



## RQF LEVEL 5



### RENPH501 RENEWABLE ENERGY

## Pneumatic and Hydraulic Systems Installation

### TRAINER'S MANUAL

October, 2024



# PNEUMATIC AND HYDRAULIC SYSTEMS INSTALLATION



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## ACRONYMS

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**BOQ:** Bill of Quantity

**CBT/A:** Competency-Based Training and Assessment

**DCV:** Directional control Valve

**HVAC:** Heating Ventilation and Air Conditioning

**MSW:** Municipal Solid Waste

**PPE:** Personal Protective Equipment

**PTFE:** Polytetrafluoroethylene

**PVC:** Polyvinyl Chloride

**RTB:** Rwanda TVET Board

**TQUM Project:** TVET Quality Management Project

**TVET:** Technical and vocational education and training

## INTRODUCTION

This trainer's manual includes all the methodologies required to effectively deliver the module titled "**Pneumatic and hydraulic systems installation.**" Trainees enrolled in this module will engage in practical activities designed to develop and enhance their competencies.

The development of this training manual followed the Competency-Based Training and Assessment (CBT/A) approach, offering ample practical opportunities that mirror real-life situations.

The trainer's manual is organized into Learning Outcomes, which is broken down into indicative content that includes both theoretical and practical activities. It provides detailed information on the key competencies required for each learning outcome, along with the objectives to be achieved.

As a trainer, you will begin by asking questions related to the activities to encourage critical thinking and guide trainees toward real-world applications in the labor market. The manual also outlines essential information such as learning hours, didactic materials, and suggested methodologies.

This manual outlines the procedures and methodologies for guiding trainees through various activities as detailed in their respective trainee manuals. The activities included in this training manual are designed to offer students opportunities for both individual and group work. Upon completing all activities, you will assist trainees in conducting a formative assessment known as the end learning outcome assessment. Ensure that trainees review the key reading and the points to remember section.

## **MODULE CODE AND TITLE: RENPH501 PNEUMATIC AND HYDRAULIC SYSTEMS INSTALLATION**

**Learning Outcome 1: Perform pneumatic and hydraulic system pre- installation activities**

**Learning Outcome 2: Install pneumatics system**

**Learning Outcome 3: Install hydraulic system**

**Learning Outcome 4: Perform pneumatic and hydraulic post- installation activities**



### Indicative contents

- 1.1 Preparation of Workplace**
- 1.2 Selection of tools, materials and equipment**
- 1.3 Drawing of hydraulic and pneumatic system**
- 1.4 1.4 Simulating control and power circuits**

### Key Competencies for Learning Outcome 1: Perform Pneumatic And Hydraulic System Pre- Installation Activities

Knowledge	Skills	Attitudes
<ul style="list-style-type: none"> <li>● Description of pneumatic and hydraulic systems</li> <li>● Identification of workplace preparation policy and procedures applied in pneumatic and hydraulic systems</li> <li>● Identification of different types of tools, materials and equipment used in pneumatic and hydraulic systems</li> <li>● Identification of symbols used in pneumatic and hydraulic drawings</li> <li>● Description of the elements of bill of quantity</li> <li>● Identification of softwares used in simulation of pneumatic and hydraulic circuits.</li> </ul>	<ul style="list-style-type: none"> <li>● Setting the workplace</li> <li>● Selecting tools, materials and equipment</li> <li>● Drawing pneumatic and hydraulic circuits</li> <li>● Simulating pneumatic circuits</li> <li>● Simulating hydraulic circuits</li> </ul>	<ul style="list-style-type: none"> <li>● Being careful</li> <li>● Being cooperative ,flexible while setting the workplace</li> <li>● Having self-confidence while drawing pneumatic and hydraulic circuits</li> <li>● Being responsible</li> <li>● Being communicator</li> </ul>



**Duration: 25 hours**



**Learning outcome 1 objectives:**

By the end of the learning outcome, the trainees will be able to:

1. Describe clearly pneumatic and hydraulic system as used in fluid power systems
2. Identify clearly the workplace policy and procedures according to the workplace preparation policy and procedures
3. Set properly the workplace for pneumatic and hydraulic system installation as applied in workplace preparation
4. Identify properly tools, materials and equipment according to the types and use
5. Select clearly tools, materials and equipment according to the types and use
6. Identify correctly symbols used in pneumatic and hydraulic systems in accordance with pneumatic and hydraulic installation requirement and drawing technics
7. Draw properly Control and power circuit diagram in accordance with pneumatic and hydraulic installation requirement and drawing technics.
8. Identify correctly softwares used in simulation of pneumatic and hydraulic circuits.
9. Simulate correctly Control and power circuit diagrams of pneumatic system using simulation software
10. Simulate correctly Control and power circuit diagrams of hydraulic system using simulation software



**Resources**

<b>Equipment</b>	<b>Tools</b>	<b>Materials</b>
<ul style="list-style-type: none"> <li>● Reservoir</li> <li>● Pumps</li> <li>● Hydraulic valves</li> <li>● Filters</li> <li>● Hydraulic actuators</li> <li>● Compressors</li> <li>● Pneumatic valves</li> <li>● Accumulators</li> </ul>	<ul style="list-style-type: none"> <li>● Toolkit</li> <li>● Drawing instruments</li> <li>● Pens</li> <li>● Pencils</li> <li>● simulation software</li> </ul>	<ul style="list-style-type: none"> <li>● Oil</li> <li>● Hydraulic transfer hoses and fittings</li> <li>● Lubricant</li> <li>● Accessories</li> <li>● Cleaning clothes and brushes</li> <li>● Papers</li> </ul>

<ul style="list-style-type: none"> <li>● Air service unit</li> <li>● Pneumatic actuators</li> <li>● Piping and plumbing fittings and other accessories</li> <li>● Hydraulic flow</li> <li>● Portable electrical drilling machine</li> <li>● Manometer</li> <li>● Gauges</li> <li>● Computer</li> </ul>		
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**Advance Preparation:**

Before delivering this learning outcome, you are recommended to:

- Avail tools, equipment and materials
- Avail workplace
- Avail computers with installed simulation software



## Indicative content 1.1: Preparation of Workplace



Duration: 5 hours



### Theoretical Activity 1.1.1: Description of pneumatic and hydraulic



#### Notes to the trainer:

- Trainer may use small groups for describing pneumatic and hydraulic systems
- The use of images and videos as didactic materials is required.



#### Key steps:

While delivering this activity, pass through the following steps:

**Step 1:** Introduce the activity and ask trainees to answer the following questions:

- Define the following terms.
  - Pneumatic system
  - Hydraulic system
  - Pneumatics
  - hydraulics
  - Fluid power
- Differentiate pneumatic hydraulic system based on working principle.
- Explain two types of fluid systems.
- Outline main components of pneumatic and that of hydraulic system.
- Explain briefly the advantages of pneumatic and hydraulic system.
- Highlight the applications of pneumatic and hydraulic systems

**Step 2:** Ask trainees to present their findings.

**Step 3:** Provide an expert view and Involve trainees to ask questions for clarification.

**Step 4:** Ask them to read key readings 1.1.1 in trainee manual



#### Points to Remember

- **Pneumatic system** is a system that uses pressurized air to perform useful mechanical works without intervention of man.
- **Hydraulic system** is a system that uses pressurized liquids to perform useful mechanical works without intervention of man.
- The difference between pneumatic and hydraulic systems is that pneumatic system uses compressed air as fluid medium while hydraulic system uses liquids as fluid medium.

- In addition to this pneumatic system utilizes the energy stored in compressed air to perform mechanical work and hydraulic system rely on the energy transmitted through pressurized hydraulic fluid.
- Pneumatic and hydraulic systems can also be differentiated based on applications, advantages and components.
- Two different types of fluid systems are fluid transport system and fluid power system.
- The main components of pneumatic system are six: compressor, electric motor, valves, actuators, and air tank and pipe lines. For hydraulic system, main components also are six: hydraulic pump, electric motor, valves, actuators, and reservoir and pipe lines.
- Advantages of hydraulic system are high power-to-weight ratio, versatility, controllability, Reliability, high efficiency, Flexibility and safety.
- Advantages of pneumatic system are safety, reliability, versatility, high efficiency, cost-effectiveness, easy maintenance, lightweight, cleanliness, precise control and quiet operation.
- Applications of pneumatic systems are manufacturing, construction, automotive industry, aerospace, industrial processes.
- Key applications of hydraulic systems are construction and heavy equipment, manufacturing, automotive industry, agriculture and aerospace.



### **Theoretical Activity 1.1.2: Identification of workplace policy and procedures**



#### **Notes to the trainer:**

- Trainer may use small groups in identification of workplace policy and procedures



#### **Key steps:**

**While delivering this activity, pass through the following steps:**

**Step1:** Introduce the activity and ask trainees to answer the questions below:

- Write short notes on the following terms a) Workplace policy b) Workplace procedure
- List the common workplace policies.

**Step2:** Ask trainees to present their findings from group discussion

**Step3:** Provide expert view and Involving trainees to ask questions for clarification.

**Step4:** Ask them to read key readings 1.1.2 in their manuals



### Points to Remember

- Workplace policy means principle of action adopted or proposed by an organization or individual.
- Workplace Procedure means an established or official way of doing something.
- Common workplace policies are code of conduct, recruitment policy, internet and email policy, mobile phone policy, non-smoking policy, drug and alcohol policy, health and safety policy, anti-discrimination and harassment policy and discipline and termination policy.



### Practical Activity 1.1.3: setting the work place



### Notes to the trainer

- Avail workplace
- Avail tools, materials, equipment, PPEs, first aids boxes, fire extinguishers that are in good condition.



### Key steps:

**While delivering this activity, pass through the following steps:**

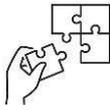
- Step 1:** Introduce the activity and ask trainees to read the task:
- i. Referring to theoretical activity 1.1.2 you are requested to set the workplace where a pneumatic and hydraulic system can be installed.
- Step 2:** Explain the task and give instructions (PPEs and time allocation).
- Step 3:** Demonstrate how to set out the workplace and while demonstrating, explain each step.
- Step 4:** Ask trainees to set out workplace and monitor the activity.
- Step 5:** Assess trainees' performance and give them feedbacks.
- Step 6:** Involve trainees to ask for clarifications.



### Points to Remember

- Steps followed in setting out a workplace are:
  1. Define the purpose
  2. Choose a location
  3. Organize tools
  4. Materials and equipment
  5. Personalize space

6. Ensure proper lighting
7. Consideration of ergonomics
8. Management of cable, hoses and pipes
9. Test and adjust.



### Application of learning 1.1

XYZ hospital would like to build a system that can help the doctors in their daily activities of taking care of patients with oxygen crisis. Hospital senior engineer preferred to use pneumatic system that can generate, control and transmit the generated oxygen. As technician you are requested to prepare the workplace where this system would be installed.

#### Checklist

SN	Criteria	Indicators	Observation	
			Yes	No
1	Purpose of the workplace is clearly defined	1.1.Purpose statement is stated		
		1.2. Purpose statement has clear message		
2	Proper Location is properly selected	2.1. Enough space is prepared		
		2.2. Enough light is provided		
		2.3.Noise level is controlled		
		2.4.Temperature is controlled		
3	Components are well organized	3.1.Tools are well arranged		
		3.2.Materials are well arranged		
		3.3.Equipment are well arranged		
		3.4.All available components are needed		
4	Workplace is safely prepared	4.1.Components are kept in storage materials to ensure its security		
		4.2.Workplace is clean		
		4.3.Safety precautions/regulations are elaborated		
		4.4.Emergency evacuations/exits are provided		
		4.5. Firefighting equipment are provided		
		4.6. First aid kits are provided		
		4.7. Workplace is clean		



## Indicative content 1.2: Selection of Tools, Materials and Equipment



Duration: 5 hours



**Theoretical Activity 1.2.1: Identification of tools, materials and equipment used in pneumatic and hydraulic systems**



**Notes to the trainer:**

- Trainer may use small group for describing tools, material and equipment
- The use of physical available tools, images and videos as didactic materials is required



**Key steps:**

**While delivering this activity, pass through the following steps:**

**Step1:** Introduce the activity and ask trainees to answer the questions below:

- Explain the followings terms used in pneumatic and hydraulic systems a)Tools b)material c) equipment
- Mention the tools, material and equipment used in pneumatic and hydraulic systems.
- Explain the use of each tool, material and equipment used in pneumatic and hydraulic systems.

**Step2:** Ask trainees to present their findings.

**Step3:** Provide expert view and Involving trainees to ask questions for clarification

**Step4:** Ask them to read key readings 1.2.1 in trainee manual



**Points to Remember**

- Tool is a device used to perform a task, while material is the tangible resource that goes into the installation of a pneumatic or hydraulic system and equipment are devices that utilize compressed air or liquids to perform mechanical work.
- Tools used in installation of pneumatic and hydraulic systems are electrical tools and plumbing tools.
- Materials used in pneumatic and hydraulic systems are oil, accessories, lubricant, heat exchanger, filter and strainer, pressure gauge, pressure and temperature switches.
- Equipment used in pneumatic and hydraulic systems are like compressor, pneumatic motor, pump, hydraulic motor.



## Practical Activity 1.2.2: Selecting tools, materials and equipment



### Notes to the trainer

- The trainer may:
  - ✓ Avail renewable energy workshop
  - ✓ Avail tools, materials, equipment PPEs, first aids boxes, fire extinguishers which are in good condition.



### Key steps:

While delivering this activity, pass through the following steps:

**Step 1:** Introduce the activity and ask learners to read the task:

- i. Based on the previous theoretical activity 1.2.1, select tools, materials and equipment required to install pneumatic and hydraulic systems.

**Step2.** Give clear instructions about the activity to be done.

**Step3.** Demonstrate how to select tools, materials and equipment used in pneumatic and hydraulic systems based on the type, functions and nature of resources.

**Step4.** Involve learners to select tools, materials and equipment.

**Step5.** Assess trainees and provide feedback to them.

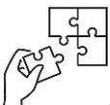
**Step 6.** Allow trainees to ask questions for clarification.

**Step 7.** Invite trainees to read more key readings 1.2.2 learn more about tips for good selection of tools.



### Points to Remember

- Tips for good selection of tools are assess the risks, use the right tool for the job, maintain your tools, use personal protective equipment (PPE) and follow manufacturer instructions.



### Application of learning 1.2.

ABC ENERGY DRINKS Ltd company wants to install a pneumatic system that can control gate door. As the right technician you are requested to select the tools, materials and equipment required to perform this installation.

## Checklist

SN	Criteria	Indicators	Observation	
			Yes	No
1	Important Tools are well selected	1.1. Pliers are selected		
		1.2. Screw drivers are selected		
		1.3. Spanners are selected		
		1.4. Tape measure is selected		
		1.5. Hammer is selected		
		1.6. Hand Drilling machine		
		1.7. Hacksaw		
2	Equipment are well selected	2.1.Compressor is selected		
		2.2.Pneumatic actuator is selected		
		2.3.Air tank is selected		
3	Materials are well selected	3.1.Pipes are selected		
		3.2.Couplings are selected		
		3.3. Hoses are selected		
		3.4. Mechanical link is selected		
		3.5. Pneumatic valves is selected		
		3.6. FRL Unit is selected		
		3.7.Air dryer is selected		



## Indicative content 1.3: Drawing of Hydraulic and Pneumatic System



Duration: 10 hours



### Theoretical Activity 1.3.1: Identification of pneumatic and hydraulic



#### Notes to the trainer:

- Trainer may help trainees to identify different pneumatic and hydraulic components
- The use of images as didactic materials is important.
- Trainer can use pairs to observe images showing symbols.



#### Key steps:

#### While delivering this activity, pass through the following steps:

**Step 1:** Introduce the activity and ask trainees to observe carefully the images and drawings of pneumatic and hydraulic components and ask them to identify available symbols.

**Step 2:** Ask trainees to present the identified symbols from observation in front of the class.

**Step 3:** Refer to the findings of trainees, provide expert view and clarify all symbols.

**Step 4:** Involve learners to observe carefully further symbols in key readings 1.3.1 in their trainee manual.



#### Points to Remember

- **Symbols used in pneumatic and hydraulic systems are obtained in the following ways:**
  - ✓ **Directional control valve:** Represented by squares connected by lines showing possible flow paths. Arrows indicate direction.
  - ✓ **Check valve:** A triangle symbol with a line indicates one-way flow.
  - ✓ **Pressure relief valve:** A symbol that shows a path leading to a reservoir when pressure exceeds a set limit.
  - ✓ **Cylinders:** Typically represented by a rectangle, with an arrow indicating the direction of movement.
  - ✓ **Motors:** Often shown as a circle with arrows inside to indicate rotation direction.

- ✓ Symbols for pressure switches, limit switches, and proximity sensors vary but are typically simple geometric shapes with lines or arrows indicating action.
- ✓ **Pumps and motors:** Represented by a circle with an arrow pointing outwards for a pump or inwards for a motor.
- ✓ **Reservoirs/Tanks:** Depicted as a rectangle or a square with a line at the top or bottom representing a liquid level.
- ✓ **Filters:** Symbols with a circle and crossing lines indicate a filter.
- **Flow Lines used mean:**
  - ✓ **Solid lines:** Indicate main hydraulic or pneumatic lines.
  - ✓ **Dashed lines:** Represent pilot or control lines.
  - ✓ **Return lines:** Shown with a dashed line ending in a triangle pointing towards the reservoir.



### Practical Activity 1.3.2: Drawing control circuit of pneumatic single and double acting cylinders



#### Notes to the trainer

- The trainer can use pairs to discuss on main elements/sections of pneumatic system
- Avail of drawing instrument to the trainees and trainer



#### Key steps:

**While delivering this activity, pass through the following steps:**

**Step 1:** Introduce the activity and ask trainees to read the following task:

- i. Referring to the previous theoretical activity 1.3.1, use identified symbols and draw:
  - a) Control circuit of pneumatic single acting cylinder.
  - b) Control circuit of pneumatic double acting cylinder

**Step 2:** Explain the task and give clear instructions to be followed while doing the task.

**Step 3:** Show trainees how to draw control circuits for pneumatic single and double acting cylinders.

**Step 4:** Involve trainees to redraw the control circuits for pneumatic single and double acting cylinders and monitor the activity.

**Step 5:** Evaluate trainees and give them feedbacks.

**Step 6:** Involve trainees to ask questions for clarifications.

**Step 7:** Invite learners to read key readings 1.3.2 for further information.



#### Points to Remember

- **Steps to draw pneumatic circuits are:**

1. Identify components, 2. determine the sequence of operations, 3. sketch the basic layout, 4. use standard symbols, 5. connect components, 6. add valves and controls, 7. indicate pressure and flow, 8. review and verify, 9. consider additional details.



### **Practical Activity 1.3.3: Drawing control and power circuit diagram of hydraulic system**



#### **Notes to the trainer**

- The trainer may use small group for drawing control and power circuit diagram of hydraulic system.
- Avail of drawing instrument to the trainees and trainer



#### **Key steps:**

**While delivering this activity, pass through the following steps:**

**Step 1:** Introduce the activity and ask trainees to read the following task:

- i. Referring to the previous theoretical activity 1.3.1, use identified symbols and draw:
  - c) Control circuit of hydraulic single acting cylinder.
  - d) Control circuit of hydraulic double acting cylinder

**Step 2.** Explain the task and give clear instructions to be followed while doing the task.

**Step 3.** Show trainees how to draw control circuits for hydraulic single and double acting cylinders.

**Step 4.** Involve trainees to redraw the control circuits for hydraulic single and double acting cylinders and monitor the activity.

**Step 5.** Evaluate trainees and give them feedbacks.

**Step 6.** Involve trainees to ask questions for clarifications.

**Step 7.** Invite learners to read key readings 1.3.3 for further information.



#### **Points to Remember**

- **Steps to draw pneumatic circuits are:** 1. identify components, 2. determine the sequence of operations, 3. sketch the basic layout, 4. use standard symbols, 5. connect components, 6. add valves and controls, 7. indicate pressure and flow, 8. review and verify, 9. consider additional details.



### Theoretical Activity 1.3.4: identification of the cost estimation of pneumatic and hydraulic system



#### Notes to the trainer:

- The small group may be used to describe the cost estimation.
- Avail the didactic materials



#### Key steps:

**While delivering this activity, pass through the following steps:**

**Step 1:** Introduce the activity and ask trainees to answer the following questions:

- Define the terms a) cost b) Estimate
- What is the requirement for preparing an estimate?
- Explain the meaning of bill of quantity and bill of quantity layout.
- Outline the content of Bill of quantity.

**Step 2:** Ask trainees to present results.

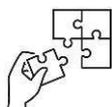
**Step 3:** Provide expert view and involve them to ask for clarification.

**Step 4:** Ask them to read key readings 1.3.4 in their manuals



#### Points to Remember

- Cost is the value of money that has been used up to produce something or deliver a service, and hence is not available for use anymore and estimate is an approximate calculation of the cost of works to be done.
- The requirement for preparing an estimate are drawing, detailed specification and standard schedule of rates of the current year.
- Bill of quantity is a document used in tendering in the construction industry in which materials, parts, and labor (and their costs) are itemized.
- Bills of quantity content is item number, item description, unit of measures on each item, quantity of each item, rate per unit and total cost (amount).



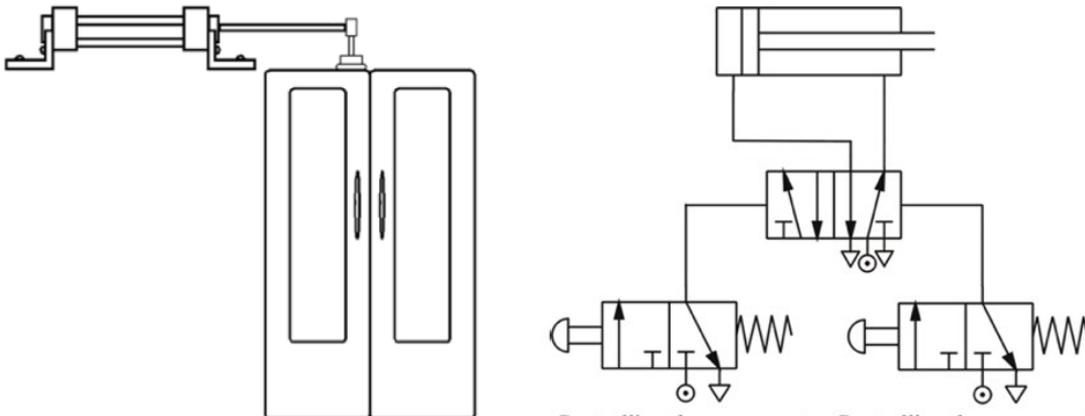
#### Application of learning 1.3.

Pneumatic system is applied to control a vehicle door in the following ways: When the push button s1 is pressed, the 5/2 valve changes the state and the cylinder outstrokes. As it outstrokes, it led the door to be closed.

When the push button S2 is pressed, the 5/2 valve changes the state and the cylinder instrokes, as it instrokes, it led to the vehicle door to be open.

Tasks: as technician, you are asking to draw the pneumatic system applied to the vehicle door and prepare its cost of estimation.

**Checklist:**



SN	Criteria	Indicators	Observation	
			Yes	No
1	Pneumatic circuit is well labeled.	1.1. Pneumatic circuit is drawn		
		1.2. Air supply is labeled		
		1.3. Service unit is labeled		
		1.4. 3/2 DCV actuated by push button S1 spring return is labeled		
		1.5. 3/2 DCV actuated by push button S1 spring return is labeled		
		1.6. 5/2 DCV piloted is labeled		
		1.7. Double acting cylinder is labeled		
2	Cost estimation is well done	2.1. The table is labeled		
		2.2. The element of BOQ are shown		
		2.3. All lists of materials and equipment are shown		
		2.4. The labors cost is shown		
		2.5. The total cost is well calculated		



## Indicative content 1.4: Simulating control and power circuits



Duration: 5 hours



**Theoretical Activity 1.4.1: Identification of steps of simulating pneumatic and hydraulic circuits**



**Notes to the trainer:**

- Trainer may:
  - ✓ Prepare/avail computer lab or smart classroom
  - ✓ Avail simulation softwares
  - ✓ Install simulation softwares in computers with enough capacity.



**Key steps:**

**While delivering this activity, pass through the following steps:**

**Step 1:** Introduce the activity and ask trainees to answer the following questions:

- Define the term simulation.
- Outline four examples of softwares used in simulation
- What are the steps to be followed while simulating pneumatic and hydraulic circuits?

**Step 2:** Ask trainees to present their findings in front of the class.

**Step 3:** Provide expert view and involve trainees to ask questions for clarifications.

**Step 4:** Invite trainees to read key readings 1.4.1 in their manual for more information



**Points to Remember**

- Simulation is a representation of something, not the real thing.
- Examples of Simulation softwares are fluidsims, MATLAB Simlink, Automation Studio, and Autocad Electrical.
- Steps to simulate pneumatic or hydraulic circuit by the help of fluidsims software are install fluidsims software, open fluidsims, create a new project, add pneumatic and hydraulic components, add control elements, connect and configure blocks, connect the inserted pneumatic or hydraulic components, execute the simulation, analyse results, experiment and modify and save and document.



## Practical Activity 1.4.2: Simulating pneumatic and hydraulic circuits



### Notes to the trainer

- The trainer may:
  - ✓ Avail enough computers according to the number of trainees
  - ✓ Avail projector that is functioning properly.



### Key steps:

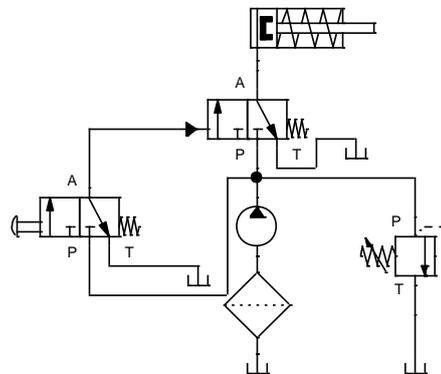
While delivering this activity, pass through the following steps:

#### Step 1:

Introduce the activity

and ask trainees to read carefully the task:

- I. Referring on the theoretical activity 1.4.1 simulate the power and control circuit of the hydraulic following circuit:



**Step 2:** Explain the task and give clear instructions.

**Step 3:** Demonstrate how to simulate hydraulic control and power circuits

**Step 4:** Engage trainees to simulate control and power hydraulic circuits and monitor the activity.

**Step 5:** Assess trainees and give the feedbacks

**Step 6:** Involve trainees to ask questions for clarifications.

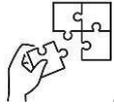
**Step 7:** Invite trainees to read key reading 1.4.2 in their manual for more details.



### Points to Remember

- Simulation is a representation of something, not the real thing.
- Examples of Simulation softwares are fluidsim, MATLAB Simlink, Automation Studio, Autocad Electrical.

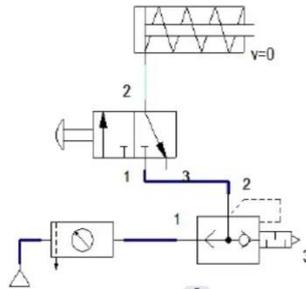
- Steps to simulate pneumatic or hydraulic circuit by the help of fluidsim software are install fluidsim software, open fluidsim, create a new project, add pneumatic and hydraulic components, add control elements, connect and configure blocks, connect the inserted pneumatic or hydraulic components, execute the simulation, analyze results, experiment and modify and save and document.



#### Application of learning 1.4.

The following circuit is illustrating the direct control of single acting cylinder. Draw and simulate these circuit in simulation software.

#### Checklist



SN	Criteria	Indicators	Observation	
			Yes	No
1	The simulating software (fluidsim) is well open	1.1. Menu bar is visible		
		1.2. Tool bar is visible		
		1.3. Components Library is open		
2	New project is well created	2.1. A new window is open		
		2.2. A new window is named and saved		
3	Components are well selected from library	3.1. Single acting cylinder is selected		
		3.2. 3/2 way valve is selected		
		3.3. Actuation with pushbutton is selected		
		3.4. Quick exhaust valve is selected		
		3.5. Air muffler is selected		
		3.6.FRL unit is selected		
		3.7.Air source is selected		
4	Configuration is well done	4.1. Single acting cylinder is configured		
		4.2. 3/2 way valve is configured		
		4.3. Quick exhaust valve is configured		
		4.4. Air muffler is configured		
		4.5. FRL unit is configured		
		4.6. Air source is configured		
5	Connection of components is	5.1. Single acting cylinder is connected to 3/2 way valve		

	well done	5.2. 3/2 way valve is connected to quick exhaust valve		
		5.3. Air muffler is connected on quick exhaust valve		
		5.4. Quick exhaust valve and FRL unit are connected		
		5.5. Air source is connected to FRL Unit		
6	Simulation (running) of the circuit is well done	6.1. Single acting cylinder can extend		
		6.2. Single acting cylinder can retract		



## Learning Outcome 1 end assessment

### Theoretical assessment

1. Define the following terms:

- a) Pneumatic system
- b) Hydraulic system
- c) Fluid power
- d) Tool
- e) Simulation
- f) Workplace policies

**Answer:**

- a) **Pneumatic system:** It is a system that uses pressurized air to perform useful mechanical works without intervention of man.
- b) **Hydraulic system:** It is a system that uses pressurized liquids to perform useful mechanical works without intervention of man.
- c) **Fluid power:** fluid power is the technology that deals with the generation, control, and transmission of power, using pressurized fluids.
- d) **Tool:** Tool is a device used to perform a task or achieve a specific purpose
- e) **Simulation software:** It is a program that allows the user to observe an operation through simulation without actually performing that operation.
- f) **Workplace Policy:** Workplace policy means principle of action adopted or proposed by an organization or individual.

2. Read the following statement related to perform pneumatic and hydraulic system pre-installation and encircle the letter corresponding to the correct answer:

i. Which one of the following is the purpose of Workplace policies and procedures?

- a. To make our lives miserable
- b. To add more complexity to it
- a. To help us act and behave professionally with each, with customers and the environment
- b. To add more formality and shape to workplace

**Answer: c. to help us act and behave professionally with each, with customers and the environment**

ii. Which of the following are the advantages of using pneumatic systems?

- a) Reliability
- b) High cost
- c) Air pollution
- d) Safety
- e) Low efficiency

**Answer: a and d are correct answers**

iii. Which of the following is not a common application of pneumatic systems?

- a) Automotive braking systems
- b) Food processing machinery
- c) Aircraft landing gear
- d) Electrical power generation

**Answer: d: Electrical power generation**

iv. A pneumatic system typically consists of:

- a) Air compressor, valves, actuators, electric motor pipe lines and tubing
- b) Electric motor, generator, transmission lines, electric motor pipe lines and tubing
- c) Hydraulic pump, valves, cylinders, tubing, electric motor pipe lines and tubing
- d) Steam boiler, turbine, generator, electric motor pipe lines and tubing

**Answer: a: Air compressor, valves, actuators, electric motor pipe lines and tubing**

**3. Read the following statement related to perform pneumatic and hydraulic system pre-installation and answer by True if the statement is correct or False if the statement is wrong:**

a) Is it mandatory to follow the policies and procedures?

**Answer: True**

b) BOQ detailed breakdown of all elements needed to execute an electrical project

**Answer: True**

c) Using direct control pneumatic cylinder, the cylinder is actuated directly via a manually or mechanically actuated valve, without any intermediate switching of additional directional control valves.

**Answer: True**

4. What is the fluid medium used in the pneumatic and hydraulic systems?

**Answer:**

- Fluid used in pneumatic system is Compressed air.
- Fluid medium used in hydraulic system is pressurized liquids.

5. Outline two types of fluid systems

**Answer: Two types of fluid systems are fluid transport system and fluid power system.**

6. What are the elements of bill of quantity?

**Answer: Elements of bill of quantity are:**

- Item number
- Item description
- Unit of measures on each item
- Quantity of each item
- Rate per unit
- Total cost (amount)

7. Write down the main five (5) elements of pneumatic system.

**Answer: Elements of pneumatic system**

- Energy supply, source
- Input elements, input signal
- Processing elements, processor signal
- Final control element, control signal
- Actuating devices, output.

8. Show any four (4) functions of the simulation software, fluidsim.

**Answer:**

- Create a pneumatic or hydraulic symbols
- Draw a pneumatic or hydraulic circuit
- Test the functionality of a given circuit
- Simulate operation of pneumatic or hydraulic circuits

9. Give any three (3) examples of simulation software

**Answer:**

- i. Fluidsim
- ii. MATLAB Simlink
- iii. Automation Studio
- iv. Autocad Electrical

10. Illustrate any five (5) tools used to install pneumatic/hydraulic systems

**Answer:**

- Pliers (Universal pliers, cutting pliers, long nose pliers, ...)
- Drilling machine
- Hammer
- Screwdrivers
- Scissors
- Hacksaw
- Bench vice
- Pipe vice
- Allen keys
- Adjustable spanner
- Open ended spanner

11. Identify at least five (5) equipment used in installation of pneumatic/ hydraulic systems.

**Answer:**

- Air compressor
- Hydraulic pump
- Electrical motors
- Valves
- Hydraulic and Pneumatic Reservoir & System Accessories
- Hydraulic and Pneumatic cylinders and pistons

- Pneumatic and Hydraulic Motors

12. Write down five (5) actuation method of actuation methods.

**Answer:**

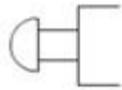
- i. Manual actuation method
- ii. Mechanical actuation method
- iii. Electrical (solenoid) actuation method
- iv. Pilot actuation method
- v. Spring actuation method

13. Give the symbol used to represent the following method of actuation of directional control valve:

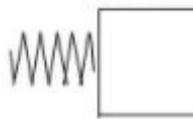
- a. Push button
- b. spring
- c. lever
- d. pedal
- e. electrical pilot

**Answer :**

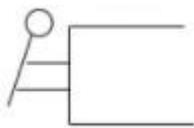
- a)** push button



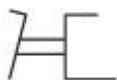
- b)** spring



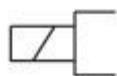
- c)** lever



- d)** pedal



- e)** electrical pilot



14. Give the difference between tools and material used in installation of pneumatic /hydraulic system

**Answer**

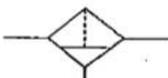
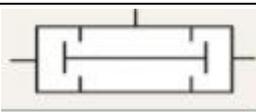
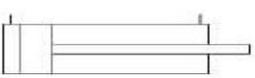
- A tool is something you use to do something (to install p/h circuit).
- while materials are consumable items on which you use tools to make, achieve or in whatever way create your product.

15. Outline The main six basic components required in a hydraulic system.

**Answer:**

- A tank (reservoir) to hold the hydraulic oil
- A pump to force the oil through the system
- An electric motor or other power source to drive the pump
- Valves to control oil direction, pressure, and flow rate
- An actuator to convert the pressure of oil into mechanical force or torque to do useful work. Actuators can either be cylinders to provide linear motion, or motors to provide rotary motion.
- Piping, which carries the oil from one location to another.

16. Match the symbols of pneumatic and hydraulic system components in **column A** with their names in **column B** in the following table, and write the letter corresponding to the correct answer in the provided space.

Answer	Symbols	Names
.....D.....	1. 	A. Double acting cylinder
.....C.....	 2	B. ON-OFF manual shut off
.....E.....	3. 	C. Air filter with automatic drain
.....A.....	4. 	D. Fixed displacement, unidirectional pump
.....B.....	5. 	E. AND valve

17. Use the table below to classify the following pneumatic and hydraulic tools, materials and equipment: Screw drivers, Plier, Spanners, cutting plier, Spirit level, Hand drilling machine, Filter, Accumulator, Oils, Lubricant, Compressor, Hydraulic Pump, Hydraulic motor.

Tools	Materials	Equipment

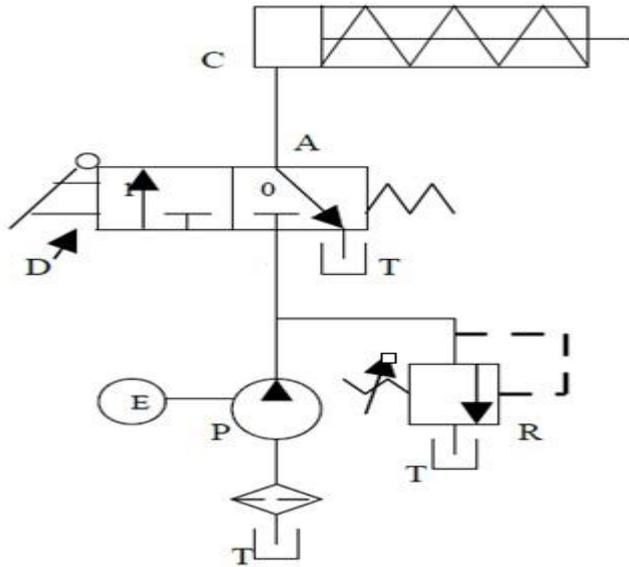
Answer:

Tools	Materials	Equipment
<ul style="list-style-type: none"> <li>✓ Screw drivers</li> <li>✓ Plier</li> <li>✓ Spanners</li> <li>✓ Cutting plier</li> <li>✓ Spirit level</li> <li>✓ Hand drilling machine</li> </ul>	<ul style="list-style-type: none"> <li>✓ Filter,</li> <li>✓ Accumulator</li> <li>✓ Oils</li> <li>✓ Lubricant</li> </ul>	<ul style="list-style-type: none"> <li>✓ Compressor</li> <li>✓ Hydraulic Pump</li> <li>✓ Hydraulic motor</li> </ul>

18. Match the Parts of pneumatic system in **column A** with their function in **column B** in the following table, and write the letter corresponding to the correct answer.

Answer	Column A, Parts of pneumatic system	Column B Function
....C...	1. Lubricant	A. mechanical devices which use the power of compressed gas or air to produce a force
....D....	2. Accumulators	B. used as driving compressors with means of coupling.
....F.....	3.Pneumatic Filters	C. is the substance used to control friction and wear by the introduction of a friction-reducing film between moving surfaces in contact.
....E....	4. Compressors	D. is basically a pressure storage reservoir in which a non-compressible hydraulic or pneumatic fluid is retained under pressure from an external source.
....A....	5.Pneumatic actuator	E. is a device used to compress air (or any gas) from a low inlet pressure (usually atmospheric pressure) to a higher desired pressure level
....B.....	6.Electrical motors	F. The life of a hydraulic or pneumatic component depends on the type, amount, and size of contaminant particles passing through it. Since each component has a different resistance to contamination, the filtration level must be matched to the system's most sensitive component.

19. Discuss the operation of the following hydraulic circuit.



**Answer:**

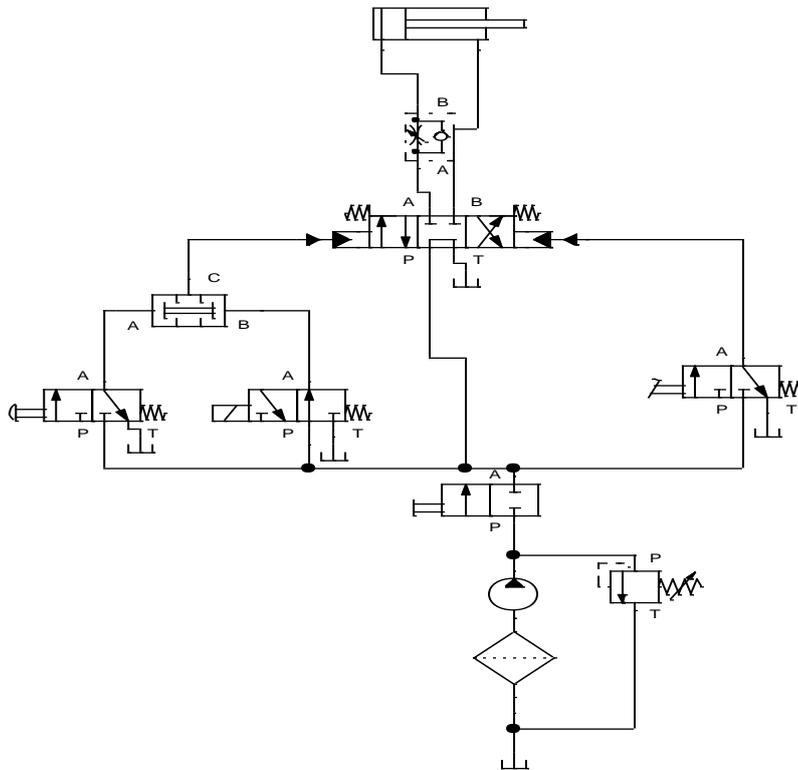
- In the spring offset mode, full pump flow goes to the tank via the pressure relief valve. The spring in the rod end of the cylinder retracts the piston as oil from the blank end 'A' drains back to the tank.
- When the valve is manually actuated the pump, flow goes to the cylinder blank end 'A' via DCV 1 position. This extends the cylinder. At full extension, pump flow goes through the relief valve. Deactivation of the DCV allows the cylinder to retract as the DCV shift into its spring – offset mode.

20. A double acting cylinder is used for pushing a box of cigarette and extension of double acting cylinder is achieved by actuating push button of 3/2 of directional control valve (V1) or solenoid of 3/2 of directional control valve (V2), the extension

Speed is regulated. And when pedal 3/2 of Directional Control valve (V3) is actuated the double acting cylinder is retracted back. Double acting cylinder is controlled by 4/3 directional control valve (V5) tandem center. Remember to use 2/2 normally closed valve (V6) to open the power supply.

Draw hydraulic circuit for this system.

**Answer:**



### Practical assessment

PHK coffee processing company Ltd is located in Gatsibo district, Muhura sector, Taba Cell. This factory would like to increase the capacity of the factory. This activity requires to install a new hydraulic system that works as elevator machine located in existing building. The machine will be controlled electro-hydraulically.

#### Task:

As technician, you are required to do the following:

- i. Prepare the workplace where this system will be installed.
- ii. Selected tools materials and equipment required for the installation of the system.
- iii. Draw a control and power circuits of this hydraulic system that will be used to install
- iv. By using software, simulate control and circuits to make sure that its implantation will be successful.

#### Notes:

- a) The system should be well protected
- b) The system should have two indication lamps (green to indicate that the actuator is lifting up materials and yellow to indicate that the actuator is lowering materials)
- c) Task will be done in four (4) hours.
- d) All resources are available.
- e) Task is to be done individually.

## Checklist

SN	Criteria	Indicators	Observation	
			Yes	No
1	Purpose of the workplace is clearly defined	1.1. Purpose statement is stated		
		1.2. Purpose statement has clear message		
2	Proper Location is selected	2.1. Enough space is prepared		
		2.2. Enough light is provided		
		2.3. Noise level is controlled		
		2.4. Temperature is controlled		
3	Components are well organized	3.1. Tools are well arranged		
		3.2. Materials are well arranged		
		3.3. Equipment are well arranged		
		3.4. All available components are needed		
4	Workplace is safely prepared	4.1. Components are kept in storage materials to ensure its security		
		4.2. Workplace is clean		
		4.3. Safety precautions/regulations are elaborated		
		4.4. Emergency evacuations/exits are provided		
		4.6. Firefighting equipment are provided		
		4.7. First aid kits are provided		
5	Hydraulic power circuit is well labeled.	5.1. Hydraulic circuit is drawn		
		5.2. Tank is labeled		
		5.3. Filter is labeled		
		5.4. 4/2 DCV actuated by double solenoid is labeled		
		5.5. Pressure relief valve is labeled		
		5.6. Pump is labeled		
		5.7. Flow control valve is labeled		
		5.8. Bidirectional hydraulic motor is labelled		
6	Control circuit is well labelled	6.1. Battery is labeled		
		6.2. Push button switches are labelled		
		6.3. Relays are labelled		
		6.4. Solenoids are labelled		
		6.5. Relay contacts are labelled		
7	Tools are well selected	7.1. Pliers are selected		
		7.2. Screw drivers are selected		
		7.3. Spanners are selected		
		7.4. Tape measure is selected		

		7.5. Hammer is selected		
		7.6. Hand Drilling machine		
		7.7. Hacksaw is selected		
8	Equipment are well selected	8.1. Pressure gauge is selected		
		8.2. Fire extinguisher is selected		
		8.3. First aid kit is selected		
		8.4. PPEs are selected		
		8.5. Pump is selected		
		8.6. Hydraulic motor (rotary actuator) is selected		
		8.7. Electric motor is selected		
9	Materials are well selected	9.1. Pipes are selected		
		9.2. Couplings are selected		
		9.3. Hoses are selected		
		9.4. Mechanical link is selected		
		9.5. Directional control valve is selected		
		9.6. Pushbutton switches is selected		
		9.7. Relays are selected		
		9.8. Solenoids are selected		
		9.9. Indicator lamps are selected		
		9.10. Flow control valve is selected		
		9.11. Tank is selected		
		9.12. Pressure relief valve is selected		
		9.13. Silencer/muffler is selected		
		9.14. Temperature switch is selected		
		9.15. Wires are selected		
10	The simulating software (fluidsim) is well open	10.1. Menu bar is visible		
		10.2. Tool bar is visible		
		10.3. Components Library is open		
11	New project is well created	11.1. A new window is open		
		11.2. A new window is named and saved		
12	Components are well selected from library	12.1. Bidirectional hydraulic motor is selected		
		12.2. 4/2 way valve is selected		
		12.3. Electrical Actuation with is selected		
		12.4. Flow control valve is selected		
		12.5. Hydraulic pump is selected		
		12.6. Electric motor is selected		
		12.7. Hydraulic filter is selected		
		12.8. Pressure relief valve is selected		

		12.9. Hydraulic tank is selected		
		12.10. Battery is selected		
		12.11. Push button switches are selected		
		12.12. Relays are selected		
		12.13. Solenoids are selected		
		12.14. Indicator lamps are selected		
13	Configuration is well done	13.1. Bidirectional hydraulic motor is Configured		
		13.2. 4/2 way valve is Configured		
		13.3. Flow control valve is Configured		
		13.4. Hydraulic pump is Configured		
		13.5. Electric motor is Configured		
		13.6. Hydraulic filter is Configured		
		13.7. Pressure relief valve is Configured		
		13.8. Hydraulic tank is Configured		
		13.9. Battery is Configured		
		13.10. Push button switches are Configured		
		13.11. Relays are Configured		
		13.12. Solenoids are Configured		
		13.13. Indicator lamps are configured		
14	Connection of components is well done	14.1. Bidirectional motor is connected to 4/2 way valve		
		14.2. 4/2 way valve is connected to flow control valve		
		14.3. Flow control valve is connected to hydraulic pump		
		14.4. Hydraulic pump is connected to filter and pressure relief valve		
		14.5. Filter and pressure relief valve are connected to tank		
		14.6. Control circuit components are connected		
15	Simulation (running) of the circuit is well done	15.1. Single acting cylinder can extend		
		15.2. Single acting cylinder can retract		



### Further information to the trainer

(n.d.). Retrieved from <https://tameson.com/pages/pneumatic-pipe-fittings>

(n.d.). Retrieved from 2.  
[https://www.festo.com/net/enir\\_ir/SupportPortal/Files/729819/Installation%20Guide\\_2022\\_EN\\_scr.pdf](https://www.festo.com/net/enir_ir/SupportPortal/Files/729819/Installation%20Guide_2022_EN_scr.pdf)

Croser, P. (1992). *Pneumatics*. Esslingen: Festo Didactic.

F.Hooper, J. (2003). *Basic Pneumatics* .

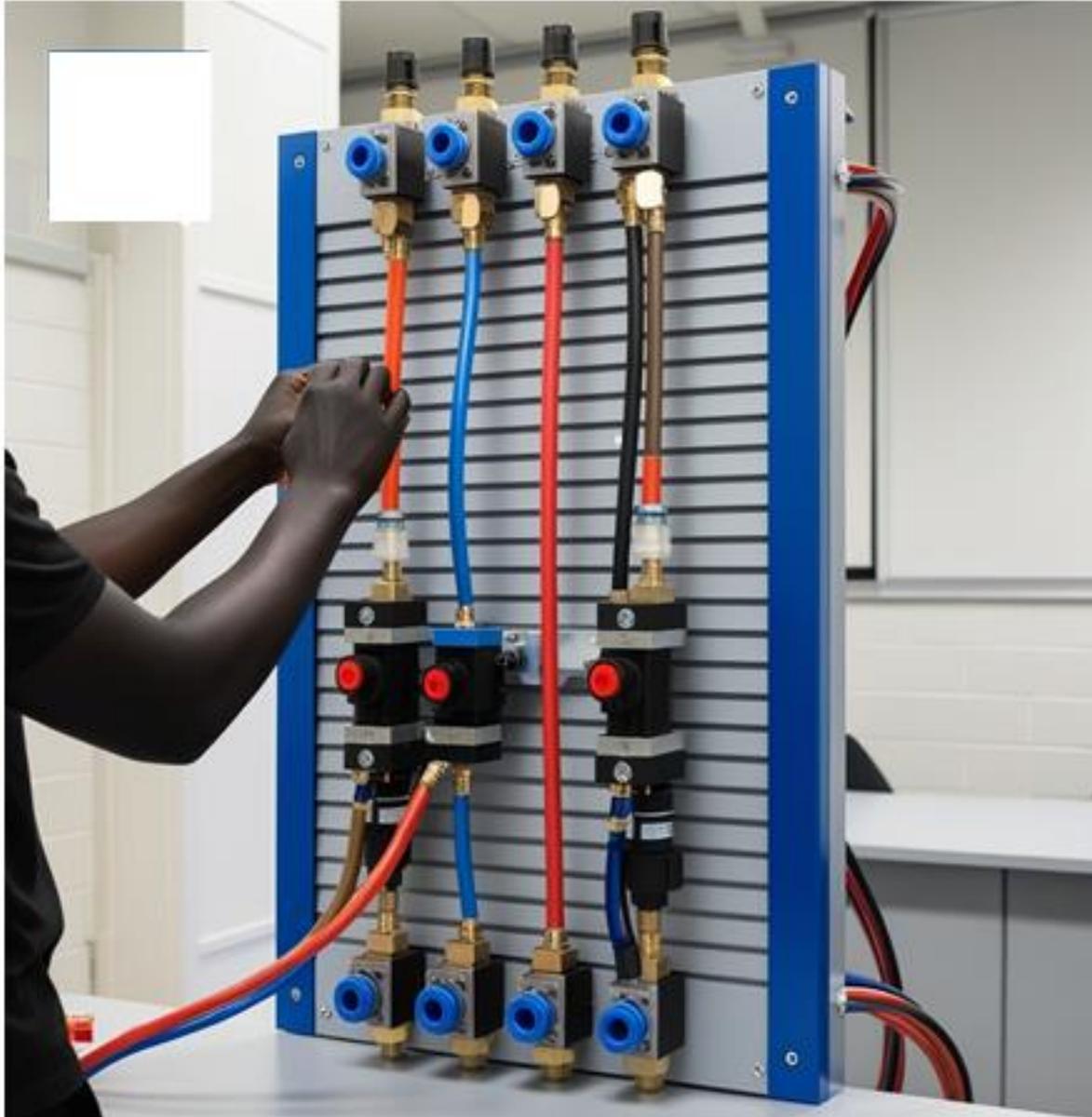
Jayakumar, V. (June, 2010). *Applied Hydraulics and Pneumatics*. Chennai: LAKSHMI Publications.

Khan, Q. (n.d.). *STUDY OF HYDRAULIC VALVES, PUMPS AND ACCUMULATORS*. MUMBAI: HYDROELECTRIC MACHINERY PREMISES.

Parr, A. A. ( March 1999 ). *Hydraulics and Pneumatics* . Elsevier Science & Technology Books

Schapoehler, M. (2024, September 12). Retrieved from Airline Hydraulics Website:  
<https://blog.airlinehyd.com/pneumatic-system-explainer>

## Learning Outcome 2: Install Pneumatic System



### Indicative contents

- 2.1. Fixing pneumatic system components
- 2.2. Assembling pneumatic system components
- 2.3. Testing pneumatic system

### Key Competencies for Learning Outcome 2: Install Pneumatic System

Knowledge	Skills	Attitudes
<ul style="list-style-type: none"><li>● Description of fixing technics to pneumatic system components</li><li>● Identification of control and power circuits of pneumatic system components.</li><li>● Description of joining technics to hose pipe of pneumatic system.</li><li>● Description of measuring/testing instruments and parameters used in pneumatic system</li></ul>	<ul style="list-style-type: none"><li>● Applying the fixing and joining technics to the components of pneumatic system.</li><li>● Fixing control circuit and power circuit components of pneumatic system</li><li>● Assembling pneumatic system components</li><li>● Connecting electrical components and pipes</li><li>● Testing control and power circuits of pneumatic system</li></ul>	<ul style="list-style-type: none"><li>● Being careful</li><li>● Being cooperative</li><li>● Being flexible</li><li>● Having self-confidence</li><li>● Being responsible</li><li>● Being communicator</li><li>● Being observant</li></ul>



**Duration: 25 hours**



**Learning outcome 2 objectives:**

By the end of the learning outcome, the trainees will be able to:

1. Describe briefly fixing and joining technics applied to the pneumatic system components installation diagram
2. Apply correctly fixing and joining technics according to the pneumatic system installation diagram
3. Identify briefly the components of control and power circuit as used in pneumatic system installation diagram
4. Fix properly the components of pneumatic system according to installation diagrams
5. Assemble correctly the components of pneumatic system based on joining technics and diagrams
6. Connect properly electrical components based on joining technics and diagrams
7. Describe briefly the measuring/testing instruments and parameters applied on pneumatic system installation diagram
8. Test accurately pneumatic system according to functionality and testing technics



**Resources**

<b>Equipment</b>	<b>Tools</b>	<b>Materials</b>
<ul style="list-style-type: none"> <li>● Computer</li> <li>● Multi-meter</li> <li>● Tachometer</li> <li>● Thermometer</li> <li>● Manometer</li> <li>● Head Protection</li> <li>● Eye and Face Protection</li> <li>● Hearing Protection</li> <li>● Respiratory Protection</li> </ul>	<ul style="list-style-type: none"> <li>● Wires tripping plier</li> <li>● Side cutter pliers</li> <li>● Combination pliers</li> <li>● long nose pliers</li> <li>● Spirit level</li> <li>● Tape measure</li> <li>● Steel rulers</li> <li>● Star screw driver</li> <li>● Flat screw driver</li> <li>● Hand drilling machine</li> <li>● Electric screw</li> </ul>	<ul style="list-style-type: none"> <li>● Fuses</li> <li>● Wires</li> <li>● Nut</li> <li>● Bolt</li> <li>● Cable clips</li> <li>● Insulators</li> <li>● Welding holder</li> <li>● Grease</li> <li>● Lubricants</li> <li>● Scotches</li> <li>● Markers</li> <li>● Pipes and hoses</li> </ul>

<ul style="list-style-type: none"> <li>● Hand Protection</li> <li>● Foot Protection</li> <li>● Body Protection</li> <li>● Fall Protection</li> <li>● Skin Protection</li> <li>● First aid</li> <li>● Compressor</li> <li>● Valves</li> <li>● Actuators</li> <li>● Miscellaneous</li> </ul>	<ul style="list-style-type: none"> <li>● driver</li> <li>● Crimping tools</li> <li>● Electrical hammer</li> <li>● Claw hammer</li> <li>● Ball pen hammer</li> <li>● Mallet hammer</li> <li>● Spring bender</li> <li>● Hack saw</li> <li>● Electrician knife</li> <li>● Allen key</li> <li>● Still Brushes</li> <li>● Span</li> <li>● Scissor</li> <li>● Vanier caliper.</li> </ul>	<ul style="list-style-type: none"> <li>● Pipe fittings</li> <li>● Switch box</li> <li>● Junction boxes</li> <li>● Spring</li> <li>● Female plugs</li> <li>● Male Plugs</li> <li>● Extension Cords</li> <li>● Drill bits</li> <li>● Wall plugs</li> <li>● Clips</li> <li>● Pneumatic Hose pipe</li> <li>● Charcoal</li> <li>● Pneumatic joints.</li> </ul>
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**Advance Preparation:**

Before delivering this learning outcome, you are recommended to:

- Prepare tools, equipment and materials
- Avail workplace /classroom
- Avail pneumatic power supply
- Avail electricity
- Avail pneumatic installation board



## Indicative content 2.1: Fixing pneumatic System Components



Duration: 10 hours



**Theoretical Activity 2.1.1: Description of pneumatic system components fixation.**



**Notes to the trainer:**

- Trainer may use small groups may for discussing to the importance of pneumatic
- The use of images and videos as didactic materials is required.



**Key steps:**

**While delivering this activity, pass through the following steps:**

**Step 1:** Introduce the activity and ask the trainees to answer the following:

- i. Discuss on Fixing and joining technics of pneumatic system components.

**Step 1:** Ask the trainees to present findings from their small group

**Step 2:** Refer to the trainees' answers, provide the expert view and involve trainees to ask questions for clarification.

**Step 3:** Direct trainees to read **the key reading 2.1.1** in their manuals



**Points to Remember**

- The importance of proper fixation of pneumatic system components are: To Prevent accidents due to accidental disconnections or failures, to Ensures that the system operates at peak efficiency without pressure drops or leaks and Facilitates easy access for inspections and repairs, reducing downtime.



**Practical Activity 2.1.2: fixing of pneumatic system components**



**Notes to the trainer**

- The trainer may avail tools, materials and equipment used to install a pneumatic system
- Avail workshop

- Trainer may avail control and power circuit diagram on task sheet, images, or videos as didactic materials.



### Key steps:

**While delivering this activity, pass through the following steps:**

**Step 1:** Introduce the activity and ask trainees to read the task:

- Referring to a key reading 2.1.1, you are asking to fix the components of pneumatic system control and power circuits of indirect control of double acting cylinder.

**Step 2:** Explain the task and give instructions (PPEs and time allocation)

**Step 3:** Demonstrate how to fix control and power circuits of pneumatic system components.

**Step 4:** Ask the trainees to fix control and power circuits of pneumatic system components and monitor the activity.

**Step 5:** Assess their performance and provide feedback

**Step 6:** Involve trainees to ask questions for clarifications.

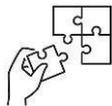
**Step 7:** Lead them to read key reading 2.1.2 in their manuals



### Points to Remember

- **Fixing Techniques of Pneumatic System Components**

Here, there are some techniques and tips for fixing and pneumatic system components: Threaded Connections, Quick-Connect Fittings, Compression Fittings, Proper Tubing Selection, Proper Hose Clamping, Flare Fittings, Proper Torque, Alignment of Components, and use of Locking Devices, Testing for Leaks, Follow Manufacturer's Guidelines, Training and Documentation.



### Application of learning 2.1.

XYZ TSS School wants to control its main gate by using pneumatic system. When you press on push button S1, it led the main gate to close and when you press on push button S2, it led the main gate to open. You as technician you are hired to fix a pneumatic components indirect control circuit used to control the main gate.

**Checklist:**

SN	Criteria	Indicators	Observation	
			Yes	No
1	Drawing is well done	1.1. Air supply is labelled		
		1.2. RL unit is labelled		
		1.4. 5/2 DCV Valve piloted is well labelled		
		1.4. 3/2 DCV valves are labelled		
		1.5. Pneumatic actuator is labelled		
		1.6. Flow control valve is labelled		
2	Tools, Materials and Equipment are well selected	2.2. Mechanical tool kit is selected		
		2.2. Electrical tool kit is selected		
		2.3. Air compressor is selected		
		2.4. DCV Valves are selected		
		2.5. FRL unit is selected		
		2.6. Pneumatic actuator is selected		
		2.7. Flow control valve are selected		
3	Components are well fixed	3.1. FRL Unit is fixed		
		3.2. Pneumatic actuator is fixed		
		3.3. Flow control valve is fixed		
		3.4. 5/2 DCV Valve piloted is fixed		
		3.5. 3/2 DCV valves are fixed		



## Indicative content 2.2: Assembling Pneumatic System Components



Duration: 8 hours



### Theoretical Activity 2.2.1: Description of pneumatic system hose pipe joining technics



#### Notes to the trainer:

- The small group may be used to discuss on technics used to join hose pipe of pneumatic system
- The images, video and illustration may be used as didactic materials



#### Key steps:

**While delivering this activity, pass through the following steps:**

- Step 1:** Introduce the activity and ask the trainees to answer the following question in the small group:
- what is a hose pipe?
  - What are the factors which may be considered for choosing the hose pipe of pneumatic system?
  - What are a variety of materials used to make a hose pipe with different properties and capabilities?
  - What are the technics applied for joining pneumatic system hose pipe?
- Step 2:** Ask the trainees to present findings from their small groups
- Step 3:** Provide the expert view and involve trainees to ask question for clarification
- Step 4:** Direct trainees to read the key reading 2.2.1 in their manuals



#### Points to Remember

- **A hose pipe** is a flexible tube that enables the transfer of fluids, such as water, chemicals, oil, or gas, from one location to another.
- **Factors to consider when choosing a hose pipe:** Fluid Compatibility, Temperature and Pressure Ratings, Size and Length, End Connections and Industry Standards and Regulations
- **The variety of materials used to make a hose pipe with different properties and capabilities:** Polyurethane, PVC, Nylon, Polyethylene, PTFE(Teflon) and stainless steel

- **common techniques for joining pneumatic system hosepipes:** Push-to-Connect Fittings, Barbed Fittings, Compression Fittings, Reusable Hose Fittings, Crimping, Threaded Connections, Flared Fittings, Hose Clamps and Swaging
- **Tips for all techniques:** Inspect Hoses, Proper Cutting, Correct Hose Size, Follow Manufacturer's Guidelines and Leak Testing.



### Practical Activity 2.2.2: joining of pneumatic system hose pipe



#### Notes to the trainer

- The trainer may avail tools, materials and equipment used to install a pneumatic system
- Avail workshop
- Form small groups for trainees.



#### Key steps:

**While delivering this activity, pass through the following steps:**

**While delivering this activity, pass through the following steps:**

- Step 1:** Introduce the topic and ask trainees to read the task described below:
- Referring to key reading 2.2.1, you are asking to join a hose pipes pneumatic system.
- Step 2:** Explain the task and give instructions (PPEs and time allocation)
- Step 3:** Demonstrate how to join a hose pipes of pneumatic system.
- Step 4:** Assess their performance and provide feedback
- Step 5:** Allow the trainees to ask questions for clarifications.



#### Points to Remember

- **Common techniques for joining pneumatic system hosepipes:** Push-to-Connect Fittings, Barbed Fittings, Compression Fittings, Reusable Hose Fittings, Crimping, Threaded Connections, Flared Fittings, Hose Clamps and Swaging
- **Tips for All Techniques:** Inspect Hoses, Proper Cutting, Correct Hose Size, Follow Manufacturer's Guidelines and Leak Testing.



### Theoretical Activity 2.2.3: Description of electro-pneumatic system.



#### Notes to the trainer:

- The small group may be used to discuss on electro-pneumatic system
- The images, video and illustration may be used as didactic materials



#### Key steps:

**While delivering this activity, pass through the following steps:**

**Step 1:** Introduce the activity and ask the trainees to answer the following:

- i. What is electro-pneumatic system?
- ii. List out electromechanical devices used in electro-pneumatic system.

**Step 2:** Ask the trainees to present findings from their small groups

**Step 3:** Provide and the expert view and involve trainees to ask questions for clarification.

**Step 4:** Direct trainees to read the key reading 2.2.3 in their manuals.



#### Points to Remember

- Pneumatic control system with a solenoid operated valves may be called **electro-pneumatic system**.
- Electro-mechanical parts(devices) used in electro-pneumatic systems are: Manually actuated push button switches, Limit switches, Pressure switches, Solenoids, Relays, Timers and Temperature switches.



### Practical Activity 2.2.4: Connecting of Electrical Components in Pneumatic System



#### Notes to the trainer

- Avail tools, materials and equipment used to install a pneumatic system
- Avail workshop
- Form small groups for trainees.



#### Key steps:

**While delivering this activity, pass through the following steps:**

**Step 1:** Introduce the topic and ask trainees to read the task described below:

i. Referring to the key reading 2.2.4, you are asking to connect Electrical Components in Pneumatic System.

**Step 2:** Explain the task and give instructions (PPEs and time allocation)

**Step 3:** Demonstrate how to fix control and power circuits of pneumatic system components.

**Step 4:** Ask the trainees to fix control and power circuits of pneumatic system components and monitor the activity.

**Step 5:** Assess their performance and provide feedback

**Step 6:** Involve trainees to ask questions for clarifications.

**Step 7:** Lead them to read key reading 2.2.4 in their manuals



### Points to Remember

- Summary of the key steps involved in connecting electrical components
- When you are connecting electrical components, you have to: Identify Components Understand the System's Wiring Diagram, Prepare the Wiring, Connect Components, Ground the System, Test the Connections and Power the System.
- Additional Considerations: Safety, Compatibility, Coding, Maintenance.



### Theoretical Activity 2.2.5: Classification of Pipes used in Pneumatic System



#### Notes to the trainer:

- The small group may be used to discuss on Classification of Pipes used in Pneumatic System
- The images, video and illustration may be used as didactic materials



#### Key steps:

**While delivering this activity, pass through the following steps:**

**Step 1:** Introduce the activity and ask the trainees to answer the following:

- i. What are the types of pipes used in pneumatic system?
- ii. Give the factors considered in selecting the pipes used in pneumatic system?

**Step 2:** Ask the trainees to present findings from their small group

**Step 3:** Provide and the expert view and involve trainees to ask questions for clarification.

**Step 4:** Direct trainees to read the key reading 2.2.5 in their manuals for more details.



### Points to Remember

- Common types of pipes used in pneumatic systems are metal pipes (steel, stainless steel, aluminium and copper), plastic pipes (polyvinyl chloride, polypropylene, Nylon and polyether ketone) and rubber tubing (natural rubber and synthetic rubber).
- The choice of pipe material and type depends on factors such as: the operating pressure, temperature, corrosive environment, and specific application requirements.



### Practical Activity 2.2.6: connecting pipes in pneumatic system.



### Notes to the trainer

- The small group may be used to discuss on types of pipes used in pneumatic system
- The images, video and illustration may be used as didactic materials
- Avail of pneumatic circuit.



### Key steps:

**While delivering this activity, pass through the following steps:**

**Step 1:** Introduce the activity and ask trainees to read the task below:

- i. Referring on key reading 2.2.5, connect the pipes of pneumatic direct control circuit of single acting cylinder.

**Step 2:** Explain the task and give instructions (PPEs and time allocation)

**Step 3:** Demonstrate how to connect pneumatic system pipes.

**Step 4:** Ask the trainees to connect pneumatic system pipes and monitor the activity.

**Step 5:** Assess their performance and provide feedback

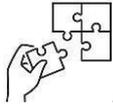
**Step 6:** Involve trainees to ask questions for clarifications.

**Step 7:** Lead them to read key reading 2.2.6 in their manuals



### Points to Remember

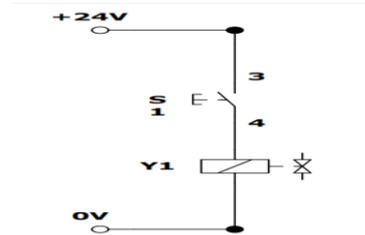
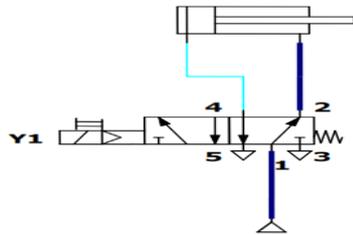
- To connect the pipes in pneumatic, there are step-by-step guide to help you ensure a secure and reliable connection as: safety first (use of PPE and disconnect power), Prepare the pipes, choose the right fittings, assembly the fittings, connect the pipes and test the system.



## Application of learning 2.2

After illustration pneumatic and electrical of Direct control of a double acting cylinder by using 5/2 DCV, single solenoid. You are requested to make the assembling the components of pneumatic and electric circuit and join pneumatic components by hose pipes and fittings on panel.

### Checklist:



a)Pneumatic power circuit

b)Electrical control circuit

SN	Criteria	Indicators	Observation	
			Yes	No
1	Drawings are well done	1.1: Pneumatic circuit is well drawn		
		1.2: Hydraulic circuit is well drawn		
2	Components are well fixed	2.1: 5/2 DCV valve, solenoid actuated is well fixed		
		2.2: Double acting cylinder is well fixed		
		2.3: FRL unit is fixed		
		2.4: Flow control valve are selected		
		2.5: Push button is well fixed		
3	Circuit components are well assembled.	3.1: Pneumatic components are well assembled by pipes hose and their fittings		
		3.2: Electrical circuit is well connected		



## Indicative content 2.3: Testing Pneumatic System



Duration: 7 hours



### Theoretical Activity 2.3.1: Description of testing pneumatic system



#### Notes to the trainer:

- The small groups may be used to discuss on pneumatic system testing.
- The images, video and illustration may be used as didactic materials.



#### Key steps:

**While delivering this activity, pass through the following steps:**

**Step 1:** Introduce the activity and ask the trainees to answer the following questions:

- what are the importance of testing pneumatic system?
- What are the common testing methods for pneumatic system?
- Which tests are required for pneumatic system?

**Step 2:** Ask the trainees to present findings from their small groups.

**Step 3:** Provide the expert view and involve trainees to ask questions for clarification.

**Step 4:** Direct trainees to read **the key reading 2.3.1** in Trainee manual.



#### Points to Remember

- Testing of pneumatic system is important to ensure their proper functioning, safety, and efficiency. By conducting thorough testing, you can identify and address potential issues before they lead to malfunctions or failures.
- Common Testing Methods for pneumatic system include: visual inspection, pressure testing, functional testing, leak detection, performance testing etc.
- Required tests for pneumatic system components include Proof of pressure, burst, performance, durability and impulse endurance.
- Measurements instruments used in pneumatic system are pressure gouge, thermometer, flow-meter, viscometer, etc.



### Practical Activity 2.3.2: Testing Pneumatic system components.



#### Notes to the trainer

- Avail tools, materials and equipment used to test a pneumatic system
- The images, video and illustration may be used as didactic materials
- Avail of pneumatic circuit.



#### Key steps:

While delivering this activity, pass through the following steps:

**Step 1:** Introduce the activity and ask trainees to read the task below:

- Referring on key reading 2.3.1**, by the help of testing instruments measure the pressure applied on the actuator of the pneumatic circuit.

**Step 2:** Explain the task and give instructions (PPEs and time allocation)

**Step 3:** Demonstrate how to make tests for pneumatic system components.

**Step 4:** Ask the trainees to make tests for pneumatic system components and monitor the activity.

**Step 5:** Assess their performance and provide feedback

**Step 6:** Involve trainees to ask questions for clarifications.

**Step 7:** Lead them to read key reading 2.3.2 in their manuals



#### Points to Remember

- There are the steps for pressure testing such as: Examination of design and specifications, selection of test method, establishment of test boundaries, verification of system readiness, evaluation of safety measures, preparation of test equipment, flushing and cleaning, pre-test inspection, sealing and isolation, communication with the personnel.



### Theoretical Activity 2.3.3: Description of laws governing pneumatic system parameters



#### Notes to the trainer:

- The small groups may be used to discuss on laws governing pneumatic system parameters
- The images, video and illustration may be used as didactic materials.



### Key steps:

While delivering this activity, pass through the following steps:

- Step 1:** Introduce the activity and ask the trainees to answer the following question:
- What are the laws governing pneumatic system parameters?
- Step 2:** Ask the trainees to present findings from their small group
- Step 3:** Provide and clarify the expert view.
- Step 4:** Direct trainees to read **the key reading 2.3.3** in Trainee manual.



### Points to Remember

- Perfect gas laws:

**1. Boyle's law States that,** if a given mass of a gas is compressed or expanded at a constant temperature, then the absolute pressure is inversely proportional to the volume.

$Pressure \propto \frac{1}{volume}$ , When temperature = constant or  $PV = \text{constant}$ , for state 1 and 2,  $P_1V_1 = P_2V_2$

**2. Charles' law states that,** if a given mass of a gas is heated or cooled at a constant pressure, then the volume is directly proportional to the absolute temperature.

Volume  $\propto$  Temperature, when pressure = constant or  $\frac{V}{T} = \text{Constant}$ , for state 1 and 2,  $V_1/T_1 = V_2/T_2$

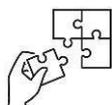
**3. Gay-Lussac's law state that,** at constant pressure, the absolute pressure of an ideal gas will vary directly with the absolute temperature.

Pressure  $\propto$  Temperature, when the Volume = constant or  $\frac{P}{T} = \text{constant}$ , for state 1 and 2,

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

**4. General Gas Law:** For any given mass of gas undergoing changes of pressure, temperature and volume, the general gas equation can be used. By combining Boyle's law and Gay-Lussac's law we get,

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$



### Application of learning 2.3.

After assembling the components of pneumatic and electrical circuits of Direct control of a double acting cylinder by using 5/2 DCV, single solenoid performed in application of learning 2.2. You are requested to test circuit for ensuring good functionality of the system.

**Checklist:**

SN	Criteria	Indicators	Observation	
			Yes	No
1	Pneumatic system components are tested	1.1: Proof of pressure is well tested		
		1.2: Performance of components is well checked.		
		1.3: Durability of components is well checked.		
		1.4: Functionality of air power supply is well checked		
		1.5: Leaks in pneumatic system is well checked		
2	Electrical circuit is well tested	2.1: Functionality of electrical power supply is well checked.		
		2.2: Continuity of circuit is well tested.		
		2.3: Functionality of solenoid is well tested		



## Learning outcome 2 end assessment

### Theoretical assessment

1. Define the following term:

- a. Hose pipe
- b. Temperature
- c. Pressure

**Answer:**

- a) **A hose pipe** is a flexible tube that enables the transfer of fluids, such as water, chemicals, oil, or gas, from one location to another.
- b) **Temperature** is a physical quantity that quantitatively expresses the attribute of hotness or coldness.
- c) **Pressure** is defined as the amount of force exerted on a surface per unit area.

**2. Read the following statement related to install pneumatic system and encircle the letter corresponding to the correct answer:**

i. What is the primary purpose of visual inspection in pneumatic systems?

- a) To check for leaks
- b) To measure pressure
- c) To assess noise levels
- d) To identify damage or misalignment

**Answer: d) To identify damage or misalignment**

ii. Which testing method involves applying pressure to the system to check for leaks and failures?

- a) Functional testing
- b) Pressure testing
- c) Leak detection
- d) Temperature monitoring

**Answer: b) Pressure testing**

iii. What is the primary purpose of testing hoses, tubing, and fittings in a pneumatic system?

- a) To assess their ability to withstand pressure and prevent leaks
- b) To measure their flow rate
- c) To check their viscosity
- d) To evaluate their rotational speed

**Answer: a) To assess their ability to withstand pressure and prevent leaks**

IV. Which instrument is used to measure pressure in a pneumatic system?

- a) Thermometer
- b) Flow meter
- c) Viscometer
- d) Pressure gauge

**Answer: d) Pressure gauge**

v. Which instrument is used to measure the humidity level in a pneumatic system?

- a) Hygrometer
- b) Tachometer
- c) Manometer
- d) Flow meter

**Answer: a) Hygrometer**

**3. Read the following statement related to install pneumatic system and answer by True if the statement is correct or False if the statement is wrong:**

a) Push-to-connect fittings require special tools for installation.

**Answer: False**

b) Flared fittings require the tubing end to be flared correctly to ensure a tight seal.

**Answer: True**

c) Regular inspection of hoses is important to ensure their reliability and safety.

**Answer: True**

d) It is not important to cut hoses cleanly and squarely when preparing them for fittings.

**Answer: False**

e) The hose size should be selected based on the application and fittings. **True**

**Answer: True**

4. Distinguish the flowmeter to the viscometer.

**Answer:**

- **Viscometer:** A viscometer (also called viscosimeter) is an instrument used to measure the viscosity of a fluid. while,
- **Flow Meters:** A flow meter is a device used to measure the volume (flow rate) or mass of a gas or liquid. Flow meters are referred to by many names, such as flow gauge, flow indicator, liquid meter, flow rate sensor

5. Give two examples (for each) of required tests on devices bellow used pneumatic systems

- a. Actuators
- b. Valves
- c. Accumulators
- d. Compressors
- e. Motors
- f. Heat exchanger
- g. Hoses, tubing and fittings.

**Answer:**

Required tests on devices/components of pneumatic system

- **For Actuators:** proof pressure, burst, piston drag, cyclic (stroke) endurance, impulse endurance
- **For Valves:** performance and durability

- **For oil Coolers / Heat Exchangers:** pressure drop, pressure, burst and/or shock
- **For Accumulators (piston, bladder, & diaphragm):** proof pressure, burst, impulse endurance, performance
  - **For Hydraulic/ Pneumatic Cylinder/Actuators rod seals and wipers:** endurance per each oil category
  - **For Hoses, tubing and fittings:** proof pressure, burst, impulse endurance
  - **For Pumps/compressors, motors:** performance and durability.

6. Give any two (2) examples of measuring instrument used in pneumatic/hydraulic system operation.

**Answer:**

- Pressure gauge
- Thermometers
- flow meters

7. Discuss on the factors which may be considered for choosing the hose pipe of pneumatic system?

**Answer:**

Factors to Consider When Choosing a Hose,

- **Fluid Compatibility:** Determine the compatibility of the hose material with the fluids it will come into contact with during operation. Chemical resistance charts can provide valuable information in this regard.
- **Temperature and Pressure Ratings:** Consider the temperature and pressure conditions the hose will be exposed to, ensuring the hose can withstand the intended range.
- **Size and Length:** Determine the appropriate hose diameter and length based on the specific requirements of your application.
- **End Connections:** Ensure the hose is compatible with the necessary end connections, such as clamps, fittings, spigots, flanges, or nozzles.
- **Industry Standards and Regulations:** Check if the hose complies with industry-specific standards and regulations to ensure safety and quality.

8. List out any five (5) varieties of materials used to make a hose with a different properties and capabilities.

**Answer:**

Variety of materials used to make a hose with different properties and capabilities.

- Polyurethane
- PVC
- Nylon
- Polyethylene
- PTFE(Teflon)
- Stainless steel

9. List out electromechanical devices used in electropneumatic system.

**Answer:**

Electro-Mechanical Parts (Devices) Used in Electro-Pneumatic Systems:

- Manually actuated push button switches
- Limit switches
- Pressure switches
- Solenoids
- Relays
- Timers
- Temperature switches

10. Give and explain the factors considered in selecting the pipes used in pneumatic system.

**Answer:**

Factors to Consider When Choosing Pipes

- **Operating pressure:** The pipe material and wall thickness must be able to withstand the maximum operating pressure.
- **Temperature:** The pipe material should be suitable for the expected temperature range.
- **Corrosion resistance:** If the system is exposed to corrosive environments, the pipe material must be resistant to those substances.
- **Flexibility:** For applications requiring flexibility, rubber tubing or flexible plastic pipes may be suitable.
- **Cost:** The cost of the pipe material and fittings should be considered within the overall budget

11. State and explain the perfect gas laws

**Answer:**

**1. Boyle's law States that,** if a given mass of a gas is compressed or expanded at a constant temperature, then the absolute pressure is inversely proportional to the volume.

*Pressure*  $\propto \frac{1}{\text{volume}}$ , When temperature = constant or  $PV = \text{constant}$ , for state 1 and 2,

$$P_1 V_1 = P_2 V_2$$

**2. Charles' law states that,** if a given mass of a gas is heated or cooled at a constant pressure, then the volume is directly proportional to the absolute temperature.

Volume  $\propto$  Temperature, when pressure = constant or  $\frac{V}{T} = \text{Constant}$ , for state 1 and 2,

$$V_1/T_1 = V_2/T_2$$

**3. Gay-Lussac's law state that,** at constant pressure, the absolute pressure of an ideal gas will vary directly with the absolute temperature.

Pressure  $\propto$  Temperature, when the Volume = constant or  $\frac{P}{T} = \text{constant}$ , for state 1 and 2,

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

12. A cylinder of gas under a pressure of 125 bar at 70 °F is left out in the sun in tropics and heats up to a temperature of 130 °F . What is the new pressure within the cylinder.

**Answer: Given Data:**

$$P_2=125 \text{ Bar (gauge)}$$

$$T_1= 70^{\circ}\text{F} =70+460 =530 \text{ K,}$$

$$T_2= 139^{\circ}\text{F} = 130 +460 = 590 \text{ K}$$

**Solution**

Since the pressure is constant, From Charles law, we have

$$P_1/T_1=P_2/T_2, 126/590 =P_2/530$$

Solving we get,  $P_2= 140.3 \text{ bar (abs)} = \mathbf{139.3 \text{ bar (gauge)}}$ .

13. A compressed air receiver has a volume of 0.5 m<sup>3</sup> is filled with compressed air at 7 bar (gauge) and at a temperature of 40°C . The temperature then cools to 20°C. What is the final pressure?

**Answer:**

**Given data**

$$V_1=V_2=0.25 \text{ m}^3$$

$$P_1= 7\text{bar (gauge)} = 7+1= 8 \text{ bar (abs)}$$

$$T_1= 20^{\circ}\text{C} = 20+273 =293 \text{ K}$$

$$T_2=40^{\circ}\text{C} = 40+273= 313\text{K}$$

Since the volume is constant we can apply, Gay-Lussac law

$$\frac{P_1}{P_2} = \frac{T_1}{T_2}$$

$$8/293=P_2/313$$

Solving we get,

Thus,  $P_2=7.5 \text{ bar (abs)} = \mathbf{6.5 \text{ bar (gauge)}}$ .

14. Gas at 70 bars gage pressure and 37.8°C is contained in the 12900cm<sup>3</sup> cylinder. A piston compresses the volume to 9680cm<sup>3</sup> while the gas is heated to 93.3°C. What is the final pressure in the cylinder?

**Answer:**

$$P_2 = \frac{P_1 V_1 T_2}{V_2 T_1} = (70 \times 10^5 + 1 \times 10^5) (12900) (93.3 + 273) / (9680) (37.8 + 273) = 111.5 \times 10^5 \text{ Pa}$$

(absolute)

=111.5 bars (absolute).

### Practical assessment

XYZ TAILORING COMPANY wants to install a pneumatic stamping machine for branding and identification of their finished product. The single-acting cylinder, spring return is controlled by 3/2 DCV valve, solenoid activated.

As technician, you are asked to do the following task:

1. Draw a control and power circuit of pneumatic system of pneumatic stamping machine

2. Fix the components of pneumatic stamping machine on panel
3. Assemble the components of the pneumatic system.
4. Test the functionality of installed pneumatic stamping machine.

**Checklist:**

SN	Criteria	Indicators	Observation	
			Yes	No
1	Drawing is well done	1.1. Air supply is labelled		
		1.2. FRL unit is labelled		
		1.3. 3/2 DCV valves, solenoid activation are labelled		
		1.4. single acting cylinder, spring return is labelled		
		1.5. Flow control valve is labelled		
2	Tools, Materials and Equipment are well selected	2.2. Mechanical tool kit is selected		
		2.2. Electrical tool kit is selected		
		2.3. Air compressor is selected		
		2.4. DCV Valves are selected		
		2.5. FRL unit is selected		
		2.6. single acting cylinder, spring return is selected		
		2.7. Flow control valve are selected		
3	Components are well fixed	3.1. FRL Unit is well fixed		
		3.2. Single acting cylinder is fixed		
		3.3. Flow control valve is fixed		
		3.4. 5/2 DCV Valve piloted is fixed		
		3.5. 3/2 DCV valves are fixed		
4	Circuit components are well assembled.	4.1: Pneumatic components are well assembled by pipes hose and their fittings		
		4.2: Electrical circuit is well connected		
5	Pneumatic system components are tested	5.1: Proof of pressure is well tested		
		5.2: Performance of components is well checked.		
		5.3: Durability of components is well checked.		
		5.4: Functionality of air power supply is well checked		
		5.6: Leaks in pneumatic system is well checked		



## Further information to the trainer

(n.d.). Retrieved from <https://tameson.com/pages/pneumatic-pipe-fittings>

(n.d.). Retrieved from 2.

[https://www.festo.com/net/enir\\_ir/SupportPortal/Files/729819/Installation%20Guide\\_2022\\_EN\\_scr.pdf](https://www.festo.com/net/enir_ir/SupportPortal/Files/729819/Installation%20Guide_2022_EN_scr.pdf)

Croser, P. (1992). *Pneumatics*. Esslingen: Festo Didactic.

F.Hooper, J. (2003). *Basic Pneumatics* .

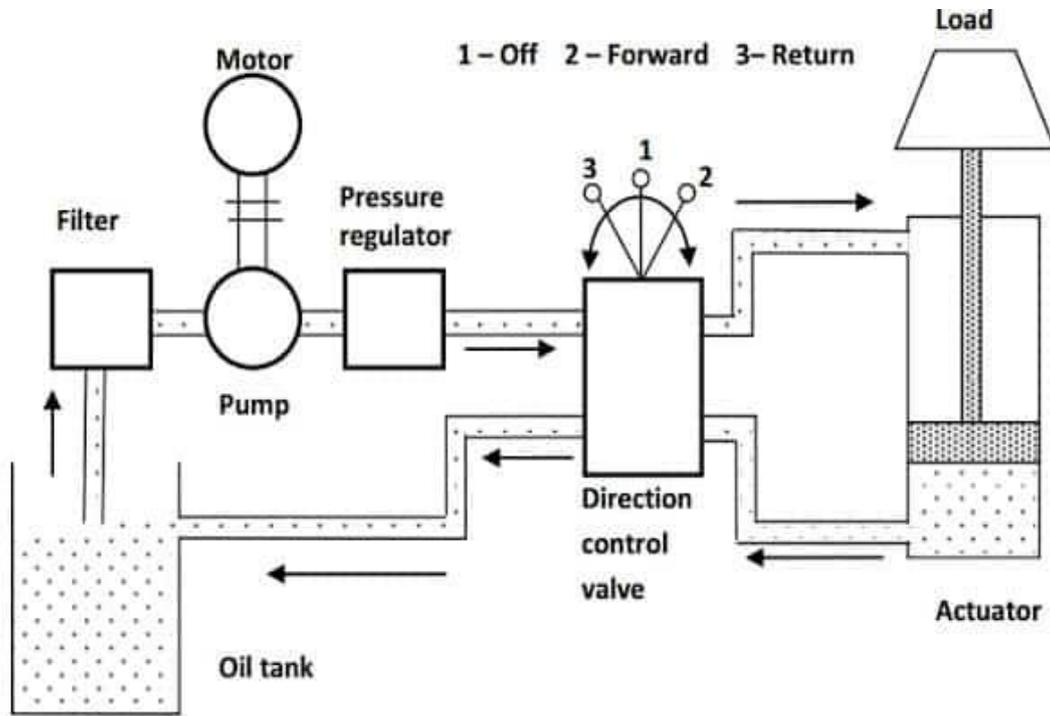
Jayakumar, V. (June, 2010). *Applied Hydraulics and Pneumatics*. Chennai: LAKSHMI Publications.

Khan, Q. (n.d.). *STUDY OF HYDRAULIC VALVES, PUMPS AND ACCUMULATORS*. MUMBAI: HYDROELECTRIC MACHINERY PREMISES.

Parr, A. A. ( March 1999 ). *Hydraulics and Pneumatics* . Elsevier Science & Technology Books

Schapoehler, M. (2024, September 12). Retrieved from Airline Hydraulics Website: <https://blog.airlinehyd.com/pneumatic-system-explainer>

## Learning Outcome 3: Install Hydraulic System



Components of a hydraulic system

<b>Indicative contents</b>
<p><b>3.1 Fixing hydraulic system components</b></p> <p><b>3.2 Assembling hydraulic system components</b></p> <p><b>3.3 Testing of hydraulic system</b></p>

**Key Competencies for Learning Outcome 3: Install hydraulic system**

<b>Knowledge</b>	<b>Skills</b>	<b>Attitudes</b>
<ul style="list-style-type: none"> <li>● Identification of fixing technics of hydraulic components</li> <li>● Identification of hosepipe joining techniques</li> <li>● Description of electrical and hydraulic tests</li> <li>● Description of measuring/testing instruments used in hydraulic system</li> <li>● Identification of hydraulic system parameters</li> </ul>	<ul style="list-style-type: none"> <li>● Fixing hydraulic control and power components</li> <li>● Connecting electrical components and pipes</li> <li>● Testing control and power circuits</li> </ul>	<ul style="list-style-type: none"> <li>● Being careful while fixing and assembling hydraulic components</li> <li>● Being accurate while testing hydraulic circuits</li> <li>● Being cooperative while assembling hydraulic components</li> <li>● Having self confidence</li> <li>● Being responsible</li> </ul>



**Duration: 25 hours**



**Learning outcome 3 objectives:**

By the end of the learning outcome, the trainees will be able to:

1. Identify correctly the fixing technics of hydraulic components according to the fixing technics.
2. Apply correctly the fixing technics of hydraulic components according to the fixing technics.
3. Fix properly hydraulic control and power components according to the fixing technics.
4. Identify properly hosepipe joining techniques according to the joining technics.
5. Apply appropriately hosepipe joining techniques according to the joining technics.
6. Connect appropriately electrical components according to assembling techniques and procedures.
7. Connect appropriately pipes according to assembling techniques and procedures.
8. Describe rightly the measuring/testing instruments used in hydraulic system testing.
9. Test properly control and power circuits according to the testing technics.
10. Identify correctly hydraulic system parameters according testing technics.



**Resources**

<b>Equipment</b>	<b>Tools</b>	<b>Materials</b>
<ul style="list-style-type: none"> <li>● Computer</li> <li>● Multi-meter</li> <li>● Tachometer</li> <li>● Thermometer</li> <li>● Flow meter</li> <li>● Viscometer</li> <li>● Manometer</li> <li>● Head Protection</li> <li>● Eye and Face Protection</li> <li>● Hearing Protection</li> </ul>	<ul style="list-style-type: none"> <li>● Wire stripping plier</li> <li>● Side cutter plier</li> <li>● Combination plier</li> <li>● Long nose plier</li> <li>● Spirit level</li> <li>● Tape measure</li> <li>● Steel rulers</li> <li>● Star screw driver</li> <li>● Flat screw driver</li> <li>● Hand drilling machine</li> <li>● Electric screw</li> </ul>	<ul style="list-style-type: none"> <li>● Fuses</li> <li>● Wires</li> <li>● Nuts and Bolts</li> <li>● Cable clips</li> <li>● Insulators</li> <li>● Welding holder</li> <li>● Grease</li> <li>● Oil</li> <li>● Pipes</li> <li>● Hoses</li> <li>● Couplings</li> <li>● Lubricants</li> </ul>

<ul style="list-style-type: none"> <li>● Respiratory Protection</li> <li>● Hand Protection</li> <li>● Foot Protection</li> <li>● Body Protection</li> <li>● Fall Protection</li> <li>● Skin Protection</li> <li>● First aid</li> <li>● Pump</li> <li>● Valves</li> <li>● Actuators</li> <li>● Miscellaneous</li> </ul>	<p>driver</p> <ul style="list-style-type: none"> <li>● Crimping tools</li> <li>● Electrical hammer</li> <li>● Claw hammer</li> <li>● Ball pen hammer</li> <li>● Mallet hammer</li> <li>● Spring bender</li> <li>● Hack saw</li> <li>● Electrician knife</li> <li>● Allen key</li> <li>● Still Brushes</li> <li>● Scissor</li> <li>● Vanier caliper</li> </ul>	<ul style="list-style-type: none"> <li>● Scotches</li> <li>● Markers</li> <li>● Pipes and hoses</li> <li>● Pipe fittings</li> <li>● Switch box</li> <li>● Junction boxes</li> <li>● Push buttons</li> <li>● Spring</li> <li>● Female plugs</li> <li>● Male Plugs</li> <li>● Extension Cords</li> <li>● Drill bits</li> <li>● Wall plugs</li> <li>● Clips</li> <li>● Charcoal</li> </ul>
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**Advance Preparation:**

Before delivering this learning outcome, you are recommended to:

- Prepare tools, equipment and materials
- Avail workplace /classroom
- Avail electricity
- Avail hydraulic installation board



## Indicative content 3.1: Fixing hydraulic System Components



Duration: 10 hours



### Theoretical Activity 3.1.1: Identification of fixing technics of hydraulic components



#### Notes to the trainer:

- The small group may be used to discuss on fixing technics of hydraulic system
- The images, video and illustration may be used as didactic materials



#### Key steps:

**While delivering this activity, pass through the following steps:**

- Step 1:** Introduce the activity and ask trainees to answer the following questions:
- Define the term hydraulic circuit.
  - Enumerate the essential components of hydraulic system.
  - Explain fixing technics of hydraulic system components.
- Step 2:** Ask the trainees to present findings in front of the class and trainer.
- Step 3:** Provide the expert view and involve trainees to ask questions for clarifications.
- Step 4:** Direct trainees to read **key reading 3.1.1** in their manuals for more details about fixing technics of hydraulic system.



#### Points to Remember

- Hydraulic circuit is a network /interconnection of components that make up a hydraulic system.
- Essential components of hydraulic system are hydraulic power pack, Hydraulic control elements, power drives/actuators and system accessories.
- The technics used to fix hydraulic system components are:
  - Use of clamps and brackets
  - Bolting and screwing
  - Welding
  - Use of glue and adhesives
  - Crimping and thread locking compounds



### Theoretical Activity 3.1.2: Identification of electrical components used in hydraulic system control circuits



#### Notes to the trainer:

- The small group may be used to discuss on electrical components used in hydraulic system control circuits.
- The images, video and illustration may be used as didactic materials.



#### Key steps:

**While delivering this activity, pass through the following steps:**

**Step 1:** Introduce the activity and ask trainees to answer the following questions in small groups:

- i. Explain electrical components which are used in hydraulic system control circuits.

**Step 2:** Ask the trainees to present findings from group discussions in front of the class and trainer.

**Step 3:** Provide and clarify the expert view.

**Step 4:** Direct trainees to read **key reading 3.1.2** in their manuals for more details about electrical components which are used in hydraulic system control circuits.



#### Points to Remember

- Basic electrical components used in hydraulic systems control circuits are manually actuated push button switches, limit switches, pressure switches, solenoids, relays, timers, temperature switches.



### Practical Activity 3.1.3: Fixing hydraulic control components



#### Notes to the trainer

- The trainer may avail tools, materials and equipment used to install a hydraulic system
- Avail workshop

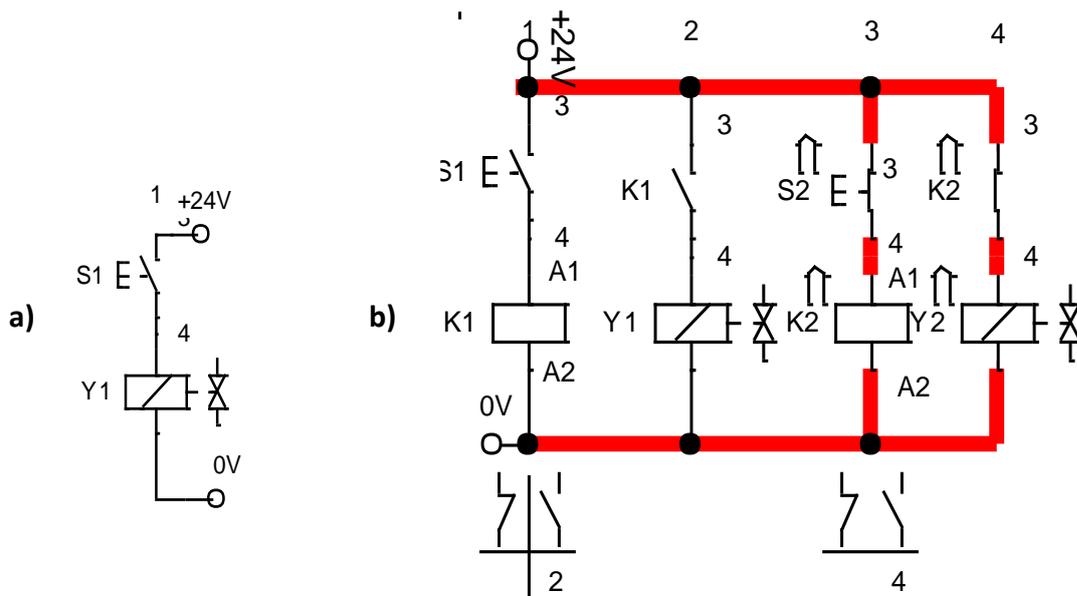


#### Key steps:

**While delivering this activity, pass through the following steps:**

**Step 1:** Introduce the activity and ask learners to read the task below:

i.Task: Based on the previous theoretical activity 3.1.1, fix the components of the following hydraulic circuits.



**Step2.** Give clear instructions about the activity to be done

**Step3.** Demonstrate how to fix hydraulic system control components and explain the steps to follow.

**Step4.** Ask trainees to fix hydraulic system control components and monitor the activity.

**Step5.** Assess trainees and provide feedback to them.

**Step 6.** Allow trainees to ask questions for clarification.

**Step 7.** Invite trainees to read more key readings 3.1.3 learn more about steps of fixing hydraulic system control components.



#### Points to Remember

- Steps for fixing/attaching hydraulic system control components are prepared the components, select the appropriate attachment method, position the components, secure the components, check for alignment and security, test for leaks and document the installation.



#### Practical Activity 3.1.4: Fixing hydraulic power components



#### Notes to the trainer

- The trainer may avail tools, materials and equipment used to install a hydraulic system
- Avail workshop

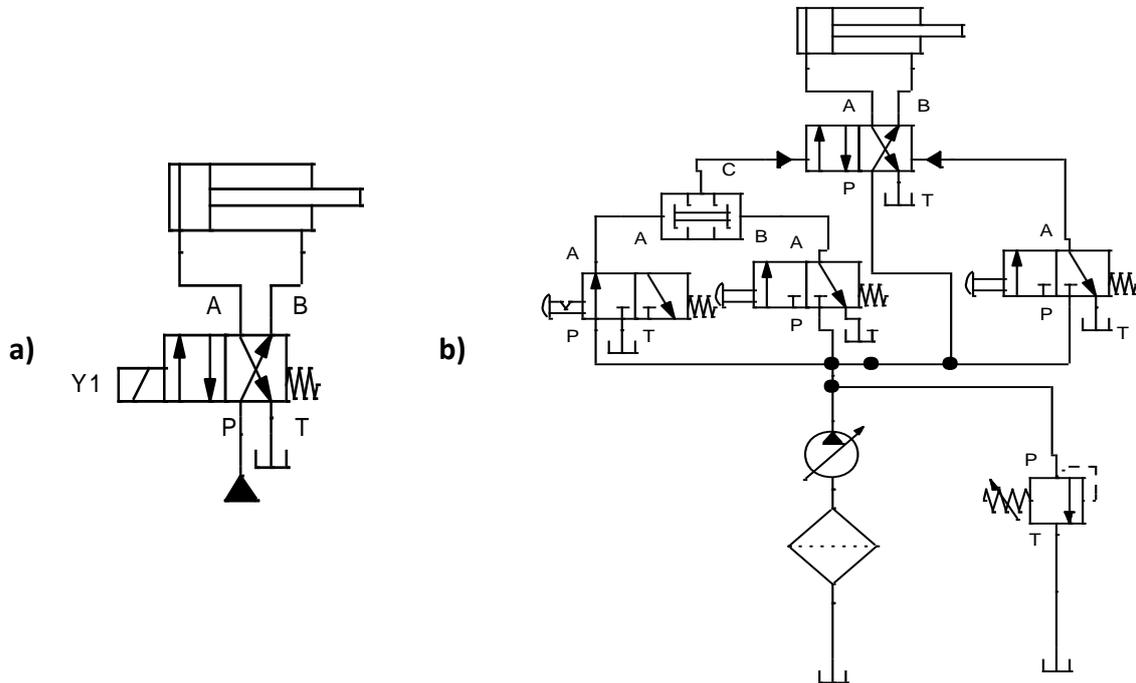


### Key steps:

**While delivering this activity, pass through the following steps:**

**Step 1:** Introduce the activity and ask learners to read the task below:

- i. Based on the previous theoretical activity 3.1.1, fix the components of the following hydraulic circuits.



**Step2.** Give clear instructions about the activity to be done

**Step3.** Demonstrate how to fix hydraulic system power components and explain the steps to follow.

**Step4.** Ask trainees to fix hydraulic system control components and monitor the activity.

**Step5.** Assess trainees and provide feedback to them.

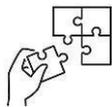
**Step 6.** Allow trainees to ask questions for clarification.

**Step 7.** Invite trainees to read more key readings 3.1.4 learn more about steps of fixing hydraulic system power components.



### Points to Remember

- Steps for fixing/attaching hydraulic system power components are prepared the components,
- Select the appropriate attachment method, position the components, secure the components, check for alignment and security, test for leaks and document the installation.



### Application of learning 3.1.

RVB Ltd is a company that is located in Kigali City, Gasabo district. This company produces cassava flour. For servicing well customers, the company wants to extend its grinding machines. That is why a new hydraulic system that can be used in production should be installed. This hydraulic system should have a power circuit and an electrical control circuit which are well fixed.

**Task:** As an expert in the field hydraulic system installation, you are requested to fix the components of control and power circuits.

**Note:** The hydraulic system should be well protected.

#### Checklist:

SN	Criteria	Indicators	Observation	
			Yes	No
1	Hydraulic components are prepared correctly.	1.1. Components are cleaned		
		1.2. Components selected are inspected for damage		
2	Appropriate attachment method is well selected	2.1. Benefits of method selected are considered		
		2.2. Size of component is considered		
3	Components are properly positioned	3.1. Alignment is done		
		3.2. Alignment tools are used		
4	Components are well secured	4.1. Components are fastened		
		4.2. Manufacturer instructions are followed while fastening		
5	Alignment and security are checked	5.1. Misalignment is evaluated		
		5.2. Components are securely attached		



## Indicative content 3.2: Assembling Hydraulic System Components



Duration: 10 hours



### Theoretical Activity 3.2.1: Identification of hosepipe joining



#### Notes to the trainer:

- The small group may be used to discuss on hosepipe joining techniques
- The images, video and illustration may be used as didactic materials



#### Key steps:

While delivering this activity, pass through the following steps:

- Step 1:** Introduce the activity and ask trainees to answer the following question:
- What are the techniques that can be used to join hosepipes?
- Step 2:** Ask the trainees to present findings in front of the class and trainer.
- Step 3:** Provide the expert view and involve trainees to ask questions for clarification.
- Step 4:** Direct trainees to read **key reading 3.2.1** in their manuals for more details about hosepipe joining techniques.



#### Points to Remember

- Technics of joining horse pipes are threaded connections, threaded connections, welding, brazing, flange connections, quick disconnects, compression fittings, hydraulic hose assemblies and inspection and testing.



### Theoretical Activity 3.2.2: Identification of types of pipelines and pipe fittings used in hydraulic system installation



#### Notes to the trainer:

- The small group may be used to discuss on pipelines and pipe fittings used in hydraulic system installation.
- The images, video and illustration may be used as didactic materials



### Key steps:

**While delivering this activity, pass through the following steps:**

- Step 1:** Introduce the activity and ask trainees to answer the following questions:
- Outline the types of pipe used in hydraulic system installation.
  - What are the types of pipe fitting used in hydraulic system installation?
  - Mention the raw materials which are used to manufacture pipe fittings.
  - Enumerate the applications of pipe fittings.
  - Outline the factors to consider while selecting pipe fittings.
- Step 2:** Ask the trainees to present results in front of the class and trainer.
- Step 3:** Provide the expert view and involve learners to ask for clarification.
- Step 4:** Direct trainees to read key reading 3.2.2 in their manuals for more details about pipelines and pipe fittings used in hydraulic system installation.



### Points to Remember

- The type of pipes used in hydraulic systems installation are metal pipes, plastic pipes, cast iron pipes, concrete pipes and clay pipes.
- Pipe Fittings used in hydraulic systems installation to connect pipes can be summarized as couplings, elbows, tees, reducers, bushings, caps, unions, adaptor fittings and wyes.
- Pipe fittings can be made from a variety of materials, including Brass, Copper, PVC, Galvanized steel and Cast iron.
- Pipe fittings are used in a variety of applications like plumbing, HVAC, irrigation and industrial applications.
- Factors to consider while selecting pipe fittings are pipe material used, size of the pipe, pressure and temperature of the system and specific application for the pipe fitting.



### Practical Activity 3.2.3: Connecting electrical components of hydraulic



### Notes to the trainer

- The trainer may avail tools, materials and equipment used to install a hydraulic system
- Avail workshop

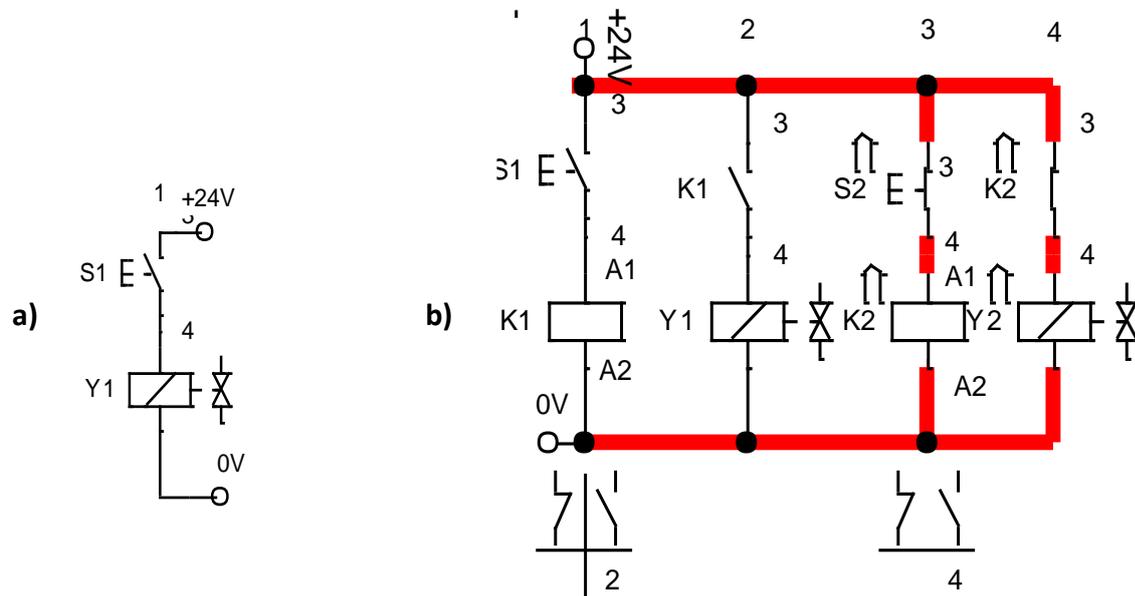


## Key steps:

While delivering this activity, pass through the following steps:

**Step 1:** Introduce the activity and ask learners to read the task below:

- i. Based on the previous theoretical activity 3.2.1, connect the electrical components of the following hydraulic control circuits fixed in practical activity 3.1.3.



**Step 2.** Give clear instructions about the activity to be done

**Step 3.** Demonstrate how to connect hydraulic system electrical components and explain the steps to follow.

**Step 4.** Ask trainees to connect hydraulic system electrical components and monitor the activity.

**Step 5.** Assess trainees and provide feedback.

**Step 6.** Allow trainees to ask questions for clarification.

**Step 7.** Invite trainees to read more key readings 3.2.3 learn more about steps of connecting hydraulic system electrical components.



## Points to Remember

- Steps for connecting electrical components in hydraulic control circuits are design and planning, prepare the components, wiring, grounding, testing and commissioning.



### Practical Activity 3.2.4: Connecting pipes of hydraulic system



#### Notes to the trainer

- The trainer may avail tools, materials and equipment used to install a hydraulic system
- Avail workshop

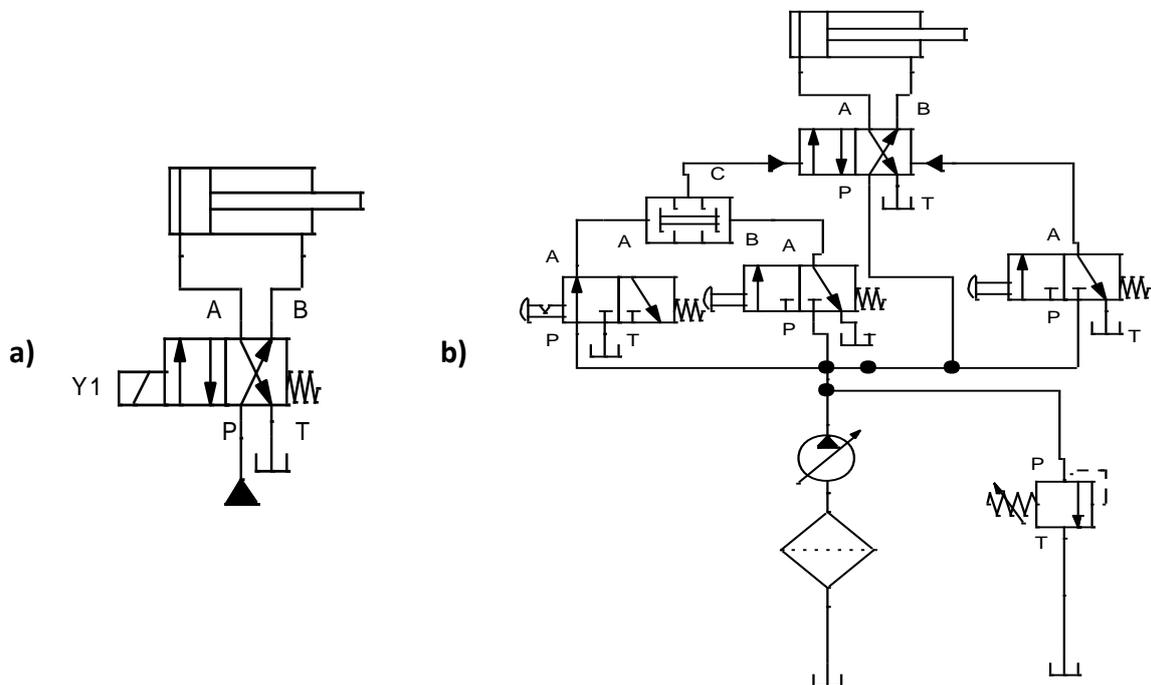


#### Key steps:

While delivering this activity, pass through the following steps:

**Step 1:** Introduce the activity and ask learners to read the task below personally:

- Task: Based on the previous theoretical activity 3.2.1, connect the pipes of the following hydraulic power circuits fixed in practical activity 3.1.4.



**Step2.** Give clear instructions about the activity to be done

**Step3.** Demonstrate how to connect pipes of hydraulic system and explain the steps to follow.

**Step4.** Ask trainees to connect pipes of hydraulic system.

**Step5.** Assess trainees and provide feedback.

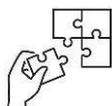
**Step 6.** Allow trainees to ask questions for clarification.

**Step 7.** Invite trainees to read more key readings 3.2.4 learn more about steps of connecting pipe of hydraulic system.



### Points to Remember

- Steps for Connecting Pipes in Hydraulic Circuits are prepare the tubing, prepare the fittings, assemble the components, test for leaks, secure the tubing, bleed the system and test the system.



### Application of learning 3.2.

RYB Ltd is company that is located in Kigali City, Gasabo district. This company produces cassava flour. For servicing well customers, the company wants to extend its grinding machines. That is why a new hydraulic system that can be used in production should be installed. This hydraulic system should have power circuit and electrical control circuit which are well fixed.

**Task:** As an expert in the field hydraulic system installation, you are requested to connect the components of hydraulic control circuits.

**Note:** The hydraulic system should be well protected.

#### Checklist:

SN	Criteria	Indicators	Observation	
			Yes	No
1	Design and planning are well done	1.1. Circuit diagram is developed		
		1.2. Components are selected		
		1.3. Safety regulations are respected		
2	Components are well prepared	2.1. Components are labelled		
		2.2. Components are organized		
		2.3. Components are checked for damage		
3	Wiring is well done	3.1. Wires are stripped		
		3.2. Wires are connected to components		
		3.4. Wiring diagram is followed		
4	Grounding is well done	4.1. Installation is grounded		
		4.2. Grounding regulation are respected		
5	Testing and commissioning are well done	5.1. Circuit is tested		
		5.2. Commissioning is done		



## Indicative content 3.3: Testing of Hydraulic System



Duration: 5 hours



**Theoretical Activity 3.3.1: Identification of testing instruments used in hydraulic system installation**



**Notes to the trainer:**

- The small group may be used to discuss on testing instruments used in hydraulic system installation.
- The images, video and illustration may be used as didactic materials.



**Key steps:**

**While delivering this activity, pass through the following steps:**

- Step 1:** Introduce the activity and ask trainees to answer the following questions:
- Define term hydraulic testing instrument.
  - Outline different types of testing instruments used in hydraulic system and explain the function of each instrument.
- Step 2:** Ask the trainees to present findings from groups in front of the whole class.
- Step 3:** Provide the expert view and involve trainees to ask questions for clarification.
- Step 4:** Direct trainees to read **key reading 3.3.1** in their manuals for more details about testing instruments used in hydraulic system.



**Points to Remember**

- Hydraulic testing instruments are specialized tools used to measure various parameters and assess the performance of hydraulic systems.
- Testing instruments used in hydraulic system are pressure gauges, flow meters, leak detectors, temperature sensors, contamination testers, vibration sensors, noise meters, particle counters, oscilloscopes and hydraulic test benches.



## Practical Activity 3.3.2: Testing hydraulic control circuits



### Notes to the trainer

- The trainer may avail tools, materials and equipment used to test an hydraulic system
- Avail workshop

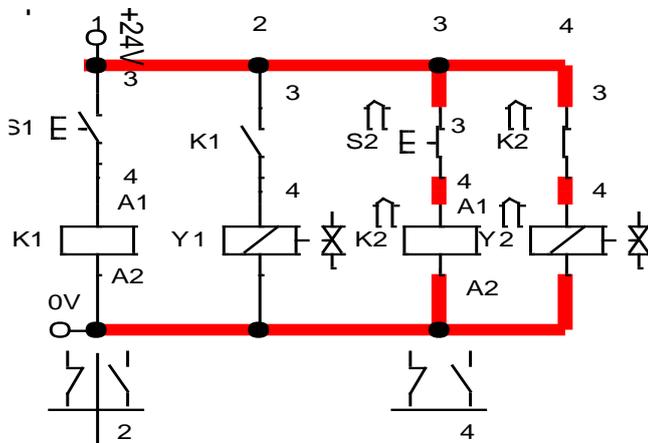


### Key steps:

While delivering this activity, pass through the following steps:

**Step 1:** Introduce the activity and ask learners to read the task below:

- Task: Based on the previous theoretical activity 3.3.1, test following hydraulic circuit connected in practical activity 3.2.3.



**Step2.** Give clear instructions about the activity to be done.

**Step3.** Demonstrate how to test hydraulic control circuit and explain the steps to follow.

**Step4.** Ask trainees to test hydraulic control circuit.

**Step5.** Assess trainees and provide feedback.

**Step 6.** Allow trainees to ask questions for clarification.

**Step 7.** Invite trainees to read more key readings 3.3.2 learn more about steps for testing the control circuit of a hydraulic circuit.



### Points to Remember

- Steps for testing the control circuit of a hydraulic circuit are prepared the system, verify power supply, test input signals, monitor outputs, check for short circuits or open circuits, test control logic, check for interference, load testing and documentation.



### Practical Activity 3.3.3: Testing hydraulic power circuits



#### Notes to the trainer

- The trainer may avail tools, materials and equipment used to test an hydraulic system
- Avail workshop

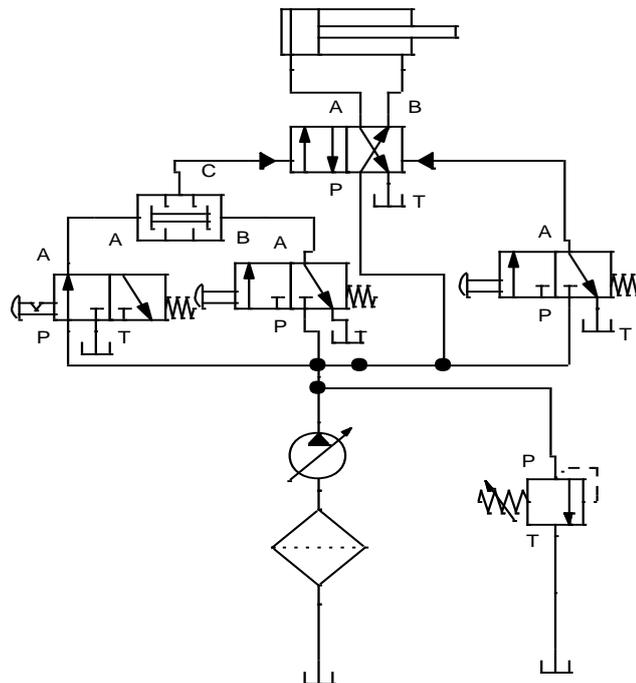


#### Key steps:

**While delivering this activity, pass through the following steps:**

**Step 1:** Introduce the activity and ask learners to read the task below:

- Based on the previous theoretical activity 3.3.1, test following hydraulic power circuit connected in practical activity 3.2.4.



**Step2.** Give clear instructions about the activity to be done.

**Step3.** Demonstrate how to test hydraulic power circuit and explain the steps to follow.

**Step4.** Ask trainees to test hydraulic power circuit and monitor the activity.

**Step5.** Assess trainees and provide feedback.

**Step 6.** Allow trainees to ask questions for clarification.

**Step 7.** Invite trainees to read more key readings 3.3.3 learn more about steps for testing the power circuit of a hydraulic circuit.



### Points to Remember

- Steps for testing the power circuit of a hydraulic circuit are: prepare the system, start the system, check for leaks, test component functionality, check for overheating, verify control system operation, load testing and record test results.



### Theoretical Activity 3.3.4: Identification of hydraulic system parameters



### Notes to the trainer:

- The small group may be used to discuss hydraulic system parameters.
- The images, video and illustration may be used as didactic materials.



### Key steps:

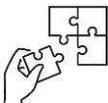
**While delivering this activity, pass through the following steps:**

- Step 1:** Introduce the activity and ask trainees to answer the following questions:
- i. Define hydraulic system parameters.
  - ii. Outline different types of hydraulic system parameters and explain each parameter.
- Step 2:** Ask the trainees to present findings in front of the whole class.
- Step 3:** Provide the expert view and involve trainees to ask questions for clarifications.
- Step 4:** Direct trainees to read key reading 3.3.4 in their manuals for more details about hydraulic system parameters.



### Points to Remember

- Hydraulic system parameters are the measurable characteristics that define the performance and behavior of a hydraulic system.
- Hydraulic system parameters are pressure, flow rate, power, temperature, viscosity, contamination, noise, efficiency, reliability and safety.



### Application of learning 3.3.

RYB Ltd is company that is located in Kigali City, Gasabo district. This company produces cassava flour. For servicing well customers, the company wants to extend its grinding machines. That is why a new hydraulic system that can be used in production has been installed.

**Task:** As an expert in the field hydraulic system installation, you are requested to test the installed hydraulic power circuit to make sure if the installation has been done correctly.

**Checklist:**

SN	Criteria	Indicators	Observation	
			Yes	No
1	The system is well prepared	1.1. System is isolated		
		1.2. Fluid level is checked		
		1.3. Leaks are checked		
2	The system is started correctly	2.1. Power source is activated		
		2.2. Pump is started		
3	Components functionality is tested properly	3.1. Valves are tested		
		3.2. Cylinders and motors are tested		
4	Pressure and flowrate are measured	4.1. Pressure is measured		
		4.2. Flowrate is measured		
5	Overheating is well checked and overloading	5.1. Temperature is measured		
		5.2. Loads are applied		



## Learning Outcome 3 end assessment

### Theoretical assessment

1. Define the following term:

- a) Hydraulic circuit
- b) Hydraulic control elements
- c) Clamps

**Answer:**

- a) **Hydraulic circuit:** Hydraulic circuit is a network /interconnection of components that make up a hydraulic system. It uses pressurized fluid to transmit power and perform mechanical work.
- b) **Hydraulic control elements:** Are various valves used to control actuators.
- a) **Clamps:** Are tools used to secure components in place, especially tubing and hoses.

2. Outline five methods used to fix/attach hydraulic components.

**Answer:**

- ✓ Clamps and brackets
- ✓ bolting and screwing
- ✓ Welding
- ✓ Use of glue and adhesives
- ✓ Crimping and thread locking compounds

3. Enumerate four essential components of hydraulic system.

**Answer:**

**Essential components of hydraulic system are:**

- ✓ Hydraulic power pack
- ✓ Hydraulic control elements
- ✓ power drives/actuators
- ✓ System accessories

**Read the following statement related to install hydraulic system and encircle the letter corresponding to the correct answer:**

4. Which of the following is not a key hydraulic system parameter?

- a. Pressure
- b. Flow Rate
- c. Temperature
- d. Voltage

**Answer: d: Voltage**

5. Hydraulic power is calculated as:

- a. Pressure divided by flow rate
- b. Pressure multiplied by flow rate

- c. Flow rate divided by pressure
- d. Pressure plus flow rate

**Answer: b: Pressure multiplied by flow rate**

6. Safety features in hydraulic systems include:

- a. Pressure relief valves
- b. Emergency stops
- c. Leak detection systems
- d. All of the above

**Answer: d: All of the above**

7. The first step in testing a hydraulic power circuit is:

- a. Checking for leaks
- b. Starting the pump
- c. Isolating the system
- d. Measuring pressure

**Answer: c: Isolating the system**

8. Why is it important to test the control system of a hydraulic circuit?

- a. To ensure proper operation of valves and actuators
- b. To verify the accuracy of pressure and flow measurements
- c. To check for electrical faults
- d. To monitor the temperature of the hydraulic fluid

**Answer: a: To ensure proper operation of valves and actuators**

9. Read the following statement related to install hydraulic system and answer by True if the statement is correct or False if the statement is wrong

- a) System parameters are used to assess the performance and efficiency of the system.

**Answer: True**

- b) Flow rate is measured in units of liters per second (L/s).

**Solution: False** (It's typically measured in L/min or gpm)

- c) Hydraulic power is calculated by multiplying pressure and flow rate.

**Answer: True**

10. Differentiate push button and limit switch.

**Answer:**

A push button is a switch actuated manually used to close or open an electric control circuit while a limit switch that is actuated due to the position of an hydraulic system component (usually a piston rod or hydraulic motor shaft or the position of load is termed as limit switch).

11. Outline five electrical components which are used in hydraulic control circuits.

**Answer:**

- Manually actuated push button switches
- Limit switches
- Pressure switches
- Solenoids

- Relays
- Timers
- Temperature switches

**12.** Distinguish the flowmeter to the viscometer.

**Answer:**

**Viscometer:** A viscometer is an instrument used to measure the viscosity of a fluid

**Flow meter:** A flow meter is a device used to measure the volume (flow rate) or mass of a gas or liquid. Flow meters are referred to by many names, such as flow gauge, flow indicator, liquid meter, and flow rate sensor.

**13.** What are factors considered while selecting pipe line?

**Answer:**

**The factors considered when selecting pipe line are:**

- Pressure of the fluid in the line
- Total flow rate per unit time through the
- Permissible pressure drop in the line
- Type of tube material and type of line fitting.
- Length and diameter of tube or other pipelines.
- Working environment

**14.** Identify at least two tests that can be performed after the installation of the following hydraulic Components

- a) Electrical motor
- b) Hydraulic pump
- c) The fluids
- d) Control valves and lines

**Answer:**

- a) Electrical motor: -check supply current, -check connections, -check Switch (ON and OFF)
- b) Hydraulic pump: -check Pressure, -check connections, - check coupling, -check leakage
- c) The fluids: -check level, -check viscosity
- d) Control valves and lines: -check leakage, - check tight of connections, -check pressure

**15.** Classify different types of pipe fittings used in hydraulic system.

**Answer:**

Pipe Fittings used in hydraulic systems installation to connect pipes are:

- Couplings
- Elbows
- Tees
- Reducers
- Bushings
- Caps
- Unions
- Adaptor fittings and wyes

16. Giving five examples of testing instruments used in hydraulic system testing.

**Answer:**

- Pressure gauges
- Flow meters
- Leak detectors
- Viscometer
- Temperature sensors
- Contamination testers
- Vibration sensors
- Noise meters etc.

17. Use the appropriate terminologies used in pneumatic and hydraulic system installation and complete the following table

Parameter	Definition	Units
Pressure	.....	Pascal (Pa), pounds per square inch (psi), bars
.....	The volume of hydraulic fluid flowing through the system per unit time	.....
Power	The rate at which hydraulic energy is transmitted	.....
.....	.....	Degrees Celsius (°C), degrees Fahrenheit (°F)
Viscosity	The resistance of the hydraulic fluid to flow	.....
.....	The presence of foreign particles or substances in the hydraulic fluid	Parts per million (ppm)
Noise	.....	Decibels (dB)
Efficiency	The ratio of output power to input power	.....

**Answer:**

Parameter	Definition	Units
Pressure	<b>The force exerted by the hydraulic fluid per unit area.</b>	Pascals (Pa), pounds per square inch (psi), bars
<b>Flow Rate</b>	The volume of hydraulic fluid flowing through the system per unit time	<b>Liters per minute (L/min), gallons per minute (gpm)</b>
Power	The rate at which hydraulic energy is transmitted	<b>Watts (W), horsepower (hp)</b>
<b>Temperature</b>	<b>It is a degree of hotness or coldness of an hydraulic fluid.</b>	Degrees Celsius (°C), degrees Fahrenheit (°F)
Viscosity	The resistance of the hydraulic fluid to flow	<b>Centipoise (cP)</b>
<b>Contamination</b>	The presence of foreign particles or	Parts per million (ppm)

	substances in the hydraulic fluid	
Noise	<b>The amount of unwanted sound generated by the hydraulic system</b>	Decibels (dB)
Efficiency	The ratio of output power to input power	<b>Percentage (%)</b>

18. Match the Steps for Testing a Hydraulic Power Circuit in A with their description in column B. Write the letter of the corresponding description in answer column.

**Answer:**

Answer	Column A:Steps	Column B: Description
.....B.....	1. Prepare the System	A. Use pressure gauges and flow meters to measure system parameters.
.....E.....	2. Start the System	B. Isolate the system, check fluid levels, and inspect for leaks.
.....H.....	3. Check for Leaks	C. Apply loads to the system to test performance under operating conditions.
.....F.....	4. Test Component Functionality	D. Monitor temperature to ensure it stays within safe limits.
.....A.....	5. Measure Pressure and Flow	E. Activate the power source and start the pump.
.....D.....	6. Check for Overheating	F. Test valves, cylinders, and motors.
.....I.....	7. Verify Control System Operation	G. Document all test findings.
.....C.....	8. Load Testing	H. Inspect for leaks and use leak detection fluid if necessary.
.....G.....	9. Record Test Results	I. Test the control system's functionality.

### Practical assessment

RJB Ltd is company that is located in Gatsibo district, Gitoki sector. This company produces super quality flour from maize. The company wants to use an hydraulic system which can be used in materials handling. The components to be used in the activity of installing the system are available.

**Task:** You are requested to:

- 1) Fix all the components in the right place
- 2) Connect the fixed components fixed to form complete hydraulic system
- 3) Conduct testing of the installed system to ensure that the system can be put into service.

**Note:** The hydraulic system should well protected.

## Checklist

SN	Criteria	Indicators	Observation	
			Yes	No
1	Hydraulic components are prepared correctly.	1.1. Components are cleaned		
		1.2. Components selected are inspected for damage		
2	Appropriate attachment method is well selected	2.1. Benefits of method selected are considered		
		2.2. Size of component is considered		
3	Components are properly positioned	3.1. Alignment is done		
		3.2. Alignment tools are used		
4	Components are well secured	4.1. Components are fastened		
		4.2. Manufacturer instructions are followed while fastening		
5	Alignment and security are checked	5.1. Misalignment is evaluated		
		5.2. Components are securely attached		
6	Design and planning are well done	6.1. Circuit diagram is developed		
		6.2. Components are selected		
		6.3. Safety regulations are respected		
7	Components are well prepared	7.1. Components are labelled		
		7.2. Components are organized		
		7.3. Components are checked for damage		
8	Wiring is well done	8.1. Wires are stripped		
		8.2. Wires are connected to components		
		8.3. Wiring diagram is followed		
9	Grounding is well done	9.1. Installation is grounded		
		9.2. Grounding regulation are respected		
10	Testing and commissioning are well done	10.1. Circuit is tested		
		10.2. Commissioning is done		
11	The system is well prepared	11.1. System is isolated		
		11.2. Fluid level is checked		
		11.3. Leaks are checked		
12	The system is started correctly	12.1. Power source is activated		
		12.2. Pump is started		
13	Components functionality is tested properly	13.1. Valves are tested		
		13.2. Cylinders and motors are tested		
14	Pressure and flowrate	14.1. Pressure is measured		

	are measured	14.2. Flowrate is measured		
15	Overheating is well checked and overloading	15.1. Temperature is measured		
		15.2. Loads are applied		



### Further information to the trainer

(n.d.). Retrieved from <https://tameson.com/pages/pneumatic-pipe-fittings>

(n.d.). Retrieved from 2.

[https://www.festo.com/net/enir\\_ir/SupportPortal/Files/729819/Installation%20Guide\\_2022\\_EN\\_scr.pdf](https://www.festo.com/net/enir_ir/SupportPortal/Files/729819/Installation%20Guide_2022_EN_scr.pdf)

Croser, P. (1992). *Pneumatics*. Esslingen: Festo Didactic.

F.Hooper, J. (2003). *Basic Pneumatics* .

Jayakumar, V. (June, 2010). *Applied Hydraulics and Pneumatics*. Chennai: LAKSHMI Publications.

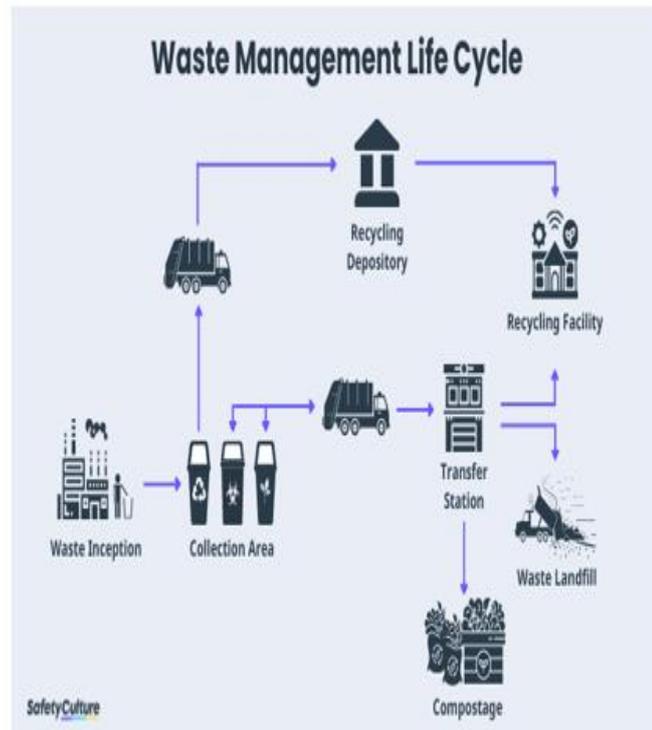
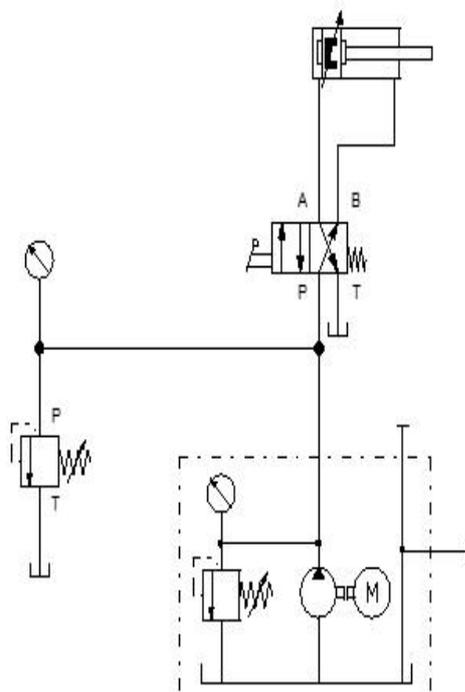
Khan, Q. (n.d.). *STUDY OF HYDRAULIC VALVES, PUMPS AND ACCUMULATORS*. MUMBAI: HYDROELECTRIC MACHINERY PREMISES.

Parr, A. A. ( March 1999 ). *Hydraulics and Pneumatics* . Elsevier Science & Technology Books

Schapoehler, M. (2024, September 12). Retrieved from Airline Hydraulics Website:

<https://blog.airlinehyd.com/pneumatic-system-explainer>

## Learning Outcome 4 Perform Pneumatic and Hydraulic Post-Installation Activities



Indicative contents
4.1 Developing as-built diagram
4.2 Disposing waste materials
4.3 Elaborating pneumatic and hydraulic system installation report

**Key Competencies for Learning Outcome 4: Perform Pneumatic And Hydraulic Post- Installation Activities**

Knowledge	Skills	Attitudes
<ul style="list-style-type: none"> <li>● Description of as-built diagram</li> <li>● Identification of waste material</li> <li>● Identification of pneumatic and hydraulic system installation report</li> </ul>	<ul style="list-style-type: none"> <li>● Recording data</li> <li>● Drawing as-built diagram</li> <li>● Managing waste material</li> <li>● Reporting installation report</li> </ul>	<ul style="list-style-type: none"> <li>● Being careful</li> <li>● Having precision while drawing as-built diagram</li> <li>● Being accurate while recording data</li> <li>● Having self-confidence while Reporting installation report</li> <li>●</li> </ul>



**Duration: 15 hours**



**Learning outcome 4 objectives:**

By the end of the learning outcome, the trainees will be able to:

1. Describe clearly As-built diagram based on installation layout
2. Draw correctly As-built diagram based on installation layout
3. Identify clearly the waste material according to the waste disposal procedure
4. Rearrange properly Workplace according to the waste disposal procedure
5. Record data accurately of pneumatic and hydraulic system parameter according to recording data technics
6. Identify clearly Pneumatic and hydraulic system according to reporting technics
7. report correctly Pneumatic and hydraulic system according to reporting technics



**Resources**

<b>Equipment</b>	<b>Tools</b>	<b>Materials</b>
<ul style="list-style-type: none"> <li>● Computer</li> <li>● Multi-meter</li> <li>● Tachometer</li> <li>● Thermometer</li> <li>● Manometer</li> <li>● Head Protection</li> <li>● Eye and Face Protection</li> <li>● Hearing Protection</li> <li>● Respiratory Protection</li> <li>● Hand Protection</li> <li>● Foot Protection</li> <li>● Body Protection</li> <li>● Fall Protection</li> <li>● Skin Protection</li> </ul>	<ul style="list-style-type: none"> <li>● Wire stripping plier</li> <li>● Side cutter plier</li> <li>● Combination plier</li> <li>● long nose plier</li> <li>● Spirit level</li> <li>● Tape measure</li> <li>● Steel rulers</li> <li>● Star screw driver</li> <li>● Flat screw driver</li> <li>● Hand drilling machine</li> <li>● Electric screw driver</li> <li>● Crimping tools</li> <li>● Still Brushes</li> <li>● Vanier caliper</li> </ul>	<ul style="list-style-type: none"> <li>● Fuses</li> <li>● Wires</li> <li>● Nut</li> <li>● Bolt</li> <li>● cable clips</li> <li>● Insulators</li> <li>● Welding holder</li> <li>● Grease</li> <li>● Lubricants</li> <li>● Scotches</li> <li>● Markers</li> <li>● pipes and hoses</li> <li>● pipe fittings</li> <li>● Switch box</li> </ul>

<ul style="list-style-type: none"><li>● First aid</li><li>● Compressor</li><li>● Valves</li><li>● Actuators</li></ul>		
 <b>Advance Preparation:</b> Before delivering this learning outcome, you are recommended to: <ul style="list-style-type: none"><li>● Avail tools, equipment and materials</li><li>● Avail workplace/classroom</li></ul>		



## Indicative content 4.1: Developing as-Built Diagram



Duration: 5 hours



### Theoretical Activity 4.1.1: Description of as-built diagram



#### Notes to the trainer:

- Trainer may use small groups for describing as-built diagram
- The use of images and videos as didactic materials is required.



#### Key steps:

While delivering this activity, pass through the following steps:

**Step1:** Introduce the activity and ask trainees to respond questions

- Define As-built diagram?
- Identify the step of developing As-built diagram

**Step2:** Ask the trainees to present findings

**Step3:** Provide and clarify the expert view and encourage trainees to ask questions for clarification

**Step4:** Direct trainees to read the key reading 4.1.1 in their manual for more details.



#### Points to Remember

- An **as-built diagram** (or as-built drawing) is a detailed and accurate representation of a construction project as it was actually built, rather than how it was originally designed.
- The step-by-step creating an as-built drawing are gather documentation and information, perform a site survey, review and record changes, update the drawings, add annotations and details, verify accuracy, format and finalize the drawings, review and approval, distribute and archive, maintain and update.



### Practical Activity 4.1.2: Draw as build diagram



#### Notes to the trainer

- Avail the all required drawing material, instrument and equipment used to draw.

- The use of images and videos as didactic materials is required



### Key steps:

**While delivering this activity, pass through the following steps:**

**Step1:** Introduce the activity and ask trainees read the task described below:

1. Referring to the previous theoretical activity 4.1.1 as pneumatic and hydraulic technician you are requested to draw:
  - i. As-built drawing of pneumatic and hydraulic system installation

**Step2:** Explain the task and provide clear instruction to be followed

**Step3:** Demonstrate how to draw and explain the drawing procedures

**Step4:** Ask trainees to redraw as-built drawing and monitor the activity

**Step5:** Assess their performance and provide feedback

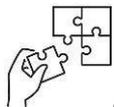
**Step6:** Allow trainees to ask question or clarification

**Step7:** Lead them to read key readings 4.1.2 in their manual



### Points to Remember

- The step-by-step Creating an as-built drawing are gather documentation and information, perform a site survey, review and record changes, update the drawings, add annotations and details, verify accuracy, format and finalize the drawings, review and approval, distribute and archive, maintain and update.



### Application of learning 4.1.

XYZ Ltd company in RUBAVU district install pneumatic system as contractor and they want to hire an employee for draw as-built diagram as one of document of handover report. As technician, you are required to create table that shows all needs to make correct as-built diagram.

**Checklist:**

SN	Criteria	Indicators	Observation	
			Yes	No
1	All information are well presented	1.1. Information are collected		
		1.2. Information are specified		
		1.3. Any change are modified		
		1.4. Photograph are obtained		
2	Site survey are well conducted	2.1. Site are visited		
		2.2. Current condition are measured		
		2.3. Measuring instrument are used		
3	All changes are well recorded	3.1. Initial drawing and actual construction are compared		
		3.2. Changes are documented		
		3.3. Changes location and specification are noted		
		4.1. Initial drawing are used to reflect as built drawing		
		4.2. all changes and modifications are accurately incorporated into the drawings		



## Indicative content 4.2: Describing Waste Materials



Duration: 5 hours



### Theoretical Activity 4.2.1: Description of waste materials



#### Notes to the trainer:

- Trainer may use small group for describing waste materials
- The use of images and videos as didactic materials is required.



#### Key steps:

**While delivering this activity, pass through the following steps:**

**Step1:** Introduce the activity and ask trainees to respond questions

- Define waste material
- Explain the groups of waste material
- Identify the step of waste material management

**Step2:** Ask the trainees to presents findings

**Step3:** Provide and clarify the expert view and encourage trainees to ask question for clarification.

**Step4:** Direct trainees to read the key reading 4.2.1 in their manual for more details.



#### Points to Remember

- Definition of waste material are referring to unwanted fluids, such as oil, water, or compressed air, that result from leaks, system maintenance, or inefficiencies.
- The main groups of waste are municipal solid waste (msw), industrial waste, hazardous waste, construction and demolition waste (c&d), electronic waste (e-waste), biomedical or healthcare waste, agricultural waste, radioactive waste, biodegradable waste, non-biodegradable waste.
- The key steps necessary to manage waste are waste assessment, waste reduction and minimization, reuse and recycling programs, composting organic waste, hazardous waste management, e-waste management, collection and transportation, waste sorting and segregation, public awareness and education, regulatory compliance, waste-to-energy and alternative technologies, monitoring and evaluation, collaboration and partnerships.



## Practical Activity 4.2.2: Managing Waste



### Notes to the trainer

- Avail the all required equipment used to manage material.
- Prepare a workplace
- The use of images and videos as didactic materials is required



### Key steps:

**While delivering this activity, pass through the following steps:**

**Step1:** Introduce the activity and ask trainees read the task described below:

- Referring to the previous theoretical activity 4.1.2 as pneumatic and hydraulic technician you are requested to manage the waste material after installed pneumatic and hydraulic system

**Step2:** Explain the task and provide clear instruction to be followed

**Step3:** Demonstrate how to draw and explain the drawing procedures

**Step4:** Ask trainees to redraw as-built drawing and monitor the activity

**Step5:** Assess their performance and provide feedback

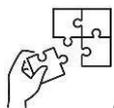
**Step6:** Allow trainees to ask question or clarification

**Step7:** Lead them to read key readings 4.2.2 in their manual



### Points to Remember

- The key steps necessary to manage waste are waste assessment, waste reduction and minimization, reuse and recycling programs, composting organic waste, hazardous waste management, e-waste management, collection and transportation, waste sorting and segregation, public awareness and education, regulatory compliance, waste-to-energy and alternative technologies, monitoring and evaluation, collaboration and partnerships.



### Application of learning 4.2.

XYZ Hospital in RULINDO district wants to find a company which manage waste material from the Hospital through the tender, for choosing the best company they propose to design document which will be composed of necessary requirement to manage waste material in effective way. As technician, you are requested to create a checklist that shows the effective ways of managing the waste.

**Checklist:**

SN	Criteria	Indicator	Observation	
			Yes	No
1	Waste are well assessed	1.1. Types and quantities of waste are generated.		
		1.2. The sources and composition of the waste are identified		
		1.3. Characteristics of waste are identified		
2	Waste material are well minimized	2.1. Measures to reduce the generation of waste are implemented		
		2.2. Waste minimization are encouraged		
3	Waste are well reused and recycled	3.1. Reuse and recycle programs are promoted		
		3.2. Reuse and recycle are implemented		
4	Waste are well composted	4.1. Composting programs of waste are settled up		
		4.2. The volume of waste are reduced		
5	Waste are well collected and transported	5.1. Efficient waste collection system are developed		
		5.2. waste transportation are regulated		
6	Waste are well segregated	6.1. Individuals and businesses to segregate waste are encouraged		
		6.2. Separate bins for different types of waste are provided		
		6.3. Waste material are putted in bin		



## Indicative content 4.3: Elaborating Pneumatic and Hydraulic System Installation Report



Duration: 5 hours



### Theoretical Activity 4.3.1: Description of data recording



#### Notes to the trainer:

- Trainer may use small group for describing pneumatic and hydraulic parameter must be recorded
- The use of images and videos as didactic materials is required.



#### Key steps:

**While delivering this activity, pass through the following steps:**

**Step1:** Introduce the activity and ask trainees to respond questions

- Explain recording data of parameter of pneumatic and hydraulic system.
- Identify method and tool used for recording data.

**Step2:** Ask the trainees to presents findings

**Step3:** Provide and clarify the expert view and encourage trainees to ask question for clarification.

**Step4:** Direct trainees to read the key reading 4.3.1 in their manual for more details.



#### Points to Remember

- In pneumatic and hydraulic systems, data recording involves monitoring and documenting parameters like pressure, flow rate, temperature, and fluid levels.
- The approach structure of recording and managing data are: system information, operational parameters, component details, maintenance records, performance data, safety checks, operational logs, calibration and testing, documentation and records.



### Practical Activity 3.3.2: Recording data



#### Notes to the trainer

- Avail the all required equipment used to record data.

- Prepare a workplace
- The use of images and videos as didactic materials is required



### Key steps:

**While delivering this activity, pass through the following steps:**

**Step1:** Introduce the activity and ask trainees read the task described below individually:

- Referring to the previous theoretical activity 4.3.1 as pneumatic and hydraulic technician you are requested to: record data of pneumatic and hydraulic system
- Record data of parameter of pneumatic and hydraulic system installation

**Step2:** Explain the task and provide clear instruction to be followed

**Step3:** Demonstrate how to record data and explain the record data procedures

**Step4:** Ask trainees to record data and monitor the activity

**Step5:** Assess their performance and provide feedback

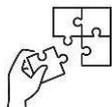
**Step6:** Allow trainees to ask question or clarification

**Step7:** Lead them to read key readings 4.3.2 in their manual



### Points to Remember

- Step-by-step guide in Recording data for pneumatic and hydraulic system parameters are preparation, define parameters to record, data collection, data recording, verification and review, documentation and reporting, archiving, feedback and improvement, compliance and safety checks.



### Application of learning 4.3.

XYZ ltd in NYARUGURU district after installing pneumatic and hydraulic system they want to record important data for future use. As technician in pneumatic and hydraulic field you are requested to make clear documentation of data recording.

### Checklist:

SN	Criteria	Indicator	Observation	
			Yes	No
1	Data recording are well prepared	1.1. components and parameters are identified		
		1.2. Tools and equipment are gathered		
		1.3. System documentation are reviewed		
2	Parameter to record are well defined	2.1. Pressure are defined		
		2.2. Flowrate are defined		

		2.3. Temperature are defined		
		2.4. Component performance are defined		
3	All data are well collected	3.1. Pressure are measured		
		3.2. Flowrate are measured		
		3.3. Temperature are measured		
		3.4. Cycle time are measured		
4	All data are well recorded	4.1. Data are recorded in logbook		
		4.2. Data are clear labelled in their unit measurement		
		4.3. Data are entered in electronics system		
5	All data are verified	5.1. Data accuracy are checked		
		5.2. Data trends are analysed		
6	All data are well documented	6.1. Recording data are updated		
		6.2. Recording data are reported		
7	Data are well archived	7.1. Data are stored in organized manner		
		7.2. Data are protected from unauthorized access		



### **Theoretical Activity 4.3.2: Describing pneumatic and hydraulic system installation report**



#### **Notes to the trainer:**

- Trainer may use small group for describing pneumatic and hydraulic parameters that must be recorded
- The use of images and videos as didactic materials is required.



#### **Key steps:**

**While delivering this activity, pass through the following steps:**

**Step1:** Introduce the activity and ask trainees to respond questions

- i. Explain pneumatic and hydraulic system installation report
- ii. Identify step of reporting

**Step2:** Ask the trainees to presents findings

**Step3:** Provide and clarify the expert view and encourage trainees to ask question for clarification.

**Step4:** Direct trainees to read the key reading 4.3.2 in their manual for more details.



#### **Points to Remember**

- Explanation about pneumatic and hydraulic installation report are a pneumatic and hydraulic system installation report provides a detailed account of the setup, configuration, and testing of pneumatic and hydraulic systems.
- The step of reporting is introduction, system overview, installation details, testing and commissioning, safety measures, documentation and compliance, issues and resolutions, conclusion, appendices, signatures and approvals.



### **Practical Activity 4.3.2: Reporting pneumatic and hydraulic system installation**



#### **Notes to the trainer**

- Avail the all required equipment used to report.
- Prepare a workplace
- The use of images and videos as didactic materials is required



### Key steps:

**While delivering this activity, pass through the following steps:**

**Step1:** Introduce the activity and ask trainees read the task described below individually:

- i. Referring to the previous theoretical activity 4.3.2 as pneumatic and hydraulic technician you are requested to report pneumatic and hydraulic system installation.

**Step2:** Explain the task and provide clear instruction to be followed

**Step3:** Demonstrate how to report and explain the report procedures

**Step4:** Ask trainees to report and monitor the activity

**Step5:** Assess their performance and provide feedback

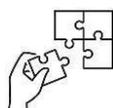
**Step6:** Allow trainees to ask question or clarification

**Step7:** Lead them to read key readings 4.3.2 in their manual



### Points to Remember

- The step of reporting pneumatic and hydraulic system installation are preparation, report structure, introduction, system overview, installation procedures, testing and commissioning, safety measures, documentation and compliance, issues and resolutions, modifications, conclusion, appendices, signatures and approvals, handover and training.



### Application of learning 4.3.

XYZ ltd in RUTSIRO district install pneumatic and hydraulic system, as a worker of company they give you the task of making clear document of report which composed of all-important information of the installation.

### Checklist:

SN	Criteria	Indicator	Observation	
			Yes	No
1	Report are well prepared	1.1. Information are collected		
		1.2. Documentation structure are reviewed		
2	Report are well structured	2.1. Title are structured		
		2.2. Table of content are provided		
3	Report are well introduced	3.1. Purpose of report are explained		
		3.2. Background information on the project are provided		

4	Installation procedures are well identified	4.1. Component are well placed		
		4.2. Piping and tubing layout are described		
		4.3. Electrical connection are documented		
		4.4. Fluid management are well documented		
5	System are well commissioned and tested	5.1. Pre-operation are checked		
		5.2. Testing procedures are described		
6	Safety are well measured	6.1. Safety protocol are documented		
		6.2. Risk are assessed		
7	Report are well documented	7.1. System standard and regulation are confirmed		
		7.2. References to installation manual are included		
		7.3. Problem or deviation from the installation plan are documented		



## Learning outcome 4 end assessment

### Theoretical assessment

1. Define as-built diagram.

**Answer:**

An as-built diagram is a detailed and accurate representation of a construction project as it was actually built, rather than how it was originally designed.

2. List the group of waste material.

**Answer:**

- i. Municipal solid waste
- ii. Industrial waste
- iii. Hazardous waste
- iv. Construction and demolition waste
- v. Electronic waste
- vi. Biomedical waste
- vii. Agricultural waste
- viii. Radioactive waste
- ix. Biodegradable waste
- x. Non-biodegradable waste

3. Identify the procedures of recording data in pneumatic and hydraulic system.

**Answer:**

- i. Preparation
- ii. Define parameter to record
- iii. Data collection
- iv. Data recording
- v. Verification and review
- vi. Documentation and reporting
- vii. Archiving

**Read the following statement related to pneumatic and hydraulic post installation activities and encircle the letter corresponding to the correct answer**

4. Which one in the following information is typically included in an as-built drawing of a pneumatic system?
  - A) Only the original design specifications
  - B) Modifications made during construction, equipment locations, and actual dimensions
  - C) Theoretical performance calculations
  - D) Marketing information about the components used

**Answer: B) Modifications made during construction, equipment locations, and actual dimensions**

5. Why are as-built drawings essential for maintenance and troubleshooting of hydraulic systems? Choice the correct answer in the following statement:
- A) They provide historical context of the project.
  - B) They include warranty information for all components.
  - C) They reflect the actual layout and configuration, aiding in identifying issues.
  - D) They offer design alternatives for future projects.

**Answer: C) They reflect the actual layout and configuration, aiding in identifying issues.**

6. Read the following statement related to pneumatic and hydraulic post installation activities and answer by True if the statement is correct or False if the statement is wrong

- i. Recycling can save communities money.

**Answer: True**

- ii. More plastic packaging is recovered for recycling than paper packaging

**Answer: False**

- iii. Effective waste material management in pneumatic and hydraulic systems is crucial for minimizing environmental impact and ensuring compliance with regulations.

**Answer: True**

- iv. Waste materials generated from pneumatic and hydraulic systems can include used hydraulic fluid, which must be disposed of in accordance with environmental regulations.

**Answer: True**

- v. **Only** mechanical components are considered waste in pneumatic and hydraulic systems; fluids and lubricants are not classified as waste materials.

**Answer: False**

- vi. Regular maintenance and monitoring of pneumatic and hydraulic systems can help reduce waste by identifying leaks and inefficiencies early.

**Answer: True**

7. Use the appropriate terminologies used in pneumatic and hydraulic system installation and complete the following table

Question	Answer option	Answer
a. What is the primary purpose of data recording in pneumatic systems?	i) To monitor performance ii) To increase costs iii) To confuse operators	.....
b. Which type of data is commonly recorded in hydraulic systems?	i) Only fluid pressure ii) Flow rates iii) Both A and B	.....
c. How often should data be recorded during system operation?	i) Continuously ii) Once a year ii) Only when problems arise	.....
d. What tools are commonly	i) Manual logs	.....

used for data recording in these systems?	ii) Electronic data loggers iii) Both A and B	
e. Why is it important to analyse recorded data from pneumatic and hydraulic systems?	i) To identify trends ii) To generate random reports iii) To ignore issues	.....
f. What kind of maintenance can data recording help to schedule?	i) Routine maintenance ii) Emergency shutdowns iii) No maintenance needed	.....
g. Which parameter is NOT typically recorded in hydraulic systems?	i) Fluid temperature ii) Ambient air quality iii) Pressure levels	.....
h. What is the benefit of using automated data recording systems?	i) Reduces human error ii) Increases workload iii) Complicates processes	.....
i. What should be done with recorded data after analysis?	i) Discard it ii) Archive it for future reference iii) Share it randomly	.....

**Answer:**

Question	Answer option	Answer
i. What is the primary purpose of data recording in pneumatic systems?	i) To monitor performance ii) To increase costs iii) To confuse operators	i) To monitor performance
j. Which type of data is commonly recorded in hydraulic systems?	i) Only fluid pressure ii) Flow rates iii) Both A and B	iii) Both A and B
k. How often should data be recorded during system operation?	i) Continuously ii) Once a year ii) Only when problems arise	i) Continuously
l. What tools are commonly used for data recording in these systems?	i) Manual logs ii) Electronic data loggers iii) Both A and B	iii) Both A and B
m. Why is it important to analyse recorded data from pneumatic and hydraulic systems?	i) To identify trends ii) To generate random reports iii) To ignore issues	i) To identify trends
n. What kind of	i) Routine maintenance	i) Routine maintenance

maintenance can data recording help to schedule?	ii) Emergency shutdowns iii) No maintenance needed	
o. Which parameter is NOT typically recorded in hydraulic systems?	i) Fluid temperature ii) Ambient air quality iii) Pressure levels	ii) Ambient air quality
p. What is the benefit of using automated data recording systems?	i) Reduces human error ii) Increases workload iii) Complicates processes	i) Reduces human error
ii. What should be done with recorded data after analysis?	i) Discard it ii) Archive it for future reference iii) Share it randomly	ii) Archive it for future reference

8. Match the items in column A to their corresponding items in column B regarding preparation of as build drawings, and write the letter corresponding to the correct answer

Answer	Column A	Column B
.....4.....	A. Final Approval	1.Implement a quality control process to review and verify the accuracy of the as-built drawings.
.....1.....	B. Quality Control	2. Organize the drawing layers to distinguish between original design elements and as-built changes
.....2.....	C. Layering and Annotation	3. Use Computer-Aided Design (CAD) software to create accurate and detailed drawings.
.....5.....	D. Collaboration and Communication	4. Obtain approval from relevant stakeholders, including architects, engineers, and clients, before finalizing the as-built drawings
.....3.....	E. CAD Software Utilization	5. Foster effective communication between stakeholders, including architects, engineers, contractors, and clients.
.....7.....	F. Data Collection	6.Verify the physical conditions on-site against the original design drawings
.....6.....	G. Site Verification	7.Gather accurate and up-to-date information about the structure or system

9. Summarize the importance of waste management in pneumatic/hydraulic system.

**Answer:**

Waste management in pneumatic and hydraulic systems is crucial for several reasons:

1. **Environmental Protection:** Proper waste management minimizes environmental impact by ensuring that hazardous materials, such as used oils and fluids, are disposed of responsibly, preventing soil and water contamination.

2. **Regulatory Compliance:** Adhering to waste management protocols helps organizations comply with local, national, and international environmental regulations, avoiding potential legal penalties and fines.
3. **Operational Efficiency:** Effective waste management practices can identify leaks and inefficiencies, leading to improved system performance and reduced operational costs.
4. **Resource Recovery:** By implementing recycling and recovery strategies, organizations can reclaim valuable materials from waste, promoting sustainability and reducing the need for new

10. Explain any three purposes of As-built drawing.

**Answer:**

- To provide a record of the installation
- To be used as a reference for future expansion or modification
- To be used for maintenance and repair
- To be used to calculate the final cost of the installation

### Practical assessment

XYZ Ltd in KARONGI district installed pneumatic system in new apartment after finishing their work of installation there are handover with the owner, as technician you are requested to prepare clear documentation used in handover.

**Task:**

- i. Draw clear as-built drawing
- ii. Shows data recorded of the system commissioning
- iii. Make clear report of the system functionality

**Checklist:**

SN	Criteria	Indicator	Observation	
			Yes	No
1	All information are well presented	1.1. Information are collected		
		1.2. Information are specified		
		1.3. Any change are modified		
		1.4. Photograph are obtained		
2	Site survey are well conducted	2.1. Site are visited		
		2.2. Current condition are measured		
		2.3. Measuring instrument are used		
3	All changes are well recorded	3.1. Initial drawing and actual construction are compared		
		3.2. Changes are documented		
		3.3. Changes location and specification are noted		
4	Drawing are well	4.1. Initial drawing are used to reflect as-		

	updated	built drawing		
		4.2. all changes and modifications are accurately incorporated into the drawings		
5	Data recording are well prepared	5.1. components and parameters are identified		
		5.2. Tools and equipment are gathered		
		5.3. System documentation are reviewed		
6	Parameter to record are well defined	6.1. Pressure are defined		
		6.2. Flowrate are defined		
		6.3. Temperature are defined		
		6.4. Component performance are defined		
7	All data are well collected	7.1. Pressure are measured		
		7.2. Flowrate are measured		
		7.3. Temperature are measured		
		7.4. Cycle time are measured		
8	All data are well recorded	8.1. Data are recorded in logbook		
		8.2. Data are clear labelled in their unit measurement		
		8.3. Data are entered in electronics system		
9	All data are verified	9.1. Data accuracy are checked		
		9.2. Data trends are analysed		
10	All data are well documented	10.1. Recording data are updated		
		10.2. Recording data are reported		
11	Data are well archived	11.1. Data are stored in organized manner		
		11.2. Data are stored in organized manner		
		11.3. Data are protected from unauthorized access		
12	Report are well prepared	12.1. Information are collected		
		12.2. Documentation structure are reviewed		
13	Report are well structured	13.1. Title are structured		
		13.2. Table of content are provided		
14	Report are well introduced	14.1. Purpose of report are explained		
		14.2. background information on the project are provided		
15	Installation procedures are well identified	15.1. Component are placed		
		15.2. Piping and tubing layout are described		
		15.3. Electrical connection are documented		
		15.4. Fluid management are well documented		
16	System are well	16.1. Pre-operation are checked		

	commissioned and tested	16.2. Testing procedures are described		
17	Safety are well measured	17.1. Safety protocol are documented		
		17.2. Risk are assessed		
18	Report are well documented	18.1. System standard and regulation are confirmed		
		18.2. References to installation manual are included		
		18.3. Problem or deviation from the installation plan are documented		



## Further information to the trainer

(n.d.). Retrieved from <https://tameson.com/pages/pneumatic-pipe-fittings>

(n.d.). Retrieved from 2.

[https://www.festo.com/net/enir\\_ir/SupportPortal/Files/729819/Installation%20Guide\\_2022\\_EN\\_scr.pdf](https://www.festo.com/net/enir_ir/SupportPortal/Files/729819/Installation%20Guide_2022_EN_scr.pdf)

Bigrentz. (2020, September 20). Retrieved from bigrentz:

[https://www.bigrentz.com/blog/as-built-drawings?srsId=AfmBOoq-3lBUczHx\\_-VNA-Ks-4kbpenezExDOt0wUBK9NPwtcl40aVb4](https://www.bigrentz.com/blog/as-built-drawings?srsId=AfmBOoq-3lBUczHx_-VNA-Ks-4kbpenezExDOt0wUBK9NPwtcl40aVb4)

Bryan Magargee and James Hamilton. (2024, January 17). Retrieved from Procore.com:

<https://www.procore.com/library/as-built-drawings>

Croser, P. (1992). *Pneumatics*. Esslingen: Festo Didactic.

F.Hooper, J. (2003). *Basic Pneumatics* .

Indeed Editorial Team. (2024, August 16). Retrieved from Indeed:

<https://www.indeed.com/career-advice/career-development/as-built>

Jayakumar, V. (June, 2010). *Applied Hydraulics and Pneumatics*. Chennai: LAKSHMI Publications.

Khan, Q. (n.d.). *STUDY OF HYDRAULIC VALVES, PUMPS AND ACCUMULATORS*. MUMBAI: HYDROELECTRIC MACHINERY PREMISES.

Parr, A. A. ( March 1999 ). *Hydraulics and Pneumatics* . Elsevier Science & Technology Books

Schapoehler, M. (2024, September 12). Retrieved from Airline Hydraulics Website:

<https://blog.airlinehyd.com/pneumatic-system-explainer>



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