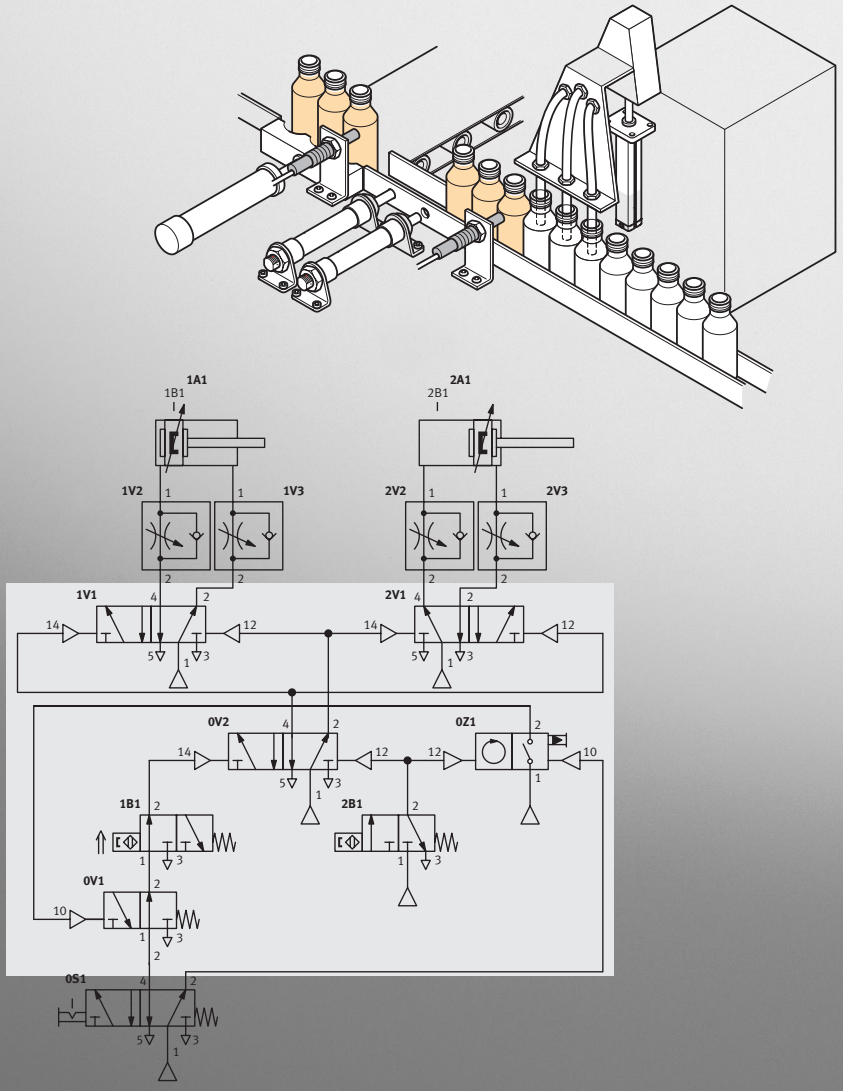
Pneumatics
Advanced level

FESTO

Workbook
TP 102

With CD-ROM



Festo Didactic
541089 EN

Use for intended purpose

The training package for pneumatics, advanced level may only be used:

- For its intended purpose in teaching and training applications
- When its safety functions are in flawless condition

The components included in the training package are laid out in accordance with the latest technology, as well as recognised safety rules. However, life and limb of the user and third parties may be endangered, and the components may be impaired if they are used improperly.

The training system from Festo Didactic has been developed and manufactured for training and vocational education in the field of automation technology. The respective training companies and/or trainers must ensure that all trainees observe the safety precautions which are described in this workbook.

Festo Didactic hereby excludes any and all liability for damages suffered by trainees, the training company and/or any third parties, which occur during use of the equipment sets in situations which serve any purpose other than training and/or vocational education, unless such damages have been caused by Festo Didactic due to malicious intent or gross negligence.

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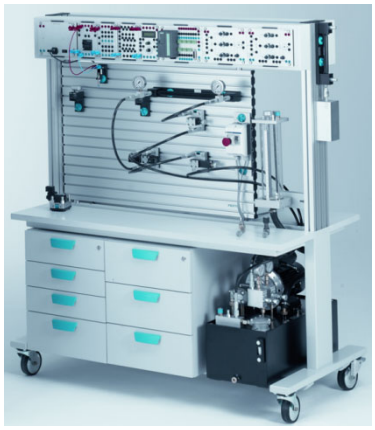
Preface

Festo Didactic's training system for automation technology is geared towards various educational backgrounds and vocational requirements. The training system is therefore broken down as follows:

- Technology-oriented training packages
- Mechatronics and factory automation
- Process automation and control technology
- Robotino® – training and research with mobile robots
- Hybrid learning factories

The technology packages deal with various technologies including pneumatics, electro-pneumatics, hydraulics, electro-hydraulics, proportional hydraulics, programmable logic controllers, sensor technology, electrical engineering and electric drives.



The modular design of the training system allows for applications which go above and beyond the limitations of the individual packages, such as, for example, PLC actuation of pneumatic, hydraulic and electric drives is possible.

All training modules have the same structure:

- Hardware
- Teachware
- Software
- Seminars

The hardware is comprised of industrial components and systems that are specially designed for training purposes.

The structure of the teachware corresponds to that of the training hardware. It includes:

- Textbooks (with exercises and examples)
- Workbooks (with practical exercises, supplementary instructions and solutions)
- Transparencies and videos (for dynamic instruction)

The teaching and learning media are available in several languages. They're intended for use in classroom instruction, but are also suitable for self-study.

Where software is concerned, computer training programs, as well as simulation, visualisation, project engineering, design engineering and programming software, are made available.

A wide range of seminars offerings covering the contents of the training packages round off the programme for training and vocational education.

If you have suggestions or feedback about this manual, please send us an e-mail at did@de.festo.com. The authors and Festo Didactic look forward to your feedback.

Introduction

This workbook is a component part of the Learning System for Automation and Technology of Festo Didactic GmbH & Co. KG. This system provides a solid basis for practice-oriented vocational and further training. Technology package TP 100 is comprised exclusively of pneumatic control systems.

Prerequisite for the assembly of control systems is a fixed workstation using a Festo Didactic profile plate. A mobile, silenced compressor (230 V, maximum 8 bar = 800 kPa) can be used for compressed air supply.

Optimal operational reliability is achieved if the control system is operated on unlubricated air at a working pressure of p = 5 bar = 500 kPa.

The equipment set of Advanced Level TP 102 is used to construct complete control systems for all of the 10 exercise definitions. The theoretical fundamentals to help you understand this collection of exercises can be found in the textbook

- Pneumatics – Basic Level

Also available are data sheets in respect individual devices (cylinders, valves, measuring devices, etc.).

Work instructions and safety precautions

General

- Trainees should only work with the circuits under the supervision of a trainer.
- Observe specifications included in the data sheets for the individual components and in particular all safety instructions!
- Faults which may impair safety must not be generated in the training environment and must be eliminated immediately.

Mechanical setup

- Mount all the components securely onto the profile plate.
- Adhere to instructions regarding positioning of the components.

Electrical setup

- Use low voltage only (max. 24 V DC).
- Electrical connections must only be established and interrupted in the absence of voltage!
- Only use connecting cables with safety plugs for electrical connections.
- Only pull the plug when disconnecting connecting cables – never pull the cable.

Pneumatics

- Do not exceed the maximum permissible pressure of 600 kPa (6 bar).
- Do not activate compressed air until all the tubing connections have been completed and secured.
- Do not disconnect tubing while under pressure.
- Danger of injury when switching compressed air on!
  Cylinders may advance and retract automatically.
- Danger of accident due to tubing slipping off!
  - Use shortest possible tubing connections.
  - Wear safety glasses.
  - In the event that tubing slips off:
    Switch compressed air supply off immediately.
- Pneumatic circuit setup:
  Connect the components with plastic tubing with an outside diameter of 4 or 6 mm. Push the tubing into the push-in connector as far as it will go.
- Switch compressed air supply off before dismantling the circuit.
- Dismantling the pneumatic circuit:
  press the blue release ring down, after which the tubing can be pulled out.

Mounting technology

The mounting boards for the components are equipped with mounting variant A, B or C:

- Variant A, snap-in system
  Lightweight components that are not load-bearing (e.g. directional control valves and sensors). Simply clip the components into the slot on the profile plate. Release the component from the slot by turning the blue lever.
- Variant B, bolt system
  Components with medium load capacity (e.g. pneumatic cylinders). These components are clamped onto the profile plate using T-head bolts. The blue, knurled nut is used for clamping and loosening.
- Variant C, screw system
  For components with high load capacity and components which are seldom removed from the profile plate (for example on-off valve with filter regulator). The components are secured with socket head screws and T-head bolts.

Technology package for pneumatics (TP 100)

The TP 100 technology package consists of a multitude of training materials and seminars. The subject matter of this package is pneumatic controllers. The individual components included in the TP 100 technology package can also be included in other modules.

Important elements of the TP 100 package

- Permanent workstation with Festo Didactic profile plate
- Compressor (230 V, 0.55 kW, max. 8 bar = 800 kPa)
- Equipment sets or individual components (e.g. cylinders, directional control valves, preset counters, stepper modules, logic components, pneumatic proximity switches)
- Optional learning materials (e.g. optical displays, 5/3-way valve, pulling/pushing load)
- Practical training models
- Complete laboratory setups

Training documentation	
Textbooks	TP 101 basic level Fundamentals of pneumatic control technology Maintenance of pneumatic components and systems Pneumatics/electro-pneumatics
Workbooks	TP 101 basic level TP 102 advanced level
Optional teachware	Set of transparencies Magnetic symbols, drawing template FluidSIM® Pneumatik simulation software WBT Pneumatics Set of cutaway models with storage case

Seminars	
P100	Basic pneumatics knowledge for machine operators
P111	Fundamentals of pneumatics and electro-pneumatics
P121	Maintenance and troubleshooting for pneumatic and electro-pneumatic systems
P-OP	Tracking down waste – economic use of pneumatics
P-NEU	Pneumatics refresher and update
IW-PEP	Repair and maintenance in the field of control technology – pneumatic and electro-pneumatic systems
P-AL	Pneumatics for vocational education
P-AZUBI	Pneumatics and electro-pneumatics for trainees

Please refer to the current seminar schedule for event locations, dates and prices.

You'll find further training materials in our catalogue and on the Internet. The training system for automation technology is continuously updated and expanded. Transparency sets, videos, CD-ROMs and DVDs, as well as textbooks, are offered in several languages.

Learning objectives for the basic level (TP 102)

- Become familiar with various types of end-position sensing.
- Become familiar with options for setting up controllers with latching functions.
- Be able to convert 3/2 and/or 5/2-way valves (normally closed/normally open).
- Become familiar with displacement-step diagrams and learn to create them for a specific circuit.
- Be able to implement push-pull circuits with parallel motion.
- Be able to use pneumatic subtraction counters.
- Be able to set up indirect actuation of cylinders.
- Be able to select and adjust suitable sensors for an application.
- Become familiar with the setup and function of a stepper module.
- Be able to set up a basic sequence control system with “continuous cycle”.
- Be able to install one-way flow control valves in accordance with specified conditions.
- Be able to implement OR operations for feedback signals.
- Be able to adjust time delay in accordance with requirements.
- Become familiar with circuits in order to interrupt delay times by means of signal inputs.
- Be able to implement the following input commands:
- emergency stop, acknowledge emergency stop, start, reset, stop at end of cycle and automatic/manual.
- Be able to setup a sequence control system with idle step.
- Become familiar with one way of enabling adjustable step repetitions within a motion sequence and be able to set up the corresponding circuit.
- Be able to develop input circuits with self-latching loop.
- Become familiar with one way or implementing a double stroke for a cylinder and be able to set up the corresponding circuit.
- Become familiar with circuits which enable reversing cylinder motion within the sub-stroke range.
- Be able to develop an input circuit for a sequence control system with secure pilot air.
- Be able to stop a double-acting cylinder within the sub-stroke range.
- Be able to invert valve ouTP ut signals.
- Be able to implement a controller with command action in combination with sequence control.

Allocation of learning objectives per exercise

Exercise / Learning objectives	1	2	3	4	5	6	7	8	9	10
Become familiar with various types of end-position sensing.	●									
Become familiar with options for setting up controllers with latching functions.	●									
Be able to convert 3/2 and/or 5/2-way valves (normally closed/normally open.	●									
Become familiar with displacement-step diagrams and learn to create them for a specific circuit.		●								
Be able to implement push-pull circuits with parallel motion.		●								
Be able to use pneumatic subtraction counters.		●								
Be able to set up indirect actuation of cylinders.			●	●						
Be able to select and adjust suitable sensors for an application.			●				●		●	●
Become familiar with the setup and function of a stepper module.				●						
Be able to set up a basic sequence control system with “continuous cycle”.				●						
Be able to install one-way flow control valves in accordance with specified conditions.				●						
Be able to implement OR operations for feedback signals.					●					
Be able to adjust time delay in accordance with requirements.					●					
Become familiar with circuits in order to interrupt delay times by means of signal inputs.					●					
Be able to set up a sequence control system with input commands including automatic/manual, start and reset.					●					

Exercise Learning objectives	1	2	3	4	5	6	7	8	9	10
Be able to develop input circuits with self-latching loop which allow for the following inputs: automatic/manual, start, stop at end of cycle and reset.							●			
Be able to set up a sequence control system with idle step							●			
Become familiar with one way of enabling adjustable step repetitions within a motion sequence and be able to set up the corresponding circuit.							●			
Become familiar with one way of implementing a double stroke for a cylinder and be able to set up the corresponding circuit.								●		
Become familiar with circuits which enable reversing cylinder motion within the sub-stroke range.								●		
Be able to develop an input circuit for a sequence control system with secure pilot air with the following inputs: start, automatic/manual and reset.								●		
Be able to stop a double-acting cylinder within the sub-stroke range.									●	
Be able to invert valve ouTP ut signals.									●	
Be able to implement a controller with command action in combination with sequence control.										●

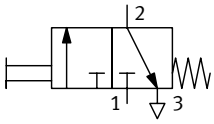
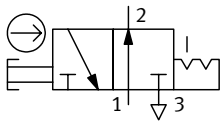
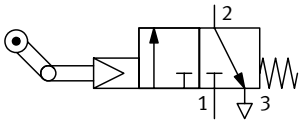
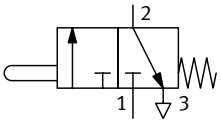
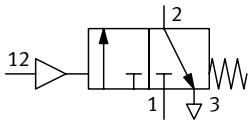
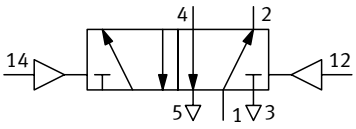
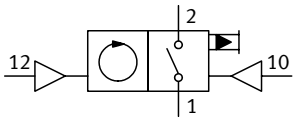
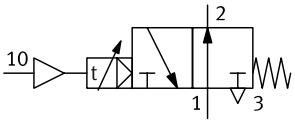
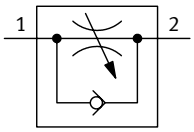
Equipment set for the advanced level (TP 102)

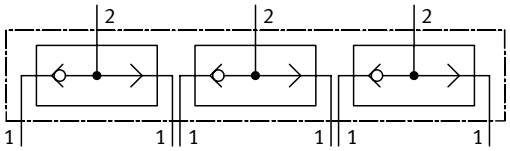
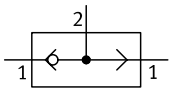
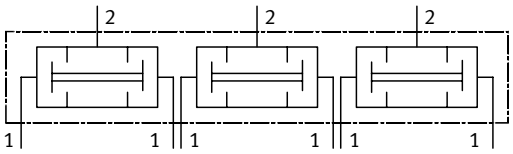
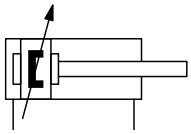
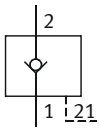
The equipment set for the advanced level has been put together for vocational training in the field of pneumatic control technology. The two equipment sets (TP 101 and TP 102) include components which are necessary for mastering the predefined learning objectives, and can be supplemented with other equipment sets for the training system for automation technology as desired.

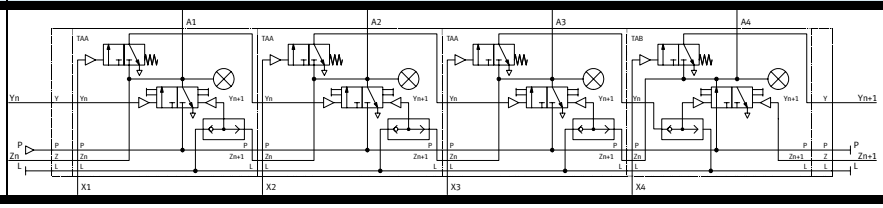
Equipment set for the advanced level (TP 102)

Quantity	Designation	Order no.
1	3/2-way roller lever valve with idle return, normally closed	152867
4	3/2--way pneumatic valve, convertible	539768
2	3/2-way valve with pushbutton actuator, normally closed	152860
1	3/2-way valve with mushroom actuator, normally open (emergency stop)	152864
2	5/2--way pneumatic valve – double pilot valve	539769
2	Double-acting cylinder	152888
2	One-way flow control valve	193967
2	Plastic tubing, 4 x 0.75, 10 m	151496
2	Non-return valve, piloted	540715
1	Back pressure valve	152868
10	Push-in sleeve	153251
1	Stepper module	152886
20	Push-in T-connector	153128
1	Time delay valve, normally open	539759
1	Pneumatic preset counter	152877
1	Shuttle valve	539771
1	Shuttle valve, 3-way	152882
1	Dual-pressure valve, 3-way	152883

Equipment set symbols

Designation	Symbol
3/2-way valve with pushbutton actuator, normally closed	
3/2-way valve with mushroom actuator, normally open (emergency stop)	
3/2-way roller lever valve with idle return, normally closed	
Back pressure valve	
3/2-way pneumatic valve, normally closed	
5/2-way double pilot valve	
Pneumatic preset counter	
Pneumatic timer, normally open	
One-way flow control valve	

Designation	Symbol
Shuttle valve, 3-way	
Shuttle valve	
Dual-pressure valve, 3-way	
Double-acting cylinder	
Non-return valve, piloted	

Designation	Symbol
Stepper module	

Allocation of components per exercise

Exercise / Equipment	1	2	3	4	5	6	7	8	9	10
Cylinder, double-acting	1	2	2	2	2	2	2	1	1	2
One-way flow control valve	2	2	2	2	2	2	2	2	2	2
Non-return valve, piloted									2	
3/2--way pneumatic valve, convertible	2	1			1	3	3	4	3	1
5/2--way pneumatic valve – double pilot valve	2	2	2	2	2	2	2	2		2
3/2-way roller lever valve with idle return, normally closed			1			1				1
Back pressure valve			1			1				1
3/2-way valve with pushbutton actuator, normally closed	1		1		2	2	2	2	1	1
3/2-way valve with mushroom actuator, normally open (emergency stop)						1		1		
Stepper module				1	1	1	1	1	1	
Time delay valve, normally open					1				1	
Pneumatic preset counter		1					1			
Shuttle valve						1		1		1
Shuttle valve, 3-way					3	3	3	3	2	
Dual-pressure valve, 3-way				1	2	3	3	1	1	2

Tools for the trainer

Learning objectives
The basic learning objectives for these exercises are the systematic drafting of circuit diagrams, as well as the practical setup of the controller on the profile plate. This direct interaction involving both theory and practice ensures faster progress and longer-lasting learning. The more specific learning objectives are documented in the matrix. Concrete, individual learning objectives are assigned to each exercise.

Required time
The time required for working through the exercises depends on the student's previous knowledge of the subject matter. For a skilled labourer in the field of metalworking or electrical installation the time required is approx. 2 weeks. For a technician or engineer it is approx. 1 week.

Equipment set components
The exercise book and the equipment set match each other. For all 10 exercises, you'll need the components included in the equipment set for the TP 101 basic level and the TP 102 advanced level.

Each exercise in the basic level can be set up on a profile plate.

Structure of the exercises

All 10 exercises have the same structure and are broken down into:
- Title
- Learning objectives
- Presentation of the problem
- Parameters

and
- Project assignment
- Layout
- Worksheets

The trainer's manual includes the solutions for all 10 exercises.
Enlarged circuit diagrams are included on A3 paper for exercises 4 through 10.

Designations of the components

Pneumatic components are designated in circuit diagrams in accordance with DIN ISO 1219 2. All the components included in any given circuit have the same primary identifying number. Letters are assigned depending on each respective type of component. Consecutive numbers are assigned if several components of the same type are included within a single circuit. Pressure lines are designated with a P and are numbered separately.

Cylinders:	1A1, 2A1, 2A2 ...
Valves:	1V1, 1V2, 1V3, 2V1, 2V2, 3V1 ...
Sensors:	1B1, 1B2 ...
Signal input:	1S1, 1S2 ...
Accessories:	0Z1, 0Z2, 1Z1 ...

CD-ROM contents

The CD-ROM supplied provides you with additional media. The worksheets and solutions have been saved as PDF files on the CD-ROM included with the trainer's manual.

The CD-ROM contains the following folders:

- Operating instructions
- Data sheets
- Demo
- Festo catalogue
- FluidSIM® circuit diagrams
- Industrial applications
- Presentations
- Product information
- Videos

Operating instructions
Operating instructions for various components included in the technology package are available. These instructions are helpful when using and commissioning the equipment.

Data sheets
The data sheets for the components included in the technology package are supplied along with the equipment set, and are available as PDF files.

FluidSIM® demo version
A demo version of the FluidSIM® pneumatics software package is included on the CD-ROM. This demo version is also suitable for testing controllers developed by the user.

Festo catalogue
You're provided with specific pages from the Festo AG & Co. KG catalogue for selected components. The representations and descriptions of the components in this format are intended to demonstrate how they are presented in an industrial catalogue. Additional information regarding the components is also included.

FluidSIM® circuit diagrams
The FluidSIM® circuit diagrams for all 19 exercises included in the technology package are contained in this directory.

Industrial applications
Photos and graphics representing industrial applications are made available. These can be used to illustrate individual tasks or to supplement project presentations.

Presentations
This directory contains short presentations for components included in the technology package. They can be used, for example, for the creation of project presentations.

Product information
This directory contains product information and data sheets from Festo AG & Co. KG for the components included in the technology package. This is intended to demonstrate which information and data is made available for industrial components.

Videos
Several short videos of industrial applications in their actual environments round off the media provided with the technology package.

Equipment set for the basic level (TP 101)

The equipment set has been put together for basic training in the field of pneumatic control technology. It includes all the components which are necessary for mastering the specified learning objectives, and can be supplemented with any other equipment sets. A profile plate and a source of compressed air are also required in order to set up functional controllers.

Equipment set for the basic level (TP 101)

Quantity	Designation	Order no.
2	3/2-way roller lever valve, normally closed	152866
1	3/2-way valve with pushbutton, normally open	152861
2	3/2-way valve with pushbutton, normally closed	152860
1	3/2-way valve with selector switch, normally closed	152863
1	3/2-way valve, pneumatically actuated at one end	539768
3	5/2-way double pilot valve, pneumatically actuated at both ends	539769
1	5/2-way valve with selector switch	152862
1	5/2-way valve, pneumatically actuated at one end	538694
1	Double-acting cylinder	152888
2	One-way flow control valve	193967
2	Pressure gauge	152865
1	Pressure regulator with pressure gauge	539756
1	Pressure sequence valve	152884
1	Single-acting cylinder	152887
1	On-off valve with filter regulator	540691
2	Plastic tubing, 4 x 0.75, silver, 10 m	151496
2	Pneumatic proximity switch with cylinder mounting	539775
1	Pneumatic timer, normally closed	540694
1	Quick exhaust valve	539772
10	Push-in sleeve	153251
10	Push-in T-connector	153128
1	Distributor block	152896
1	Shuttle valve (logical OR)	539771
2	Dual-pressure valve (logical AND)	539770

Learning objectives for the advanced level (TP 102)

- Detect end-positions without limit switches
- Understand and set up memory circuits (flip-flop, double pilot valve)
- Retrofit a 3/2 and/or a 5/2-way valve
- Evaluate, use and adjust various sensors
- Explain the function of a back-pressure end stop
- Explain the function of stepper modules
- Develop basic sequence control systems (continuous cycle)
- Implement a sequence control system with the following operating modes: automatic/manual, start and reset
- Implement an OR operation for feedback signals
- Set and coordinate delays
- Be able to abort delay times with an OR operation
- Implement a sequence control system with idle step (3 steps)
- Describe and set up variable step repetition within a motion sequence using a preset counter
- Develop an input circuit with self-latching loop including the following functions: automatic/manual, start, stop at end of cycle and reset
- Evaluate and use sensors for detecting materials
- Actuate the final control element with two steps via a shuttle valve (double cylinder stroke)
- Use a proximity switch within the stroke sub-range in order to reverse cylinder motion
- Development of an input circuit for a sequence control system with secure pilot air, as well as start, emergency stop and reset functions
- Stop the cylinder within the sub-stroke range (positioning) through pneumatic actuation at both ends (preloading)
- Adjust proximity switches in the end positions, and within the sub-stroke range
- Combined use of quick exhaust valve and pressure regulator with pressure gauge
- Set up an inverted timer signal
- Implement a controller with command action in combination with sequence control

Table of contents

Solutions

Exercise 1: Opening and closing an oven door

Learning objectives

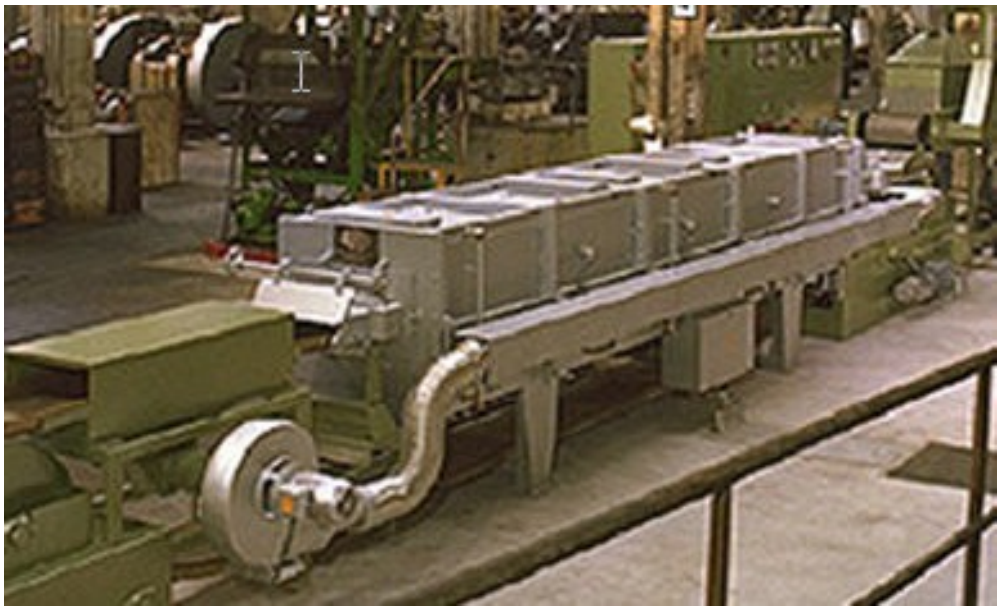
After completing this exercise:

- You'll be familiar with various types of end-position sensing.
- You'll be familiar with the options for setting up controllers with latching functions.
- You'll be able to convert 3/2 and/or 5/2-way valves (normally closed/normally open).

Presentation of the problem

The hardening system is laid out for continuous hardening of mass produced metal parts. The workpieces are hardened by heating them up, and then quenching them in an oil bath. The flaps at the hardening system's inlet and outlet are opened with double-acting cylinders. This exercise deals with the controller for only one of the two oven doors.

Layout



Hardening oven

Parameters

- Due to the generation of heat, limit switches should not be used. Pressure needs to be sensed when the cylinder travels into one of its two end-positions.

Procedure

1. Opening and closing is started with a pushbutton.
2. A 5/2-way double pilot valve controls the double-acting cylinder. Pressure which occurs when the cylinder travels into one of its two end-positions will be used as a control pulse.
3. Either a “retract” pulse is transmitted to valve 1V4 via valves 1V1 and 1V3,
4. Or an “advance” pulse is transmitted to valve 1V4 via valves 1V2 and 1V3.
5. The abbreviated notation for cylinder motion is: 1A1+ 1A1–

Project assignment

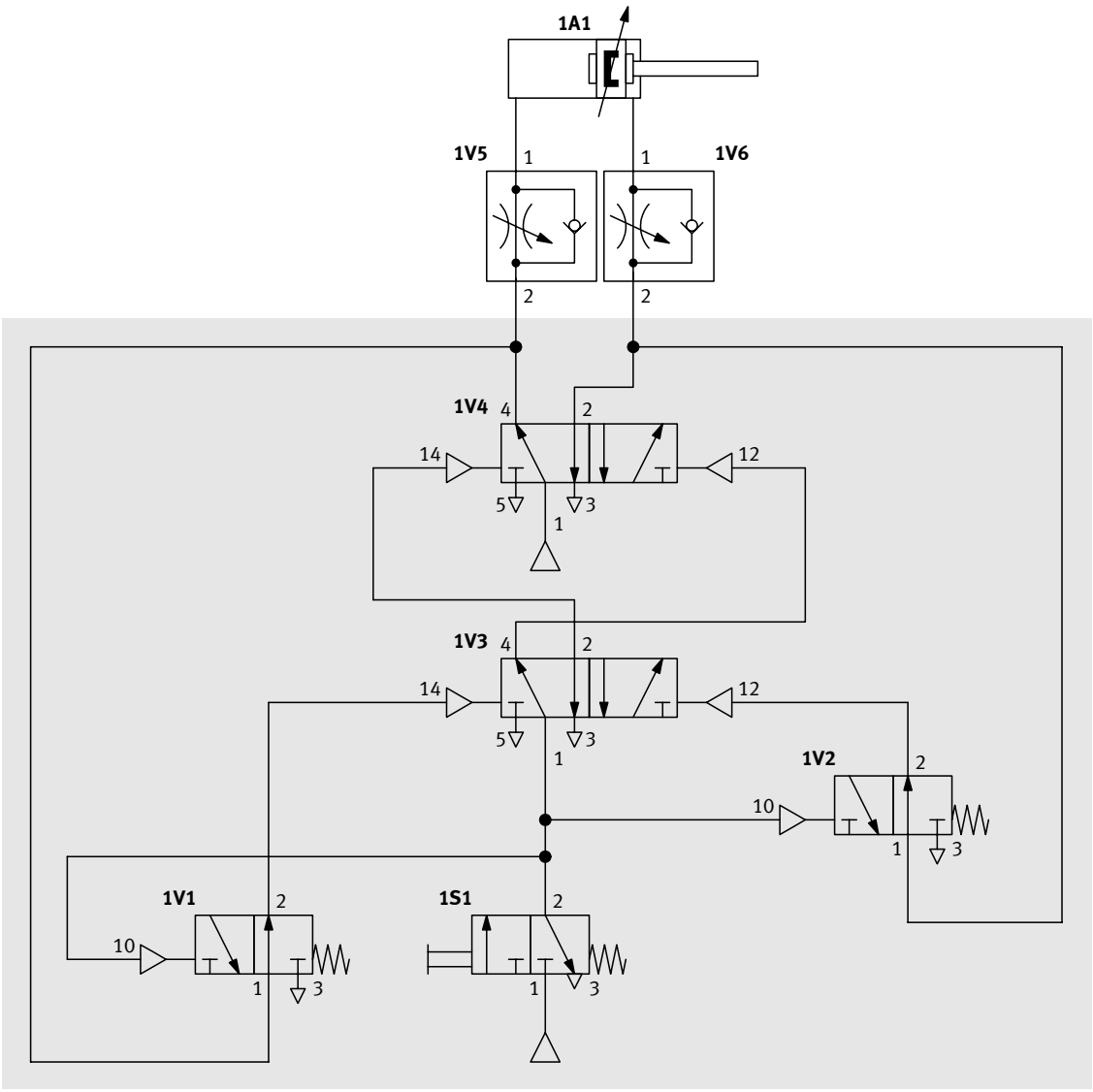
1. Complete the pneumatic circuit diagram.
2. Convert the directional control valves included in the equipment set.
3. Set up the controller.
4. Double check the controller configuration.
5. Describe the mode of operation of the controller.
6. Create the equipment list.

Additional exercises

Which errors might occur when connecting the controller’s tubing?
What consequences would these errors have?
The convertible 3/2-way pneumatic valves are earmarked for use as the required 3/2-way valves 1V1 and 1V2. These valves are shipped with a default setting of normally closed. How do they have to be converted in order to fulfil the required function?
Use 5/2-way valves as an alternative. How do they have to be converted?
How does the controller respond to a pressure drop?

Completing the pneumatic circuit diagram

– Complete the pneumatic circuit diagram by adding in the missing compressed air lines.



Pneumatic circuit diagram

Sequence description

– Set up the controller and describe the sequence used.

Initial position
The oven door is closed. The piston rod of cylinder 1A1 is advanced. 5/2-way double pilot valve 1V4 (final control element) pressurises the piston chamber and exhausts the piston rod chamber. 5/2-way double pilot valve 1V3 (reversing valve) is switched for flow from 1 to 4.

Step 1-2 – Opening the oven door
If the pushbutton at 3/2-way valve 1S1 is pressed, 3/2-way pneumatic valves 1V1 and 1V2 are actuated simultaneously. Pilot ports 12 and 14 at reversing valve 1V3 are pressurised. Compressed air is now capable of pressurising pilot port 12 at 5/2-way double pilot valve 1V4 via ports 1 and 4 at 5/2-way double pilot valve 1V3. Valve 1V4 is reversed as a result. The piston rod side of cylinder 1A1 is pressurised. The piston travels to its rear end-position.
At the same time, pilot port 12 at reversing valve 1V3 is pressurised with compressed air due to working air via 3/2-way pneumatic valve 1V2. Reversing valve 1V3 is connected so that final control element 1V4 can be reversed by means of a new start signal.

Step 2-3 – Closing the oven door
If the pushbutton at 3/2-way valve 1S1 is pressed once again, 3/2-way pneumatic valves 1V1 and 1V2 are actuated simultaneously. Pilot ports 12 and 14 at reversing valve 1V3 are pressurised. Compressed air is now capable of pressurising pilot port 14 at final control element 1V4 via ports 1 and 2 at reversing valve 1V3. Cylinder 1A1 is pressurised at the piston side. The piston rod advances.
At the same time, pilot port 14 at reversing valve 1V3 is once again pressurised with compressed air due to working air via 3/2-way pneumatic valve 1V1. The controller is once again in its initial position. The oven door can be opened again by means of a new start signal.

Creating the equipment list

In addition to the circuit diagram, complete project documentation also includes an equipment list.

– Create an equipment list by entering the required components in the table below.

Quantity	Designation
1	Cylinder, double-acting
2	One-way flow control valve
2	5/2-way double pilot valve
1	3/2-way valve with pushbutton actuator, normally closed
2	3/2-way pneumatic valve, normally open
1	Distributor block
1	On-off valve with filter regulator
1	Compressed air source

Equipment list

Solutions to additional exercises

The convertible 3/2-way pneumatic valves are earmarked for use as the required 3/2-way valves 1V1 and 1V2. These valves are supplied with a default setting of normally closed.

– How do the 3/2-way valves have to be converted in order to fulfil the required function?

The valves are converted to normally open by interchanging the blanking plug and the working port.

– Which errors might occur when connecting the controller's tubing? What consequences would these errors have? Describe the errors.

If the 3/2-way valves have not been correctly converted, the controller doesn't work.
If ports 2 and 4 are reversed at valve 1V4, the cylinder doesn't advance.

– Use 5/2-way valves as an alternative. How do they have to be converted? How do the 5/2-way pneumatic valves have to be converted?

Working port 4 has to be plugged.

Note
Possible solution in the event that a plug is not available: connect a barbed T-connector to the valve, using a short tube. Connect the remaining outlets of the barbed T-connector to each other with a short tube.

– How does the controller respond to a pressure drop?

The controller retains its status in memory. Result: if the door moves when pressure drops, it returns to its last position when pressure is restored.

Exercise 1: Opening and closing an oven door

Learning objectives

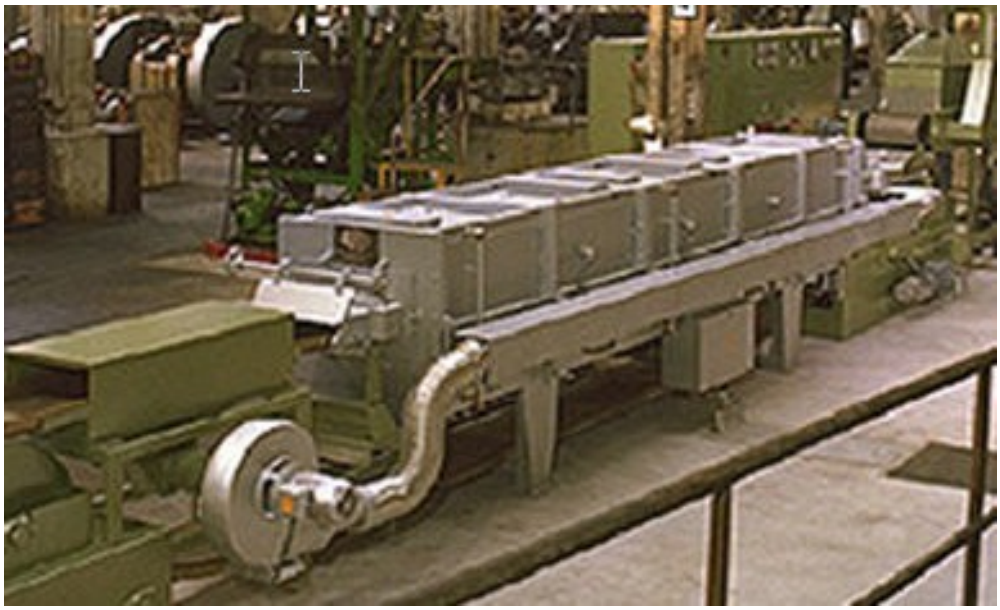
After completing this exercise:

- You'll be familiar with various types of end-position sensing.
- You'll be familiar with the options for setting up controllers with latching functions.
- You'll be able to convert 3/2 and/or 5/2-way valves (normally closed/normally open).

Presentation of the problem

The hardening system is laid out for continuous hardening of mass produced metal parts. The workpieces are hardened by heating them up, and then quenching them in an oil bath. The flaps at the hardening system's inlet and outlet are opened with double-acting cylinders. This exercise deals with the controller for only one of the two oven doors.

Layout



Hardening oven

Parameters

- Due to the generation of heat, limit switches should not be used. Pressure needs to be sensed when the cylinder travels into one of its two end-positions.

Procedure

1. Opening and closing is started with a pushbutton.
2. A 5/2-way double pilot valve controls the double-acting cylinder. Pressure which occurs when the cylinder travels into one of its two end-positions will be used as a control pulse.
3. Either a “retract” pulse is transmitted to valve 1V4 via valves 1V1 and 1V3,
4. Or an “advance” pulse is transmitted to valve 1V4 via valves 1V2 and 1V3.
5. The abbreviated notation for cylinder motion is: 1A1+ 1A1–

Project assignment

1. Complete the pneumatic circuit diagram.
2. Convert the directional control valves included in the equipment set.
3. Set up the controller.
4. Double check the controller configuration.
5. Describe the mode of operation of the controller.
6. Create the equipment list.

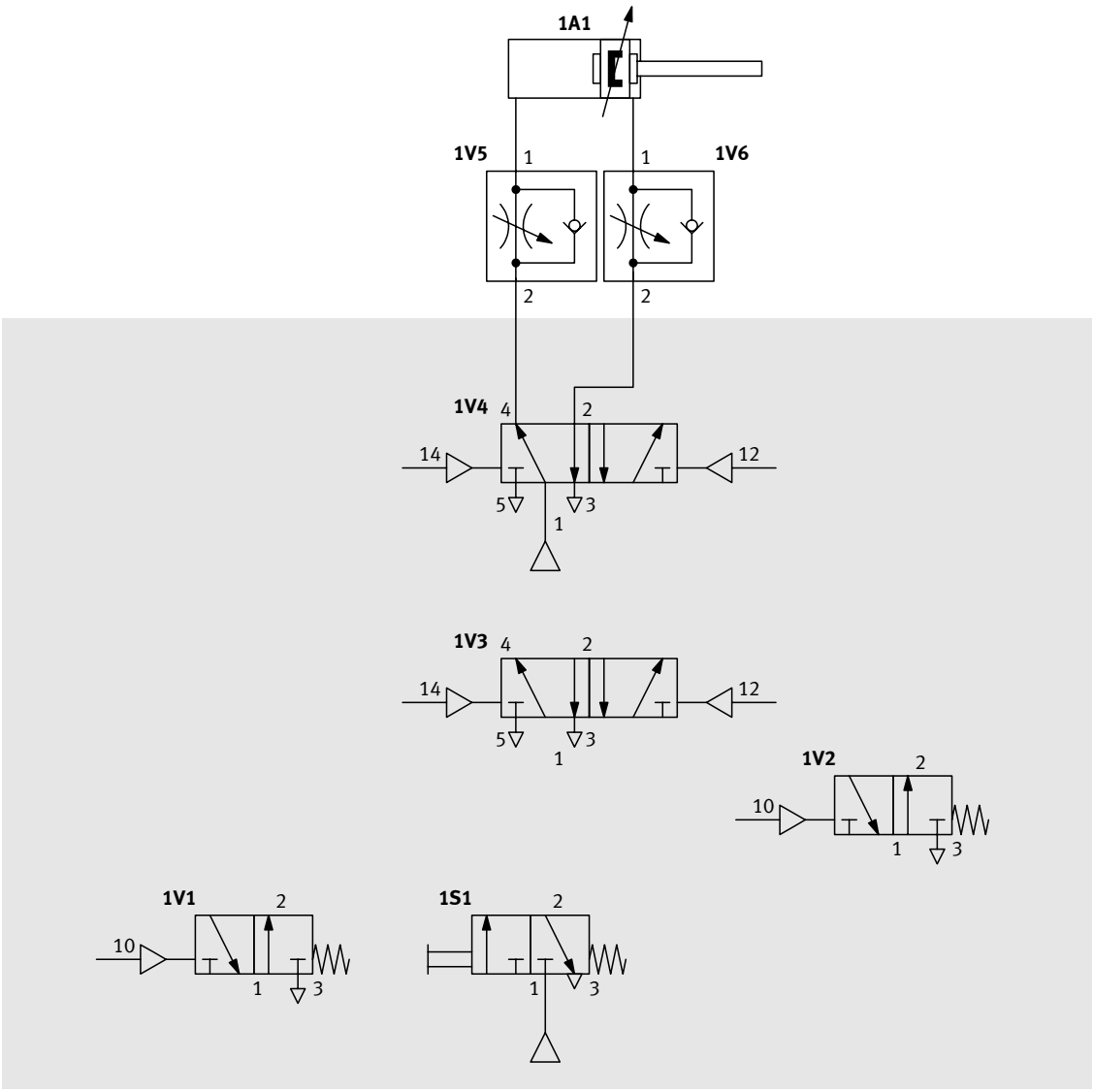
Additional exercises

Which errors might occur when connecting the controller’s tubing?
What consequences would these errors have?
The convertible 3/2-way pneumatic valves are earmarked for use as the required 3/2-way valves 1V1 and 1V2. These valves are shipped with a default setting of normally closed. How do they have to be converted in order to fulfil the required function?
Use 5/2-way valves as an alternative. How do they have to be converted?
How does the controller respond to a pressure drop?

 Name: _____ Date: _____

Completing the pneumatic circuit diagram

– Complete the pneumatic circuit diagram by adding in the missing compressed air lines.



Pneumatic circuit diagram

Sequence description

– Set up the controller and describe the sequence used.

Initial position

Step 1-2 – Opening the oven door

Step 2-3 – Closing the oven door

 Name: _____ Date: _____

Creating the equipment list

In addition to the circuit diagram, complete project documentation also includes an equipment list.

– Create an equipment list by entering the required components in the table below.

Quantity	Designation

Equipment list

Solutions to additional exercises

The convertible 3/2-way pneumatic valves are earmarked for use as the required 3/2-way valves 1V1 and 1V2. These valves are supplied with a default setting of normally closed.

– How do the 3/2-way valves have to be converted in order to fulfil the required function?

_____

_____

_____

– Which errors might occur when connecting the controller's tubing? What consequences would these errors have? Describe the errors.

_____

_____

_____

– Use 5/2-way valves as an alternative. How do they have to be converted? How do the 5/2-way pneumatic valves have to be converted?

_____

_____

_____

Note
Possible solution in the event that a plug is not available: connect a barbed T-connector to the valve, using a short tube. Connect the remaining outlets of the barbed T-connector to each other with a short tube.

– How does the controller respond to a pressure drop?

_____

_____

_____

