Nov 2018 9th

4. With reference to pneumatic control systems, explain EACH of the following:

(a) why moisture is undesirable; (4)

(b) why oil is generally undesirable; (3)

(c) why oil may be intentionally introduced into parts of the system. (3)

Moisture and Oil in Pneumatic Control Systems

(a) Why Moisture is Undesirable:

Moisture (water) is generally undesirable in pneumatic control systems for several reasons:

- **Corrosion:** Water can cause corrosion of metal components within the system, including pipes, valves, cylinders, and actuators. This can lead to sticking valves, reduced performance, and premature component failure.
- **Freezing:** In cold environments, moisture can freeze within the system, causing blockages that prevent proper operation of control equipment. This can lead to malfunctions and potential damage to components due to pressure surges.
- **Reduced Efficiency:** Moisture can interfere with the lubrication properties of compressed air, leading to increased friction within moving parts. This can reduce the overall efficiency of the system and shorten the lifespan of components.
- **Reduced Service Life of Components:** Water can erode seals and damage internal components of valves and actuators, leading to premature wear and tear.

(b) Why Oil is Generally Undesirable:

While some control systems utilize oil, in most general pneumatic applications, oil is generally undesirable for the following reasons:

- **Gumming:** Oil can build up on internal surfaces of valves, solenoids, and other components over time. This can cause them to stick or malfunction, hindering proper operation of the control system.
- **Contamination of Downstream Equipment:** Oil can contaminate downstream processes or products that are sensitive to oil contact. This can lead to product defects or safety hazards.
- **Compatibility Issues:** Certain materials used in control components might not be compatible with oil, leading to degradation or damage.

(c) Why Oil May Be Intentionally Introduced:

Despite the drawbacks mentioned above, oil may be intentionally introduced into specific parts of a pneumatic control system in some cases:

- **Lubrication of Specific Components:** Certain pneumatic components, such as cylinders with sliding seals or bearings, may require lubrication to reduce friction and wear. In such

cases, a small amount of oil mist is introduced into the compressed air stream to provide lubrication for these specific components.
- **Corrosion Protection:** Oil can help protect internal surfaces from corrosion in environments with high humidity or where there's a risk of condensation. However, this approach should be carefully considered as oil can also attract contaminants.
- **Operating in Dusty Environments:** A small amount of oil can help to trap dust particles within the system, preventing them from reaching and damaging sensitive components.

Important Note:

If oil is used in a pneumatic system, it's crucial to select the appropriate oil type and viscosity compatible with the specific components and avoid excessive use. Regular maintenance practices are essential to remove accumulated oil and prevent buildup that can cause problems. In many modern systems, proper filtration and compressed air dryers can eliminate the need for oil altogether.

Sept 2021

Sept 2021

4. With reference to hydraulic systems:

(a) state FOUR applications for a hydraulic system on board a vessel; (4)

(b) state the effects and possible causes of EACH of the following:

(i) air in the system; (2)

(ii) dirt and foreign particles in the system; (2)

(iii) separated water in the system. (2)

Hydraulic Systems on Board a Vessel

(a) Four Applications for Hydraulic Systems on a Vessel:

Hydraulic systems are widely used on board vessels due to their ability to transmit high power efficiently through pressurized fluids. Here are four common applications:

1. **Deck Machinery:** Hydraulic systems power various deck machinery essential for cargo handling and operations. This includes:
    - **Cargo winches and cranes:** For lifting and lowering cargo containers, anchors, and other equipment.
    - **Mooring winches:** Used for mooring and maneuvering the vessel during docking procedures.
    - **Hatch covers:** Hydraulic systems operate mechanisms for opening and closing large hatch covers on cargo holds.
2. **Steering Gear:** Modern ships often utilize hydraulic steering gear systems. These systems use high-pressure hydraulic fluid to move the rudder, providing precise control over the vessel's direction.
3. **Stabilizers:** Hydraulically powered stabilizers are deployed to reduce a ship's roll in rough seas, improving passenger comfort and stability during cargo operations.

4. **Auxiliary Systems:** Hydraulics can be used for various auxiliary functions on board, such as:
   - **Door opening mechanisms:** For watertight doors, engine room doors, etc.
   - **Lifeboat davits:** Hydraulic systems can power the davits used to launch lifeboats during emergencies.
   - **Windlass:** Used for raising and lowering the anchor chain.

(b) Effects and Possible Causes of Contaminants in Hydraulic Systems:

Contamination within a hydraulic system can lead to several problems and malfunctions. Here's a breakdown of three common contaminants and their effects:

(i) Air in the System:

- **Effects:** Air entering the hydraulic system can cause problems like:
  - **Spongy Operation:** Air compresses more readily than hydraulic fluid, leading to a spongy or unresponsive feel in hydraulically operated equipment. This can make precise control difficult.
  - **Cavitation:** Air bubbles can collapse under pressure within the system, creating shockwaves that damage pump components and reduce overall efficiency.
  - **Increased Noise:** Air in the system can cause excessive noise during operation.
- **Possible Causes:** Air can enter the system through:
  - **Leaking connections:** Improperly sealed connections, loose fittings, or worn seals can allow air to be sucked into the system.
  - **Low fluid level:** If the hydraulic fluid reservoir is not properly filled, air can be drawn in as the pump operates.
  - **Air entrainment during refilling:** Introducing new hydraulic fluid too quickly can trap air bubbles within the system.

(ii) Dirt and Foreign Particles in the System:

- **Effects:** Dirt and foreign particles can cause significant damage to hydraulic components:
  - **Abrasive Wear:** Dirt particles act like sandpaper, accelerating wear on pump components, valves, and cylinders. This reduces efficiency and shortens the lifespan of components.
  - **Sticking Valves:** Contaminants can jam or stick valves, preventing proper operation of hydraulic equipment.
  - **Increased System Friction:** Dirt particles can increase friction within moving parts, leading to reduced performance and overheating.
- **Possible Causes:** Dirt and foreign particles can enter the system through:
  - **Contaminated new fluid:** Using dirty or unfiltered hydraulic fluid can introduce contaminants.
  - **Improper maintenance:** Failure to replace filters or maintain proper fluid cleanliness can allow dirt to accumulate within the system.
  - **External leaks:** Leaks in the system can allow dirt and debris from the surrounding environment to enter.

(iii) Separated Water in the System:

- **Effects:** Water contamination in hydraulic systems can have various detrimental effects:

  - **Corrosion:** Water can cause corrosion of metal components within the system, leading to premature wear and failure.
  - **Hydrolysis:** Water can react with the hydraulic fluid, breaking it down and reducing its lubricating properties. This increases wear and tear on components.
  - **Freezing:** In cold environments, separated water can freeze within the system, causing blockages and potentially damaging components.
- **Possible Causes:** Water can enter the system through:
  - **Condensation:** Moisture in the air can condense within the system, especially in environments with significant temperature fluctuations.
  - **Contaminated new fluid:** Using hydraulic fluid that already contains water can introduce contamination.
  - **Coolant leaks:** In systems where the hydraulic fluid is cooled by a separate water-based system, a leak in the heat exchanger can allow water to mix with the hydraulic fluid.

Sept 2020

Sept 2020

4. Outline the safety precautions which should be taken when carrying out repairs or maintenance on hydraulic systems. (10)

Question 4. All give some understanding of the safety requirements, most fail to mention anything about fire.

feb 2024

4. Outline the safety precautions which should be taken when carrying out repairs or maintenance on hydraulic systems. (10)

Here are some safety precautions that should be taken when carrying out repairs or maintenance on hydraulic systems:

Before Starting Work:

- **Lock Out/Tag Out (LOTO):** Always follow proper Lock Out/Tag Out procedures before beginning any work on the hydraulic system. This ensures that the system is isolated from its energy source and no one can accidentally activate it while you're working.
- **Pressure Relief:** Release all residual pressure within the system before starting any work. This can be done by following the manufacturer's instructions for bleeding pressure from specific components or using a designated pressure relief valve.
- **System Drainage:** Drain the hydraulic fluid from the system as much as possible, following proper disposal procedures for the used fluid. This minimizes the risk of exposure to hot oil and reduces the amount of fluid that could escape during repairs.
- **System Cleaning (Optional):** In some cases, depending on the nature of repairs or the severity of contamination, the system might require cleaning before disassembly. This could involve flushing the system with a cleaning solution or using specialized cleaning procedures outlined by the manufacturer.
- **Personal Protective Equipment (PPE):** Wear appropriate personal protective equipment (PPE) when working on hydraulic systems. This includes:

  - **Safety glasses:** To protect eyes from splashes of hydraulic fluid or debris.
  - **Gloves:** Chemical-resistant gloves to protect hands from hot oil and potential contamination.
  - **Coveralls:** Oil-resistant coveralls to protect clothing from spills and contamination.
  - **Foot protection:** Safety boots with proper slip resistance to prevent falls on potentially oily surfaces.

During Repairs and Maintenance:

- **Follow Service Manuals:** Always refer to the manufacturer's service manuals or maintenance instructions for the specific equipment. These will provide detailed procedures for disassembly, inspection, repair, and reassembly of the hydraulic components.
- **Use Proper Tools:** Use the correct tools specifically designed for working on hydraulic systems. This will help prevent damage to components and ensure proper tightening of fittings.
- **Beware of High-Pressure Components:** Be aware of high-pressure lines and components within the system. Avoid any actions that could put stress on these components or lead to accidental fluid leaks.
- **Maintain a Clean Work Area:** Keep the work area clean and organized to avoid tripping hazards or losing track of tools and components.
- **Work Buddy System:** Consider working with a partner for certain tasks, especially when dealing with high-pressure components or heavy equipment.
- **Safe Lifting Practices:** Use proper lifting techniques and equipment when handling heavy components within the hydraulic system.

After Completing Work:

- **Reassembly and Inspection:** Carefully reassemble the system components according to the manufacturer's instructions. Double-check all connections and ensure everything is tightened properly.
- **System Refill and Bleeding:** Refill the system with clean, fresh hydraulic fluid of the recommended type and viscosity. Follow the manufacturer's procedures for bleeding air from the system to ensure proper operation without trapped air pockets.
- **Test and Verification:** Once the system is refilled and bled, conduct a test run to verify proper operation and identify any leaks or malfunctions before placing the system back into full service.
- **Safety Checks:** Perform final safety checks to ensure all LOTO procedures are reversed, no tools are left behind, and the system is functioning safely and without leaks.

Additional Tips:

- **Training and Experience:** Ensure you have the proper training and experience necessary for the specific repairs or maintenance tasks being performed on the hydraulic system.
- **Waste Disposal:** Dispose of used hydraulic fluid and any other waste materials generated during maintenance according to local environmental regulations.
- **Proper Record Keeping:** Maintain records of the maintenance procedures performed, parts replaced, and any safety concerns encountered.

By following these safety precautions, you can minimize the risk of accidents and injuries when working on hydraulic systems. Remember, hydraulic systems operate under high pressure and contain hazardous fluids. It's crucial to prioritize safety throughout the entire maintenance process.

Feb 2021

Feb 2021

4. With reference to using air as a pneumatic medium:

(a) state FOUR advantages; (4)

(b) state, with reasons, THREE disadvantages. (6)

Advantages and Disadvantages of Using Air as a Pneumatic Medium

(a) Advantages of Using Air:

1. **Readily Available:** Air is a virtually inexhaustible resource, readily available at atmospheric pressure. This eliminates the need for purchasing and managing large volumes of hydraulic fluid.
2. **Clean and Environmentally Friendly:** Compressed air is a clean and non-polluting medium. Unlike hydraulic fluids, accidental leaks do not pose a significant environmental hazard. This makes it suitable for applications where cleanliness and environmental impact are critical concerns.
3. **Safe Operation:** Compressed air systems typically operate at lower pressures compared to hydraulic systems. This reduces the risk of catastrophic failures or injuries due to high-pressure fluid leaks. In case of leaks, air readily escapes, minimizing the risk of fluid splashes or fire hazards.
4. **Simplicity and Ease of Use:** Pneumatic systems are generally simpler in design compared to hydraulic systems. This translates to easier installation, maintenance, and troubleshooting. Components are often lighter and more compact, making them suitable for space-constrained applications.

(b) Disadvantages of Using Air:

1. **Compressibility:** Air is a compressible gas, unlike hydraulic fluid. This compressibility can lead to:
   - **Slower Response Times:** The compressibility of air can cause a slight delay in the response of pneumatic actuators compared to hydraulic systems. This can be a disadvantage in applications requiring very fast and precise movements.
   - **Loss of Pressure Over Long Distances:** As compressed air travels through pipelines, there can be a pressure drop due to the compressibility of the air. This can limit the effective range of pneumatic systems compared to hydraulic systems.
2. **Lower Power Density:** For a given cylinder size, pneumatic systems can transmit less force compared to hydraulic systems operating at the same pressure. This is because hydraulic fluid is essentially incompressible, allowing for transmission of higher forces. For applications requiring high power output, hydraulic systems might be a better choice.

3. **Moisture and Contamination Concerns:** Moisture in the compressed air can lead to corrosion of components and potential malfunctioning of actuators. Additionally, dust particles in the air can cause wear and tear on internal components. Proper filtration and drying of compressed air are essential for reliable operation of pneumatic systems.

Nov 2021

Nov 2021

4. With reference to air compressors and pneumatic control systems:

(a) state ONE advantage and ONE disadvantage of a compressed air system compared to a hydraulic system; (2)

(b) explain why it is desirable to remove moisture from the air; (2)

(c) explain why its desirable to limit oil carry over; (2)

(d) describe how EACH of the following is achieved:

(i) removal of moisture from the air; (2)

(ii) limiting of oil carry over. (2)

Question 4. Well answered by most

Air Compressors vs. Hydraulic Systems and Maintaining Clean Air

(a) Advantage and Disadvantage of Compressed Air vs. Hydraulic Systems:

- **Advantage: Clean and Environmentally Friendly:** Compressed air systems are generally cleaner and more environmentally friendly. Leaks pose less risk of environmental contamination compared to hydraulic fluid leaks.
- **Disadvantage: Lower Power Density:** For the same size actuator, compressed air systems can transmit less force compared to hydraulic systems due to the compressibility of air. Hydraulic systems are better suited for high-power applications.

(b) Importance of Removing Moisture from Compressed Air:

Moisture (water) in compressed air is undesirable for several reasons:

- **Corrosion:** Water can cause corrosion of metal components within the system, including pipes, valves, cylinders, and actuators. This can lead to sticking valves, reduced performance, and premature component failure.
- **Freezing:** In cold environments, moisture can freeze within the system, causing blockages and potentially damaging components due to pressure surges.
- **Reduced Efficiency:** Moisture can interfere with the lubrication properties of compressed air, leading to increased friction within moving parts. This reduces the overall efficiency of the system and shortens the lifespan of components.
- **Reduced Service Life of Components:** Water can erode seals and damage internal components of valves and actuators, leading to premature wear and tear.

Therefore, removing moisture from compressed air is crucial for reliable operation, efficient performance, and extended lifespan of the pneumatic control system.

(c) Importance of Limiting Oil Carry Over:

While some control systems utilize oil, limiting oil carry over in most pneumatic applications is desirable for these reasons:

- **Gumming:** Oil can build up on internal surfaces of valves, solenoids, and other components over time. This can cause them to stick or malfunction, hindering proper operation of the control system.
- **Contamination of Downstream Equipment:** Oil can contaminate downstream processes or products that are sensitive to oil contact. This can lead to product defects or safety hazards.
- **Compatibility Issues:** Certain materials used in control components might not be compatible with oil, leading to degradation or damage.

Therefore, minimizing oil carry over helps ensure smooth operation, prevent contamination of downstream equipment, and avoid compatibility issues with components.

(d) Methods for Maintaining Clean Air:

(i) Removing Moisture from Air:

Several methods can be employed to remove moisture from compressed air:

- **Refrigerated Air Dryers:** These dryers use refrigeration to cool the compressed air, causing moisture to condense and separate from the air stream. The condensate is then drained automatically.
- **Desiccant Air Dryers:** These dryers utilize desiccant materials that absorb moisture from the compressed air as it passes through. The desiccant is then regenerated by heat or purging with dry air.
- **Membrane Dryers:** These dryers use semi-permeable membranes that allow water vapor to pass through but not air. This separates the moisture from the compressed air stream.

(ii) Limiting Oil Carry Over:

Several methods can be used to limit oil carry over from lubricated compressors into the air stream:

- **Aftercoolers:** These heat exchangers cool the compressed air after leaving the compressor. This helps condense and separate oil vapors from the air stream.
- **Oil Separators:** These separators utilize baffles, filters, or centrifugal force to remove oil droplets from the compressed air stream.
- **Coalescing Filters:** These filters contain fine fibers that allow air to pass through but trap oil droplets due to surface tension. This helps coalesce the oil droplets into larger drops that can be drained from the filter.

By implementing these methods, compressed air systems can be equipped to deliver clean, dry, and oil-free air for optimal performance and longevity of pneumatic control systems.

May 2024

4. With reference to hydraulic systems:

(a) state THREE possible contaminations; (3)

(b) state possible causes of the contaminations stated in part (a). (3)

(c) explain how the contaminants stated in part (a) are prevented from affecting the system. (4)

Nov 2020

Nov 2020

4. With reference to hydraulic systems:

(a) state THREE possible contaminations; (3)

(b) state possible causes of the contaminations stated in part (a). (3)

(c) explain how the contaminants stated in part (a) are prevented from affecting the system. (4)

Question 4. Well answered by most.

Hydraulic System Contamination and Prevention

Hydraulic systems rely on clean fluid for efficient and reliable operation. However, contamination can pose a significant threat. Here's a breakdown of three common contaminants and methods to prevent them:

(a) Three Possible Contaminations:

1. **Dirt and Foreign Particles:** These can include dust, sand, metal shavings, or any foreign debris that enters the system.
2. **Air:** Air entering the hydraulic system can cause problems like spongy operation, cavitation, and increased noise.
3. **Water:** Water contamination can lead to corrosion, hydrolysis (breakdown of hydraulic fluid), and freezing in cold environments.

(b) Possible Causes of Contamination:

- **Dirt and Foreign Particles:**
  - Contaminated new fluid: Using dirty or unfiltered hydraulic fluid can introduce contaminants.
  - Improper maintenance: Failure to replace filters or maintain proper fluid cleanliness allows dirt to accumulate.
  - External leaks: Leaks in the system can allow dirt and debris from the surrounding environment to enter.
- **Air:**

    - Leaking connections: Improperly sealed connections, loose fittings, or worn seals can allow air to be sucked into the system.
    - Low fluid level: If the hydraulic fluid reservoir is not properly filled, air can be drawn in as the pump operates.
    - Air entrainment during refilling: Introducing new hydraulic fluid too quickly can trap air bubbles within the system.
- **Water:**
    - Condensation: Moisture in the air can condense within the system, especially in environments with significant temperature fluctuations.
    - Contaminated new fluid: Using hydraulic fluid that already contains water can introduce contamination.
    - Coolant leaks: In systems where the hydraulic fluid is cooled by a separate water-based system, a leak in the heat exchanger can allow water to mix with the hydraulic fluid.

(c) Preventing Contamination in Hydraulic Systems:

Several methods can be implemented to prevent contamination and protect your hydraulic system:

- **High-Quality Filtration:** Using high-quality filters at the reservoir inlet, return line, and potentially within critical components like valves helps trap dirt and foreign particles before they can enter the system. Regularly changing filters is crucial.
- **Proper Maintenance:** A well-maintained system is less prone to contamination. This includes regular inspections for leaks, timely replacement of worn seals and components, and maintaining proper fluid cleanliness levels through fluid analysis and changes when necessary.
- **Sealing and Breather Selection:** Using proper seals and breathers on components can prevent leaks and minimize air intake from the environment. Breathers should be equipped with filters to prevent dust ingress.
- **Reservoir Design:** Reservoirs with proper baffling and breathers help minimize air intake and allow for settling of contaminants at the bottom, where they can be drained periodically.
- **Fluid Management:** Using clean, high-quality hydraulic fluid and following proper storage and handling practices minimizes contamination risks.
- **Closed-Loop Systems:** Where feasible, designing closed-loop systems can significantly reduce the risk of contamination from external sources.

By implementing these preventative measures, you can maintain the cleanliness and integrity of your hydraulic system, ensuring reliable operation and extended lifespan for your equipment.

May 2021

4. With reference to hydraulic systems:

(a) state TWO functions of an accumulator; (2)

(b) describe, with the aid of a sketch, a gas charged diaphragm or bladder accumulator; (6)

(c) describe how the bladder is prevented from being extruded from the accumulator described in part (b). (2)

Question 4. The question asks for a description of an accumulator, several give no description, many explain how it works – which is not asked for – instead.

Hydraulic Accumulators and Bladder Design

(a) Two Functions of an Accumulator:

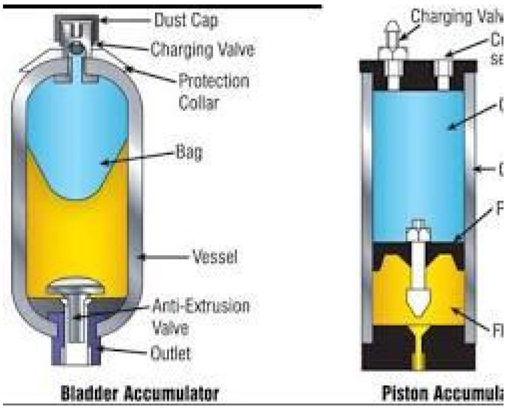
Hydraulic accumulators serve two primary functions within a hydraulic system:

pen_spark

1. **Energy Storage:** Accumulators can store hydraulic fluid under pressure, acting as a reservoir of potential energy. This stored energy can be used to:
   - **Supplement Pump Flow:** During sudden demands for hydraulic power, the accumulator can release stored fluid to meet the temporary surge in demand, reducing the workload on the pump.
   - **Dampen Pressure Shocks:** Accumulators can absorb pressure spikes caused by rapid load changes or actuator movements, protecting other components from damage and providing smoother system operation.
2. **Maintaining System Pressure:** In some applications, accumulators can help maintain a relatively constant system pressure, even during fluctuations in pump flow or demand. This can be beneficial for systems with sensitive components requiring consistent pressure.

(b) Gas Charged Diaphragm or Bladder Accumulator (Sketch and Description):

A gas charged diaphragm or bladder accumulator is a common type of accumulator that utilizes a flexible bladder to separate the hydraulic fluid from a compressed gas pre-charge. Here's a description with a corresponding sketch:



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Bladder Accumulator Hydraulic System

Components:

1. **Shell:** A sturdy metal housing that contains the entire accumulator assembly.
2. **Hydraulic Fluid Port:** The connection point for the hydraulic fluid to enter and exit the accumulator.
3. **Bladder:** A flexible, gas-impermeable membrane made of high-strength elastomeric material. It separates the hydraulic fluid from the compressed gas.
4. **Pre-Charged Gas:** Inert gas (typically nitrogen) at a predetermined pressure that fills the space above the bladder.
5. **Diaphragm (Optional):** Some designs may incorporate a diaphragm plate to provide additional support for the bladder and prevent excessive bulging.

Operation:

- When hydraulic fluid enters the accumulator through the port, it pushes against the bladder, causing it to expand and compress the pre-charged gas in the upper chamber.
- The compressed gas provides a counterforce that balances the pressure of the incoming hydraulic fluid.
- As more fluid enters, the pressure within the accumulator increases until it reaches a predetermined level.
- When the demand for hydraulic fluid exceeds the pump's capacity, the stored energy in the accumulator pushes the bladder back, releasing pressurized fluid back into the system.
- The pre-charged gas pressure determines the accumulator's pre-charge pressure and influences the response characteristics of the accumulator.

(c) Preventing Bladder Extrusion:

To prevent the bladder from extruding or rupturing from the accumulator shell, several design features are employed:

- **High-Strength Bladder Material:** The bladder is made of a robust elastomeric material that can withstand high pressures and resist bulging or tearing.

- **Pre-Charge Pressure Setting:** The pre-charge gas pressure is carefully chosen to be lower than the maximum pressure rating of the bladder and accumulator shell. This ensures the bladder remains within its safe operating range.
- **Diaphragm Support (Optional):** Some designs utilize a diaphragm plate to provide additional support for the bladder, preventing excessive bulging and potential extrusion.
- **Safety Features:** Certain accumulators may incorporate pressure relief valves to automatically vent excess pressure in case of malfunctions, protecting the bladder from overpressure.

By implementing these design considerations, bladder accumulators can operate safely and reliably within hydraulic systems.

Nov 2018 2nd

Nov 2018 2nd

4. With reference to pneumatic control systems, explain EACH of the following:

   (a) why moisture is undesirable; (4)

   (b) why oil is generally undesirable; (3)

   (c) why oil may be intentionally introduced into parts of the system. (3)

Moisture and Oil in Pneumatic Control Systems

(a) Why Moisture is Undesirable:

Moisture (water) in compressed air systems used for pneumatic control is highly undesirable for several reasons:

- **Corrosion:** Water can cause corrosion of metal components within the system, including pipes, valves, cylinders, and actuators. This can lead to sticking valves, reduced performance, and premature component failure. Rust weakens components and creates leaks.
- **Freezing:** In cold environments, moisture can freeze within the system, causing blockages that prevent proper operation of control equipment. This can lead to malfunctions and potential damage to components due to pressure surges. Frozen water can also expand and crack components.
- **Reduced Efficiency:** Moisture can interfere with the lubrication properties of compressed air, leading to increased friction within moving parts. This reduces the overall efficiency of the system and shortens the lifespan of components. As friction increases, more energy is wasted.
- **Reduced Service Life of Components:** Water can erode seals and damage internal components of valves and actuators, leading to premature wear and tear. Water can wash away lubricants and cause parts to bind or wear unevenly.

(b) Why Oil is Generally Undesirable:

While some control systems utilize oil, in most general pneumatic applications, oil is generally undesirable for the following reasons:

- **Gumming:** Oil can build up on internal surfaces of valves, solenoids, and other components over time. This can cause them to stick or malfunction, hindering proper operation of the control system. Oil residue can harden and restrict movement within valves and other components.
- **Contamination of Downstream Equipment:** Oil can contaminate downstream processes or products that are sensitive to oil contact. This can lead to product defects or safety hazards. For example, oil can stain or damage delicate materials used in manufacturing processes.
- **Compatibility Issues:** Certain materials used in control components might not be compatible with oil, leading to degradation or damage. Some plastics can become brittle or swell when exposed to oil.

(c) Why Oil May Be Intentionally Introduced into Parts of the System:

Despite the drawbacks mentioned above, oil may be intentionally introduced into specific parts of a pneumatic control system in some cases:

- **Lubrication of Specific Components:** Certain pneumatic components, such as cylinders with sliding seals or bearings, may require lubrication to reduce friction and wear. In such cases, a small amount of oil mist is introduced into the compressed air stream to provide lubrication for these specific components. This targeted lubrication can extend the lifespan of components and improve efficiency.
- **Corrosion Protection:** Oil can help protect internal surfaces from corrosion in environments with high humidity or where there's a risk of condensation. However, this approach should be carefully considered as oil can also attract contaminants.
- **Dust Control:** A small amount of oil can help to trap dust particles within the system, preventing them from reaching and damaging sensitive components. Oil can act as a sticky barrier, capturing dust before it enters critical parts.

Important Note:

If oil is used in a pneumatic system, it's crucial to select the appropriate oil type and viscosity compatible with the specific components. Using the wrong oil can cause more harm than good. Regular maintenance practices are essential to remove accumulated oil and prevent buildup that can cause problems. In many modern systems, proper filtration and compressed air dryers can eliminate the need for oil altogether, improving system cleanliness and reducing maintenance needs.

Oct 2020

Oct 2020

4. With reference to water contamination of hydraulic systems:

(a) state possible sources of water; (2)

(b) explain the possible consequences; (5)

(c) describe the actions to be taken should it be suspected. (3)

Water Contamination in Hydraulic Systems

Water is a major enemy of hydraulic systems, causing a variety of problems. Here's a breakdown of its sources, consequences, and what to do if you suspect contamination:

(a) Sources of Water Contamination:

- **Condensation:** Moisture in the air can condense inside the system, especially during temperature fluctuations.
- **Leaking Seals:** Worn or damaged seals around pistons, rods, or reservoirs can allow water to enter.
- **Breather Contamination:** Breather filters are designed to prevent dust and moisture, but malfunctioning or clogged filters can let water in.
- **Coolant Leaks:** If a heat exchanger leaks coolant (often water-based) into the hydraulic fluid, it can cause contamination.
- **Improper Maintenance Practices:** Leaving the system open during maintenance or using contaminated refilling fluids can introduce water.

(b) Consequences of Water Contamination:

- **Corrosion:** Water reacts with metal components, leading to rust and accelerated wear.
- **Cavitation:** Water vapor bubbles can form and collapse under pressure, damaging pump components.
- **Reduced Lubricity:** Water weakens the lubricating film of the hydraulic fluid, increasing friction and wear.
- **Sludge Formation:** Water and contaminants can mix, forming sludge that clogs filters and restricts flow.
- **Freezing:** In cold environments, water can freeze and damage components.
- **Reduced Efficiency:** All these problems combine to decrease overall system efficiency and performance.

(c) Actions to Take if Water Contamination is Suspected:

- **Fluid Analysis:** Perform a test to determine the water content in the hydraulic fluid.
- **Visual Inspection:** Look for a milky appearance in the fluid, which can indicate water contamination.
- **Identify the Source:** Investigate potential entry points for water to locate the source of the problem.
- **System Flushing:** If water contamination is confirmed, the system needs to be flushed with clean fluid to remove the water.
- **Filter Replacement:** Change all filters in the system to remove any trapped water.
- **Seal Repair/Replacement:** Replace any worn or damaged seals that might be allowing water ingress.
- **Dehydration Process:** In severe cases, specialized dehydration equipment may be required to remove large amounts of water.
- **Preventive Maintenance:** Implement a regular maintenance schedule that includes fluid analysis, filter changes, and inspection for potential leaks.

By taking these steps promptly, you can minimize the damage caused by water contamination and ensure the smooth operation of your hydraulic system.

4. With reference to an air supply for pneumatic control systems:

(a) state THREE contaminants that may be present; (3)

(b) explain why the contaminants stated in part (a) are undesirable. (7)

Sept 18th 2020

Sept (18th) 2020

4. With reference to an air supply for pneumatic control systems:

(a) state THREE contaminants that may be present; (3)

(b) explain why the contaminants stated in part (a) are undesirable. (7)

Contaminants in Pneumatic Control Systems Air Supply

Here's a look at three common contaminants in the air supply for pneumatic control systems and why they're undesirable:

(a) Three Contaminants:

1. **Moisture (Water Vapor):** This is a prevalent contaminant in compressed air systems.
2. **Solid Particles (Dust, Dirt):** These can enter through leaks or from the environment.
3. **Oil (Lubricating Oil):** Oil carryover can happen from compressors or from lubricated moving parts within the system.

(b) Why These Contaminants Are Undesirable:

1. **Moisture (Water Vapor):**
   - **Corrosion:** Water reacts with metal components in valves, cylinders, and pipelines, leading to rust and premature wear.
   - **Freezing:** In cold environments, water can freeze and cause blockages or damage components.
   - **Reduced Lubricity:** Water weakens the lubricating film formed by condensed moisture in the system, increasing friction and wear.
2. **Solid Particles (Dust, Dirt):**
   - **Abrasion:** Particles can cause wear and tear on internal components, reducing efficiency and lifespan.
   - **Sticking Valves:** Particles can jam or restrict movement in valves, affecting system operation.
   - **Filter Clogging:** Particles can clog filters, reducing air flow and potentially leading to pressure drops.
3. **Oil (Lubricating Oil):**
   - **Valve Malfunction:** Oil can coat spools and seals in valves, causing them to stick or malfunction.

- **Contaminated System Components:** Oil can contaminate downstream components like sensors and actuators, affecting their performance.
- **Fire Hazard:** In some applications, oil contamination can create a fire hazard, especially near high-temperature components.

April 2021

April 2021

4. With reference to accumulators in pneumatic control systems:

(a) state the TWO main purposes; (2)

(b) explain why EACH of the purposes stated in part (a) are required. (8)

Accumulators in Pneumatic Control Systems

Accumulators play a vital role in pneumatic control systems by serving two key purposes:

(a) Two Main Purposes:

1. **Maintaining System Pressure:** Accumulators act as a reservoir to store compressed air, ensuring consistent pressure during peak demand periods when the compressor cannot keep up.
2. **Smoothing Pressure Fluctuations:** Accumulators help dampen pressure spikes and surges caused by rapid actuator operation or system cycling.

(b) Importance of Each Purpose:

1. **Maintaining System Pressure (Prevents Pressure Drops):**
- **Ensures Consistent Operation:** In applications requiring constant pressure for reliable operation (e.g., assembly lines, presses), pressure drops due to high demand can disrupt processes. Accumulators provide a buffer, maintaining pressure for smooth operation even when the compressor cycles on and off.
- **Protects Components:** Sudden pressure drops can stress components like valves and cylinders. Accumulators help mitigate these drops, reducing strain and extending component life.
2. **Smoothing Pressure Fluctuations (Prevents Erratic Behavior):**
- **Improves System Performance:** Pressure spikes caused by rapid actuator movement can lead to erratic system behavior or even damage components. Accumulators absorb these spikes, ensuring smoother operation and precise control.
- **Reduces Noise and Vibration:** Pressure fluctuations can generate noise and vibration. Accumulators dampen these fluctuations, creating a quieter and more stable operating environment.

By fulfilling these functions, accumulators contribute to a more reliable, efficient, and smoother operation of pneumatic control systems.

Feb 19th 2021

4. With reference to pneumatic control systems, explain EACH of the following:

(a) why moisture is undesirable; (4)

(b) why oil is generally undesirable; (3)

(c) why oil may be intentionally introduced into parts of the system. (3)

Moisture and Oil in Pneumatic Control Systems

Here's a breakdown of why moisture and oil are generally undesirable in pneumatic control systems, along with the exceptions where oil might be intentionally introduced:

(a) Why Moisture is Undesirable:

Moisture, in the form of water vapor, is a major enemy of pneumatic systems for several reasons:

- **Corrosion:** Water reacts with metal components in valves, cylinders, and pipelines, leading to rust and premature wear. This can cause leaks, reduced performance, and ultimately system failure.
- **Freezing:** In cold environments, water can freeze and cause blockages or damage components. Frozen water can restrict air flow, disrupt system operation, and even burst pipes or valves.
- **Reduced Lubricity:** Compressed air naturally condenses some moisture, which can form a thin film on internal surfaces. However, excessive moisture weakens this film, increasing friction and wear on moving parts.

(b) Why Oil is Generally Undesirable:

While some pneumatic systems use oil lubrication, it's generally undesirable for most due to its potential negative effects:

- **Valve Malfunction:** Oil can coat spools and seals in valves, causing them to stick or malfunction. This can lead to erratic system behavior, reduced responsiveness, and even complete control loss.
- **Contaminated System Components:** Oil can migrate downstream and contaminate components like sensors and actuators, affecting their performance and accuracy. Sensors may become less sensitive, and actuators might experience increased friction or even binding.
- **Fire Hazard:** In some applications, especially those involving high-temperature components or flammable materials, oil contamination can create a fire hazard. Oil can act as a fuel source and ignite if exposed to sparks or high temperatures.

(c) When Oil Might Be Intentionally Introduced:

Despite its downsides, oil is intentionally introduced in specific situations:

- **Lubrication of Moving Parts:** In certain pneumatic systems, particularly those with moving parts like pistons or bearings, oil is used for lubrication to reduce friction and wear. This is especially important for components that experience high loads or frequent cycling.
- **Sealing Purposes:** In some cases, a small amount of oil may be used to improve sealing in specific components, such as threaded connections or specialized pneumatic cylinders. The oil helps create a tighter seal to prevent air leaks.

However, it's crucial to use the correct type and amount of oil specifically designed for pneumatic systems. Using excessive oil or inappropriate types can still lead to the problems mentioned earlier.

July 2021

July 2021

4. With reference to the cleanliness of hydraulic systems on board an ocean going vessel:

(a) list FOUR contaminants; (4)

(b) describe the steps that should be taken to eliminate the contaminants listed in part(a). (6)

Contaminants and Cleaning in Hydraulic Systems on Ocean Vessels

Maintaining clean hydraulic systems is crucial for the smooth operation of machinery on an ocean vessel. Here's a look at some common contaminants and how to eliminate them:

(a) Four Contaminants:

1. **Water:** A major enemy of hydraulic systems, water causes corrosion, reduces lubrication, and promotes sludge formation.
2. **Dirt and Dust:** Airborne particles can enter through leaks or during maintenance, causing abrasion and jamming components.
3. **Wear Debris:** As components wear, tiny metal particles can circulate in the fluid, accelerating wear and damaging other parts.
4. **Microbial Growth:** In warm, moist environments, bacteria and fungi can grow in the hydraulic fluid, degrading its properties and potentially causing blockages.

(b) Steps to Eliminate Contaminants:

1. **Fluid Filtration:** Utilize high-quality filters with the appropriate micron rating to remove particles like dirt, dust, and wear debris. Regular filter changes are essential.
2. **Fluid Analysis:** Periodically analyze the hydraulic fluid to check for water content, viscosity, and contamination levels. This helps identify problems early on.
3. **System Flushing:** If significant contamination is suspected, flushing the system with clean fluid can remove water, debris, and microbial growth. Specialized flushing procedures might be required.
4. **Breather Maintenance:** Breather filters prevent external contamination from entering the system. Regularly inspect and replace breather elements to ensure proper function.
5. **Sealing Practices:** Utilize proper sealing techniques during maintenance to prevent leaks that could allow water or dirt ingress.

6. **Reservoir Maintenance:** Regularly clean the hydraulic fluid reservoir to remove any settled contaminants or sludge buildup.
7. **Moisture Control:** Implement measures to minimize condensation in the system, such as using moisture-absorbent breather elements or maintaining proper operating temperatures.
8. **Biocide Treatment:** In some cases, biocides might be added to the fluid to control microbial growth. However, this should be done under the guidance of a qualified technician to ensure compatibility with the system and avoid harming components.

By implementing these steps and maintaining a good preventive maintenance program, you can significantly reduce contamination in your vessel's hydraulic systems, ensuring reliable operation and extending equipment life.

March 19th 2021

March 19th 2021

4. With reference to pneumatic control systems, explain EACH of the following:

(a) why having a supply of clean dry air is important; (5)

(b) how a supply of clean dry air is achieved. (5)

lean and Dry Air in Pneumatic Control Systems

(a) Why Clean and Dry Air is Important:

A clean and dry air supply is crucial for optimal performance and longevity in pneumatic control systems for several reasons:

- **Prevents Corrosion:** Moisture (water vapor) reacts with metal components in valves, cylinders, and pipelines, leading to rust and premature wear. This can cause leaks, reduced performance, and ultimately system failure. Clean, dry air minimizes water content, preventing corrosion and extending component life.
- **Reduces Friction and Wear:** Compressed air naturally condenses some moisture, which can form a thin film on internal surfaces. However, excessive moisture weakens this film, increasing friction and wear on moving parts like pistons and seals. Clean, dry air ensures proper lubrication and reduces wear.
- **Prevents Malfunctions:** Water can cause valves to stick or malfunction due to internal corrosion or ice formation (in cold environments). Clean, dry air prevents these issues, ensuring reliable and precise control of pneumatic actuators.
- **Protects Downstream Equipment:** Some pneumatic systems have components like sensors and air tools that are sensitive to contamination. Clean, dry air minimizes the risk of oil or dirt contamination from upstream components, protecting these downstream elements.
- **Improves System Efficiency:** Moisture and contaminants can restrict air flow and cause pressure drops. Clean, dry air ensures smooth flow and efficient operation, maximizing system performance.

(b) How a Clean and Dry Air Supply is Achieved:

There are several methods for achieving a clean and dry air supply in pneumatic systems:

1. **Air Filtration:** Multistage air filters are used to remove solid particles like dust, dirt, and rust from the compressed air. These filters typically consist of a pre-filter for larger particles and a coalescing filter for finer particles and water droplets.
2. **Refrigerated Air Dryers:** These dryers cool the compressed air to a temperature below its dew point, causing moisture to condense and separate. The condensate is then drained automatically, leaving behind dry air.
3. **Desiccant Air Dryers:** These dryers utilize desiccant materials that absorb moisture from the compressed air. The desiccant is regenerated by heating it periodically, releasing the absorbed moisture.
4. **Drain Traps:** These automatic traps collect and drain condensate that accumulates in pipelines or low-point areas of the system. This helps prevent water from re-entering the air stream.

The specific method used to achieve clean and dry air depends on factors like the required level of dryness, ambient temperature, and system pressure. Consulting with a compressed air specialist can help determine the most suitable solution for your specific needs.

March 26th 2021

March 26th 2021

4. Describe TWO methods of drying compressed air for use in a pneumatic control system. (10)

Here are two common methods for drying compressed air used in pneumatic control systems:

1. **Refrigerated Air Dryers:**

This method utilizes refrigeration technology to remove moisture from the compressed air. Here's how it works:

- **Cooling Process:** The compressed air passes through a heat exchanger where it's cooled by a refrigerant. This cooling process lowers the air temperature to a point below its dew point, the temperature at which water vapor condenses into liquid water.
- **Moisture Condensation:** As the air cools below its dew point, the water vapor present in the air condenses and forms droplets.
- **Separation and Drainage:** The condensed water droplets are separated from the air stream using a separator. This separator can be a cyclone separator that utilizes centrifugal force or a coalescing filter that allows water droplets to merge into larger drops, facilitating easier separation.
- **Dry Air Output:** The separated water is automatically drained from the system, leaving behind dry air that exits the dryer.

Refrigerated dryers are a popular choice for pneumatic control systems due to their:

- **Simplicity:** They have a relatively simple design with readily available components.
- **Reliability:** They offer reliable operation and require minimal maintenance compared to other methods.
- **Cost-Effectiveness:** They are a cost-effective solution for applications requiring moderate levels of dryness.

However, refrigerated dryers have limitations:

- **Energy Consumption:** The refrigeration process requires continuous energy input, adding to the operating cost.
- **Temperature Dependence:** Their effectiveness depends on the ambient temperature. In very cold environments, additional measures like pre-heating the air might be needed to prevent excessive moisture from reaching the dryer.
- **Dew Point Limitations:** Refrigerated dryers typically achieve a dew point in the range of 35°F to 50°F (2°C to 10°C). For applications requiring extremely dry air, other methods might be necessary.

2. **Desiccant Air Dryers:**

This method utilizes desiccant materials to remove moisture from the compressed air. Here's the basic process:

- **Desiccant Adsorption:** The compressed air is passed through a vessel containing a desiccant material, a highly hygroscopic substance that readily absorbs moisture from its surroundings. As the air comes in contact with the desiccant, the water vapor is adsorbed (attracted and held on the surface) by the desiccant.
- **Dry Air Output:** The dehydrated air exits the vessel, now significantly drier than before entering.
- **Desiccant Regeneration:** Over time, the desiccant becomes saturated with moisture and loses its effectiveness. Desiccant dryers typically employ a regeneration cycle where the desiccant is heated. This heating process drives off the absorbed moisture, allowing the desiccant to be reused.

Desiccant dryers offer several advantages:

- **Lower Dew Points:** They can achieve much lower dew points than refrigerated dryers, reaching dew points below -100°F (-73°C) in some cases. This makes them ideal for applications requiring extremely dry air.
- **Temperature Independence:** They are less affected by ambient temperature fluctuations compared to refrigerated dryers.

However, desiccant dryers also have some drawbacks:

- **Complexity:** They can be more complex and require more maintenance compared to refrigerated dryers. The regeneration process needs to be carefully controlled to ensure efficient operation and prevent desiccant degradation.
- **Higher Initial Cost:** They typically have a higher initial cost than refrigerated dryers.
- **Energy Consumption:** While they don't require continuous energy input like refrigeration, the regeneration cycle does consume energy.

The choice between these two methods depends on the specific needs of your pneumatic control system. Consider factors like the required level of dryness, ambient temperature, energy consumption, budget, and maintenance requirements when making your decision.

May 28th 2021

4. Describe, with the aid of a sketch, a pressure reducing valve suitable for supplying control air from the main starting air supply. (10)

For supplying control air from the main starting air supply in a pneumatic control system, a pilot-operated pressure reducing valve is the most suitable option. Here's a breakdown of its features and why it's well-suited for this application:

Pilot-Operated Pressure Reducing Valve:

This type of valve uses a separate pilot section to control the main valve, offering precise and stable pressure regulation. Here's how it works:

1. **Main Valve and Seat:** The main valve consists of a spool or poppet that controls the flow of air from the high-pressure (starting air) inlet to the low-pressure (control air) outlet. The valve seat provides a seal against the main spool or poppet.
2. **Pilot Section:** The pilot section has a small diaphragm or piston that senses the downstream (control air) pressure. It is typically connected to the outlet of the main valve.
3. **Pressure Regulation:** When the downstream pressure falls below the desired set point, the pilot section senses the decrease. This triggers a signal (pneumatic or mechanical) that opens the main valve slightly, allowing more high-pressure air to flow and increase the downstream pressure.
4. **Pressure Feedback and Stability:** As the downstream pressure rises towards the set point, the pilot section detects the increase and closes the main valve slightly, maintaining a constant downstream pressure. This feedback loop ensures stable and precise pressure regulation.

Suitability for Supplying Control Air:

- **Accurate Pressure Regulation:** Pilot-operated valves offer high accuracy in maintaining the desired control air pressure, crucial for reliable operation of pneumatic actuators.
- **Wide Pressure Range:** These valves can handle a wide range of upstream (starting air) pressures while precisely regulating the lower downstream (control air) pressure.
- **Stable Operation:** The pilot section's feedback loop ensures stable pressure output, even with fluctuations in the upstream pressure or downstream demand.
- **Dirt Tolerance:** Pilot-operated valves can be relatively tolerant of dirt particles compared to some other pressure reducing valve designs.

Additional Considerations:

- **Material Selection:** The valve body and internal components should be made of materials compatible with the compressed air system and any lubricants used.
- **Flow Capacity:** Select a valve with a flow capacity sufficient to meet the maximum required control air demand in your system.
- **Pressure Relief Option:** Some models may have a built-in pressure relief valve to protect the downstream system from excessive pressure in case of malfunction.

By choosing a pilot-operated pressure reducing valve with the appropriate specifications, you can ensure a reliable and stable supply of control air for your pneumatic control system.

Nov 2023

4. Sketch a hydraulic circuit using standard symbols showing a unidirectional, constant pressure pump driving a bidirectional motor that is reversed by means of a manually operated direction valve. The motor should have pilot non-return valves as isolating valves. (10)

Hydraulic Circuit with Unidirectional Pump, Bidirectional Motor, and Manual Direction Valve

This circuit uses a fixed displacement pump (unidirectional) to drive a bidirectional motor controlled by a manually operated direction valve. Pilot non-return valves act as isolating valves for the motor.

Components (Standard Symbols):

- **P** - Fixed Displacement Pump (Triangle with arrow pointing upwards)
- **PRV** - Pressure Relief Valve (Triangle with spring on top)
- **M** - Bidirectional Motor (Gear symbol with two arrows, one on each side)
- **LV1** - Pilot Non-Return Valve (Arrow pointing right with check valve symbol) - Installed on Line A to Motor
- **LV2** - Pilot Non-Return Valve (Arrow pointing left with check valve symbol) - Installed on Line B to Motor
- **DVC** - Manually Operated 4-Way, 3-Position Direction Control Valve (Square with two spools, center position with blocked paths, other positions with connected paths)
- **T** - Reservoir (Rectangle)

Connections:

1. **P** outlet connects to the line feeding **PRV**.
2. **PRV** outlet connects to a line that splits into two paths.
3. One path connects to the inlet port of **DVC**.
4. The other path connects to the reservoir (**T**).
5. **DVC** has three positions: Center, Forward, and Reverse.
6. In the **Center** position, both paths from the pressure relief valve are blocked within the valve.
7. In the **Forward** position, the line from the pressure relief valve connects to the outlet port of **DVC** which in turn connects to the inlet port of **LV1** (Line A). The outlet of **LV1** connects to Line A of the **M**.
8. In the **Reverse** position, the line from the pressure relief valve connects to the other outlet port of **DVC** which connects to the inlet port of **LV2** (Line B). The outlet of **LV2** connects to Line B of the **M**.
9. The outlet of the **M** drains back to the reservoir (**T**).

Operation:

- The pump continuously delivers pressurized fluid.
- The pressure relief valve maintains a constant system pressure by bypassing excess flow back to the reservoir.
- In the **Center** position of the direction control valve, the motor is stopped because both lines to the motor are blocked by the pilot non-return valves.

- In the **Forward** position, the pressurized fluid flows through **DVC** to **LV1** and then to Line A of the motor, causing it to rotate in one direction. The pilot non-return valve (**LV2**) on Line B prevents backflow from the motor.
- In the **Reverse** position, the pressurized fluid flows through **DVC** to **LV2** and then to Line B of the motor, causing it to rotate in the opposite direction. The pilot non-return valve (**LV1**) on Line A prevents backflow from the motor.

Notes:

- This is a simple open-loop system. It lacks feedback on the motor's actual speed or position.
- The pilot non-return valves act as isolating valves, allowing flow in one direction only and preventing backflow when the motor is not energized.
- By manually operating the direction control valve, the operator can control the direction of the motor.

This circuit is suitable for applications requiring a simple and cost-effective method for controlling the direction of a bidirectional motor using a constant pressure source.