Pneumatics and Hydraulics

Lecture 12: Pneumatic system design and development part 2

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Outline

- Development of pneumatic systems
- Design of the circuit diagram
- Control System Development
- Positional sketch
- Motion diagram
- Control chart
- Function diagram
- Function chart
- Circuit diagram
- The life cycle of a pneumatic system

Development of pneumatic systems

- The solution to a control problem is worked out according to a system with documentation playing an important role in communicating the final result.
- The circuit diagram should be drawn using standard symbols and labeling.

Comprehensive documentation is required including most of the following:

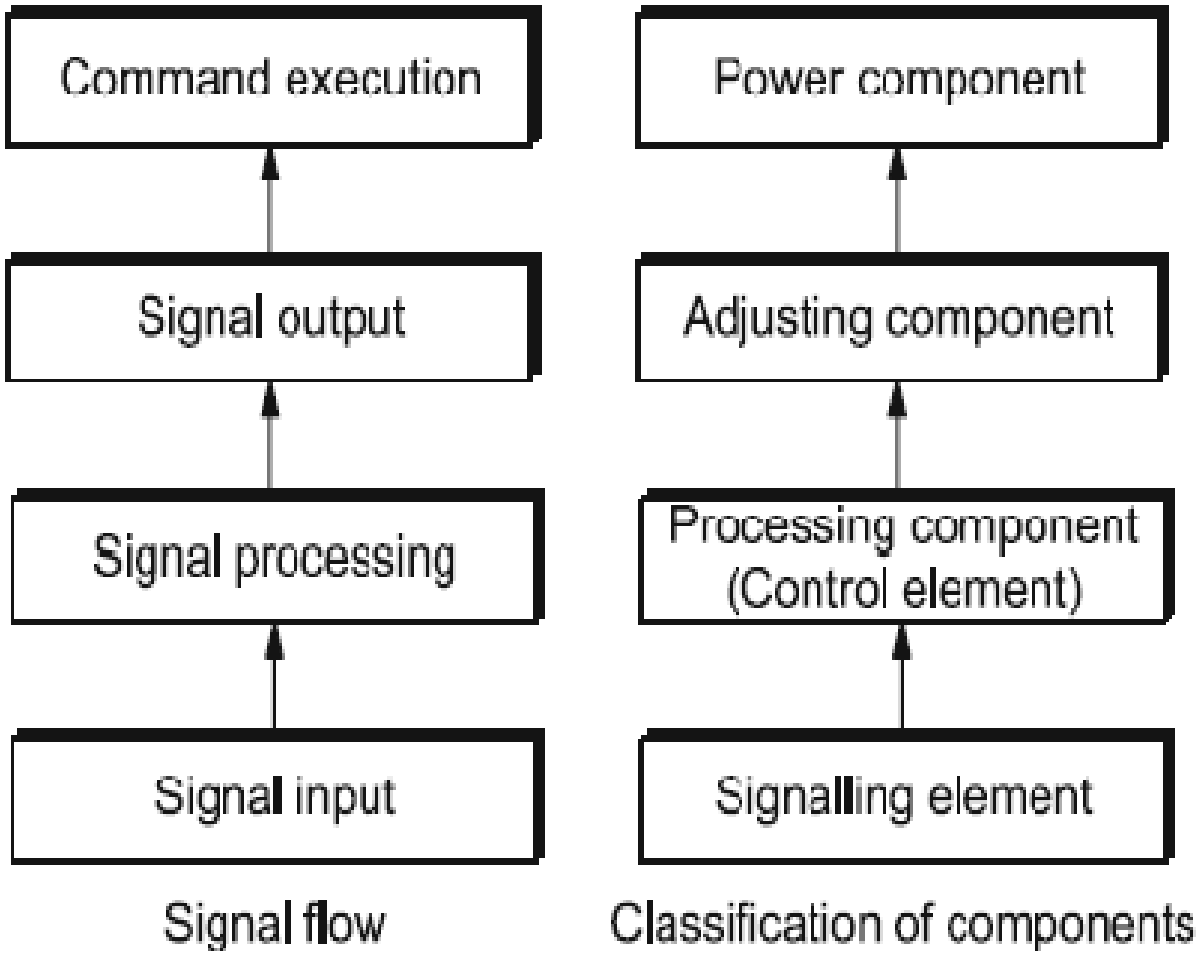
1. Function diagram
2. Circuit diagram
3. Description of the operation of the system
4. Technical data on the components

Supplementary documentation comprising:

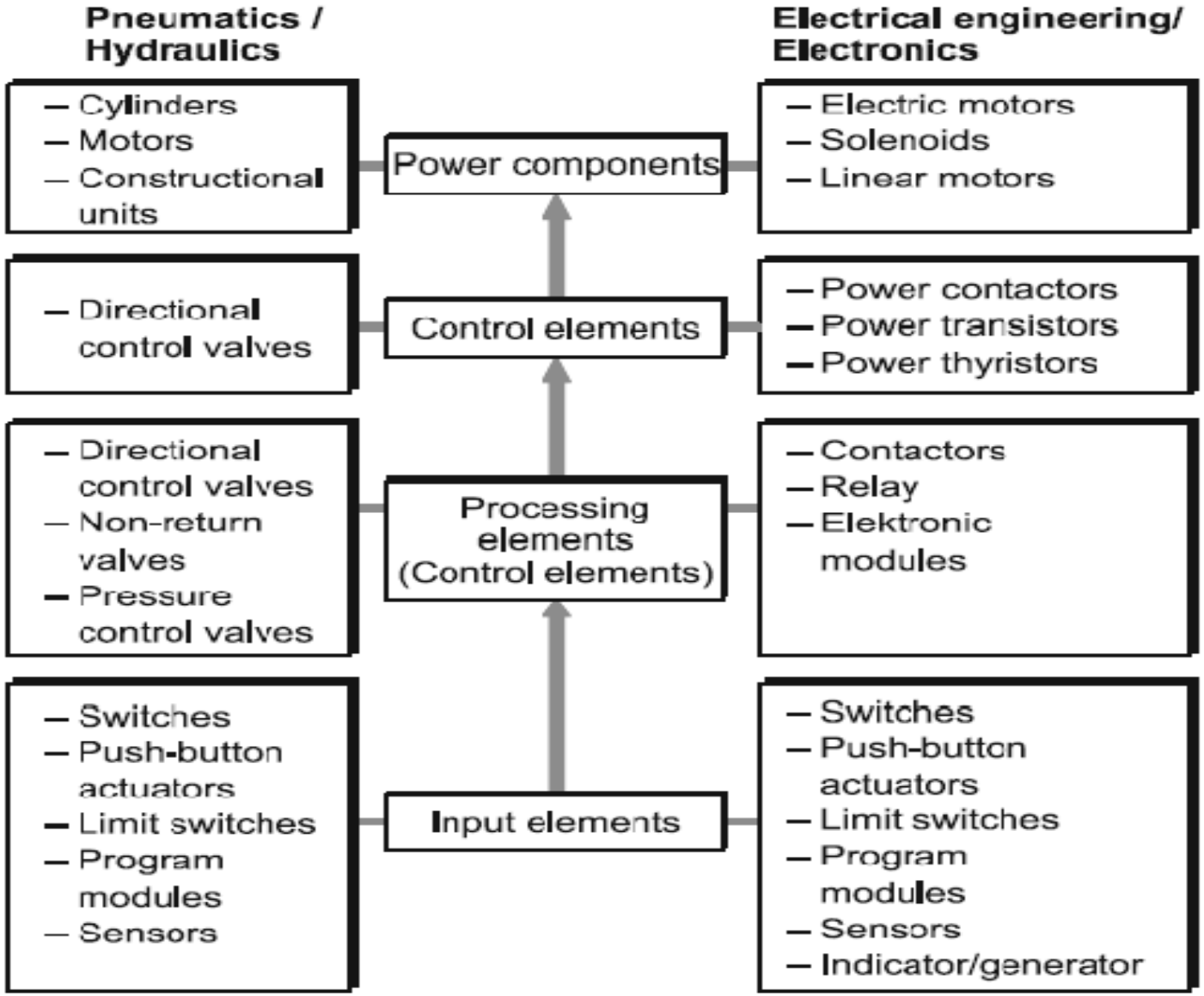
1. Parts list of all components in the system
2. Maintenance and fault-finding information
3. Spare parts list

Design of the circuit diagram

Control Chain(Control System Representation)



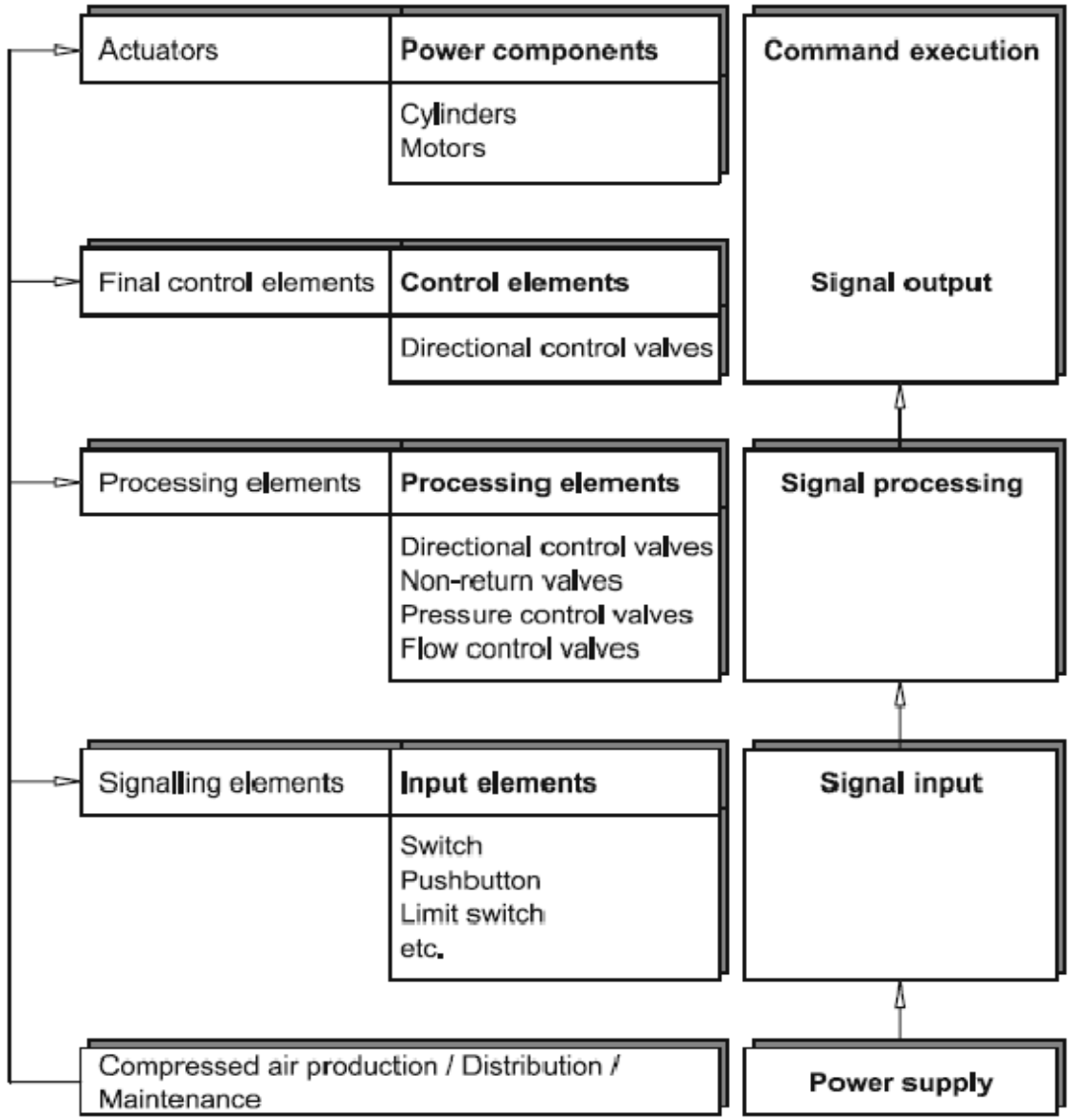
Design of the circuit diagram



Design of the circuit diagram

- The circuit diagram shows signal flow and the relationship between components and the air connections.
- The structure of the circuit diagram should correspond to the control chain, whereby the signal flow is represented from the bottom to the top.
- Simplified or detailed symbols may be used for the representation of the circuit diagram.
- In the case of larger circuit diagrams, the power supply parts (service unit, shut-off valve, various distributor connections) are shown on a separate page of the drawing for the purpose of simplification

Design of the circuit diagram



Design of the circuit diagram

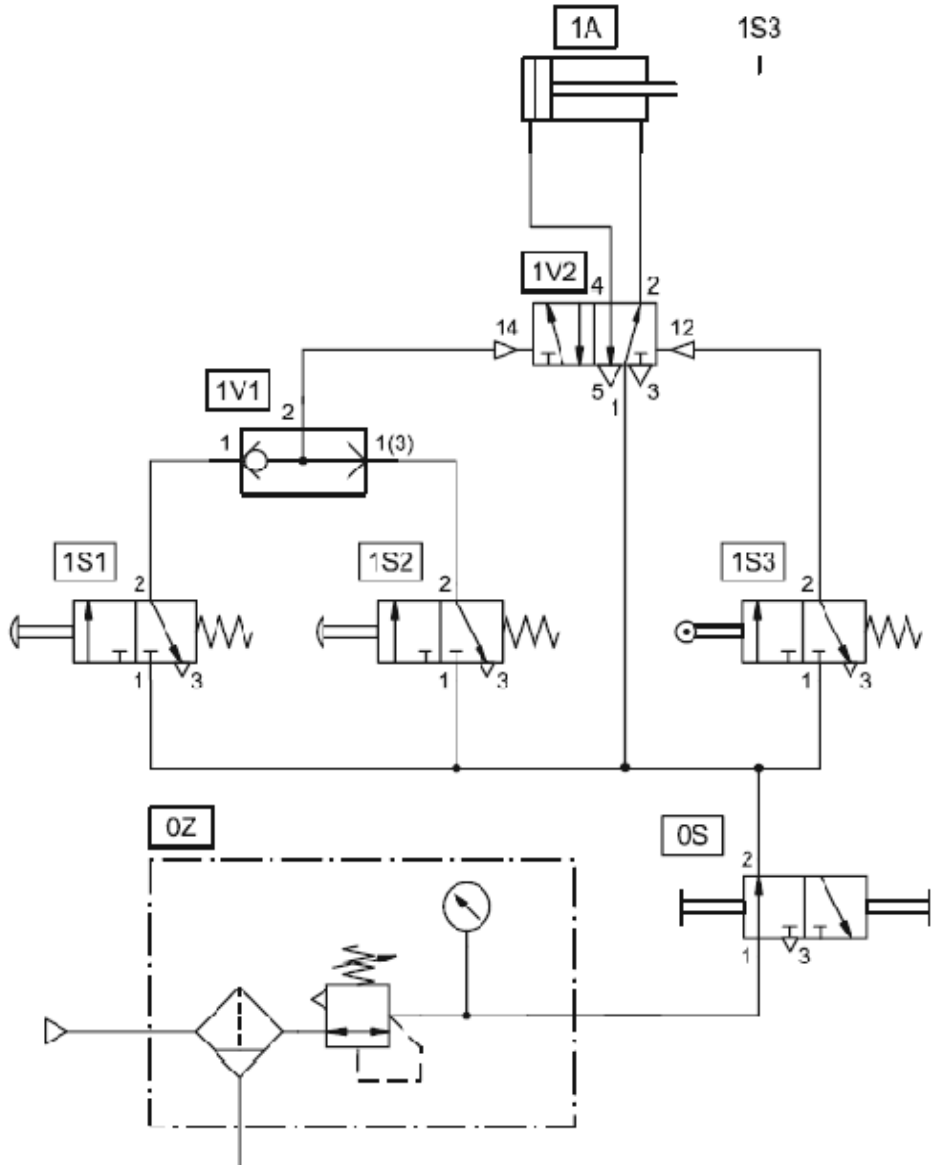
Power component

Control element

Processing element

Input elements

Supply elements



Designation of individual elements

- Signal elements should be represented in the normal position in the circuit diagram. (remember some valves are normally open or normally closed)
- If valves are actuated in the initial position as a start precondition, this must be indicated by the representation.
- In this case, the actuated switching position must be connected.

Designation by numbers

- With this type of designation, elements are divided into groups. Group 0 contains the elements for the power supply, groups 1,2,... Designate the individual control chains.
- One group number is generally allocated for each cylinder.

0Z1, 0Z2 etc.	Energy supply unit
1A, 2A, etc.	Power components
1V1, 1V2, etc	Control elements
1S1, 1S2, etc	Input elements (manually and mechanically actuated valves)

Designation by Letters

- This type of designation is used primarily for a systematic development of circuit diagrams. Here, limit switches are allocated to the cylinder, which acknowledges them.

1A, 2A, etc.	Power components
1S1, 2S1, etc.	Limit switches, activated in the retracted end position of cylinders 1A, 2A
1S2, 2S2, etc.	Limit switches, activated in the forward end position of cylinders 1A, 2A

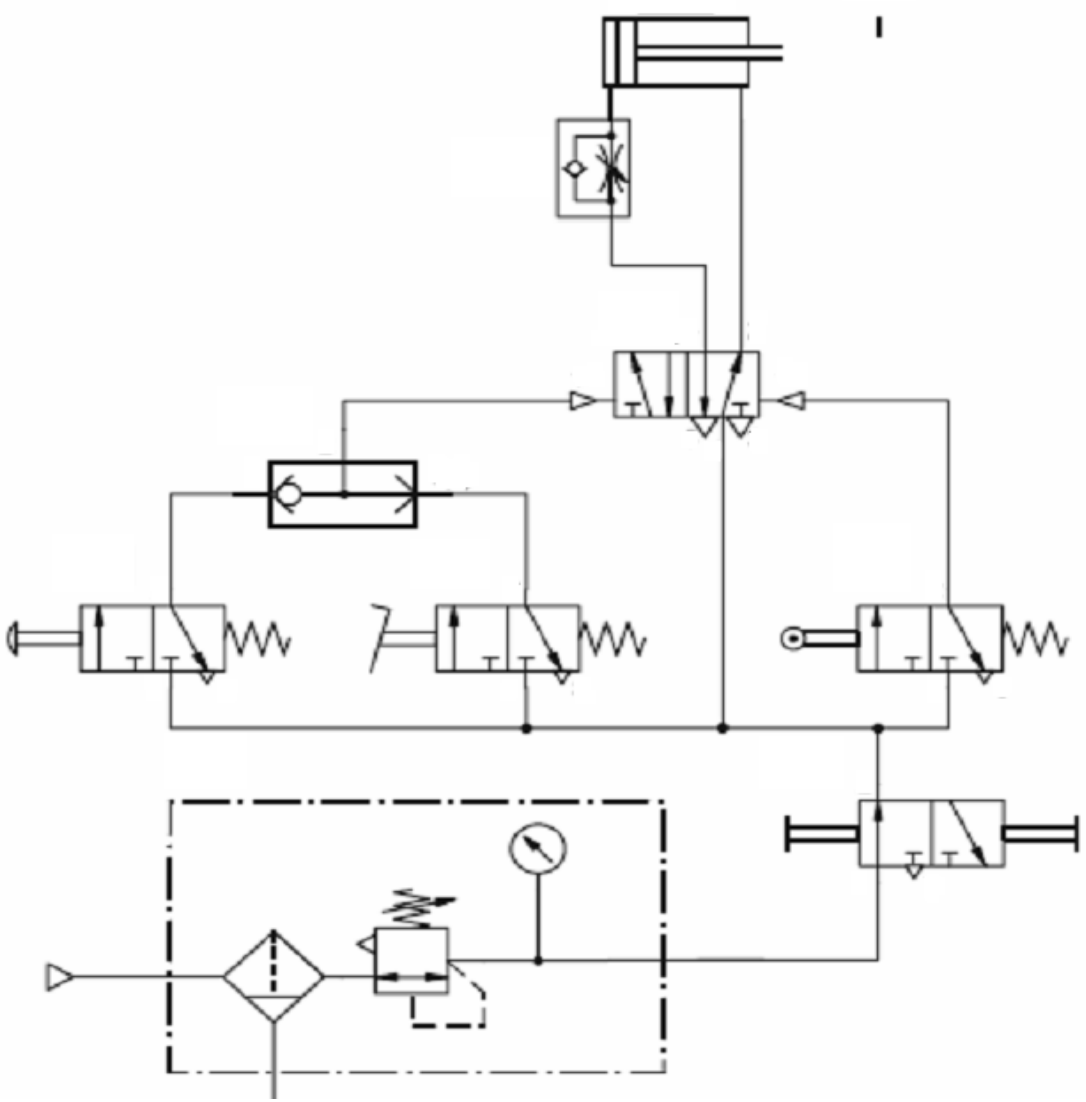
Example:

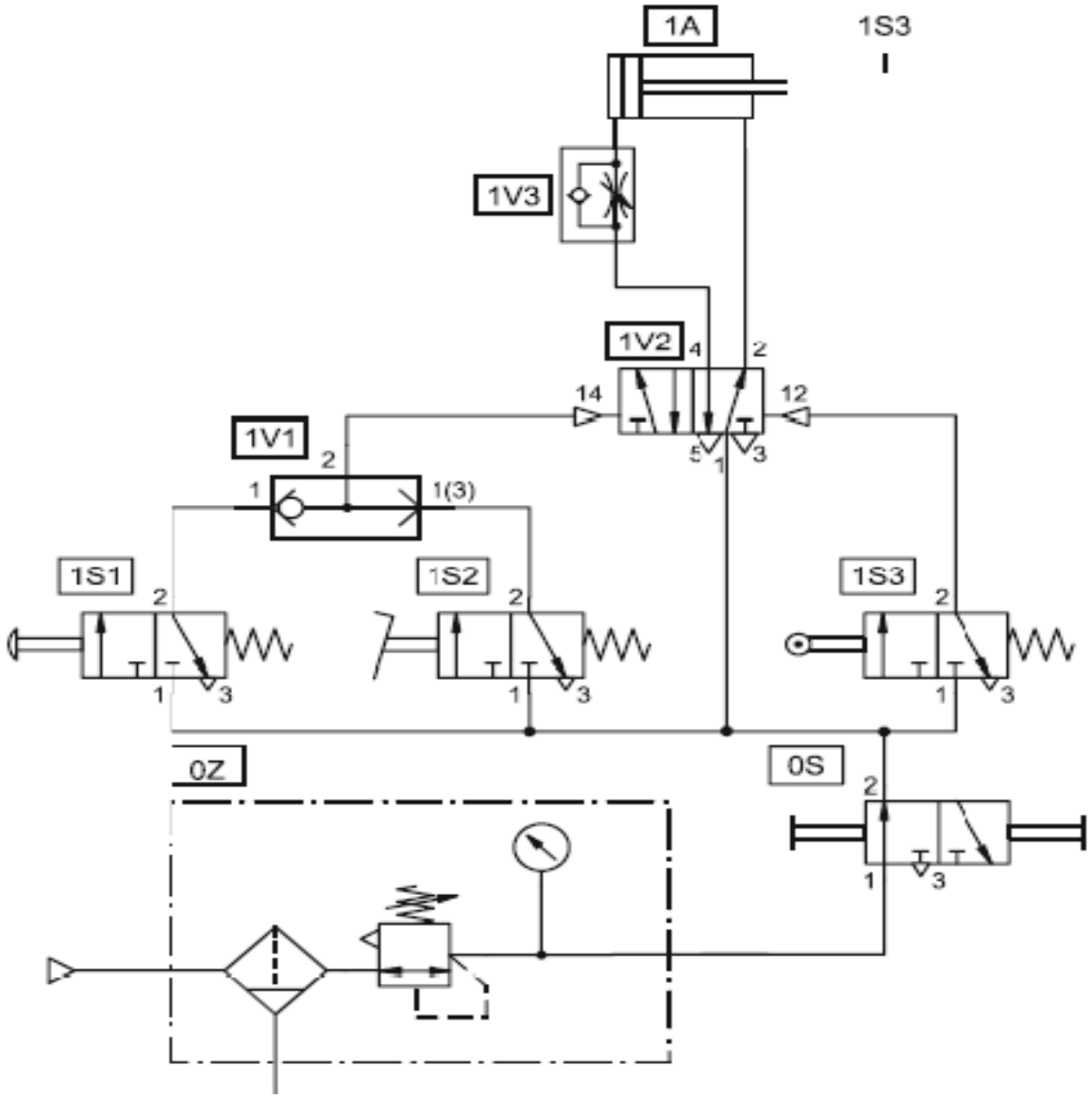
- **Typical problem:**
  - The piston rod of a double-acting pneumatic cylinder advances if either a manual push button or a foot pedal is operated.
  - The cylinder returns to its starting position slowed down after fully extending.
  - The piston rod will return provided the manual actuators have been released.

Example: Solution

- The roller lever valve 1S3 is positioned as a limit switch in the forward end position of the cylinder.
- The circuit diagram shows this element situated at the signal input level and does not directly reflect the orientation of the valve.
- The mark on the circuit at the extended cylinder position indicates the physical position of the limit switch 1S3 for circuit operation.
- If the control is complex and contains several working elements, the control should be broken down into separate control chains, whereby a chain is formed for each cylinder.
- Wherever possible, these chains should be drawn next to each other in the same order as the operating sequence.

Example:




1A
1S3
1V3
1V2
4
2
14
12
5
1
3
1V1
2
1
1(3)
1S1
2
1
3
1S2
2
1
3
1S3
2
1
3
0Z
0S
2
1
3

Summary of design of the circuit diagram

- Physical arrangement of the elements is ignored.
- Draw the cylinders and directional control valves horizontally wherever possible.
- The energy flow within the circuit moves from the bottom to the top.
- Energy source can be shown in simplified form.
- Show elements in the initial position of the control. Identify actuated elements.
- Draw pipelines straight without cross-over wherever possible.

Control System Development

•The development of the control system solution requires that the problem is defined clearly.

•There are many ways of representing the problem in a descriptive or graphical form.

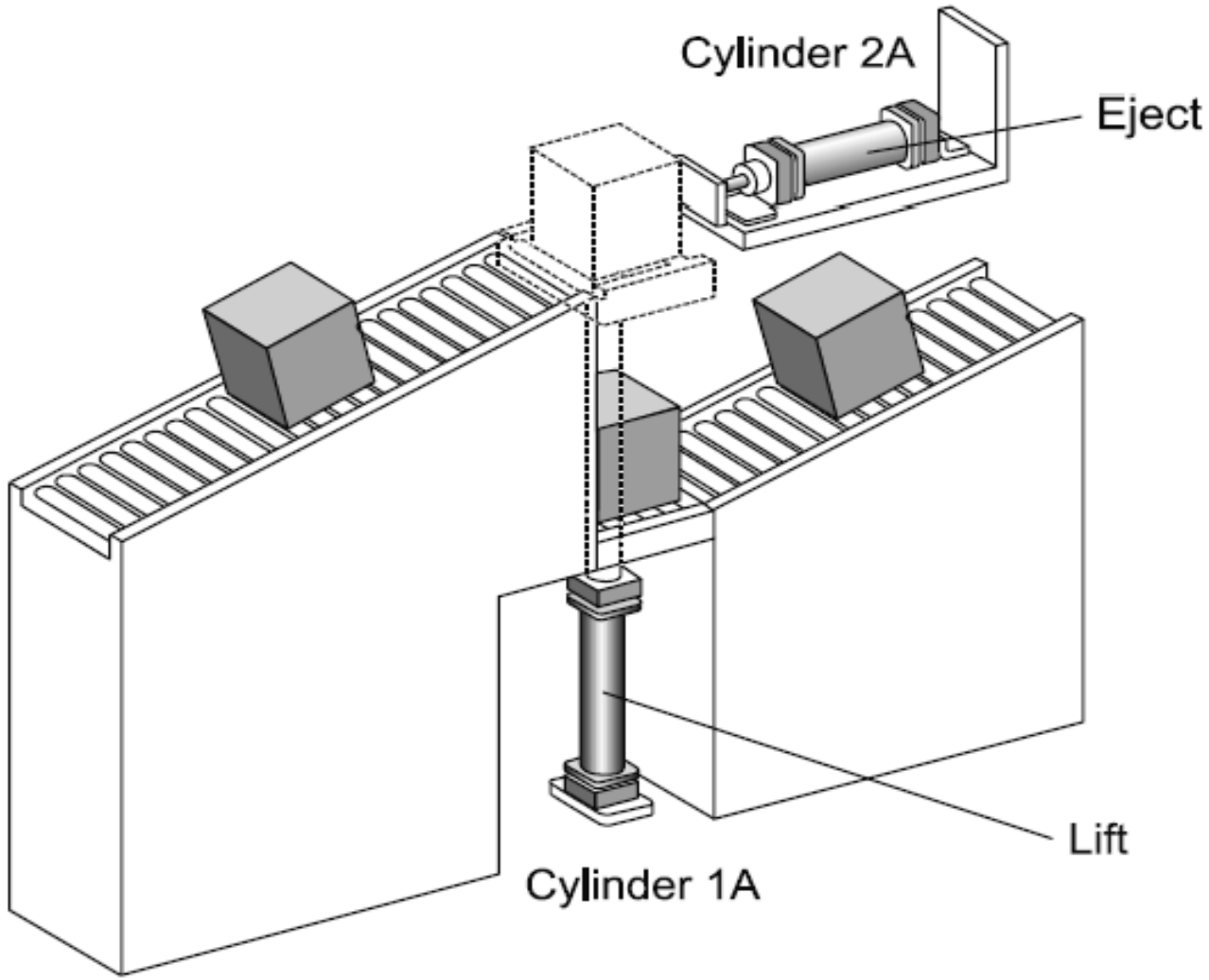
The methods of representing the control problem include:

- Positional sketch
- Motion diagram:
  -Displacement-Step Diagram.
  -Displacement-Time Diagram.
- Control chart
- Function diagram
- Function chart
- Circuit diagram

Positional sketch

- The positional sketch shows the relationship between the actuators and the machine fixture.
- The actuators are shown in the correct orientation.
- The positional sketch is not normally to scale and should not be too detailed.
- The diagram will be used in conjunction with the description of the machine operation and the motion diagrams.

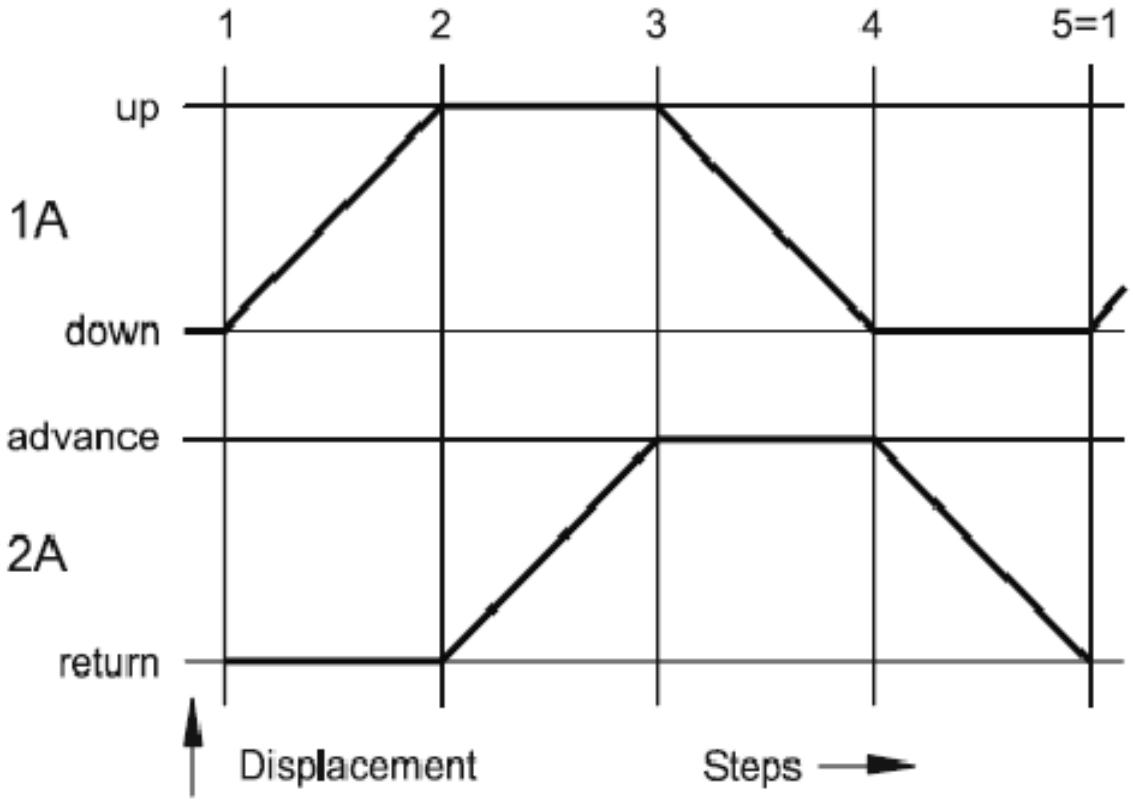
Positional sketch



Motion diagram

- The displacement-step diagram and the displacement-time diagram are used for motion sequences.
- The displacement-step diagram represents the operating sequence of the actuators; the displacement is recorded in relation to the sequence step.
- If a control system incorporates a number of actuators, they are shown in the same way and are drawn one below the other.
- Their interrelation can be seen by comparing the steps.

Motion diagram: Displacement-step diagram

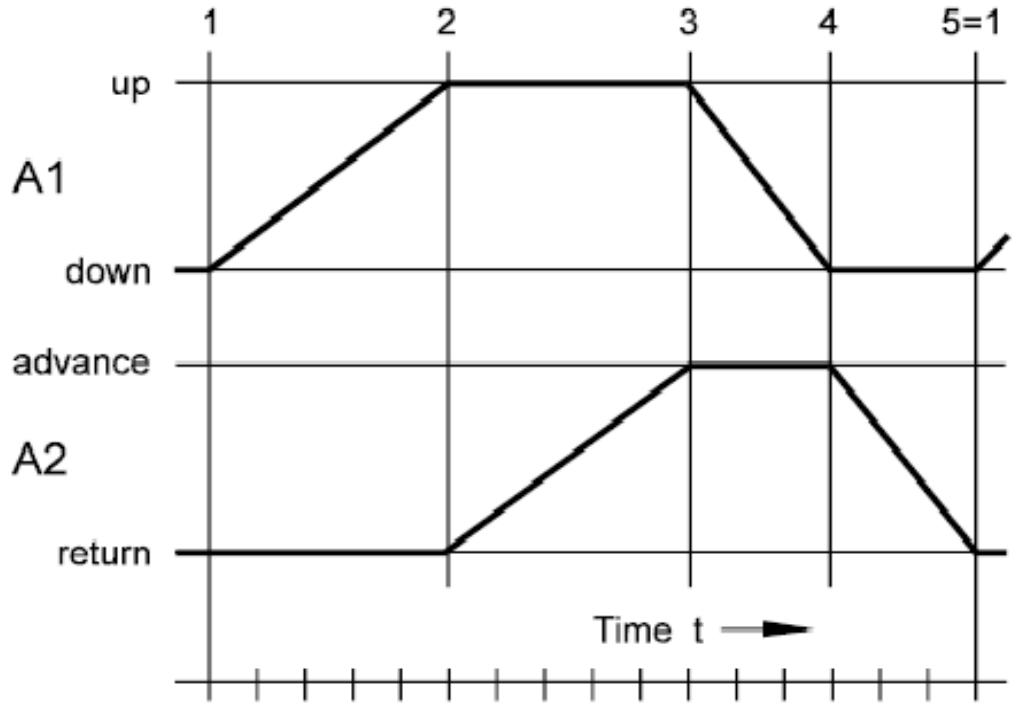


Displacement-step diagram

In this case there are two cylinders 1A and 2A. In step 1, cylinder 1A extends and then cylinder 2A extends in step 2. In step 3, cylinder 1A retracts and in step 4, cylinder 2A retracts. Step number 5 is equivalent to step 1.

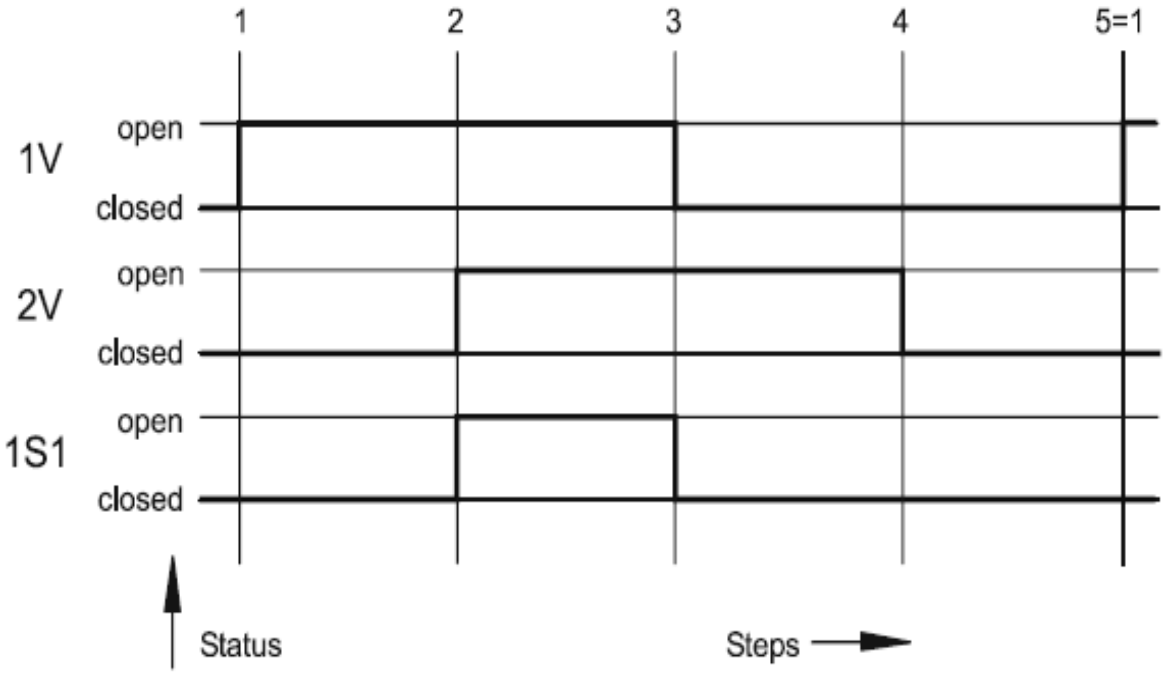
Displacement-time diagram

In the case of a displacement-time diagram, the displacement is plotted in relation to the time.



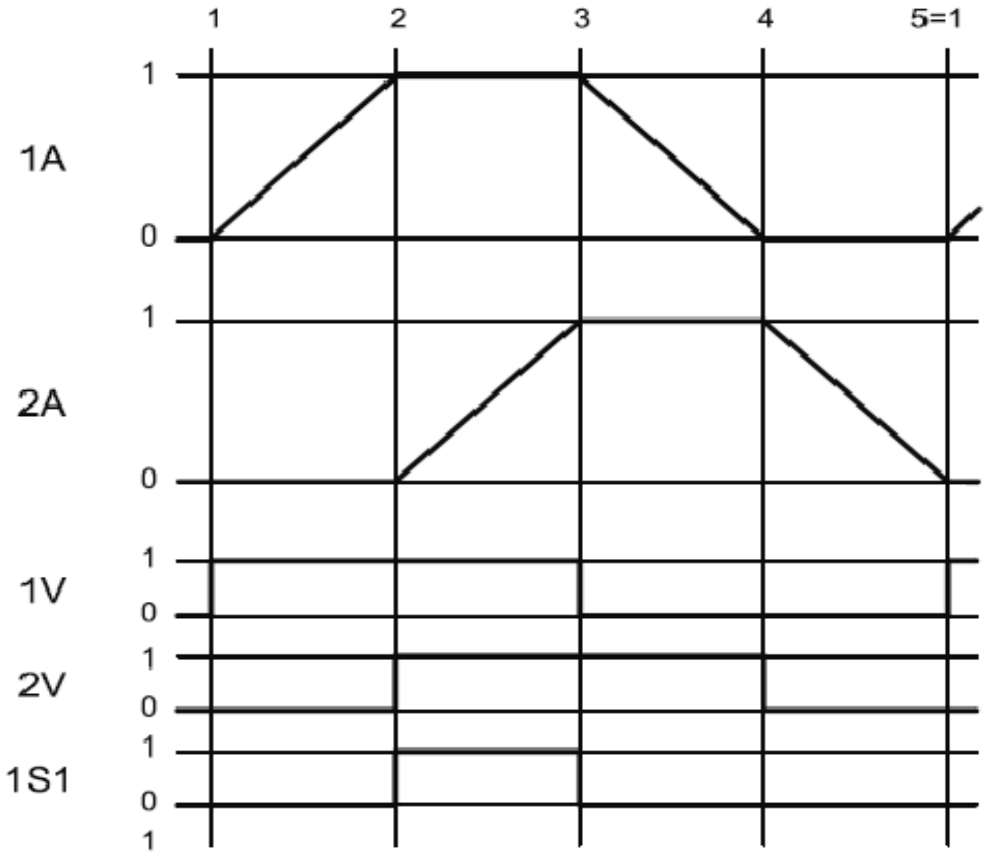
Control chart

- In the control chart, the switching status of the control element is represented in relation to the steps or the time.
- The switching time is not taken into account.
- The control diagram in the following figure shows the statuses of the control components (1V for cylinder 1A and 2V for cy1inder 2A) and the status of the limit switch 1S1 fitted at the front end position of the cylinder 1A.



Function diagram

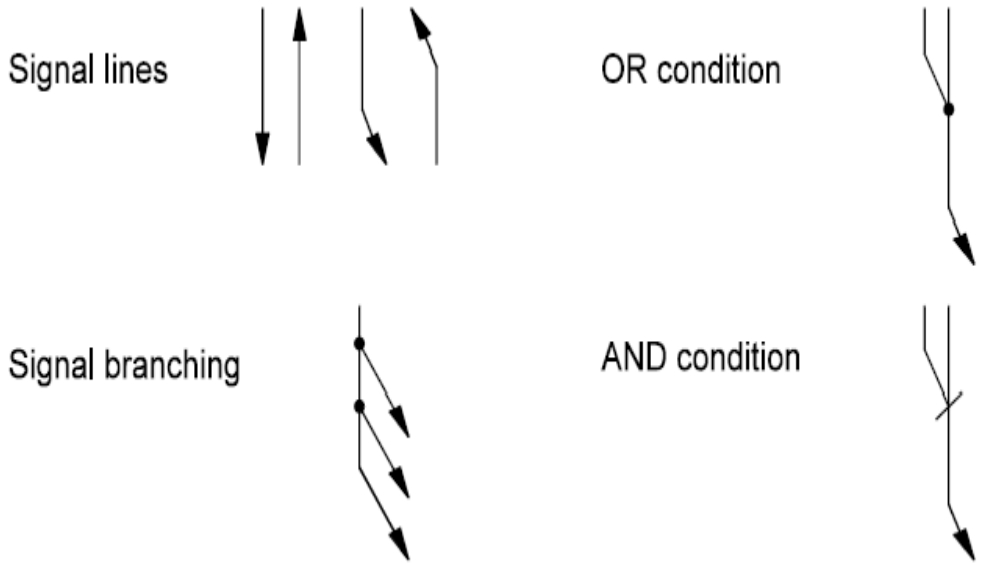
- The function diagram is a combination of the motion diagram and the control chart.
- The lines representing the individual states are referred to as function lines.



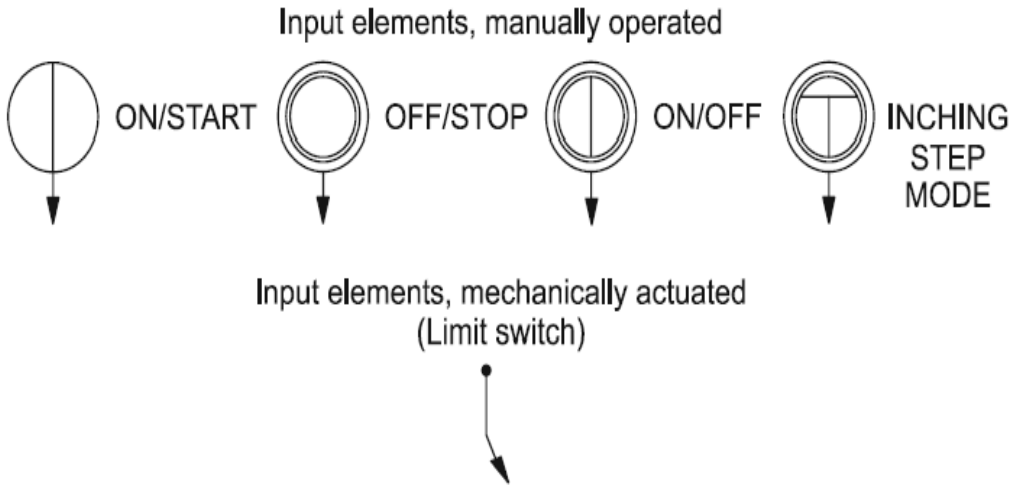
Function diagram

- Apart from the function lines, signal lines can also be entered in the function diagram.
- The signal line output is at the signal element and the end at the point, where a change in status occurs, dependent on this signal.
- Arrows on the signal lines indicate the direction of signal flow.
- Signal branching are denoted by a dot at the point of branching.
- Several changes in status of components are introduced by a signal output.
- In the case of the OR condition, a dot is placed at the point of conjunction of the signal lines.
- Several signal outputs effect the same change in status irrespective of one another.
- The AND condition is designated by means of an oblique stroke at the point of conjunction of the signal lines.
- A change in status only occurs, if all signal outputs are present.

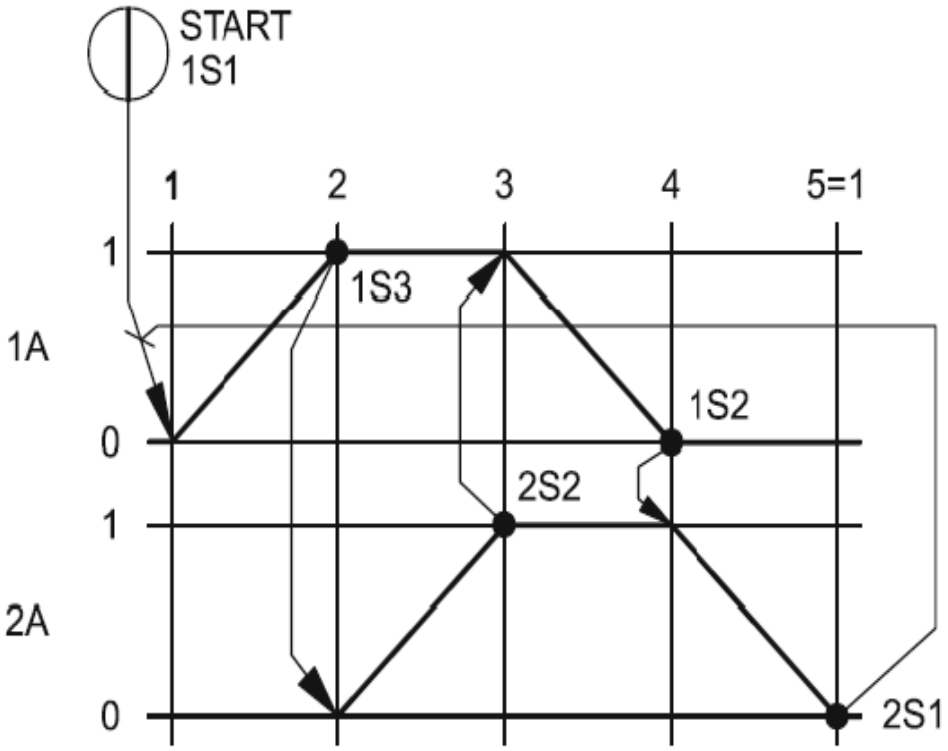
Representation of signal lines



Representation of input elements



example



The diagram illustrates the following sequence:

- If the limit switch 2S1 is actuated ***and*** the push button 1S1 is pressed by the operator, the piston rod of cylinder 1A extends.
- When the cylinder 1A reaches its forward end position, the limit switch 1S3 is actuated and the piston rod of cylinder 2A advances.
- When the cylinder 2A reaches its forward end position, the limit switch 2S2 is actuated and the piston rod of cylinder 1A retracts.
- When the cylinder 1A reaches its retracted end position, the limit switch 1S2 is actuated and the piston rod of cylinder 2A retracts.
- When cylinder 2A reaches its retracted end position, the limit switch 2S1 is actuated and the initial position is reached again.

Abbreviated notation

- Abbreviated notation is another possibility of representing motion sequences. In this case, the cylinder designations 1A, 2A, etc. are used in the sequence.
- The signal for advancing is designated using a '+' and the signal for retracting using a '-'.

- The sequence 1A+ 2A+ 2A- 1A- is to be read as follows: Cylinder 1A advances, cylinder 2A advances, cylinder 2A retracts, cylinder 1A retracts. Sequential movements are written consecutively.

- The sequence 1A+ 2A+ 2A-1A- is to be read as:
- Cylinder 1A advances, cylinder 2A advances ***and*** cylinder 1A retracts, cylinder 2A retracts. ***Simultaneous movements are written vertically***

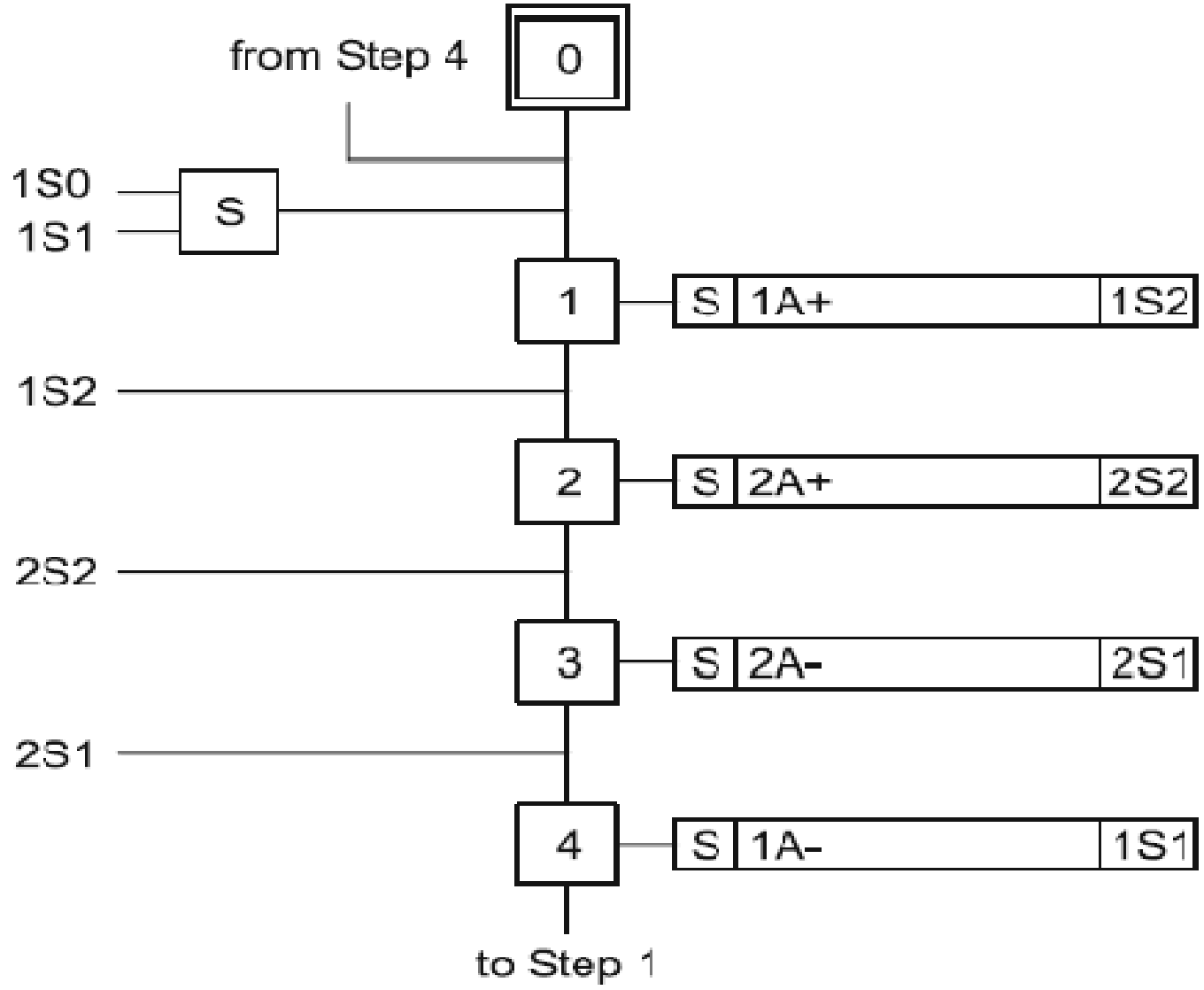
Function chart

- The function chart gives a clear picture of action, and reactions in sequences.

The diagram describes the following sequence: The clamp cylinder 1A is extended (1A+) and the limit valve then operated is 1S2.

- This limit 1S2 initiates the extension of cylinder 2A (2A+) which is the riveting process.
- The riveting cylinder fully extends and operates the limit 2S2.
- The limit 2S2 initiates the retraction of the riveting cylinder (2A-).
- The limit 2S1 is then operated which initiates the movement of cylinder 1A unclamping and retracting (1A-).
- The full retraction of cylinder 1A is indicated by the limit 1S1 and this is the initial condition required for a new cycle to commence.

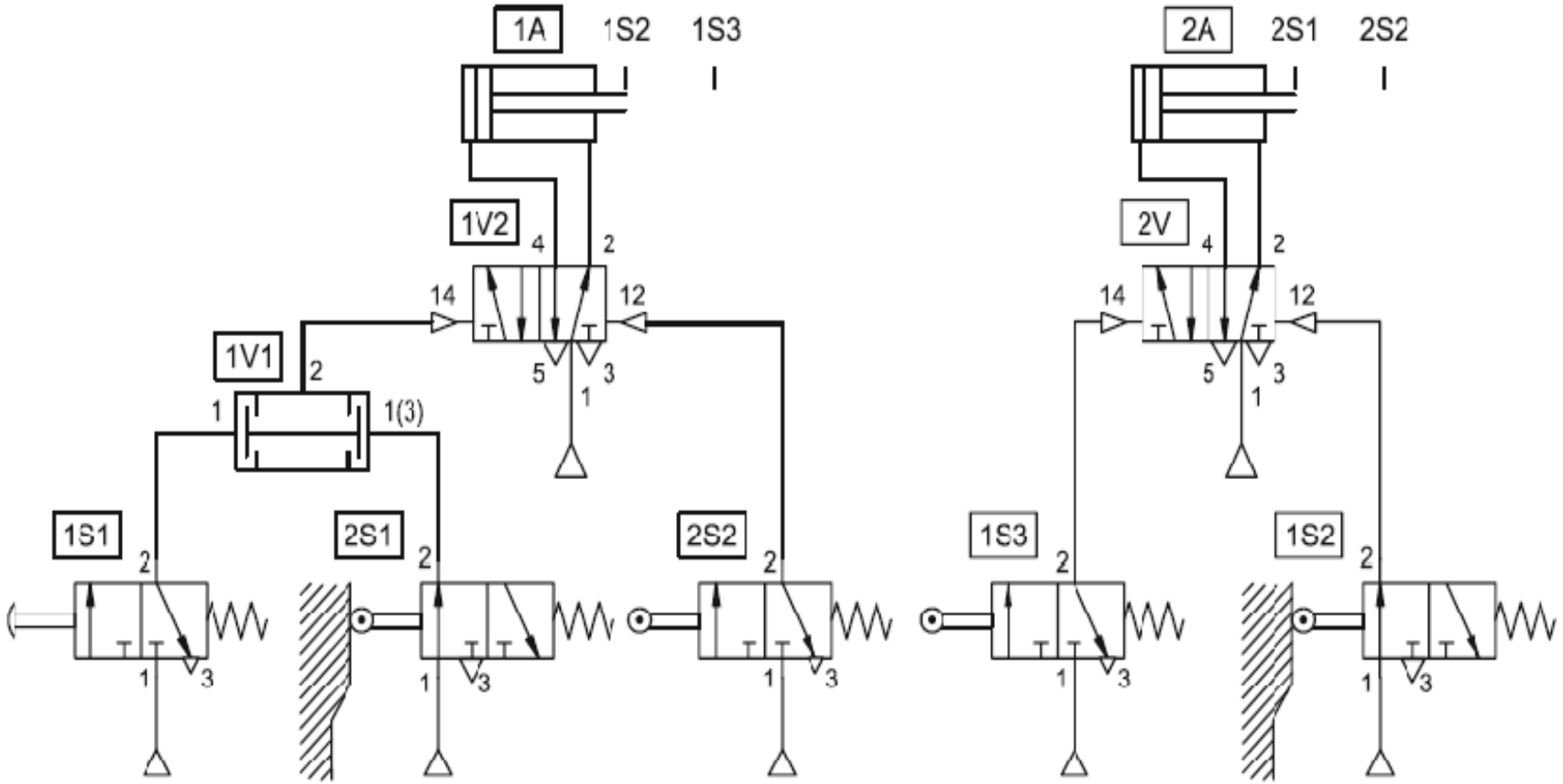
Function chart



Circuit diagram

- The circuit diagram shows signal flow and the relationship between components and the air connections.
- There is no mechanical layout representation with the circuit diagram.
- The circuit is drawn with the energy flow from the bottom to the top.
- The various levels of a circuit include the energy source, signal inputs, signal processing, control elements and the actuators.
- The position of the limit valves are marked at the actuator.
- Components and lines are identified by the component numbering system and the port (way) connection numbers.
- These allow cross reference to the components on the actual machine and make the circuit readable.

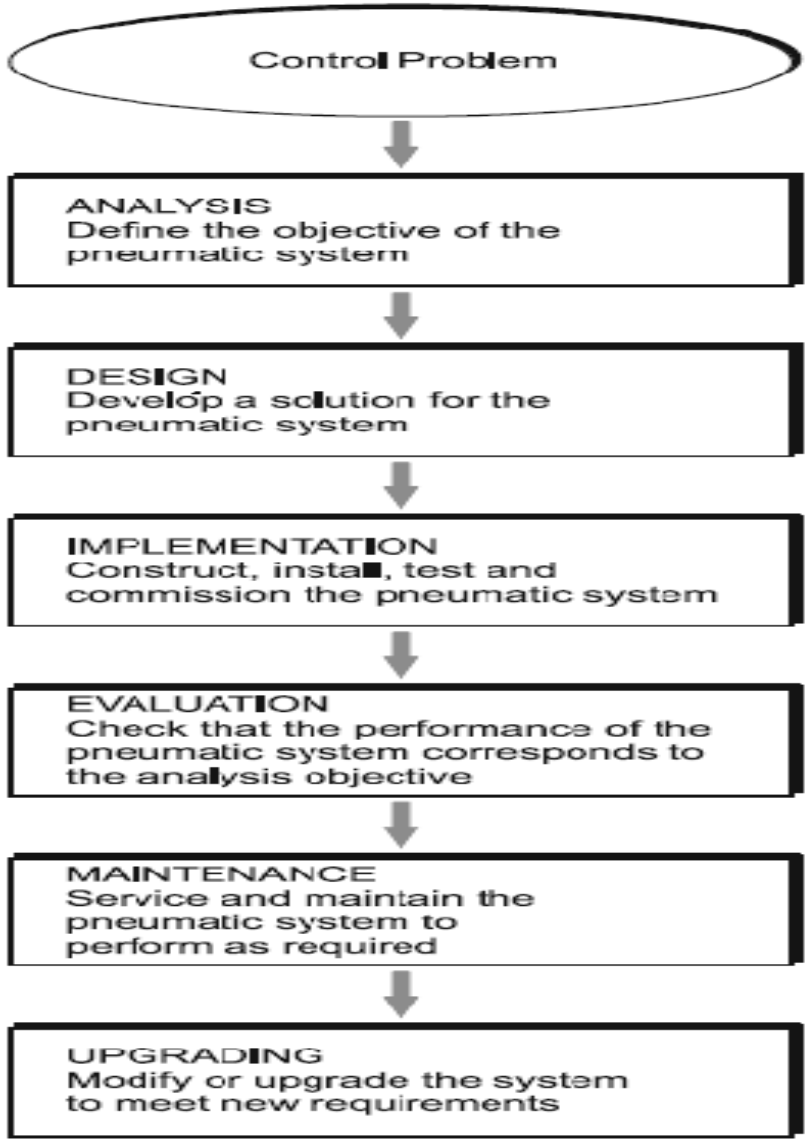
Circuit diagram



The life cycle of a pneumatic system

•The development of solutions for pneumatic control systems is dependent upon methodical planning.

• The various phases involved in the life cycle of such systems from the initial problem to upgrading the system are shown here.



The life cycle of a pneumatic system

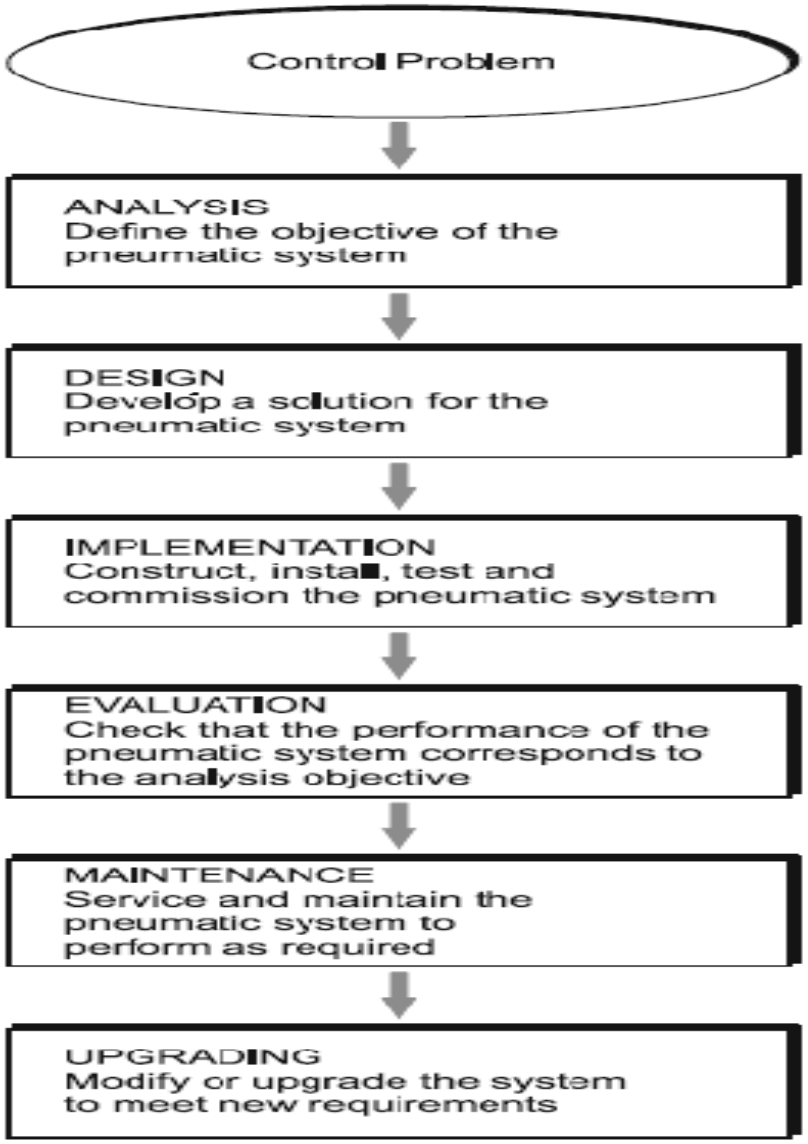
The first step is the definition of objectives for the project with a clear definition of the problem(s). Design or development of the solution is not involved at the analysis stage. A flow chart of the total project plan can be developed to define the step-orientated processes.

There are two stages of design development.

The first is the overall system design where general systems hardware and control medium decisions are made. At this stage alternative solutions may be addressed for consideration.

The next stage of the design process involves the following :

- Development of hardware systems
- Documentation development
- Definition of further requirements
- Time schedules for project implementation
- Product lists and specifications
- Costing data



The life cycle of a pneumatic system

Prior to the system installation, the system's functions must be fully tested. Another function test must be carried out on the final completion of the installation. Finally to ensure the sequence operates under all conditions, the machine must be cycled under all of the expected and specified operating conditions, e.g. manual cycle, auto cycle, emergency conditions, blockages etc.

Upon completion of the commissioning process the final result is evaluated and compared to the original specification and if necessary improvements are made.

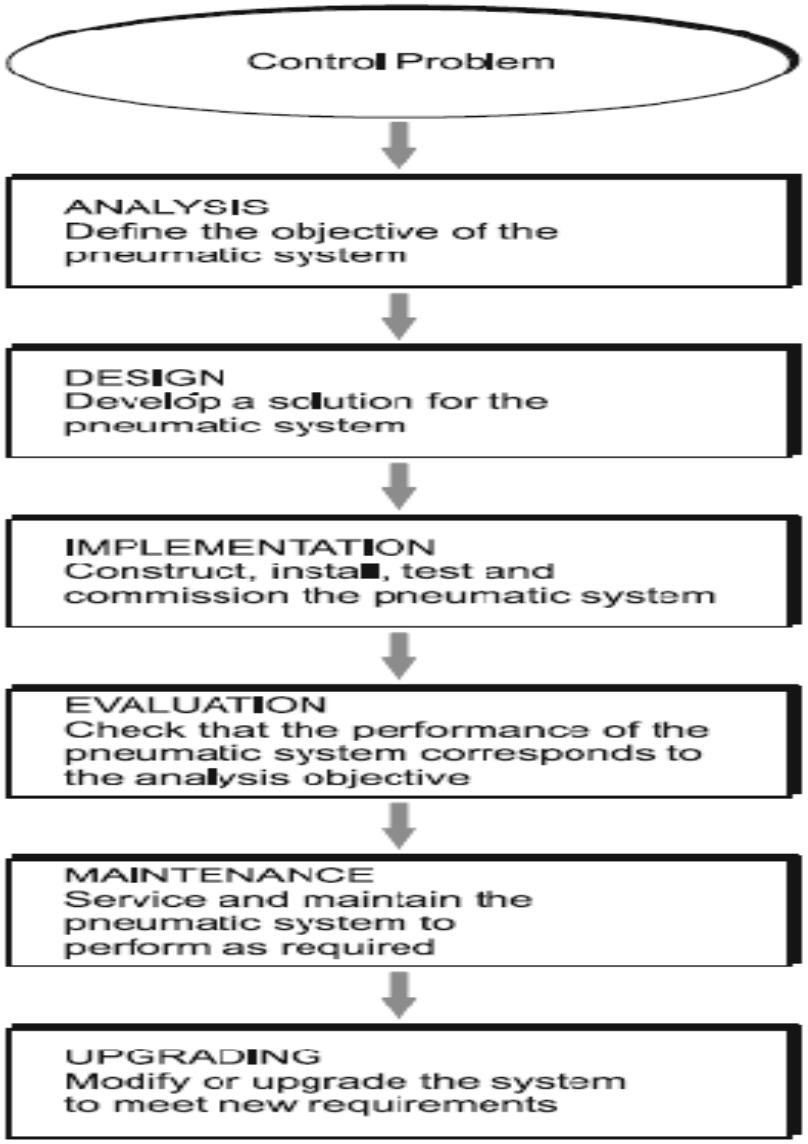
Maintenance is essential to minimise the system downtimes.

Regular and careful maintenance helps to increase the reliability of a system and to reduce the operating costs.

After a certain number of cycles, some components may show signs of early deterioration which might be due to

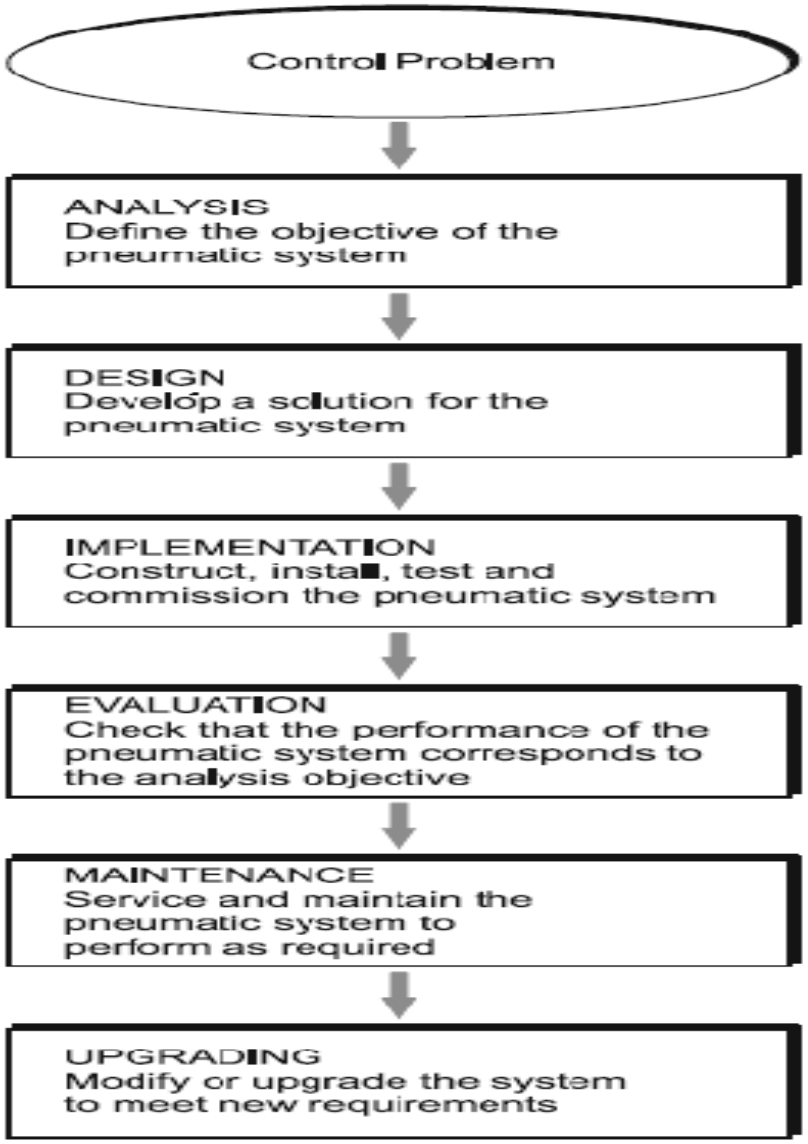
- incorrect product selection or
- a change in operating conditions.

Basic preventive maintenance carried out at regular intervals helps to diagnose failures of this kind and thus avoids system downtimes.



The life cycle of a pneumatic system

Experience gained from the operation, maintenance and repairing of a system, will ensure greater reliability in the event of any system improvements.



Questions