RQF LEVEL 5

RENPH501

RENEWABLE ENERGY

Pneumatic and Hydraulic Systems Installation

TRAINEE'S MANUAL

October, 2024

PNEUMATIC AND HYDRAULIC SYSTEMS INSTALLATION

KOICA Korea International Cooperation Agency

TQUM TVET Quality Management Project

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COORDINATION TEAM

RWAMASIRABO Aimable
MARIA Bernadette M. Ramos
NTASHAMAJE Aimable

PRODUCTION TEAM

Authoring and Review

SIBOMANA Valens

MANIKUZWE Maurice

NIYONTEZE Erneste

Validation

NIYUBAHWE Alain

NTEZIRYAYO Emmanuel

Conception, Adaptation and Editorial works

HATEGEKIMANA Olivier

GANZA Jean Francois Regis

HARELIMANA Wilson

NZABIRINDA Aimable

DUKUZIMANA Therese

NIYONKURU Sylvestre

NYINAWUMUNTU Gaudence

Formatting, Graphics, Illustrations, and infographics

YEONWOO Choe
SUA Lim
SAEM Lee
SOYEON Kim
WONYEONG Jeong
HAKIZAYEZU Adrien

Financial and Technical support

KOICA through TQUM Project

TABLE OF CONTENT

ACRONYMS

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 trainee's manual includes all the knowledge and skills required in renewable energy specifically for the module of **" 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 trainee'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.

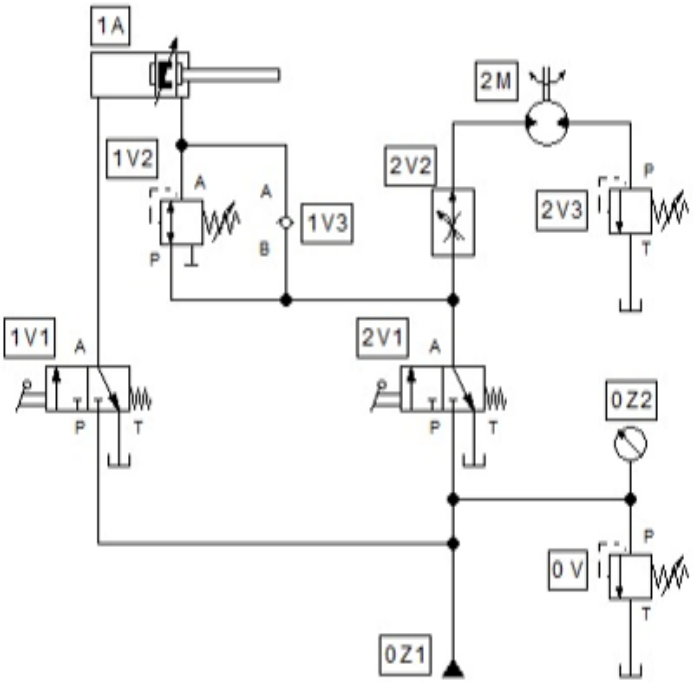
As a trainee, you will start by addressing questions related to the activities, which are designed to foster critical thinking and guide you towards practical applications in the labor market. The manual also provides essential information, including learning hours, required materials, and key tasks to complete throughout the learning process.

All activities included in this training manual are designed to facilitate both individual and group work. After completing the activities, you will conduct a formative assessment, referred to as the end learning outcome assessment. Ensure that you thoroughly review the key readings 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 pneumaticsystem
Learning Outcome 3: Install hydraulicsystem
Learning Outcome 4: Perform pneumatic and hydraulic post- installation activities

Learning Outcome 1: Perform Pneumatic and Hydraulic System Pre-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 Simulating control and power circuits**

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

Knowledge	Skills	Attitudes
● Description of pneumatic and hydraulic systems ● Identification of workplace preparation policy and procedures applied in pneumatic and hydraulic systems ● Identification of different types of tools, materials and equipment used in pneumatic and hydraulic systems ● Identification of symbols used in pneumatic and hydraulic drawings ● Description of the elements of bill of quantity ● Identification of software used tin simulation of pneumatic and hydraulic circuits.	● Setting the workplace ● Selecting tools, materials and equipment ● Drawing pneumatic and hydraulic circuits ● Simulating pneumatic circuits ● Simulating hydraulic circuits	● Being careful while selecting tools, materials and equipment and drawing pneumatic and hydraulic systems ● Being decisive ● Being cooperative, flexible while setting the workplace ● Having self confidence ● Being responsible

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 clearly software 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

Equipment	Tools	Materials
● Reservoir ● Pumps ● Hydraulic valves ● Filters ● Hydraulic actuators ● Compressors, ● Pneumatic valves ● Accumulators ● Air service unit ● Pneumatic	● Toolkit, ● Drawing instruments ● Pens and ● Pencils ● simulation software	● Oil ● Hydraulic transfer hoses and fittings ● Lubricant ● Accessories ● Cleaning cloths and brushes ● Papers

actuators ● Piping and plumbing fittings and other accessories ● Hydraulic flow ● Meter ● Portable electrical drilling machine ● Manometer ● Gauges ● Computer		

Indicative content 1.1: Preparation of Workplace

Duration: 5 hours

Theoretical Activity 1.1.1: Description of pneumatic and hydraulic

Tasks:

1.Answer the following questions

i. Define the following terms.
   a) Pneumatic system
   b) Hydraulic system
   c) Pneumatics
   d) hydraulics
   e) Fluid power

ii. Differentiate pneumatic hydraulic system based on working principle.

iii. Explain two types of fluid systems.

iv. Outline main components of pneumatic and that of hydraulic system.

v. Explain briefly the advantages of pneumatic and hydraulic system.

vi. Highlight the applications of pneumatic and hydraulic systems.

2. Present your findings from group discussion in front of your classmates and trainer.

3. Read the key readings 1.1.1 or more clarifications.

Key readings 1.1.1: Description of pneumatic and hydraulic systems

1.Definitions

1.1 Pneumatic system: It is a system that uses pressurized air to perform useful mechanical works without intervention of man.

1.2 Hydraulic system: It is a system that uses pressurized liquids to perform useful mechanical works without intervention of man.

1.3 Pneumatics is the branch of engineering that deals with the use of compressed air to perform mechanical work. It involves the application of pressurized air to operate various devices and systems.

1.4 Fluid power : fluid power is the technology that deals with the generation, control, and transmission of power, using pressurized fluids.

Fluid power is called hydraulics when the fluid is a liquid and called pneumatics when the fluid is a gas. Thus fluid power is the general term used for both hydraulics and pneumatics.

1.5 Hydraulics is the branch of engineering that deals with the application of

pressurized fluids, typically liquids, to perform mechanical work. It involves the use of hydraulic power to transmit and control force and motion.

2. Difference between pneumatic and hydraulic systems based on working principle

The primary difference between pneumatic and hydraulic systems lies in the working fluid they use:

2.1 Pneumatic Systems:

- **Working fluid:** Compressed air.
- **Operating principle:** The system utilizes the energy stored in compressed air to perform mechanical work. When compressed air is released, it exerts force on pneumatic actuators (like cylinders or motors) to produce motion or power.

2.2 Hydraulic Systems:

- **Working fluid:** Hydraulic fluid (typically oil-based).
- **Operating principle:** These systems rely on the energy transmitted through pressurized hydraulic fluid. The fluid is pumped through a system of valves and pipes, exerting force on hydraulic actuators (like cylinders or motors) to produce mechanical motion or power.

2.3 Key Differences:

Feature	Pneumatic Systems	Hydraulic Systems
Working Fluid	Compressed air	Hydraulic fluid (e.g., oil)
Power Source	Air compressor	Hydraulic pump
Operating Pressure	Typically lower pressure (e.g., 100-200 psi)	Typically higher pressure (e.g., 1000-5000 psi)
Efficiency	Generally less efficient due to compressibility of air	Generally more efficient due to the incompressibility of hydraulic fluid
Noise	Can be noisy due to the compression and release of air	Generally quieter than pneumatic systems
Environmental Impact	Can be more environmentally friendly due to the use of air	May require proper disposal of hydraulic fluid and consideration of environmental impact

3. There are actually two different types of fluid systems:

- **Fluid transport systems** have as their main objective the delivery of fluid from one location to another to accomplish some useful purpose.
- **Fluid power systems** are designed specifically to perform work. The work is accomplished by a pressurized fluid bearing directly on an operating fluid cylinder or fluid motor.

4. Pneumatic and hydraulic systems components

4.1 Pneumatic system main components: Pneumatic systems have components that are similar to those used in hydraulic systems. Essentially the following six basic components are required for a pneumatic system:

a. An air tank to store a given volume of compressed air

b. A compressor to compress the air that comes directly from the atmosphere

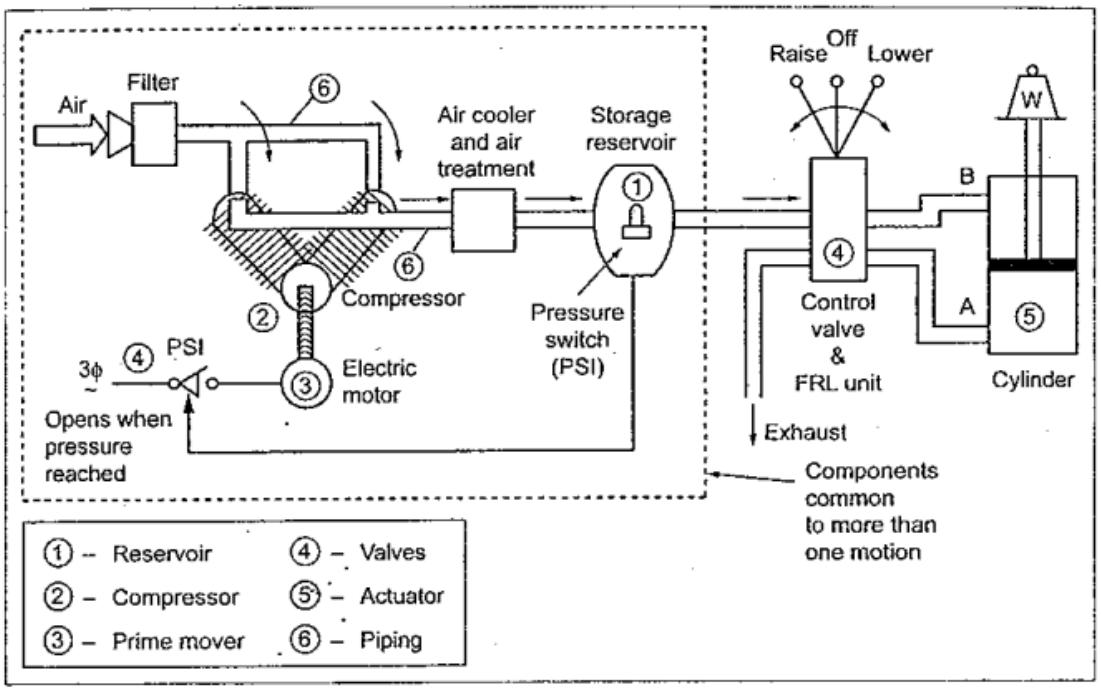
c. An electric motor or other prime mover to drive the compressor

d. Valves to control air direction, pressure, and flow rate

e. Actuators which are similar in operation to hydraulic actuators.

f. Piping and fittings to carry the pressurized air from one location to another.

4.2 General arrangement of pneumatic system



4.3 Hydraulic system main components: There are six basic components required in a hydraulic system.

a. A tank (reservoir) to hold the hydraulic oi

b. A pump to force the oil through the system

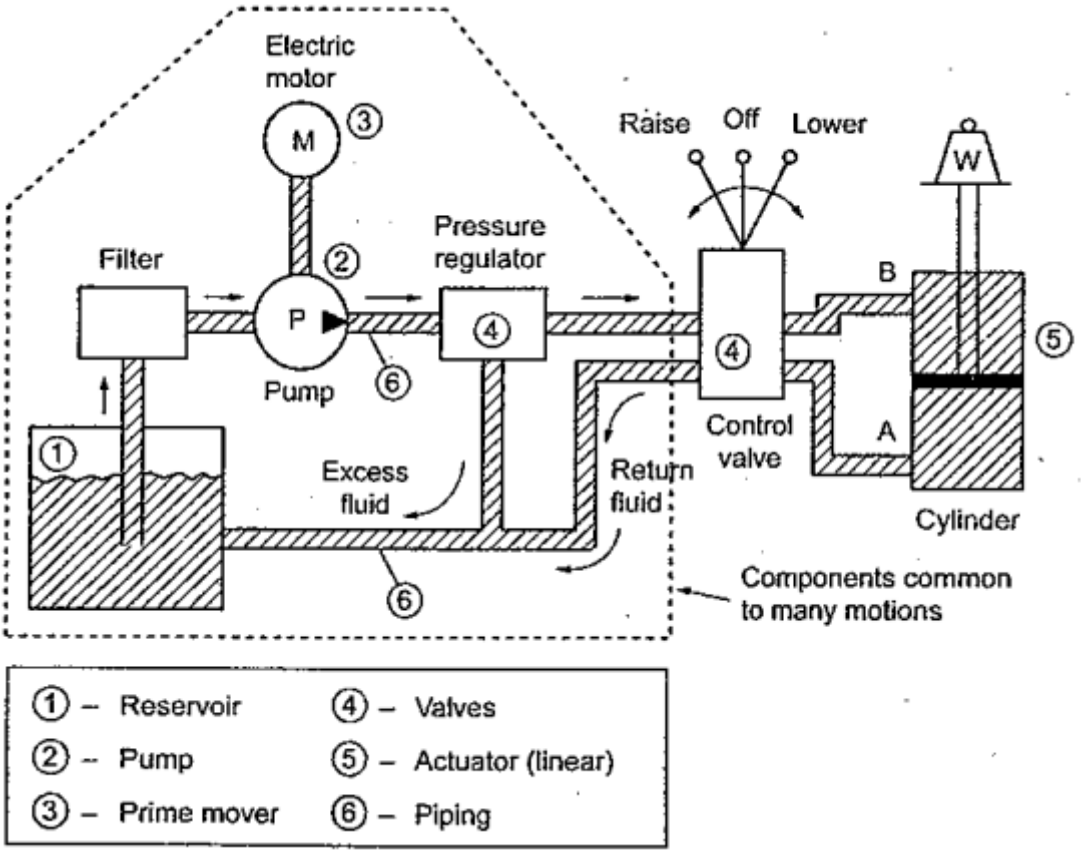
c. An electric motor (prime mover) or other power source to drive the pump

d. Valves to control oil direction, pressure, and flow rate

e. 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

f. Piping and fittings which carries the oil from one location to another.

4.4 General arrangement of hydraulic system



5. Advantages of pneumatic and hydraulic system

5.1 Advantages of Hydraulic Systems:

- **High power-to-weight ratio:** Hydraulic systems can transmit large amounts of power in a relatively compact size.
- **Versatility:** They can be used in a wide range of applications, from heavy machinery to precision control systems.
- **Controllability:** Hydraulic systems offer precise control over force, speed, and direction.
- **Reliability:** They are generally reliable and can operate in harsh environments.
- **High Efficiency:** Hydraulic systems can be highly efficient in converting energy into mechanical work.
- **Flexibility:** They can be easily adapted to different needs and applications.
- **Safety:** Hydraulic systems can be designed to be safe and reliable, with appropriate safety measures in place.

5.2 Advantages of Pneumatic Systems

Pneumatic systems offer several advantages that make them suitable for a wide range of applications:

- **Safety:** Compressed air is generally considered safe and non-toxic, reducing the risk of hazards compared to other power sources.
- **Reliability:** Pneumatic components are known for their reliability and durability, ensuring consistent performance over time.
- **Versatility:** Pneumatic systems can be used in a variety of applications, from manufacturing to construction and consumer products.
- **Efficiency:** They can be highly efficient in converting energy into mechanical work.
- **Cost-effectiveness:** Pneumatic components are often relatively affordable compared to other technologies.
- **Easy maintenance:** Pneumatic systems are generally easy to maintain and repair.
- **Lightweight:** Pneumatic components can be lightweight, making them suitable for portable applications.
- **Cleanliness:** Compressed air can be filtered to remove impurities, making pneumatic systems suitable for applications in clean environments.
- **Precise control:** Pneumatic systems can provide precise control over the force and speed of output.
- **Quiet operation:** Compared to some other power sources, pneumatic systems can be relatively quiet.

6. Applications of pneumatic and hydraulic systems

6.1 Applications of pneumatic systems

Pneumatic systems, which utilize compressed air to perform mechanical work, are widely used across various industries due to their versatility, efficiency, and reliability. Here are some key applications:

Manufacturing:

- **Assembly lines:** Pneumatic cylinders and actuators are used to automate assembly processes, moving and positioning parts with precision.
- **Material handling:** Robotic arms and grippers powered by pneumatic systems are used for handling heavy loads, packaging, and material transfer.
- **Presses and stamping machines:** Pneumatic presses are used for forming, stamping, and cutting metal parts.

Picture: Hydro pneumatic press

Construction:

- **Power tools:** Pneumatic drills, hammers, and other tools are commonly used in construction for drilling, breaking, and fastening.
- **Jacks and lifts:** Pneumatic jacks can be used to lift heavy loads for maintenance or construction purposes.

Automotive Industry:

- **Brakes:** Some vehicles use pneumatic brakes, especially larger commercial vehicles.
- **Power steering:** Pneumatic power steering systems can be used in certain vehicles.
- **Aerospace:**
- **Landing gear:** Pneumatic systems can be used to retract and extend the landing gear of aircraft.
- **Aircraft doors:** Pneumatic actuators can be used to open and close doors and hatches.

Consumer Products:

- **Nail guns:** Pneumatic nail guns are used for fastening materials in construction and woodworking.
- **Air mattresses:** Pneumatic air mattresses are inflated using compressed air.
- **Sports equipment:** Some sports equipment, like paintball guns or air-powered toys, use pneumatic systems.

Other Applications:

- **Robotics:** Pneumatic actuators can be used to power robotic arms and grippers.
- **Medical equipment:** Some medical devices, like dental drills, utilize pneumatic power.
- **Industrial processes:** Pneumatic systems can be used for various tasks in industries such as food processing, packaging, and textile manufacturing, stamping, hoisting, assembling, riveting, drilling, punching, Clamping, Material handling, hammering.

6.2 Applications of hydraulic systems

Hydraulic systems, which utilize pressurized fluid to transmit power and perform mechanical work, are found in a wide range of industries and applications. Here are some key areas where they are commonly used:

Construction and Heavy Equipment:

- **Excavator and bulldozer arms:** Hydraulic cylinders provide the necessary force for lifting, digging, and pushing.
- **Cranes and lifts:** Hydraulic systems are used to lift heavy loads, such as construction materials or large machinery.
- **Jacks and presses:** Hydraulic presses are used for forming, bending, and stamping metal, while hydraulic jacks can lift heavy objects.

Manufacturing:

- **Assembly lines:** Hydraulic cylinders and actuators are used to automate various assembly processes.
- **Machine tools:** Lathes, milling machines, and other machine tools often incorporate hydraulic systems for precise positioning and operation.
- **Presses:** Hydraulic presses are used for forming, stamping, and cutting metal parts.

Automotive Industry:

- **Brakes:** Most cars use hydraulic brakes, where fluid pressure is converted into mechanical force to stop the wheels.
- **Steering systems:** Hydraulic power steering assists in turning the steering wheel.
- **Suspension systems:** Some cars use hydraulic systems for adjustable suspension.

Agriculture:

- **Tractors and farm machinery:** Hydraulic systems are used to operate various attachments, such as plows, balers, and harvesters.
- **Irrigation systems:** Hydraulic valves and actuators can be used to control irrigation systems and water distribution.

Aerospace:

- **Landing gear:** Hydraulic systems are used to retract and extend the landing gear of aircraft.
- **Flight controls:** Some aircraft use hydraulic systems to control flight surfaces like ailerons, rudders, and elevators.

Other Applications:

- **Robotics:** Hydraulic actuators can be used to power robotic arms and grippers.
- **Medical equipment:** Some medical devices, such as dental drills or surgical tools, utilize hydraulic power.

- **Consumer products:** Hydraulic systems can be found in everyday items like nail guns and air mattresses.

Theoretical Activity 1.1.2: Identification of workplace policy and

Tasks:

1: Answer the questions below:

i. Explain the following terms a) Workplace policy b) Workplace procedure

ii. Outline the common workplace policies that you know.

2: Present your findings from group discussion in front of your classmates and trainer.

3: You are directed to read the key readings 1.1.2 for further information.

Key readings 1.1.2: Identification of workplace policy and procedures

1. Workplace policy and procedures

1.1 Workplace policy means principle of action adopted or proposed by an organization or individual.

1.2 Workplace Procedure means an established or official way of doing something.

- Workplace policies often reinforce and clarify standard operating procedure in a workplace.
- Well written policies help employers manage staff more effectively by defining acceptable and unacceptable behaviour in the workplace, and set out the implications of not complying with those policies.
- A workplace policy consists of a statement of purpose and one or more broad guidelines on action to be taken to achieve that purpose.

2.Types of common workplace policies

1. **Code of conduct:** This Code of Conduct outlines the ethical principles and standards expected of all employees, contractors, and volunteers associated with Your Organization. It is essential to maintaining a positive and professional work environment that promotes integrity, respect, and fairness.
2. **Recruitment policy:** This recruitment policy outlines the procedures and guidelines for attracting, selecting, and hiring qualified individuals to join Your

Organization.

3. **Internet and email policy**: This policy outlines the guidelines for the use of internet and email resources within Your Organization. It aims to ensure responsible and productive use of these resources while protecting the organization's assets and reputation.
4. **Mobile phone policy**: This policy outlines the guidelines for the use of mobile phones within Your Organization.
5. **Non-smoking policy**: This policy establishes a smoke-free environment within Your Organization to promote the health and well-being of employees, visitors, and the community.
6. **Drug and alcohol policy**: This policy establishes guidelines for the use of drugs and alcohol within Your Organization. It aims to promote a safe, healthy, and productive work environment.
7. **Health and safety policy:** This policy establishes guidelines for health and safety within Your Organization. It aims to create a safe and healthy work environment for all employees and visitors.
8. **Anti-discrimination and harassment policy:** This policy establishes guidelines to prohibit discrimination and harassment within [Your Organization]. It aims to create a workplace free from discrimination and harassment of any kind.
9. **Discipline and termination policy:** This policy outlines the procedures for addressing employee misconduct and disciplinary actions within [Your Organization]. It aims to maintain a fair and consistent approach to disciplinary matters.

Practical Activity 1.1.3: setting the work place

Task:

1: Referring to the key reading 1.1.3 you are requested to set the workplace where a pneumatic and hydraulic system can be installed.

2: Follow the instructions and steps provided in the key reading and perform the task.

3: Present your final product to your classmate or parent.

Key readings 1.1.3 setting the work place

Steps to set out a workplace

1. Define the Purpose: Clearly identify the purpose of the workplace.

2. Choose a Location: The following factors are considered while choosing location

- **Space availability:** Ensure there's enough space for your needs.
- **Lighting:** Natural light is ideal, but artificial lighting can be adjusted.
- **Noise level:** Choose a quiet area if concentration is crucial.
- **Temperature control:** Ensure you can maintain a comfortable temperature.

3. Organize tools, materials and Equipment:

- Arrange tools (electrical and mechanical toolkit) in a way that promotes efficiency and comfort.
- Arrange materials (oils, accessories, …) properly.
- Place essential equipment (Compressor, motors, actuators etc) within easy reach.
- Consider ergonomic principles for proper posture and comfort.
- Keep your workspace clean and organized to minimize distractions and improve productivity.
- Use storage materials to keep the security of tools, materials and equipment.

4. Personalize Space:

- Add personal touches to make your workspace more inviting and enjoyable. This could include plants, photos, or decorative items.

5. Ensure Proper Lighting:

- Adequate lighting is essential for both comfort and productivity.
- Consider natural light and artificial lighting options.

6. Ergonomics:

- Set up your workspace to promote good posture and prevent discomfort.
- Adjust chair height, desk height, and monitor position for optimal ergonomics.

7. Cable, hoses and pipes Management:

- Organize and hide cables, hose and pipes to create a neater and safer workspace. Use cable clips or sleeves to manage cords.

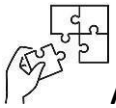
8. Test and Adjust:

- Use your workspace for a few days and make adjustments as needed to ensure comfort and productivity.

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, air tank and pipe lines. For hydraulic system, main components also are six: hydraulic pump, electric motor, valves, actuators, 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.
- 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.
- **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.

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

Tasks:

1: Answer the following question.

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

2: Present your findings from group discussion in front of your trainer and classmates.

3: You are directed to read the key readings 1.2.1 for more clarifications.

Key readings 1.2.1.: Identification of tools, materials and equipment used in pneumatic and hydraulic systems

1.Explanations

1.1. Tool is a device used to perform a task or achieve a specific purpose.

1.2. Material is the tangible resource that goes into the installation of a pneumatic or hydraulic system.

1.3 Equipment are devices that utilize compressed air or liquids to perform mechanical work.

2.Tools, material and equipment used in pneumatic and hydraulic systems

2.1 Electrical Toolkit

- **Pliers (Universal pliers, cutting pliers, long nose pliers**,): **Pliers** are versatile tools used in pneumatic systems for various tasks, including

- **Cutting and Crimping:** Pliers with specialized jaws can be used to cut tubing, crimping fittings, or stripping wires.
- **Gripping and Holding:** Pliers can grip and hold components in place during assembly or maintenance.
- **Bending and Twisting:** Certain types of pliers can be used to bend or twist tubing or wires.
- **Removing and Installing Fittings:** Pliers can be used to remove or install fittings on tubing.

Phase tester : A phase tester is an essential tool for ensuring the proper functioning of an electro-pneumatic/ hydraulic system by verifying the presence and correct phase sequence of the electrical power supply.

Drilling machine: Drilling machines are commonly used in pneumatic and hydraulic systems for various tasks, including:

1. **Hole Creation:**

- **Material Processing:** Drilling machines create holes in materials for various purposes, such as fastening, tapping, or allowing fluid flow.
- **Component Assembly:** They are used to create holes for bolts, screws, or pins to connect components in pneumatic and hydraulic systems.
- **Screwdrivers: Screwdrivers** are essential tools in pneumatic and hydraulic

systems for several reasons:

2. **Assembly and Disassembly:** Screwdrivers are used to secure or loosen screws and bolts that hold components together. This includes mounting brackets, valves, cylinders, and other parts.
3. **Maintenance and Repair:** When troubleshooting or repairing pneumatic or hydraulic systems, screwdrivers are often needed to access internal components, replace seals, or tighten connections.
4. **Adjustments:** Some components, such as valves or pressure regulators, may require adjustments using screwdrivers. These adjustments can affect the system's performance and operation.
5. **Installation of Sensors and Accessories:** Screwdrivers are used to install sensors, switches, and other accessories that may be integrated into pneumatic or hydraulic systems.

Clamp: Clamps are essential components in pneumatic and hydraulic systems, serving various purposes. Here are the primary roles of clamps:

1. Securing and Positioning:

- **Holding Components:** Clamps are used to securely hold components in place during assembly, maintenance, or operation. This prevents movement and ensures proper alignment.
- **Positioning:** Clamps can be used to position components accurately, ensuring correct alignment and preventing misalignment.

2. Creating a Seal:

- **Preventing Leaks:** Clamps are used to create a tight seal between components, preventing leaks of fluid or air. This is crucial for maintaining system efficiency and preventing damage.

3. Applying Force:

- **Force Exertion:** In some cases, clamps can be used to apply force to components or objects. For example, a clamp can be used to hold a workpiece securely in place while a cutting or drilling operation is performed.

Ladder

Common Uses of Ladders in Pneumatic and Hydraulic Systems:

- **Installation and Maintenance:** Ladders allow technicians to reach components that are mounted at heights, such as valves, cylinders, and tubing.

- **Troubleshooting:** When diagnosing issues or performing repairs, ladders provide access to components that may be difficult to reach from the ground.
- **Safety Inspections:** Regular inspections of pneumatic and hydraulic systems often require access to elevated areas, which can be safely reached using ladders.
- **Cleaning and Maintenance:** Ladders are essential for cleaning and maintaining components that are located at heights.

Wire strippers: Wire strippers are essential tools in pneumatic and hydraulic systems for:

1. **Preparing Wires for Connections:**

- Stripping the insulation from electrical wires allows for proper connection to terminals, switches, and other components.
- This ensures good electrical contact and prevents short circuits.

2. **Maintaining Safety:**

- Stripped wires reduce the risk of electrical shock or short circuits, which can be hazardous.

3. **Facilitating Repairs and Modifications:**

- When troubleshooting or modifying pneumatic or hydraulic systems, wire strippers are necessary for accessing and repairing wires.

Allen keys: Here are some specific applications of Allen keys in pneumatic and hydraulic systems:

- **Connecting tubing and fittings:** Allen keys are used to secure fittings onto tubing, ensuring a tight and leak-free connection.
- **Mounting components:** They are used to mount components like cylinders, valves, and pressure regulators onto a base or frame.
- **Adjusting settings:** Some components, such as pressure regulators, may have adjustable settings that can be accessed using Allen keys.

Adjustable spanner : Adjustable spanners, also known as adjustable wrenches, are versatile tools commonly used in pneumatic and hydraulic systems for a variety of tasks.

Here are some of their primary roles:

1. **Tightening and Loosening Nuts and Bolts:** This is the most common application. Adjustable spanners allow you to adjust the jaw width to fit different sizes of nuts and bolts, making them a valuable tool for tightening or loosening connections.
2. **Pipe Wrenching:** Although not as specialized as pipe wrenches, adjustable spanners can be used to tighten or loosen pipes, especially in situations where a pipe wrench is not available.
3. **Emergency Repairs:** In case of unexpected leaks or breakdowns, an adjustable spanner can be a handy tool for making temporary repairs or adjustments.

4. **Installation and Maintenance:** They are essential for installing and maintaining pneumatic and hydraulic components, such as valves, cylinders, and fittings.

- **Radiator keys**: Radiator keys, also known as bleed screws or bleed valves, are used in pneumatic and hydraulic systems to remove air from the system.

- **Tape measure** : Tape measures are essential tools for **measuring and verifying dimensions** during the installation, maintenance, and troubleshooting of these systems.

2.2. Plumber tool kit

The major tools used in plumbing are categorised as:

1. Holding tools

(a) **Bench vice :** A vice is a tool used for holding an object for various tasks

(b) **Pipe vice :** It is a tool used for holding a pipe for carrying out assembly, disassembly, threading, cutting, etc. Pipe vices are of two types:

i. Open side pipe vice

ii. Fixed side pipe vice

Standard sizes of vices are 80 mm, 105 mm, 130 mm, 170 mm, etc., as per the opened size of the jaws.

2. Fitting tools

a) Wrenches : These are hand tools used for tightening and loosening the nuts and bolts. Wrenches hold slippery or small nuts and bolts for loosening or tightening them.

b) **Water-pump pliers :** It is a common plier used by plumbers for holding, tightening and loosening work during fixing process. Steel is used for manufacturing water-pump pliers.

c) **Spanners :** This tool is used for tightening and loosening nuts and bolts of standard size. The standard spanners used are: Ring spanners, combinational spanners, bi hexagonal ring spanners and open ended spanners.

- ✓ Ring spanner
- ✓ Combinational spanner
- ✓ Bi hexagonal ring spanner

3. Cutting tools

(a) **Pipe cutter :** This is a manual tool used to cut a pipe at the work site, especially when it is difficult to use a hacksaw frame.

(b**) Hacksaw :** This tool is generally used with both the hands. It cuts material like plastic pipe, steel rod, angle iron, sheets, iron pipes, etc.

Power hacksaw

4. Pipe bending tools

(a) **Pipe bending machine** : This equipment is used to bend or turn pipes. The size and strength of the machine depends upon the diameter of the pipe and the type of the pipe material to be bent.

(b) **Threading dies** : Threading is crucial for joining pipes and fixtures effectively. A threading die is used for making threads in a pipe where it is to be joined with another pipe or fixture.

2.3 Materials used in pneumatic and hydraulic systems

Oil : While pneumatic systems primarily use compressed air as their working fluid, hydraulic systems rely on hydraulic oil. This oil serves several critical functions:

1. **Power Transmission:** Hydraulic oil transmits mechanical energy throughout the system. It acts as a medium for transferring pressure and force from the pump to the actuators (cylinders or motors).
2. **Lubrication:** Hydraulic oil lubricates the moving parts within the system, reducing friction and wear. This extends the life of components and improves system efficiency.
3. **Cooling:** Hydraulic oil can also act as a coolant, absorbing heat generated by the system and preventing overheating.

4. **Protection:** Hydraulic oil helps protect components from corrosion and contamination.
5. **Sealing:** It helps maintain seals between components, preventing leaks and ensuring proper system operation.

Types of Hydraulic Oil:

1. **Mineral Oil-Based Hydraulic Oil**:
    - **Description**: Derived from refining crude oil, this is the most common type of hydraulic oil.
    - **Applications**: Used in general industrial and construction machinery.
    - **Advantages**: Cost-effective, widely available, and provides good performance under standard operating conditions.
2. **Synthetic Hydraulic Oil**:
    - **Description**: Made from synthetic materials, offering enhanced performance in extreme temperatures and conditions.
    - **Applications**: Used in high-performance systems, aerospace, and applications with stringent temperature or operating conditions.
    - **Advantages**: Better stability, higher viscosity index, longer service life, and better performance in extreme temperatures.
3. **Water-Based Hydraulic Fluids**:
    - **Description**: Composed of water and an additive package (such as water-glycol mixtures).
    - **Applications**: Used in certain industrial applications where fire resistance is critical.
    - **Advantages**: Fire-resistant, but lower lubrication and corrosion protection compared to mineral oils.
4. **Biodegradable Hydraulic Oil**:
    - **Description**: Made from renewable resources like vegetable oils, this type of hydraulic oil is designed to break down naturally when exposed to the environment.
    - **Applications**: Used in environmentally sensitive areas, such as forestry and agriculture, where leakage could impact the ecosystem.
    - **Advantages**: Environmentally friendly, reducing the risk of pollution.

Properties of Hydraulic Oil:

- **Viscosity**: Determines how easily the oil flows under different temperatures. It's essential to choose oil with the right viscosity for the operating temperature range.
- **Viscosity Index**: A measure of how much the oil's viscosity changes with temperature. A higher index means the oil maintains its viscosity across a wider temperature range.
- **Flash Point**: The temperature at which the oil can ignite. A higher flash point provides better fire resistance in high-temperature applications.
- **Pour Point**: The lowest temperature at which the oil will still flow. A lower pour point is ideal for operations in cold environments.

Applications of Hydraulic Oil:

- **Construction Equipment**: Excavators, backhoes, bulldozers, and cranes rely on hydraulic systems for lifting, digging, and moving heavy loads.
- **Industrial Machinery**: Presses, injection molding machines, and other factory equipment.
- **Aerospace**: Aircraft landing gear and flight control systems often use specialized hydraulic oils.
- **Automotive**: Power steering systems and transmission systems often use hydraulic oil.

Accessories: accessories in pneumatic and hydraulic systems play crucial roles in enhancing functionality, safety, and efficiency.

Here are some common types and their functions:

1. Filters:

- **Air Filters:** Remove impurities like dust, dirt, and moisture from compressed air, preventing damage to system components and ensuring optimal performance.
- **Hydraulic Filters:** Remove contaminants from hydraulic fluid, preventing wear and tear on system components and maintaining fluid cleanliness.

2. Pressure Regulators:

- **Pneumatic Pressure Regulators:** Control the output pressure of compressed air, ensuring consistent and safe operation of pneumatic components.
- **Hydraulic Pressure Regulators:** Maintain a constant pressure in hydraulic systems, preventing excessive pressure fluctuations and protecting components.

3. Lubricators:

- **Pneumatic Lubricators:** Add a controlled amount of lubricant to compressed air, reducing friction and wear in pneumatic components.
- **Hydraulic Lubricators:** Ensure proper lubrication of hydraulic components, preventing premature wear and extending system life.

4. Quick-Connect Couplings:

- Provide quick and easy connections between components, saving time and reducing the risk of leaks.

5. Silencers:

- Reduce noise levels generated by pneumatic and hydraulic systems, improving the working environment.

6. Check Valves:

- Prevent fluid from flowing backward, ensuring proper direction and preventing backflow.

7. Pressure Relief Valves:

- Protect the system from excessive pressure by automatically venting excess fluid.

✓ **There are three main types**:

- Pressure regulating valves without relief port

- Pressure limiting valves with relief port
- Pressure sequence valves

    - **The pressure regulating valve** controls the operating pressure in a control circuit and keeps the pressure constant irrespective of any pressure fluctuations in the system.

    - **The pressure limiting valves** are utilized on the up-stream side of the compressor to ensure the receiver pressure is limited, for safety, and that the supply pressure to the system is set to the correct pressure.

    - **The sequence valve senses** the pressure of any external line and compares the pressure of the line against a preset adjustable value, creating a signal when the preset limit is reached.

8. Flow Control Valves:

- Regulate the flow rate of fluid, ensuring precise control of system operation.

9. Sensors:

- Monitor various parameters such as pressure, flow rate, temperature, and position, providing feedback for control and troubleshooting.

Types of pressure sensors

1. **Strain Gauge Sensors**: Measure pressure by detecting changes in material dimensions under force. Common for long-term monitoring due to versatility.
2. **Piezoelectric Sensors**: Generate electric charge through physical material changes, ideal for small, high-frequency measurements.
3. **Capacitive Sensors**: Measure capacitance between plates separated by a gap, sensitive to pressure changes. Used in harsh environments.
4. **Manometers**: Traditional devices using liquid movement in a tube to measure pressure, typically U-shaped.
5. **Vacuum Pressure Sensors**: Measure pressure below atmospheric levels without relying on mechanical methods, focusing on material properties.
6. **Bourdon Tube**: Mechanical sensor using physical movement to drive a dial for pressure readings. Inexpensive and durable for high pressures.
7. **Aneroid Barometer**: A mechanical device to measure atmospheric pressure, often used in aircraft to assess altitude changes.
8. Strain gauges are the most widely used sensor type due to their availability.
9. Piezoelectric sensors are compact and ideal for dynamic, high-frequency measurements.
10. Capacitive sensors are suited for applications like jet engines and car tires, offering simple designs and environmental resistance.

10. Accumulators:

- Store energy in the form of compressed air or hydraulic fluid, providing a buffer and smoothing out pressure fluctuations.

Lubricant : Lubricants play a vital role in pneumatic and hydraulic systems by:

- **Reducing Friction:** Lubricants create a protective film between moving components, reducing friction and wear. This extends the lifespan of components and improves system efficiency.
- **Preventing Wear and Tear:** By reducing friction, lubricants help prevent premature wear and tear on seals, pistons, and other moving parts.
- **Preventing Corrosion:** Lubricants can help protect metal components from corrosion, especially in environments with moisture or corrosive agents.
- **Improving System Efficiency:** Reduced friction and wear lead to improved system efficiency and lower energy consumption.
- **Ensuring Smooth Operation:** Lubricants help ensure smooth and quiet operation of pneumatic and hydraulic systems.

Directional control valves:

Directional control valves (DCVs) are devices used in pneumatic and hydraulic systems to control the path of the fluid (air or hydraulic fluid) within the system. These valves regulate the direction of flow, determining how the fluid moves through the system to control the movement of actuators (e.g., cylinders, motors).

Directional control valves are essential for controlling the motion of machinery and automation systems, allowing for functions like extending or retracting a piston, starting or stopping a motor, and selecting specific movement paths for different parts of a machine.

Key Characteristics:

1. **Valve Positions**: The number of positions the valve can hold determines how many different flow paths it can control. For example, a 2/2 valve has two ports and two positions, whereas a 5/2 valve has five ports and two positions.
2. **Port Types**: Valves have ports that connect to the fluid supply and the actuator. Ports are typically labeled as "P" (pressure), "T" (tank or exhaust), "A" (actuator), and "B" (second actuator port).
3. **Actuation Method**: Directional control valves can be actuated manually (via levers or push buttons), electrically (solenoid), pneumatically (pilot-operated), or mechanically (through a spring-loaded mechanism).

Common Types of Directional Control Valves:

- **2/2 Valve**: Two ports, two positions. Used for simple on/off control.
- **3/2 Valve**: Three ports, two positions. Used in applications like controlling single-acting cylinders.
- **5/2 Valve**: Five ports, two positions. Often used with double-acting cylinders for controlling extend and retract motions.
- **5/3 Valve**: Five ports, three positions. Provides a neutral position, often used for more complex control, such as centering, allowing for stop or holding

positions.

Types of valves based on their configuration or mode of operation:

- Poppet (seat) valves
- Sliding spool valves
- Rotary spool valves

Heat exchanger: Heat exchangers are essential components in many pneumatic and hydraulic systems, primarily to:

1. **Cool the fluid:** In both pneumatic and hydraulic systems, the fluid can become heated due to friction, compression, and other factors. Heat exchangers help to cool the fluid back to a desired operating temperature. This is important for maintaining system efficiency and preventing overheating or damage to components.
2. **Prevent freezing:** In colder climates, heat exchangers can be used to prevent hydraulic fluid from freezing, which can cause the system to malfunction or become damaged.
3. **Protect components:** By maintaining a suitable operating temperature, heat exchangers can help protect components from excessive wear and tear.
4. **Improve system performance:** Cooling the fluid can improve the overall performance and efficiency of the pneumatic or hydraulic system.

Filter and strainer : **Filters and strainers** play crucial roles in pneumatic and hydraulic systems by removing contaminants and impurities from the fluid, ensuring optimal system performance and preventing damage to components.

Functions:

- **Contaminant Removal:** Filters and strainers capture and remove contaminants such as dirt, dust, rust particles, and other debris from the fluid. These contaminants can cause wear and tear on system components, leading to reduced efficiency and potential failures.
- **System Protection:** By removing contaminants, filters and strainers help protect sensitive components like valves, cylinders, and seals from damage. This extends the lifespan of the system and reduces maintenance costs.
- **Performance Enhancement:** Clean fluid improves the system's overall performance by reducing friction and increasing efficiency.
- **Preventing Blockages:** Filters and strainers help prevent blockages in the system, which can lead to reduced flow rates, increased pressure drops, and even system failure.

Pressure gauge: Pressure gauges are essential components in pneumatic and hydraulic systems. Their primary function is to **measure and display the pressure of the fluid** within the system.

Pressure and temperature switch: Pressure and temperature switches are essential components in pneumatic and hydraulic systems, serving to monitor and control system operations based on these critical parameters.

Pressure Switches:

- **Function:** Detect and respond to changes in pressure within the system.
- **Applications:**
  - **Overpressure protection:** Prevent system damage by shutting down or venting excess pressure.
  - **Under pressure protection:** Ensure adequate pressure for system operation and prevent component failure.
  - **Sequencing:** Control the sequence of operations based on pressure levels.
  - **Pressure regulation:** Maintain a desired pressure level within the system.

Temperature Switches:

- **Function:** Detect and respond to changes in temperature within the system.
- **Applications:**
  - **Over temperature protection:** Prevent overheating and damage to components.
  - **Under temperature protection:** Ensure adequate temperature for system operation.
  - **Temperature control:** Maintain a desired temperature level within the system.

Fluid Conditioners

1. **Filters**
   - **Function**: Remove contaminants such as dirt, dust, and moisture from compressed air to ensure clean air reaches the system components.
   - **Importance**: Prevents wear and damage to valves, actuators, and other equipment, increasing their lifespan.
2. **Lubricators**
   - **Function**: Add a fine mist of oil to the compressed air, reducing friction and wear on moving parts.
   - **Importance**: Enhances the smooth operation of components like cylinders and motors, ensuring reliability and efficiency.
3. **Pressure Regulators**
   - **Function**: Maintain a consistent air pressure within the system, regardless of fluctuations in supply pressure.
   - **Importance**: Protects components from damage due to overpressure and ensures optimal system performance.
4. **Air Mufflers**
   - **Function**: Reduce noise generated by the exhaust of compressed air from pneumatic components.
   - **Importance**: Improves workplace safety and comfort by minimizing noise pollution.

5. **Air Dryers**
    - **Function**: Remove moisture from compressed air to prevent condensation and corrosion in the system.
    - **Importance**: Essential for maintaining system integrity, especially in environments with high humidity.

Note: An **FRL unit** (Filter-Regulator-Lubricator) is a combination of three essential fluid conditioners used in pneumatic systems to ensure that compressed air is clean, properly regulated, and lubricated for optimal performance of equipment. The FRL unit is typically installed near the air source or at the point of use to treat the compressed air before it enters the machinery or tools.

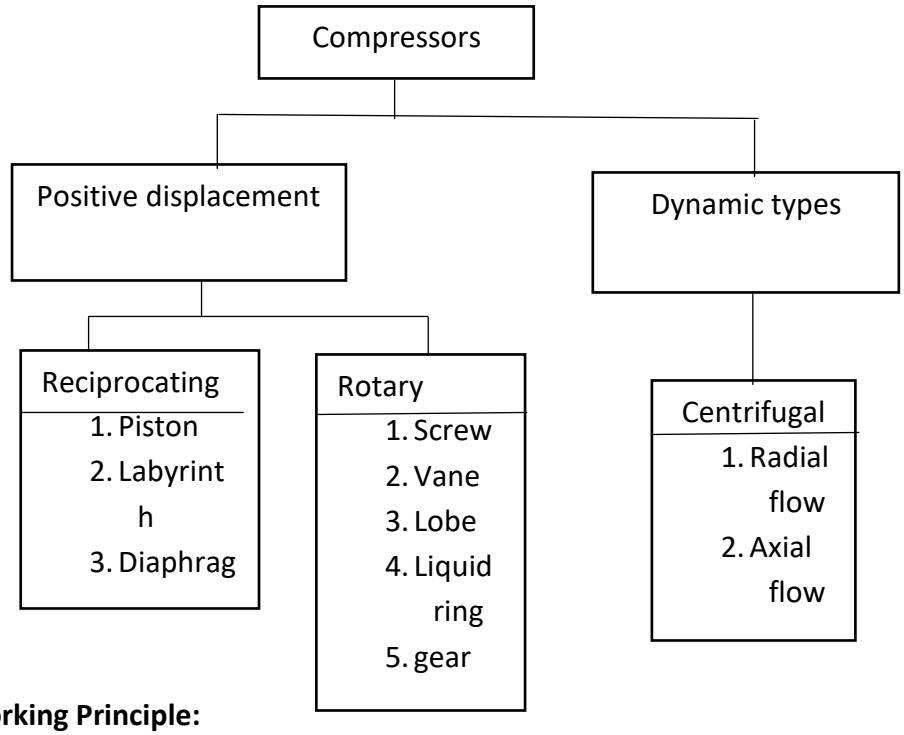
2.4 Equipment used in pneumatic and hydraulic systems

- **Compressor:** is a mechanical device used to increase the pressure of air by reducing its volume. It takes in air at ambient pressure and compresses it into a smaller volume, thereby increasing its pressure. This high-pressure air is then stored in tanks or directed into pipelines for use in various applications, including powering pneumatic tools, operating machinery, or in air-conditioning systems.

Types of Air Compressors:

1. **Positive Displacement Compressors**:
    - **Piston (Reciprocating) Compressors**: Use pistons driven by a crankshaft to compress the air. Common in small to medium applications.
    - **Rotary Screw Compressors**: Use two interlocking helical screws to compress the air. These are more efficient than piston compressors and are used in larger, continuous-duty applications.
    - **Diaphragm Compressors**: Use a diaphragm to compress air, suitable for high-purity air applications.
2. **Dynamic Compressors**:
    - **Centrifugal Compressors**: Use high-speed rotating blades to increase the velocity of air, which is then converted into pressure. These are often used in large industrial applications like power plants and air-conditioning systems.

Compressors summary chart:



Working Principle:

- **Suction**: Ambient air is drawn into the compressor through the intake valve.
- **Compression**: The air is compressed by reducing its volume in the compressor chamber.
- **Discharge**: The compressed air is then expelled into the storage tank or through a discharge valve for immediate use.

Applications:

- **Industrial**: Used in factories for powering tools, machinery, and production lines.
- **Construction**: Supplies compressed air for pneumatic tools like drills, hammers, and nail guns.
- **Automotive**: Used in car repair shops for tools and in air brakes for heavy vehicles.
- **HVAC**: In air-conditioning and refrigeration systems.
- **Medical**: Provides clean, compressed air for respiratory support and equipment.

Pneumatic motor: A **pneumatic motor** is a type of motor that converts the energy from compressed air into mechanical motion. These motors are used in applications where electric motors or internal combustion engines are unsuitable, often because of environmental factors like explosive atmospheres or in systems where electrical power is not available.

Key Characteristics of Pneumatic Motors:

1. **Power Source**: The motor uses compressed air as its power source, which is typically supplied from a compressor or an air tank.
2. **Motion Type**: Pneumatic motors can produce either **rotary** or **linear** motion, depending on the design of the motor.
3. **Speed and Torque Control**: The speed and torque of a pneumatic motor can be easily controlled by regulating the air flow and pressure.
4. **Lightweight**: Pneumatic motors are often lighter than electric motors, making them ideal for portable tools and machines.
5. **Explosion-Proof**: Since they do not involve electricity, pneumatic motors are suitable for hazardous environments, such as those containing flammable materials or gases.
6. **No Overheating**: Pneumatic motors do not overheat, as there is no electrical current that could cause excessive heat buildup.

Types of Pneumatic Motors:

1. **Vane Pneumatic Motors**:
    - **Description**: These motors use a rotor with vanes that move outward as the air pressure pushes them, creating rotary motion. The vanes slide in and out of slots on the rotor as they are pushed by compressed air.
    - **Applications**: Light industrial applications, handheld tools like drills or sanders, and small machines.
2. **Gear Pneumatic Motors**:
    - **Description**: Use internal gears to convert the pressure of the compressed air into rotational motion. These motors typically generate higher torque and are compact.
    - **Applications**: Applications requiring high torque, such as conveyors and certain automotive tools.
3. **Piston Pneumatic Motors**:
    - **Description**: Use a series of pistons and cylinders to convert air pressure into rotational motion. The pistons move back and forth in cylinders, and this reciprocating motion is then converted into rotary motion via a crankshaft or similar mechanism.
    - **Applications**: Heavy-duty applications, such as in larger machinery, industrial mixers, and more demanding tools.
4. **Turbine Pneumatic Motors**:
    - **Description**: Similar to gas turbines, these motors use a series of turbine blades that are turned by the flow of compressed air, creating high rotational speeds.
    - **Applications**: Used for high-speed, low-torque applications where rotational speed is critical, such as in certain industrial and scientific applications.

Advantages of Pneumatic Motors:

- **Simple and durable**: Few moving parts, making them more reliable in demanding conditions.

- **Explosion-proof**: Ideal for use in explosive or flammable environments.
- **Constant power**: Can deliver consistent power without overheating, unlike electric motors.
- **Compact and lightweight**: Suitable for portable equipment like hand tools.

Disadvantages:

- **Limited energy efficiency**: Pneumatic motors are generally less efficient compared to electric motors due to energy losses in compressing the air.
- **Compressed air supply**: Requires a reliable and constant supply of compressed air, which may not be readily available in some environments.

Hydraulic pump: is a mechanical device that converts mechanical energy into hydraulic energy, generating a flow of hydraulic fluid under pressure. The fluid produced by the hydraulic pump is used to power various hydraulic systems, including actuators like cylinders and motors, allowing for a wide range of applications in industries like construction, manufacturing, automotive, and aerospace.

Key Functions:

- **Generate Flow**: The pump creates a flow of hydraulic fluid to move machinery parts.
- **Create Pressure**: By forcing fluid into a closed system, the pump generates pressure that can then be used to do work, such as lifting, pushing, or rotating.
- **Transfer Energy**: The hydraulic pump transfers mechanical energy from an engine or motor into fluid power.

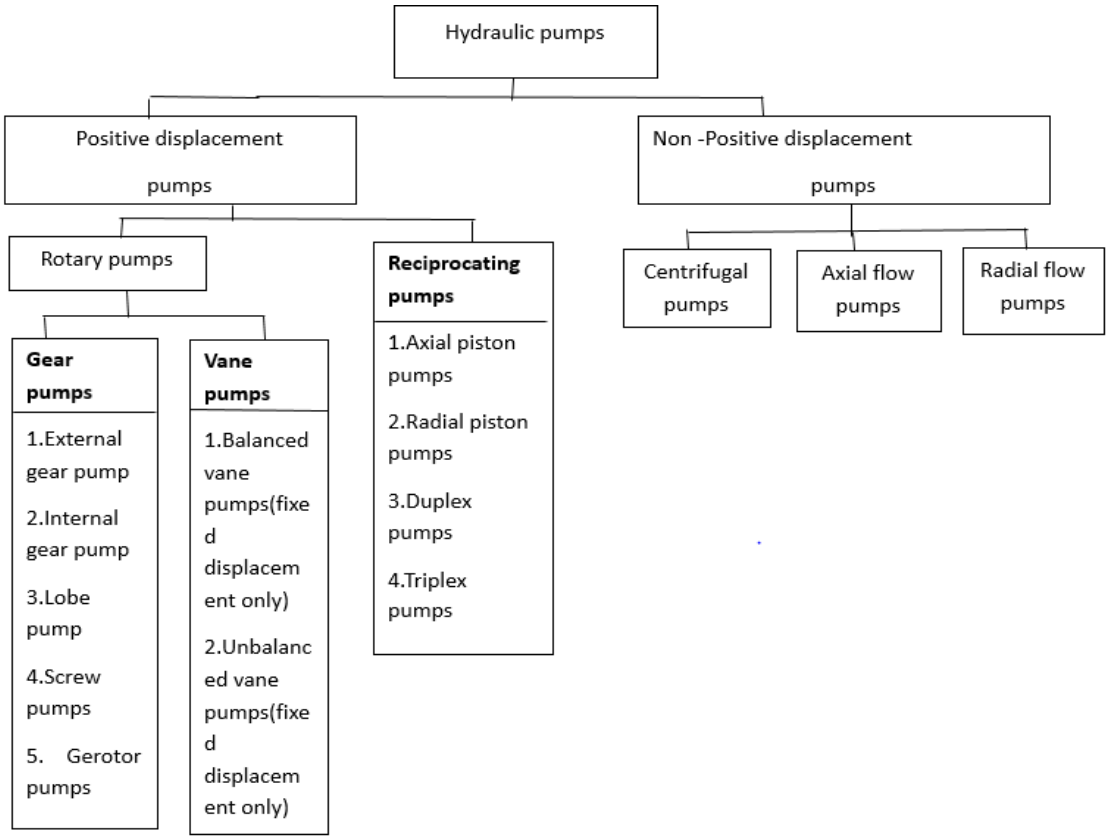
Types of Hydraulic Pumps:

1. **Gear Pumps**:
    - **Description**: Use meshing gears to move the hydraulic fluid.
    - **Types**: External gear pumps and internal gear pumps.
    - **Advantages**: Simple design, cost-effective, and reliable for low-pressure applications.
    - **Applications**: Small hydraulic systems, automotive power steering.
2. **Piston Pumps**:
    - **Description**: Use reciprocating pistons to displace fluid, providing higher pressures and more precise control over flow.
    - **Types**: Axial piston pumps (pistons arranged in a circular pattern) and radial piston pumps (pistons arranged in a radial pattern).
    - **Advantages**: High efficiency, capable of delivering higher pressures and flows.
    - **Applications**: Heavy-duty hydraulic systems, construction machinery, high-performance industrial applications.
3. **Vane Pumps**:
    - **Description**: Use a rotating vane (or blades) within a chamber to move fluid.
    - **Types**: Unidirectional and bidirectional vane pumps.

- **Advantages**: Moderate pressure and flow capabilities, smooth operation.
- **Applications**: Medium-pressure systems, industrial machinery, forklifts.

4. **Diaphragm Pumps**:
   - **Description**: Use a diaphragm that moves back and forth to pump the fluid.
   - **Advantages**: Good for handling a variety of fluids, including those with contaminants or abrasives.
   - **Applications**: Chemical handling, food processing, and systems requiring self-priming.

Hydraulic pumps summary chart



Components of a Hydraulic Pump:

- **Pump Housing**: Encases the internal components and directs fluid flow.
- **Motor or Drive**: Provides mechanical power to the pump, typically through an electric motor, internal combustion engine, or even a manual handle.
- **Suction Port**: Where hydraulic fluid enters the pump.
- **Discharge Port**: Where the pressurized fluid exits the pump.
- **Internal Mechanism**: Gear, piston, or vane system that moves the fluid.

Operation:

1. The pump draws hydraulic fluid from a reservoir through the **suction port**.
2. The mechanical energy from the pump's motor or drive forces the fluid into the

pump's internal mechanism (gears, pistons, or vanes).

3. The pump increases the pressure of the fluid as it is displaced and sends it out through the **discharge port** to power hydraulic actuators or other components in the system.

Applications:

Hydraulic pumps are widely used across various industries, powering equipment such as:

- **Construction machinery**: Excavators, cranes, loaders.
- **Agricultural equipment**: Tractors, harvesters.
- **Manufacturing**: Machine tools, press machines.
- **Automotive**: Power steering systems, braking systems.

Hydraulic motor:

Hydraulic motors are essential components in hydraulic systems that convert hydraulic pressure into rotary mechanical energy.

Key Components:

1. **Housing**: The outer casing of the motor, which contains all the internal components and directs fluid flow.
2. **Rotating Element**: The part of the motor that rotates in response to the pressurized fluid. This can be a gear, vane, or piston depending on the motor type.
3. **Fluid Inlet and Outlet Ports**: Ports where the pressurized hydraulic fluid enters and exits the motor, controlling its operation.
4. **Seals and Bearings**: Used to reduce friction and maintain pressure integrity within the motor.

Types of Hydraulic Motors:

1. **Gear Motors**:
   - **Description**: Use gears to create rotational movement. The hydraulic fluid moves the gears, causing them to rotate and produce mechanical output.
   - **Advantages**: Simple design, reliable, and cost-effective.
   - **Applications**: Used in low to medium power applications like conveyors, winches, and small machinery.
2. **Vane Motors**:
   - **Description**: Use a set of vanes mounted on a rotor that slides in and out of a housing, converting fluid pressure into rotational motion.
   - **Advantages**: Provide smooth, continuous motion and are efficient at low speeds.
   - **Applications**: Often used in medium to high-speed applications such as industrial automation, forklifts, and agricultural machinery.

3. **Piston Motors**:
    - **Description**: Utilize pistons that move in a cylinder block, driven by hydraulic pressure. The pistons convert the fluid's pressure into rotational motion.
    - **Advantages**: Can provide high torque and efficiency, especially in variable displacement configurations.
    - **Applications**: Common in high-power applications like construction machinery, marine equipment, and heavy-duty vehicles.

Operation:

Hydraulic motors operate by using pressurized hydraulic fluid to push or pull internal components (such as gears, pistons, or vanes). The motor then converts this force into rotational movement, which can be used to drive various mechanical systems.

Advantages:

- **High Torque at Low Speed**: Hydraulic motors provide significant torque at low rotational speeds, making them ideal for heavy-duty applications.
- **Precise Control**: Fluid pressure can be precisely controlled, allowing for accurate control over speed and torque.
- **Durability and Reliability**: Hydraulic motors can operate in harsh conditions, making them suitable for tough environments like construction sites and mining operations.

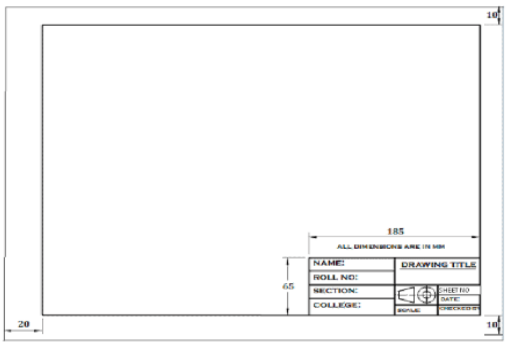
Applications:

Hydraulic motors are widely used in industries such as:

- **Construction**: Excavators, backhoes, and bulldozers.
- **Agriculture**: Tractors, harvesters, and plowing equipment.
- **Marine**: Winches, rudder drives, and deck machinery.
- **Mining and Heavy Equipment**: Drills, conveyors, and crushing equipment.

Drawing instruments

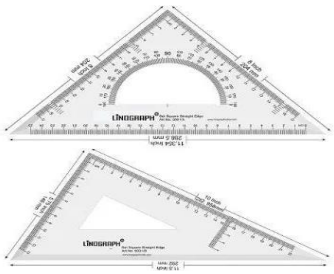
- **Drawing sheet :** A drawing sheet is one type of normal white paper on which an object is drawn that is available in various sizes and the sheet is used for engineering drawing.



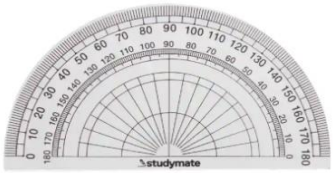
- **Drawing Board:** A drawing board is a rectangular type board that is made up of soft wood and the main purpose of using it is to support the drawing sheet, so the drawing board is made according to the drawing sheet.

- **T-Square:** T- Square is mainly used for drawing the vertical and horizontal lines on the drawing sheet, and it is made up of plastic and wood material.

- **Set Squares :** The set square is used to draw the lines with an angle between them and mostly the line is 30 degrees, 45, 60, and 90 degrees, so the set square is make work easy for this type of angle drawing.



- **Protractor:** This protractor is used to measure the accurate angle as well as draw the line in the drawing sheet; it is made of plastic material and transparent in nature.



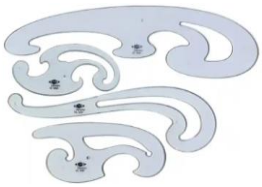
- **Drawing Pencils:** This protector is used to measure the accurate angle as well as draw the line in the drawing sheet; it is made of plastic material and transparent in nature.

- **Paper holder/Clips:** When the drawing sheet is put on the drawing board it may not be fixed in position so that this paper holder or clips are used for putting the

sheet in place.

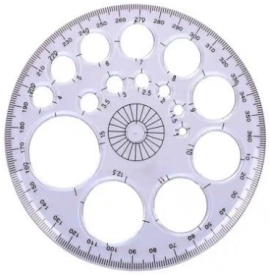
- **Compass:** This compass instrument is made of steel material and consists of two legs, one leg contains a needle at the bottom and the other leg contains a ring that rings placing a pencil for making a circle.

- **French Curve:** This is made up of plastic or steel and is used for drawing small arcs and long splines.



- **Roller Scale:** A Roller scale is a multipurpose instrument that allows you to draw a horizontal parallel line, vertical parallel line as well as crosshatching, triangle, and angles.

- **Circle Master:** Circle Master is a very useful **template-type** engineering drawing instruments that allow to you quickly draw the various radius of circles.



- **Sharpener:** This sharpener is used for sharpening the pencil worn and makes the surface worn pointed and smooth, the sharpener is important as it is a pencil, and erasers are used for making a drawing.

- **Eraser :** Erasers are used for removing lines or any spot that is drawn by mistake or drawn with the wrong measurement and also remove the extra projection lines.

- **Handkerchief :** The handkerchief is used to make the paper clean on which the drawing is being done.

Practical Activity 1.2.2: Selecting tools, materials and equipment

Task:

1.Refering to the key readings 1.2.1 and 1.2.2 , You are going to the workshop to select tools, materials and equipment.

2: Follow the instructions given about the activity to be done and perform the given task.

3: Present your selected resources to your colleagues.

Key readings 1.2.2 Selecting tools, materials and equipment

1.Tips for good selection of tools.

i. **Assess the risks:** Before starting any job, assess the potential hazards and risks involved. Identify the tools needed to complete the job safely and effectively. Consider the type of material, the environment, and any other factors that could impact safety.

ii. **Use the right tool for the job**: Always use the appropriate tool for the task at hand. Avoid using makeshift tools or adapting tools for unintended purposes. Using a tool that is not designed for a particular job can result in accidents, injury, or damage to the tool itself.

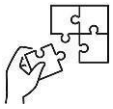
iii. **Maintain your tools:** Keep your tools in good condition by cleaning, inspecting, and repairing them as needed. Dull or damaged tools can lead to accidents and injuries.

iv. **Use personal protective equipment (PPE): Depending** on the job, wearing PPE such as safety glasses, gloves, and hard hats can provide an extra layer of protection against potential hazards.

v. **Follow manufacturer instructions:** Read and follow the manufacturer's instructions and warnings for using and maintaining your tools. Make sure you understand the tool's capabilities and limitations.

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.
- 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.

Indicative content 1.3: Drawing of Hydraulic and Pneumatic System

Duration: 10 hours

Theoretical Activity 1.3.1: Identification of pneumatic and hydraulic symbols

Tasks:

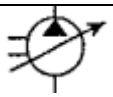
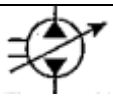
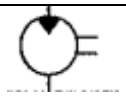
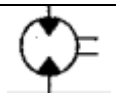
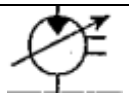
1: Observe carefully the images and drawings of pneumatic and hydraulic components given to you and identify available symbols.

2: present the identified symbols from observation to the class and trainer.

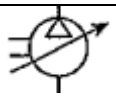
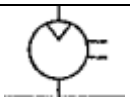
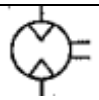
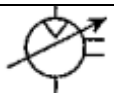
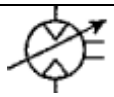
3: You are Invited to observe carefully further symbols in key readings 1.3.1 to see all symbols.

Key readings 1.3.1.: Identification of pneumatic and hydraulic symbols

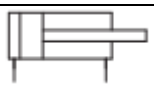
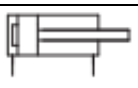
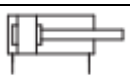
1. **Role of symbols:** Representation of pneumatic and hydraulic components
2. **Graphic symbols used for pumps, compressors and motors**

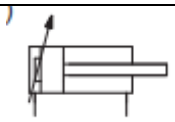
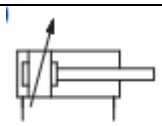
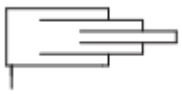
S/N	Hydraulic Symbols	Explanation / Description
1		Fixed displacement, unidirectional pump
2		Fixed displacement, bidirectional pump
3		Variable displacement, unidirectional pump
4		Variable displacement, bidirectional pump
5		Fixed displacement, unidirectional motor
6		Fixed displacement, bidirectional motor
7		Variable displacement, unidirectional motor
8		Variable displacement, bidirectional motor
9		Oscillator motor

S/N	Pneumatic	Explanation / description

	symbols	
1		Fixed displacement, unidirectional compressor
2		Fixed displacement, bidirectional compressor
3		Variable displacement, unidirectional compressor
4		Variable displacement, bidirectional compressor
5		Fixed displacement, unidirectional motor
6		Fixed displacement, bidirectional motor
7		Variable displacement, unidirectional motor
8		Variable displacement, bidirectional motor
9		Oscillator motor
10		Rotary actuator

3. Graphic symbols used for cylinders

No	Symbols	Explanation / Description
1		Single-acting cylinder returned stroke by external force
2		Single-acting cylinder returned stroke through a spring
3		Double-acting cylinder single rod
4		Double-acting cylinder double rod
5		Cylinder with fixed stroke end cushioning on one side
6		Cylinder with fixed stroke end cushioning on both sides

7		Cylinder with adjustable stroke end cushioning on one side
8		Cylinder with adjustable stroke end cushioning on both sides
9		Single-acting telescopic cylinder
10		Double -acting telescopic cylinder

4. Directional control valves

✓ Directional control valves are used to determine the path of the fluid through which should travel within a given circuit.

✓ Directional control valves are shown by means of several connected squares:

Number of squares: indicate the number of switching positions possible.

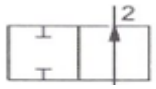
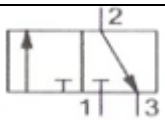
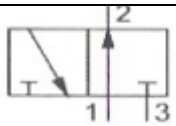
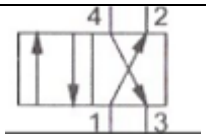
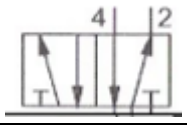
Arrow within square: indicate the flow direction

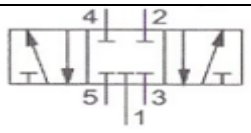
Lines: indicate how the ports are inter-connected in the various switching positions.

✓ **Naming convention for valve**: number of ports / numbers of switching positions

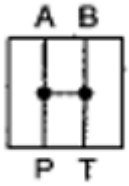
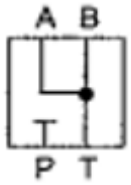
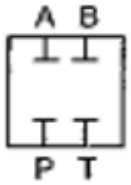
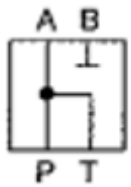
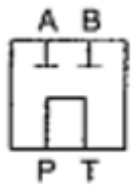
Example: 4/3valve has 4ports and 3 switching positions.

5. Graphical symbols for directional control valves

No	Symbols	Explanation / Description
1		2/2-way direction control valves, normally open
2		3/2-way directional control valve, normally closed
3		3/2-way directional control valve, normally open
4		4/2-way directional control valve flow from 1 to 2 and from 4 to 3.
5		5/2-way directional control valve flow from 1 to 2 and 4 to 5

6		5/3-way directional control valve mid position closed

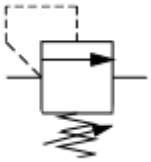
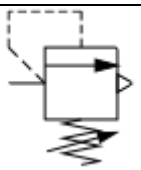
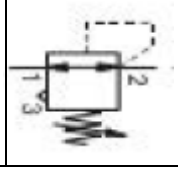
Different center positions for 4 way 3 positions:

Center position	Explanation
	Open center
	Float type(Pressure P and port B closed)
	Float type(Pressure P is closed, Port A and B open to tank)
	Closed center
	Pressure P, port A and B are open to tank while Port B is closed
	Tandem center

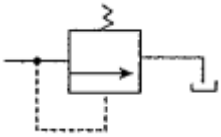
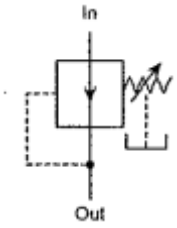
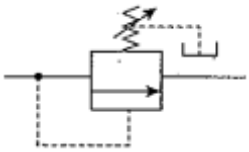
6. Pressure valves

Pressure valves are used to protect pneumatic and hydraulic systems against over pressure. Pressure valves are indicated by using squares. Arrows indicate flow direction.

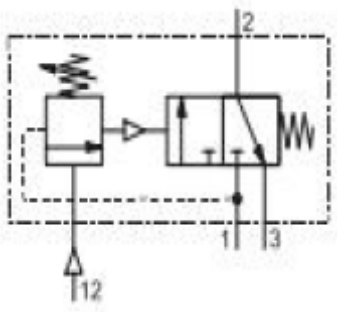
7. Pneumatic pressure valves

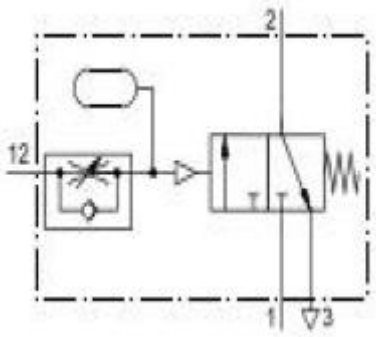
No	Symbol	Explanation
1		Pressure sequence valve in line
2		Pressure relief valve
3		Pressure regulating valve

8. Hydraulic pressure valves

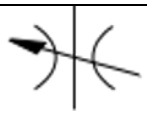
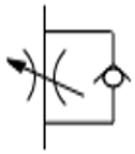
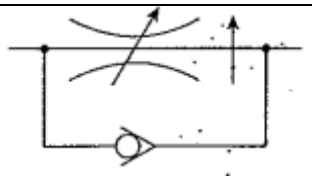
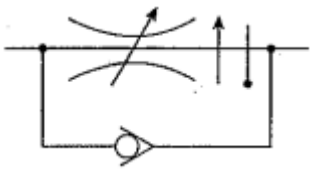
Simple hydraulic pressure relief valve	
Hydraulic pressure regulating valve	
Hydraulic Pressure sequence valve	

9. Pneumatic combinational valves

No	Symbol	Explanation
1		**Pressure sequence valve combination**

2		**Time delay valve**

10. Flow control valves

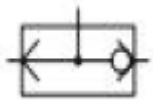
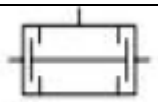
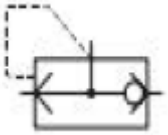
	Adjustable Flow control valve
	One way Flow control valve
	Flow control valve with pressure compensation
	Flow control valve with pressure and temperature compensation

11. **Non return valves**

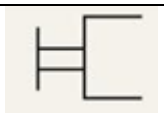
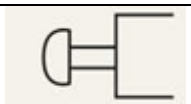
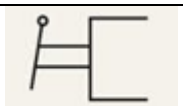
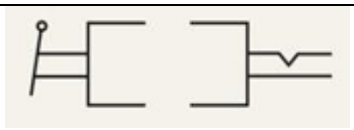
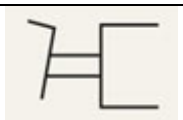
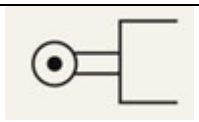
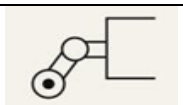
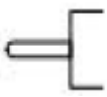
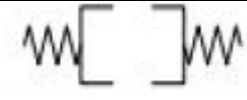
No	Symbol	Explanation
1		Spring load non return valve
2		Unloaded no return valve
3		Pilot controlled no return valve
4		Shut off valve

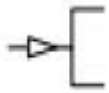
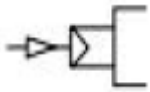
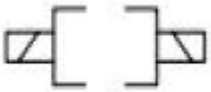
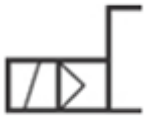
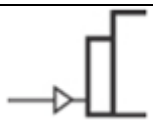
12. Pneumatic logic valves

No	Symbol	Explanation

1		Shuttle valve /OR valve
2		Dual pressure valve / AND Valve
3		Quick exhaust valve

13. Actuation methods

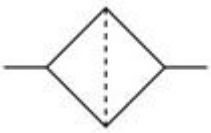
No	Symbols	Explanation / Description
Manual Actuation		
1		General manual actuation
2		Push button actuation
3		Level actuation
4		Detent level actuation
Mechanical Actuation		
5		Foot pedal actuation
6		Roller level actuation
7		Idle return roller actuation
8		Spring actuation
9		Plunger actuation
10		Spring centred

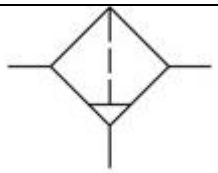
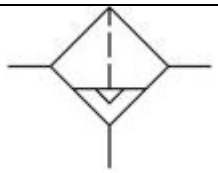
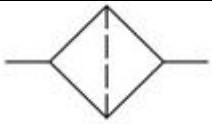
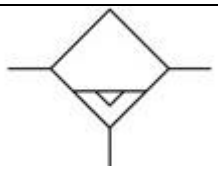
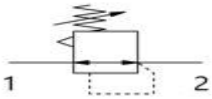
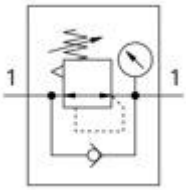
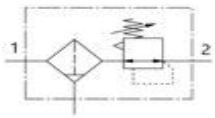
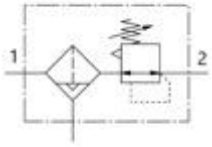
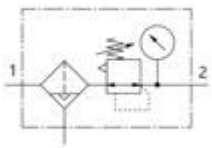
Pneumatic Actuation		
11		Direct pneumatic actuation
12		Indirect (piloted) pneumatic actuation
Electrical Actuation		
13		Single solenoid operation
14		Double solenoid operation
Combined Actuation		
15		Double solenoid and pilot operation with manual override
16		Electrical actuated, solenoid pilot valve
17		Pneumatically actuate, differential piston, dominating sides

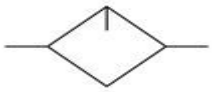
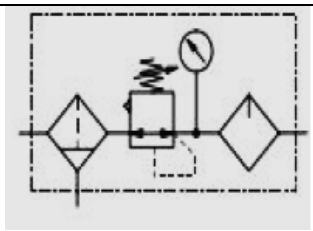
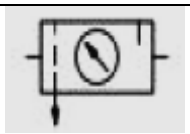
14. Supply components symbols

No	Symbol	Explanation
		Air reservoir
		Pneumatic pressure source
		Hydraulic pressure source

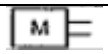
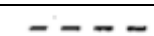
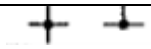
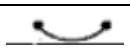
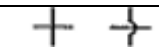
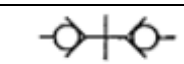
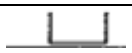
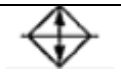
15 . Graphic Symbols Used for Service Components

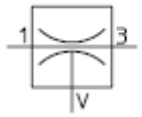
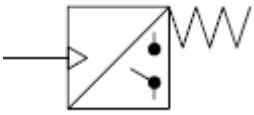
No	Symbols	Explanation / Description
1		Filter Without Drain

2		Filter With Manual Drain
3		Filter With Automatic Drain
4		Vacuum Filter
5		Water Separator Automatic Drain
6		Regulator With Relieving
7		Regulator, Return Flow And Pressure Gouge
8		Filter Regulator, Manual Drain
9		Filter Regulator, Automatic Drain
10		Filter Regulator, Automatic Drain, Pressure Gouge

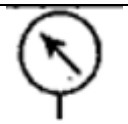
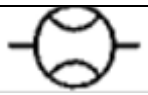
11		Lubricator
12		Air Service Unit
13		Simplified Air Service Unit

16.Graphic symbols for energy transmission

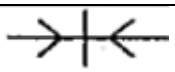
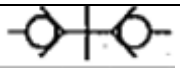
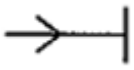
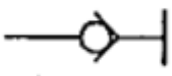
No	Symbols	Explanation / Description
1		Electric motor
2		Non-electric drive unit
3		Pressure, power, return line
4		Control (pilot) line
5		Drain line
6		Plugged port
7		Line connection
8		Flexible line
9		Line crossing
10		Exhaust, continuous
11		Quick-acting coupling connected with mechanically opening non-return valves
12		Vented reservoir
13		Pressurized reservoir
14		Cooler
15		Heater
16		Exhaust port without fixture for connection
17		Exhaust port with threaded connection

18		Vacuum ejector
19		Pressure switch (non-adjustable)
20		accumulator
21		Spring loaded accumulator
22		Gas loaded accumulator
23		Weighted accumulator

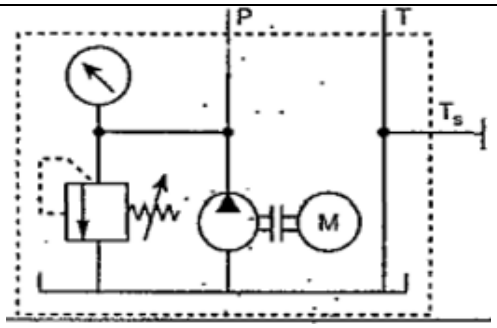
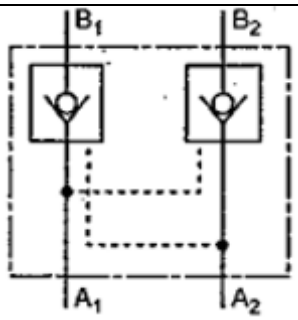
17. Graphic Symbols Used For Measuring Devices

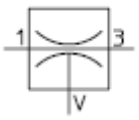
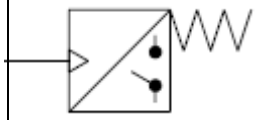
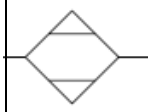
NO	SYMBOLS	EXPLANATION / DESCRIPTION
1		Pressure gouge
2		Thermometer
3		Flowmeter
4		Filling level indicator

18. Graphic Symbols Used For Couplings

No	Symbols	Explanation / Description
1		Coupled without check valve
2		Coupled with check valve
3		Half of quick release-coupling without valve
4		Half of quick release-coupling with check valve

18. Graphic Symbols Used For Coupling

No	Symbols	Explanation / Description
1		Hydraulic power pack
2		Pilot-operated double non-return valve

Vacuum ejector	Pressre switch (non adjustable)	Air dryer
		

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

Task:

1: Referring on the previous theoretical activity 1.3.1 and key reading 1.3.2 draw:

i. Control circuit of pneumatic single acting cylinder.
ii. Control circuit of pneumatic double acting cylinder.

2: Follow the instructions given in key reading and perform the task given.

3: Present your final drawing to your colleagues/parents.

4: You invited to read key readings 1.3.2 for further learning

Key readings 1.3.2 Drawing control circuit of pneumatic single and double acting

cylinders

Steps to draw pneumatic circuits

Drawing pneumatic circuits involves representing the components and their connections using standard symbols. Here's a step-by-step guide:

1. Identify Components:

Determine the necessary components based on the desired function of the pneumatic system. Common components include:

- **Air compressor:** Supplies compressed air.
- **Air cylinders:** Convert compressed air into mechanical force.
- **Valves:** Control the flow and direction of compressed air (e.g., solenoid valves, directional valves).
- **Tubing and fittings:** Connect components and transport compressed air.
- **Pressure regulators:** Control the output pressure of the system.
- **Filters:** Remove impurities from the compressed air.

2. Determine the Sequence of Operations:

- Outline the desired sequence of events or actions that the pneumatic system should perform. This will help determine the necessary components and their connections.

3. Sketch the Basic Layout:

- Start by sketching a basic layout of the system, showing the general arrangement of components.
- Consider factors like space constraints, accessibility, and ease of maintenance.

4. Use Standard Symbols:

- Represent each component with its corresponding standard pneumatic symbol. These symbols are widely recognized and help in understanding the circuit.
- Refer to pneumatic symbol libraries or textbooks for reference.

5. Connect Components:

- Draw lines to represent the tubing connections between components.
- Use arrows to indicate the direction of airflow.
- Label each component and connection for clarity.

6. Add Valves and Controls:

- Incorporate valves (e.g., solenoid valves, pressure relief valves) to control the flow of compressed air.
- Draw the symbols for these valves and their connections to the system.

7. Indicate Pressure and Flow:

- If necessary, add symbols or labels to indicate desired pressure levels or flow rates at different points in the circuit.

8. Review and Verify:

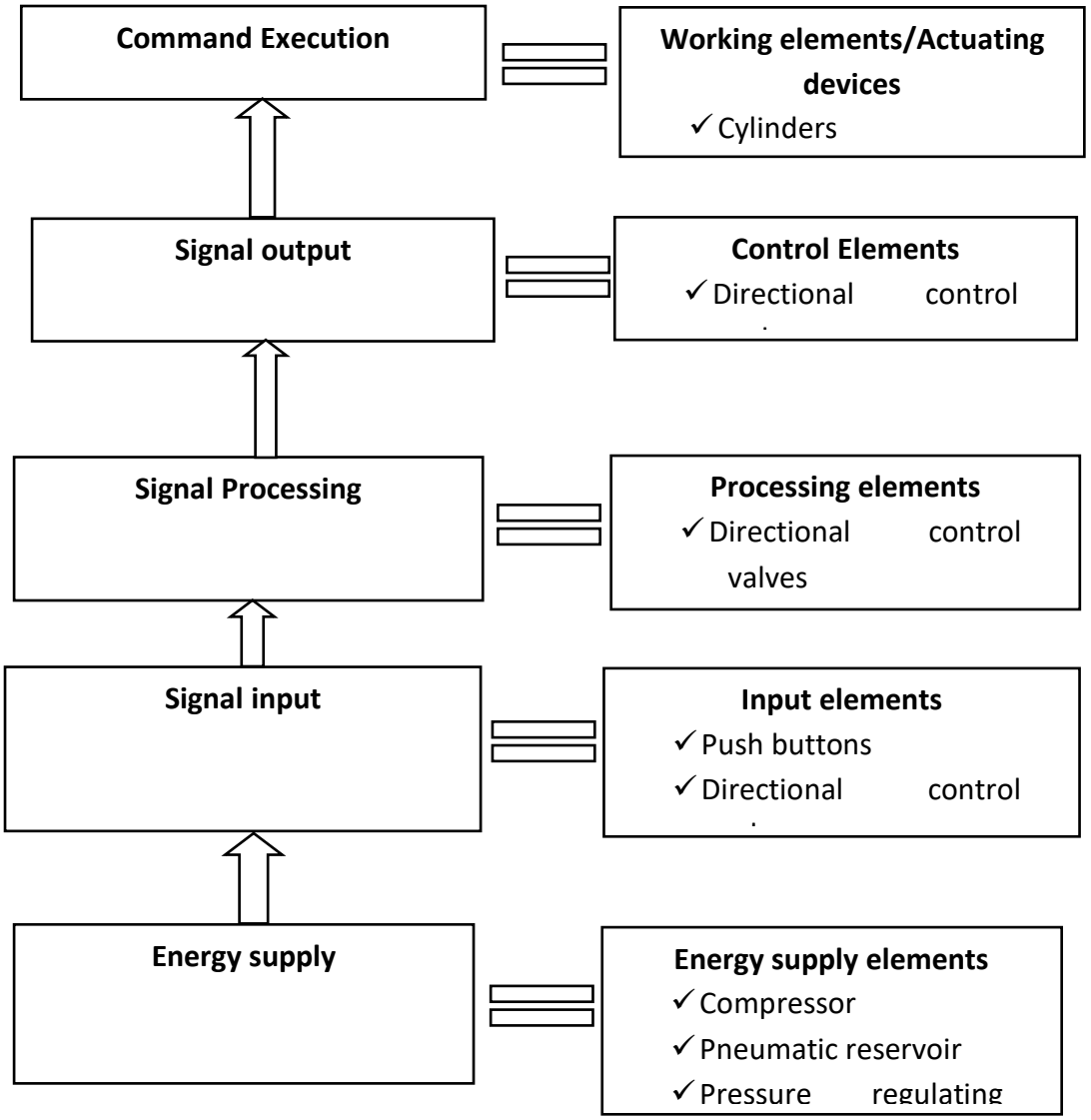
- Check the circuit diagram for accuracy and completeness.
- Ensure that the connections and component placement are logical and will achieve the desired function.

9. Consider Additional Details:

- If applicable, include symbols for sensors, actuators, or other devices that interact with the pneumatic system.
- Label any specific control signals or inputs/outputs

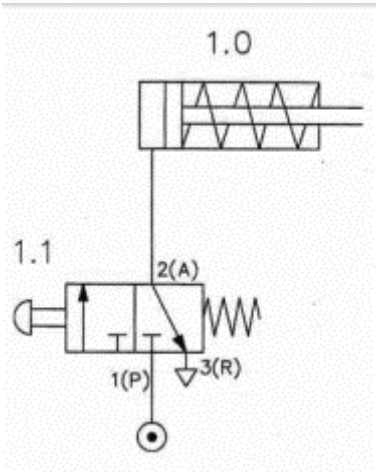
Elements of pneumatic system

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



Direct control of a single-acting cylinder

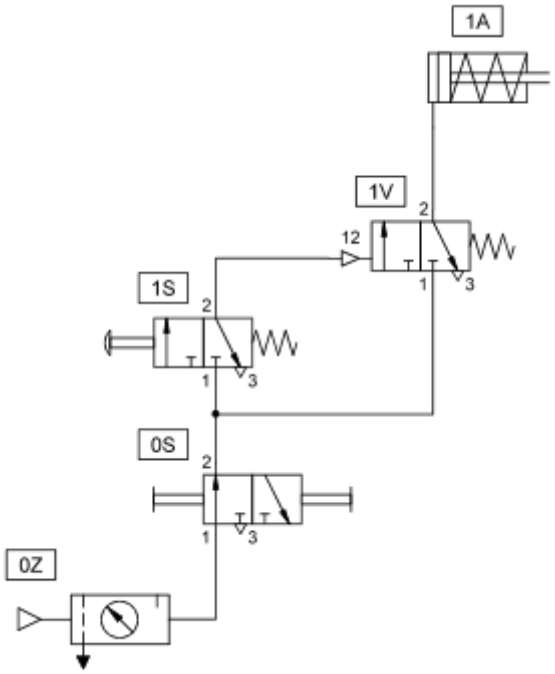
Situation : A single acting cylinder of 25mm diameter is to advance a component when a push button is pressed. As long as the push button is activated the cylinder is to remain in the clamped position. If the push button released, the clamp is to retract. Design its pneumatic circuit.



Indirect control of single acting cylinder

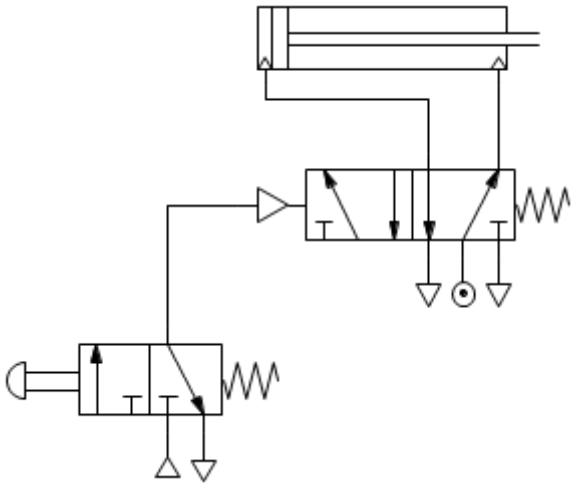
Situation:

A single acting cylinder with a large piston diameter is to clamp a workpiece following actuation of push button. The cylinder is to retract once the push button is released.



Indirect control of a double acting cylinder

Situation : A double acting cylinder is to extend when a push button is operated. Upon release of the push button the cylinder is to retract. Design its pneumatic circuit.



The logic AND function

Situation: The piston rod of a double acting cylinder is to advance when both push button of the 3/2 way valve is actuated. If either of these is released, then the cylinder is to return to the initial position. Design its pneumatic circuit.

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

Task:

1: Referring on the previous theoretical activity 1.3.1 and key reading 1.3.3 draw:

i. Control circuit of hydraulic single acting cylinder.
ii. Control circuit of hydraulic double acting cylinder.

2: Follow the instructions given in key reading and perform the task given.

3: Present your final drawing to your colleagues/parents.

4: You invited to read key readings 1.3.3 for further learning

Key readings 1.3.3 Drawing control and power circuit diagram of hydraulic system

Steps to draw hydraulic circuits

Drawing hydraulic circuits involves representing the components and their connections using standard symbols. Here's a step-by-step guide:

1. Identify components:

- Determine the necessary components based on the desired function of the hydraulic system. Common components include:
  - **Hydraulic pump:** Generates hydraulic pressure.

- **Hydraulic cylinder:** Converts hydraulic pressure into linear motion.
- **Hydraulic motor:** Converts hydraulic pressure into rotary motion.
- **Hydraulic valves:** Control the flow and direction of hydraulic fluid.
- **Tubing and fittings:** Connect components and transport hydraulic fluid.
- **Hydraulic accumulator:** Stores hydraulic energy.
- **Filters:** Remove contaminants from hydraulic fluid.

2. Determine the Sequence of Operations:

- Outline the desired sequence of events or actions that the hydraulic system should perform. This will help determine the necessary components and their connections.

3. Sketch the Basic Layout:

- Start by sketching a basic layout of the system, showing the general arrangement of components.
- Consider factors like space constraints, accessibility, and ease of maintenance.

4. Use standard symbols:

- Represent each component with its corresponding standard hydraulic symbol. These symbols are widely recognized and help in understanding the circuit.
- Refer to hydraulic symbol libraries or textbooks for reference.

5. Connect components:

- Draw lines to represent the tubing connections between components.
- Use arrows to indicate the direction of fluid flow.
- Label each component and connection for clarity.

6. Add Valves and Controls:

- Incorporate valves (e.g., directional valves, pressure relief valves) to control the flow and direction of hydraulic fluid.
- Draw the symbols for these valves and their connections to the system.

7. Indicate Pressure and Flow:

- If necessary, add symbols or labels to indicate desired pressure levels or flow rates at different points in the circuit.

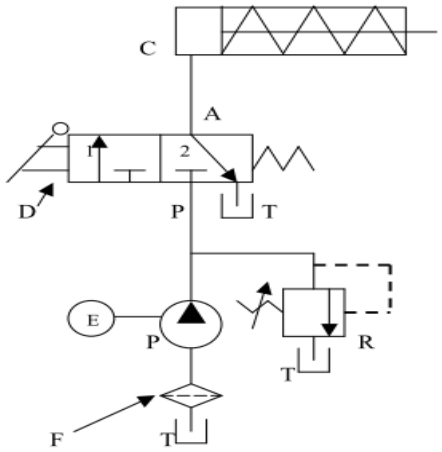
8. Review and verify:

- Check the circuit diagram for accuracy and completeness.
- Ensure that the connections and component placement are logical and will achieve the desired function.

9. Consider additional details:

- If applicable, include symbols for sensors, actuators, or other devices that interact with the hydraulic system.
- Label any specific control signals or inputs/outputs.

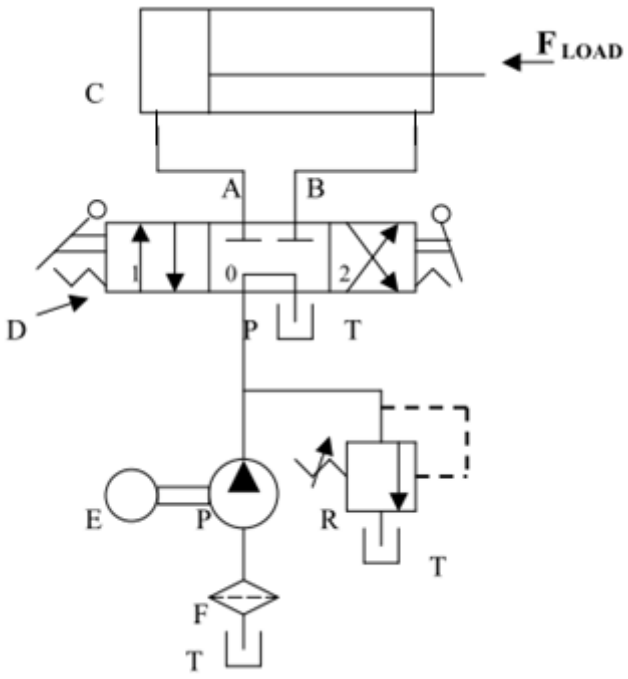
Control of single acting cylinder



C: Single acting cylinder
P: Pump
E: Electric motor
T: Tank
F: Filter
R: Relief Valve
D: DCV

Operation: 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.

Control of double acting cylinder



C: Double acting cylinder
P: Pump
E: Electric motor
T: Tank
F: Filter
R: Relief Valve
D: DCV

Operation:

- ✓ When the four way valve is in centered configuration, the cylinder is hydraulically locked as the ports A and B is blocked. The pump flow is unloaded back to the tank at essentially atmospheric pressure.
- ✓ When the four way valve is actuated into the 1 st position, the cylinder is extended
- ✓ against its load force F load as oil flows to the blank end of the cylinder from port P through port A. Also, oil in the rod end of the cylinder is free to flow back to the tank via the four way valve from port B through port T. Note that the cylinder would not extend if this oil were not allowed to leave the rod end of the cylinder.
- ✓ When the four way valve is actuated into the 2^{nd} position , the cylinder is retracts against as oil flows to the rod end of the cylinder from port P through port B. Oil in the blank end of the cylinder is returned to the tank from port A to port T. At the end of the stroke, there is no system demand for oil. Thus, the pump flow goes through the relief valve at its pressure- level setting unless the four- way valve is deactivated. In any event the system is protected from any cylinder overloads.

Indirect control of single acting cylinder: it is the circuit where many valves control indirectly actuator. means that

- ✓ valve control other valve before reaching to the actuator.
- ✓ Example: Indirect control of single acting hydraulic cylinder.

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

Tasks:

1: Answer the following questions

i. Define the terms
   a. Cost
   b. Estimate
ii. What are The requirement for preparing an estimate?
iii. Explain the meaning of bill of quantity and bill of quantity layout.
iv. Outline the content of Bill of quantity

2: Present your findings in front of the class and trainer.

3: Read key readings 1.3.4 for more information

Key readings 1.3.4.: identification of the cost estimation of pneumatic and hydraulic system

1.Definitions

1.1 Cost: a 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.

1.2 Estimate: is an approximate calculation of the cost of works to be done.

2.The requirement for preparing an estimate

1. Drawing
2. Detailed specification
3. Standard schedule of rates of the current year

3.Meaning of bill of quantity and bill of quantity layout

3.1 Bill of quantity: It is a document used in bidding**.** A bill of quantities is a document used in tendering in the construction industry in which materials, parts, and labor (and their costs) are itemized.

3.2 Bills of quantity layout

Item No.	Item Description	Unit of Measurement / Specifications	Quantity	Unit Rate (Currency/Unit)	Extended Total (Currency)
1					
2					

3					
4					
5					
...					
Total					**Total Cost (Currency)**

4.Bills Of Quantity Content

1. Item number
2. Item description
3. Unit of measures on each item
4. Quantity of each item
5. **Unit Rate (Currency/Unit)**
6. Total cost (amount)/ **Extended Total (Currency)**

Pro-forma invoice: is a preliminary bill of sale sent to buyers in advance of a shipment or delivery of good.

Invoice: is a statement listing good or services provided and their prices used in business as record of sale.

Proforma invoice

Bill from:……..Bill to:…….Invoice No:……

Name:……Name:……Invoice Date:……..

Company name:…….. Company name:…… Due Date:……..

Address:……Addres

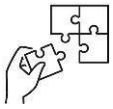
Telefone number:..... Telefone number:.....

S/N	Description	Quantity	Price(s)	Total(s)
1				
2				
3				
4				
5				
…….				
			Subtotal	
			Sales Tax	
			Other	
			Total	

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.
- **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
- **Steps to draw hydraulic 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.
- 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 outstrockes, 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

.

Indicative content 1.4: Simulating Control and Power Circuits

Duration: 5 hours

Theoretical Activity 1.4.1: Identifying steps of simulating pneumatic and hydraulic circuits

Tasks:

1: Answer the following questions

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

2: Present your findings in front of the trainer and classmates.

3: You are oriented to read key reading 1.4.1 for more information

Key readings 1.4.1.: Identifying steps of simulating pneumatic and hydraulic circuits

1.Simulation: It is a representation of something, not the real thing.

1.1 Simulation software: It is a program that allows the user to observe an operation through simulation without actually performing that operation.

2.Examples of Simulation softwares: FluidSIM, MATLAB Simlink, Automation Studio, Autocad Electrical

3.Steps to simulate pneumatic or hydraulic circuit by the help of fluidSim software

1. Install fluidsim software
2. Open fluidsim
3. Create a New project:

✓ In fluidsim, create a new project by selecting File > New.

1. **Add Pneumatic and Hydraulic Components:**

✓ Drag and drop pneumatic and hydraulic components from the Simulink Library Browser. Include components like cylinders, valves, pumps, and reservoirs.

2. **Add Control Elements:**

✓ Include control elements such as sensors, controllers, and actuation signals.

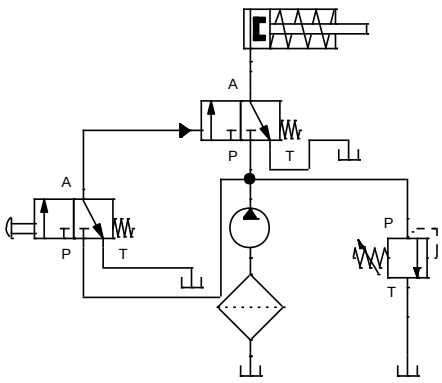
✓ For example, use a signal source block to represent a control signal, a sensor block to represent a pressure or position sensor, and a controller block to implement a control algorithm.

3. **Connect and Configure Blocks:**
   - ✓ Connect the blocks using appropriate signal lines to model the flow of air or hydraulic fluid and control signals.
   - ✓ Set parameters for each component, such as pressure limits, flow rates, …
4. **Connect the inserted pneumatic or hydraulic components**
   Use the software tools to connect the elements.
5. **Execute the Simulation:**
   - ✓ Execute the simulation to observe how the control elements influence the behavior of the pneumatic and hydraulic system.
6. **Analyze Results:**
   - ✓ Observe how the extension, retraction, are being done.
7. **Experiment and Modify:**
   - ✓ Experiment with different control algorithms, parameters, and system configurations to understand the impact on system performance.
8. **Save and Document:**
   - ✓ Save your simulation model and document the control logic, parameters, and any observations made during the simulation.

Practical Activity 1.4.2: Simulating pneumatic and hydraulic circuits

Task:

1: Referring on key reading 1.4.1 simulate the power and control circuit of the hydraulic following circuit:



2: Follow the steps given and simulate the circuit.

3: Present your final product to your colleagues.

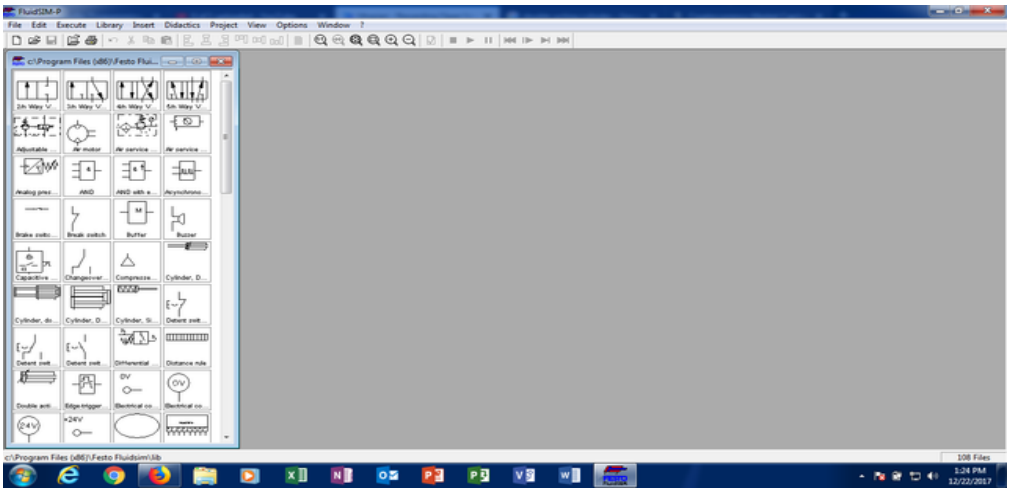
4: You are advised to read key reading 1.4.2 for more details

Key readings 1.4.2.:

A step-by-step guide on how to design a pneumatic circuit to control double-acting cylinder.

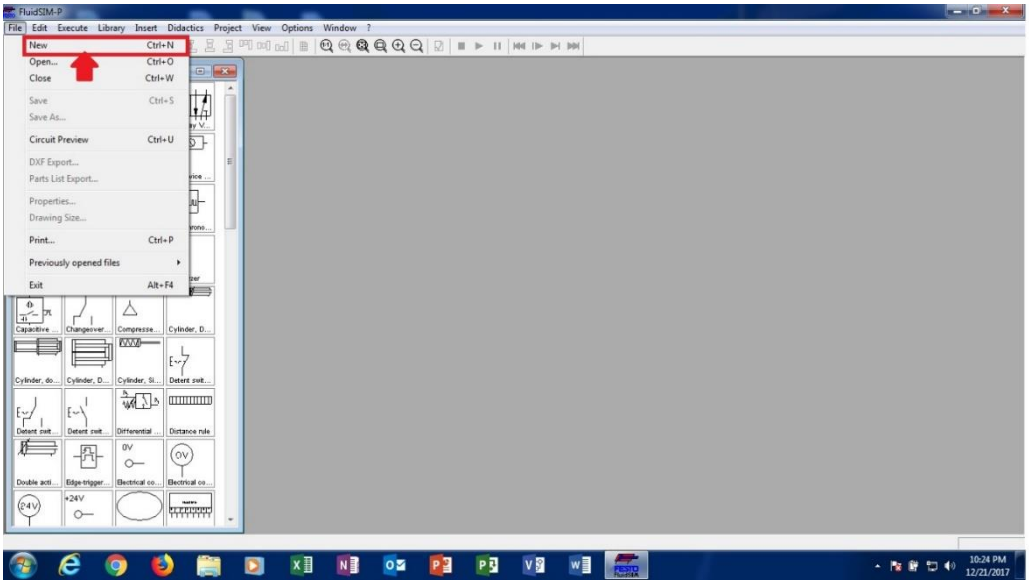
Step-by-step Guide

Step 1: Open FluidSim

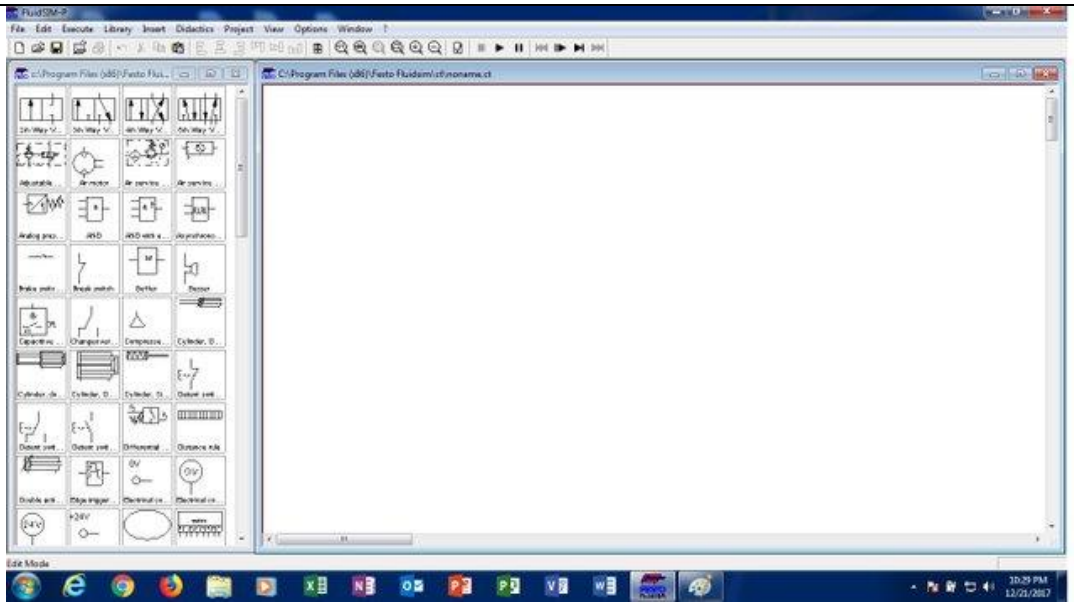


Step 2: Create a NEW Project

Locate FILE on the menu bar, and a drop-down option appears. Select NEW or you can directly use shortcut key CRTL + N.

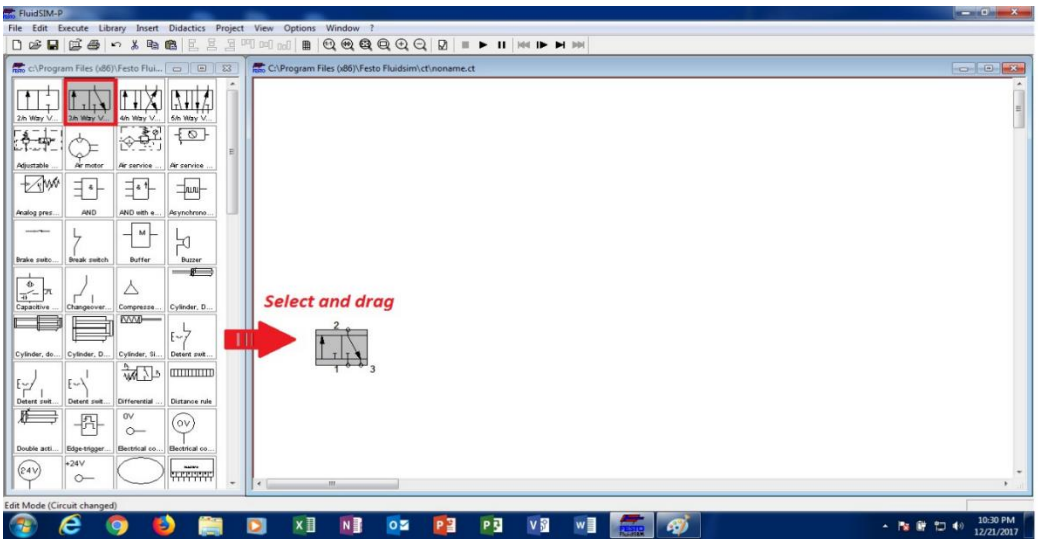


Then, a new project workplace appears. (the same as the picture shown below.)

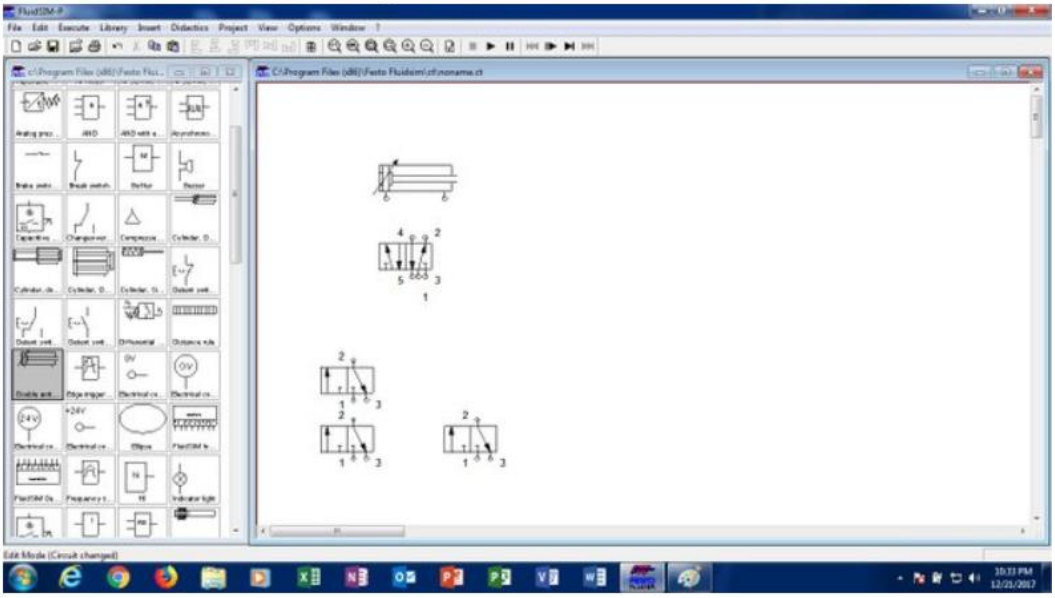


Step 3: Select the Materials to be used

To select the materials to be used, you click the symbol of material as indicated in the lef t pane in the worksheet. After clicking the material, you simply drag it to the new project workplace.

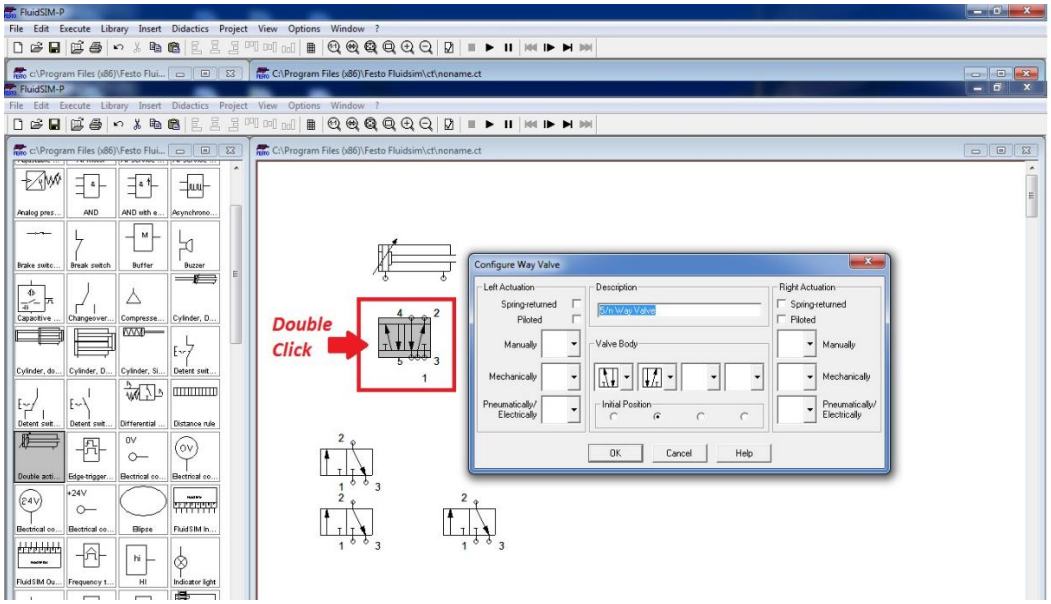


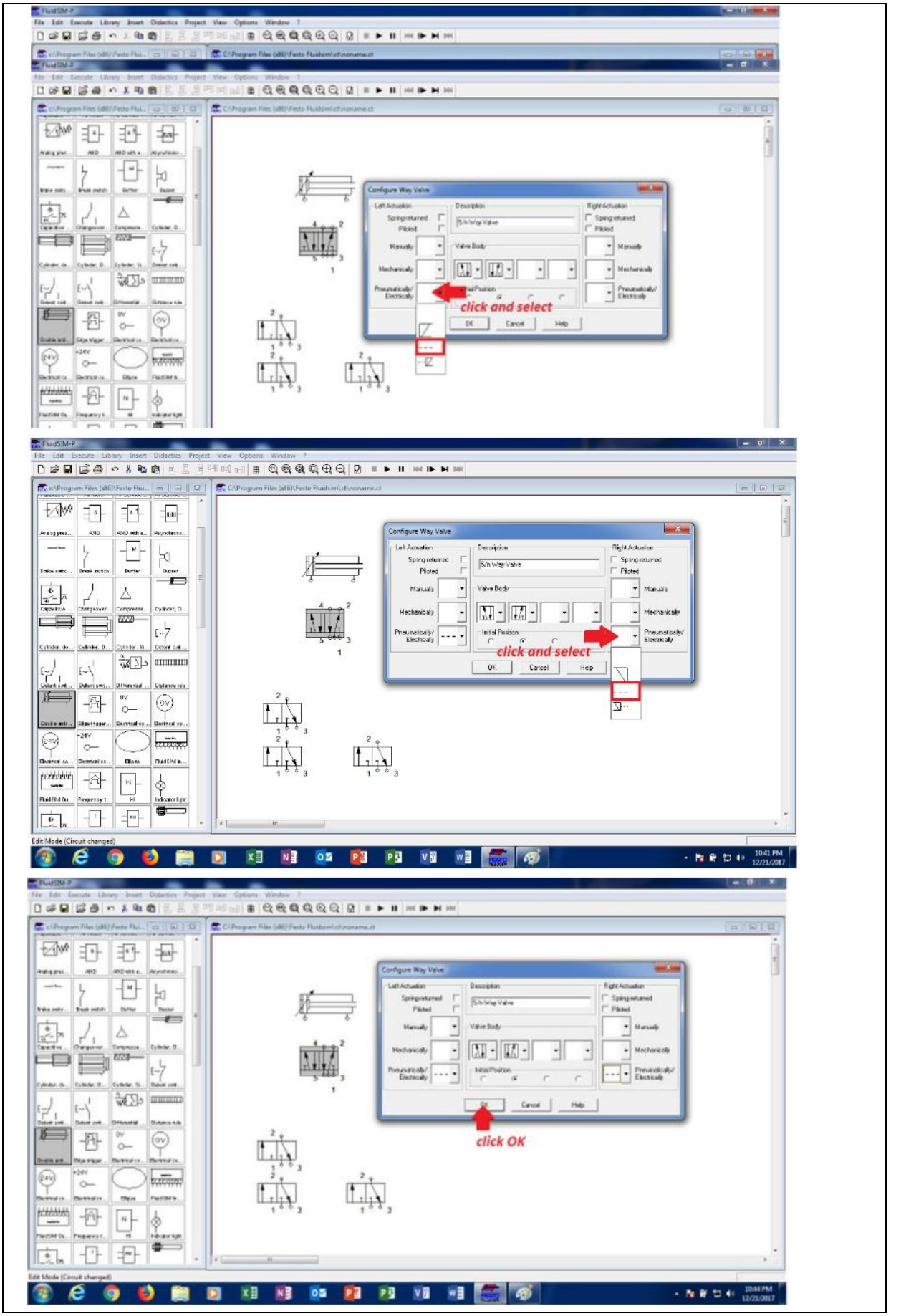
Do it until you selected all the necessary listed materials. And, arrange the materials acco rding to the picture shown below.



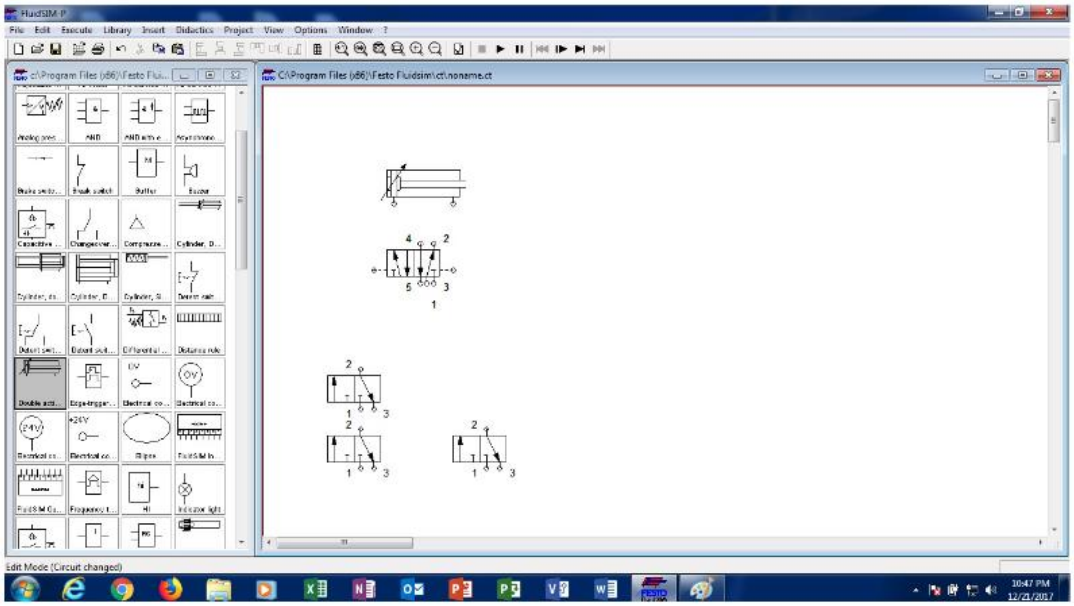
Step 4: Configure and connect equipment

Configuring the 5/2 way directional control valve, simply follow the steps as indicated in the figure.

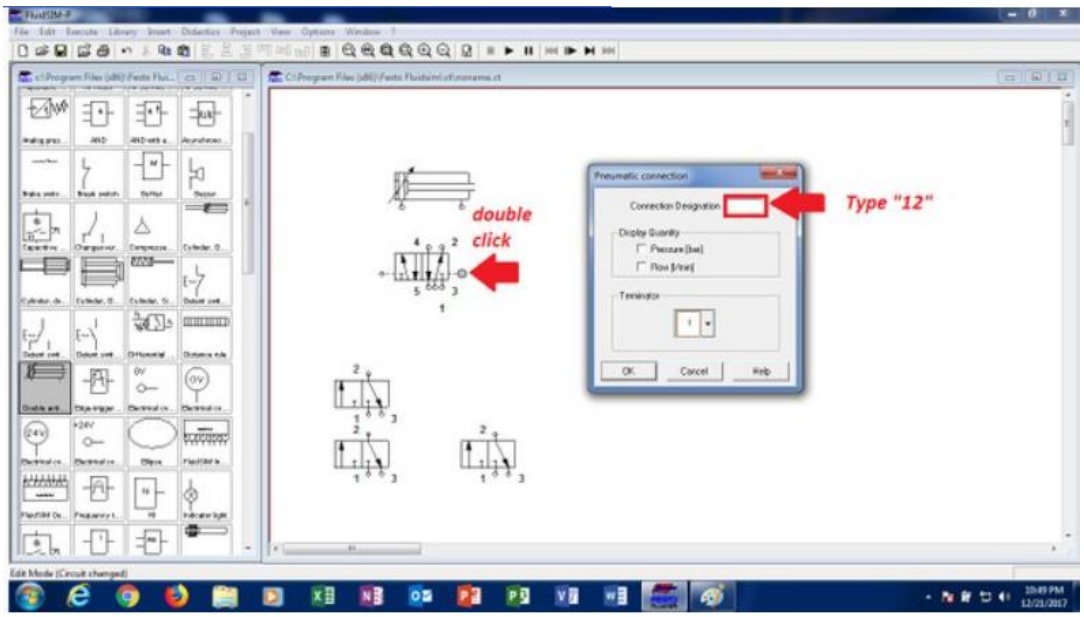


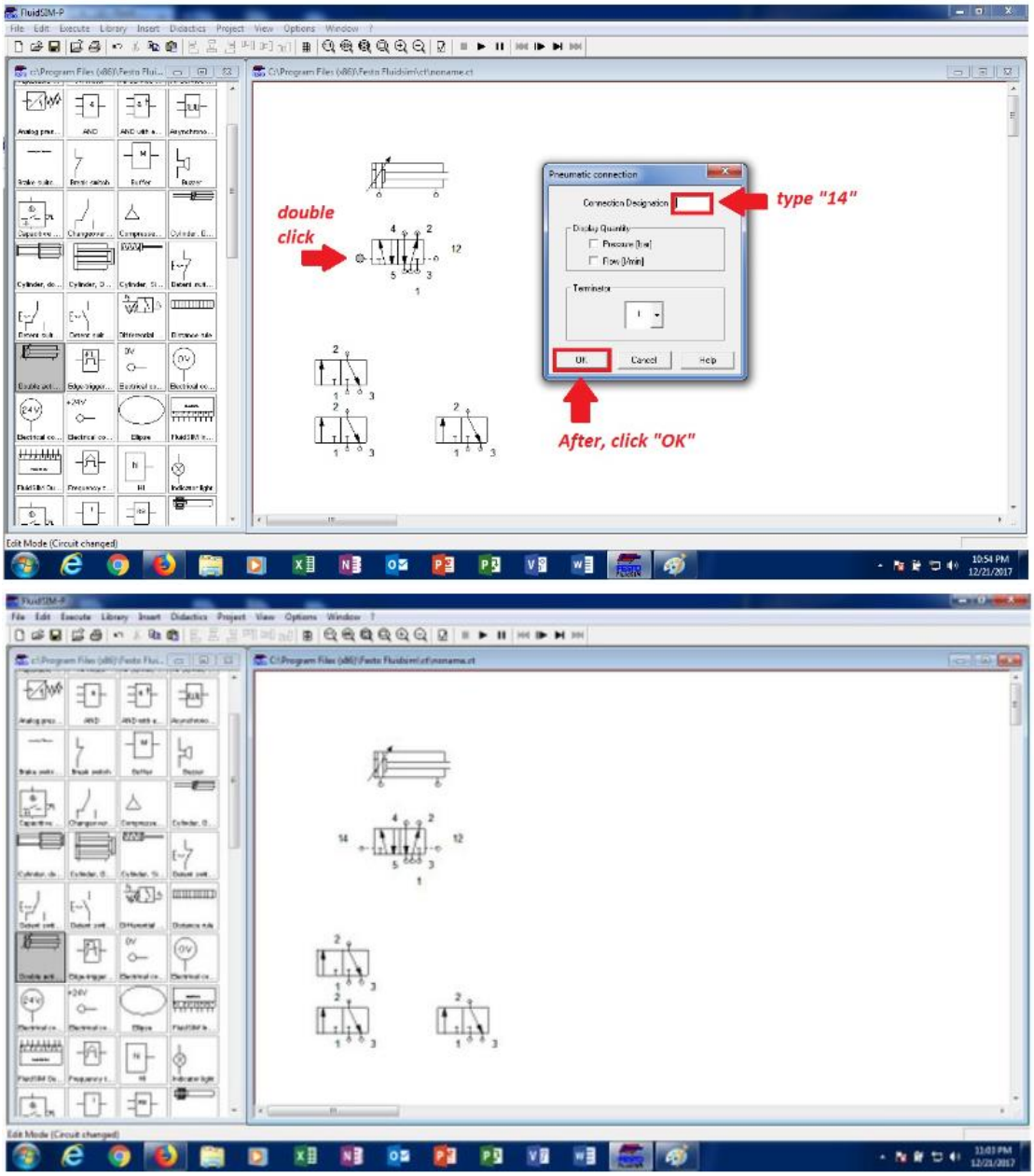

click and select
click and select
click OK

After following the procedure as indicated in the figure above. The result will look the sa me with the figure below.

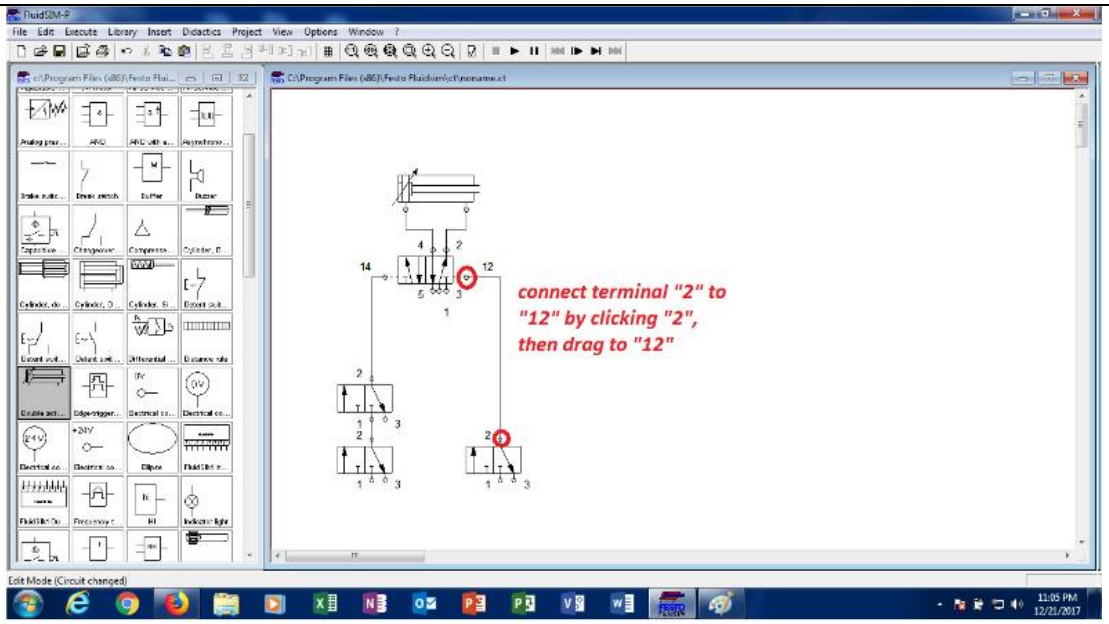


To finish the configuration of the 5/2 way DCV, put the terminal designation number for the pneumatic actuation of the 5/2 way DCV. Follow the procedure as indicated in the fig ure below. Double click the 5/2 way DCV first before a dialog box appears.

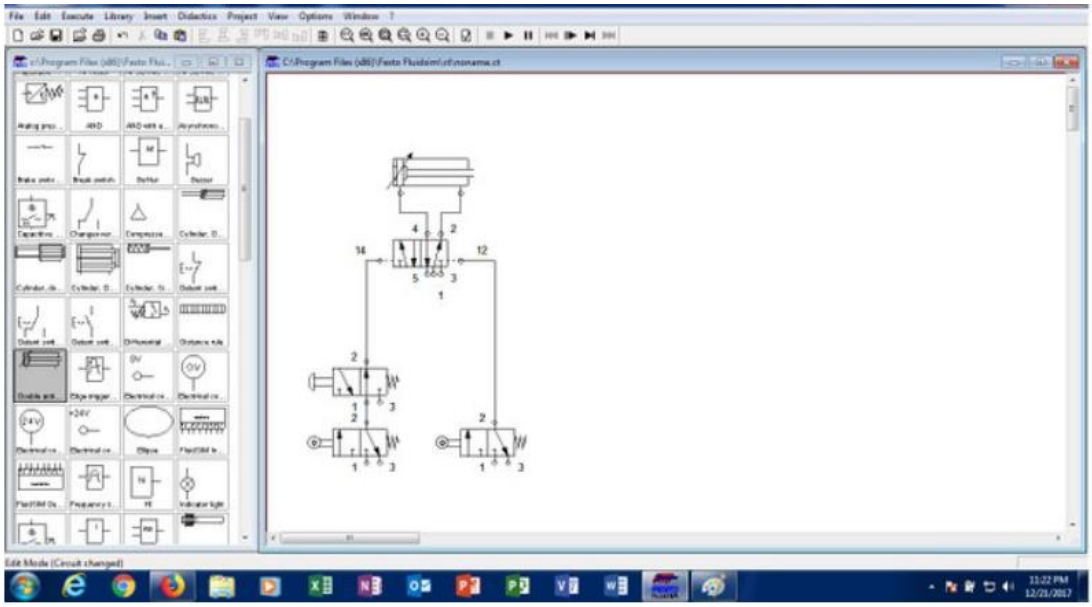




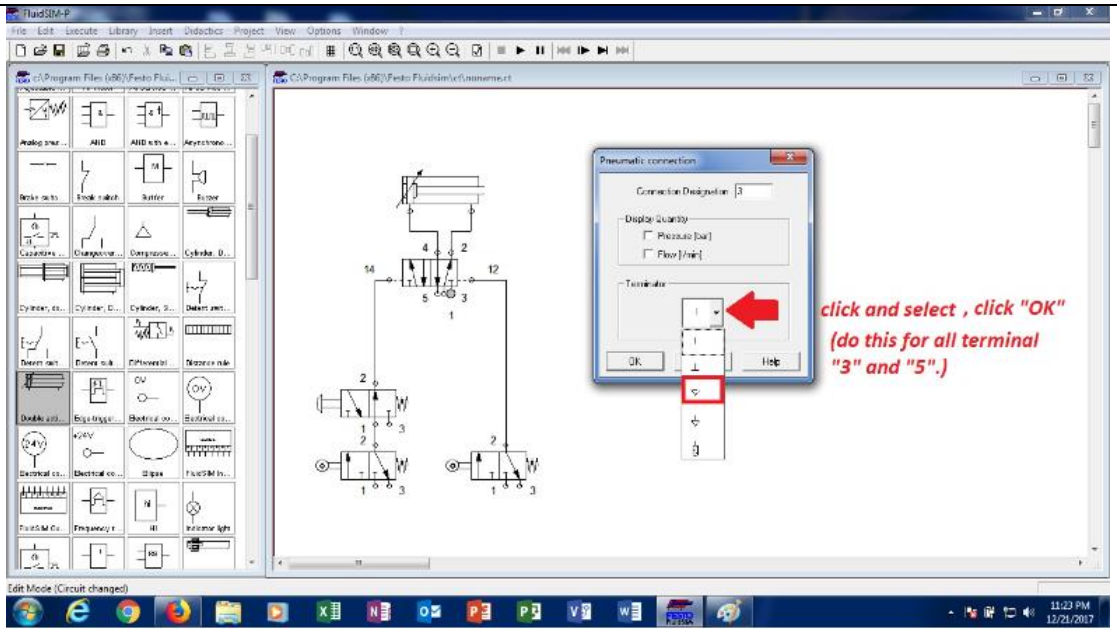
Connecting the 5/2 way DCV to the 3/2 way DCV. Click first the terminal designation, h old then drag to the next terminal. Do this step for all equipment, as shown in figure.



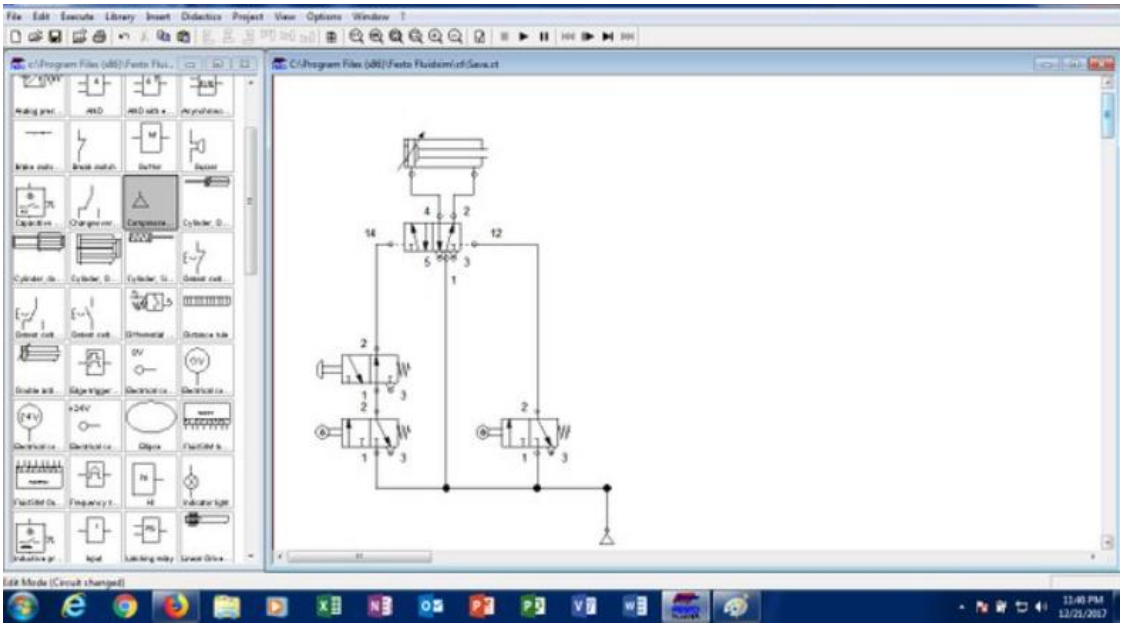
Configuring the 3/2 way DCV. Follow the same steps as applied on 5/2 way DCV.



Configure all exhaust terminal as designated to terminal no. 3 and no. 5 for all directio nal control valve.



Connect first all terminals to air supply, as indicated in the figure below.

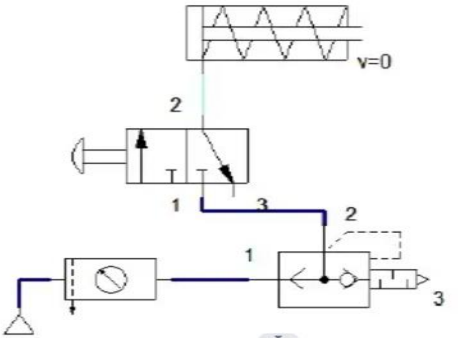


Points to Remember

- 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 Fluidsim software.



Learning outcome 1 end assessment

Written assessment

1. 1. Define the following terms:

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

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

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

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

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

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?

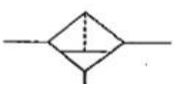
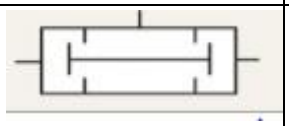
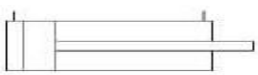
b) BOQ detailed breakdown of all elements needed to execute an electrical project

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.

4. What is the fluid medium used i the pneumatic and hydraulic systems?
5. Outline two types of fluid systems
6. What are the elements of bill of quantity?
7. Write down the main five (5) elements of pneumatic system.
8. Show any four (4) functions of the simulation software, fluidsim.
9. Give any three (3) examples of simulation software
10. Illustrate any five (5) tools used to install pneumatic/hydraulic systems
11. Identify at least five (5) equipment used in installation of pneumatic/ hydraulic systems.
12. Write down five (5) actuation method of actuation methods
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

14. Give the difference between tools and material used in installation of pneumatic /hydraulic system
15. Outline The main six basic components required in a hydraulic system.
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**
……	1. 	A. Double acting cylinder
……	 2 .	B. ON-OFF manual shut off
……	3. 	C. Air filter with automatic drain
……	4. 	D. Fixed displacement, unidirectional pump

……	5. 	E. AND valve

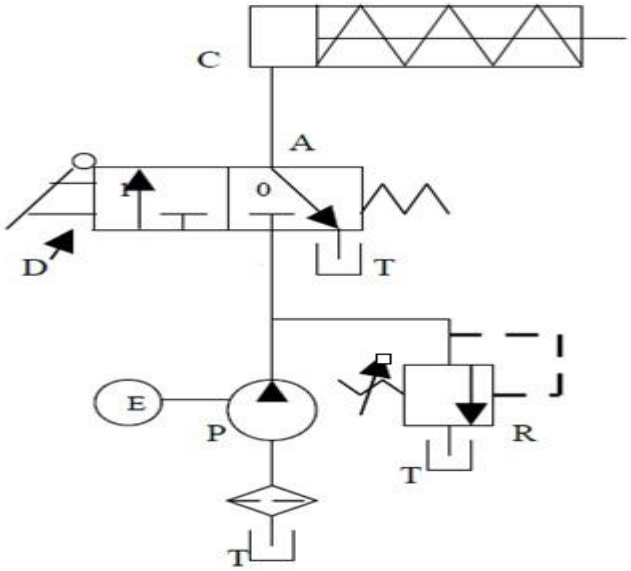
17.Use the table below to classify the following pneumatic and hydraulic tools, materials and equipment: Screw drivers, Plier, Spanners, cutting plier, Spirit level, Hand drilling machine, Filter, Accumulator, Oils, Lubricant, Compressor, Hydraulic Pump, Hydraulic motor.

Tools	Materials	Equipment

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
…….	1. Lubricant	A. mechanical devices which use the power of compressed gas or air to produce a force
……..	2. Accumulators	B. used as driving compressors with means of coupling.
……...	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.
……..	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.
……..	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
……..	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.



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 3/2of 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.

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.

Notes:

f) The system should be well protected
g) Task will be done in four (4) hours.
h) All resources are available.
i) Task is to be done individually.

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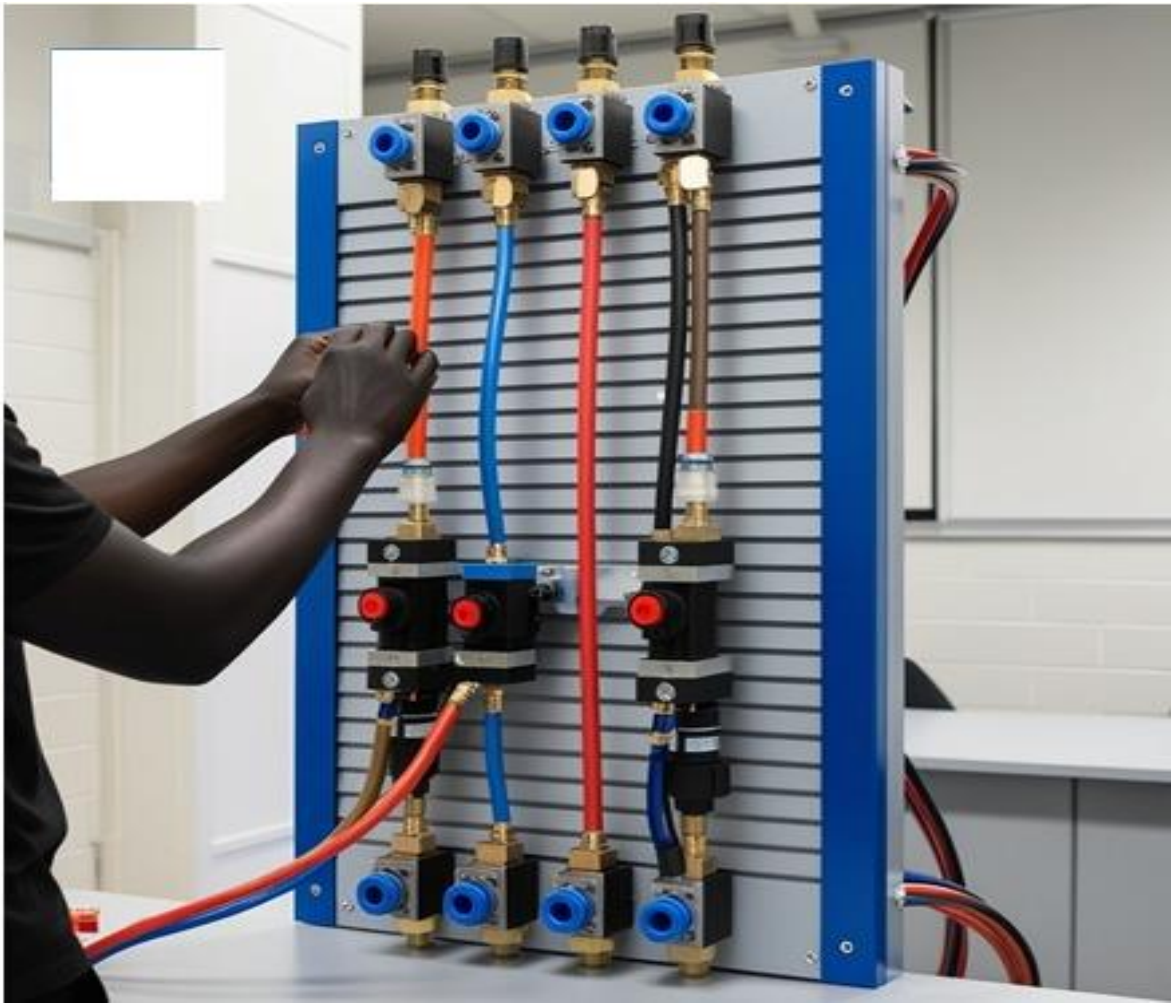


Indicative contents
2.1. Fixing pneumatic system components
2.2. Assembling pneumatic system components
2.3. Testing pneumatic system

Key Competencies for Learning Outcome 2 : Install pneumatic system

Knowledge	Skills	Attitudes
● Description of fixing technics to pneumatic system components ● Identification of control and power circuits of pneumatic system components. ● Description of joining technics to hose pipe of pneumatic system. ● Description of measuring/testing instruments and parameters used in pneumatic system	● Applying the fixing and joining technics to the components of pneumatic system. ● Fixing control circuit and power circuit components of pneumatic system ● Assembling pneumatic system components ● Connecting electrical components and pipes ● Testing control and power circuits of pneumatic system	● Being careful ● Being cooperative ● Being flexible ● Having self-confidence ● Being responsible ● Being communicator ● Being observant

Duration: 25 hrs

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. 8. Test accurately pneumatic system according to functionality and testing technics

Resources

Equipment	Tools	Materials
● Computer ● Multi-meter ● Tachometer ● Thermometer ● Manometer ● Head Protection ● Eye and Face Protection ● Hearing Protection ● Respiratory Protection ● Hand Protection	● Wires tripping plier ● Side cutter pliers ● Combination pliers ● long nose pliers ● Spirit level ● Tape measure ● Steel rulers ● Star screw driver ● Flat screw driver ● Hand drilling machine ● Electric screw driver	● Fuses ● Wires ● Nut ● Bolt ● cable clips ● Insulators ● Welding holder ● Grease ● Lubricants ● Scotches ● Markers ● pipes and hoses

● Foot Protection ● Body Protection ● Fall Protection ● Skin Protection ● First aid ● Compressor ● Valves ● Actuators	● Crimping tools ● Electrical hammer ● Claw hammer ● Ball pen hammer ● Mallet hammer ● Spring bender ● Hack saw ● Electrician knife ● Allen key ● Still Brushes ● Span ● Scissor ● Vanier caliper.	● pipe fittings ● Switch box ● Junction boxes ● Spring ● Female plugs ● Male Plugs ● Extension Cords ● Drill bits ● wall plugs ● Clips ● Pneumatic Hose pipe ● Charcoal ● pneumatic joints.

Indicative content 2.1: Fixing Pneumatic System Components

Duration: 10 hours

Theoretical Activity 2.1.1: Description of pneumatic system components fixation.

Tasks:

1: Answer the following question

i. what are the importance of pneumatic system components fixation?

2: Present your findings to the whole class.

3: Read the key reading 2.1.1 for more clarification.

Key readings 2.1.1: Description of pneumatic system components fixation.

1. Fixation of Pneumatic System Components

1.1. Overview:

Fixation in pneumatic systems involves securely attaching and aligning various components to ensure optimal performance and safety. Proper fixation is critical for preventing leaks, ensuring efficiency, and facilitating maintenance.

1.2. Importance of Proper Fixation:

- **Safety:** Prevents accidents due to accidental disconnections or failures.
- **Performance:** Ensures that the system operates at peak efficiency without pressure drops or leaks.
- **Maintenance:** Facilitates easy access for inspections and repairs, reducing downtime.

Practical Activity 2.1.2: Fixing of pneumatic system components.

Task:

1: Answer the following question:

i. 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.

2: Follow the instructions and the technics provided in key reading and perform the task.
3: Present your final product to whole class and trainer or parents.
4: You are directed to read the key readings 2.1.2 for more clarification.

Key readings 2.1.2: : Fixing of pneumatic system components

1. Fixing and Joining Techniques of Pneumatic System Components

When working with pneumatic systems, it's important to ensure that components are properly fixed and joined to create a reliable and efficient system. Here are some techniques and tips for fixing and joining pneumatic system components:

1.1. Threaded Connections:

- Use threaded connections for components such as valves, cylinders, and fittings.
- Apply thread sealant or Teflon tape on threaded connections to prevent air leaks.

1.2. Quick-Connect Fittings:

- Consider using quick-connect fittings for easy and rapid assembly and disassembly.
- Ensure that the quick-connect fittings are properly engaged to prevent air leaks.

1.3. Compression Fittings:

- Use compression fittings for tubing connections.
- Ensure that tubing is cut squarely to achieve a proper seal with the compression fitting.

1.4. Proper Tubing Selection:

- Choose the right type and size of tubing for your application (e.g., polyurethane, nylon).
- Ensure that tubing is free from kinks and sharp bends to avoid restrictions in airflow.

1.5. Proper Hose Clamping:

- If hoses are used, use appropriate clamps to secure them to fittings.
- Inspect hoses regularly for wear and damage and replace them as needed.

1.6. Flare Fittings:

- In certain applications, flare fittings may be used for metal tubing connections.
- Ensure that flared connections are properly tightened to prevent leaks.

1.7. Proper Torque:

- Use a torque wrench when tightening threaded connections to ensure the correct amount of force is applied.
- Over-tightening can damage components, while under-tightening can lead to air leaks.

1.8. Alignment of Components:

- Ensure that components are aligned properly before tightening connections.
- Misalignment can cause stress on components and lead to leaks.

1.9. Use of Locking Devices:

- In applications where vibration is a concern, consider using locking devices such as lock washers or thread-locking compounds.

1.10. Testing for Leaks:

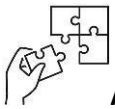
- After assembling the pneumatic system, conduct a thorough leak test.
- Use a soapy water solution to check for bubbles around connections, indicating air leaks.

1.11. Follow Manufacturer's Guidelines:

- Always refer to the manufacturer's guidelines and specifications for each component.
- Follow recommended torque values, installation procedures, and maintenance practices.

1.12. Training and Documentation:

- Ensure that personnel involved in the assembly and maintenance of pneumatic systems are properly trained.
- Maintain detailed documentation of the system layout, component specifications, and maintenance procedures.
- By following these techniques, you can help ensure the reliability and performance of your pneumatic system while minimizing the risk of leaks and malfunctions.



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.

Indicative content 2.2: Assembling Pneumatic System Components

Duration: 8 hours

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

Tasks:

1: Answer the following question:

i. what is a hose pipe?
ii. what are the factors which may be considered for choosing the hose pipe of pneumatic system?
iii. what are a variety of materials used to make a hose pipe with different properties and capabilities?
iv. What are the technics applied for joining pneumatic system hose pipe?

2: Present your findings from group discussion to the whole class.

3: Read the key reading 2.2.1 for more clarification.

Key readings 2.2.1.: Description of pneumatic system hose pipe joining technics.

1. Introduction to Hose Pipe Used in Pneumatic System.

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. Unlike rigid pipes, hoses offer flexibility, allowing for easy manoeuvrability and adaptability in various environments. They are typically cylindrical in shape, featuring a circular cross-section.

2. Factors to Consider When Choosing A Hose

2.1. 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.

2.2. Temperature and Pressure Ratings: Consider the temperature and pressure conditions the hose will be exposed to, ensuring the hose can withstand the intended range.

2.3. Size and Length: Determine the appropriate hose diameter and length based on

the specific requirements of your application.

2.4. End Connections: Ensure the hose is compatible with the necessary end connections, such as clamps, fittings, spigots, flanges, or nozzles.

2.5. Industry Standards and Regulations: Check if the hose complies with industry-specific standards and regulations to ensure safety and quality.

3. There are a variety of materials used to make a hose with different properties and capabilities.

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

4. Pneumatic System Hose Pipe Joining Technique

Joining pneumatic system hosepipes properly is crucial to ensure a leak-free and efficient pneumatic system. Here are common techniques for joining pneumatic system hosepipes:

4.1. Push-to-Connect Fittings:

- Use push-to-connect fittings for quick and easy hose connections without the need for special tools.
- Ensure that the hose end is cut cleanly and squarely.
- Push the hose into the fitting until it reaches the internal stop.

4.2. Barbed Fittings:

- Use barbed fittings for secure connections.
- Select the appropriate hose size and ensure a proper fit over the barbed end.
- Secure the connection with hose clamps or crimping for added stability.

4.3. Compression Fittings:

- Use compression fittings for metal tubing in pneumatic systems.
- Slide the compression nut and ferrule onto the hose, then insert the hose into the fitting.
- Tighten the compression nut to create a secure and leak-resistant connection.

4.4. Reusable Hose Fittings:

- Consider reusable hose fittings for applications where hoses need to be frequently replaced.
- Attach the fitting to the hose using a wrench, ensuring a tight connection.

4.5. Crimping:

- Use a crimping tool to permanently attach fittings to the hose.
- Ensure the hose is cut cleanly and insert it into the fitting.

- Crimp the fitting using the appropriate tool to create a secure, leak-resistant connection.

4.6. Threaded Connections:

- Use threaded connections for hose pipes in situations where frequent disassembly is not required.
- Apply thread sealant or Teflon tape to prevent air leaks.
- Tighten the connections using a wrench or appropriate tool.

4.7. Flared Fittings:

- Use flared fittings for metal tubing in applications that require a tight seal.
- Ensure the tubing end is flared correctly, and insert it into the flared fitting.
- Tighten the connection to create a secure seal.

4.8. Hose Clamps:

- Use hose clamps to secure hoses to barbed fittings or other connections.
- Ensure the hose is securely placed over the barb, and tighten the clamp with a screwdriver or wrench.

4.9. Swaging:

- Swaging involves compressing a collar onto the hose using a specialized tool.
- This technique is often used for high-pressure applications.

Tips for All Techniques:

- **Inspect Hoses:** Regularly inspect hoses for wear, damage, or deterioration, and replace them as needed.
- **Proper Cutting:** Cut hoses cleanly and squarely using a proper cutting tool to ensure a good fit with fittings.
- **Correct Hose Size:** Ensure that the hose size matches the specifications for the fittings and application.
- **Follow Manufacturer's Guidelines:** Adhere to the manufacturer's recommendations and guidelines for specific fittings and connections.
- **Leak Testing:** Perform a thorough leak test after assembling the pneumatic system to identify and address any potential leaks.

Always refer to the manufacturer's instructions and guidelines for the specific hose and fittings you are using in your pneumatic system. Following proper techniques and guidelines will help ensure the reliability and efficiency of the pneumatic system

Practical Activity 2.2.2: joining of pneumatic system hose pipe

Task:

1: Answer the following question:

i. Referring to key reading 2.2.1, you are asking to join a hose pipes pneumatic system.

2: Follow instructions and technics provided in that key reading and perform task

3: Present your findings to your colleagues or parents.

Theoretical Activity 2.2.3: Description of Electro-pneumatic system.

Tasks:

1: answer the following questions:

i. what do you think on electro-pneumatic system?

ii. List out electromechanical devices used in electropneumatic system.

2: Present your findings from group discussion to the whole class.

3: Read the key reading 2.2.3 for more clarification.

Key readings 2.2.3: Description of electro-pneumatic system

1. Introduction to Electro-Pneumatics

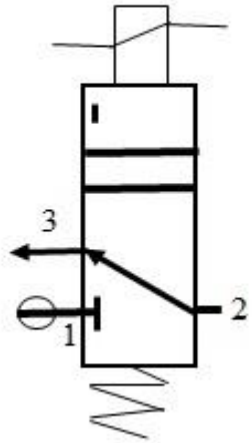
Pneumatic circuits can be controlled by electric circuits. The interface between these two circuits is a solenoid valve. Solenoid valves perform the same function as normal pneumatic valves but there are operated electrically.

Pneumatic control system with a solenoid operated valves may be called electro-pneumatic system.

Inside the solenoid valve, there is a coil of wire through which an electric current is passed. It produces a magnetic field which attracts an iron armature. The movement of the armature operates the valve.

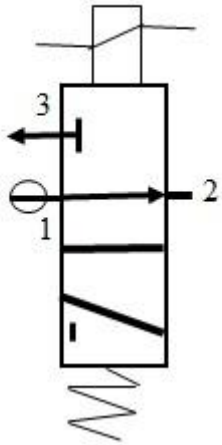
Solenoid Operation Off: When the electric current is not flowing, a spring pushes the iron armature out of the coil. A seal connected to the armature blocks port 1. Air can flow between ports 2 and 3.

Solenoid valve OFF



Solenoid Operation On: When current flows, the iron armature is attracted into the coil by a magnetic field. The spring pressure is overcome and the seal moves to block port 3. Air can flow between port 1 and 2.

Solenoid valve ON



When the solenoid valve is on, an electric current will flow through the coil. When current flows through the coil, the iron armature is attracted by magnetism. The solenoid has control of the valve. Port 1 is connected to port 2 and air flows to inflate the soft robot.

When the solenoid valve is off, the coil is de-energized and the spring has control of the valve. Port 2 is connected to port 3 and air flows out of the soft robot.

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

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

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

Task:

1: Answer the following question:

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

2: Follow the instructions and the technics provided in key reading and perform the task.

3: Present your final product to whole class and trainer or parents.

4: You are directed to read the key readings 2.2.4 for more clarification.

Key readings 2.2.4: Connecting of Electrical Components in Pneumatic System.

1. Connecting Electrical Components in Pneumatic Systems

Electrical components play a crucial role in controlling pneumatic systems. They are used to activate valves, solenoids, and other devices that regulate the flow of compressed air.

Here's a summary of the key steps involved in connecting electrical components:

1. Identify Components:

- Determine the specific electrical components required for your pneumatic system, such as solenoids, pressure switches, relays, and control panels.

2. Understand the System's Wiring Diagram:

- Refer to the system's wiring diagram to understand the interconnection of electrical components and their connection points.

3. Prepare the Wiring:

- Cut wires to the appropriate lengths and strip the insulation at the ends.

4. Connect Components:

- Securely connect the wires to the terminals of the respective components. Use appropriate connectors, such as crimp terminals or screw terminals.
- Ensure correct polarity when connecting components that require it (e.g., solenoids, motors).

5. Ground the System:

- Connect the ground wire of the system to a suitable grounding point to provide a safe electrical path.

6. Test the Connections:

- Use a multi-meter to verify that the connections are secure and that there are no short circuits or open circuits.

7. Power the System:

- Connect the power supply to the system and ensure it's compatible with the voltage requirements of the components.

Additional Considerations:

- **Safety:** Always follow safety guidelines and wear appropriate protective equipment when working with electrical components.
- **Compatibility:** Ensure that the electrical components you use are compatible with the pneumatic system's operating voltage and current.
- **Coding:** For complex systems, consider using wire coding or labeling to identify different circuits and components.
- **Maintenance:** Regularly inspect electrical connections for signs of wear or damage and tighten them as needed.
- By following these steps and considering the additional factors, you can ensure that the electrical components in your pneumatic system are connected correctly and operate reliably.

Theoretical Activity 2.2.5: Classification of Pipes used in Pneumatic

Tasks:

1: Answer the following question

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

2: Present your findings from group discussion to the whole class.

3: Read the key reading 2.2.5. for more clarification

Key readings 2.2.5: Classification of pipes used in pneumatic system.

1. Types of Pipes Used in Pneumatic Systems

Pneumatic systems rely on pipes to transport compressed air to various components and devices. Here are some common types of pipes used in pneumatic systems:

1.1. Metal Pipes:

- **Steel:** The most common type, offering excellent strength, durability, and resistance to high pressures. It can be used in a wide range of pneumatic applications.
- **Stainless steel:** Provides superior corrosion resistance, making it ideal for environments with moisture, chemicals, or aggressive substances.
- **Aluminum:** Lightweight and corrosion-resistant, often used in applications where weight reduction is critical. However, it may not be suitable for extremely high pressures.
- **Copper:** Offers good corrosion resistance and thermal conductivity. It's sometimes used in specific applications, but less commonly than steel or stainless steel.

1.2. Plastic Pipes:

- **Polyvinyl chloride (PVC):** A popular choice for low-pressure applications due to its low cost, ease of installation, and chemical resistance.
- **Polypropylene (PP):** Offers excellent chemical resistance and can withstand higher temperatures than PVC.
- **Nylon:** A flexible and lightweight option, often used for tubing and smaller-diameter lines.
- **Polyether ether ketone (PEEK):** A high-performance thermoplastic with excellent chemical resistance, heat resistance, and mechanical properties, suitable for demanding applications.

1.3. Rubber Tubing:

- **Natural rubber:** Flexible and durable, often used for connecting components or creating temporary lines.
- **Synthetic rubber:** Offers various properties, including oil resistance, heat resistance, and chemical resistance, depending on the specific type.

2. Factors to Consider When Choosing Pipes

The choice of pipe material and type depends on factors such as the operating pressure, temperature, corrosive environment, and specific application requirements.

- **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.

Practical Activity 2.2.6: Connecting pipes in pneumatic system.

Task:

1: Referring on key reading 2.2.5, connect the pipes of pneumatic direct control circuit of single acting cylinder.
2: Follow steps provided in that key reading and perform the given task
3: Present your findings to the whole class and trainer.
4: You are directed to read the key readings 2.2.6 for more clarification

Key readings 2.2.6. Connecting pipes in pneumatic system.

1.Connecting Pipes in a Pneumatic System:(A Step-by-Step Guide)

Connecting pipes in a pneumatic system is a crucial task that requires precision and attention to detail. Improper connections can lead to leaks, reduced efficiency, and even safety hazards. Here's a step-by-step guide to help you ensure a secure and reliable connection:

1.1. Safety First:

- **Wear protective gear:** Always wear safety glasses and gloves, especially when working with sharp tools or pressurized systems.
- **Disconnect power:** If your system is powered, ensure it's disconnected to prevent accidental activation.

1.2. Prepare the Pipes:

- **Cut pipes cleanly:** Use a pipe cutter or hacksaw to cut the pipes at the desired

length. Ensure the cut is clean and free of burrs to prevent leaks.

- **D**

  eburr the ends: Use a deburring tool to remove any sharp edges from the cut ends of the pipes.

1.3. Choose the Right Fittings:

- **C**

  onsider pipe size and material: Select fittings that match the size and type of your pipes.

- **D**

  etermine connection type: Choose fittings based on the desired connection method (e.g., threaded, push-to-connect, flared).

1.4. Assemble the Fittings:

- **F**

  ollow manufacturer's instructions: Refer to the specific instructions provided with your fittings for proper assembly.

- **U**

  se thread sealant (if applicable): Apply thread sealant to threaded fittings to ensure a tight seal and prevent leaks.

1.5. Connect the Pipes:

- **In**

  sert pipes into fittings: Carefully insert the prepared pipes into the fittings, ensuring they are fully seated.

- **Ti**

  ghten connections: Tighten any nuts or clamps securely, but avoid overtightening, as this can damage the fittings or pipes.

- **C**

  heck for leaks: Once the connections are made, check for any leaks by turning on the system and inspecting the joints for air escaping.

1.6. Test the System:

- **Pr**

  essure test: If applicable, perform a pressure test to ensure the system can handle the intended operating pressure without leaks.

- **F**

unctional test: Test the system's functionality to verify that the connections are holding and the air is flowing as expected.

Additional Tips:

- **U**
  se the right tools: Having the correct tools, such as wrenches, pliers, and pipe cutters, will make the process easier and more efficient.
- **Pl**
  an your layout: Before starting, plan the layout of your pneumatic system to ensure that the pipes and fittings are positioned correctly.
- **C**
  onsult a professional: If you're unsure about any aspect of connecting pipes in a pneumatic system, consult a qualified technician or engineer.

By following these steps and taking necessary precautions, you can safely and effectively connect pipes in your pneumatic system, ensuring its reliable and efficient operation.

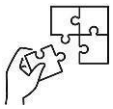
Points to Remember

- **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**.**
- **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.

- **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, Power the System.

- **Additional Considerations:** Safety, Compatibility, Coding, Maintenance.
- 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), 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.

Indicative content 2.3: Testing Pneumatic System

Duration: 7 hours

Theoretical Activity 2.3.1: Description of Testing pneumatic system.

Tasks:

1: Answer the following question:

i. what are the importance of testing pneumatic system?
ii. what are the common testing methods for pneumatic system?
iii. which tests are required for pneumatic system?

2: Present your findings from group discussion to the whole class.

3: Read the key reading 2.3.1 for more clarification

Key readings 2.3.1: Description of Testing pneumatic system

1.Introduction to testing Pneumatic system

Pneumatic circuits are systems that utilize compressed air to power mechanical devices. Testing these circuits is crucial 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.

Importance of Pneumatic Circuit Testing

- **Safety:** Testing helps identify potential hazards such as leaks, overpressure, or electrical faults that could pose safety risks.
- **Efficiency:** By ensuring the circuit is operating optimally, you can improve efficiency and reduce energy consumption.
- **Reliability:** Regular testing helps maintain the reliability of the pneumatic system, minimizing downtime and costly repairs.
- **Compliance:** Testing may be required to comply with industry standards, regulations, or customer specifications.

2. Common Testing Methods for pneumatic system

Various methods can be used to test pneumatic circuits. Some common approaches include:

- **Visual inspection:** Inspect components for damage, leaks, or misalignment.
- **Pressure testing:** Verify that the system can withstand the required operating pressure without leaks or failures.
- **Functional testing:** Operate the components to ensure they function as intended.

- **Leak detection:** Use soapy water or electronic leak detectors to identify leaks.
- **Noise and vibration analysis:** Assess noise and vibration levels to detect potential issues.
- **Temperature monitoring:** Measure temperatures to ensure components are operating within safe limits.
- **Performance testing:** Evaluate the system's output (e.g., force, speed, accuracy) to ensure it meets specifications.

3. Required Tests for Pneumatic System Components

- **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
- Pressure drop is defined as the difference in total pressure between two points of a fluid carrying network.
- A pressure drop occurs when frictional forces, caused by the resistance to flow, act on a fluid as it flows through the tube.
- **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.

4. Types of Measurements Instruments Used in Pneumatic System.

4.1. Pressure gauge: Pressure measurement is the analysis of an applied force by a fluid (liquid or gas) on a surface. Pressure is typically measured in units of force per unit of surface area.

Figure: Pressure gauge

4.2. Thermometers: Thermometer is one of the most common instruments used today to measure temperature.

Figure: Thermometer

4.3. flow meters: A flow meter is an instrument used to measure linear, nonlinear, mass or volumetric flow rate of a liquid or a gas.

Figure: hydraulic flow meter

4.4. Viscometer: Viscometers measure the viscosity and flow properties of fluids. Viscosity arises from the internal friction of a fluid and is defined as a liquid's resistance to flow or shear stress.

Figure: viscometer

4.5. **Manometer: is instrument used to** measures pressure, especially in low-pressure applications.

4.6. **Hygrometer:** is instrument used to measure the humidity level within the pneumatic system.

4.7. **Tachometer:** is an instrument used to measure the rotational speed of a shaft or disk in a machine. It provides information about the rate at which an object is rotating, typically expressed in revolutions per minute (RPM) or another unit of frequency.

Practical Activity 2.3.2: Testing pneumatic system components.

Task:

1. Referring to the key reading 2.3.1**,** you are asked to show a leakage pressure between the out-put pressure from air compressor indicated by barometer and the pressure indicated with pressure gouge connected to the pipe line between DCV Valve and actuator of the pneumatic circuit.
2. Follow the instructions and the technics provided in key reading and perform the task.
3. Present your final product to whole class and trainer or parents.
4. You are directed to read the key readings 2.3.2 for more clarification

Key readings 2.3.2 Testing of pneumatic system components

1.Steps for Pressure Testing

The preparation steps for pressure testing involve the following:

1.1. Examination of Design and Specifications

Thoroughly review the system or component's design and specifications to understand the intended operating conditions, maximum allowable pressure, and specific requirements for the pressure test.

1.2. Selection of Test Method

Determine the suitable pressure testing method based on the system or component's characteristics, choosing between hydrostatic testing or pneumatic testing, considering the nature of the fluid or gas to be handled.

1.3. Establishment of Test Boundaries

Clearly define the boundaries of the system or component to be tested, including entry and exit points, connections, valves, and any isolated sections requiring separate testing.

1.4. Verification of System Readiness

Ensure that the system is ready for testing by confirming the proper installation and unobstructed status of all components, equipment, and instruments.

1.5. Evaluation of Safety Measures

Assess and implement appropriate safety measures, including the utilization of personal protective equipment (PPE), safety barriers, and emergency response protocols, to ensure the protection of personnel and equipment during the testing process.

1.6. Preparation of Test Equipment

Ensure the calibration, functionality, and suitability of test equipment such as pressure

gauges, sensors, and control devices to meet the testing requirements.

1.7. Flushing and Cleaning

Thoroughly flush and clean the system to eliminate contaminants, debris, or foreign substances that may affect the accuracy of the pressure test or potentially damage the system.

1.8. Pre-Test Inspection

Conduct a visual inspection of the system or component to identify any visible defects, damages, or indications of leakage. Address and resolve any identified issues before proceeding with the pressure test.

1.9. Sealing and Isolation

Properly seal and isolate the test boundaries to prevent leaks or pressure loss during the test. Ensure the secure and tight connection of all joints, seals, and connections.

1.10. Communication with Personnel

Notify relevant personnel, including operators, supervisors, and technicians, regarding the impending pressure test, its schedule, and the necessary safety precautions they need to be aware of.

Theoretical Activity 2.3.3: Description of laws governing pneumatic system parameters

Tasks:

1: Answer the following question related to testing pneumatic system:

i. What are the laws governing pneumatic system parameters?

2: Present your findings from group discussion to the whole class.

3: Read the key reading 2.3.3 for more clarification.

Key readings 2.3.3: Description of laws governing pneumatic system parameters

1. Perfect gas laws

Early experiments were conducted concerning the behavior of air and similar gases. These experiments were conducted by scientists such as **Boyle**, **Charles** and **Gay-Lussac**. The results of their experiments indicated that gases behaviors

follow the law known as ideal gas laws.

1.1 Boyle's Law

Statement: 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.

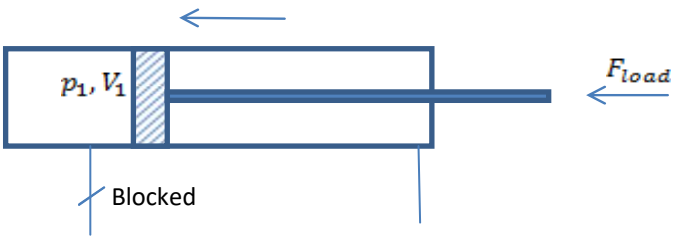
$Pressure\alpha \frac{1}{volume}$, when temperature = constant or PV=constant, for state 1 and 2, $P_1V_1 = P_2V_2$

Example 1: .50 mm diameter piston of the pneumatic cylinder of below retracts 130 mm

from its present position. (P_1=2bar(gauge) and V_1=300cm^3) due to the external load on the

rod. If the part at the blind end of the cylinder is blocked, find the new pressure, assuming temperature remains constant.

Retraction



Given Data:

D= diameter of piston = 50mm =5cm

Stroke= L = 130 mm =13 cm

P_1=2bar(gauge) and V_1=300cm^3

Solution

P1=2bar(gauge)+atmospheric pressure

P1= 3bar absolute.

Final volume=$V_1 = V_2 - (\frac{\pi}{4}D^2L)$

V_1=300-(0.7854*5^2*13) =45 cm^3

Since the temperature is constant, we can use Boyle's Law

Thus, P_1V_1=P_2V_2

3*300=P_2*45

P_2= 20 bar (abs) = **19 bar (gauge)**

Example 2: 4 m^3 of nitrogen are under a pressure of 7 bar (gauge) the nitrogen is allowed to expand to a volume of 6 cubic meter. What is the new gauge pressure?

Given Data:

P_1=7bar(gauge)= 8bar (abs), V_1=4m^3 and V_2= 6m^3

Solution

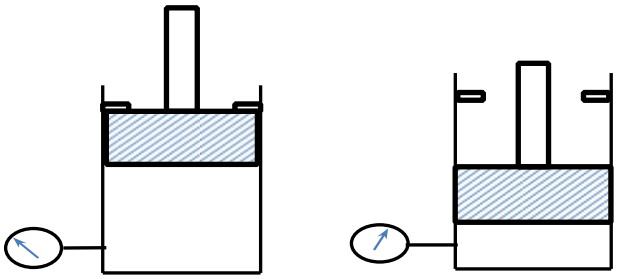
Since the temperature is constant, we can use Boyle's Law

P_1V_1=P_2V_2

8*4= P_2*6

Thus, P_2=5.333 bar (abs) = **4.333 bar(gauge**)

Example 3: Piston compresses air at atmospheric pressure to 1/7th the volume as illustrated in the Figure below Assuming constant temperature, what is the gauge pressure of the resulting air?



Solution

$P_1 V_1 = P_2 V_2$, $P_2 = P_1 V_1/V_2$, Note that $V_2 /V_2 = 1/7$

P_2 = 1 x 7/1 =7bar absolute.

P_2=6 bar (gauge).

1.2. Charles law

Boyle's law assumes conditions of constant temperature. In actual situations this is rarely the case. Temperature changes continually and affects the volume of a given mass of gas.

Statement: 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 α Temperature, when pressure = constant or $\frac{V}{T} = Constant$, for state 1 and 2, $V_1/T_1=V_2T_2$

Example 1: 0.8m3 air at temperature T1 = 303K (300C) are heated to T2 = 345K (720C). How much does the air expand?

Solution

$V_2 = V_1/T_1 (T_2 –T_2)$

$V_2 = 0.8m^3 + 0.8/303(345 -303)\ m^3$

$V_2= 0.8m^3 + 0.11m^3 = 0.91m^3$

The air has expanded by $0.11m^3$ to $0.91m^3$.

Example 2: 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.

Given Data:

P_2=125 Bar (gauge)

T_1= 70°F =70+460 =530 K,

T_2= 139°F = 130 +460 = 590 K

Solution

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

$P_1/T_1=P_2/T_2$, 126/590 =$\mathbf{P_2}$/530

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

1.3 Gay-Lussac's Law

A third gas law may be derived as a corollary to Boyle's and Charles's laws. Suppose we double the thermodynamic temperature of a sample of gas. According to Charles's law, the volume should double. Now, how much pressure would be required at the higher temperature to return the gas to its original volume? According to Boyle's law, we would have to double the pressure to halve the volume. Thus, if the volume of gas is to remain the same, doubling the temperature will require doubling the pressure.

Statement: At constant pressure, the absolute pressure of an ideal gas will vary directly with the absolute temperature.

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

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

Example 1: The cylinder of Figure (same as above figure no) has a locked (V_1=constant). P_1=2bar (gauge) and T_1=25℃. If the temperature increases to 70℃,What is the new pressure in the blank end.

Given Data:

P_1=2bar (gauge), V_1=constant, T_1= 25℃,T_2=70℃

Solution

Since the volume is constant, by applying Gay–Lussac's law, we get,

P_1=2bar (gauge0 = 2+1 + 3 bar (abs)

T_1= 25+273= 298K

T_2= 70+273= 343K,

$\frac{P}{T}$ = constant or $P_1/T_1=P_2/T_2$

3/298= $\mathbf{P_2}$/343

Solving we get**,** $\mathbf{P_2}$= 3.45 bar (Absolute) = 2.24 bar (gauge).

Example 2: If the cylinder has a locked position (V_1 = constant), P_1 = 20psig and T_1 = 60^0F. If the temperature increases to 160^0F, what is the new pressure in the blank end?

SOLUTION:

P_1 (Absolute pressure in psi abs) = gage pressure (psig) + 14.7 =20+14.7=34.7psia

T_1(Absolute temperature in ^{0}R) = temperature (^{0}F) +460 = 60+460=520^0R

T_1 = 160 + 460 = 620^0R

So, $\frac{P1}{P2} = \frac{T1}{T2}$ or $\frac{34.7}{P2} = \frac{520}{620}$

P_2 = (620 x 34.7)/ 520 = 41.4 psi(abs) = 26.7 psi (gauge).

Example 3. A compressed air receiver has a volume of 0.5 m^3 is filled with compressed air at 7 bar (gauge) and at a temperature of 40℃. The temperature then cools to 20℃. What is the final pressure?

Given data

V_1=V_2=0.25 m^3

P_1= 7bar (gauge)= 7+1= 8 bar (abs)

T_1= 20℃ = 20+273 =293 K

T_2=40℃ = 40+273= 313K

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

$$\frac{P1}{P2} = \frac{T1}{T2}$$

8/293=**P_2**/313

Solving we get,

Thus, **P_2**=7.5 bar (abs) = 6**.5 bar (gauge).**

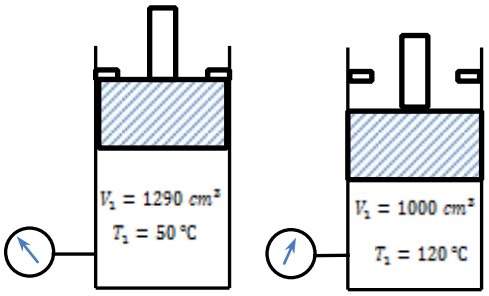
4. GENERAL GAS LAW

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,

$$\frac{P1V1}{T1} = \frac{P2V2}{T2}$$

Example 1: Gas at 80 bar (gauge) and 50 ℃ is contained in the 1290 cm^3 cylinder of Figure below. A piston compresses the volume to 1000cm^3 while the gas is heated to 120℃.

what is the final pressure of the cylinder.



Given Data:

P_1= 80 bar (gauge)

V_1=1290 cm^3

V_2= 1000 cm^3

T_1=50 ℃

T_2= 120℃

Solution

Since the volume is constant

P_1= 80 bar (gauge) = 81 bar (abs)

T_1=50 ℃ =50+273=323k

T_2= 120℃ = 120+273= 393 k

Using General gas law

$$\frac{P1V1}{T1} = \frac{P2V2}{T2}$$

81*1290/323=P_2*1000/393

Solving we get, P_2= 127.13 bar (abs) = 126.17 bar (gauge).

Example 2: Gas at 70 bars gage pressure and 37.8^{0}C is contained in the 12900cm^3 cylinder. A piston compresses the volume to 9680cm^3 while the gas is heated to 93.3^{0}C. What is the final pressure in the cylinder?

SOLUTION:

$P_2 = \frac{P1V1T2}{V2T1}$ = (70x10^5 +1x10^5) (12900) (93.3+273)/ (9680) (37.8+273) = 111.5x10^5 Pa (absolute)

=111.5 bars (absolute).

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.
- **Perfect gas laws:**

1. Boyle's low 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.

$Pressure\alpha \frac{1}{volume}$, when temperature = constant or PV=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 α Temperature, when pressure = constant or $\frac{V}{T} = Constant$, for state 1 and 2, $V_1/T_1=V_2T_2$

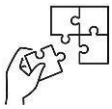
***3*. Gay-Lussac's law state that,** at constant pressure, the absolute pressure of an ideal gas will vary directly with the absolute temperature.

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

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

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,

$$\frac{P1V1}{T1} = \frac{P2V2}{T2}$$



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.

Learning outcome 2 end assessment

Written assessment

1. Define the following term:

a) Hose pipe

b) temperature

c) pressure

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

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

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

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

a) Thermometer

b) Flow meter

c) Viscometer

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

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.

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

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

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

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

4. Distinguish the flowmeter to the viscometer.

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.

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

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

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

9.List out electromechanical devices used in electropneumatic system.

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

11. State and explain the perfect gas laws

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

13. A compressed air receiver has a volume of 0.5 m^3 is filled with compressed air at 7 bar (gauge) and at a temperature of 40$^{\circ}C$. The temperature then cools to 20$^{\circ}C$. What is the final pressure?

14. Gas at 70 bars gage pressure and 37.8^{0}C is contained in the 12900cm^3 cylinder. A piston compresses the volume to 9680cm^3 while the gas is heated to 93.3^{0}C. What is the final pressure in the cylinder?

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.

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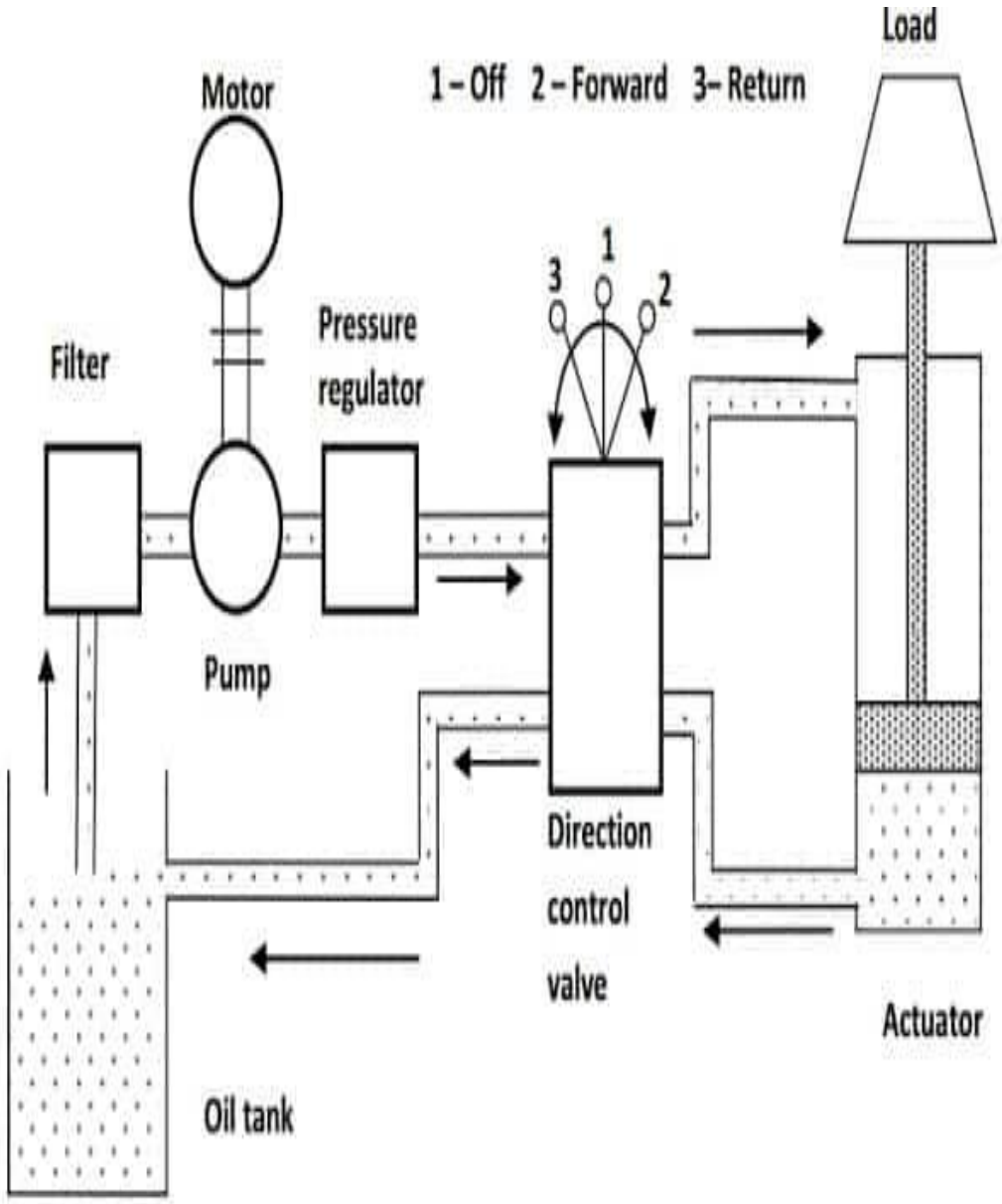


Components of a hydraulic system

Indicative contents
3.1 Fixing hydraulic system components **3.2 Assembling hydraulic system components** **3.3 Testing of hydraulic system**

Key Competencies for Learning Outcome 3: Install hydraulic system

Knowledge	Skills	Attitudes
● Identification of fixing technics of hydraulic components ● Identification of hosepipe joining techniques ● Description of electrical and hydraulic tests ● Description of measuring/testing instruments used in hydraulic system ● Identification of hydraulic system parameters	● Fixing hydraulic control and power components ● Connecting electrical components and pipes ● Testing control and power circuits	● Being careful while fixing and assembling hydraulic components ● Being accurate while testing hydraulic circuits ● Being cooperative while assembling hydraulic components ● Having self confidence ● Being responsible

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

Equipment	Tools	Materials
● Computer ● Multi-meter ● Tachometer ● Thermometer ● Flow meter ● Viscometer ● Manometer ● Head Protection ● Eye and Face Protection ● Hearing Protection ● Respiratory	● Wire stripping plier ● Side cutter plier ● Combination plier ● Long nose plier ● Spirit level ● Tape measure ● Steel rulers ● Star screw driver ● Flat screw driver ● Hand drilling machine ● Electric screw driver ● Crimping tools	● Fuses ● Wires ● Nuts and Bolts ● Cable clips ● Insulators ● Welding holder ● Grease ● Oil ● Pipes ● Hoses ● Couplings ● Lubricants

Protection ● Hand Protection ● Foot Protection ● Body Protection ● Fall Protection ● Skin Protection ● First aid ● Pump ● Valves ● Actuators ● Miscellaneous	● Electrical hammer ● Claw hammer ● Ball pen hammer ● Mallet hammer ● Spring bender ● Hack saw ● Electrician knife ● Allen key ● Still Brushes ● Scissor ● Vanier calliper	● Scotches ● Markers ● Pipes and hoses ● Pipe fittings ● Switch box ● Junction boxes ● Push buttons ● Spring ● Female plugs ● Male Plugs ● Extension Cords ● Drill bits ● Wall plugs ● Clips ● Charcoal

Indicative content 3.1: Fixing Hydraulic System Components

Duration: 5 hours

Theoretical Activity 3.1.1: Identification of fixing technics of hydraulic

Tasks:

1: You are requested to answer the following questions:

i. Define the term hydraulic circuit.
ii. Enumerate the essential components of hydraulic system.
iii. Explain fixing technics of hydraulic system components.

2: Present your findings to the class and trainer.

3: You are directed to read key reading 3.1.1 for more clarification on technics of fixing hydraulic system components fixing.

Key readings 3.1.1.: Identification of fixing technics of hydraulic

1.Hydraulic Circuits

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.

1. Essential components of hydraulic system

- ✓ **Hydraulic power pack:** It consists of pump, drive motor, mechanical couplings, oil reservoir, strainers, coolers, etc.
- ✓ **Hydraulic control elements:** They include various types of directional control valves, pressure control valves, flow control valves, electrical control valves, etc.
- ✓ **Power drive units (Or Actuators):** They are hydraulic cylinders and hydraulic motors.
- ✓ **System accessories:** They include pipes and fluid conductors, accumulators, pressure boosters, pressure and temperature gauges. Filters, etc.

2. Technics used to fix/attach hydraulic system components

Fixing /attaching hydraulic system components securely is crucial for the safe and reliable operation of the system. Here are some common techniques used:

1. Clamps and brackets:

- **Clamps:** Used to secure components in place, especially tubing and hoses. They come in various sizes and styles, including U-clamps, saddle clamps, and hose

clamps.

- **Brackets:** Provide support for components and help maintain proper alignment. Brackets can be made of metal, plastic, or other materials.

Clamps

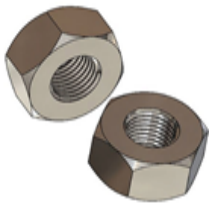
Brackets

2. Bolting and screwing:

- **Bolts and screws:** Used to fasten components together or to a support structure. Choose the appropriate size and type of fasteners based on the component's weight and the material being attached.
- **Washers:** Used to distribute the load and prevent leaks.

Bolts

Nuts



Bolts and nuts

3. Welding:

- **Welding:** In some cases, components may be welded together for a permanent and secure connection. This is often used for large or heavy components.

4. Glue and adhesives:

- **Adhesives:** Can be used to bond components together, especially for smaller or lighter parts. Choose an adhesive that is suitable for the materials being bonded.

5. Crimping:

- **Crimping tools:** Used to secure fittings to tubing or wires. Crimping tools apply pressure to deform the metal and create a secure connection.


6. Thread Locking Compounds:

- **Locking compounds:** Applied to threaded connections to prevent loosening due to vibration or other factors.

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

Tasks:

1: Answer the following question:

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

2: Present your findings to the class and trainer.

3: You are directed to read key reading 3.1.2 for more details.

Key readings 3.1.2.: Identification of electrical components used in hydraulic system control circuits

1.Basic Electrical components used in hydraulic system control circuits

1. Manually actuated push button switches
2. Limit switches
3. Pressure switches
4. Solenoids
5. Relays
6. Timers
7. Temperature switches

1.1 Push button switches

A push button is a switch used to close or open an electric control circuit. They are primarily used for starting and stopping of operation of machinery. They also provide manual override when the emergency arises. Push button switches are actuated by pushing the actuator into the housing. This causes set of contacts to open or close.

Push buttons are of two types

i. Momentary push button

ii. Maintained contact or detent push button

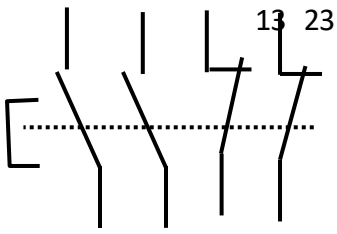
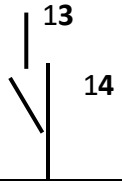
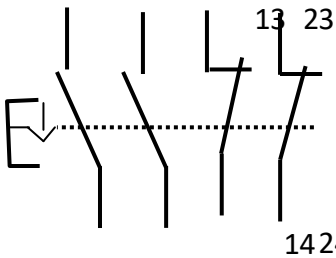
Momentary push buttons return to their unactuated position when they are released. Maintained (or mechanically latched) push buttons has a latching mechanism to hold it in the selected position.

The contact of the push buttons, distinguished according to their functions,

i. Normally open (NO) type
ii. Normally closed (NC) type
iii. Change over (CO) type.

Type of devices	***Terminal Numbers***	
	Normally closed contacts	**Normally open contacts**
Push buttons and Relays	1 and 2	3 and 4
Timers and Counters	5 and 6	7 and 8

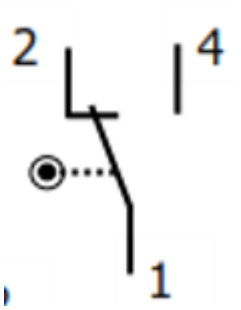
1.1.1 Designation of the pushbuttons

Type of contact	**Designation**
Momentary contact type PB station (2 NO +2 NC) 	First digit indicates the function of contact. Second digit represents a serial ordering. 3 and 4 represents **NO** contacts and 1 is the serial no. 
Maintained Contact type PB station (2NO+2 NC) 	First digit indicates the function of contact. Second digit represents a serial ordering. 3 and 4 represents **NO** contacts and 1 is the serial no. 

1.2 Limit switches

Any 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). The actuation of a limit switch provides an electrical signal that causes an appropriate system response.

Symbol:



Limit switches perform the same function as push button switches. Push buttons are manually actuated whereas limit switches are mechanically actuated.

Pressure switches

A pressure switch is a pneumatic-electric signal converter. Pressure switches are used to sense a change in pressure, and opens or closes an electrical switch when a predetermined pressure is reached. Bellow or diaphragm is used to sense the change of pressure.

1.4 Solenoids

Electrically actuated directional control valves form the interface between the two parts of an electro- pneumatic control. The most important tasks of electrically

actuated DCVs include.

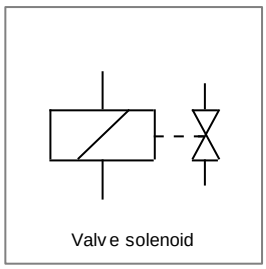
i. Switching supply air on or off
ii. Extension and retraction of cylinder drives

Electrically actuated directional control valves are switched with the aid of solenoids. They can be divided into two groups:

i. Spring return valves only remain in the actuated position as long as current flows through the solenoid
ii. Double solenoid valves retain the last switched position even when no current flows through the solenoid.

In the initial position, all solenoids of an electrically actuated DCVs are de-energised and the solenoids are inactive. A double valve has no clear initial position, as it does not have a return spring. The possible voltage levels for solenoids are 12 V DC, 12V AC, 12 V 50/60 Hz, 24V 50/60 Hz, 110/120V 50/60 Hz, 220/230V 50/60 Hz.

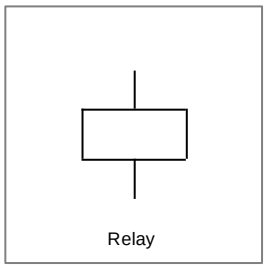
Solenoid coil symbol:



1.5 Relays

A relay is an electro magnetically actuated switch. It is a simple electrical device used for signal processing. Relays are designed to withstand heavy power surges and harsh environment conditions. When a voltage is applied to the solenoid coil, an electromagnet field results.

Relay coil symbol:



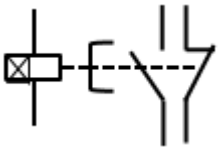
1.6 Timer Or Time delay relays

Timers are required in control systems to effect time delay between work operations. This is possible by delaying the operation of the associated control element through a timer. Most of the timers we use is Electronic timers. There are two types of time relay

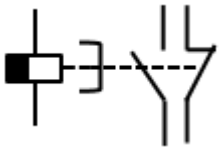
i) Pull in delay (on –delay timer)

ii) Drop –out delay (off delay timer)

On delay timer symbol:



Off delay timer symbol:



1.7 Temperature Switch

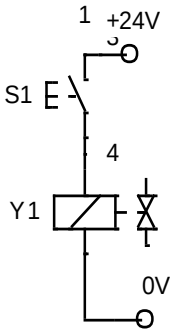
Temperature switches automatically senses a change in temperature and opens or closes an electrical switch when a predetermined temperature is reached. This switch can be wired either normally open or normally closed.

Practical Activity 3.1.3: Fixing hydraulic control components

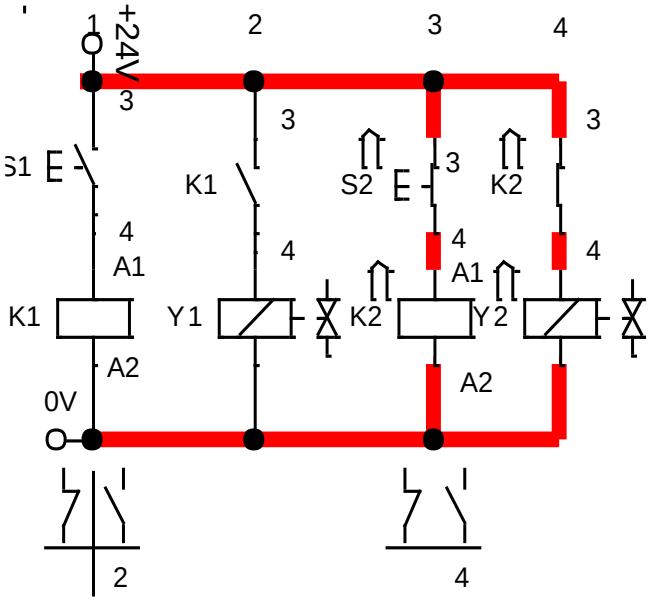
Task:

1: Referring to the theoretical activity 3.1.1 and key reading 3.1.3 ,you are requested to fix the components of the following hydraulic circuits.

a)



b)



2: Follow the instructions and steps provided in the key reading and perform the task.

3: Present your final product to your classmate or parent.

4: You are Invited to read more key readings 3.1.3 to learn more about steps of fixing hydraulic system control components

Key readings 3.1.3: Fixing hydraulic control components

Steps for fixing/attaching Hydraulic System Components

Attaching hydraulic system components requires precision, care, and a thorough understanding of the system's design and operation. Here are the general steps involved:

1. Prepare the Components:

- **Clean the components:** Remove any dirt, debris, or foreign particles from the components to be attached.
- **Inspect for damage:** Ensure that the components are in good condition and free from defects.

2. Select the appropriate attachment method:

- **Consider factors:** Evaluate the weight, size, and location of the components to determine the most suitable attachment method.
- **Choose clamps, brackets, bolts, screws, welding, or adhesives based on the specific requirements.**

3. Position the components:

- **Align components:** Ensure that the components are properly aligned and positioned according to the system's design.
- **Use alignment tools:** Use jigs, fixtures, or other alignment aids to ensure accurate positioning.

4. Secure the components:

- **Fasten components:** Use the chosen attachment method to securely fasten the components in place.
- **Tighten bolts and screws to the specified torque:** Refer to the manufacturer's instructions for torque values.
- **Apply adhesives or sealants:** If using adhesives or sealants, follow the manufacturer's instructions for application and curing time.

5. Check for alignment and security:

- **Inspect the installation:** Verify that the components are securely attached and properly aligned.
- **Check for any gaps or misalignment.**

6. Test for Leaks:

- **Apply pressure:** Pressurize the hydraulic system and check for any leaks around the attachment points.
- **Use leak detection fluid:** If necessary, apply leak detection fluid to identify leaks.

7. Document the Installation:

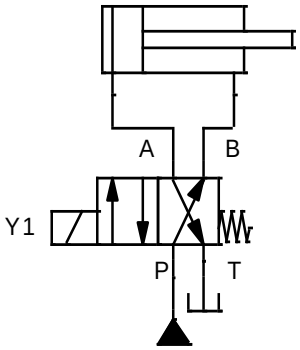
- **Record the installation:** Document the attachment method, torque values, and any other relevant information.

Practical Activity 3.1.4: Fixing hydraulic power components

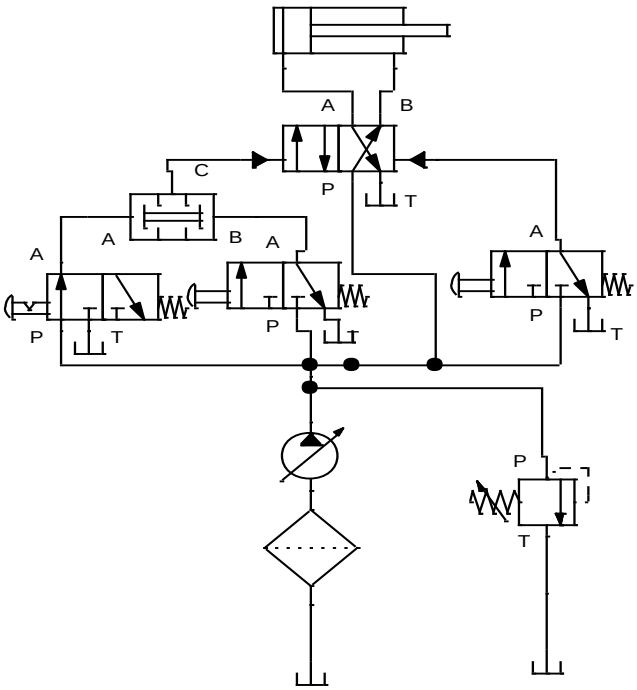
Task:

1: Referring to the theoretical activity 3.1.1 and key reading 3.1.4, you are requested to fix the power components of the following hydraulic circuits.

a)



b)



2: Follow the instructions and steps provided in the key reading and perform the task.

3: Present your final product to your classmate or parent.

Key readings 3.1.4: Fixing hydraulic power components

Steps for fixing/attaching Hydraulic System Components

Attaching hydraulic system components requires precision, care, and a thorough understanding of the system's design and operation. Here are the general steps involved:

1. Prepare the components:

- **Clean the components:** Remove any dirt, debris, or foreign particles from the components to be attached.
- **Inspect for damage:** Ensure that the components are in good condition and free from defects.

2. Select the appropriate attachment method:

- **Consider factors:** Evaluate the weight, size, and location of the components to determine the most suitable attachment method.
- **Choose clamps, brackets, bolts, screws, welding, or adhesives based on the specific requirements.**

3. Position the components:

- **Align components:** Ensure that the components are properly aligned and positioned according to the system's design.
- **Use alignment tools:** Use jigs, fixtures, or other alignment aids to ensure accurate positioning.

4. Secure the components:

- **Fasten components:** Use the chosen attachment method to securely fasten the components in place.
- **Tighten bolts and screws to the specified torque:** Refer to the manufacturer's instructions for torque values.
- **Apply adhesives or sealants:** If using adhesives or sealants, follow the manufacturer's instructions for application and curing time.

5. Check for alignment and security:

- **Inspect the installation:** Verify that the components are securely attached and properly aligned.
- **Check for any gaps or misalignment.**

6. Test for leaks:

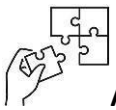
- **Apply pressure:** Pressurize the hydraulic system and check for any leaks around the attachment points.
- **Use leak detection fluid:** If necessary, apply leak detection fluid to identify leaks.

7. Document the installation:

- **Record the installation:** Document the attachment method, torque values, and any other relevant information.

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
- Basic electrical components used in hydraulic systems control circuits are manually actuated push button switches, limit switches, pressure switches, solenoids, relays, timers, temperature switches.
- Steps for fixing/attaching hydraulic system control components are preparing 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.
- Steps for fixing/attaching hydraulic system power components are preparing 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.

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 fix the components of control and power circuits.

Note: The hydraulic system should well protected.

Indicative content 3.2: Assembling Hydraulic System Components

Duration: 10 hours

Theoretical Activity 3.2.1: Identification of hosepipe joining techniques

Tasks:

1: You are requested to answer the following question:

i. What are the techniques that can be used to join hosepipes?

2: Present your findings to the class and trainer.

3: You are directed to read key reading 3.2.1 for more clarification on technics hosepipe joining techniques.

Key readings 3.2.1.: Identification of hosepipe joining techniques

1.Hosepipe joining techniques

Joining techniques for hydraulic system components are crucial to ensure the proper functioning and reliability of the system. Here are some common techniques used in the assembly and maintenance of hydraulic systems:

1. **Threaded Connections:**
   - Hydraulic components often feature threaded connections for ease of assembly and disassembly.
   - Ensure proper thread engagement and use thread sealants or Teflon tape to prevent leaks.
2. **Flared Joints:**
   - Flaring is commonly used for joining metal tubing in hydraulic systems.
   - The tube end is flared, and a nut is used to compress it against a mating fitting.
3. **Welding:**
   - Welding is suitable for permanently joining metal components.
   - Ensure that welding does not compromise the structural integrity or the material properties of the components.
4. **Brazing:**
   - Similar to welding but at lower temperatures, brazing can be used to join components made of different metals.
   - It provides a strong and leak-proof joint.
5. **Flange Connections:**
   - Flange connections are used in high-pressure hydraulic systems.
   - Bolts are used to secure two flanges together, and a gasket ensures a leak-free

seal.

6. **Quick Disconnects:**
   - Quick disconnect fittings allow for rapid connection and disconnection of hydraulic components.
   - Ensure proper matching of the male and female connectors to prevent fluid leakage.
7. **Compression Fittings:**
   - Compression fittings are commonly used with plastic tubing.
   - A compression nut compresses a ferrule onto the tubing, creating a seal.
8. **Hydraulic Hose Assemblies:**
   - Proper assembly of hydraulic hoses is crucial.
   - Use the correct fittings, ensure proper hose length, and follow manufacturer specifications for crimping or swaging.
9. **Inspection and Testing:**
   - After assembly, conduct thorough inspections and pressure tests to ensure the integrity of the hydraulic system.
   - Check for leaks, and address any issues promptly.

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

Tasks:

1: You are requested to answer the following questions:

i. Outline the types of pipe used in hydraulic system installation.
ii. What are the types of pipe fitting used in hydraulic system installation.
iii. Mention the raw materials which are used to manufacture pipe fittings.
iv. Enumerate the applications of pipe fittings.
v. Outline the factors to consider while selecting pipe fittings.

2: Present your findings to the class and trainer.

3: You are directed to read key reading 3.2.2 for more clarification on types pipelines and pipe fittings used in hydraulic system installation.

Key readings 3.2.2.: Identification of types of pipelines and pipe fittings used in hydraulic system installation

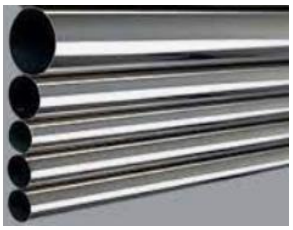
1.Types of pipes

There are many different types of pipes used in a variety of applications. Some of the most common types of pipes include:

1.1 Metal pipes

- **Copper pipes:** Copper pipes are durable, corrosion-resistant, and can be used for both hot and cold water. They are a popular choice for plumbing applications, but they can be more expensive than other types of pipes.

- **Stainless steel pipes:** Stainless steel pipes are highly resistant to corrosion and rust. They are a good choice for applications where durability and hygiene are important, such as food processing and medical facilities. Stainless steel pipes are more expensive than other types of pipes, but they have a long lifespan.



1.2 Plastic pipes

- **PVC pipes**: PVC pipes are lightweight, durable, and corrosion-resistant. They are a popular choice for plumbing, drainage, and irrigation applications. PVC pipes are relatively inexpensive and easy to install.

- **PEX pipes:** PEX pipes are made from cross-linked polyethylene. They are flexible, durable, and resistant to corrosion and freezing. PEX pipes are a good choice for plumbing applications, especially in cold climates. PEX pipes can be more expensive than PVC pipes, but they are easier to install.

- **ABS pipes:** ABS pipes are made from acrylonitrile butadiene styrene. They are strong, durable, and resistant to corrosion and chemicals. ABS pipes are a good choice for drainage and sewer applications. ABS pipes are similar in price to PVC pipes.

1.3 Other types of pipes

- **Cast iron pipes:** Cast iron pipes are heavy-duty and durable. They can withstand high pressures and temperatures. Cast iron pipes are often used for drainage and sewer applications. Cast iron pipes are more expensive than other types of pipes, and they can be difficult to install.

- **Concrete pipes:** Concrete pipes are strong and durable. They are often used for drainage and sewer applications, as well as for water mains and culverts. Concrete pipes are relatively inexpensive, but they can be difficult to install.

- **Clay pipes:** Clay pipes are made from baked clay. They are resistant to corrosion and chemicals. Clay pipes are often used for drainage and sewer applications, as well as for irrigation systems. Clay pipes are relatively inexpensive, but they can be fragile and difficult to install.

1.4 Types of lines used in fluid power systems

1. Tubing (semi-rigid)

2. Pipe (Rigid)
3. Hose (flexible)

2.Pipe Fittings

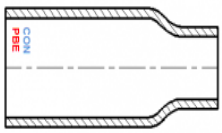
Pipe fittings are used to connect and join pipes together. They come in a variety of types, each with its own specific function. Some of the most common types of pipe fittings include:

- **Couplings:** Couplings are used to connect two pipes of the same size together.

- **Elbows:** Elbows are used to change the angle or direction of the pipe run. The most common elbows come in 90 degree and 45 degree turns. Elbows are used to change the direction of a pipe run.

- **Tees**: Tees are used to connect three pipes together.

- **Reducers:** Reducers are used to connect two pipes of different sizes together.



- **Bushings:** Bushings are used to connect a pipe to a fitting of a different size.

- **Caps:** Caps are used to close off the end of a pipe.

- **Unions:** Unions are used to create a disconnectable joint in a pipe run. Unions are used to join pieces of pipe where pipes cannot be turned or when a piece of equipment may have to be removed for maintenance or replacement.

- A nipple fitting is a short piece of pipe with male threads on both ends. It is used to connect two other fittings together, or to extend a pipe run. Nipple fittings are available in a variety of materials, including brass, steel, stainless steel, and plastic.

- **Adaptor fittings:** Adaptor fittings are used to change the end of a non-threaded pipe to male or female threads as needed. Adaptors are commonly used in copper and plastic plumbing jobs.

- Flare fittings are a type of compression fitting used with metallic tubing, such as soft steel, copper, and aluminum. They are a popular choice for high-pressure and high-temperature applications, as they can provide a leak-proof seal.

- **Wyes:** Pronounced like the letter “Y” and used primarily to gain inside access to DWV(drain waste vent) systems.

3.Pipe fittings materials

Pipe fittings can be made from a variety of materials, including:

- **Brass:** Brass fittings are strong and durable, and they are resistant to corrosion.(Brass is a metal alloy of copper and zinc containing trace amounts of lead, iron, and other elements)
- **Copper:** Copper fittings are also strong and durable, and they are easy to solder.
- **PVC:** PVC fittings are lightweight and inexpensive, and they are resistant to corrosion.
- **Galvanized steel:** Galvanized steel fittings are strong and durable, but they are susceptible to corrosion. (***Galvanized steel*** is standard steel that is coated in zinc to provide enhanced corrosion resistance)
- **Cast iron:** Cast iron fittings are strong and durable, but they are also heavy and expensive.

4.Applicationns of pipes fittings

Pipe fittings are used in a variety of applications, including:

- **Plumbing**: Pipe fittings are used to connect and join pipes in plumbing systems.
- **HVAC**: Pipe fittings are used to connect and join pipes in heating, ventilation, and air conditioning systems.
- **Irrigation**: Pipe fittings are used to connect and join pipes in irrigation systems.
- **Industrial**: Pipe fittings are used to connect and join pipes in industrial applications, such as manufacturing and power generation.

5.Factors to consider while choosing pipe fittings

When choosing pipe fittings, it is important to consider the following factors:

- The type of pipe material being used.
- The size of the pipe.
- The pressure and temperature of the system.
- The specific application for the pipe fitting.

It is also important to choose pipe fittings that are made of high-quality materials and that are rated for the pressure and temperature of the system.

Here are some tips for installing pipe fittings:

- Make sure that the pipes are clean and free of debris before installing the fittings.
- Apply a sealant to the threads of the fitting before installing it.

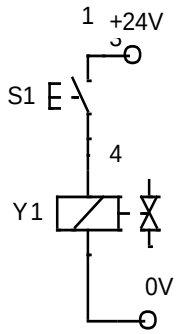
- Tighten the fitting until it is comfortable, but do not overtighten it.
- Test the system for leaks after installing the fittings.

Practical Activity 3.2.3: Connecting electrical components of hydraulic system

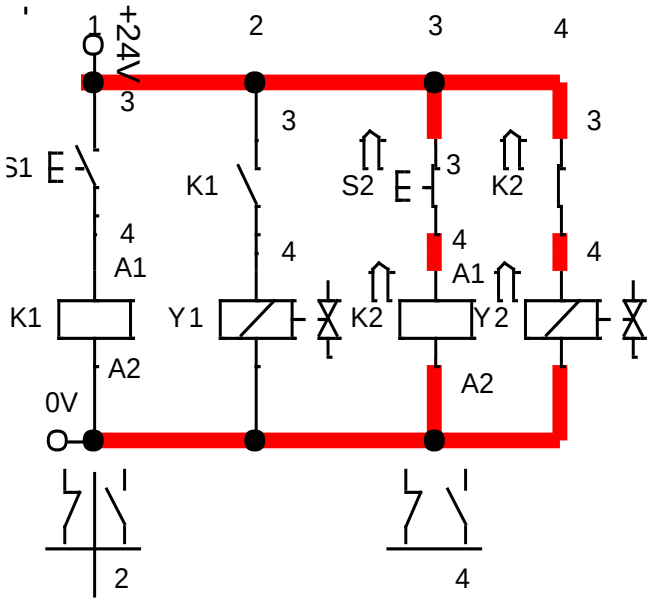
Task:

1: Referring to the theoretical activity 3.2.1 and key reading 3.2.3, you are requested to connect electrical components of the following hydraulic control circuits fixed in practical activity 3.1.3.

a)



b)



2: Follow the instructions and steps provided in the key reading and perform the task.

3: Present your final product to your classmate or parent.

4: You are oriented to read key readings 3.2.3 for more clarifications about steps of connecting electrical components.

Key readings 3.2.3: Connecting electrical components of hydraulic system

1.Steps for connecting electrical components in hydraulic control circuits

Connecting electrical components in hydraulic control circuits requires precision and careful attention to detail. Here are the general steps involved:

1. Design and planning:

- **Develop a circuit diagram:** Create a detailed diagram outlining the components, connections, and control logic.
- **Select appropriate components:** Choose the right electrical components based on the system's requirements, including voltage, current, and functionality.
- **Consider safety regulations:** Ensure compliance with relevant electrical safety standards.

2. Prepare the components:

- **Label components:** Clearly label each component for identification and troubleshooting.
- **Organize components:** Arrange the components in a logical and accessible manner.
- **Check for damage:** Inspect components for any physical damage or defects.
- **Wiring:**
- **Strip wires:** Remove the insulation from the ends of the wires to expose the conductors.
- **Connect wires to terminals:** Securely connect the wires to the appropriate terminals on the electrical components.
- **Follow wiring diagrams:** Refer to the circuit diagram for correct wiring connections.
- **Use appropriate wire gauges:** Select the correct wire gauge based on the current requirements.

4. Grounding:

- **Connect to ground:** Ensure that the system is properly grounded to provide a safe path for electrical current in case of a fault.
- **Follow grounding regulations:** Adhere to local grounding standards and practices.

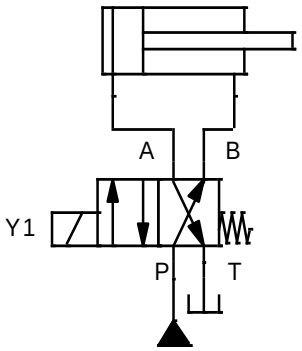
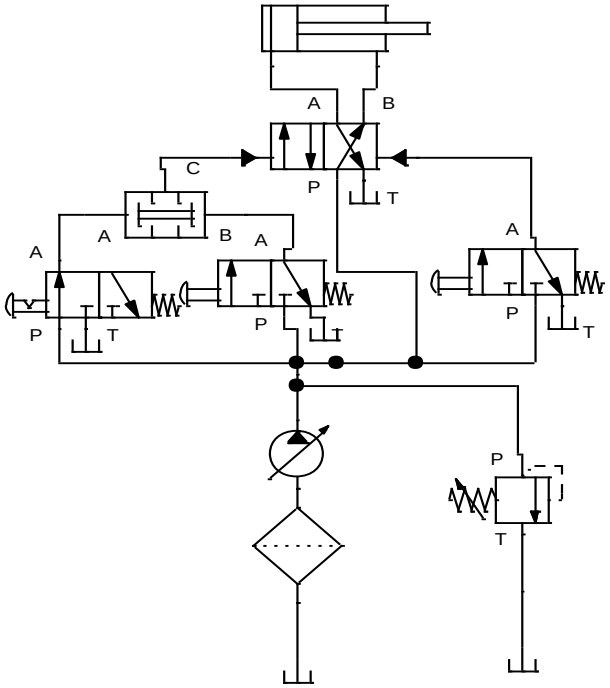
5. Testing and commissioning:

- **Test circuits:** Use a multimeter or other testing equipment to verify the electrical connections and functionality.
- **Check for short circuits or open circuits.**
- **Commission the system:** Once the electrical components are connected and tested, commission the entire hydraulic control system to ensure proper operation.

Practical Activity 3.2.4: Connecting pipes of hydraulic system

Task:

1: Referring to the theoretical activity 3.2.1 and key reading 3.2.4, you are requested to connect pipes of the following hydraulic power circuits fixed in practical activity 3.1.4.

a)		b)	

2: Follow the instructions and steps provided in the key reading and perform the task.

3: Present your final product to your classmate or parent.

Key readings 3.2.4: Connecting pipes of hydraulic system

1.Steps for Connecting Pipes in Hydraulic Circuits

Connecting pipes in a hydraulic circuit is a critical step in ensuring the proper flow and distribution of hydraulic fluid. Here are the general steps involved:

1. Prepare the Tubing:

- **Cut tubing to length:** Use a tubing cutter to accurately cut the tubing to the required length.
- **Deburr the ends:** Remove any burrs or sharp edges from the cut ends of the tubing.

- **Clean the tubing:** Ensure the tubing is clean and free of debris or contaminants.

2. Prepare the Fittings:

- **Clean the fittings:** Remove any dirt or debris from the fittings.
- **Apply sealant or lubricant:** If necessary, apply a sealant or lubricant to the threads of the fittings to prevent leaks.

3. Assemble the Components:

- **Position the components:** Place the tubing and fittings in the desired positions.
- **Connect the fittings:** Screw the fittings onto the tubing, ensuring a tight and secure connection. Use the appropriate wrenches or tools to tighten the fittings to the specified torque.
- **Check for alignment:** Ensure that the tubing and fittings are properly aligned to prevent kinks or bends.

4. Test for Leaks:

- **Pressurize the system:** Gradually increase the pressure in the hydraulic system.
- **Inspect for leaks:** Carefully check all connections and joints for signs of leaks.
- **Use leak detection fluid:** If necessary, apply leak detection fluid to help identify leaks.

5. Secure the Tubing:

- **Use clamps or brackets:** If needed, use clamps or brackets to secure the tubing in place and prevent it from moving or rubbing against other components.

6. Bleed the System:

- **Remove air:** If necessary, bleed the system to remove any air pockets that may be trapped in the tubing or components. This can be done by opening bleed valves or using a bleeding tool.

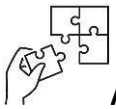
7. Test the System:

- **Verify proper operation:** Once the system is assembled and bled, test it to ensure that the hydraulic fluid is flowing properly and that the components are functioning as intended.

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.

- 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 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.
- Steps for connecting electrical components in hydraulic control circuits are design
- and planning, prepare the components, wiring, grounding, testing and commissioning.
- 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.
- 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 juices from different fruits. For servicing well customers, the company wants to extend its grinding machines, and an hydraulic system that can be used in production should be installed.

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 well protected.

Indicative content 3.3: Testing of Hydraulic System

Duration: 5 hours

Theoretical Activity 3.3.1: Identification of testing instruments used in

Tasks:

1: You are requested to answer the following questions:

i. Define term hydraulic testing instrument.

ii. Outline different types of testing instruments used in hydraulic system and explain the function of each instrument.

2: Present your findings to the whole class.

3: You are directed to read key reading 3.3.1 for more clarification on types pipelines and pipe fittings used in hydraulic system installation.

Key readings 3.3.1: Identification of testing instruments used in hydraulic

1.Definition of hydraulic testing instruments

Hydraulic testing instruments are specialized tools used to measure various parameters and assess the performance of hydraulic systems. They play a crucial role in ensuring the safety, efficiency, and reliability of hydraulic equipment.

2.Types of hydraulic testing instruments

Hydraulic systems require various instruments to assess their performance, identify potential issues, and ensure safe and efficient operation. Here are some common instruments used for hydraulic testing:

1. Pressure gauges:

- Used to measure the pressure of hydraulic fluid within the system.
- Types include analog and digital gauges.

2. Flow meters:

- Used to measure the flow rate of hydraulic fluid.
- Can be mechanical or electronic.

3. Leak detectors:

- Used to identify and locate leaks in hydraulic systems.
- Can be ultrasonic, dye-based, or electronic.

4. Temperature sensors:

- Used to measure the temperature of hydraulic fluid, which is important for monitoring system performance and preventing overheating.

5. Contamination testers:

- Used to detect and measure contaminants in hydraulic fluid, such as dirt, water, and wear particles.

6. Vibration sensors:

- Used to measure vibration levels in the hydraulic system, which can indicate problems such as misalignment or bearing wear.

7. Noise meters:

- Used to measure noise levels generated by the hydraulic system, which can be an indicator of operational issues.

8. Particle counters:

- Used to measure the concentration of particles in hydraulic fluid, which can affect system performance and cleanliness.

9. Oscilloscopes:

- Used to analyze electrical signals related to hydraulic system components, such as valves and pumps.

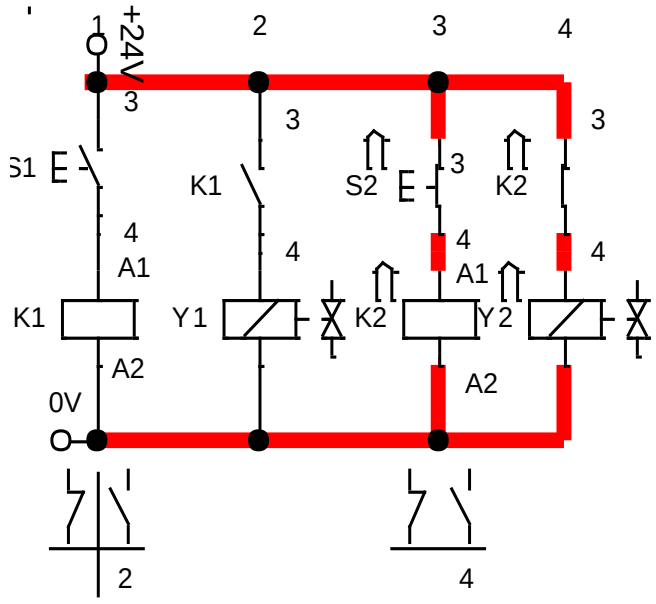
10. Hydraulic test benches:

- Specialized equipment used to test hydraulic components and systems under controlled condition

Practical Activity 3.3.2: Testing hydraulic control circuits

Task:

1: Referring to the theoretical activity 3.3.1 and key reading 3.3.2 ,you are requested to test the hydraulic control circuit below connected in practical activity 3.2.3.



2: Follow the instructions and steps provided in the key reading and perform the task.
3: Present your final product to your classmate or parent.
4: You are Invited to read more key readings 3.3.2 to learn more about steps for testing the control circuit of a hydraulic circuit.

Key readings 3.3.2: Testing hydraulic control circuits

1.Steps for testing the control circuit of a hydraulic circuit

Testing the control circuit of a hydraulic system is essential to ensure its proper operation and prevent malfunctions. Here are the general steps involved:

1.1. Prepare the system:

- **Isolate the system:** Ensure the system is isolated from power sources and pressurized fluid to prevent accidents.
- **Check for any obvious damage:** Inspect the control circuit for any visible damage to wires, connectors, or components.

1.2. Verify power supply:

- **Check for voltage:** Ensure that the control circuit is receiving the correct voltage from the power supply.
- **Use a multimeter to measure voltage.**

1.3. Test input signals:

- **Simulate inputs:** If possible, simulate the input signals to the control circuit to verify its response.
- **Use test equipment or software to generate simulated inputs.**

1.4. Monitor outputs:

- **Observe outputs:** Monitor the outputs of the control circuit, such as solenoid valves or indicator lights, to ensure they are responding correctly.
- **Use measuring instruments to verify output values.**

1.5. Check for short circuits or open circuits:

- **Use a multimeter:** Conduct continuity tests to check for short circuits or open circuits in the wiring.
- **Look for signs of overheating or burning.**

1.6. Test control logic:

- **Verify functionality:** Ensure that the control logic is functioning as intended.
- **Simulate different input conditions and observe the corresponding outputs.**

1.7. Check for Interference:

- **Identify potential interference:** Look for sources of electrical noise or interference that could affect the control circuit's operation.
- **Take measures to reduce interference:** If necessary, shield cables or relocate components to minimize interference.

1.8. Load testing:

- **Apply load:** If applicable, apply a load to the hydraulic system to test the control circuit's response under operating conditions.
- **Monitor performance:** Observe the system's performance and ensure that it meets the desired specifications.

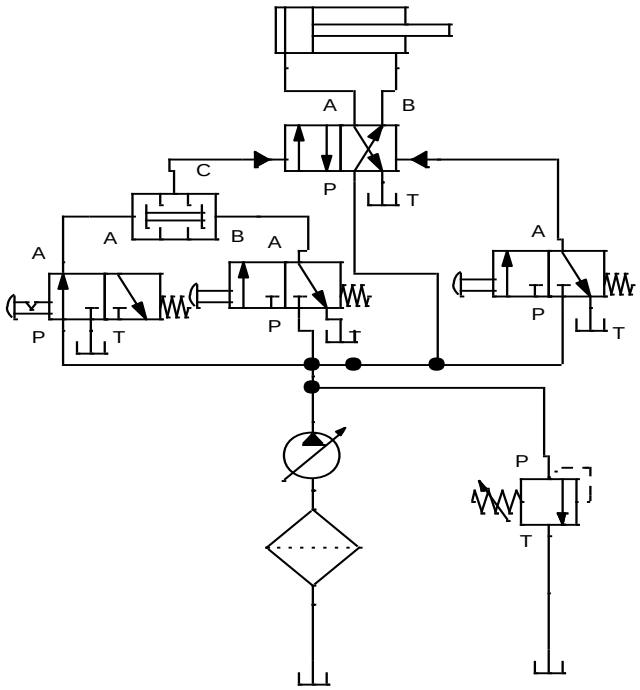
1.9. Documentation:

- **Record test results:** Document the test results, including any issues or problems identified.
- **Update maintenance records:** Update the system's maintenance records to reflect the testing and any necessary repairs or adjustments.

Practical Activity 3.3.3: Testing hydraulic power circuits

Task:

1: **Task**: Referring to the theoretical activity 3.3.1 and key reading 3.3.3, you are requested to test the hydraulic power circuit below connected in practical activity 3.2.4.



2: Follow the instructions and steps provided in the key reading and perform the task.

3: Present your final product to your classmate or parent.

Key readings 3.3.3: Testing hydraulic power circuits

1.Steps for testing the power circuit of a hydraulic circuit

Testing a hydraulic power circuit is essential to ensure its proper functioning and identify any potential problems. Here are the general steps involved:

1. Prepare the System:

- **Isolate the system:** Ensure the system is isolated from other hydraulic systems or equipment to prevent interference.
- **Check fluid levels:** Verify that the hydraulic fluid level is at the correct level.
- **Inspect for leaks:** Inspect the system for any visible leaks.

2. Start the System:

- **Activate the power source:** Turn on the power supply to the hydraulic system.
- **Start the pump:** Start the hydraulic pump to circulate the fluid.

3. Check for Leaks:

- **Inspect for leaks:** Carefully inspect the system for any leaks around joints, fittings, and hoses.
- **Use leak detection fluid:** Apply leak detection fluid to areas where leaks may be suspected.

4. Test Component Functionality:

- **Operate valves:** Test the operation of various valves, such as directional valves, pressure relief valves, and flow control valves.
- **Activate cylinders and motors:** Test the functionality of hydraulic cylinders and motors to ensure they are operating as expected.

5. Measure Pressure and Flow:

- **Use pressure gauges:** Measure the pressure at various points in the system to verify that it meets the specified requirements.
- **Use flow meters:** Measure the flow rate of hydraulic fluid to ensure it is within the desired range.

6. Check for Overheating:

- **Monitor temperature:** Monitor the temperature of the hydraulic fluid and components to ensure it does not exceed safe operating limits.

7. Verify Control System Operation:

- **Test controls:** Verify that the control system is functioning properly and that it can accurately control the hydraulic system.

8. Load Testing:

- **Apply loads:** If applicable, apply loads to the system to test its performance under operating conditions.

9. Record Test Results:

- **Document findings:** Record the test results, including pressure readings, flow rates, temperatures, and any issues encountered.

Theoretical Activity 3.3.4: Identification of hydraulic system parameters

Tasks:

1: You are requested to answer the following questions:

i. Define hydraulic system parameters.
ii. Outline different types of hydraulic system parameters and explain each parameter.

2: Present your findings to the whole class.

3: You are directed to read key reading 3.3.4 for more clarification on hydraulic system parameters**.**

Key readings 3.3.4: Identification of hydraulic system parameters

1.Definition of hydraulic system parameters

Hydraulic system parameters are the measurable characteristics that define the performance and behavior of a hydraulic system. They provide valuable information for understanding, monitoring, and troubleshooting the system.

2. Key hydraulic system parameters

Hydraulic systems operate based on various parameters that determine their performance and efficiency. Here are some of the most important parameters:

2.1. Pressure:

- **Operating Pressure:** The typical working pressure of the system, measured in pascals (Pa), pounds per square inch (psi), or bars.
- **Maximum Pressure:** The highest pressure the system can safely withstand.
- **Minimum Pressure:** The lowest pressure required for proper system operation.

2.2. Flow Rate:

- **Flow Rate:** The volume of hydraulic fluid flowing through the system per unit time, measured in liters per minute (L/min) or gallons per minute (gpm).
- **Maximum Flow Rate:** The highest flow rate the system can achieve.
- **Minimum Flow Rate:** The lowest flow rate required for proper system operation.

2.3. Power:

- **Hydraulic Power:** The rate at which hydraulic energy is transmitted, calculated as the product of pressure and flow rate.

2.4. Temperature:

- **Operating Temperature:** The recommended temperature range for the hydraulic fluid.
- **Maximum Temperature:** The highest temperature the hydraulic fluid can safely withstand.

2.5. Viscosity:

- **Hydraulic Fluid Viscosity:** The resistance of the hydraulic fluid to flow. It affects the system's efficiency and the power required to operate it.

2.6. Contamination:

- **Hydraulic Fluid Contamination:** The presence of foreign particles or substances in the hydraulic fluid, which can reduce system performance and lead to premature wear.

2.7. Noise:

- **Noise Level:** The amount of noise generated by the hydraulic system, measured in decibels (dB).

2.8. Efficiency:

- **System Efficiency:** The ratio of the output power to the input power, indicating how effectively the system converts hydraulic energy into mechanical work.

2.9. Reliability:

- **Mean Time Between Failures (MTBF):** A measure of the reliability of the system, indicating the average time between failures.

2.10. Safety:

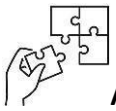
- **Safety Features:** The system's safety features, such as pressure relief valves, emergency stops, and leak detection systems.

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.
- Steps for testing the control circuit of a hydraulic circuit are: prepare 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.
- Steps for testing the power circuit of a hydraulic circuit are preparing the system, start the system, start the system, check for leaks, test component functionality,

check for overheating, verify control system operation, load testing and record test results.

- Hydraulic system parameters are the measurable characteristics that define the performance and behaviour 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.

Learning outcome 3 end assessment

Written assessment

1.Define the following term:

a) Hydraulic circuit

b) Hydraulic control elements

c) Clamps

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

3. Enumerate four essential components of hydraulic system**.**

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

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

6. Safety features in hydraulic systems include:

a. Pressure relief valves

b. Emergency stops

c. Leak detection systems

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

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

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.
b) Flow rate is measured in units of liters per second (L/s).
c) Hydraulic power is calculated by multiplying pressure and flow rate.

10. Differentiate push button and limit switch**.**

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

12. Distinguish the flowmeter to the viscometer.

13. What are factors considered while selecting pipe line?

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

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

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

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

Parameter	Definition	Units
Pressure	…….	Pascals (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	

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

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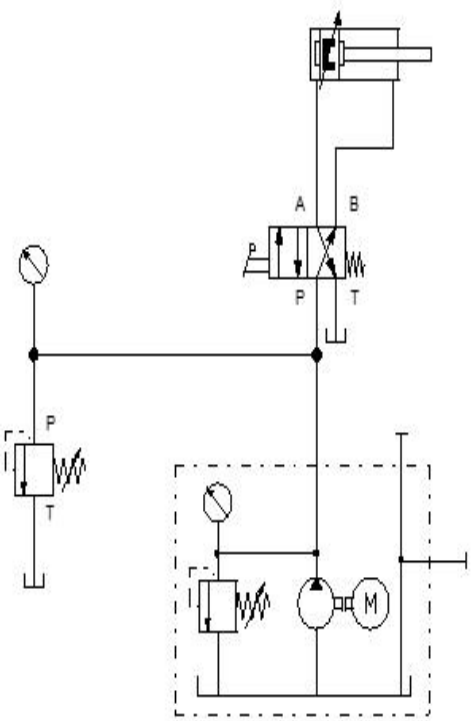
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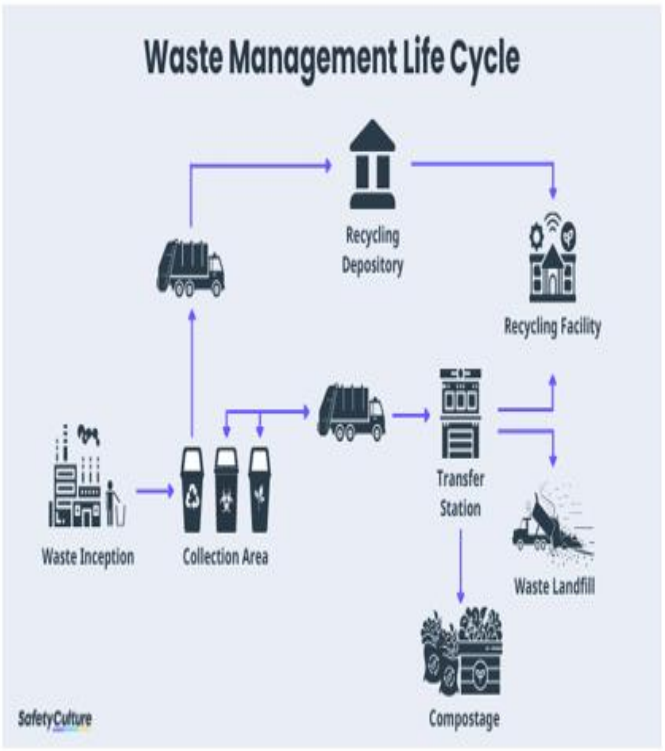

Waste Management Life Cycle
Recycling Depository
Recycling Facility
Transfer Station
Waste Landfill
Waste Inception
Collection Area
Compostage
SafetyCulture

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
● Description of as-built diagram ● Identification of waste material ● Identification of pneumatic and hydraulic system installation report	● Recording data ● Drawing as-built diagram ● Managing waste material ● Reporting installation report	● Being careful ● Having precision while drawing as-built diagram ● Being accurate while recording data ● Having self-confidence while Reporting installation report

Duration: 15hours

Learning outcome 2 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 correctly 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

Equipment	Tools	Materials
● Computer ● Multi-meter ● Tachometer ● Thermometer ● Manometer ● Head Protection ● Eye and Face Protection ● Hearing Protection ● Respiratory Protection ● Hand Protection ● Foot Protection ● Body Protection ● Fall Protection ● Skin Protection ● First aid ● Compressor ● Valves ● Actuators	● Wire stripping plier ● Side cutter plier ● Combination plier ● long nose plier ● Spirit level ● Tape measure ● Steel rulers ● Star screw driver ● Flat screw driver ● Hand drilling machine ● Electric screw driver ● Crimping tools ● Spring bender ● Hack saw ● Still Brushes ● Vanier caliper	● Fuses ● Wires ● Nut ● Bolt ● cable clips ● Insulators ● Welding holder ● Grease ● Lubricants ● Scotches ● Markers ● pipes and hoses ● pipe fittings ● Switch box

Indicative content 4.1: Developing as-Built Diagram

Duration: 5 hours

Theoretical Activity 4.1.1: Description of as-built diagram

Tasks:

1: You are invited to answer the following question related to As-built drawing

i. Define as-built diagram?

ii. Identify the step for developing as-built diagram

2: Present your findings to the whole class and trainer

3: You are directed to read the key readings 4.1.1. for more clarification on basic concept of As-built diagram.

Key readings 4.1.1.: Description of as-built diagram

1. Definition

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. It captures all the modifications, changes, and deviations from the original construction plans that occurred during the building process.

2. Step of creating as-built drawing

The procedures for creating as-built drawings typically involve the following steps:

1. Gather Documentation

- **Original Plans:** Obtain the original design drawings and specifications.
- **Construction Drawings:** Collect any revisions or changes made during construction.
- **Survey Data:** Get the latest survey data if available, including site measurements and conditions.

2. Conduct Site Inspection

- **On-Site Verification:** Visit the site to verify the actual built conditions.
- **Measure & Document:** Measure key dimensions and note any discrepancies from the original design.
- **Photograph:** Take detailed photographs of the construction and any areas with significant deviations.

3. Update Drawings

- **Software:** Use CAD (Computer-Aided Design) or BIM (Building Information

Modeling) software to update the drawings.

- **Layering:** Create separate layers for as-built changes to clearly distinguish them from the original design.
- **Accuracy:** Ensure all measurements and details are accurately reflected in the updated drawings.

4. Incorporate Changes

- **Mark Changes:** Clearly mark deviations and modifications from the original plans on the updated diagram.
- **Details:** Include details of changes such as altered dimensions, new elements, and relocated components.

5. Review and Verify

- **Cross-Check:** Review the as-built diagram against site measurements and photographs to ensure accuracy.
- **Stakeholder Review:** Have the updated diagram reviewed by relevant stakeholders, such as architects, engineers, and contractors, to confirm accuracy.

6. Finalize and Document

- **Finalize Drawings:** Make any necessary revisions based on stakeholder feedback and finalize the as-built diagram.
- **Documentation:** Prepare a report or accompanying documentation that explains the changes and provides context for the as-built diagram.

7. Distribute and Archive

- **Distribution:** Share the finalized as-built diagrams with all relevant parties, including project managers, facility managers, and regulatory bodies.
- **Archiving:** Store the diagrams in a secure and accessible location, both digitally and physically, for future reference and maintenance purposes.

8. Maintain Updates

- **Future Changes:** Update the as-built diagrams if further modifications are made to the structure or project.
- **Regular Reviews:** Periodically review and update the diagrams as necessary to reflect any new changes or conditions.

Practical Activity 4.1.2: Drawing as build diagram

Task:

1: Referring to key readings 4.1.2, you are requested to draw:

i. As-built drawing of pneumatic and hydraulic system installation

2: Follow instruction and procedures provided in that key readings and perform the given task

3: Present your final product to your parent/guardians.

Key readings 4.1.2: Drawing as build diagram

1. Step of creating as-built drawing

Creating an as-built drawing involves several steps to accurately represent the final constructed state of a building or project. Here's a step-by-step guide to help you through the process:

1.1. Gather Documentation and Information:

- Collect all relevant documents, including design drawings, specifications, and any changes or modifications that occurred during construction.
- Obtain field notes, photographs, and any other documentation that reflects the actual construction**.**

1.2. Perform a Site Survey:

- Conduct a thorough site visit to measure and document the current conditions of the construction.
- Use tools like laser distance meters, measuring tapes, or total stations to ensure accurate measurements**.**

1.3. Review and Record Changes:

Compare the original design drawings with the actual construction to identify any deviations, additions, or modifications.

Document these changes clearly, noting their locations and specifics.

1.4. Update the Drawings:

Using software (like AutoCAD, Revit, or similar), begin updating the original design drawings to reflect the as-built conditions.

Ensure that all changes and modifications are accurately incorporated into the drawings**.**

1.5. Add Annotations and Details:

Include annotations, labels, and notes that explain any deviations or special conditions.

Add details for components that might not have been fully captured in the original drawings.

1.6. Verify Accuracy:

Double-check measurements and information to ensure that the as-built drawings are accurate and reflect the true state of the construction.

It might be helpful to have a second set of eyes review the drawings for verification

1.7. Format and Finalize the Drawings

Prepare the final version of the drawings, ensuring that they are clear, legible, and professionally presented.

Include a title block with relevant information, such as project name, date, scale, and the names of those who prepared and reviewed the drawings.

1.8. Review and Approval:

Submit the as-built drawings for review and approval by the relevant stakeholders, such as project managers, architects, or engineers.

Make any necessary revisions based on feedback.

1.9. Distribute and Archive:

Distribute the approved as-built drawings to all relevant parties, including the client, maintenance teams, and regulatory bodies if required.

Archive a copy for future reference and for compliance with any legal or contractual obligations.

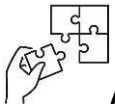
1.10. Maintain and Update:

Keep the as-built drawings updated with any future modifications or maintenance work to ensure they remain accurate.

Following these steps will help ensure that your as-built drawings accurately reflect the completed project and provide valuable information for future maintenance and renovations.

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 a technician, you are required to create a table that shows all needs to make correct as-built diagram.

Indicative content 4.2: Describing Waste Materials

Duration: 5 hours

Theoretical Activity 4.2.1: Description of waste materials

Tasks:

1: You are invited to answer the following question related to waste material

i. Define waste material?
ii. Explain the group of waste material
iii. Identify the step of waste material management

2: Present your findings to the whole class and trainer

3: You are directed to read the key readings 4.2.1. for more clarification on basic concept of waste material.

Key readings 4.2.1.: Description of waste materials

1. Define waste material

In pneumatic and hydraulic systems, waste material typically refers to unwanted fluids, such as oil, water, or compressed air, that result from leaks, system maintenance, or inefficiencies. This waste can contaminate the working fluid, reduce system efficiency, and potentially damage components. Proper management of these waste materials is crucial for maintaining system performance and environmental compliance. Would you like to delve deeper into specific waste management practices for these systems?

2. Main groups of waste

Waste can be broadly categorized into different main groups based on its characteristics and sources. The main groups of waste include:

2.1. Municipal Solid Waste (MSW):

- This category includes everyday items that individuals and businesses dispose of, such as household waste, packaging, food scraps, and non-hazardous materials. MSW is typically collected by municipal waste management services.

2.2. Industrial Waste:

- Generated by manufacturing, industrial processes, and construction activities. Industrial waste can include manufacturing by-products, chemicals, solvents, andother materials produced during industrial operations. Some industrial waste may be hazardous.

2.3. Hazardous Waste:

- Waste that poses a substantial threat to human health and the environment due to its chemical, biological, or physical characteristics. Examples include certain chemicals, pesticides, batteries, and electronic waste. Proper handling and disposal are crucial to prevent environmental contamination.

2.4. Construction and Demolition Waste (C&D):

- Generated during construction, renovation, and demolition activities. This includes materials such as concrete, wood, metal, drywall, and other construction-related debris. Effective management of C&D waste is essential for sustainable construction practices.

2.5. Electronic Waste (e-Waste):

- Discarded electronic devices and equipment, including computers, smartphones, televisions, and appliances. E-waste contains valuable materials but also hazardous substances. Proper recycling and disposal methods are necessary to prevent environmental and health risks.

2.6. Biomedical or Healthcare Waste:

- Generated in healthcare facilities and includes infectious waste, pathological waste, pharmaceutical waste, and other materials contaminated with blood or other bodily fluids. Healthcare waste requires special handling and treatment to prevent the spread of infections.

2.7.Agricultural Waste:

- Generated in agricultural activities and includes crop residues, animal waste, and agrochemical containers. Agricultural waste management is important for environmental sustainability and preventing soil and water pollution.

2.8. Radioactive Waste:

- Waste that contains radioactive materials, often generated in nuclear power plants, medical facilities using nuclear technology, and research laboratories. Proper containment and disposal methods are crucial to prevent harm to

2.9. Biodegradable Waste:

- Organic waste that can decompose naturally, including food scraps, yard waste, and certain paper products. Proper disposal, such as composting, can reduce the environmental impact of biodegradable waste in landfills.

2.10. Non-biodegradable Waste:

- Waste that does not decompose naturally over time. Examples include plastics, metals, and certain synthetic materials. Effective management of non-biodegradable waste is crucial for minimizing environmental impact.

Understanding the main groups of waste is essential for developing effective waste management strategies, including recycling, reuse, and proper disposal methods tailored to the specific characteristics of each waste type

3. Steps necessary to proper manage waste

Proper waste management is crucial for environmental sustainability, public health,

and resource conservation. Here are the key steps necessary to manage waste effectively:

1. **Waste Assessment:**
    - Conduct a comprehensive assessment of the types and quantities of waste generated.
    - Identify the sources, composition, and characteristics of the waste to tailor management strategies accordingly.
2. **Waste Reduction and Minimization:**
    - Implement measures to reduce the generation of waste at the source.
    - Encourage practices such as reusing materials, minimizing packaging, and adopting sustainable consumption habits.
3. **Reuse and Recycling Programs:**
    - Establish and promote reuse programs to extend the lifespan of products and materials.
    - Implement recycling initiatives for materials like paper, cardboard, plastics, glass, and metals to divert them from landfills.
4. **Composting Organic Waste:**
    - Set up composting programs for organic waste, including food scraps and yard waste.
    - Composting reduces the volume of waste and produces nutrient-rich compost for soil enrichment.
5. **Hazardous Waste Management:**
    - Identify and segregate hazardous waste from non-hazardous waste.
    - Follow strict guidelines for the handling, storage, and disposal of hazardous materials to prevent environmental contamination and protect human health.
6. **E-Waste Management:**
    - Establish systems for the proper disposal and recycling of electronic waste.
    - Encourage the return of electronic devices to manufacturers or authorized recycling facilities to recover valuable materials and prevent environmental pollution.
7. **Collection and Transportation:**
    - Develop an efficient waste collection system, including regular pickups and designated collection points.
    - Ensure that waste transportation is conducted in compliance with safety and environmental regulations.
8. **Waste Sorting and Segregation:**
    - Encourage individuals and businesses to segregate waste at the source.
    - Provide separate bins for different types of waste, making it easier to recycle

and dispose of materials properly.

9. **Public Awareness and Education:**
   - Conduct awareness campaigns to educate the public and businesses about the importance of proper waste management.
   - Promote responsible waste disposal practices and the benefits of reducing, reusing, and recycling.
10. **Regulatory Compliance:**
   - Stay informed about local, regional, and national regulations governing waste management.
   - Ensure compliance with permit requirements, reporting obligations, and environmental standards.
11. **Waste-to-Energy and Alternative Technologies:**
   - Explore environmentally friendly technologies for converting waste into energy or other usable resources.
   - Assess the feasibility of waste-to-energy projects, anaerobic digestion, or other innovative waste management solutions.
12. **Monitoring and Evaluation:**
   - Establish monitoring systems to track waste generation, recycling rates, and other key metrics.
   - Regularly evaluate the effectiveness of waste management programs and make adjustments as needed.
13. **Collaboration and Partnerships:**
   - Collaborate with government agencies, businesses, nonprofit organizations, and communities to enhance waste management efforts.
   - Foster partnerships for shared resources, expertise, and community engagement.

By following these steps, communities and organizations can develop comprehensive waste management strategies that address environmental concerns, promote sustainability, and contribute to a circular economy

Practical Activity 4.2.2: Managing Waste

Task:

1: Referring to key readings 4.2.2, you are requested to:

i. manage the waste material after installing pneumatic and hydraulic system

2: Follow instruction and procedures provided in that key readings and perform the given task

3: Present your final product to your parent/guardians

Key readings 4.2.1: Managing Waste

1.Steps necessary to proper manage waste

Proper waste management is crucial for environmental sustainability, public health, and resource conservation. Here are the key steps necessary to manage waste effectively:

1. Waste Assessment:

a) Conduct a comprehensive assessment of the types and quantities of waste generated.

b) Identify the sources, composition, and characteristics of the waste to tailor management strategies accordingly**.**

2. Waste Reduction and Minimization:

a) Implement measures to reduce the generation of waste at the source.

b) Encourage practices such as reusing materials, minimizing packaging, and adopting sustainable consumption habits**.**

3. Reuse and Recycling Programs:

a) Establish and promote reuse programs to extend the lifespan of products and materials.

b) Implement recycling initiatives for materials like paper, cardboard, plastics, glass, and metals to divert them from landfills.

4.Composting Organic Waste:

- Set up composting programs for organic waste, including food scraps and yard waste.
- Composting reduces the volume of waste and produces nutrient-rich compost for soil enrichment.

5.Hazardous Waste Management:

- Identify and segregate hazardous waste from non-hazardous waste.
- Follow strict guidelines for the handling, storage, and disposal of hazardous materials to prevent environmental contamination and protect human health.

6.E-Waste Management:

- Establish systems for the proper disposal and recycling of electronic waste.
- Encourage the return of electronic devices to manufacturers or authorized recycling facilities to recover valuable materials and prevent environmental pollution.

7.Collection and Transportation:

- Develop an efficient waste collection system, including regular pickups and designated collection points.
- Ensure that waste transportation is conducted in compliance with safety and environmental regulations.

8. Waste Sorting and Segregation:

- Encourage individuals and businesses to segregate waste at the source.
- Provide separate bins for different types of waste, making it easier to recycle and dispose of materials properly.

9. Public Awareness and Education:

- Conduct awareness campaigns to educate the public and businesses about the importance of proper waste management.
- Promote responsible waste disposal practices and the benefits of reducing, reusing, and recycling.

10. Regulatory Compliance:

- Stay informed about local, regional, and national regulations governing waste management.
- Ensure compliance with permit requirements, reporting obligations, and environmental standards**.**

11. Waste-to-Energy and Alternative Technologies:

- Explore environmentally friendly technologies for converting waste into energy or other usable resources.
- Assess the feasibility of waste-to-energy projects, anaerobic digestion, or other innovative waste management solutions.

12. Monitoring and Evaluation:

- Establish monitoring systems to track waste generation, recycling rates, and other key metrics.

- Regularly evaluate the effectiveness of waste management programs and make adjustments as needed**.**

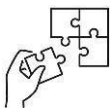
14. Collaboration and Partnerships:

- Collaborate with government agencies, businesses, nonprofit organizations, and communities to enhance waste management efforts.
- Foster partnerships for shared resources, expertise, and community engagement.

By following these steps, communities and organizations can develop comprehensive waste management strategies that address environmental concerns, promote sustainability, and contribute to a circular economy

Points to Remember

- Definition: waste material refers 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



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 an electrician you are requested to create a checklist that shows the effective ways of managing the waste.

Indicative content 4.3: Elaborating Pneumatic and Hydraulic System Installation Report

Duration: 5 hours

Theoretical Activity 4.3.1: Description of data recording

Tasks:

1: You are invited to answer the following question related to record data:

i. Explain recording data of parameter of pneumatic and hydraulic system?

ii. Identify method and tool used for recording data

2: Present your findings to the whole class and trainer

3: You are directed to read the key readings 4.3.1. for more clarification on basic concept of waste material.

Key readings 4.3.1.: Description of data recording

1.Explanation about data recording

In pneumatic and hydraulic systems, data recording involves monitoring and documenting parameters like pressure, flow rate, temperature, and fluid levels. This information is typically captured using sensors and data loggers, allowing for real-time analysis and system performance evaluation. Proper data recording helps identify inefficiencies, detect leaks, and ensure safety, ultimately enhancing the reliability and longevity of the system. Would you like to delve into specific data recording techniques used in these systems?

2. Method of recording data

When recording data for pneumatic and hydraulic systems in a workplace, it's important to capture information that ensures system efficiency, safety, and compliance. Here's a structured approach to recording and managing this data:

1. System Information

- **System ID/Name:** Unique identifier for each system.
- **Location:** Where the system is installed.
- **Type:** Pneumatic or hydraulic.
- **Manufacturer:** Details of the system manufacturer.
- **Model/Serial Number:** For tracking and reference.

2. Operational Parameters

- **Pressure Levels:** Operating pressure ranges for both pneumatic (e.g., PSI, bar) and hydraulic systems (e.g., PSI, bar).
- **Flow Rates:** Volume of air or fluid passing through the system per unit time

(e.g., liters per minute, cubic feet per minute).

- **Temperature:** Operating temperature ranges for both pneumatic and hydraulic systems.
- **Cycle Times:** Duration of system cycles or operational sequences.

3. Component Details

- **Valves:** Type, model, and operational status.
- **Actuators:** Specifications, performance data.
- **Pumps (Hydraulic) / Compressors (Pneumatic):** Performance data, maintenance schedules.
- **Filters:** Type, capacity, replacement schedules.
- **Hoses and Tubes:** Material, size, condition.

4. Maintenance Records

- **Maintenance Dates:** When maintenance was performed.
- **Type of Maintenance:** Routine, preventive, corrective.
- **Parts Replaced:** Details of any components replaced or repaired.
- **Issues Found:** Problems identified during maintenance.

5. Performance Data

- **Efficiency Metrics:** Data on how effectively the system is performing its intended function.
- **Energy Consumption:** Measurement of energy use, if applicable.
- **Downtime Records:** Instances and durations of system downtime.

6. Safety Checks

- **Safety Inspections:** Dates and results of safety inspections.
- **Emergency Procedures:** Records of any emergency incidents or shutdowns.
- **Compliance:** Ensuring adherence to safety regulations and standards.

7. Operational Logs

- **Daily/Shift Logs:** Notes on daily operations, issues encountered, and system performance.
- **Incident Reports:** Details of any incidents or unusual occurrences.

8. Calibration and Testing

- **Calibration Dates:** When calibration was performed on pressure gauges, flow meters, etc.
- **Test Results:** Outcomes of any tests conducted to ensure system performance.

9. Documentation and Records

- **Technical Drawings:** Schematics of the pneumatic or hydraulic systems.
- **Manuals and Guides:** Operation and maintenance manuals for reference.
- **Regulatory Compliance Documents:** Any documents related to industry standards and regulations.

Tools and Methods for Data Recording:

- **Manual Logs:** Paper-based logs or forms.
- **Digital Records:** Spreadsheet software, database systems, or specialized maintenance management software.
- **Automated Systems:** Use of sensors and monitoring systems that log data automatically

Practical Activity 4.3.2: Recording data

Task:

1: Referring to key readings 4.3.2, you are requested to:

ii. Record data of parameter of pneumatic and hydraulic system installation

2: Follow instruction and procedures provided in that key readings and perform the given task

3: Present your final product to your parent/guardians

Key readings 4.3.2: Recording data

Step of recording data

Recording data for pneumatic and hydraulic system parameters involves a structured approach to ensure accuracy and reliability. Here's a step-by-step guide:

1. Preparation

1. **Identify System Components:**
   Determine which components and parameters you need to measure (e.g., pressure, flow rate, temperature).
2. **Gather Tools and Equipment:**
   Measurement Tools: Pressure gauges, flow meters, temperature sensors, and any other relevant instruments.
   Recording Tools: Data sheets, logbooks, or electronic devices for data entry.
3. **Review System Documentation:**
   Consult manuals and previous records to understand normal operating ranges and data recording requirements.

2. Define Parameters to Record

Pressure:

Pneumatic Systems: Input pressure, output pressure, pressures at key components (e.g., regulators, filters).

Hydraulic Systems: Pressures at pump outlets, actuators, and other critical points.

Flow Rate:

Pneumatic Systems: Air flow rates at different system points.

Hydraulic Systems: Fluid flow rates through various system components.

Temperature:

Measure the temperature of fluids or air at various points.

Cycle Times (if applicable):

Record the time for operational cycles or sequences.

Component Performance:

Performance metrics of valves, actuators, pumps, and compressors.

3. Data Collection

Pressure Measurement:

Use pressure gauges or sensors to measure pressure at designated points.

Record readings at regular intervals or during specific operational conditions.

Flow Rate Measurement:

Use flow meters to measure and record flow rates.

Ensure that flow meters are properly calibrated.

Temperature Measurement:

Use thermometers or temperature sensors to measure temperature.

Record temperatures at various points in the system.

Cycle Time Measurement:

Use timers or data acquisition systems to measure cycle times.

Record times for different phases of operation.

4. Data Recording

Manual Logging:

Record data in logbooks or data sheets with clear labels and units of measurement.

Digital Entry:

Enter data into electronic systems such as spreadsheets, databases, or specialized maintenance software.

Ensure data is entered accurately and in the correct format.

Verification and Review

Check Accuracy:

Verify that all recorded data is accurate and consistent with expected values.

Analyze Trends:

Review data for trends or anomalies that may indicate potential issues with the system.

6. Documentation and Reporting

Update Records:

Ensure that all records are current and accurately reflect the system's performance.

Generate Reports:

Prepare reports summarizing key findings and system performance for management or regulatory compliance.

Archiving

Organize Data:

Store records in an organized manner, either physically (e.g., files, binders) or digitally (e.g., cloud storage, secure servers).

Ensure Security:

Implement measures to protect data from unauthorized access or loss.

8. Feedback and Improvement

Review Process:

Regularly evaluate the data recording process to identify areas for improvement.

Implement Changes:

Adjust procedures or tools based on feedback and observations to enhance data accuracy and recording efficiency.

9. Compliance and Safety Checks

Regulatory Compliance:

Ensure that all recorded data meets industry standards and regulatory requirements.

Safety Records:

Document any safety checks, incidents, or unusual occurrences related to the system.

By following these steps, you can ensure that data recording for pneumatic and hydraulic systems is thorough, accurate, and useful for monitoring and optimizing system performance.

Theoretical Activity 4.3.2. Description of pneumatic and hydraulic system

Tasks:

1: You are invited to answer the following question related to record data:

i. Explain pneumatic and hydraulic system installation report?

ii. Identify the step of reporting

2: Present your findings to the whole class and trainer

3: You are directed to read the key readings 4.3.2. for more clarification on basic concept of waste material.

Key readings 4.3.2.: Description of pneumatic and hydraulic system

1. Explanation of pneumatic and hydraulic installation report

A pneumatic and hydraulic system installation report provides a detailed account of the setup, configuration, and testing of pneumatic and hydraulic systems. These systems use compressed air and fluids, respectively, to perform work, and their installation must be documented thoroughly to ensure proper functioning and safety.

2. Step of reporting

Here's an outline of what such a report might include:

1. Introduction

- Purpose of the Report: Explain the objective of the installation, including any specific requirements or goals.
- Scope: Outline what the report covers, such as the installation of pneumatic and hydraulic systems, including any ancillary systems.

2. System Overview

- Pneumatic System: Description of the pneumatic system, including key components like compressors, filters, regulators, valves, actuators, and piping.
- Hydraulic System: Description of the hydraulic system, including components such as pumps, hydraulic cylinders, valves, filters, and hoses.

3. Installation Details

- **Pneumatic System Installation:**
  - **Component Placement**: Details on the location and mounting of compressors, regulators, valves, and actuators.
  - **Piping Layout:** Diagrams and descriptions of the piping network, including sizes and types of pipes used.
  - **Electrical Connections:** Wiring for controls and monitoring systems.
- **Hydraulic System Installation:**
  - **Component Placement**: Details on the location and mounting of hydraulic pumps, cylinders, and valves.
  - **Hose and Piping Layout**: Diagrams and descriptions of hydraulic lines and connections, including hose types and specifications.
  - **Fluid Management**: Details on fluid reservoirs, filtration, and any necessary fluid levels or types.

4. Testing and Commissioning

- Pre-Operational Checks: Lists of inspections conducted before powering up the systems, such as checking connections, leaks, and component integrity.
- Operational Testing: Procedures and results for testing the systems under normal

operating conditions. This includes verifying pressures, flows, and system responsiveness.

- Performance Verification: Confirmation that the systems meet performance specifications and requirements.

5. Safety Measures

- Safety Protocols: Description of safety measures and protocols followed during installation, including personal protective equipment (PPE) and emergency procedures.
- Risk Assessments: Any risk assessments conducted and their outcomes.

6. Documentation and Compliance

- Regulatory Compliance: Confirmation that the installation complies with relevant industry standards and regulations.
- Documentation: Copies or references to manuals, diagrams, and installation guides used.

7. Issues and Resolutions

- Problems Encountered: Documentation of any issues faced during installation and the steps taken to resolve them.
- Modifications: Any changes or adjustments made to the original installation plan.

8. Conclusion

- Summary: Recap of the installation process and any notable outcomes or observations.
- Recommendations: Any recommendations for future maintenance or improvements.

9. Appendices

- Diagrams and Schematics: Detailed drawings of the pneumatic and hydraulic systems.
- Checklists: Installation and testing checklists used.
- Photographs: Images of the installation process and final setup.

10. Signatures and Approvals

- Installers: Names and signatures of the personnel who carried out the installation.
- Project Managers: Signatures from project managers or supervisors who reviewed and approved the installation.

Practical Activity 4.3.3: Reporting pneumatic and hydraulic system installation

Task:

1: Referring to key readings 4.3.2, you are requested to:

i. report pneumatic and hydraulic system installation parameter

2: Follow instruction and procedures provided in that key readings and perform the given task

3: Present your final product to your parent/guardians

Key readings 4.3.3: Reporting pneumatic and hydraulic system installation

1. Step of reporting

Reporting the installation of pneumatic and hydraulic systems involves documenting every aspect of the installation process to ensure clarity, compliance, and future reference. Here's a detailed procedure for creating a comprehensive installation report:

1. Preparation

1.1. Collect Information:

- Gather all relevant data, including system designs, installation plans, and component specifications.
- Ensure you have all test results, inspection checklists, and photographs.

1.2. Review Documentation Standards:

- Familiarize yourself with reporting standards and requirements specific to your industry or organization.

2. Report Structure

2.1. Title Page:

- Report Title: "Pneumatic and Hydraulic System Installation Report"
- Project Name: Include the project title or system name.
- Date: Date of the report completion.
- Prepared By: Name and contact information of the person preparing the report.
- Reviewed By: Name and contact information of the reviewer or supervisor.

2.2. Table of Contents:

- Provide a clear and organized table of contents for easy navigation through the report**.**

3. Introduction

3.1. Purpose:

- Explain the purpose of the installation and the objectives of the report.

3.2. Scope:

- Define the scope of the installation, including what was covered in the report (e.g., pneumatic and hydraulic systems).

3.3. Background:

- Provide background information on the project, including the need for the

systems and any relevant project details.

4. System Overview

4.1. Pneumatic System:

- Description: Summarize the pneumatic system's function and components.
- Components: List major components (compressors, valves, actuators) and their roles.

4.2. Hydraulic System:

- Description: Summarize the hydraulic system's function and components.
- Components: List major components (pumps, cylinders, valves) and their roles.

5. Installation Procedures

5.1. Pneumatic System Installation:

5.1.1. Component Placement:

- Detail the locations and mounting of components such as compressors, regulators, and actuators.

5.1.2. Piping and Tubing:

- Describe the piping layout, including pipe sizes, materials, and connections.
- Include diagrams or schematics if available**.**

5.1.3. Electrical Connections:

- Document the wiring process, including connections to control panels and sensors**.**

5.2. Hydraulic System Installation:

5.2.1. Component Placement:

- Detail the locations and mounting of components such as hydraulic pumps, cylinders, and valves.

5.2.2. Hose and Piping Installation:

- Describe the layout of hydraulic hoses and pipes, including specifications and connections.
- Include diagrams or schematics if available**.**

5.2.3. Fluid Management:

- Document the installation of fluid reservoirs, filters, and any related components**.**

6. Testing and Commissioning

6.1. Pre-Operational Checks:

- List and describe pre-operational checks performed, such as visual inspections

and component verification.

6.2. System Testing:

6.2.1. Pneumatic System Testing:

- Describe testing procedures, including pressure testing and functional checks.
- Document test results and any issues encountered**.**

6.2.2. Hydraulic System Testing:

- Describe testing procedures, including leak tests and performance verification.
- Document test results and any issues encountered**.**

6.3. Performance Verification:

- Summarize how the system's performance was verified against design specifications**.**

7. Safety Measures

7.1. Safety Protocols:

- Document the safety measures implemented during installation.
- Include any safety equipment used and emergency procedures**.**

7.2. Risk Assessments:

- Provide a summary of risk assessments conducted and their findings.

8. Documentation and Compliance

8.1. Regulatory Compliance:

- Confirm compliance with industry standards and regulations.

8.2. Documentation:

- Include references to installation manuals, component datasheets, and compliance certificates**.**

9. Issues and Resolutions

9.1. Problems Encountered:

- Document any problems or deviations from the installation plan.
- Describe how these issues were addressed or resolved.

9.2. Modifications:

- Note any modifications made to the original installation plan**.**

10. Conclusion

10.1. Summary:

- Recap the installation process, key findings, and overall results.

10.2. Recommendations:

- Provide recommendations for future maintenance or system improvements.

11. Appendices

11.1. Diagrams and Schematics:

- Include detailed diagrams and schematics of the installed systems.

11.2. Checklists:

- Attach any checklists used during installation and testing.

11.3. Photographs:

- Include photographs of the installation process and final setup.

12. Signatures and Approvals

12.1. Installers:

- Include names and signatures of the personnel involved in the installation.

12.2. Project Managers:

- Obtain signatures from project managers or supervisors who reviewed the report.

13. Handover and Training

13.1. Training:

- Document any training provided to end-users or maintenance personnel.

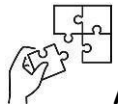
13.2. Handover:

- Confirm the transfer of all relevant documentation and system knowledge to the end-users.

By following these procedures, you create a comprehensive and detailed report that ensures the installation of pneumatic and hydraulic systems is well-documented and provides a clear record for future reference.

Points to Remember

- The step-by-step are preparation, define parameters to record, data collection, data recording, verification and review, documentation and reporting, archiving, feedback and improvement, compliance and safety checks
- 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 Company in RUTSIRO district install pneumatic and hydraulic system, as a worker of the company they give you the task of making clear documentation of report which composed of all important information of the installation.

Learning outcome 4 end assessment

Written assessment

1. Define as-build diagram.
2. List the group of waste material.
3. Identify the procedures of recording data in pneumatic and hydraulic system.

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
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.

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

i. Recycling can save communities money.
ii. More plastic packaging is recovered for recycling than paper packaging
iii. Effective waste material management in pneumatic and hydraulic systems is crucial for minimizing environmental impact and ensuring compliance with regulations.
iv. Waste materials generated from pneumatic and hydraulic systems can include used hydraulic fluid, which must be disposed of in accordance with environmental regulations.
v. Only mechanical components are considered waste in pneumatic and hydraulic systems; fluids and lubricants are not classified as waste materials.
vi. Regular maintenance and monitoring of pneumatic and hydraulic systems can help reduce waste by identifying leaks and inefficiencies early.

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 used for data recording in these systems?	i) Manual logs 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	……

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	olumn A	olumn B
…….	Final Approval	Implement a quality control process to review and verify the accuracy of the as-built drawings.
…….	Quality Control	Organize the drawing layers to distinguish between original design elements and as-built changes
…….	Layering and	Use Computer-Aided Design (CAD) software to

	Annotation	create accurate and detailed drawings.
……	Collaboration and Communication	Obtain approval from relevant stakeholders, including architects, engineers, and clients, before finalizing the as-built drawings
……	CAD Software Utilization	Foster effective communication between stakeholders, including architects, engineers, contractors, and clients.
…….	Data Collection	Verify the physical conditions on-site against the original design drawings
…….	Site Verification	Gather accurate and up-to-date information about the structure or system

9. Summarize the importance of waste management in pneumatic/hydraulic system.
10.Explain any three purposes of As-built drawing**.**

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:

3. Draw clear as-built drawing
4. Shows data recorded of the system
5. Make clear report of the system

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