators should therefore be “consequences and tools for evaluating and assisting in decision-making, not goals in themselves”.

Self check -3	Written Test

Directions: Answer the following questions.

1. What is the role of the maintenance management consultant?(3pt)
2. An engineering consultant expertise is expected to master a wide range of skills:*(5pt)*

……, ……, ……, ……...and ……..

Note: Satisfactory rating – 4 and above points, Unsatisfactory - below 4 points

Answer Sheet

Score=_____

Rating:_____

Name:_____Date:_____

Information Sheet-4	Obtaining necessary Materials.

During diagnosing and troubleshooting of Mechatronics system**,** Wires, Terminal lugs, Terminal wire marker and Terminal blocks may be needed in different sizes.

4.1 Wire

A wire is a single usually cylindrical, flexible strand or rod of metal. Wires are used to bear mechanical loads or electricity and telecommunications signals. Wire is commonly formed by drawing the metal through a hole in a die or draw plate. Wire gauges come in various standard sizes, as expressed in terms of a gauge number. The term 'wire' is also used more loosely to refer to a bundle of such strands, as in "multi-stranded wire", which is more correctly termed a wire rope in mechanics, or a cable in electricity.

4.2 Terminal Lugs

There are four types of cable connectors are commonly used in the electrical construction areas. Ring type lug, U type lug and Pin type lug and Boot lace type are the four types of lugs popularly used by electricians. The component is used for connecting cable to the electrical equipment.

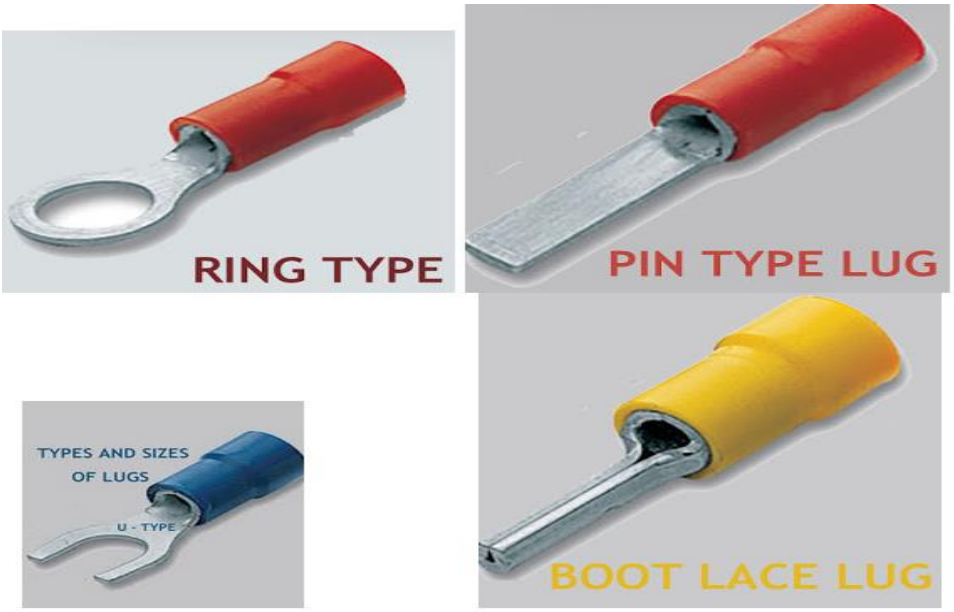

Figure2. Four types of cable lugs

Since most cable wires are stranded, it is necessary to use terminal lugs to hold the strands together to aid in fastening the wires to terminal studs. The terminals used in electrical wiring are either of the soldered or crimped type. Terminals used in repair work

must be of the size and type specified on the electrical wiring diagram for the particular equipment

4.3 Terminal wire marker

Wire markers and cable markers are used to label wires and cables. Wire marking can be done before or after termination. There is a large variety of markers available, including an array of sizes, colors, and lengths.

4.3.1. Types of Wire Markers and Cable Markers

Selecting wire markers and cable markers requires an understanding of product types. Product categories include dot matrix labels and dot matrix ribbons, laser labels and laser sheets, pre-printed markers, and self-laminating labels. Wire markers and cable markers also include thermal transfer labels, thermal transfer ribbons, tags, and wire wraps.

4.4 Terminal blocks

A terminal block is a modular, insulated block that secures two or more wires together. Factories use terminal blocks to secure and/or terminate wires. In their most basic form, terminal blocks consist of several individual terminals which are arranged in a long strip.

Figure3. Different types of Terminal Blocks

Self-check 4	Written Test

Directions: For the following questions, write TRUE if the statement is correct and FALSE if it is incorrect. (1pteach)

1. A terminal block is a single usually cylindrical, flexible strand or rod of metal.
2. Wire markers and cable markers are used to label wires and cables.
3. A wire is a modular, insulated block that secures two or more wires together.

Note: Satisfactory rating – 3 and above points, Unsatisfactory - below 3 points

Answer Sheet

Score=_____

Rating:_____

Name:_____Date:_____

Information Sheet-5	Obtaining tools, equipment and testing devices and checking them.

The trainee will be expected to prepare for the diagnosis of faults in Mechatronics systems activities by obtaining all the necessary information, documentation, tools and equipment required, and to plan how you intend to carry out the required diagnosis of faults activities and the sequence of operations you intend to use.

5.1. Select of appropriate equipment and Tools

The trainee will be required to select the appropriate equipment to use, based on the maintenance operations to be carried out and the type of instrumentation and control equipment being maintained, such as pressure, flow, level and temperature instruments, fiscal monitoring equipment, fire and gas detection and alarm systems, industrial weighing systems, speed measurement and control systems, vibration monitoring equipment, nucleonic and radiation measurement, telemetry systems and emergency shutdown systems.

The followings are some of common tools, equipment and testing devices during the diagnosis of faults in Mechatronics systems.

Test equipment/instruments

- Multi-tester
- Signal generator
- Oscilloscope
- Programmers or PC, etc…

Tools

- Pliers;
- Assorted
- Screwdrivers; assorted
- Soldering iron, etc…

5.2. Duty and responsibility

The trainee will be expected to use a variety of maintenance diagnostic techniques and procedures, such as gathering information from fault reports, using recognized fault finding techniques and diagnostic aids, measuring, inspecting and operating the equipment. You will also be expected to cover a range of maintenance activities, such as isolating and locking off, disconnecting, removing and reconnecting instruments and faulty peripheral components, setting and adjusting components, and testing the equipment, using appropriate techniques and procedures.

5.2.1. Checking equipment and tools

Checking equipment is reviewing hazards associated with hand and power tools during diagnosis & inspections. The tools will be reviewed to make sure they are in good working order, suitable for the jobs they are used for, and do not pose a hazard to the operator.

Self-check- 5	Written Test

Directions: For the following questions, write TRUE if the statement is correct and FALSE if it is incorrect. (1pteach)

1. Select ing of the appropriate equipment and tools is the responsibility of the trainer.
2. Tools will be reviewed to make sure they are in good working order.
3. Oscilloscope is used to measure speed.

Note: Satisfactory rating – 2 and above points, Unsatisfactory - below 2 points

Answer Sheet

Score=_____

Rating:_____

Name:_____Date:_____

Information sheet - 6	Checking Mechatronics system.

6.1. System in Mechatronics

Mechatronics is an interdisciplinary area of engineering that combines mechanical and electrical engineering and computer science.

A typical Mechatronics system picks up signals from the environment, processes them to generate output signals, transforming them; for example into forces, motions and actions.

6.2. Key Elements of Mechatronics

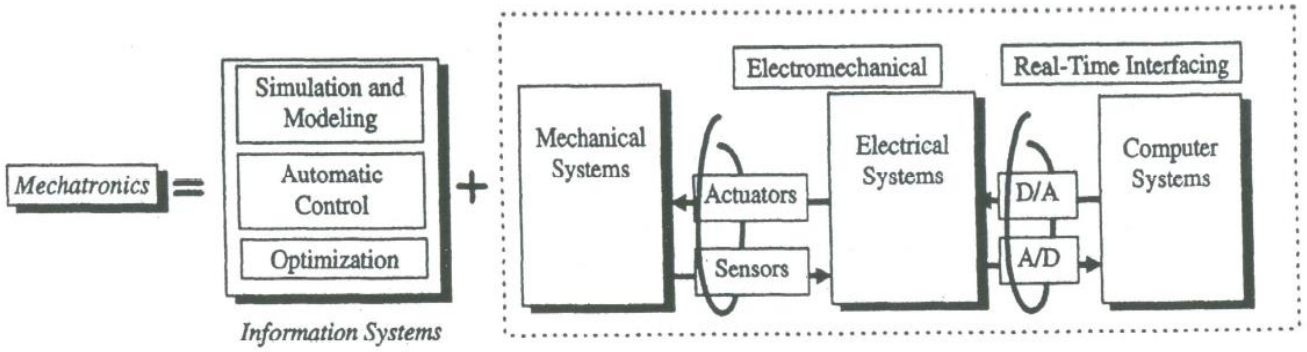

Figure4. Key Elements of Mechatronics

6.3. Mechatronics Applications

- Smart consumer products: home security, camera, microwave oven, toaster, dish washer, laundry washer-dryer, climate control units, etc.
- Medical: implant-devices, assisted surgery, haptic, etc.
- Defense: unmanned air, ground, and underwater vehicles, smart munitions, jet engines, etc.
- Manufacturing: robotics, machines, processes, etc.
- Automotive: climate control, antilock brake, active suspension, cruise control, air bags, engine management, safety, etc.
- Network-centric, distributed systems: distributed robotics, tele-robotics, intelligent highways, etc.

Figure 5. Application area of Mechatronics

6.4. How is temperature sensor connected to Mechatronics?

Inside a Mechatronics device, sensors detect changes in temperature, pressure, position, acceleration, vibration, etc. and transmit the change in data to microcontrollers that then signals an actuator to make a change in the device's function.

6.5. Advantages and Disadvantages of Mechatronics system

Mechatronics systems help in optimizing performance and quality. These can be adapted to changing needs. Mechatronics systems are not without their disadvantages. One disadvantage is that the field of Mechatronics requires knowledge of different disciplines.

6.6. Electro- Pneumatic Circuits

In electro pneumatic circuits the components generating, detecting and processing the signals (pushbuttons, limit switches and logic elements) have an electric operation, while the cylinders and the relevant distributors use the pneumatic energy.

This results in the realization of two different circuits representing:

- **The pneumatic circuit, the power**

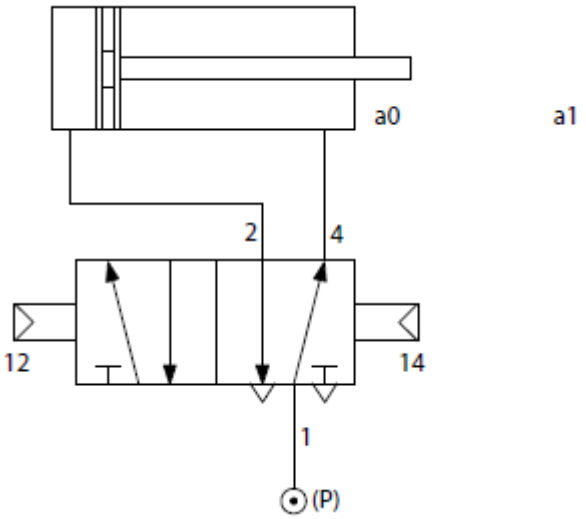

Figure 6. Power circuit

- **The electric circuit, the signal control and processing**

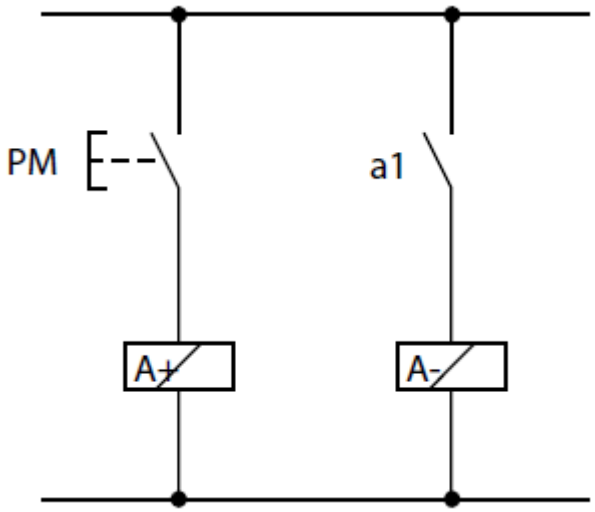

Figure 7. Control circuit

The component receiving the processed electric signal and transforming it into a pneumatic signal is the ELECTROVALVE (E.V.). This is an assembly made up of:

- an electromagnet whose moving core is attracted by the magnetic field generated by an electric current flow;
- a valve body whose "1 (P) with 2 (A)" way is opened and closed by the moving core with shutter function.

  The positions of the moving core are:

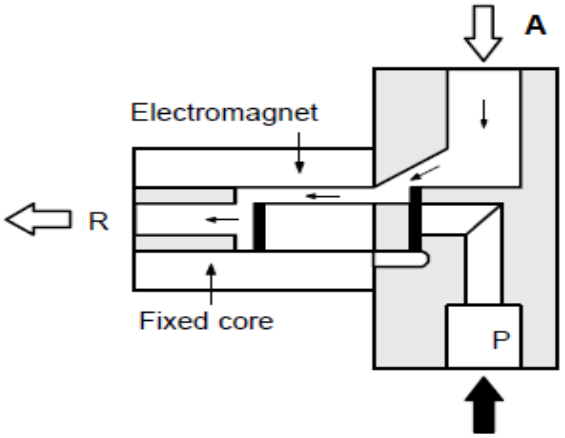

Figure 8. With unexcited coil (A with R = Release)

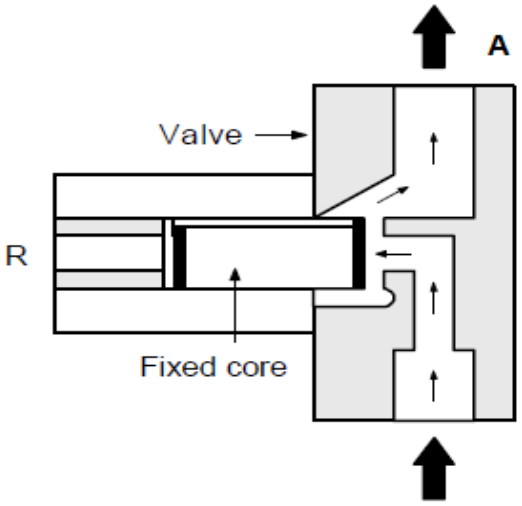

Figure 9. With excited coil (P with A)

The "task" of the E.V. is to move the distributor that, on its turn, causes the motion of the cylinder.

Normally, both components are integral; a hole connects the P of the E.V. to the P of the distributor.

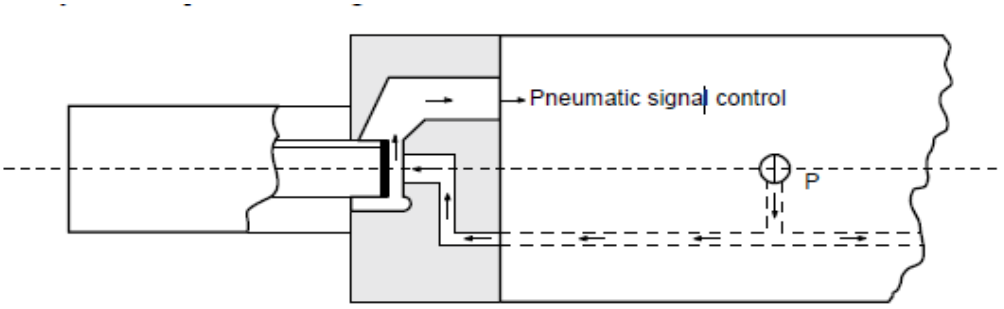

Figure 10.ElectroValve (E.V.)

On the board, on the contrary, the two components are separated and with independent supply.

Therefore, the following pneumatic connections must be realized:

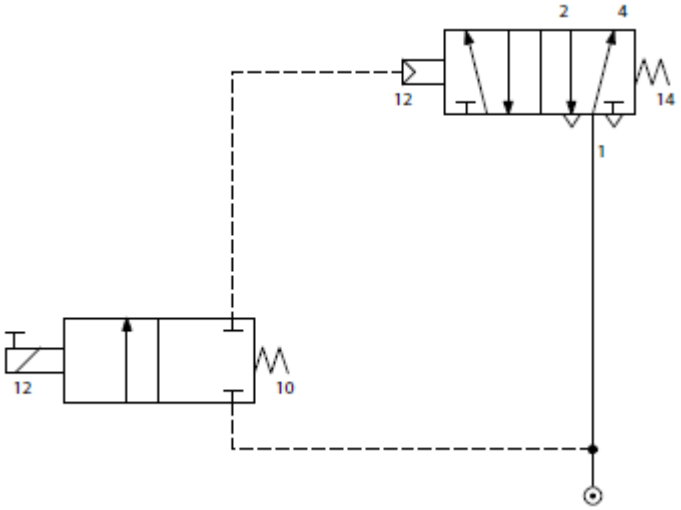

Figure 11.UNSTABLE SOLUTION

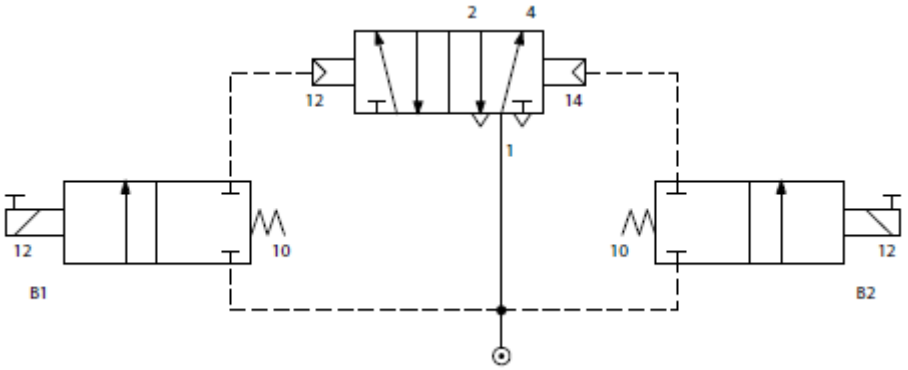

Figure 12. STABLE SOLUTION

Self-check - 6	Written Questions

Directions: - For the following statements, write TRUE if it is correct or write FALSE if it is incorrect on another answer sheet..

1. Mechatronics systems help in optimizing performance and quality.
2. Inside a Mechatronics device, sensors detect changes in temperature, pressure, etc…
3. Computer system is not one of the key elements of Mechatronics.
4. Electro- valve is receiving the processed electric signal and transforming it into a pneumatic signal.
5. In electro pneumatic circuits, the electric circuit is the power and the pneumatic circuit is control.

Note: Satisfactory rating – 3 and above points, Unsatisfactory - below 3 points

Answer Sheet

Score=_____

Rating:_____

Name:_____Date:_____

Operation title1: - 4/ 3 manual valve commutation circuit.

Purpose	To understand and complete the commutation circuit test of a 4/3 manual valve.
Equipment ,tools and materials	Supplies and equipment needed or useful for 4/ 3 manual valve commutation circuit. : • DL 8110H hydraulics trainer bench • Hydraulic station • Oil tubes • Pressure gauge • Relief valve • 4/3 manual valve • Double acting hydraulic cylinder
Conditions or situations for the operations	• Set up the 4/3 manual valve commutation loop by the hydraulic components of the DL 8110H bench and complete the hydraulic loop test.
Procedures	**Step1.** Referring to Fig.13, establish a 4/3 manual valve commutation loop. **Step2**. Connect and check the hydraulic circuit, set the lever at the intermediate position and then start the hydraulic pump.. **Step3.** Push the lever of the manual valve and observe the movement of the hydraulic cylinder and the pressure gauge value. Pull the lever, the hydraulic cylinder move backward; observe the movement of the hydraulic cylinder and the pressure gauge value simultaneously.
Precautions	• When you keep or remove the one-way valve on the hydraulic cylinder (see below), you may analyze the difference of the experimental results. • Through the manual valve commutation and experimental circuit, think the principle of the internal commutation function and structure of this valve.
Quality criteria	• At starting the hydraulic station process, the hydraulic cylinder will not move, but the hydraulic station is working properly. This shows that the hydraulic station is in the internal fluid circulation. Analyze how it works.

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary tools and materials you are required to perform the following task within 3 hrs.

Task 1: Install 4/ 3 manual valve commutation circuits**.**

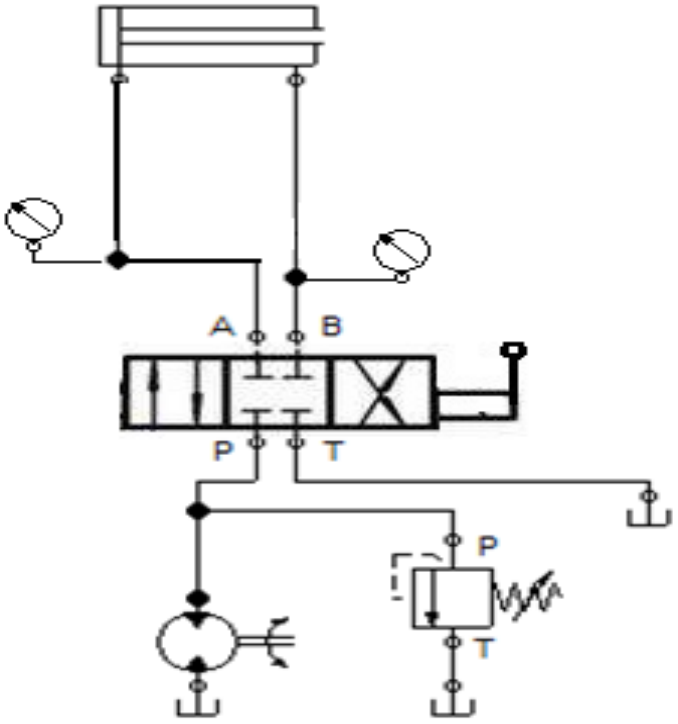

Fig. 1.3. 4/ 3 manual valve commutation circuits

LG #51	LO # 2 Diagnose faults of Mechatronics systems
Instruction sheet	

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

- Using appropriate personal protective equipment.
- Diagnosing fault or problem in the Mechatronics system.
- Managing and implementing contingency measures.
- Responded unplanned events or conditions.

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:

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7. Perform “the Learning activity performance test” which is placed following “Operation sheets” ,
8. If your performance is satisfactory proceed to the next learning guide,
9. If your performance is unsatisfactory, see your trainer for further instructions or go back to “Operation sheets”.

Information sheet .1	Using appropriate personal protective equipment.

Personal Protective Equipment or PPE as it is commonly known has been designed specifically to protect employees in the work environment. Not only is it important to protect employees but also to protect the employer from unwanted legal claims. Furthermore, PPE is often a legal requirement and it is the responsibility of the employer to ensure employees wear protective clothing and observe safety and health regulations. It is also a responsibility, which employees must take seriously.

1.1. Common Personal Protective Equipment (PPE)

During diagnose and troubleshoot Mechatronics system, the following Personal Protective Equipment or PPE are most commonly used.

- Safety hat
- Safety shoes
- Ear muffs
- Goggles
- Safety belt/Harness
- Gloves
- Mask

1.2. Risks if technicians not use appropriate personal protective equipment

The followings are some of the main risks of not using appropriate personal protective equipment:

- The lungs will be affected, example, from breathing in contaminated air
- The head and feet will be affected, example from falling materials
- The eyes, example from flying particles or splashes of corrosive liquids
- The skin will affected, example from contact with corrosive materials
- The body will affected, example from extremes of heat or cold

Self-check 1	Written Questions

Directions: **Match the followings from Column B to Column A** (1pt each)

A	B
……1. The lungs will be affected	A. Not using Goggles
……2. The head and feet will be affected	B. Gloves
……3. The eyes will be affected	C. Not using mask
……...4. The skin will be affected	D. Not using apron
……...5. The body will be affected	E. Not using Safety hat

Note: Satisfactory rating – 3 and above points, Unsatisfactory - below 3 points

Answer Sheet

Score=_____

Rating:_____

Name:_____Date:_____

Information sheet - 2	Diagnosing fault or problem in the Mechatronics system.

2.1 The Main Idea of Fault Diagnosis

The main idea of fault diagnosis is to determine the type, size and location of the fault as well as its time of detection, based on the available measurements of the system. A general scheme of model based fault diagnosis is shown in Figure 14 below.

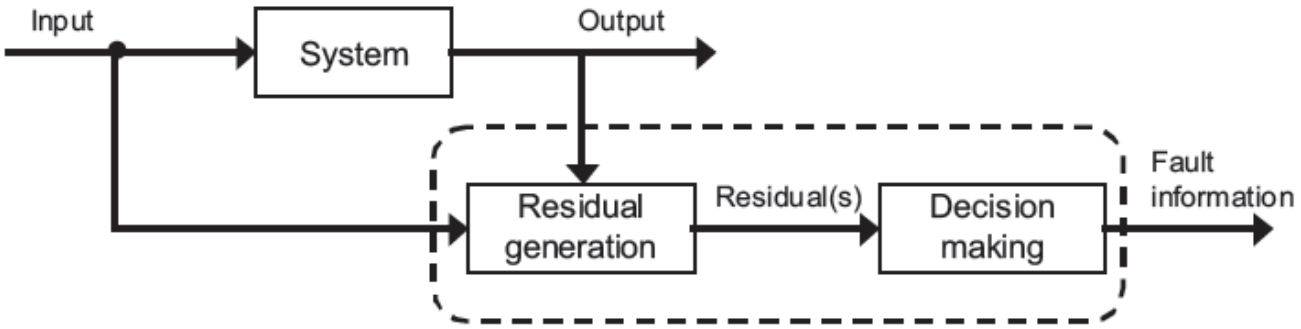


Figure 14. General scheme of model-based diagnosis

Usually, fault diagnosis is achieved in a two-stage process. First, a signal called *residual* is generated using available input–output measurements from the system under consideration. When the system is fault free, then residual should be zero or close to zero, and otherwise when the fault is presence, residual should be different from zero. Residual could be scalar signal carrying information of a single fault or vector carrying information of multiple faults.

The type of the residual generator varies from an analytical mathematical model to a black-box model of the system.

The second stage is the decision-making process where residuals are examined for the likelihood of faults. The type of the decision-making mechanism varies from a simple threshold to a number of sophisticated statistical approaches.

2.2 Troubleshooting

Troubleshooting is a form of problem solving, often applied to repair failed products or processes on a machine or a system. It is a logical, systematic search for the source of a problem in order to solve it, and make the product or process operational again.

Troubleshooting is needed to identify the symptoms.

2.2.1. General Steps to Troubleshoot an Issue

1. Identify the problem. ...
2. Establish a theory of probable cause. ...
3. Test probable cause theory to determine actual cause. ...
4. Establish an action plan and execute the plan.
5. Verify full system functionality. ...
6. Document the process

2.3 Hydraulic Systems Components of Mechatronics

Hydraulic systems are everywhere in mechanical systems and made of a variety of standard components. With properly located and perfectly designed components, the hydraulic system should generate a minimum of heat (waste energy) and operate with minimum maintenance.

Figure15. Hydraulic systems installation overview

2.3.1. . Primary Components of Hydraulic Systems

Essential components of a hydraulic system are:-

- Reservoir oil tank.
- Piping.
- Hydraulic pump.
- Power source.
- Actuator.
- Valves.
- Filters.

The hydraulic power pack is the heart of any hydraulic system. It has a motor, hydraulic pump, oil reservoir, air breather and various other components.

Figure16. Hydraulic power pack

The function of each sub-component is as follows…

1. Hydraulic power pack (featuring Reservoir, Primary energy source, Hydraulic pump, Pressure relief valve and pressure indicator, Filters, Fluid level indicator, Air breather)
2. Direction control valve
3. Other control valves
4. Actuator
5. Hoses (fixed and flexible)

2.3.2. Mechanical Components

The reservoir stores hydraulic fluid and protects it from contamination. The primary energy source is the unit which will supply mechanical energy to the hydraulic pump. The primary energy source can be either an internal combustion engine (for mobile applications), a DC motor powered by DC batteries (mostly used on ships) or a 3-phase AC motor (for industrial application). The primary energy source converts input energy into mechanical energy. This mechanical energy goes into the hydraulic pump to generate hydraulic energy (pressure and flow). The selection of the primary energy source doesn't

affect the performance of the hydraulic system, even though it may affect the weight, vibration, noise and size of the system.

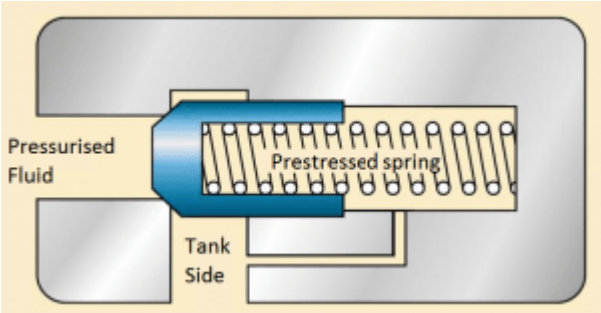


Figure17. Hydraulic pressure relief valve

The hydraulic pump develops hydraulic energy. It can be one of many different types depending upon the application. The most frequently used pumps are reciprocating piston pumps, vane pumps, and gear pumps. This pump-motor unit together decides the power of the system and its selection limits the maximum pressure and maximum flow rate that can be generated from the system.
The pressure relief valve is an NC (normally closed) safety valve for the hydraulic system. As the pressure increases beyond a certain prescribed limit, the relief valve will bypass the fluid into the tank and maintain the system pressure below the maximum level.

Filters are another important component in any hydraulic system. A filter prevents

Figure18. Hydraulic filter

Contaminants from entering the hydraulic system and ensures satisfactory working with minimum maintenance. A suction line filter is located at the suction side of the pump and prevents the contaminants in the reservoir fluid from entering the hydraulic system. Reservoir fluid can get

contaminated from small atmospheric dust particles coming from the air breather. The return line filter is located at the end of the return line. Small particles enter the fluid due to wear of the system and the return line filter takes care of them.

There are various sources of contamination:

1. Reservoir vents ports.
2. Ingression during maintenance and topping of new liquid.
3. Degradation of hydraulic fluid.
4. Wear and scratch by existing particles.

If a filter is not used in a hydraulic system, the following problems can occur:

- Increase in viscosity of fluid.
- Abrasive particles can wear critical components, seals, and valves.
- logging of pipes and hence decrease in flow rate.
- Wear of hydraulic pump (in the case of vane pump or gear pump).

2.3.3. Troubleshooting Hydraulic Systems

The following diagram shows the major components used in nearly all hydraulic systems. Most system failures can be pinpointed to one of these components.

Symptoms

Many of the failures in a hydraulic system show similar symptoms: a gradual or sudden loss of high pressure, resulting in loss of power or loss of speed in the cylinders. The cylinder(s) may not move at all, or if they do they may move too slowly or may stall under light loads. Often the loss of power is accompanied by an increase in pump noise, especially as the pump tries to build up pressure against a load.

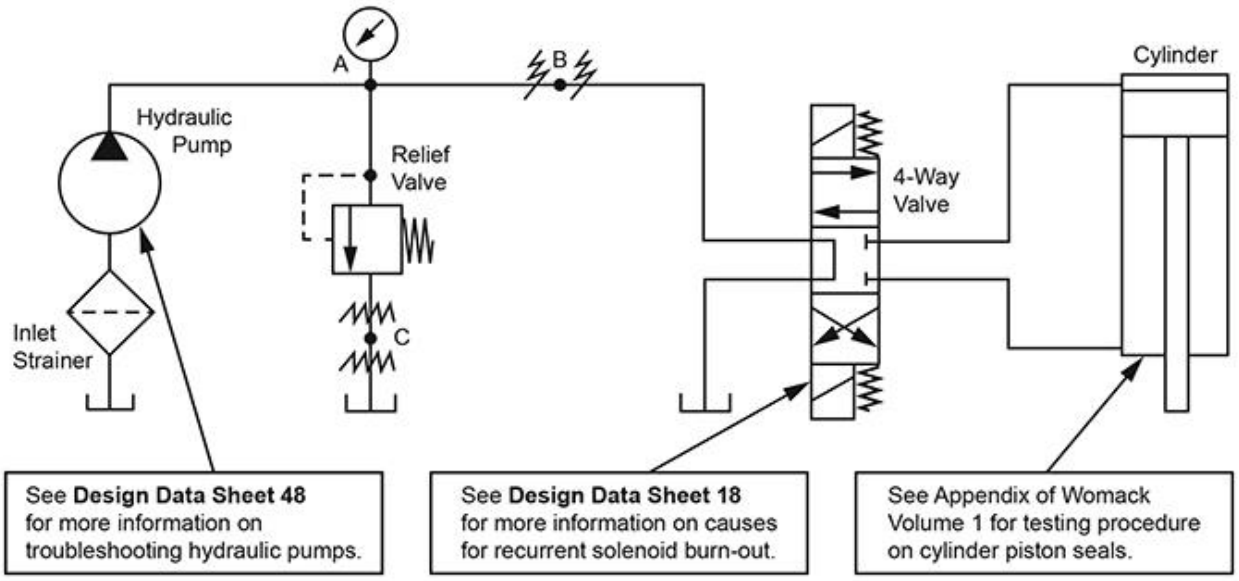


Figure 19. Basic Diagram for a Typical Hydraulic System

By following an organized step-by-step testing procedure in the order given here, the problem can usually be traced to a general area, and then if necessary, each component in that area can be tested or can temporarily be replaced by another similar component known to be good.

Step 1 - Pump Inlet Strainer

Probably the field trouble encountered more often is cavitations of the hydraulic pump inlet caused by dirt build-up on the inlet strainer. This can happen on a new system after only a few hours operation as well as on a system which has been in service for a long time. It produces the symptoms described above: increased pump noise, loss of high pressure and/or speed.

If the strainer is not located next to the pump inlet, it will usually be found immersed below the oil level in the reservoir. Some operators are not aware of this strainer, or if they are, they do not give it attention until the system fails, at which time the pump may be ruined. If not regularly cleaned or replaced, sooner or later the strainer will become sufficiently restricted to cause a breakdown of the entire system.

The inlet strainer should be removed for inspection and should always be cleaned before re-installation. Wire mesh strainers can be cleaned with an air hose, blowing from the inside out. They can also be washed in a solvent, scrubbing them with a bristle brush. The solvent should be compatible with the hydraulic fluid in the tank. For example, kerosene may be used on strainers

operating in petroleum oil. Avoid the use of gasoline, lacquer thinner or other solvents which are explosive or highly flammable. The strainer should then be blown out whether or not it appears to be dirty. Some clogging materials cannot be seen except on very close inspection. If there are any holes in the mesh or if there is any apparent physical damage, the strainer should be replaced.

When re-installing the strainer, inspect all joints in the inlet plumbing for air leaks, particularly at union joints. There must be no air leaks in the pump inlet line. Check the tank oil level to be sure it covers the top of the strainer by at least 3″ at minimum oil level, which is with all cylinders extended. If it does not, there is danger of a vortex forming above the strainer which may allow air to enter the system when the pump is running.

Notice the condition of the inlet hose (if one is used). A partially collapsed hose or one with internal swelling has the same effect as a clogged inlet strainer.

Step 2- Pump and Relief Valve

If cleaning the pump inlet strainer does not correct the trouble, isolate the pump and relief valve from the rest of the system by disconnecting the plumbing at Point B and capping both ends of the disconnected lines. This deadheads the pump into the relief valve. Start the pump and watch for build-up of pressure on the gauge while tightening the relief valve adjustment. If full pressure can be developed, obviously the pump and relief valve are operating correctly and the trouble is further down the line. If full pressure cannot be developed in this test, continue with Step 3.

Step 3 - Pump or Relief Valve

Further testing must be done to determine whether the pump or the relief valve is at fault. If possible, disconnect the tank return line from the relief valve at Point C. Attach a short length of hose to the relief valve outlet. Hold the open end of this hose over the tank filler opening where the rate of oil flow can be observed. Start the pump and run the relief valve adjustment up and down while observing the relief valve discharge flow. If the pump is bad, a full stream of oil may possibly be observed when the relief valve is backed off and this stream will greatly diminish or stop as the relief setting is increased.

If a flow meter is available, the flow rate can be measured and compared with the catalog rating for the pump. If a flow meter is not available, the flow can be measured by discharging the stream into a measuring container while timing with the sweep hand on a watch. Or, if the relief valve tank return

line cannot be disconnected, the mechanic can place his hand in the discharge stream under the oil level in the tank to detect a drop-off in flow velocity.

During this test if the gauge pressure does not rise above a low value, says 100 PSI, and if the flow does not substantially decrease as the relief valve setting is increased, the relief valve is at fault and should be cleaned or replaced as instructed in Step 5.

If the flow decreases as the relief setting is raised, and only a moderate, but not full pressure can be developed, this indicates pump trouble. Proceed to Step 4.

Step 4 - Pump

If a full stream of oil isn't obtained in Step 3, or if the stream diminishes markedly as the relief setting is raised, the pump may be worn out. Assuming that the inlet strainer has been cleaned and the inlet plumbing has been examined for air leaks or collapsed hose, the oil is slipping internally from outlet back to inlet. The pump may be worn out or the oil may be too thin. Excessively high temperature in the oil causes the oil to thin out and to slip excessively in the pump. High slippage in the pump will cause it to run much hotter than the oil in the tank. In normal operation with a good pump, the pump case may run 20 to 30°F more than the tank oil temperature. If greater than this, excessive pump slippage may be the cause.

Step 5 - Relief Valve

If Step 3 has indicated the relief valve to be at fault, the quickest remedy is to replace it with one known to be good. The faulty valve may later be disassembled and cleaned. Pilot-operated relief valves have small internal orifices which may become blocked with dirt. Blow out all passages with an air hose and run a small wire through orifices. Check also for free movement of the spool. Pipe thread connections in the body may distort the body and cause the spool to bind. If possible, check for spool bind before removing threaded line connections, or while testing on the bench, screw pipe fittings tightly into the port threads.

Step 6 - Cylinder

If the pump will develop full pressure while operating across the relief valve in Step 2, both of these components can be assumed to be good.

Step 7 - Directional (4-Way) Valve

If the cylinder has been tested for piston leakage and found to have a reasonably tight piston, the 4-way directional valve may be checked for excessive spool leakage. It is rare that a valve becomes worn so badly that the pump cannot build up full pressure but it can happen. Symptoms of excessive leakage are a loss of cylinder speed -together with difficulty in building up to full pressure even with the relief valve adjusted to a high setting. This condition would be more likely to happen when using a pump with small displacement operating at very high pressure, and might have developed gradually over a long period of time.

Other Components

If the above procedure does not pinpoint the trouble, check other components individually. Usually the quickest and best troubleshooting procedure is to replace these components one at a time with similar components known to be good. Pilot-operated solenoid valves which will not shift out of center position may have insufficient pilot pressure.

2.3.4. Hydraulic System Operates slowly; the cause may be:

1. Oil viscosity too high, cold oil. Allow oil to warm up before operating machine.
2. Low pump drive speed. Increase engine speed (check manual for recommendations.)
3. Air in system. ...
4. Badly worn pump, valves, cylinders, etc ...
5. Restrictions in filters or lines. ...
6. Improper adjustments. ...
7. Oil leaks.

Common Causes of Hydraulic Failure

1. Air and Water Contamination. Air and water contamination are the leading causes of hydraulic failure, accounting for 80 to 90% of hydraulic failures. ...
2. Temperature Problems. ...
3. Fluid Levels and Quality. ...
4. Human Error.

Causes of overheat in hydraulic system

Heating of hydraulic fluid in operation is caused by inefficiencies. Inefficiencies result in losses of input power, which are converted to heat. ... If the total input power lost to heat is greater than the heat dissipated, the hydraulic system will eventually overheat.

Adjustment of a hydraulic relief valve

Adjust the pressure regulating valve, located next to the pressure switch, by using a wrench to loosen the lock-nut on the switch, then turning the adjusting screw clockwise to increase the pressure setting. The switch should be adjusted to ensure a pressure differential of about 300 psi.

2.4 Electro mechanical components of Mechatronics

An electromechanical component is one that uses an electrical signal to cause some kind of mechanical change, such as motor turning. These normally use an electrical current to create a magnetic field which causes a physical movement. All types of relays and switches are available in this category.

Self-check 2	Written Test

Directions: **Answer the following questions.**

1. What are the sources of contamination for hydraulic fluid?(5pt)
2. Write at least three common causes of hydraulic failure.(3)

Note: Satisfactory rating – 4 and above points, Unsatisfactory - below 4 points

Answer Sheet

Score=_____

Rating:_____

Name:_____Date:_____

Information sheet -3	Managing and implementing contingency measures

A contingency plan is a course of action designed to help an organization respond effectively to a significant future event or situation that may or may not happen. A contingency plan is sometimes referred to as "Plan B," because it can be also used as an alternative for action if expected results fail to materialize.

3.1 Contingency planning as a necessity

One of the first tasks the workshop supervisor and the technicians participate in the identification of the risks that may impact the diagnosis and trouble shooting. The initial step is to identify events that pose a threat or risk to the trouble shooting's success.

Basically, there are two types of risks that need to be identified and evaluated: internal and external risks. Internal risks are those "things that the workshop team can control or influence" while external risks are those "things that are beyond the control of the workshop team". Of the two types, the internal risks are often easier to identify because external risks are not as obvious.

3.2 Key elements of any contingency plan

The key elements of a contingency plan are:

- protection,
- detection, and
- Recoverability."

3.3 Managing contingencies

Here are the steps you need to follow in a contingency planning process.

Step 1: List down the key risks. ...

Step 2: Prioritize the Risks Based on Their Impact. ...

Step 3: Create Contingency Plans for Each Event. ...

Step 4: Share and Maintain the Plan.

Self-check 3	Written Test

Directions: Answer the following Questions.

1. Write key elements of a contingency plan (3pt).
   a. ……
   b. ……..
   c. ……
2. Write down the steps of contingency planning process.(4pt)

Step 1: ……..

Step 2: ……..

Step 3: …….. ...

Step 4: ……

Note: Satisfactory rating – 4 and above points, Unsatisfactory - below 4 points

Answer Sheet

Score=_____

Rating:_____

Name:_____Date:_____

Information sheet - 4	Responded unplanned events or conditions

4.1. Normal State of Equipment and Power ON OFF precautions and food baking

Figure 20. Normal State of the Equipment Food Baking Oven

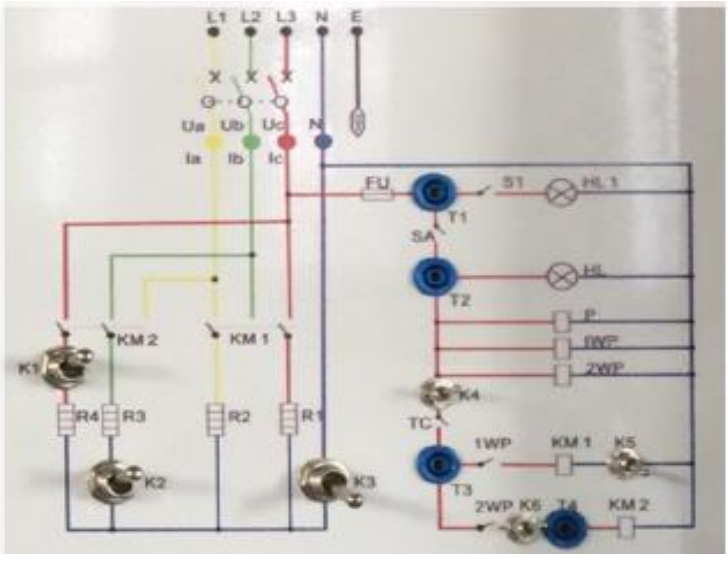


Figure 21. Power and control circuits of Food Baking Oven

As shown in the above figure 21, the main switch is off, short Ia, Ib, Ic, all switches are in the up position, the front door of the oven is closed, and the circuit cover on the right side is installed.
All this is the initial normal state of the device

4.2. Power ON and power OFF instructions and precautions

- Check that the power cord of the equipment is connected to the power supply.
- Power supply, orange indicator light.
- Close the main switch, the oven power indicator lights up.
- Open the oven lighting switch, the oven light HL1 is on (put the food to be baked on the tray).
- Set the top fire temperature, set the bottom fire temperature, set the baking time.
- Open the baking switch, the oven starts working and the oven work light HL is on.
- When the baking time is over, the oven stops working.
- Open the oven and remove the food tray with gloves

4.3. Voltage and current detection

Connect the test leads, connect Ua - U1, N - U2, remove the Ia short component, connect I_1 - Ia1, I_2 - Ia2, repeat the power on – power off instructions, the voltage and the current can be detected in the total process.
Similarly, other phase voltages and phase currents can be detected.

4.4. Equipment failure, fault analysis and troubleshooting

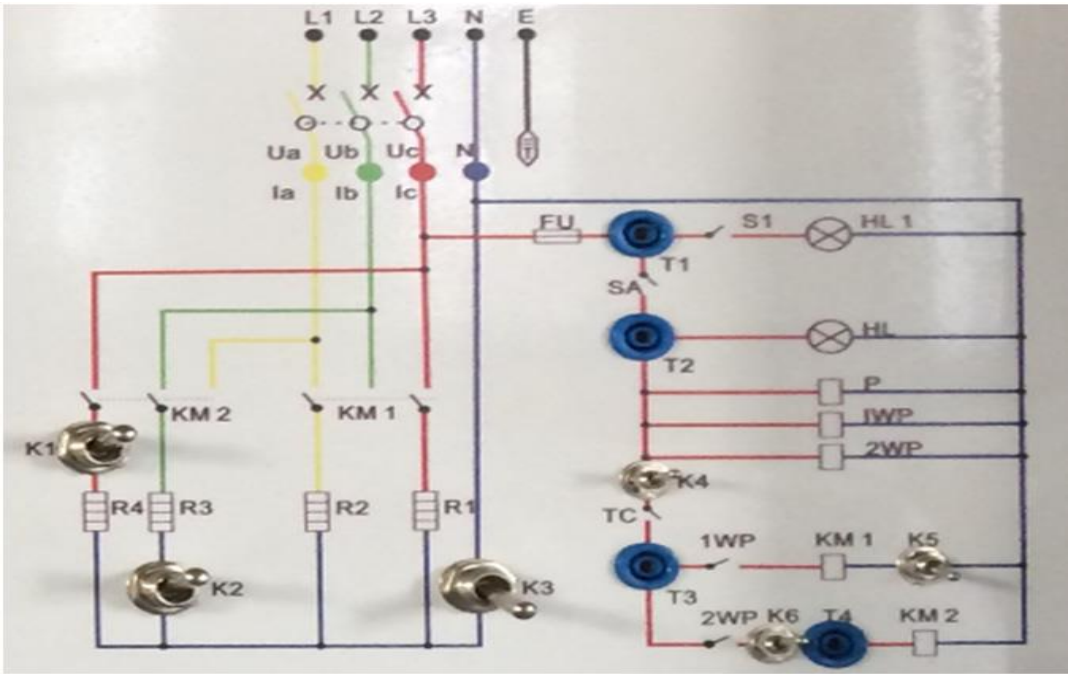


Figure 22. Fault detection panel

L1, L2, L3, N, E	Three-phase power lines, neutral, ground
KM1, KM2	Contactor coil or contact
R1, R2, R3, R4 4	Electric components
Fu	Fuse
S1, HL1	Oven internal lighting switch and light bulb
HL	Oven work indicator
P, Tc	Time relay and its control contacts
1WP, 2WP	Top fire, bottom fire thermostat and its contacts

4.5. Detection points

Ua, Ub, Uc, N	The four detection points correspond to the detection hole below the voltmeter
Ia, Ib, Ic	The three symbols correspond to the detection hole below the ammeter
T1, T2, T3, T4	Correspond to the key detection points of the oven control circuit
K1, K2, K3, K4, K5, K6	Correspond to the typical check positions of the oven circuit fault

Fault simulation, fault phenomena, fault detection, troubleshooting, fault location & solution

No.	fault simulation	fault phenomena	voltage	cause of fault	Solution
1	K1 open	No bottom fire		R4 bad or wire open	Replace the heat part or check the wiring
2	K2 open	No bottom fire		R3 bad or wire open	Replace the heat part or check the wiring
3	K1, K2 open	Bottom fire not hot		R3,R4 bad or wire open	Replace the heat part or check the wiring
4	K3 open	Top fire normal, bottom fire not hot		Wire open	Check and treat the wiring
5		Oven work light is off and the meter is off	T1 has not AC 220V voltage	Fuse open	Replace the fuse
6		Bottom fire not hot	T4 has AC220V voltage	KM2 contactor coil is bad	Replace the contactor coil or handle the line
7	K4 open	Top fire and bottom fire not hot	T2 has AC220V T3 hasn't AC220V	Time relay is bad or TC-related wiring is open	Replace the contactor coil or handle the line
8	K6 open	Bottom fire not hot	T2 has AC220V T3 has AC220V	bottom fire thermostat bad	Replace the bottom fire thermostat

9	K5 open	Top fire not hot	T3 has AC220V T4 has AC220V	Top fire thermostat bad or KM1 coil open or K5 related line bad	Replace the top fire thermostat or the KM1 contactor coil
10		Bottom fire not hot	T4 has AC220V	KM2 coil broken or KM2 contact bad	Replace KM2
11		Top fire and bottom fire normal, thermometer does not change or shows a negative value		Temperature sensor is bad or sensor line is bad	Check the temperature sensor, if it is open or short, replace the sensor
12		Oven inside light does not light on	T2 has AC 220V	The light inside the oven is bad	Replace the light bulb

4.6. Safety Precautions

Although the product is necessary to comply with the relevant standards of circuit protection, it still has to comply with the following rules of use.

1. If the ground of the power supply is not properly grounded, the ground terminal at the back of the oven must be grounded to prevent accidental electric shocks.
2. Do not touch the oven high temperature box during operation; wear gloves to move the food tray at high temperatures.
3. The interface jack cannot be shorted! Phase line - neutral line jack cannot be shorted.
4. Any maintenance work must be carried out after power off.

Self-check 4	Written Test

Directions: **Match the followings from Column B to Column A ,for fault analysis and troubleshooting of food baking oven** (1pt each)

A	B
……1. K1 open	A. Bottom fire not hot
……2. K5 open	B. Top fire and bottom fire not hot
……3. K1, K2 Open	C. No bottom fire
……...4. K3 open	D. Top fire not hot
……...5. K4 open	E. Top fire normal, bottom fire not hot

Note: Satisfactory rating – 3 and above points, Unsatisfactory - below 3 points

Answers Sheet

Score=_____

Rating:_____

Name:_____Date:_____

Operation title1: - Hydraulic cylinder parallel circuit test.

Purpose	To become familiar with and to complete the hydraulic cylinder parallel circuit test.
Equipment ,tools and materials	Supplies and equipment needed or useful for 4/ 3 manual valve commutation circuit. : • DL 8110H hydraulics trainer • Hydraulic station • Oil tubes • Pressure gauge • Relief valve • 4/2 manual valve • Throttle valve • Double acting hydraulic cylinder
Conditions or situations for the operations	• Set up the hydraulic cylinder parallel loop by the hydraulic components of the DL 8110H bench and complete the hydraulic loop test.
Procedures	**Step1.** Referring to Fig.23, establish the hydraulic cylinder parallel circuit. **Step2**. Connect and check the hydraulic circuit, then start the hydraulic pump. **Step3.** Manually push the lever of the manual valve, watch the hydraulic cylinder movement and pressure gauge values. Push forward, the hydraulic cylinder will move forward. When the cylinder rod reaches the end position, move the manual lever backward and the hydraulic cylinder will move backward. **Step4.** Adjust the throttle valve and repeat step 3 again. Observe the movement state of the hydraulic cylinder and the pressure gauge value.
Precautions	Changing the one-way throttle valve with the two-way throttle valve, repeat the above experiment and observe the hydraulic cylinder forward and backward movement. Which different pressure changes do we have?
Quality criteria	• Through the movement of the cylinder, analyze two hydraulic cylinder movement sequence factors, analyzing the decompression principle and decompression structure of the hydraulic reducing valve and the decompression adjustment method.

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary tools and materials you are required to perform the following task within 3 hrs.

Task 1: Install 4/ 3 manual valve commutation circuits**.**

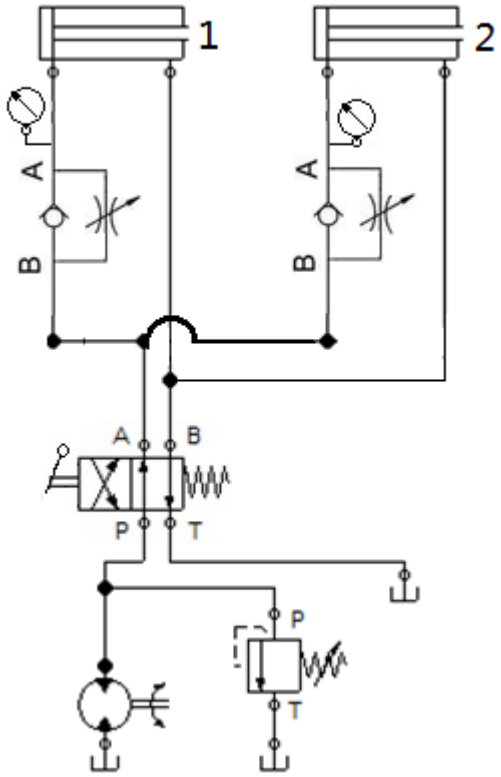


Fig. 23 - Hydraulic cylinder parallel circuit

LG #53	LO # 3 Rectify/correct faults in the Mechatronics system
Instruction sheet	

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

- Using appropriate personal protective equipment.
- Isolating systems and associated equipment.
- Replacing or correcting defective components or parts without damage.
- Making adjustments where necessary.
- Responding unplanned events.

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:

- Use appropriate personal protective equipment.
- Isolate systems and associated equipment.
- Replace or correct defective components or parts without damage.
- Make adjustments where necessary.
- Respond unplanned events.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them
4. Accomplish the “Self-checks” which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets
7. Perform “the Learning activity performance test” which is placed following “Operation sheets” ,
8. If your performance is satisfactory proceed to the next learning guide,
9. If your performance is unsatisfactory, see your trainer for further instructions or go back to “Operation sheets”.

Information sheet-1	Using appropriate personal protective equipment.

PPE for electrical work, including testing and fault finding must be suitable for the work, properly tested and maintained in good working order. The PPE must be able to withstand the energy at the point of work when working energized. Training must be provided in how to select and fit the correct type of equipment, as well as training on the use and care of the equipment so that it works effectively. Depending on the type of work and the risks involved.

The following PPE should be considered:

- Face Protection—use of a suitably arc rated full face shield may be appropriate when working where there is potential for high current and arcing.
- Eye Protection—metal spectacle frames should not be worn.
- Gloves—use gloves insulated to the highest potential voltage expected for the work being undertaken. Leather work gloves may be considered for de-energized electrical work.
- Clothing—use non-synthetic clothing of non-fusible material and flame resistant. Clothing made from conductive material or containing metal threads should not be worn.
- Footwear—use non-conductive footwear, for example steel toe capped boots or shoes manufactured to a suitable standard.
- Safety Belt/Harness—safety belts and harnesses should be checked and inspected each time before use with particular attention being paid to buckles, rings, hooks, clips and webbing.

Self check 1	Written Test

Directions: 1. Write at least five commonly used in electrical workshop.

a. …….

b. ……

c. ……

d. …….

e. ……

Note: Satisfactory rating – 3 and above points , Unsatisfactory - below 3 points

Answer Sheet

Score = _____

Rating: _____

Name: _____Date: _____

Information sheet 2	Isolating systems and associated equipment.

2.1 Isolations

Isolations are a necessary aspect of safe work. Managing isolations can be a complicated process, with many variables to consider, for example managing multiple isolation points on a single item of equipment and managing the isolations for multiple people involved in several maintenance jobs in a common plant area.

By adopting the principle of isolations, always using positive isolation you will ensure that people are assured to work under safe conditions. Positive isolations are best managed using a system of locks and keys that are controlled in lock-boxes and cross-referenced using the permit to work. A number of automated systems are available for special circumstances. The goal as always is to enhance safe work.

For example, in the case of an electrical supply system, the incoming power to the equipment is isolated using a switch. This local switch is locked in the “off” position using a padlock. In most situations, a double isolation is preferred. An electrical circuit might therefore be isolated at the main control centre by “racking out” the switchgear, as well as separately isolated in the plant by a switch. Teams working in the field can visibly see that the local switch is locked in the off position.

Complications are possible if shutting down power at the control centre also shuts down other unrelated items of electrical equipment. Further complications can occur if during maintenance power needs to be temporarily restored to the equipment for reasons related to the maintenance procedure; for example, to test the repairs done before returning the section of plant into service.

Similarly, valves might need to be locked open or closed (depending on the scenario) with a lock placed on the valve handle to prevent accidental operation. Where valves don’t exist or are inadequate (due to leaks), slip plates might need to be bolted in position between flanges that provide a proper physical barrier.

Generally, it is not acceptable to rely on electronic process control systems to isolate equipment. All isolations should be “positive”, and checked, locked out, and later removed by the persons responsible for doing the work. This principle of positive isolation is very important to ensure work takes place safely. Connecting control system sensors, IIoT (industrial internet of things) devices and so on can act as an additional layer of protection and warning, but they can never replace the primary method of protection.

Every isolation should be clearly labelled with a lock-out “do not operate” tag. It is more efficient if these tags can be generated automatically by the permit system. The information on the tag can indicate the relevant date/time, details of the work and responsible person, a tag/isolation number, the associated permit and the equipment detail.

2.2 Complex systems

Maintenance is often necessary on equipment that forms part of a complex, interconnected system. The isolation points in these situations can be quite extensive and amount to dozens of individual lock-outs for a single job. Each of these lock-outs (or isolation points) needs to be carefully considered in terms of the impact on the overall process. Because the isolations introduce a new variable, it is also important to make sure that they do not in turn introduce any additional risk.

Owing to the possibility of human error, work on complex systems is usually planned carefully ahead of time and the isolations documented as part of a safe work procedure. The resulting procedure can be reused whenever similar work is required on the same item. Safe work and isolation procedures must be subject to careful change control and when used should only be applied in very specific situations, having duly considered the risks for the specific circumstances of each job.

2.3 Verification of isolations

Before work starts it is important that each isolation is verified in the field by a competent person. These checks might involve inspection of the isolations and the work area, pressure tests, testing for the presence of high voltages, and so on. The inspection and tagging process can sometimes be done together to streamline the process. The field inspection needs to be done by someone familiar with the plant and equipment; and a single job may involve inspections by different engineering disciplines, e.g. electrical, mechanical and so on.

2.4 Multiple people and working parties

So far, the discussion has been about isolating an item of equipment with one or more physical isolation points. In practice however, things can be more complicated. Several individuals or independent teams/working parties may be involved in the maintenance job. Each individual in the working party needs to be assured that they are protected from accidental removal of the isolation by someone else.

For this reason, it is normal for two or more people to add their “personal” padlock to the isolation point. In order to restore the energy source, both locks then need to be removed. In order to manage the keys and avoid the scenario where the plant cannot be re-commissioned if people are unavailable, the keys are often put in a lock box (or “key safe”). The lock box itself is locked and controlled by a master key held by a third party, who then effectively controls that group of isolation locks related to the job.

Self check 2	True/false

Directions: Write TRUE if the statement is correct and write FALSE if the statement is wrong.

1. A number of automated systems are available for special circumstances.
2. Every isolation shouldn't be clearly labelled with a lock-out "do not operate" tag.
3. Safe work and isolation procedures must be subject to careful change control.

Note: Satisfactory rating – 2 and above points , Unsatisfactory - below 2 points

Answer Sheet

Score = _____

Rating: _____

Name: _____Date: _____

Information sheet - 3	Replacing or correcting defective components or parts without damage

3.1. Repair

Repair is any activity which returns the capability of an asset that has failed to a level of performance equal to, or greater than, that specified by its Functions, but not greater than its original maximum capability. An activity which increases the maximum capability of an asset is a modification.

Hence the term repair does not reflect the actual but only the time duration consumed to perform the corrective action. Based on the time the repair may be minor one like adjustment of fasters, adjustment of belt tension, etc, or major one like un conditioning the bed surfaces, guide ways and cleaning of bearings etc. To create maintenance scheduling program, the various maintenance activities may be classified into four categories which are as follows:

- Inspection
- Minor Repair
- Medium or major and
- Overhauling Repair cycle

The repeated performance of all/ some of the above mentioned activities in sequence between successive overhauling is termed as Repair cycle”

It is clear that first an inspection activity is scheduled followed by minor/major repair activities. Then an inspection takes place followed by a major repair. Again a second inspection is followed by major repair.

Like this is goes and completes one repair cycle the set of these activities between two consecutive. Overhauling is defined as a repair cycle. This typical repair cycle covers three inspection and two minor and major repair activities.

3.2. Repairable

Repairable parts are parts that are deemed worthy of repair, usually by virtue of economic consideration of their repair cost. Rather than bear the cost of completely replacing a finished product, repairable typically are designed to enable more affordable maintenance by being more modular. This allows components to be more easily removed, repaired, and replaced, enabling cheaper replacement. Spare parts that are needed to support condemnation of repairable parts are known as replenishment spares.

A rotable pool is a pool of repairable spare parts inventory set aside to allow for multiple repairs to be accomplished simultaneously. This can be used to minimize stock out conditions for repairable items.

3.3. Consumable

Parts that are not repairable are considered consumable parts. Consumable parts are usually scrapped, or "condemned", when they are found to have failed. Since no attempt at repair is made, for a fixed mean time between failures (MTBF), replacement rates for consumption of consumables are higher than an equivalent item treated as a repairable part.

Because of this, consumables tend to be lower cost items.

Because consumables are lower cost and higher volume, economies of scale can be found by ordering in large lot sizes, a so-called Economic order quantity. If a product or service you buy fails to meet a consumer guarantee, you have the right to ask for a repair, replacement or refund.

If the business fails to give you a free repair within a reasonable time or cannot fix your problem, you can:

- Get it done elsewhere and pass on the costs to the business
- Ask for a replacement
- Ask for a refund
- Recover compensation for the drop in value below the price paid.

3.4. Objectives of Replacement

The primary objective of replacement is to direct the organization towards profit maximization or cost minimization. Deciding the replacement policy that determines the optimal replacement age of equipment, instead of using with higher maintenance costs for long time, is the main objective of replacement problem. For instance, in order to replace an:

- Item whether to wait till its failure or replacing at an early age with higher cost.
- Equipment whether to replace the inefficient equipment with a similar type of equipment or with a modern one.

The replacement situation arises due to the following reasons:

1. Weak performance of the existing equipment and needs expensive maintenance.
2. Failure of the existing equipment because of industrial accident or some other reason, or anticipating the failure of existing equipment soon.
3. Availability of mechanized or fully automated modern equipment with better design, made the existing equipment outdated.

The equipment, whose efficiency gradually decreases according to their age, requires paying out more money towards running cost, and scrap etc., Therefore, the only alternative way to prevent such increased expenses is the replacement of old equipment with new one.

Consumable parts need to be replenished from outside suppliers, whereas repairable items are sent to a repair shop. Repairable parts are usually repaired by replacing one or more lower level parts. These lower level parts are called Shop Replaceable Units. They can either be consumable or repairable or need to be replenished from external suppliers/repair shops or an internal repair shop, respectively.

Self check 3	Written Test

Directions: Choose the answer for the following questions listed below.

1. The various maintenance activities to create maintenance scheduling program are:
    A. Inspection
    B. B. Minor Repair
    C. C. Medium or major and
    D. D. Overhauling Repair cycle
    E. E. All
2. The primary objective of replacement is to direct the organization towards profit maximization or cost minimization. (True/False)

.

Note: Satisfactory rating – 2 and above points, Unsatisfactory - below 2 points

Answer Sheet

Score = _____

Rating: _____

Name: _____Date: _____

Information sheet - 4	Making adjustments where necessary.

4.1. The Principle of Air Conditioning and Components.

The Trainer uses a heat pump split air conditioner, whose main components are compressor, pressure gauge, four-way valve, evaporator, condenser, sight glass, strainer, capillary, air conditioning valves, accumulator, control valves and so on.

The air conditioner system diagram is shown in Figure 24.

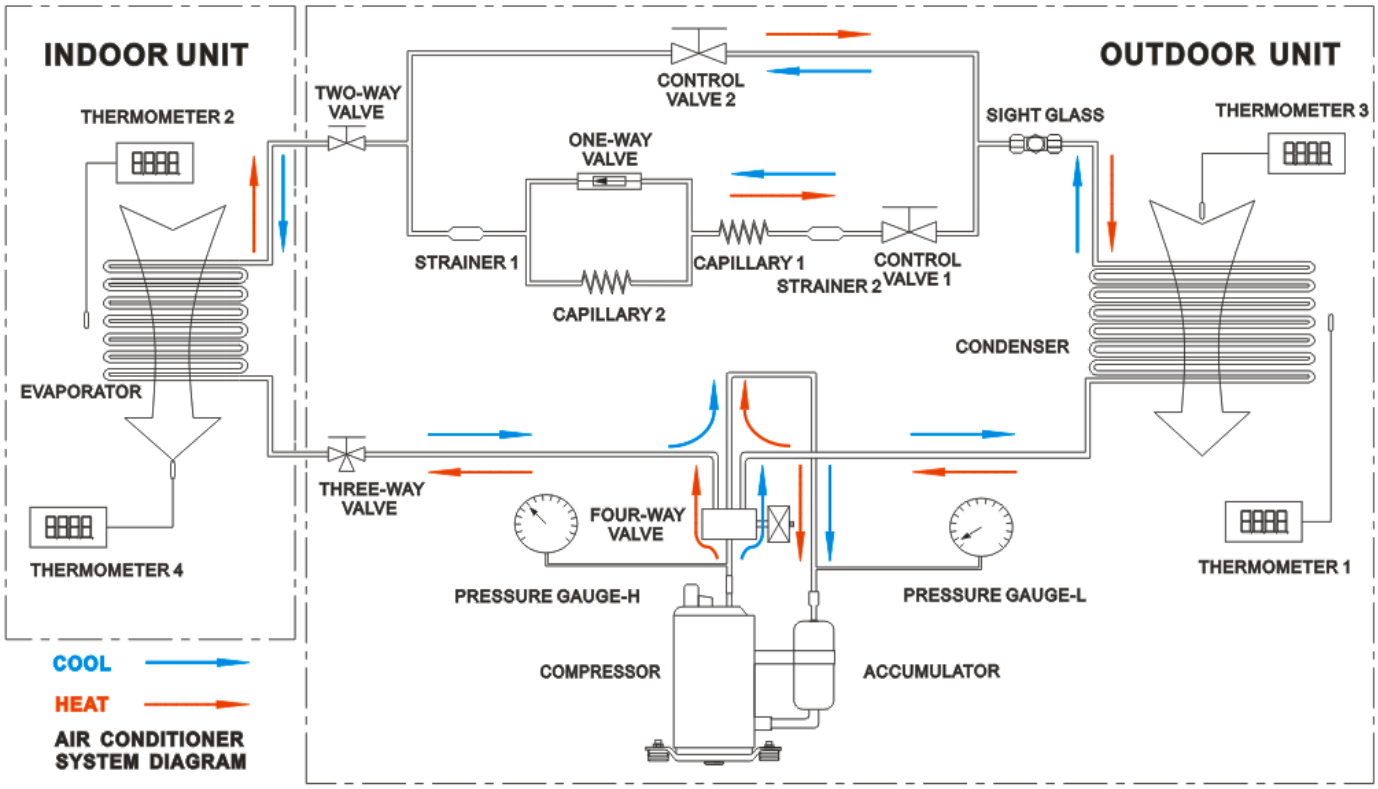


Figure 24. The flowchart of the air conditioning system

A heat pump is basically a device that transfers heat from one substance to another substance.

The difference is that it can also reverse the refrigeration cycle to perform heating, as well as cooling, by reversing the functions of the two heat exchangers.

The operation of the refrigeration cycle changes depending on whether the unit is in cooling or heating mode.

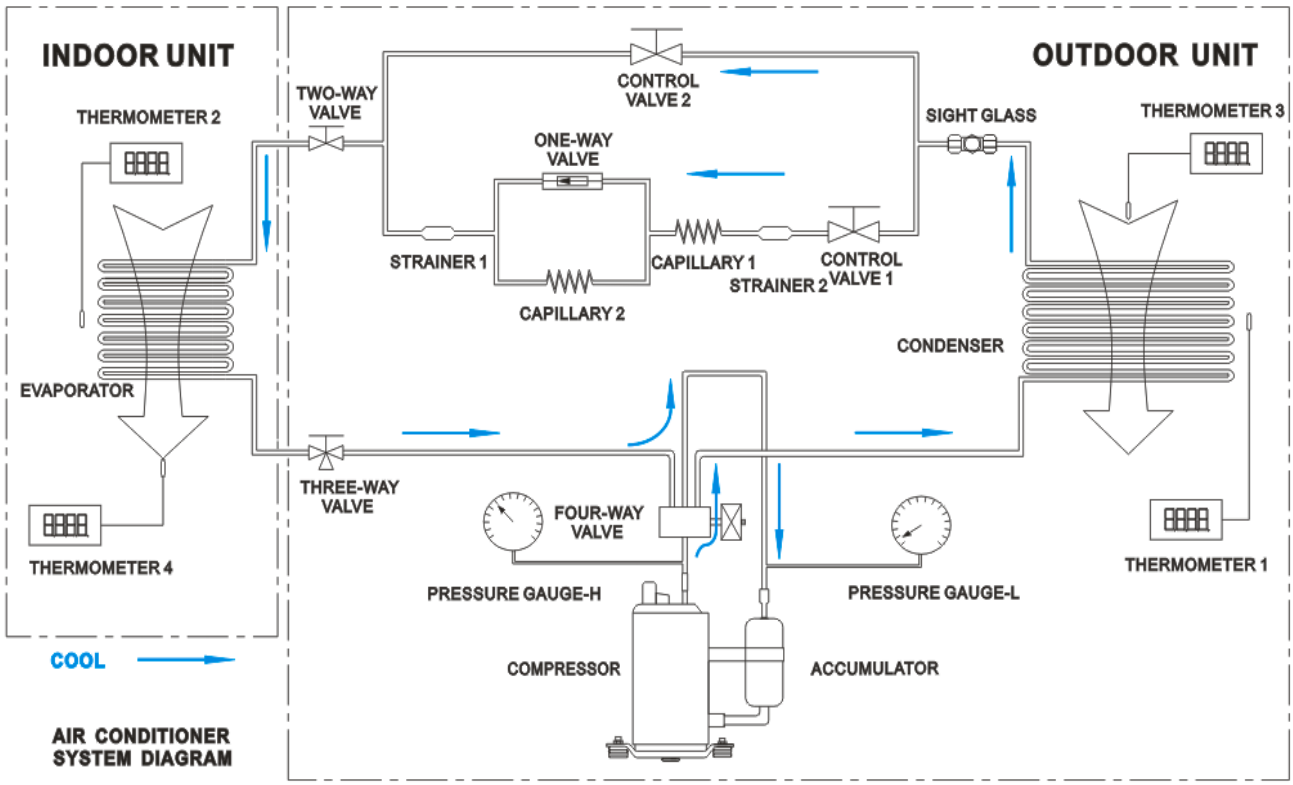


Figure 25. Air-conditioning system in cooling mode

High temperature, high-pressure vapor is pumped from the compressor to the outdoor heat exchanger that, in the cooling mode, operates as the condenser.

Inside the outdoor heat exchanger, the refrigerant condenses into normal temperature and high-pressure liquid. When the control valve 2 is closed and the control valve 1 is open, the user can see the liquid flowing clearly through the sight glass.

The liquid passes through the control valve 1 and the strainer 2, then the liquid refrigerant flows pass through capillary 1 that reduces the pressure and the temperature of the refrigerant.

The resulting mixture of cool liquid and vapor (normal temperature and low-pressure liquid) passes through the one-way valve and strainer 1, and then travels to the indoor heat exchanger that, in the cooling mode, operates as the evaporator.

Inside the indoor heat exchanger, the refrigerant absorbs heat from the relatively warm air, cooling the air and causing the liquid refrigerant to boil.

The resulting refrigerant vapor (or low temperature and low-pressure vapor) is then pumped back to the compressor, which increases its pressure and temperature to repeat the cycle.

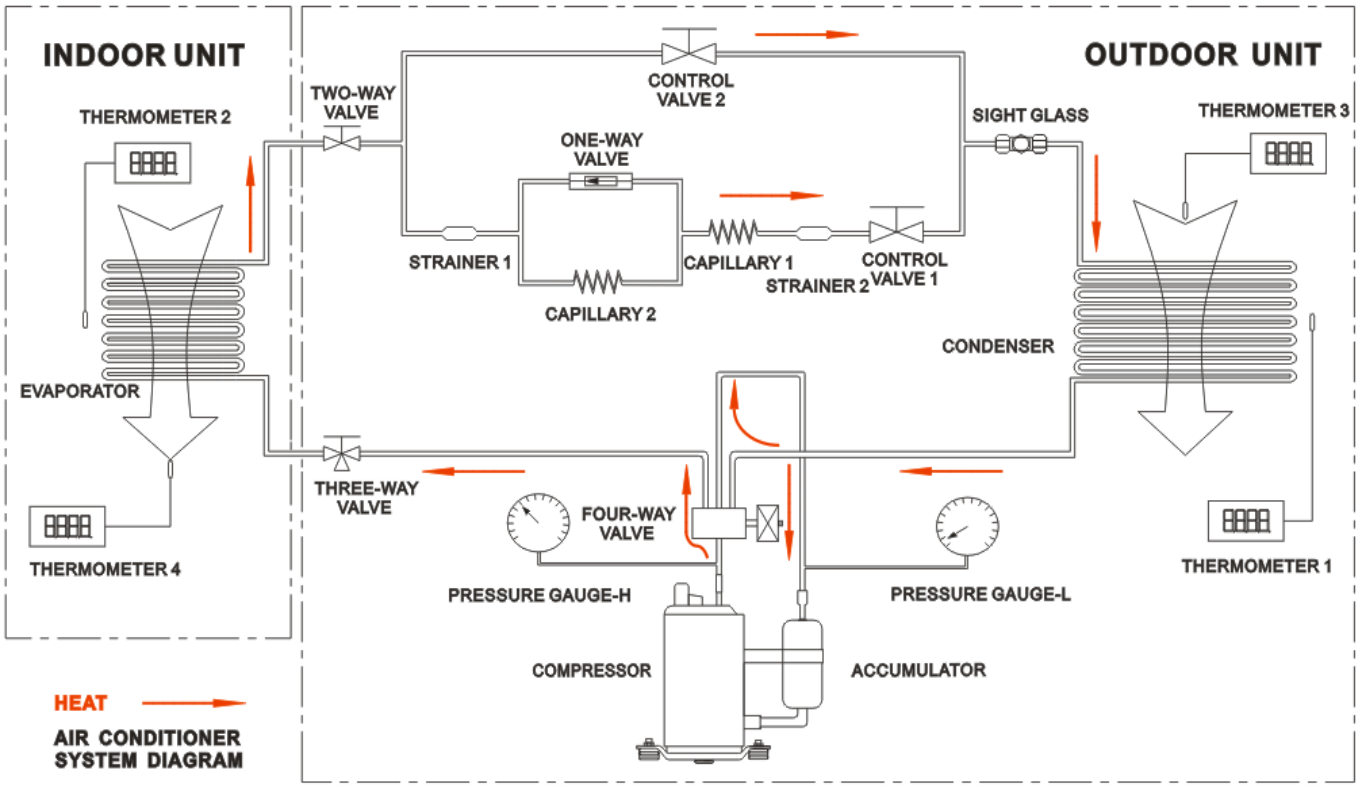


Figure 26. Air-conditioning system in heating mode

A heat pump includes a four-way valve that allows it to also operate in the heating mode. In the heating mode, high temperature, high-pressure vapor is pumped from the compressor and diverted by this reversing valve to the indoor heat exchanger.

In the heating mode, this heat exchanger operates as the condenser and heat is transferred from the refrigerant vapor to the lower temperature air.

The air is heated and the refrigerant condenses into normal temperature and high-pressure liquid.

The control valve 2 is closed and the control valve 1 is open.

The liquid passes through the strainer 1 and is filtered, the liquid refrigerant then flows through the capillary 2 and the capillary1 to reduced pressure and throttle.

The low temperature and low-pressure liquid passes through the strainer 2 and the control valve 1 and through the sight glass you can see the liquid flow.

Then, the liquid travels to the outdoor heat exchanger that, in the heating mode, now operates as the evaporator. Inside the outdoor heat exchanger, the refrigerant absorbs heat from the relatively warm air, causing the liquid refrigerant to boil.

The refrigerant vapor (or low temperature and low-pressure vapor) travels back through the reversing valve to the compressor to repeat the cycle. The reversing valve, piping, and controls inside the heat pump allow it to perform both cooling and heating functions.

Note: *when the air conditioner is operating, control valve 1 and control valve 2 must be open; before using, read the Safety Manual carefully.*

4.2. The Main Components of the Air Conditioner

- **Compressor**

The compressor is the most important component of the air conditioner. The compressor operates through compressing and passing the refrigerant. A rotary compressor is used in the system. Compressor, just as its name implies, converts refrigerant gas states with high pressure.

The compressor introduces the outside energy for the cooling or heating cycle. In the air conditioning system, compressors work to keep the pressure in the pipeline. Without it, the system cannot run the refrigeration cycle.

Figure 27. Compressor

- **Condenser**

The refrigerant part with its heat absorbed from the evaporator and the waste heat produced during the operation of the compressor. The heat is released into the open air and the overheat vapor from the compressor is condensed into overcool liquid.

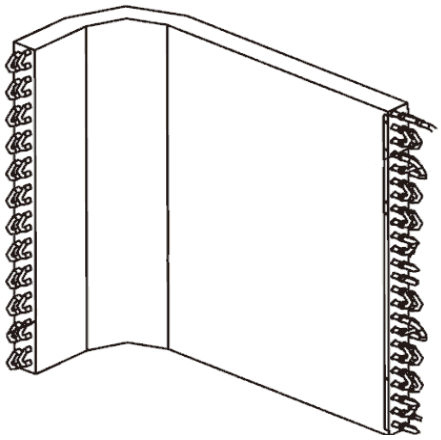


Figure 28. Condenser

- **Outdoor unit of air conditioner**

The condenser is installed in the interior of the outdoor unit.

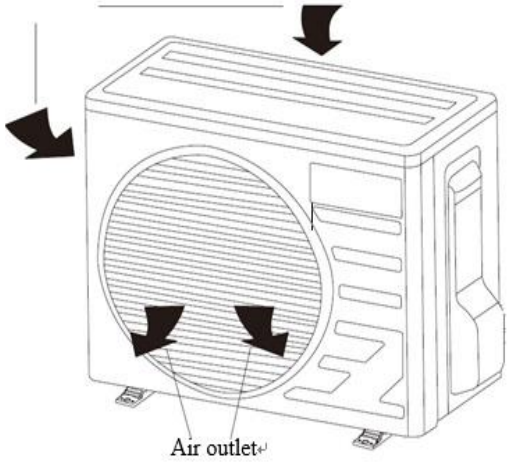


Figure 29. Outdoor unit of the air conditioner

- **Evaporator**

The evaporator is a device in which the environment evaporates while absorbing heat from the inner compartment. The condenser and the evaporator have similar structure. They are in a row of bending around the pipeline full of heat with metallic flake to realize the outside air pipe heat exchanger with the material of the device.

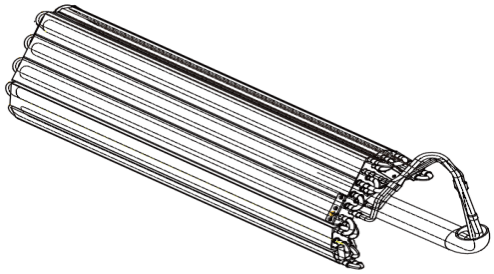


Figure 30..Evaporator

Figure 31. Capillary

Figure 32. Four-way valve

Figure 33. Sight glass

Figure 34.Accumulator

Self-check 4	Written Test

Directions: For the following questions, say TRUE if the statement

is correct and FALSE if it is incorrect (wrong).

1. A heat pump is basically a device that transfers heat from one substance to another substance.
2. Inside the indoor heat exchanger, the refrigerant absorbs heat from the relatively cold air.
3. The evaporator is a device in which the environment evaporates while absorbing heat from the inner compartment.
4. The compressor is the most important component of the air conditioner.
5. A heat pump includes a four-way valve that allows it to also operate in the heating mode.

Note: Satisfactory rating – 3 and above points, Unsatisfactory - below 3 points

Answer Sheet

Score=_____

Rating:_____

Name:_____Date:_____

Information sheet - 5	Responding unplanned events.

5.1. Responding unplanned events or conditions

It is essential that the unconditioned events observed in the following aspects:

- demonstrate knowledge of the Entertainment and Events Technology equipment and associated disconnection, storage and cleaning requirements
- determine work requirements and plan and organize work to fulfill such requirements
- identify, select and use tools, equipment and material to complete tasks to specifications
- disconnect equipment and cables safely and in accordance with specifications
- handle material and equipment safely
- identify and report problems promptly and handle them as directed
- prepare equipment and storage site
- complete cleaning and storage related tasks in accordance with health and safety procedures
- Perform inspection and quality checks - interpret and apply technical information to work activities
- demonstrate compliance with Occupational Health and Safety regulations applicable to workplace operations
- show compliance with organizational quality procedures and processes within the context of disconnecting, cleaning and storing Entertainment and Events Technology equipment
- Interactively communicate with others to ensure safe and effective operations.

Self-check: 5	Written test

Name ……. Date……..

Direction:

Say true if the sentence is correct and say false if the statement is incorrect

1. Interactively communicate with others to ensure safe and effective operations is available if unplanned condition is happen.
2. Perform inspection is available to responding unplanned events.

Note: Satisfactory rating - 2 points, Unsatisfactory - below 2 points

Answer Sheet

Score=_____

Rating:_____

Name:_____Date:_____

Operation title1: - The Air Conditioner Refrigerating Faults.

Purpose	• To familiarize with the air conditioner refrigerating principle. • To learn the method of solving the air conditioner refrigerating faults.
Equipment ,tools and materials	Supplies and equipment needed or useful for the air conditioner refrigerating faults : • DL TMAC10GR Trainer Model Air Conditioner • D4 wire cables
Conditions or situations for the operations	• Make sure that there is no fault in the fault insertion unit. • The air conditioning cooling and heating faults must be set respectively. • If you cut off the power supply, wait for more than five minutes, then you can power on the trainer. • Every air condition refrigerating fault should not run for more than 30 seconds. After the experiment, quickly restore the normal operation of the air conditioning state. • During the experiment. If there is something wrong, quickly cut off the power supply.
Procedures	**Step1.** Before the trainer is powered on, use the D4 wire cables to connect the components in the connection area correctly. **Step2**. Turn up the RCCB and turn on the Key-Switch, then the trainer is powered on and in standby mode. Record the measurement data of AC voltmeter, AC ammeter, four thermometers and two vacuum pressure gauges. **Step3.** Use the remote control to set the trainer in cooling mode. After 5 minutes, record the measurement data of AC voltmeter, AC ammeter, four thermometers and two vacuum pressure gauges.. **Step4.** To simulate a capillary blockage, close the control valve 1 for one minute and then record all the measurement data of the instruments, then open the control valve 1.
Precautions	• Before the experiment, trainers must read the User Manual, the Safety Instructions, the Experimental Instructions, the Installation Manual. • Before the trainer is powered on, open the control valve 1 and the control valve 2 and make sure that the air inlet and air outlet are not blocked.
Quality criteria	• In normal operating conditions. If the value of the pressure gauge-H is above 3.0MPa, quickly cut off the power supply, and if the value of the pressure gauge-L is above 1.5MPa, cut off the power.

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary tools and materials you are required to perform the following task within 2 hrs.

Task 1: Record the testing results of the Air Conditioner Refrigerating by doing the experiment indicated on the above operation title.

	AMMETER/A	VOLTMETER/V	Temperature/℃				Pressure/P	
			Compensator	Evaporator	Outdoor Air Inlet	Indoor Air Outlet	High pressure side	Low pressure side
standby state								
20min after the trainer is powered on								
capillary blockage								

LG #53	LO # 4 Test the corrected Mechatronics system
Instruction sheet	

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

- Testing Mechatronics system and associated equipment.
- Checking Mechatronics system and associated equipment.
- Responding unplanned events or conditions.
- Preparing/completing report/s.

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:

- Test Mechatronics system and associated equipment.
- Check Mechatronics system and associated equipment.
- Respond unplanned events or conditions.
- Prepare/complete report/s.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them
4. Accomplish the “Self-checks” which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets
7. Perform “the Learning activity performance test” which is placed following “Operation sheets” ,
8. If your performance is satisfactory proceed to the next learning guide,
9. If your performance is unsatisfactory, see your trainer for further instructions or go back to “Operation sheets”.

Information sheet- 1	Testing Mechatronics system and associated equipment.

1.1. Tests without Operation of the Mechatronics Systems

If repairs are carried out during or after completion of a commissioning test, the affected partial sections of the instrumentation and control systems important to safety shall be subjected to renewed overlapping tests .

1.1.1. General requirements

The tests of the instrumentation and controls without operation of the process-engineering systems shall be performed as two partial tests, namely, the visual inspections and the function tests.

1.1.1.1. Visual inspections

- At the beginning of the tests without operation of the process-engineering systems, visual inspections of the instrumentation and control systems important to safety shall be performed both in the test field and in the power plant on the basis of the documents design-reviewed by the authorized expert.
- With these inspections it shall be verified that a correct functioning can be expected on the basis of the layout of the instrumentation and control equipment taking into account the arrangement of the other power plant components (e.g., the mechanical and electrical components, the ventilation and air filtration systems), and that maintenance possibilities are provided.

Test criteria include:

- ✓ Completed fabrication and component assembly and software implementation in accordance with the configuration and identification documentation of that part of the instrumentation and control equipment to be tested,
- ✓ Physical integrity of that part of the instrumentation and control equipment to be tested,
- ✓ Suitable construction with regard to the function of the mechanical parts of the measurement assemblies (e.g., sensors, sampling lines, transducers),
- ✓ Comprehensive marking of all devices, modules and cabinets and their correct allocation to the redundancy groups,

- ✓ Protection against mechanical impacts (e.g., resulting from maintenance work in the plant) of that part of the instrumentation and control equipment to be tested, and
- ✓ Accessibility of the devices, modules and measurement assembly arrangements with regard to tests, servicing and repairs.

- The visual inspections shall not be carried out before all accompanying tests of those parts of the instrumentation and control systems important to safety to be tested are completed, and not before the assembly tasks in the compartments accommodating the instrumentation and control equipment to be tested has reached a stage where further assembly tasks can no longer have any detrimental effects on the systems tested with respect to the test criteria specified

1.1.1.2. Function tests

- The function tests shall be carried out at the final location of installation and shall verify that the instrumentation and control equipment fulfills the functions specified in the documents design-reviewed by the authorized expert (e.g., overview diagrams, functional diagrams, circuit diagrams, measuring circuit data sheets, functional descriptions, specifications, explanatory reports).
- Integration tests shall be performed with the instrumentation and control equipment of the power plant (e.g., process computer, hazard alarm facility, control room displays, feedback signals).
- The function tests shall normally be performed together with the mechanical and electrical components by checking the feed-back signals from actuators, solenoids and circuit breakers created when triggering the components. The process- engineering systems do not need to be in operation for these tests. In the case of media-derived signals (e.g., pressure, flow) the physical values may be created by auxiliary testing aids.
- The characteristics specified for the system shall be checked. This shall include checking
- Those wiring and function tests of system parts which have already been carried out in the test field as well as any integral system tests already performed do not have to be repeated at the final location of installation, provided.

Self check 1	True/false

Directions: Write TRUE if the statement is correct and write FALSE if the statement is wrong. (1pt. each)

1. Visual inspections of electrical instruments should be performed as part of maintenance.
2. Visual inspections conducted before installation during periodic routine maintenance
3. The function tests shall be carried out at the final location of installation.
4. Without operation of the process-engineering systems, visual inspections and the function tests are the two partial tests.
5. Physical integrity of that part of the instrumentation and control equipment to be tested is not important.

Note: Satisfactory rating – 3 and above points , Unsatisfactory - below 3 points

Answer Sheet

Score = _____

Rating: _____

Name: _____Date: _____

Information sheet 2	Checking Mechatronics system and associated equipment

2.1. Belt Conveyor with PLC

The DL 2122PB mainly simulates a small assembly line.

All devices are common industrial devices, mainly including S7-200SMART series CPU, pneumatic components, sensors, control buttons and so on. The integrated structure design is adopted in the experimental equipment, with all the devices being distributed on the sheet metal platform. The users can see almost all the devices intuitively, so that it is easy to research and study.

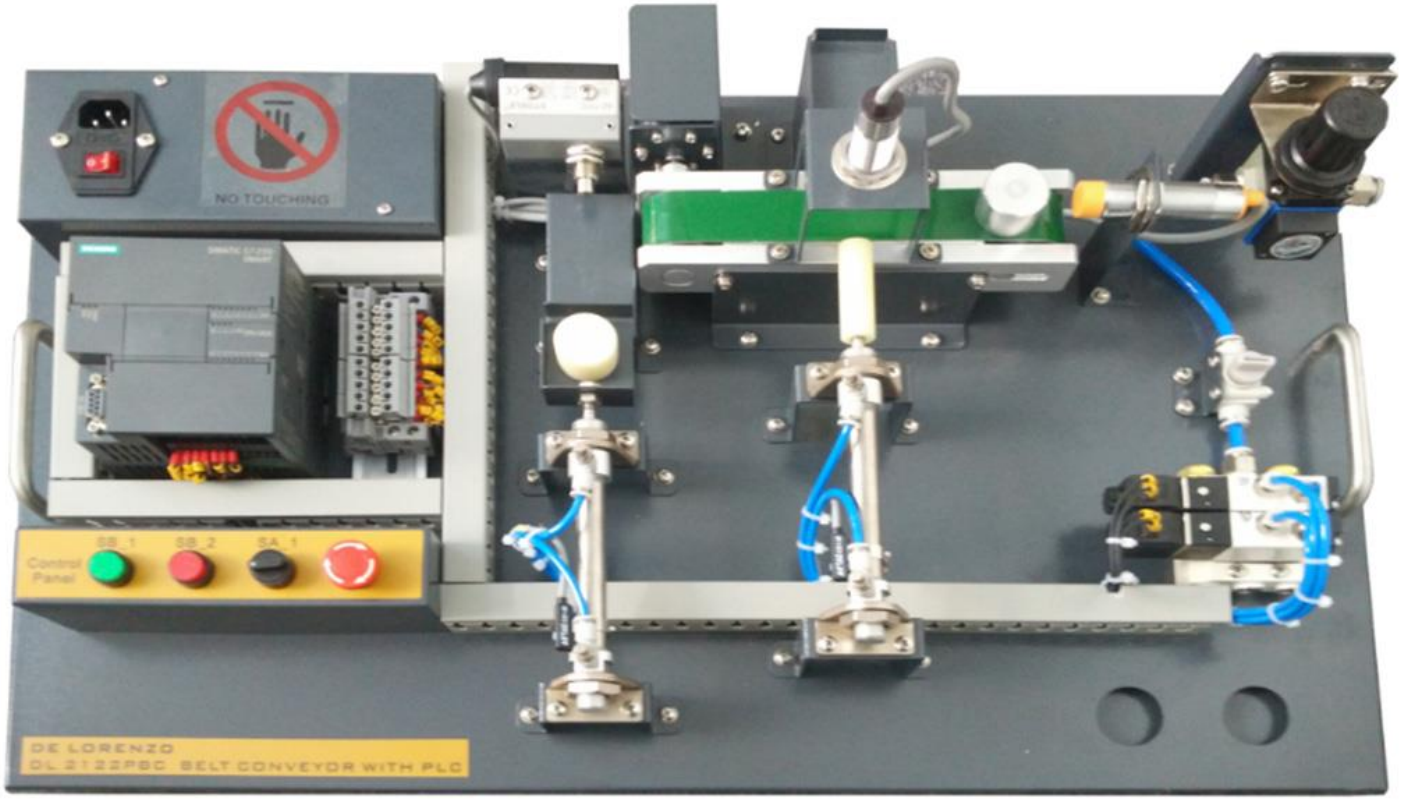


Figure 35. Belt Conveyor Trainee's Module

2.2. Function of the DL 2122PBC Belt Conveyor with PLC

2.2.1. Function of the Laboratory Box

According to the function, the DL 2122PBC Belt Conveyor with PLC is divided into five function areas. The introduction of the five function areas is mentioned below.

1. **The Power Supply Interface** of the DL 2122PBC is a one-in-all socket, which includes power supply socket, power supply switch and fuse holder.
2. **CPUSR20**:- A CPU can communicate with a STEP 7-Micro/WIN SMART programming device on an Ethernet network.
3. **The Control Panel**:- The Control Panel is mainly used for the operation control of the DL 2122PBC, including two self-reset buttons, SB_1 and SB_2, one selection switch, SA_1, and one emergency stop button.

Figure36. Control Panel

4. **Final execution part** of DL 2122PBC, which includes: - DC motor, cylinder, solenoid valve, transmission mechanism and so on.

- **DC motor**

The DC motor is the power source of the transmission structure.

Figure 37. DC motor and cylinder

- **Transmission Mechanism**

The transmission mechanism is fixed on the experimental platform, used for the transmission of materials, and through the drive of the DC motor the material is conveyed to the required position. It is an important link between the experimental systems.

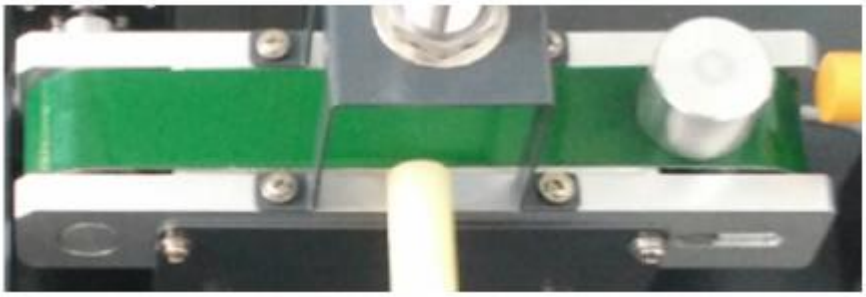


Figure 38: transmission mechanism

- **Sensor**

The DL 2122PBC has applied many kinds of industrial sensors, including inductance sensors, capacitive sensors, stroke switches, reed sensors and so on.

- ***Inductance sensor***

The inductance sensor uses the electromagnetic induction to convert the measured physical quantity such as displacement, pressure, flow, vibration etc. into coefficient variation of self inductance and mutual inductance of the coil, and then through the circuit to convert into voltage or current to realize the conversion of non-electric quantities to electric quantities. The DL 2122PBC uses the inductance sensor to distinguish between metal material and nylon material. The sensor is normally open, with three-wire system, and the tail is equipped with indicator light.

When the metal material is in the sensor detection range, the tail indicator light will light on.

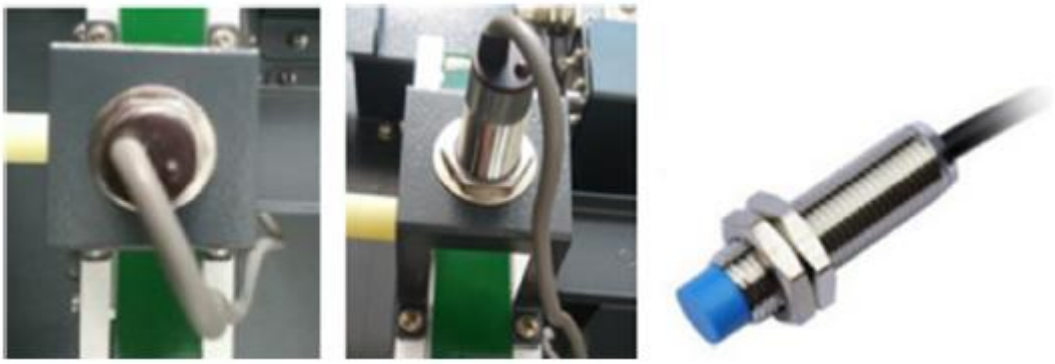


Figure 39. Inductance sensor

- ***Capacitive sensor***

Capacitive sensors are made of various types of capacitors as sensing elements and of a conversion device that converts the measured physical or mechanical quantity into capacitance changes, which is actually a capacitor with variable parameters.

Capacitive sensors are widely used in displacement, angle, vibration, velocity, pressure, component analysis, dielectric characteristics and other aspects of measurement. The most commonly used are parallel plate capacitors or cylindrical capacitors. The DL 2122PBC uses capacitive sensors to detect whether there are materials. The sensor is normally open, with three-wire system, and the tail is equipped with indicator light and adjusting button. When the metal material is in the sensor detection range, the tail indicator light will light on and the adjusting button is rotated to adjust the sensing distance.

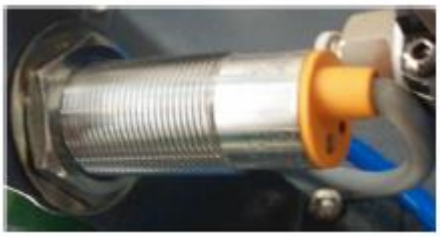


Figure 40. Capacitive sensor

Capacitive sensors are able to detect most materials at distances up to a few centimeters.
We know that

$$capacitance = \frac{Area\ of\ plates\ \times dielectric\ constant}{distance\ between\ plates\ (\ electrodes)}$$

In the sensor the area of the plates and distance between them is fixed. But, the dielectric constant of the space around them will vary as different material is brought near the sensor.

- ***Stroke switch***

The stroke switch, a kind of position switch (also known as limit switch), is a commonly used low current master device. It uses the collision of the mechanical moving parts to make the contact act in order to realize the connecting or breaking control circuit, so as to achieve certain control purpose. In general, such switches are used to limit the position or stroke of a mechanical movement, achieve the self-stop movement, reverse movement, variable motion, and automatic round trip movement etc. of moving machinery in a certain position or stroke.
The DL 2122PBC applies a stroke switch to limit the groove position.

Figure 41. Stroke witch

- ***Reed sensor***

✓ Its basic pattern is to seal two pieces of magnetic reed in the glass tube, while the two pieces overlap, but there is a small space between them. When the external magnetic field makes the two reeds contact, it conducts. Once the magnet is pulled away from the switch, the reed switch will return to its original position.

✓ The DL 2122PBC applies the reed sensor to detect the position of the cylinder.

Figure 42. **Reed sensor**

The two wire reed switch consists of two reeds. One of reed is connected to positive terminal of electric supply and other is connected to signal output. The three wire reed wire consists of three reed contacts. One is connected to positive terminal of electric supply. Second one is connected to negative terminal of the electric supply and third one is connected to the signal output. Symbol of the three wire reed switch and two wire reed switch is shown in Figure 43.

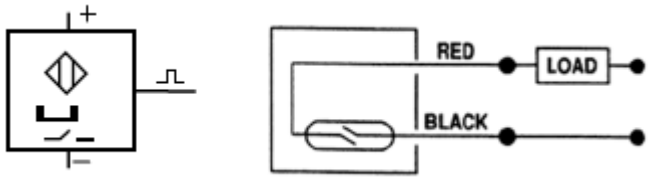


Figure 43: **Symbol of 3 wire and 2 wire reed switch**

- **Pneumatic components**

The DL 2122PBC applies the cylinder, solenoid valve group, inlet and outlet gas control valve, pressure control valve, throttle switch etc. to complete the push operation of the material.

- ***Pressure control valve***

One end of the pressure control valve is connected to an air compressor and the other is connected to a gas equipment, and the inlet air pressure is regulated according to the working pressure of the gas equipment, thereby ensuring the stability of the gas equipment and the whole gas utilization system. The gas equipment in DL 2122PBC is a cylinder, whose maximum working pressure is no more than 0.7MPa. So, in order to ensure the normal operation of the cylinder, it is generally set to 0.4-0.6MPa.

Adjustment method:

First, raise the black knob cap of the pressure control valve up, and then slowly rotate clockwise, while observing the dial. The pressure rises gradually. Stop rotating and press the knob cap, when the pressure is between 0.4-0.6MPa. Adjustment is completed.

If the pressure is too high, you can rotate it counterclockwise and the pressure will reduce.

Note: Turn off the throttling switch before adjusting the pressure. For throttling switches, see the “throttle switch” section.

Figure 44. **Pressure control valve**

- ***Throttle switch***

The throttle switch is a limit switch that controls the flow of air and opens or closes the switch according to the demand of the gas.

Figure 45. Throttle switch

Application method:

The throttle switch is on the open position in the diagram above, and the gas can get through the switch. Pinch the handle to counterclockwise rotate 90° and the throttle switch is closed, through which the gas cannot get.

- ***Solenoid valve group***

The solenoid valve group is composed of a solenoid valve, a base, a silencer, a plug head and a trachea rapid interface. The user connects the solenoid valve into the gas path to drive the cylinder by hand or by electric means.

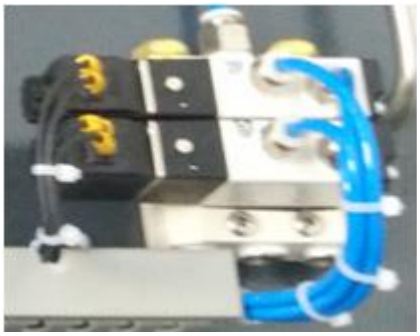


Figure 46. Solenoid valve group

- ***Cylinder***

A complex type with magnet cylinder is used in DL 2122PBC, whose bore is 12mm and stroke is 60mm. A reed sensor can be used to monitor its position. Both the intake and outlet of the cylinder are equipped with throttle valves. The user can adjust the inlet and outlet of air according to the actual demand, so as to control the speed of the cylinder.

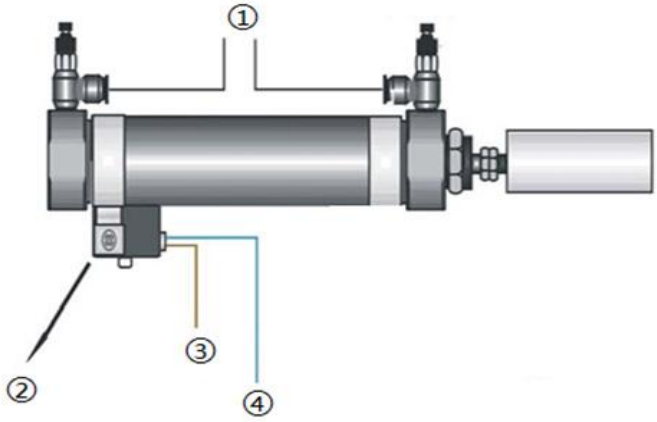


Figure 47.Cylinder

① Throttle valves

② Reed sensor, retraction limit of the cylinder

③ Brown wire, sensor’s positive

④ Blue wire, sensor’s negative

5. The DL 2122PBC is assembled based on the sheet metal platform, which is equipped with 2 handles easy to extract and move. Its bottom is equipped with rubber pads to ensure the stability of the platform and also to protect the desktop from scratch.

Self check 2	True/false

Directions: Write TRUE if the statement is correct and write FALSE if the statement is wrong.

1. Reed switches are magnetically actuated proximity switches.
2. Capacitive sensors are able to detect most materials at distances up to a few meters.
3. Another factor which affects the sensing range of inductive sensors is the diameter of sensing coil.
4. Inductive sensor uses currents induced by magnetic field to detect the nearby metal objects.
5. The two wire reed wire consists of three reed contacts..

Note: Satisfactory rating – 3 and above points , Unsatisfactory - below 3 points

Answer Sheet

Score = _____

Rating: _____

Name: _____Date: _____

Information sheet 3	Responding unplanned events or conditions.

3.1 How to respond to unplanned events.

In order to know how to respond to unplanned events or conditions, one must first start in assessing or analyzing the situation. The first response should not be making an action right away, but thinking of the situation and possible solutions. After fully understanding the situation and listing down possible solutions, it's time to take action by trying all possible means to cope with the changes or unexpected events

3.2 Unconditioned events

It is essential that the unconditioned events observed in the following aspects:

- demonstrate knowledge of the Entertainment and Events. Technology equipment and associated disconnection, storage and cleaning requirements
- determine work requirements and plan and organize work to fulfill such requirements
- identify, select and use tools, equipment and material to complete tasks to specifications
- disconnect equipment and cables safely and in accordance with specifications
- handle material and equipment safely
- identify and report problems promptly and handle them as directed
- prepare equipment and storage site
- complete cleaning and storage related tasks in accordance with health and safety procedures
- Perform inspection and quality checks - interpret and apply technical information to work activities
- demonstrate compliance with Occupational Health and Safety regulations applicable to workplace operations

Self check 3	Written test

Directions: For the following questions, say TRUE if the statement is correct and FALSE if it is incorrect (wrong).

1. Assessing or analyzing the situation is not the first response to know the respond of unplanned events.
2. Perform inspection is available to responding unplanned events.
3. Unconditioned events observed in the handle material and equipment safely.

Note: Satisfactory rating – 2 and above points, Unsatisfactory - below 2 points

Answer Sheet

Score = _____

Rating: _____

Name: _____Date: _____

Information sheet - 4	Preparing/completing report/s.

4.1 Work report

A work report is a formal document that discusses information about a specific topic related to an aspect of your job. Most work reports are addressed to a particular audience such as a manager. There are a variety of reports that may need to be written at work, including sales reports, daily reports, budget reports and business data analysis reports. Depending on the type, you may be given a report brief that outlines what you should include in your report. Most reports should be written in a structured format to clearly demonstrate what the report is trying to convey.

4.2 How to write a work report

Writing effective work reports takes practice and requires good communication skills. The more reports you write, the more efficient you will be in composing them. The following are steps you can take to write a professional report in the workplace:

1. Identify your audience.
2. Decide which information you will include.
3. Structure your report.
4. Use concise and professional language.
5. Proofread and edit your report.

4.3 Structure your report

When writing a report, you should structure it so that it can be easily read and digested. While each report will vary in the sections you should include, you can use the following report components as a guide when writing your report:

1. Title or title page
2. Executive summary/abstract that briefly describes the content of your report
3. Table of contents (if the report is more than a few pages)
4. An introduction describing your purpose in writing the report.
5. A body paragraph where you include the information you are conveying with the report
6. Conclusion or recommendation depending on the purpose of the report

4.4 Equipment Maintenance Documentation

Equipment documents and records are an essential part of the quality system. The policies and procedures for maintenance should be defined in appropriate documents, and keeping good equipment records will allow for thorough evaluation of any problems that arise. Each major piece of equipment will have its own equipment maintenance document. Smaller, commonly used equipment such as centrifuges and pipettes may be managed with an equipment maintenance document or manual that deals with all such equipment in the laboratory.

An equipment maintenance document should include:

- Step-by-step instructions for routine maintenance, including frequency of performance, and how to keep records of performance;
- Instructions for carrying out function checks, frequency of performance, and how to record the results;
- Directions for calibrating the instrument;
- Guide for troubleshooting;
- Any required manufacturer's service and repair;
- List of any specific items needed for use and maintenance, such as spare parts.

For major equipment, include identification of the specific instrument, and perhaps information on its performance.

4.5 Work report template

The following is a template you can use when formatting a work report:

[Project name]
[Date]
[Prepared by: your first and last name]
[Company name]

[**Executive summary or abstract:** Use this section to note your conclusions or recommendations that will be made in the report. You should also include the most important ideas discussed in the report. If you are writing a daily work report or progress report, you do not need to include this section.]

[**Introduction:** Your introduction should be two to four paragraphs summarizing what you will cover in the report as well as your reason for writing the report. Be as specific and concise as possible when

writing your introduction so that the reader can clearly understand what they will find in your report. For daily or progress reports, your introduction only needs to be a few sentences detailing work you've completed and what you plan to work on next.]

[**Body:** For the body of your report, you should focus on detailing the information you wish to convey. You can include results, conclusions and findings that were made related to a project. For daily or progress reports, include the accomplishments you have achieved or tasks you have completed.]

[**Recommendations:** In this section, you should list your recommendations based on the conclusions or results of a project or that will solve a particular issue. For example, you may write "*spend one hour training employees on the new handbook each week*" as a recommendation. For a daily or progress report, you can list your next goals or tasks in this section.]

[**Conclusion:** Conclude your report by summarizing the findings or results discussed and reiterating the most important recommendations.]

Self-check 4	Written Test

Directions: For the following questions, say TRUE if the statement is correct and FALSE if it is incorrect (wrong).

1. The more reports you write, the more efficient you will be in composing them.
2. When writing a report, you should structure it.
3. Your report's introduction should be two to ten paragraphs.

Note: Satisfactory rating – 2 and above points, Unsatisfactory - below 2 points

Answer Sheet

Score=_____

Rating:_____

Name:_____Date:_____

Operation title1: - Wiring Measurement of the Sensor.

Purpose	• To master the wiring method of the sensor • To understand sensor's applications
Equipment ,tools and materials	Supplies and equipment needed or useful for the Wiring Measurement of the Sensor: • Inductance sensor • Capacitive sensor • Stroke switch • Reed sensor (left) • Reed sensor (right) • multimeter
Conditions or situations for the operations	• Make sure that there is no fault on measuring instrument.. • During the experiment, if there is something wrong, quickly stop the experiment.
Procedures	**Step1.** Find the inductance sensor on the experimental platform. **Step2**. Use the multimeter to measure the position of the terminals of the sensor. **Step3.** Find the capacitive sensor on the experimental platform **Step4.** Use the multimeter to measure the position of the terminals of the sensor. **Step5.**Find the stroke switch on the experimental platform. **Step6.** Use the multimeter to measure the position of the terminals of the stroke switch. **Step7.** Find the reed sensor on the experimental platform. **Step8.** Use the multimeter to measure the position of the terminals of the sensor.
Precautions	• Care should be taken while wiring measurement of the sensors. • Preparing materials, tools and equipment used for wiring measurement of the sensors.
Quality criteria	• Did personal protective equipment worn while wiring Measurement of the Sensors? • Did trainees explain different sensor's applications?

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary tools and materials you are required to perform the following task within 3 hrs.

Task 1: Record the testing results of the inductance sensor.

Task 2. Record the testing results of the capacitive sensor.

Task 3. Record the testing results of the stroke switch.

Task 4. Record the testing results of the reed sensor.

Testing Results

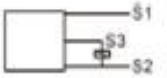
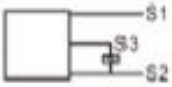
	Position of sensor	Diagram of sensor wiring	Connection position	
Inductance sensor				
Capacitive sensor				
Stroke switch		S1 / S2		
Reed sensor (left)		S1 / S2		
Reed sensor (right)				

Table 3-2. Fault simulation data

Module Title: Maintaining and Repairing Mechatronics Devices and Process Instrument

<u>Answer Key</u> to Corrections (for Learning Guides # 50-54)

<table>
<tr><th colspan="2">Learning Guide #50</th></tr>
<tr><td colspan="2">LG# 50, LO1, Information sheet (1-6)</td></tr>
<tr><td>Answers for self-check 1
a. Collect the Evidence
b. Analyze the Evidence
c. Locate the Fault
d. Determination and Removal of the Cause
e. Rectification of the Fault
f. Check the System</td><td>Answers for self-check 2
1. False
2. True
3. True</td></tr>
<tr><td>Answers for self-check 3
1. To evaluate and assess maintenance performance
2.
a. project management,
b. auditing,
c. diagnostic techniques,
d. management, benchmarking,
e. information management</td><td>Answers for self-check 4
1. False
2. True
3. False</td></tr>
<tr><td>Answers for self-check 5
1 False
2 True
3 False</td><td>Answers for self-check 6
1 True
2 True
3 False
4 True
5 False</td></tr>
</table>

Learning Guide #51

LG# 51, LO2, Information sheet (1-4)

Answers for self-check 1

1. C
2. E
3. A
4. B
5. D

Answers for self-check 2

1.

a. Reservoir vents ports.
b. Ingression during maintenance and topping of new liquid.
c. Degradation of hydraulic fluid.
d. Wear and scratch by existing particles

2.

a. Temperature Problems. ...
b. Fluid Levels and Quality. ...
c. Human Error

Answers for self-check 3

Directions: Answer the following Questions.

1.

a. protection,
b. detection, and
c. Recoverability."

Answers for self-check 4

1. C
2. D
3. A
4. E
5. B

2.. Step 1: List down the key risks. ... Step 2: Prioritize the Risks Based on Their Impact. Step 3: Create Contingency Plans for Each Event. Step 4: Share and Maintain the Plan.	

Learning Guide #52

LG# 52, LO3, Information sheet (1-5)

Answers for self-check 1	Answers for self-check 2
1. Goggle 2. Safety belt 3. Safety shoe 4. Glove 5. Ear plug	1. True 2. False 3. True
Answers for self-check 3 1. True 2. True	**Answers for self-check 4** 1. True 2. False 3. True 4. True 5. True
Answers for self-check 5 1. True 2. True	

Learning Guide #53

LG# 53, LO4, Information sheet (1-4)	
Answers for self-check 1 1. True 2. False 3. True 4. True 5. False	**Answers for self-check 2** 1. True 2. False 3. True 4. True 5. False
Answers for self-check 3 1. False. 2. True 3. True	**Answers for self-check 4** 1. True 2. True 3. False

List of Reference Materials

1. Alexandros Mouzakitis; Classification of Fault Diagnosis Methods for Control Systems
2. Lecture 41; Electro – Pneumatic Control
3. Cabral, J. P. S. (2006). Organização e Gestão da Manutenção, dos conceitos à prática...[Maintenance Management and Organization, from Concepts to Practice]. Lisbon, LidelPublishers
4. Patton R, Frank P, Clark R. *Fault Diagnosis in Dynamic Systems: Theory and Application. L*ondon: Prentice Hall International, 1989.
5. *F*rank PM. Fault diagnosis in dynamic systems using analytical and knowledge-based redundancy – A survey and some new results. *Automatica* 1990; 26(3): 459–74.
6. Isermann R, Balle P. Trends in the application of model based fault detection and diagnosis of technical processes. *Control Engineering Practice* 1997; 5(5): 709–19.

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